2026 ABSTRACTS OF THE AsMA SCIENTIFIC SESSIONS

2026 Annual Scientific Meeting	**Sheraton Denver Downtown Hotel**
May 17–21, 2026	**Denver, CO**

The following are the sessions and abstracts with rooms and presentation times for all presentations accepted after blind peer-review—in workshop, panel, slide, or interactive presentation sessions—for the 2026 Annual Scientific Meeting of the Aerospace Medical Association. The numbered abstracts are keyed to both the daily schedule and the author index. The Sessions numbers are listed as S-01 through S-89 (including workshops). Session chairs are included in the index to participants. The order of some sessions may have changed, so some abstracts may be out of numerical order. Abstracts withdrawn are listed as **WITHDRAWN**. Presenters are underlined in the text.

SLIDES & PANELS: Each slide presentation is scheduled for 15 minutes (10-min talk and 5-min Q&A). We strive to keep slide presentations on time. Panel presentations have more flexibility and may not keep to a strict 15 minutes per presenter format. There will be a discussion period of 15 minutes at the end of each panel.

INTERACTIVE PRESENTATIONS: Interactive presentations (posters) will be presented digitally. Poster authors must be present for the full session in which their poster is scheduled.

EXHIBITS: Exhibits will be open Sunday evening during the Welcome Reception, 6:30–8:30 p.m. Monday 7:00 a.m.–4:00 p.m. Tuesday 7:15 a.m.–4:00 p.m. and Wednesday 7:30 a.m.–4:30 p.m. Please wear your badge and visit every exhibit.

CONFLICT OF INTEREST: All meeting planners and presenters completed financial disclosure forms for this live educational activity. All potential conflicts of interest were resolved before planners and presenters were approved to participate in the educational activity. Any conflicts of interest that could not be resolved resulted in disqualification from any role involved in planning, management, presentation, or evaluation of the educational activity.

TEMPLATES: All Abstracts were submitted according to a certain category and type using provided templates. Not all abstracts submitted fit the mold for Original Research abstracts. We therefore have created an Education category with three additional types: Case Report, Program/Process, and Tutorial. The templates for these are provided for your information.

ORIGINAL RESEARCH TEMPLATE:

This type of abstract describes the results and significance of new research undertaken to address gaps in the current knowledge of aerospace medicine or human performance. It is typically an original analysis of a hypothesis involving data collection and analysis.

INTRODUCTION: *<This section includes the background, including a statement of the problem and why it is important, the status of the current research, and the hypothesis to be tested.>*

METHODS: *<This section includes a brief description of how the study was conducted, the number, type, and gender of the subjects, and how they were selected and grouped. It should also include the metrics collected, how they were measured, and how frequently they were recorded. The types of scales or questionnaires administered should be identified. Environmental condition and administered medications should be described. In addition, a summary of the statistical methods should be provided. A statement concerning ethics approval for studies using human or animal subjects is also required.>*

RESULTS: *<This section includes a summary of the data and metrics of operational and/or statistical significance.* ***"Results will be discussed" is not acceptable.****>*

DISCUSSION: *<This section interprets the meaning of the results in terms of their application to the operational/clinical/scientific community and suggests areas for future research.>*

EDUCATION: CASE STUDY: CLINICAL OR HUMAN PERFORMANCE TEMPLATE:

This type of abstract describes the analysis of an individual clinical or operational case that is not a research study but provides pertinent information directly applicable to aeromedical practices, safety, or human performance.

INTRODUCTION: *<This section concisely summarizes the case.>*

BACKGROUND: *<This section describes the importance of the case and provides supporting evidence in the form of a literature review.>*

CASE PRESENTATION: *<This section describes the event.>*

DISCUSSION: *<This section explains the applicability and relevance to civilian and military operations.>*

EDUCATION: PROGRAM/PROCESS REVIEW TEMPLATE:

This type of abstract can describe a new Service thrust, e.g., identifying capability gaps, or reviews of critical areas, e.g., safety. It may be a description of a program or process that is used to solve a problem or accomplish a task.

BACKGROUND: *<This section describes why this is important to AsMA attendees and why this needs to be addressed now.>*

OVERVIEW: *<This section concisely describes the effort and how it applies to current or future gaps.>*

DISCUSSION: *<This section describes (1) the operational or clinical significance, (2) how it will this advance aeromedicine/human performance, and (3) address whether it supports cross Service/International/Military – Civilian spheres.>*

EDUCATION: TUTORIAL TEMPLATE:

This type of abstract describes new tools, models, techniques, methodologies pertinent to civilian and military aerospace

medicine and human performance.

INTRODUCTION: *<This section summarizes what will be covered, e.g., list of topics or syllabus.>*

TOPIC: *<Description of new technology, procedure, methodology.>*

APPLICATION: *<This section details how the new material will be implemented and how broadly it applies to aerospace medicine and human performance.>*

RESOURCES: *<This is an optional section to provide citations where additional information can be found.>*

Sunday, 05/17/2026

Workshop: AVIATION MISHAP EPIDEMIOLOGY: CANCELLED

Sunday, 05/17/2026, 8:00 AM

Plaza A/B

[S-1] Workshop: MENTAL WELLNESS IN GLOBAL AVIATION: BOUNDLESS FRONTIERS AND RELENTLESS PROGRESS

Chair: Quay Snyder

Co-Chairs: William Hoffman

Workshop Overview: *Mental health (MH) is one of the most consequential frontiers in aerospace medicine. Across aviation communities, persistent barriers to help seeking behavior, inconsistent policy frameworks, and limited integration of mental wellness into safety systems continue to create risk to individuals, organizations, and the aviation safety. This workshop*

convenes leaders in operational aviation medicine, peer support, safety science and regulatory policy to explore emerging innovations that advance MH as a core component of aviation safety, readiness and performance. The morning will include 4 presentations by global leaders in innovative mental health/aviation safety integration programs. The 1st presentation examines real world efforts to establish trusted protected reporting with the Safe Haven program. Building on this foundation, the 2nd presentation on Safety Management Systems in MH Risk Mitigation emphasizes the need to embed mental wellness within SMS frameworks to enable proactive hazard identification, recovery pathway planning and evidence-based operational risk management. The 3rd presentation highlights the work of an aviation safety coalition developing a confidential medical event reporting designed to enhance transparency, surveillance capability, and trust while supporting regulatory compliance. The 4th presentation on aviation peer support demonstrates global collaboration across regulators, airlines, clinicians, unions, and peer support networks, showcasing the momentum toward unified strategies to strengthen resilience and safety outcomes across the aviation ecosystem. Afternoon sessions include the value, challenges and ethical issues associated with MH data collection followed by a presentation on an operational focused risk assessment for ADHD. Two breakouts will follow. One focuses on the challenges of integrating MH into aviation SMS and the second addresses the real-world benefits and challenges associated with peer support programs. The workshop closes with a discussion of the future mental wellness initiatives in aviation followed by a networking session for all attendees. Together, these interactive sessions explore mental wellness not as an individual liability but as a system level safety priority requiring integrated solutions and ongoing progress. Small group discussions will synthesize lessons learned and identify practical actions aviation stakeholders can adopt to transform mental health into a proactive safety capability.

[1] SAFE HAVEN – IMPLEMENTATION CHALLENGES, CURRENT EXPERIENCE AND FUTURE GOALS

David Powell[1], Tim Sprott[2]

[1]Safe Haven Trust of New Zealand, Auckland, Auckland, New Zealand; [2]Civil Aviation Authority of New Zealand, Wellington, New Zealand

(Education - Program / Process Review)

BACKGROUND: Safe Haven represents a new approach in civil aviation regulation, designed to tackle the known problems in aviation of under-declaration and worse, healthcare avoidance, amongst aviators. **OVERVIEW:** The essence of this approach is that selected and trained aeromedical examiners (AMEs) are given the legal freedom to advise aviators (in our case pilots and air traffic controllers) on medical and/or psychological issues, and make decisions about their safety to continue operating, without the usual requirements to declare diagnoses to the aviation regulatory authority. This is a high trust model aimed at facilitating more open and honest discussions between aviators and AMEs. **DISCUSSION:** There are guard rails in place to prevent concealment of safety-critical issues, and associated escalation pathways for more serious conditions. Funding in our case is shared between the aviation regulator and the largest pilot professional association. This presentation will discuss the concept, legal basis, formation

and execution of Safe Haven drawing on the first few months of actual experience. This will be shared from the perspective of both the regulator and the Safe Haven medical director overseeing the programme. This is the first opportunity at AsMA to hear about the real-world experience of one of the world's first Safe Haven programmes.

Learning Objectives

1. State the concept and aims of a Safe Haven program in civil aviation.
2. Describe possible legal requirements for introducing a Safe Haven program.
3. List possible obstacles to implementation of Safe Haven in civil aviation.

[2] MENTAL WELLNESS IN GLOBAL AVIATION: SAFETY MANAGEMENT SYSTEMS - INTEGRATING MENTAL HEALTH INTO SMS

Ben Johnston

Air New Zealand, Auckland, Auckland, New Zealand

(Education - Tutorial / Review)

INTRODUCTION: In 2024 the Aerospace Medical Association Mental Health Working Group drafted a resolution recommending that "ICAO and member states require that aviation organizations incorporate an integrated program of health and wellness as part of their SMS programs that identifies hazards associated with workload stressors and implements efforts to control the associated hazards" **TOPIC:** This presentation will outline how the ICAO SMS Framework of four core components of (Policy and Objectives, Risk Management, Assurance and Promotion) and their 12 interdependent elements can be applied to mental health and wellbeing, using examples from one airline's experience. **APPLICATION:** Strengths and weaknesses, and key learnings, will be shared to assist aviation organisations who are considering integrating mental health and wellness into their SMS.

Learning Objectives

1. The participant will be able to understand how the four core components of the ICAO SMS Framework are applied to mental health and wellbeing.
2. The participant will be able to understand how the twelve interdependent elements of the ICAO SMS Framework may be applied to integrating mental health and wellbeing programs.
3. The audience will learn about sources of data which can be used in SMS assurance processes applicable to controls for mental health and wellbeing risks.

[3] ADVANCING AVIATION SAFETY THROUGH PROTECTED REPORTING OF HEALTH-RELATED CONTRIBUTING FACTORS FOR SAFETY EVENTS

Travis Ludwig[1], Anthony Tvaryanas[2]

[1]ALPA-I, McLean, VA, USA; [2]Federal Aviation Admiration, Oklahoma City, OK, USA

(Education - Program / Process Review)

BACKGROUND: Despite advances in data-driven aviation safety risk management, such as the aggregation of Flight Operational Quality Assurance and Aviation Safety Action Program (ASAP) data to identify systemic hazards to the US national airspace, the role of human performance as a safety driver is relatively unexplored and data-scarce. To the extent that the current state of US medical certification discourages pilots' proactive health-seeking and medical disclosure behaviors, this only compounds the challenge. The Aeromedical Safety Coalition's (ASC) cross-sector collaboration on health- and human performance-related safety research is addressing personnel health as a core safety topic and advancing safer skies through healthier pilots and air traffic controllers. **OVERVIEW:** To begin to address this challenge, this presentation explores a proposed voluntary, protected medical safety event reporting program. Like the current ASAP, this proposed program is designed to promote a safety culture and deliver safety risk management (SRM) and safety assurance insights not otherwise available. It offers a privacy-protected mechanism for collecting health-related contributing factors in safety event reporting. It emphasizes voluntary participation, confidentiality and privacy safeguards modeled on ASAP, a role for trusted medical intermediaries, and integration into operators' Safety Management Systems to support proactive, data-driven aviation SRM. The presentation also proposes prototyping an initial solution as one step toward full realization of the concept. This optional feature would capture when a medical factor was present in events reported through ASAP. The prototype would assess adoption of the feature, yield de-identified safety insights, seek to maintain pilot trust and protections, and inform a more robust future solution. This session will share the conceptual model, stakeholder considerations, and anticipated value for pilots, unions, airlines, medical professionals, and regulators as the aviation community explores next steps in aeromedical safety innovation. **DISCUSSION:** By addressing this gap in human performance safety data and elevating health as a SRM topic, the proposed program can strengthen organizations' safety culture, enable early and appropriate support/remedies by cognizant parties, and drive better SMS coordination across sectors.

Learning Objectives

1. The participant will be able to list the key attributes of a proposed program for including health-related contributing factors in aviation safety event reporting.
2. The participant will be able to describe how such a program can strengthen aviation safety.
3. Participants will be able to define the mission of the Aeromedical Safety Coalition.

[4] WE'RE ALL IN THIS TOGETHER – IPAAC'S ROLE IN SUPPORTING EVERY AVIATION SAFETY PROFESSIONAL

David Fielding[1], Quay Snyder[2], Johann Wium[3], William Hoffman[4]

[1]IPAAC, London, London, United Kingdom; [2]Aviation Medicine Advisory Service, Centennial, CO, USA; [3]European Association of Aviation Psychology, Keflavik, Iceland; [4]U.S. Air Force, San Antonio, TX, USA

(Education - Program / Process Review)

In the 1970s "pilot error" was labelled as the reason for many accidents. It was only extensive cause and analysis work from the 1980s onwards that led to CRM and detailed Human Factors frameworks being created for pilot training. We are now at a similar stage where the distraction element of poor mental health amongst safety-critical aviation personnel is being recognised as significant and is being studied through the lens of cause and effect. The goal is to create appropriate education material and effective support systems to prevent poor mental health and wellbeing impacting on flight safety. The high-profile nature of major incidents like the Germanwings crash of 2015 made the focus of much of this work revolve around pilots. However, it has become clear that mental health is a continuum across all safety-critical aviation personnel. For example: pilots may be operating at an optimal level of personal wellbeing, but if the mechanic fixing the engine pre-departure is not and makes a mistake because they are distracted then everyone has a bad day if the engine subsequently fails. There is an obvious need here for a central body to connect and co-ordinate all the multiple agencies involved in supporting aviation personnel with mental health issues. The role of IPAAC, the International Peer Assist Aviation Coalition, is to bring together all the expertise in the field: firstly to assist with the creation of quality Peer Support Programs amongst all safety-critical aviation personnel; and secondly to work towards global standardisation of support mechanisms for those personnel with mental health conditions. There are unacceptable variations of handling mental health issues in different states, and the work of IPAAC to highlight these differences and effect change is already bearing fruit. This panel will outline the work that IPAAC is doing and why mental health and wellbeing represents a critical factor in flight safety. The panellists will bring their expertise in various areas in the field (regulatory, medical, research and support providers) to explain the work that is being done as detailed in this abstract, along with the challenges which we face going forwards.

Learning Objectives

1. To illustrate that good mental health and wellbeing is critical for anyone who touches an aircraft either literally or metaphorically.
2. To demonstrate how poor mental health and wellbeing amongst safety-critical personnel in aviation is a distraction and thus a potential threat to flight safety.
3. To highlight inconsistencies of regulatory and operator handling of mental issues globally and why this is unacceptable.

[5] SAVIOR OR SHYSTER — DOES AI HAVE A ROLE IN AVIATION MENTAL WELLNESS?

Johann Wium Magnusson[1], Kimberly Perkins[2]

[1]Reykjavik University, Reykjavik, Iceland; [2]University of Washington, Seattle, WA, USA

(Education - Program / Process Review)

Artificial intelligence (AI) is increasingly positioned as a transformative force in global healthcare, including mental wellbeing; however, its role within aviation remains contested. Persistent barriers to help-seeking, fragmented mental-health policies, and limited integration of wellbeing within Safety Management Systems (SMS) continue to challenge the aviation community. These challenges are further compounded by the international regulatory environment, in which mental health standards, access to treatment, and aeromedical certification requirements vary across jurisdictions. Concurrently, there is growing recognition that psychosocial hazards (e.g., burnout, anxiety, depression, stress, etc.) represent safety-relevant risks that are inadequately captured by traditional SMS hazard identification processes. Framed within mental wellbeing as a system- level safety priority, this work examines whether AI can (1) serve as a stigma-reducing bridge to peer support programs, thereby enhancing accessibility and engagement; (2) provide meaningful decision-support and training tools for peer support program volunteers; and (3) support psychosocial risk assessment within SMS. The workshop presents peer-reviewed literature on mental-health chatbots and AI-enabled wellbeing interventions, complemented by recent empirical findings on aviation professionals' use of AI-based conversational tools, including perceptions of trust, acceptability, and perceived therapeutic relevance. Participants will also engage in hands-on comparative testing of publicly available large language models alongside a purpose-built, aviation-specific AI tool, evaluating operational fit, regulatory alignment, and ethical considerations through small-group analysis. The workshop further explores AI-supported resilience training, peer-support augmentation, and the use of aggregated, de-identified psychosocial indicators to inform safety assurance processes and safety culture measurement. Rather than functioning as a clear "devil" or "savior," AI is best understood as a mirror reflecting the values, assumptions, and safeguards of the systems into which it is designed. In aerospace medicine, its ultimate role in mental wellness will reflect our collective commitment to safety, ethics, and human-centered design. Whether AI heals or harms will depend on the choices we make now.

Learning Objectives

1. Assess the role of AI-enabled mental wellbeing tools within global aviation safety systems by evaluating their impact on help-seeking behavior, peer support programs, psychosocial risk identification, and Safety Management Systems, while accounting for regulatory variability, protected reporting principles, and safety-critical constraints.
2. Apply a system-level, safety-first framework to determine where AI can responsibly support mental wellbeing initiatives—such as peer support, resilience training, and

psychosocial risk assessment—and where governance, ethical safeguards, and human oversight are required to preserve trust, regulatory compliance, and operational safety.

[6] OPERATIONALLY DRIVEN ADHD ASSESSMENT

Kate Manderson

Civil Aviation Safety Authority Australia, Canberra, Australian Capital Territory, Australia

(Education - Program / Process Review)

BACKGROUND: Assessing the impact of medical conditions, medications and neurodiversity on the safe and effective performance of aviation duties continues to be a challenge. Aviation regulators, employers, operators, participants and clinicians all have different expectations and requirements for how and why these assessments are done. There will never be a single correct way, nor will there ever be a perfectly sensitive, specific and reliable process. This means the best approach will be based in collaboration, pragmatism and compromise. It will also require an element of trust and acceptance of risk, so that an imperfect assessment process can still be an important and meaningful element of aeromedical assessments. **OVERVIEW:** As part of our review of aeromedical risk assessment for ADHD, Australia and New Zealand have jointly designed an Aviation Operational Performance Assessment process by integrating the expertise of aerospace physicians, aeromedical regulators, psychiatry, neuropsychology, flight instructors and examiners. The process we have designed includes a form for completion by an experienced aviation operator, using multisource input regarding the subject's behaviour, performance and safety across a range of tasks and settings. The form is accompanied by guidance material describing how and why the parameters have been included and support for how the forms should be completed. Training materials for the senior and experienced operators have also been developed to ensure the most valid and reliable outcome is achieved. **DISCUSSION:** The formulation of this process, supported by documentation, guidance material and training resources, is intended to provide a mechanism to analyse and risk-assess the impact of health and medical issues in the aviation setting. With the majority of aviation safety events and incidents now related to human performance and behaviour rather than medical incapacity due to physical disease, a process for aviation authorities and aerospace medicine clinicians to formulate an objective, reliable and reproducible assessment is imperative. We believe our process achieves the desired aim of having something that is fit for purpose, acceptable to all stakeholders, and will be an effective part of a wider system of aeromedical assessment.

Learning Objectives

1. The participant will be able to describe the aviation tasks and duties that are aligned with important neurocognitive parameters.
2. The audience will learn about how safety-relevant neurocognitive tasks can be observed and measured in the aviation setting.

[7] SMS: IS IT POSSIBLE TO INTEGRATE MENTAL FITNESS?

Kimberly Perkins[1], Anthony Tvaryanas[2], Keith Frank[3], Aedrian Bekker[4]

[1]University of Washington, Seattle, WA, USA; [2]FAA, Oklahoma City, OK, USA; [3]International Peer Aviation Assist Coalition, Denver, CO, United Kingdom; [4]Centre for Aviation Psychology, London, United Kingdom

(Education - Program / Process Review)

BACKGROUND: Safety Management System (SMS) is widely adopted as the primary framework for managing risk in aviation and other safety-critical industries. Yet, despite growing recognition that mental health and psychosocial factors influence performance, these elements remain largely absent from formal SMS implementation. This workshop explores whether—and how—mental fitness can be integrated into SMS in a way that is operationally meaningful, ethically sound, and aligned with existing regulatory frameworks. **DISCUSSION:** Participants will engage with current research from human factors, Safety-II, and psychosocial risk management to examine mental fitness as a system-level construct that affects decision-making, communication, workload management, and adaptive capacity. The workshop will address common concerns, including confidentiality, stigma, regulatory overreach, and unintended consequences, while highlighting practical pathways for integration that avoid individual medicalization or fitness-for-duty determinations. Through guided discussion, case examples from aviation peer support and resilience programs, and small-group exercises, participants will identify where psychosocial risk already exists within SMS processes and how it can be addressed using leading indicators, safety assurance mechanisms, and safety promotion strategies. Attendees will leave with a conceptual framework and practical tools for incorporating mental fitness into SMS in a manner that supports safety culture, enhances organizational resilience, and respects ethical and regulatory boundaries. **CONCLUSION:** This workshop is designed for safety managers, regulators, human factors professionals, union leaders, and training organizations seeking evidence-based, actionable approaches to modernizing SMS for today's operational realities.

Learning Objectives

1. Participants will be able to identify where psychosocial risk already exists within SMS processes (e.g., hazard identification, safety assurance, safety promotion) and evaluate evidence-based methods for integrating mental fitness using non-punitive, system-level indicators.
2. Participants will be able to apply a practical framework for incorporating mental fitness into SMS in a way that strengthens safety culture, supports operational resilience, and aligns with ethical, regulatory, and organizational constraints.

[8] UNIQUE NEEDS, COMMON GOALS - PEER SUPPORT CHALLENGES & SUCCESSES

Sky Overbo[1], Quay Snyder[2], Keith Frank[3], Aedrian Bekker[4]

[1]University of North Dakota, Grand Forks, ND, USA; [2]AMAS, Centenial, UT, USA; [3]Self, Fort Collins, CO, USA; [4]Centre for Aviation Psychology, Blackford, United Kingdom

(Education - Program / Process Review)

BACKGROUND: Peer support programs are becoming an essential component of mental health, early intervention, and safety culture across aviation and aerospace systems. For AsMA attendees, understanding how these programs function in real-world settings is increasingly critical. As workforce stressors intensify, reporting hesitancy persists, and mental health is more openly discussed than ever before, peer support has emerged as a key bridge between informal help-seeking and formal care. While the foundational goals of peer support are shared, the effectiveness of these programs varies widely based on population, culture, and operational context, creating an urgent need to examine what works, what does not, and why. **OVERVIEW:** This breakout session examines peer support implementation across diverse aviation populations (e.g., pilots, air traffic controllers, maintenance personnel, students, etc.) to address persistent gaps in aviation mental health systems. Drawing on real-world program development and operational experience, the session identifies common challenges such as stigma, confidentiality concerns, fear of professional consequences, unclear role boundaries, and peer supporter fatigue. It highlights successful, practical strategies that improve trust, credibility, and engagement, offering scalable insights to strengthen current programs and inform future peer support development across aerospace settings **DISCUSSION:** This session clarifies how peer support functions as an early-intervention approach that complements formal medical and psychological care, supports timely referral, and helps mitigate escalation of distress that may affect safety-sensitive performance. By addressing psychosocial stressors before they impair cognition, decision-making, sleep, and emotional regulation, effective peer support contributes to sustained human performance and readiness, advancing aeromedicine's emphasis on prevention, resilience, and system-wide safety culture. The concepts and strategies discussed are relevant across all aviation contexts. Accordingly, this session highlights adaptable peer support practices that translate across aerospace systems and global operational environments. Attendees will leave with actionable insights to strengthen peer support programs as sustainable, trusted components of mental health systems that support both individual well-being and operational safety in aerospace environments.

Learning Objectives

1. Differentiate how peer support programs operate across diverse aviation populations (e.g., pilots, air traffic controllers, military personnel, students) and identify population-specific factors that influence engagement, trust, and effectiveness.
2. Analyze common implementation challenges, including stigma, confidentiality concerns, fear of professional consequences, role ambiguity, and peer supporter fatigue, and evaluate evidence-informed strategies that mitigate these barriers within safety-sensitive environments.
3. Apply practical peer support principles as an early-intervention tool that complements formal medical and psychological care, enhancing human performance, timely referral, and safety culture across civil, military, and international aerospace systems.

Sunday, 05/17/2026, 8:00 AM

Plaza F

[S-2] Workshop: REVIEW OF SPACE RADIATION FOR AEROMEDICAL PROFESSIONALS

Chair: Annette Sobel

Co-Chair: David Wexler

Workshop Overview: *Many aerospace medicine professionals lack an adequate understanding of the operational principles of space radiation safety and medical monitoring of astronauts and aircrew. In addition, application of these principles to health safety and disease prevention in potentially contaminated extreme environments is insufficient. By using a topically organized, science-based approach to operational considerations and translational research overview, we propose a space radiation workshop that will serve as the cornerstone of practice and implementation of health radiation safety. This workshop will cover a comprehensive set of space radiation topics to include: the basics of radiation physics; acute and chronic radiation illness; space radiation environments with an emphasis on reference missions; brain and neuro-cognitive effects of radiation; radiation detection technologies; shielding and countermeasures; and reference medical standards. The workshop will include relevant demonstrations of equipment in the context of low-level radiation materials and provide the attendee with a working knowledge of measurement science, dosing, terminology. A relevant series of familiarization demonstrations will cement the techniques necessary for real world applications in spacecraft and potential contaminated environments. The workshop will end with a synthesis panel of re-enforcing practical takeaways and facilitated discussion. Each attendee will receive a certificate of workshop completion and a primer that summarizes the workshop core material in a ready-reference format.*

[9] BASIC RADIATION PHYSICS

Robert Duncan[1], David Wexler[2], Philip Brady[3]

[1]Texas Tech University, Lubbock, TX, USA; [2]Space Science Laboratory, University of Massachusetts Lowell, Lowell, MA, USA; [3]Trinity College, Dublin, Ireland

(Education - Program / Process Review)

BACKGROUND: We begin the workshop with a review of key concepts and terminology used in radiation physics, with emphasis on examples pertinent to manned space missions.
OVERVIEW: Radiation is energy transfer through space and materials via propagating electromagnetic waves and moving subatomic particles. Ionizing radiation involves energies sufficient to eject electrons from atoms, and trails of such ionized atoms through biological tissue are associated with tissue and DNA damage that can result in carcinogenesis and cell

degeneration effects. We distinguish the two main categories of ionizing radiation, namely photonic (gamma, x-ray and short ultraviolet) and particulate (the key subatomic particles being protons, alpha and beta particles, metal ions, neutrons and muons). Concepts of flux, fluence and kinetic energy are presented along with the standard units for reporting these quantities. Penetrating power and linear energy transfer are introduced. Dosing terminology in System International (SI) units is developed, from physical dosing in Grays, to effective biological dosing and equivalent doses in Sieverts by means of radiation- and tissue-weighting factors. Stochastic and deterministic applications of radiation dosing are explained. The basics of radiation shielding are presented in preparation for later parts of the workshop. Examples are discussed and a demonstration of radiation measurements will be provided. **DISCUSSION:** While life on Earth inherently includes continuous background exposure to naturally occurring radioactivity from the ground as well as from secondary cosmic ray particles from above, spaceflight subjects humans to higher energy radiation regimes. The next lecture in this workshop will elaborate these space radiation environments and summarize the typical dose rates encountered during spaceflight.

Learning Objectives

1. The audience will understand the basic the types of ionizing radiation pertinent to aerospace operational settings.
2. The audience will be able to distinguish between dosing units of Grays and Sieverts and will become familiar with radiation exposure guidelines.
3. The audience will appreciate the radiation weighting factors that convert physical radiation dose in Grays into statistical risk dose units of Sieverts.

[10] SPACE RADIATION ENVIRONMENTS

Phil Brady[1], David Wexler[2], Stuart George[3], Lawrence Forsley[4]

[1]Trinity College Dublin, Dublin 8, Leinster, Ireland; [2]Space Science Laboratory, University of Massachusetts Lowell, Lowell, MA, USA; [3]NASA/JSC-SD211, Houston, TX, USA; [4]NASA GRC, San Diego, CA, USA

(Education - Program / Process Review)

BACKGROUND: As aerospace operations extend out from the aviation altitudes and Low Earth Orbit (LEO) towards the lunar surface and beyond, the radiological exposure regime undergoes fundamental shifts, with increasing risks. Accurate risk assessment and mitigation strategies require a clear understanding of the hazard domains and potentiating factors. **OVERVIEW:** This part of the workshop provides a comparative radiation physics analysis of different regimes pertinent to aviation altitudes and space missions. We review the types and intensities of radiation in terrestrial settings, aviation altitudes, LEO, radiation belts, deep interplanetary space and lunar/martian surfaces. Radiation intensity in all of these settings are modulated by the level of global solar activity, as indexed by the 11-year sunspot cycle. In general, there is an inverse relationship between level of solar activity (and specifically, heliospheric magnetic field strength), and the flux of galactic cosmic rays (GCRs) in

interplanetary space. This inverse relationship is highlighted during transient Solar Particle Events (SPEs) that may present as rapid transients, as in solar flares, or as larger, slower coronal mass ejections. SPEs diminish interplanetary GCR flux (the Forbush decrease) and accordingly the character and intensity of radiation in the geospace zones. However, while SPEs decrease GCR flux, the very high-energy solar particle streams bring danger-level acute radiation risks in space. Since SPE events are not easily predicted and the warning times may be limited, continuous space weather monitoring and direct lines of communication with the flight medical operations team are important throughout space missions - for example, to time EVA activities and activate enhanced shielding protocols. **DISCUSSION:** Known baseline space radiation dose rates and effectiveness weighting factors can be used to estimate reference mission total radiation loads. These correlate with stochastic risk of adverse sequelae like cancer. The risk of added-on acute radiation from SPEs must also be built into the mission monitoring and operational protocols. Looking ahead towards manned lunar missions, we will present representative measurements from the Artemis I spacecraft during its lunar flyby mission in 2022, demonstrating dose rates in LEO, the radiation belts, interplanetary excursion and in circumlunar space.

Learning Objectives

1. Understand the main differences between the types and intensity of radiation encountered at aviation altitudes, in Low Earth Orbit and in interplanetary space.
2. Describe the inverse correlation between solar activity level and the Galactic Cosmic Ray (GCR) radiation intensity in interplanetary space. Apply space weather principles to identify optimal launch windows for long-duration deep space missions.
3. Understand the impact of Solar Particle eruption Events (SPEs) on astronaut radiation exposure risk, with need to discontinue any EVA operations and reposition to heavily shielded shelter regions inside the spacecraft.

[11] ACUTE RADIATION SYNDROME WITH IMPLICATIONS FOR HUMAN SPACEFLIGHT

Jamil Jomaa[1], Jumana Alshaikh[2], Thomas Hoffman[3]

[1]Corewell Health Dearborn, Canton, MI, USA; [2]University of Utah, Salt Lake City, UT, USA; [3]Acuity International LLC, Satellite Beach, FL, USA

(Education - Program / Process Review)

BACKGROUND: Acute Radiation Syndrome (ARS) is an infrequent but severe multisystem illness resulting from exposure of the whole body (or majority of the body) to high dose ionizing radiation over a short duration of time. This educational workshop is designed to enhance awareness and understanding of ARS in the aeromedical community, emphasizing both terrestrial and aerospace contexts in which such exposures may occur. **OVERVIEW:** Historical examples of ARS can be seen in survivors of Hiroshima and Nagasaki atomic bombs, as well as first responders in the Chernobyl Nuclear Power Plant event. In the modern day, terrestrial

manifestations of ARS most commonly arise from nuclear power incidents, radiological dispersal devices, and medical radiation accidents. The effects of ARS range from hematopoietic suppression, gastrointestinal injury, neurovascular compromise, and cutaneous damage. The severity of effects is determined by absorbed dose and exposure duration. Supportive measures are initiated immediately. Recent advances in medical countermeasures include hematopoietic growth factors, cytokine therapy, stem cell transplantation, and general care protocols. These countermeasures, however, are largely contingent upon early recognition with rapid and accurate absorbed dose assessment, as well as multidisciplinary medical attention. In aerospace environments, unique radiation hazards emerge from solar particle outburst events (SPEs) and galactic cosmic rays, especially during long-duration missions beyond low Earth orbit. High-intensity SPEs may potentially expose astronauts to very high radiation dose rates that pose immediate health risks for astronauts, compromising crew safety and mission performance. Ongoing space weather surveillance is necessary to adjust activities and shielding to minimize the chance of ARS. Although to date, there have been no documented incidents of ARS in human spaceflight, further research on the risks and management of ARS during spaceflight is critical for long duration mission planning. **DISCUSSION:** We will provide clinicians and first responders with practical knowledge to identify, evaluate, and manage ARS across diverse environments. Secondarily, participants will gain a comprehensive overview of the pathophysiology of ARS, with an emphasis on countermeasures for ARS on Earth and in human spaceflight.

Learning Objectives

1. Describe the dosing thresholds and clinical signs of acute radiation syndrome. Identify appropriate diagnostic tests/biomarkers to assess the degree of organ-specific effects.
2. Understand evidence-based treatments for acute radiation syndrome, with emphasis on cytokine-based therapies and current supportive care measures.
3. Describe potential countermeasures and mitigation principles for acute radiation syndrome, with emphasis on applications for human spaceflight beyond lower Earth orbit.

[12] BRAIN AND NEUROCOGNITIVE EFFECTS OF RADIATION

Jumana Alshaikh[1], Phil Brady[2]

[1]University of Utah, Salt Lake City, UT, USA; [2]Trinity College Dublin, Dublin 8, Ireland

(Education - Program / Process Review)

BACKGROUND: The potential impact of space radiation on brain health is a growing concern, particularly as space exploration extends beyond low Earth orbit (LEO) and into deep space. **OVERVIEW:** Space radiation differs significantly from radiation on earth in both composition and exposure profile. On earth, radiation affects the brain primarily during cranial radiation therapy in which it is predominantly photon-based (gamma rays), and to a lesser extent hadron-

based (protons and carbon ions). Earth-based radiation is typically low linear energy transfer (LET) and in radiation therapy is delivered acutely at high doses over short intervals. In contrast, space radiation is a complex mixture of radiation types, with the most concerning components being high LET particles, such as high-speed protons, alpha particles, and high atomic number and energy (HZE) ions, which are predominantly encountered at chronic low doses. Current knowledge about space radiation's impact on the brain is limited. Most of information comes from the neurologic effects observed in cancer irradiation, and from animal models exposed to simulated galactic cosmic radiation (GCR). Primary concerns include neurocognitive effects such as deficits in memory, attention, cognitive flexibility, and alterations in mood and behavior. Additional neurologic risks include the increased risk of central nervous system (CNS) malignancies, neurodegeneration, and cerebrovascular disease. **DISCUSSION:** Proposed pathophysiological mechanisms of brain injury, which also represent potential opportunities for countermeasures, include oxidative stress, neuroinflammation with microglial and astrocyte activation, changes in neuronal morphology such as reduced dendritic density and synaptic complexity, mitochondrial dysfunction, altered protein synthesis and cellular signaling, and vascular endothelial damage leading to blood-brain barrier disruption. Other space-related stressors such as microgravity, isolation and confinement, hypercapnia, and sleep disruption, also affect the CNS and may interact with the effects of space radiation, further complicating the overall impact on brain health. This presentation, as part of the space radiation workshop, explores the latest research on the brain and neurocognitive effects of space radiation, potential mechanisms of brain injury, and a framework for clinically evaluating space travelers experiencing suspected radiation-induced cognitive decline.

Learning Objectives

1. Describe the neurologic, neurocognitive, and behavioral problems that could be associated with space radiation.
2. Explain proposed pathophysiological mechanisms of radiation-induced brain injury, and possible countermeasures.
3. Outline a clinical evaluation framework for return space travelers experiencing suspected radiation-induced cognitive decline.

[13] RADIATION SHIELDING, PHYSIOLOGIC MONITORING and COUNTERMEASURES FOR SPACE RADIATION

Annette Sobel[1], Robert Duncan[2], Michael Schmidt[3], Lawrence Forsley[4], David Wexler[5]

[1]Texas Tech University and BlankSlateInnovation, LLC, Lubbock, TX, USA; [2]Texas Tech University, Lubbock, TX, USA; [3]Sovaris Aerospace, Boulder, CO, USA; [4]NASA GRC, San Diego, CA, USA; [5]Space Science Laboratory, University of Massachusetts, Lowell, MA, USA

(Education - Program / Process Review)

BACKGROUND: Although protection from ionizing radiation has always been an important consideration in astronaut safety, the planning towards exploration class missions and long-term

habitation off Earth now mandates more robust radiation mitigation and countermeasure strategies. This workshop addresses the challenges and limits of physical shielding for interplanetary space travel. In parallel with improvements in passive shielding designs, advances in precision medicine and medical countermeasures will be incorporated to enhance astronaut radiation resilience. **OVERVIEW:** Passive shielding of astronauts from space radiation has been the core of space radiation safety and remains an active area of research. Low atomic number elements and hydrogen-rich molecules tend to provide the best overall protection from particulate ionization radiation, while heavier metals are more effective against high-energy electromagnetic radiation like gamma rays. Common shielding materials including aluminum, polyethylene and modern composites are discussed in the presentation. Shielding designs are subject to constraints and tradeoffs. In some cases, thicker shielding may actually expose the astronauts within the spacecraft to enhanced secondary ionizing radiation including neutrons and gamma rays due to spallation (nuclear particle collision reactions). A particular hazard needing further study is the effect of high atomic number energetic ions (HZEs) which cannot be entirely shielded. The significance of secondary nuclear particles and x-rays within the shielded environment are discussed. NASA guidelines for astronaut exposure limits are reviewed. Extended deep space exploration and habitation will require not only optimized physical shielding, but also radiation-pertinent physiologic monitoring and strategies to enhance astronaut resilience to unavoidable residual radiation exposures. **DISCUSSION:** Beyond the magnetosphere, exposure to the complete energy and particle spectrum of galactic cosmic rays (GCRs) becomes impractical to fully shield. This aspect of long-duration missions in deep space must be addressed with the combined efforts of space physicists, engineers and biomedical researchers to offer multifaceted strategies to protect astronauts. Recent research on physiologic profiles, potential biomarkers, and medical countermeasure approaches on the horizon is discussed. This presentation builds upon the prior sections of this workshop, with emphasis on space radiation monitoring and protection strategies.

Learning Objectives

1. Familiarize with the common types of passive radiation shielding, and their practical limits.
2. Describe potential biomarkers for radiation exposure monitoring in the space environment.
3. Understand the cumulative radiation exposures that may be expected in a 3-year Mars mission, and key strategies to reduce the radiation risks.

Monday, 05/18/2026, 2:00 PM

Plaza A/B

[S-3] Slide: AGILE ANALOGS

Chair: Kathleen Samoil

Co-Chair: Samantha King

[14] PHYSIOLOGICAL AND OMICS PROFILING OF METABOLIC SUPPRESSION FOR RESOURCE CONSERVATION IN LONG-DURATION SPACEFLIGHT: A HUMAN GROUND ANALOG STUDY

Erik LeRoy[1], Katharyn Flickinger[2], Victor Wu[2], Omarf Ortega-Reyes[2], Tao Sheng[2], Daniel Neofes[2], Clifton Callaway[2], Aaron Berliner[1], Alexandra Weissman[2], Francis Guyette[2], Ben Gordon[2]

[1]Weill Cornell Medicine, New York, NY, USA; [2]University of Pittsburgh, Pittsburgh, PA, USA

(Original Research)

INTRODUCTION: Long-duration space missions, including future expeditions to Mars, impose substantial demands on Environmental Control and Life Support Systems (ECLSS), particularly regarding oxygen production, carbon dioxide removal, and nutrition logistics. Recent work has demonstrated the feasibility of a 5-day pharmacologically induced metabolic suppression protocol in a terrestrial analog environment. This secondary analysis examines the operational implications of those findings by quantifying changes in metabolic load relative to each participant's baseline. **METHODS:** Five healthy participants underwent a 5-day metabolic suppression protocol using dexmedetomidine with continuous physiological monitoring. Resting metabolic rate (RMR), oxygen consumption (VO_2), and carbon dioxide production (VCO_2) were measured using indirect calorimetry, supplemented by doubly labeled water for total energy expenditure estimates. Participants completed a spaceflight-relevant exercise regimen to mitigate deconditioning. For this analysis, observed metabolic values during suppression were compared directly to baseline measurements collected prior to the intervention. Differences were translated into estimated savings in consumable mass and corresponding reductions in ECLSS burden. **RESULTS:** Participants exhibited reductions in RMR, VO_2, and VCO_2 during the first three days of the suppression period compared with their baseline values. After day three drug tolerance was observed, but some metabolic reduction still occurred. Preliminary calculations indicate potential decreases in consumable requirements (e.g., oxygen, food, carbon dioxide scrubbing capacity) and associated reductions in thermal and humidity loads. Functional performance metrics (e.g., grip strength, VO_2max) were maintained. **DISCUSSION:** Framed in operational terms, short-duration metabolic suppression produced measurable reductions in crew metabolic load relative to baseline, suggesting meaningful implications for mass, power, and life support requirements during exploration-class missions. Although further validation is required, these results support continued investigation of metabolic suppression as a strategy to optimize mission design and resource allocation for human exploration beyond low Earth orbit.

Learning Objectives

1. Describe how pharmacologically induced metabolic suppression alters metabolic markers (RMR, VO_2, VCO_2) relative to baseline measurements and explain the methods used to assess these changes in a spaceflight analog setting.

2. Evaluate the potential operational implications of reduced metabolic load—including impacts on consumable mass, ECLSS demands, and crew functional performance—for long-duration human space missions.

[15] EFFECTS OF A 60-DAY BED REST ON CEREBRAL PERFUSION ASSESSED BY ARTERIAL SPIN LABELING

Manuel Michno[1], Henning Weis[2], Laura de Boni[2], Claudia Stern[2], Darius Gerlach[2], Daniel Aeschbach[2], David Elmenhorst[3], Eva-Maria Elmenhorst[2]

[1]University of Cologne, Faculty of Medicine and University Hospital, Department of Anesthesiology and Intensive Care Medicine, Cologne, Germany; [2]Institute of Aerospace Medicine, German Aerospace Center, Cologne, Germany; [3]Institute of Neuroscience and Medicine, Molecular Organization of the Brain (INM-2) Forschungszentrum Jülich, Jülich, Germany

(Original Research)

INTRODUCTION: Head-down tilt bed rest (HDT bed rest, −6° tilt) is an established model for simulating the physiological effects of microgravity. This positioning leads to a headward fluid shift and induces cardiovascular, muscular, and neurological changes similar to those observed during long-duration spaceflight. While structural and cognitive alterations of the brain in the context of HDT bed rest are well documented, little is currently known about the effects on cerebral perfusion. Pseudo-continuous arterial spin labeling (ASL), a non-invasive MRI technique, enables the quantitative measurement of cerebral blood flow (CBF) and thus provides new insights into the brain's vascular adaptability under simulated microgravity conditions. **METHODS:** Within a 60-day HDT bed rest study conducted in the :envihab facility of the German Aerospace Center in Cologne, 23 healthy participants (12 m, 11 f) were examined using ASL at 6 time points: 6d before the start of bed rest (baseline), on days 2, 30, and 57 of the bed rest phase, and 2 and 12 days after its end (recovery). Cerebral perfusion was analyzed in seven predefined regions of interest (ROIs). In this way, we tested whether a 60-day HDT bed rest period results in reduced cerebral perfusion. **RESULTS:** The results show a significant decrease in cerebral perfusion in all 7 examined regions during HDT bed rest compared to baseline. This reduction in cerebral perfusion ranges from 12.4% in central brain structures to 15.5% in the frontal lobe (p<0.01). The most pronounced decline was already observed on day 2, followed by gradual partial recovery up to day 57. Two days after the end of bed rest, an "overshoot" effect was observed, in which perfusion values rose above baseline. Twelve days after remobilization, values had largely normalized. The temporal pattern was consistent across all regions, although interindividual differences were present. **DISCUSSION:** HDT bed rest induces a reversible reduction in cerebral perfusion, followed by a temporary overcompensation after remobilization. These findings underscore the high vascular plasticity of the brain under altered gravitational and positioning conditions. The results are relevant for the preparation of astronaut long-duration missions in space as well as for clinical scenarios involving prolonged immobilization. Further analyses will investigate the relationship between perfusion changes, cognitive function, and neurovascular regulation over time.

Learning Objectives

1. The audience will understand how prolonged head-down tilt bed rest affects regional cerebral perfusion and cerebrovascular regulation as quantified by arterial spin labeling.
2. The audience will understand the temporal dynamics and reversibility of cerebral perfusion changes during immobilization and subsequent remobilization, and their relevance for spaceflight and prolonged clinical bed rest.
3. The audience will appreciate the relevance of cerebral perfusion plasticity under altered gravitational conditions for astronaut health monitoring and countermeasure development.

[16] THE EFFECTS OF TELEGUIDANCE ON NOVICE ULTRASONOGRAPHER COGNITIVE DEMANDS IN ANALOG ASTRONAUTS FOR EARTH-INDEPENDENT MEDICAL OPERATIONS

Victoria Hurd[1], Erin Richardson[1], Aaron Allred[1], Karina Marshall-Goebel[2], Allison Hayman[1]

[1]University of Colorado - Boulder, Boulder, CO, USA; [2]NASA Johnson Space Center, Houston, TX, USA

(Original Research)

INTRODUCTION: Lunar and Martian missions will necessitate greater crew autonomy in medical care, as evacuation to Earth for expert treatment is operationally infeasible. Given mass, volume, and power constraints, ultrasound is the most viable in-flight imaging modality, despite its high operator skill requirements. In scenarios where the designated medic is physically unavailable to conduct imaging, medic-given verbal assistance via teleguidance may improve on-site novice operator performance. However, it remains unclear how teleguidance affects novice operator cognitive demands in representative populations. This prospective study investigates the effects of verbal teleguidance from crew medics on crewmate cognitive measures in analog astronaut crews at the Mars Desert Research Station (MDRS). **METHODS:** 18 participants (3 crews of 6, 9 female/9 male) completed an IRB-approved, within-subjects study at MDRS in Hanksville, Utah. Participants were previously enrolled in an MDRS analog mission, recruited based on their astronaut-adjacent educational and occupational demographics; the present study acted as a simulated medical task with representative crew roles. One participant per mission served as medic based on formal medical experience. Non-medic participants received didactics training and collected four apical 4-chamber self-examinations across two counterbalanced conditions: unassisted and teleguidance-mimicking with medic verbal support. Participants completed NASA-TLX and system usability surveys after examinations and knowledge assessments before/after training. Linear mixed-effects models and paired t-tests assessed effects. **RESULTS:** Knowledge assessment scores increased after training (p<.001). Total workload was lower (p<.001) and perceived system usability was higher (p<.001) for medics than novices, but there were no differences in either outcome variable between unassisted and teleguided conditions, nor were effects observed due to condition or role with the number of

sessions completed over the 2-day period. **DISCUSSION:** While teleguidance may support image acquisition in resource-constrained environments, these results indicate that obtaining medical-quality ultrasound images remains more cognitively demanding for novice operators than for formally trained medics, even with verbal support, which may impact downstream diagnostic decisions. Future work will assess how teleguidance implementation influences image quality and diagnostic utility.

Learning Objectives

1. Prioritizing medical independence of spaceflight crews is of particular importance for deep-space missions due to the operational infeasibility of returning to Earth for treatment by expert teams.
2. Crew medics found ultrasound operation to require less cognitive workload than their crewmates who were novice users. During teleguided imagining, novices' workload remained high.

[17] A COMPUTER-VISION MODEL FOR MEASURING FAT FRACTION CHANGES IN SPACE RESEARCH

Vienna Tran[1], Evert Wesselink[2], Julie Hides[3], James Elliott[4], Mark Hoggarth[5], Kenneth Weber[6], Kirsty Lindsay[7], Tobias Weber[8], Nick Caplan[7], Paul Hodges[9], Jonathan Scott[8], Enrico De Martino[10]

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(Original Research)

INTRODUCTION: Prolonged exposure to microgravity during space missions induces significant deleterious adaptations in the paraspinal muscles, including an increase in fat fraction (FF), has been observed in lumbopelvic muscles after spaceflight and head-down tilt (HDT) bed rest. While magnetic resonance imaging (MRI) is the gold standard for assessing FF, manual segmentation of individual muscles is time-consuming and limited to a few images per lumbar level. To address these limitations, we developed and evaluated the accuracy and reliability of a convolutional neural network (CNN)-based computer vision model for automated segmentation of lumbopelvic muscles. **METHODS:** Twenty-four healthy participants (16 males, 8 females) were recruited for the AGBRESA project held at envihab in Cologne, Germany. An MRI of the lumbopelvic region was performed at baseline, after 59 days of head-down tilt bed rest, and after 13 days of reconditioning. A chemical shift-based two-point Dixon sequence was used to differentiate lipid and water signals, enabling FF quantification in the lumbar multifidus (LM), lumbar erector spinae (LES), quadratus lumborum (QL), psoas major (PM), gluteus maximus

(GMax), gluteus medius (GMed), and gluteus minimus (GMin) muscles. Manual segmentation was performed by two operators who delineated each slice, while the CNN-based model automatically segmented the same muscles across all MRI slices. Accuracy and reliability were assessed using Pearson correlations, intraclass correlation coefficients (ICC), and the Bland-Altman method. **RESULTS:** For the LM, LES, and GMed muscles, FF values were 1.4%, 1.6%, and 0.8% higher with manual segmentation compared to the computer-vision model, respectively. For the PM, QL, GMax, and GMin muscles, FF was 1.7%, 0.9%, 0.8%, and 1.4% lower with manual segmentation than with the computer-vision model, respectively. The CNN model demonstrated high efficiency and accuracy, with strong positive correlations (r > 0.80, p < 0.001) between automatic and manual segmentations, particularly for LM and LES. **DISCUSSION:** The CNN-based model rapidly segmented all lumbopelvic muscles within seconds, offering a reliable and efficient alternative to manual segmentation which typically requires many months. This approach holds significant promise for advancing research on muscle deconditioning in both spaceflight and clinical contexts by enabling efficient, comprehensive muscle health evaluation.

Learning Objectives

1. The audience will learn about the accumulation of fat fraction in muscles as a marker of physiological adaptation to spaceflight.
2. The audience will learn about the utility of convolutional neural networks to automatically segment lumbopelvic muscles on MRI to measure fat fraction changes in a bed rest analogue.

[18] THE IMPACT OF BACK-TO-BACK EXTRAVEHICULAR ACTIVITY ON DECOMPRESSION SICKNESS RISK: THE NASA EXPLORATION ATMOSPHERE TEST 6

Alejandro Garbino, Brett Siders, Patrick Estep, Monica Hew, Karina Marshall-Goebel, Stijn Thoolen

NASA JSC, Houston, TX, USA

(Original Research)

INTRODUCTION: Space suits operate at low pressures to optimize astronauts' performance. The drop in pressure from the habitat environment to the suit prior to Extravehicular Activities (EVA) carries a risk of decompression sickness (DCS), which is mitigated by a 95% O2 prebreathe protocol. EVAs on the lunar surface have a significantly higher risk compared to International Space Station microgravity EVAs primarily due to increased metabolic workload. In previous studies, we validated a surface EVA prebreathe protocols for single (independent) EVA exposures through hypobaric chamber testing; however, Artemis mission plans also include daily ('back-to-back') EVAs. NASA has minimal data exploring the DCS risk impacts of ~16hrs 'surface intervals', ie, breaks between EVAs. The purpose of this study was to investigate if conducting back-to-back simulated surface EVAs influences DCS incidence as this could have

significant impacts on mission planning and EVA operations. **METHODS:** Sixteen volunteers, separated into two cohorts with eight subjects each, completed 7-day hypobaric chamber studies simulating daily EVAs. Subjects acclimated for 48 hrs at the proposed Exploration Atmosphere (66.2kPa, 28.5% O2) and then participated in daily 6-hour simulated EVAs at 29.6 kPa, 95% O2 over a five day period. Prior to each EVA, subjects underwent a 120 or 150-minute prebreathe. The EVA simulation was designed to be representative of future planetary EVAs, proportionate to the subject's VO2max. Decompression stress and Venous gas emboli (VGE) were monitored by real-time doppler and echocardiograph alternating every 15 min, as well as clinical monitoring for DCS signs/symptoms. Venous gas emboli (VGE) and DCS outcomes were verified against NASA-STD-3001 acceptance criteria. **RESULTS AND DISCUSSION:** Two Type II DCS cases occurred in the 120-min/29.6kPa prebreathe protocol, terminating further testing of this protocol. One Type I DCS case was identified in the 150 min/29.6kPa protocol. All DCS symptoms resolved with treatment, with no residual sequelae post hyperbaric oxygen treatments of DCS. VGE were identified during all EVAs. Within the statistical power of these limited exposures, there was no apparent increase or decrease in VGE as a result of back-to-back EVAs (within +/- 1 VGE grade). This test highlighted the importance of characterizing DCS risk factors and their potential impact on EVA cadence and operations.

Learning Objectives

1. The audience will learn about the risk of decompression sickness on Lunar EVAs.
2. Audience will learn about how NASA tests/validates prebreathe protocols for extravehicular activities (EVAs).
3. Audience will learn about the impacts of repetitive EVAs.

[19] IMMUNE RESPONSES TO OPERATIONAL STRESSORS IN ICE ENVIRONMENTS AND THEIR RELEVANCE FOR LONG-DURATION SPACEFLIGHT

Darshankumar m Raval[1], Tooba Tahir[2], Anushka Gupta[3], Jason-Flor Sisante[4], Lydia Varghese[5]

[1]ICAHN School of Medicine at Mount Sinai/Elmhurst, New York, NY, USA; [2]RAF, Anglesey, United Kingdom; [3]University of Queensland, Queensland, Australia; [4]Kansas City University College of Osteopathic Medicine, NASA-JPL Solar System Ambassadors, US Navy, Kansas city, MO, USA; [5]Johannes Wesling Klinikum Minden, University Hospital, Minden, Germany

(Education - Tutorial / Review)

INTRODUCTION: Personnel in isolated, confined, and extreme (ICE) environments, including Mars 500, Antarctic winterovers, and NASA's HERA campaigns, encounter psychological, circadian, sensory, and workload stressors that disrupt immune function before illness develops. Across analog and spaceflight studies, these stressors reduce antiviral defenses by 50% during spaceflight, impair NK cell activity, shift T and B-cell distributions, and increase latent virus reactivation. Key observations include elevated cortisol and viral shedding in Mars-500 participants, while Antarctic crews experience chronic inflammation and a decline in naive T

cells during 12-month deployments. Astronauts show inflammation spikes and reduced cellular immunity during and after flight, underscoring how ICE-related vulnerabilities compromise mission readiness, infection risk, and health. **TOPIC:** Stressors across ICE settings cause chronic immune strain, shifting the body toward persistent inflammation, declining cellular defenses, and exaggerated cytokine release. Isolation and confinement impair monocyte and neutrophil antimicrobial capacity while shifting lymphocytes toward activated and memory phenotypes. Extended-duration missions like Mars-500 demonstrate cumulative immune activation, altered hematopoiesis, and epigenetic modifications, signaling failure to restore baseline immune balance. In the Antarctic, sensory monotony and understimulation accelerates immune aging, including a documented 30% loss of naive T-cells. Concordia missions foster circadian disruption, weakening antiviral immunity by reducing NK-cell function, impairing T-cell signaling, and disrupting leukocyte trafficking rhythms. NASA's HERA missions further demonstrate that workloads trigger cortisol-mediated fluctuations in adaptive signaling, which nutritional interventions may partially mitigate. **APPLICATION:** These findings reveal that immune degradation begins with ICE stressors prior to microgravity or radiation exposure. By reframing immune risk as a pre-flight determinant, ICE factors create baseline vulnerability that space-specific hazards later exacerbate. Consequently, proactive management of circadian rhythms, workload, and nutrition is essential to stabilize innate and adaptive functions before launch. Preserving this physiological reserve reduces susceptibility to compounded immune suppression and minimizes the need for intensive biological countermeasures during exploration-class missions.

Learning Objectives

1. The participant will be able to explain how isolated, confined, and extreme (ICE) operational stressors disrupt innate and adaptive immune function before overt illness occurs.
2. The audience will learn about immune alterations observed across ICE analogs and spaceflight, including inflammation, cellular immunity shifts, and latent virus reactivation.
3. The participant will be able to recognise the operational relevance of circadian, workload, and nutritional factors in preserving immune resilience during long-duration missions.

Monday, 05/18/2026, 2:00 PM

Plaza D

[S-4] Panel: SAFE HAVEN - TARGETED PROGRAMMES TO TACKLE HEALTHCARE AVOIDANCE AND ENHANCE TRUST

Chair: Tim Sprott

Co-Chair: Kate Manderson

Panel Overview: *BACKGROUND: Research has shown clear evidence that not only are pilots reluctant to declare medical problems, especially of a mental health nature, but they also avoid seeking help for fear that they will need to declare this and jeopardise their ability to fly. OVERVIEW: Alongside well-established peer assistance pathways, there have been attempts to develop medical processes which are less threatening than the traditional pathway of declaring a problem to an aviation medical examiner who is obliged to inform the regulatory authority. DISCUSSION: Safe Haven is a high trust model sanctioned by the regulator to facilitate more open discussions between aviators and clinicians. The concept is that selected and trained examiners are given latitude to advise, refer, and decide on ability to fly, without the usual declaration requirements. Guard rails and escalation protocols are in place to preserve safety. The panel explores legal, ethical, practical and financial aspects of this new approach now under way in some jurisdictions.*

[20] AEROMEDICAL SAFE HAVEN IN PRACTICE - INTEGRATING OPERATIONAL AND CLINICAL INFORMATION TO ASSESS RISK

David Powell[1], Tim Sprott[2]

[1]Safe Haven Trust of New Zealand, Auckland, Auckland, New Zealand; [2]Civil Aviation Authority of New Zealand, Wellington, Wellington, New Zealand

(Education - Program / Process Review)

BACKGROUND: Safe Haven represents a new approach in civil aviation regulation, designed to tackle the known problems in aviation of under-declaration and worse, healthcare avoidance, amongst aviators. **OVERVIEW:** The essence of this approach is that selected and trained aeromedical examiners (AMEs) are given the legal freedom to advise aviators (in our case pilots and air traffic controllers) on medical and/or psychological issues, and make decisions about their safety to continue operating, without the usual requirements to declare diagnoses to the aviation regulatory authority. This high trust model aims to facilitate more open and honest discussions between aviators and AMEs. **DISCUSSION:** There are guard rails in place to prevent concealment of safety-critical issues, and associated escalation pathways for more serious conditions. This presentation will discuss the first few months of actual experience in integrating the clinical, operational and aeromedical information to apply a practical risk assessment.

Learning Objectives

1. To understand practicalities of implementing a Safe Haven programme in civil aviation.
2. To outline the spectrum of cases expected in a Safe Haven programme.
3. To list ways to understand and manage risk in the context of a Safe Haven programme.

[21] THE LEADING EDGE: THE FIRST TWO YEARS OF IMPLEMENTING AN AIRLINE PROGRAMME TO MANAGE MENTAL HEALTH CONCERNS AND IMPROVE TRUST

Johana Giraldo-Alzate, Mateo González-Agudelo

National University of Colombia, Bogotá, Colombia

(Education - Program / Process Review)

BACKGROUND: Mental health conditions are critical in the aviation industry, as they can impair cognitive performance, potentially leading to incidents or accidents. Studies show that the longest medical leaves are often linked to psychiatric conditions. Reports from the Colombian CAA indicate that mental health cases are the second leading cause of medical sick leave and the primary cause for denial of aeromedical certification (AMC), accounting for 18% of all cases. Research further suggests that pilots frequently avoid disclosing mental health concerns due to stigma and fear of AMC loss, highlighting a critical need for trusted, supportive programs. **OVERVIEW:** Recognizing the gap in mental health support from authorities and airlines, pilot associations established a support network to provide comprehensive care for crew members. This network creates a safe space where individuals can address mental health issues in an environment built on confidentiality, transparency, trust, and mutual respect. Although funded by the airline to support all personnel, the program operates with full independence and confidentiality. It focuses on substance use, sleep disorders, and aeromedical certification support, while also providing mental health emergency assistance. Remote guidance is available through an aerospace medicine specialist, offering access to psychiatry, psychology, couples therapy, and other services to ensure comprehensive care. In the first 21 months, follow-up rates included 47% for mental health, 29% for aeromedical certification support, 6% for sleep disorders, and 5% for substance use. Additionally, 13% receive guidance through the Peer Pilot Support Program. After the Program presented their cases and the CAA completed its review, nineteen pilots whose AMC had been suspended returned to active flight operations. Emergency mental health support has also been provided in four cases. **DISCUSSION:** This program offers an innovative alternative to traditional wellness initiatives, introducing a new model for mental health support in Latin America. It promotes a biopsychosocial well-being culture, positively impacting crew members and their family lives. Its cost-effective approach reduces medical leaves, AMC suspensions, and prevents mental health disorders. By fostering trust and encouraging care-seeking behaviors, the program strengthens human performance and enhances operational safety, positioning itself as a key resource for aviation professionals.

Learning Objectives

1. Describe the structure and objectives of a care program designed to support the mental health and well-being of aeronautical personnel in Colombia and Latin America.
2. Identify the benefits of implementing an independent mental health support program for aviation personnel in reducing medical leaves and promoting operational safety.

[22] FROM RISK-AVERSE SILOS TO AN INTEGRATED SMS APPROACH: TRANSFORMING AEROMEDICAL REGULATORY APPROACHES

Timothy Sprott

Civil Aviation Authority of New Zealand, Wellington, Wellington, New Zealand

(Education - Program / Process Review)

BACKGROUND: Civil aviation medical certification is on a journey from rules-based risk-averse siloed aeromedical decision making to a risk-based model. This risked-based model that incorporates an aviation system wide SMS approach for mental health hat involves aeromedical, operational and standards assessment and risk management. **OVERVIEW:** This presentation outlines how the components of a Safety Management System can be applied to organizational psychological risk to identify and mitigate system level stressors and support both safety and workforce health. **DISCUSSION:** Key research questions are needed to be addressed to identify the best practices to integrate and operationalise mental health into aviation SMS.

Learning Objectives

1. Describe how components of a Safety Management System can be applied to organizational psychological risk to identify and mitigate system level stressors and support both safety and workforce health.
2. State the limitations of current knowledge and outline key research questions that must be addressed to determine best practices for integrating mental health into aviation Safety Management Systems.
3. Outline how the SMS approach can encourage open disclosure of health concerns and promote healthcare utilisation by pilots or controllers.

[23] THE BRAIN OUTSIDE THE PLANE: ASSESSING MENTAL HEALTH IN THE CONTEXT OF AN AEROMEDICAL EXAMINATION AND ASSESSMENT

Kate Manderson

Civil Aviation Safety Authority of Australia, Canberra, Australian Capital Territory, Australia

(Education - Program / Process Review)

BACKGROUND: Understanding the performance of the aviator’s brain and mind is one of the most safety-critical elements of an aviation medical assessment. Together mental health problems, substance misuse, and the cognitive impact of medical issues and the impact of life events are easily more common as causative factors in air transport mishaps than physical

medical factors. Yet such issues are often difficult to identify and address in the context of an aviation medical assessment, and the medical examination remains focused on physical issues. **OVERVIEW:** Aviation medical examinations are carried out by experienced generalist doctors with extra training in aerospace medicine. While they usually include only a limited psychiatric examination or mental health assessment, they do provide an important opportunity to gain insight into the mental health and current issues of the pilot-patient which can be optimised. For many pilots, especially early in their career, the aviation medical examination may be the only encounter with a doctor that they experience. The opportunity to establish a foundation of trust and collaboration to support healthy mental status and performance can't be underestimated. **DISCUSSION:** This discussion addresses the context, aims, approach, limitations of an aviation medical assessment as they pertain to mental health and explores available tools for building a picture of mental health of the aviator in this unique context. The challenges and opportunities for gaining maximum value, from a mental health perspective, for both pilot and medical examiner, will be explored.

Learning Objectives

1. Identify the challenges and barriers to assessing the mental health status and neurocognitive performance of pilots and air traffic controllers.
2. Identify the opportunities provided by an aviation medical examination for exploring mental health and neurocognitive performance of pilots and controllers.

Monday, 05/18/2026, 2:00 PM

Plaza F

[S-5] Slide: HUMANS IN THE LOOP - SENSORS, SIMULATION, AND DIRECTED HUMAN MACHINE PERFORMANCE

Chair: Allen Parmet

Co-Chair: Jennifer Hunt

[24] AUTONOMY BY CONSENT: HOW TRANSPARENCY AND CONTROL HANDOFF SHAPE WORKLOAD, SITUATION AWARENESS, AND TRUST IN ADAPTIVE AUTOMATION

Jonathan Vogl[1], Joseph Andrew Atchley[2], Jared Basso[1], Sharon Bommer[3], Charles McCurry[3]

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(Original Research)

INTRODUCTION: Military aviation increasingly depends on automation to manage complex missions, yet static or pilot-initiated systems risk misuse, disuse, or over-reliance. Adaptive automation offers a potential solution by dynamically adjusting autonomy in response to an operator's needs. This study examined two foundational design features, system transparency (transparent vs. opaque displays of automation state/rationale) and handoff method (voluntary vs. forced activation), to assess their effects on pilot cognitive workload (CWL), situation awareness (SA), and trust in automation. **METHODS:** Twenty-four rated Army aviators performed four sessions of the USAARL MATB augmented with an adaptive automation controller driven by workload modeling. A within-subjects 2 × 2 design crossed transparency and handoff manipulations. Multimodal outcomes were collected, including subjective workload ratings, behavioral performance, physiological measures (ECG, pupillometry, eye tracking), and validated SA and trust assessments. **RESULTS:** Results revealed a differentiated pattern across manipulations. Transparency was the dominant driver of workload demonstrating that transparent displays increased CWL ($p = .002$, $\eta^2 = .35$). For SA, opaque displays produced higher comprehension and projection ($p = .005$, $\eta^2 = .29$), while voluntary handoffs strongly preserved comprehension across control transitions ($p < .001$, $\eta^2 = .58$). Their interaction was significant ($p = .012$, $\eta^2 = .24$), with opaque-voluntary yielding the most favorable SA profile. Trust was governed primarily by handoff method ($p = .002$, $\eta^2 = .34$); voluntary handoffs improved reliance calibration and reduced over-monitoring while a task was automated whereas transparency alone did not increase trust ($p = .098$). Discriminant analyses elaborated and corroborated these multivariate patterns (classification accuracies of 97% for CWL, 83% for SA, and 74% for trust). **DISCUSSION:** Together, the results highlight a central design principle: transparent conditions influence cognitive workload, voluntariness governs trust calibration, and SA is optimized when these display modes and handoff methods are aligned. These findings provide guidance for adaptive automation in safety-critical environments: default to opaque displays with voluntary, autonomy-by-consent handoffs, and deploy transparency selectively/phase-specifically or on-demand to avoid workload penalties while preserving situation awareness and trust.

Learning Objectives

1. Adaptive automation system design benefits from optimal configurations of how much information is displayed regarding the system (i.e., automation transparency) as well as the interaction methods utilized (i.e., controlled handoffs); however, these configurations may be counterintuitive, demonstrating that research with new systems is required.
2. Multivariate assessments of cognitive workload, situation awareness, and trust in automation can be more robust than single measures of the constructs.

[25] CHARACTERIZING TEAM DYNAMICS ELEMENTS THAT CONTRIBUTE TO PSYCHOLOGICAL SAFETY IN HUMAN-ROBOT INTERACTIONS FOR HIGH-RISK OPERATIONAL ENVIRONMENTS

Jasmin Chadha, Patrick Pischulti, Ciara Hume, Zachary Selleck, William Roessmann, Katya Arquilla

University of Colorado Boulder, Boulder, CO, USA

(Original Research)

INTRODUCTION: Psychological safety, the shared belief held by team members that it is safe to take interpersonal risks, is important to maintain human performance in high-risk situations such as spaceflight or working with autonomous medical assistants. Psychological safety has been assessed in human corporate teams but is understudied in operational environments or with human-robot teams. We aim to characterize and predict team dynamics that contribute to psychological safety during spaceflight-relevant tasks through subjective self-assessments and objective psychophysiological measurements (electrocardiogram, respiration monitor, and electrodermal activity). **METHODS:** We developed study tasks derived from crewed spaceflight mission concepts and conducted a within-participants experiment with n=33 (16F, 17M) each completing 6 trials with a robot teammate and 6 with a human teammate while wearing psychophysiological sensing devices. Tasks were designed to elicit changes in psychological safety by providing participants with multiple tools and levels of difficulty, prompting risk-taking. After each trial, participants scored their human or robot teammate with items from the Pertinence of Robot Decisions in a Human-Robot joint Action questionnaire to assess elements of team dynamics that contribute to psychological safety. We employed two-way repeated-measures Analyses of Variance with Greenhouse-Geisser corrections to test differences between the human and robot conditions along with changes over trials. If significance was found, we completed post-hoc pairwise comparisons with Bonferroni corrections. RESULTS: Participants scored humans significantly higher than robots across all questionnaire dimensions for both task types (p<0.05 for all tests). Generally, participants scored their human and robot teammates consistently across trials. However, Perception scores varied between earlier and later trials for human teaming with significant differences between trials 1 and 5 (p<0.05), 1 and 6 (p<0.05), and 2 and 6 (p<0.05) (early trials had lower scores), while there was no variation for robot teaming. **DISCUSSION:** Our results indicate participants have significantly different experiences with human vs. robot teammates when working on collaborative, spaceflight-relevant tasks. This is a first step at characterizing psychological safety in human-robot teams and will be enhanced with models that predict questionnaire responses based on psychophysiological signals.

Learning Objectives

1. The audience will learn about the study tasks we developed to elicit changes in psychological safety while being relevant to spaceflight operations.
2. The audience will learn about the differences in participant questionnaire responses on team dynamics constructs that contribute to psychological safety when working with human vs. robot teammates on spaceflight-relevant operational tasks.

[26] PILOTS AND AIRCREW PERCEPTIONS OF A HUMAN PERFORMANCE PROGRAM

Nicole Heimark McClougan, Kaila Vento, Kaitlyn Buell, Charles Weisenbach

Naval Medical Research Unit-Dayton, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: Aviation human performance programs (HPPs) are designed to address the unique flight-related physical and cognitive demands pilots and aircrew experience. However, limited information has been collected from the individuals using these programs. The purpose of this study was to investigate the perspectives of active-duty Navy pilots and aircrew utilizing a HPP. **METHODS:** A total of 15 participants (n=4 pilots, n=11 aircrew) completed in-person or virtual semi-structured interviews in July 2025. Interview duration ranged between 15-30 minutes. Inclusion criteria were met if they were a Navy pilot or aircrew utilizing a HPP at least once per week. Participants were asked about their perception of the programs' ability to address physical fitness, occupational performance, and quality of life. Additionally, they were asked to comment on the program itself (e.g., accessibility, practicality, and improvements). Interview transcriptions were independently analyzed by 3 investigators using a Thematic Analysis approach, applying comparison and consensus measures to identify themes and aggregate tallies shown as mean±standard deviation. RESULTS: The top 3 themes identified were: Accessibility (49.4±3.53), Culture and Community (47.3±4.23), and Health Management (36.7±4.36). Participants stated the HPP enabled better physical health and stress management by providing space and staff who could deliver individualized services. Participants valued the location of the HPP on the flightline, and the timeliness of services/resources provided by the staff. Participants felt the tools provided by the HPP to manage pain and improve task management enhanced occupational performance. Recommendations to improve the HPP included expansion into other wings and diversifying staff specialties (e.g., nutrition and sleep). **DISCUSSION:** Participants viewed the HPP positively and provided insights into program benefits. Accessibility to experts including rehabilitation specialists, strength and conditioning coaches, cognitive performance specialists, nutritionists, and sleep scientists is desired. Prioritizing the experiences of pilots and aircrew utilizing the HPPs can develop heuristics for the refinement of these programs.

Learning Objectives

1. Identify important themes expressed by pilots and aircrew surrounding human performance programs.
2. Understand the importance of pilot and aircrew experience when implementing and expanding human performance programs.

[27] SMAC-ING DOWN BARRIERS: REVOLUTIONIZING AIRCREW HEALTH AND PERFORMANCE WITH SENSOR-BASED AUTOMATION

Peter Le[1], Therese Parr[2], Leutrim Mehmeti[3], Justin Reed[4], Robert Briggs[1]

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Laboratory, Reef Systems, Wright-Patterson AFB, OH, USA; [4]Air Force Research Laboratory, KBR, Wright-Patterson AFB, OH, USA

(Education - Program / Process Review)

BACKGROUND: Optimizing aircrew performance relies on the capability to leverage data at scale for data-driven intervention guidance. The Aircrew Conditioning Program-Assessment (ACP-A) currently provides valuable insights into aircrew physical readiness. However, it relies on manual, time-intensive procedures that limit consistent implementation, introduce variability, and face scalability challenges. This highlights the need for innovative solutions to enhance the efficiency and reliability of aircrew human performance (HP) testing. **DESCRIPTION:** The Sensor for Measurement of Aircrew Conditioning (SMAC) project seeks to enhance ACP-A testing through an automated, sensor-based system. By utilizing inertial measurement units (IMUs) and a custom-developed application, SMAC enables streamlined, objective HP testing across multiple Airmen simultaneously, significantly reducing costs, personnel demands, and throughput challenges. Validation studies demonstrate high reliability and accuracy for IMUs compared to traditional methods, yielding results such as R^2 values above 0.93 and ICCs above 0.95 for tests like Deep Neck Flexor and Sorensen, and correlations above 0.90 for CMJ when compared to force plates. A functional proof-of-concept Android application has also been developed, with plans to transition to iOS. This intends to enhance current ACP-A testing for the Comprehensive Readiness for Aircrew Flying Training and Optimizing the Human Weapon System programs. SMAC has garnered support from key Air Force leadership, leading to endorsements from the Chiefs of Medical Modernization in both Air Education and Training Command and Air Combat Command. **DISCUSSION:** SMAC aims to expand HP programs beyond ACP-A by integrating new kinetic and movement-based assessments. The immediate goal is to automate manual processes and enhance repeatability. The mid-term goal is to scale to additional functional movements and integrate iOS, while the long-term vision is to enable passive monitoring with minimal sensors. Additionally, SMAC seeks to be a cost-effective, portable force multiplier adhering to Modular Open Systems Architecture. The project also plans to transition to commercial industry, developing dual-use cases for product development and sustainment. This strategic approach revolutionizes aircrew HP testing with automated tools standardized across Tri-Service sites, optimizing readiness and ensuring a resilient and mission-ready force.

Learning Objectives

1. Participants will describe the limitations of manual procedures in the Aircrew Conditioning Program-Assessment (ACP-A) and recognize the need for scalable, efficient solutions for enhancing aircrew human performance testing.
2. Participants will explain the benefits of the Sensor for Measurement of Aircrew Conditioning (SMAC) project in automating human performance testing, including validation results, integration plans, and potential dual-use applications.

[28] IDENTIFYING THE NEUROBIOLOGY OF PERFORMANCE AND TRAINING RETENTION IN PILOTS

VIA TASK-BASED FUNCTIONAL MAGNETIC RESONANCE IMAGING

Meghan Robinson[1], Bianca Cerqueira[2], Jeremy Beer[2], Goldie Boone[3], David Freeman[2], Monroe Turner[4], Kelly McKay[3], Pedro Ramos[3], Holly Chapapas[5], Ayla Ulfberht[6], Adam Willis[3], Robert Smalley[7], Paul Sherman[3]

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(Original Research)

INTRODUCTION: Establishing, maintaining, and quantifying readiness in high performance individuals– such as active-duty pilots–remains a significant challenge in the DoD. Proficiency in pilots consists of mastering multiple tasks. For physical tasks, training regimens can be prescribed to strengthen necessary muscles to improve G-LOC performance. However, other pilot tasks are cognitive– such as precisely controlling an aircraft to maintain a specific trajectory, despite the presence of cross-winds and other perturbations. Without understanding this circuitry, or knowledge of how training can strengthen the performance of it– targeted and efficient training cannot be prescribed. **METHODS:** Active-duty pilots underwent MRI to identify the anatomic and functional circuits associated with performance on;three aviation paradigms –;the Unexpected Attitude Recovery (UAR) task, Precision Instrument Control Task (PICT), and Vertical S task. These were rendered in XPlane, a flight simulation suite with MR-compatible flight controls to present high-fidelity simulated sorties with visual characteristics and demands of real flight. Twenty-four active-duty pilots (twelve Remote Piloted Aircraft (RPA) and twelve Instructor Pilot) were scanned. Twenty have completed sessions before and after training to quantify changes in functional activations. Imaging data were processed using AFNI to find brain activity associated with the flight tasks, combining all sessions. **RESULTS:** Brain activations from the UAR and PICT tasks showed significant involvement of motor and premotor areas, frontal networks, and basal ganglia circuitry. Increased activity in the bilateral frontal eye fields was correlated with more precise flight during the simulation. **CONCLUSIONS:** The tasks included in our study identify brain networks associated with aviation control. These were consistent across tasks, and with prior work in glider pilots. We were able to detect brain activity that is correlated with performance, indicating the feasibility of measuring cognitive activity related to aviation and training by simulating flight tasks in the scanner environment. **DISCLAIMERS:** The views expressed are those of the authors and do not reflect the official views or policy of the Department of Defense or its Components. The voluntary, full informed consent of the subjects used in this research was obtained as required by 32 CFR 219 and DPDO 3216.06.

Learning Objectives

1. Describe functional magnetic resonance imaging tasks related to pilot training.

2. Describe magnetic resonance imaging techniques that can be used to quantify functional and anatomical connectivity.

[29] PHYSIOLOGICAL DYNAMICS OF ADAPTIVE RESPONSE TO FAILURE IN SIMULATED FLIGHT TASKS

Brett Bennett

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(Original Research)

INTRODUCTION: Long-duration and exploration-class spaceflight place crews in self-sufficient, high-consequence environments where adaptive response to failure is fundamental to expeditionary behavior. Adaptive behavior is a cross-cutting risk factor in human spaceflight operations. While prior research has linked physiological state and performance, objective characterization of adaptive response following operational failure remains limited. This study examines autonomic nervous system dynamics associated with adaptive response to failure in simulated flight tasks. **METHODS:** Ten participants with mixed aviation experience completed six counterbalanced failure scenarios in a high-fidelity Cirrus Vision SF50 flight simulator, including propulsion, environmental, navigation, and fuel system anomalies. Continuous physiological data were collected using electrocardiography and respiration measures, with heart rate variability quantified using RMSSD. Subjective assessments of performance and adaptive behavior were collected post-trial. Adaptive response was defined as successful task completion following a prior failure, and participants were analyzed by experience level and median recovery rate. **RESULTS:** Descriptive analyses showed performance differences between novice and experienced participants; however, recovery from failure occurred across experience levels, indicating that adaptive response is not attributable to experience alone. Although inferential models did not reach statistical significance, consistent physiological trends were observed. High-recovery participants exhibited more stable autonomic regulation, with narrower RMSSD distributions and reduced variability across time points, while low-recovery participants demonstrated extreme physiological variability. Complementary trends were observed in heart rate, respiratory measures, and frequency-domain HRV indices. **DISCUSSION:** Adaptive response to failure appears to be reflected in the stability of autonomic regulation rather than absolute performance or experience level. Adaptive behavior represents a dynamic process involving effective physiological reallocation following disruption. Objective physiological monitoring may complement subjective assessments and inform training, operational monitoring, and countermeasure development for aerospace operations and future long-duration spaceflight.

Learning Objectives

1. Explain how autonomic nervous system dynamics, quantified through heart rate variability metrics, reflect adaptive physiological response to operational failure in simulated flight tasks.

2. Differentiate adaptive response from aviation experience and trait resilience by interpreting physiological patterns associated with recovery following failure.
3. Assess the potential application of real-time physiological monitoring to support resilience, performance maintenance, and countermeasure development in aerospace and operational aviation environments.

Monday, 05/18/2026, 2:00 PM

Governor's 10

[S-6] Slide: FROM THE PHARM

Chair: Mary Van Baalen

Co-Chair: Emma Ives

[30] VASTX: DIGITAL TWIN PHARMACOKINETICS FRAMEWORK FOR PREDICTING DRUG BEHAVIOR IN MICROGRAVITY

Raj Badhan[1], Susan Jewell[2]

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(Original Research)

INTRODUCTION: Spaceflight induces multi-system physiological adaptation altering absorption, distribution, metabolism, and excretion (ADME). Yet astronaut dosing remains Earth-derived, risking sub- or supra-therapeutic exposure. The Virtual Astronaut Simulation for Therapeutic eXploration (VASTX) integrates verified physiologically-based pharmacokinetic (PBPK) modeling to quantify microgravity effects on acetaminophen exposure and support precision dosing in low-gravity environments. **METHODS:** A human PBPK model for acetaminophen (625 mg oral) was developed and validated against terrestrial datasets (n = 100; 50 % female; 20–50 y; 65–81 kg). Model performance satisfied regulatory verification criteria (Cmax and AUC within 0.5–2 ×; Tmax ± 0.25 h). Physiological parameters were modified for microgravity (gastric emptying +50–100 %, cardiac output -20 %, plasma volume -15 %, hepatic enzyme activity -25 %) and hyperbaric analogs. Monte Carlo simulations (n = 1000; log-normal variability) generated virtual astronaut populations. Sensitivity analysis assessed parameter influence on Cmax, AUC, CL, and t½. **RESULTS:** Predicted microgravity pharmacokinetics demonstrated Cmax ↓ 25 %, AUC ↓ 30 %, Tmax ↑ 0.25 h, and apparent CL = 9.8 $L \cdot h^{-1}$ (vs 15.4 $L \cdot h^{-1}$ Earth). t½ prolonged from 2.1 → 2.9 h (+38 %). Model diagnostics showed residual bias < 10 %, r^2 > 0.93, and VPC alignment within 95 % CI bounds. **DISCUSSION:** VASTX establishes an AI-augmented, multi-fidelity pharmacokinetic infrastructure validated against analog mission datasets. The digital-twin framework integrates Bayesian reinforcement learning and omics-based priors to update dosing predictions in real time. This approach aligns with

FDA/EMA PBPK qualification standards and supports autonomous, explainable, mission-specific pharmacotherapy. Findings indicate standard 625 mg acetaminophen dosing in microgravity may achieve only ≈70 % of terrestrial exposure, requiring dose or formulation optimization. The system provides a translational pathway toward individualized astronaut dosing and dual-use terrestrial applications in submarines, polar bases, and remote medicine.

Learning Objectives

1. Demonstrate how digital-twin PBPK models can quantify environment-specific drug kinetics.
2. (2) Show how AI-driven modelling supports adaptive dosing for astronaut safety and mission success.

[31] VOLUMETRIC ABSORPTIVE MICROSAMPLING DURING SPACEFLIGHT FOR ANALYSIS OF ACETAMINOPHEN PHARMACOKINETICS IN WHOLE BLOOD

David Mampre[1], Robert Guttendorf[2], Jennifer Zimmer[3], Brooke Whitson[3], James Huggins[3], Chad Christianson[3], Erik Burns[3], Nicolas Heft[4], Marissa Rosenberg[5], Amran Asadi[5], Jaime Mateus[5], James Rudge[6], Takako Mizuno[6], John Donehoo[7]

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(Original Research)

INTRODUCTION: Spaceflight induces altered physiology that has the potential to alter medication pharmacokinetics due to factors including gastrointestinal motility, fluid balance, circulatory dynamics, hormonal changes, and metabolic alterations. Here, we report the first pharmacokinetic analysis using blood samples during spaceflight. **METHODS:** The four SpaceX Polaris Dawn crewmembers ingested 500 mg of oral acetaminophen pre-flight, in-flight, and post-flight. Post-ingestion capillary blood samples were collected using volumetric absorptive microsampling. Samples were analyzed using liquid chromatography - tandem mass spectrometry. **RESULTS:** All samples collected in microgravity were adequate for post-flight analysis. Compared to pre-flight baseline, in-flight increases were observed in the Cmax;(mean [SD] ng/mL: pre-flight=9,110 [3,290], in-flight=43,300 [5,700],;p<0.001), AUC0-last;(mean [SD] hr*ng/mL: pre-flight=26,100 [4,520], in-flight=109,000 [29,400]), and λz;(mean [SD] 1/hr: pre-flight=0.227 [0.0688], in-flight=0.336 [0.0209]). Compared to pre-flight baseline, in-flight decreases were observed in tmax;(mean [SD] hr: pre-flight=1.06 [0.657], in-flight=0.688 [0.239]), t1/2;(mean [SD] hr: pre-flight=3.27 [0.950], in-flight=2.07 [0.130]), CL/F (mean [SD] mL/hr: pre-flight=16,200 [2,990], in-flight=3,890 [559]), and Vz/F (mean [SD] mL: pre-flight=74,700 [18,800], in-flight=11,500 [1,100]). **DISCUSSION:** Compared to pre-flight

baseline, Cmax, AUC, and λz;increased in-flight,;while tmax, t1/2, Vz/F, and CL/F decreased in-flight. Cmax, AUC, Vz/F, and CL/F showed residual changes 3 days post-flight (R+3). Supratherapeutic blood levels with standard terrestrial dosing raises concern for inadvertent toxicity in the spaceflight environment, and highlights the value of further pharmacokinetic study of medications commonly included within spaceflight medical systems. Overall, volumetric absorptive microsampling enabled pharmacokinetic study during spaceflight and could serve as a platform for future pharmacokinetic studies.

Learning Objectives

1. Describe the methodology for collecting blood samples during a spaceflight mission.
2. Understand how drug pharmacokinetics are altered in spaceflight compared to a terrestrial setting.
3. Understand physiological changes that have potential to alter pharmacokinetics in spaceflight.

[32] AEROSPACE TOXICOLOGY: FOUNDATIONS, EXPOSURES, AND CLINICAL DECISION-MAKING

Richard Pleus

Intertox Inc., Seattle, WA, USA

(Education - Program / Process Review)

BACKGROUND: Aerospace medicine training focuses on the physiological stressors of flight but offers limited instruction in toxicology, even though chemical exposures are a routine concern in aviation. Aircrew and passengers may experience symptoms linked to chemicals from aircraft systems, materials, and operations. Aerospace medical specialists often need to interpret environmental measurements and symptom reports without a structured toxicological framework. As attention to aviation-related chemical exposures grows in both civilian and military sectors, it is increasingly essential to integrate core toxicological principles into aerospace medicine education. **OVERVIEW:** This presentation proposes a practical framework for embedding essential toxicological concepts into aviation medical training. Using aviation-related chemicals—such as cabin air and onboard oxygen generation systems—as examples, it illustrates foundational principles like dose–response relationships, exposure duration, and the distinction between chemical presence and toxicity. The framework references regulatory evaluations, consensus statements, and exposure data for chemicals, including jet fuel constituents, turbine oils, hydraulic fluids, and combustion by-products. Case examples and a structured approach to exposure data collection highlight current gaps in aeromedical training and decision-making. **DISCUSSION:** The program addresses an educational gap by providing aerospace medical specialists with a defensible process for evaluating chemical exposure information and symptom reports without presuming causation. The framework supports proportionate medical response, consistent risk communication, and informed decision-making. By positioning toxicology as a complementary discipline, this approach enhances human

performance, preserves trust among aircrew and passengers, and reduces misinterpretation of exposure data across civilian and military aviation.

Learning Objectives

1. Describe core toxicological principles relevant to aviation environments, including dose–response relationships, exposure duration, and the distinction between chemical presence and toxicity.
2. Evaluate reported symptoms occurring in aviation environments by assessing whether observed chemical exposures are toxicologically consistent with the timing, magnitude, and nature of those symptoms, using exposure context and available data.
3. Apply toxicological evidence to clinical decision-making and risk communication following aviation-related exposure events, supporting proportionate medical management and informed aeromedical recommendations.

[33] TOXICOLOGY FINDINGS AND IMPAIRMENT RULINGS IN FATAL U.S. CIVIL AVIATION ACCIDENTS

Lorna A. Evans[1], Javin J. Patel[2], Alvaro Ducas[3], Anthony P. Tvaryanas[4], Leigh L. Speicher[5]

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(Original Research)

INTRODUCTION: Assessing pilot impairment is essential for understanding causal factors in fatal aviation accidents and informing aviation safety policy. Although toxicology is routinely reviewed during accident investigations, the extent to which substances identified in toxicology reports are officially determined to impair pilot performance remains unclear. This study quantifies how often substances identified during toxicological analysis were subsequently ruled impairing and contributory based on National Transportation Safety Board (NTSB) determinations. **METHODS:** A retrospective analysis was conducted of fatal U.S. civil aviation accidents with completed NTSB investigations occurring between January 1, 2017, and December 31, 2022. Pilot toxicology reports were reviewed. Detected substances were classified into alcohol, illicit drugs, prescription medications, and over-the-counter (OTC) agents. Impairment determinations were based exclusively on official Federal Aviation Administration and NTSB rulings documented in final accident reports. Accident characteristics and toxicology findings were summarized using descriptive statistics. **RESULTS:** A total of 1,303 fatal accidents were analyzed. The cohort was predominantly male (86.6%) with a mean age of 56.2 ± 16.1 years. Most accidents involved fixed-wing aircraft (82.0%), single-engine aircraft (82.5%), and occurred in visual meteorological conditions (82.8%). Substances from all major drug classes were frequently detected in toxicology reports. Commonly identified OTC agents included sedating and non-sedating antihistamines, decongestants, antitussives, and analgesics. Frequently identified prescription medications included opioids, benzodiazepines,

antidepressants, anticonvulsants, cardiovascular agents, and sedative-hypnotics. Illicit drugs were detected less frequently than prescription and OTC medications. Polypharmacy involving multiple prescription and/or OTC medications was common. Despite frequent detection of substances across all major drug classes, official impairment determinations were uncommon. Alcohol was ruled impairing in 19 cases (1.6%), illicit drugs in 21 cases (1.8%), prescription medications in 17 cases (1.5%), and OTC medications in 11 cases (0.9%). **DISCUSSION:** Although a wide range of substances were commonly identified during toxicological analysis, official determinations of pilot impairment were infrequent. These findings highlight the distinction between substance detection and meaningful impairment in U.S. aviation accident investigations. Improved standardization in evaluating medication effects, combined drug exposure, and operational relevance may enhance consistency in impairment determinations and inform aeromedical guidance, pilot education, and aviation safety policy.

Learning Objectives

1. Identify the types of illicit, prescription, and OTC substances most commonly detected in pilot toxicology reports from fatal aviation accidents.
2. Critically evaluate the relationship between toxicology findings and official impairment determination in U.S. aviation accident investigations.

[34] FIRST INTRAVENOUS FLUID INFUSION ONBOARD THE INTERNATIONAL SPACE STATION: A MEDICAL TRAINING DEMONSTRATION

Craig Kutz[1], Joseph Dervay[2], Xy Rivera-Buytaert[3], Molly Freedman[3], Colin Hills[3], Carlos Navarro[1], Stephen Hart[2], Jonny Kim[2], Zena Cardman[2]

[1]University of Texas Medical Branch / KBR / NASA, Houston, TX, USA; [2]NASA, Houston, TX, USA; [3]KBR / NASA, Houston, TX, USA

(Education - Case Study)

INTRODUCTION: We report on the first end-to-end intravenous fluid (IVF) administration during International Space Station (ISS) operations as part of an on-orbit medical contingency training. IVF administration is a fundamental procedure in acute resuscitation of critically ill patients. In the 25-years of ISS, the need for fluid infusion has not been required. Yet, as we push the limits of space exploration, the likelihood of necessity increases. Our demonstration represents a historic achievement in space medicine and human medical capabilities during microgravity operations. **BACKGROUND:** IVF may be indicated in theoretical medical scenarios such as – but not limited to – severe dehydration, trauma, sepsis, or suspected renal calculi. Crew medical officers (CMOs) train prior to missions on IVF preparation and bubble removal, antiseptic technique, and administration. However, on-orbit ISS demonstrations are limited to preparation and have not infused IVF into a crewmember. In 1993, STS-55 crewmembers injected saline as part of a payload study to replace body fluids lost during space adaptation. However, our goal focused on generating lessons learned to inform medical

procedure development, hardware selection, and determine feasibility assessments in microgravity medical care. **CASE PRESENTATION:** Two Expedition 73 CMOs successfully performed the first complete IVF infusion on the ISS during an on-board training demonstration. Under guidance from crew surgeons and medical trainers, the crew successfully inserted a 20-gauge IV catheter and infused 400-450mL of normal saline utilizing standard ISS health maintenance system medical kits and procedures. **DISCUSSION:** Our demonstration represented the first IVF infusion onboard the ISS. Set-up and mitigation steps to minimize air within the system continue to be a challenge, as they take disproportionate time compared to terrestrial. In addition, hardware created unique barriers in microgravity, such as real-time feedback of flow rates without visualization of gravity-dependent drip chambers. Our infusion indicated lower flow rates than terrestrially (15-20mL/min vs 100mL/min, respectively). This demonstration directly generated critical feedback to inform medical system design, training, and procedural planning for future lunar and deep-space exploration missions. Key takeaways will be presented, integrating crewmember debriefs on procedural technique and resource utilization, with supplementary procedure video recordings.

Learning Objectives

1. The audience will visualize videos of the first intravenous fluid infusion onboard the international space station and understand the challenges unique to microgravity in performing this procedure.
2. Recognize critical limitations in intravenous fluid administration as it may pertain to future exploration medical capabilities and spaceflight.

[35] ASYMPTOMATIC NONSUSTAINED VENTRICULAR TACHYCARDIA IN A HIGH PERFORMANCE PILOT-A CASE REPORT AND REVIEW OF CURRENT EVIDENCE

Hadar Lahav, Ivan Gur

Israeli Air Force Aeromedical Center, Tel Hashomer, Ramat Gan, Israel

(Education - Case Study)

INTRODUCTION: Non-sustained ventricular tachycardia (NSVT) in aircrew is an aeromedical challenge. Even when clinically benign, ventricular arrhythmias raise concern due to possible sudden in-flight incapacitation, particularly in high-performance aviation. We report the evaluation and aeromedical disposition of an experienced fighter pilot with incidental asymptomatic NSVT. **BACKGROUND:** Idiopathic NSVT in the absence of cardiomyopathy-often from the right ventricular outflow tract-typically carries a favorable prognosis and low annual event rates. Aviation medicine, however, has a lower tolerance for residual risk. Cardiac magnetic resonance imaging (CMRI) is pivotal for excluding occult cardiomyopathy or myocardial fibrosis and refining aeromedical risk stratification. **CASE PRESENTATION:** A 52-year-old male fighter pilot undergoing routine screening demonstrated premature ventricular contractions (PVCs) during exercise testing. He had no recent syncope/presyncope and no family

history of sudden cardiac death. One remote syncope episode occurred during high-G exposure years earlier. A 24-hour Holter recorded rapid (180–200 bpm) monomorphic NSVT with RVOT morphology. Comprehensive evaluation-including repeat ambulatory monitoring, exercise stress echocardiography, coronary CT angiography, and CMRI-showed preserved biventricular function and no cardiomyopathy, fibrosis, or inflammatory myocardial disease. Electrophysiology review identified PVCs with multiple morphologies (atypical for classic idiopathic RVOT NSVT) but recommended no ablation or pharmacologic therapy given absent symptoms and lack of structural substrate. **DISCUSSION:** Although estimated annual incapacitation risk was very low (<1%), the rapid NSVT and polymorphic ectopy precluded unrestricted return to flight. After multidisciplinary aeromedical review, a conditional waiver permitted high-performance flight only in an instructor role. Risk mitigation included restricting instruction to trainees certified for solo flight and mandatory annual surveillance with Holter monitoring and exercise stress echocardiography. This case supports that, with thorough evaluation-particularly CMRI-and individualized operational restrictions, selected aircrew with idiopathic NSVT may safely continue limited duties.

Learning Objectives

1. Describe the diagnostic value of Cardiac MRI (CMRI) in distinguishing benign idiopathic NSVT from occult structural heart disease in asymptomatic aircrew.
2. Discuss the unique aeromedical challenges of NSVT in high-performance aviation, including the arrhythmogenic potential of G-forces and the distinction between clinical prognosis and flight safety risk.
3. Apply risk mitigation strategies, such as restricted waivers and targeted surveillance, to manage experienced aviators with low-risk arrhythmias.

Monday, 05/18/2026, 2:00 PM

Governor's 12

[S-7] Slide: AVIATION ACCIDENTS, SURVIVAL, INJURY

Chair: Douglas Boyd

Co-Chair: Swee Wang Fan

[36] GENERAL AVIATION MID-AIR COLLISIONS OVER A PERIOD OF TECHNOLOGICAL ADVANCEMENTS/TRAINING TARGETTING HUMAN PERFORMANCE DEFICITS

Douglas Boyd[1], Carolina Anderson[2]

[1]Embry Riddle Aeronautical University, Daytonna Beach, FL, USA; [2]Embry Riddle Aeronautical University, Daytona Beach, FL, USA

(Original Research)

INTRODUCTION: Mid-air collisions (MACs), while rare for air carriers, are not infrequent for general aviation (GA). Considering advances in technology/training programs to counter the limitations of the see-and-avoid method common to general aviation, we sought to determine, for the first time: (i) whether the mishap rate has declined over time and (ii) the underlying causes/factors. **METHODS:** MACs (1995-2023) were identified using the NTSB database and injury severity, mission type, ambient conditions extracted from the corresponding records. MAC rates were calculated either per fleet time or annual aerodrome operations. Statistical tests employed Poisson Distributions/Chi-Square tests. **RESULTS:** 480 aircraft (90 and 8% fixed-/rotary-wing aircraft respectively) were involved in 257 mid-air events. Despite an overall decline in the MAC rates (63% reduction (p<0.001, 95% CI 0.229, 0.603)) for the most recent period, the proportion of lethal mishaps (44-58%) was unchanged (p=0.666). The MAC rate for aircraft engaged in training missions, but not for personal missions, declined 70% (p=0.001, 95% CI 0.155, 0.604) over the three decades. Although traffic density is the highest surrounding aerodromes, surprisingly, only half of the MACs were within this environment. The MAC rate, adjusted for arrivals/departure counts, at aerodromes with a Control Tower (CT) was 6.5-fold lower compared with airports not served by such a facility. For MACs involving aircraft receiving traffic de-confliction services (within the aerodrome environment and also enroute) pilots not heeding air traffic control instructions and/or failing to maintain visual separation were causal/contributory to 33 and 78% of the mishaps, respectively. **DISCUSSION:** The static MAC rate for personal missions and an unchanged fraction of fatal accidents warrants redress. Two recommendations are advanced. First, pilots should prioritize operating to/from aerodromes with an operational control tower-this having the ancillary benefit of reducing the aviators workload in a task-saturation environment. Second, aviators should remain vigilant for traffic conflicts even when receiving de-confliction services- from a human performance perspective such vigilance also helping offset complacency commonly incurred enroute.

Learning Objectives

1. Attendees will learn that mid-air collisions carry a higher proportion of fatal accidents compared with mishaps unrelated to this cause.
2. Audience will learn that while the rate of mid-air collisions involving aircraft engaged in training missions has diminished over 3 decades, no such reduction was apparent for those conducted for personal missions.

[37] WITHDRAWN

[38] THE 5 W'S OF NAVAL AVIATION INJURIES: 2015-2025

Jonathan Erpenbach[1], G. Merrill Rice[1], Steven Linnville[2], Matthew McCombs[1]

[1]United State Navy - Naval Safety Command, Norfolk, VA, USA; [2]Naval Aerospace Medical Research Unit- Dayton (NAMRU-D), Dayton, OH, USA

(Original Research)

INTRODUCTION: The Naval Enterprise transitioned its injury reporting system from the Web-Enabled Safety System (WESS) to the Risk Management Information (RMI) reporting system in 2020. Changes to mishap classification definitions were also implemented to include Class E mishaps encompassing injuries requiring only minor first aid or having a total cost of $25,000 or less. The focus of this research project was to understand the results of these changes on Naval Aviation injury data reporting and trends with the expectation for a higher number of total reported injuries. **METHODS:** To understand the effects of these transitions on reporting of Naval Aviation injuries, all Class A to E mishaps and Hazards for fiscal years 2015-2025 were queried for injuries. Fiscal year 2020 data was excluded due to the transition of reporting systems during that year. Injury data characteristics were then analyzed to include age, gender, rank, personnel category, mechanism of injury, type of injury, lost workdays, and associated human factors. Injury rates were also analyzed based on exposure for each personnel class such as flight hours for aircrew or maintenance hours for maintainers. **RESULTS:** Comparing the periods of 2021-2025 to 2015-2019, the number of reported injuries increased from 774 to 1407. The age and rank of those injured decreased from a mean of 27.2 years of age to 25.5 while the number of injuries occurring to personnel of the rank E6 and below increased from 59% to 88%. Maintenance injuries increased as a proportion of the total number of injuries with inadequate real-time risk assessment cited as the leading human factor. **DISCUSSION:** Understanding injury trends is critical for the Naval Aviation Enterprise to better protect people, resources, and mission capability. Evaluating changes in safety data collection systems and mishap definitions across the years studied may offer insight into how to reduce injuries in the future and whether these modifications have resulted in improvements for operational safety

Learning Objectives

1. Understand how expanding the definition of injuries and changes to the Naval Enterprise mishap database have impacted the current rate and pattern of reported Naval Aviation injuries.
2. Identify which service members are at most risk of incurring an injury, what actions they are performing, where the injury is likely to occur, how it may happen and why.

[39] THE EFFECTS OF SEAT RECLINE ANGLE ON POST-MORTEM HUMAN SUBJECT (PMHS) SPINAL INJURY OUTCOMES DURING DYNAMIC VERTICAL TESTING

Danielle Rhodes, Blake Johnson, Michael Schlick, B. Joseph McEntire

U.S. Aeromedical Research Laboratory, Fort Rucker, AL, USA

(Original Research)

INTRODUCTION: Most U.S. Army helicopter pilot seats are designed to mitigate impact energy by stroking (i.e., displacement) when exposed to vertical crash events. This vertical seat

stroke is performed with mechanical energy attenuation mechanisms and effectively reduces the thoracolumbar compressive loads experienced by the seated occupant. The U.S. Army Aeromedical Research Laboratory (USAARL) previously assessed spinal injury risk with a 90-degree (°) seat bucket angle (the angle between the seat pan and the seat back) and a vertical seat back aligned to the acceleration vector. However, seat stroke direction is not aligned with the seat back in most crashworthy seat designs. In fact, a range of seat geometries are used in U.S. Army aviation rotary-wing aircraft. These geometries refer to the seat back angle and the seat bucket angle. The effects of different seat bucket angles and the recline seat angles on the thoracolumbar spinal injury risk were assessed in this study. **METHODS:** Thirteen male post-mortem human subjects (PMHSs) were exposed to the vertical acceleration performance limit of MIL-S-58095A (DoD, 1986), using three seat configurations: Eight from a previous 2020 USAARL study with a 90° seat back and 0° seat pan (A), three with a 110° seat back and 0° seat pan (B), and two with a 110° seat back and 20° seat pan (C). These three configurations covered a range of operationally relevant seat back/pan angles, including AH-64, UH-60, and 160th Special Operations Aviation Regiment (SOAR) MH-60M pilot seats. Injury type and severity were graded in accordance with the Abbreviated Injury Scale (AIS) (Gennarelli & Wodzin, 2005). Spinal injury outcomes were compared across configurations. **RESULTS:** Configurations A and B resulted in multiple AIS 2 or higher spinal fractures, while configuration C resulted in only one AIS 2 spinal fracture per specimen. **DISCUSSION:** The reclined seat conditions showed no greater risk of injury than the USAARL legacy rigid seat (Condition A). Configuration C showed fewer and less severe injuries. Reclining the seat back alone (Configuration B) may not reduce spinal injury risk.

Learning Objectives

1. The most common spinal injury types sustained in Army rotary-wing mishaps.
2. There are multiple seating configurations across the U.S. Army rotary-wing platforms.

[40] MAPPING CRASH SURVIVAL: SURVIVABILITY AND INJURY PATTERNS IN CIVIL AVIATION ACCIDENTS.

Christian Camilo Munoz Rivera, Diego M. García

National University of Colombia., Bogotá, Colombia

(Original Research)

INTRODUCTION: Accident survivability analysis is central to aerospace safety, crashworthiness, and post-crash medical response. Although civil aviation accidents are rare, survival outcomes vary widely depending on operational and contextual factors. Detailed injury characterization linked to survivability remains limited. This study analyzes two decades of civil aviation accidents in Colombia to characterize fatal and non-fatal injury patterns and explore factors associated with survivability across phases of flight, occupant roles, and operational contexts. **METHODS:** A descriptive, cross-sectional study was conducted using official civil aviation accident investigation reports and forensic autopsy records from Colombia (2004–

2024). Fixed-wing civil aviation accidents were included. Flight crew and passengers of all ages and genders were analyzed. Variables included phase of flight, type of operation, accident causality taxonomy (ICAO ADREP 2000), occupant role, injury patterns, causes and mechanisms of death, and fatal outcome. Data were retrospectively extracted from National Forensic Service and Civil Aviation Authority records. Fatality odds were calculated, and survivability associations were explored using descriptive and comparative analyses.
RESULTS: The overall fatality rate was 30.54%. Higher fatality risk was observed in executive (91.11%) and charter aviation (70.81%), with markedly lower risk in regular commercial transport (1.44%). Increased fatality risk was associated with CFIT (84.38%), fuel-related events (86.49%), and the approach phase of flight (82.5%). Cruise (25.15%) and landing (19.2%) were the most frequent accident phases, while loss of control in-flight (LOC-I) (12.3%) and powerplant-related system or component failure (SCF-PP) (24.0%) were the predominant causality codes. Agricultural (34.2%) and air taxi operations (29.2%) accounted for the highest proportion of accidents. Flight crew injuries most commonly involved upper extremities (44.7%), craniofacial structures (71.64%), and intracranial trauma (67.16%). Polytrauma was the leading cause of death (80.5%), with traumatic and neurogenic shock as principal mechanisms.
DISCUSSION: Distinct operational contexts, accident taxonomies, and injury patterns were associated with increased fatality risk. The identification of potentially survivable scenarios supports injury-based strategies to improve aircraft safety, operational risk management, and post-crash medical response.

Learning Objectives

1. Identify the most frequent injury patterns and causes of death in civil aviation accidents in Colombia and their association with accident survivability.
2. Analyze how operational factors such as accident causality, and phase of flight influence fatality risk in civil aviation accidents.
3. Apply injury-based and operational findings to identify potentially survivable scenarios relevant to flight safety and accident investigation.

[41] WITHDRAWN

Monday, 05/18/2026, 2:00 PM

Governor's 14

[S-8] Panel: HEADACHE IN AVIATION MEDICINE: A PRACTICAL APPROACH FROM EVALUATION TO CERTIFICATION

Chair: William Hoffman

Panel Overview: *INTRODUCTION: Headache disorders are among the most frequent neurological complaints encountered in aviation medicine and represent a major cause of aeromedical evaluation, grounding, and delayed return to flight. For Aeromedical Examiners*

(AMEs), assessing headache requires navigating the intersection of clinical best practices with operational, regulatory, and safety demands unique to aircrew populations. This five-speaker panel provides a comprehensive, practical framework for AMEs and aerospace clinicians, covering evaluation, classification, treatment, certification, and the expanding domain of aerospace-specific headache syndromes across both military and civilian settings. OVERVIEW: The session begins with a structured approach to headache evaluation, emphasizing targeted history taking, neurologic examination, appropriate use of imaging, and recognition of relevant red flags. A second presentation provides a review of primary and secondary headache disorders and their underlying pathophysiology to support accurate classification in the aeromedical environment. The third presentation highlights contemporary management strategies, including acute, preventive, and emerging treatments, with attention to flight operations. A fourth presentation addresses aeromedical certification considerations, including regulatory standards, documentation requirements, Special Issuance pathways, and effective collaboration between treating clinicians and AMEs. The final presentation explores the evolving field of space-associated headaches and aerospace-unique headache syndromes related to microgravity, acceleration forces, and high-altitude flight, representing an emerging frontier in aerospace neurology. DISCUSSION: These presentations provide an comprehensive review for managing headache disorders in aviation medicine, from initial evaluation through treatment and certification. A central theme is the need for structured, efficient assessment pathways that support aircrew and safeguard flight safety. The inclusion of space-associated headache syndromes highlights the expanding environments in which aeromedical professionals must function and emphasizes the need for continued research into neurologic risks across increasingly diverse aerospace conditions.

[42] HEADACHE ASSESSMENT FOR THE AME: HISTORY, EXAM, AND IMAGING

William Hoffman

Brooke Army Medical Center, Ft Sam Houston, TX, USA

(Education - Program / Process Review)

INTRODUCTION: Headache is one of the most common neurologic complaints in aviation medicine and frequently prompts evaluation, temporary grounding, and delays in return to flight. Before an Aeromedical Examiner (AME) can apply aeromedical standards or assess operational risk, the most critical step is establishing an accurate clinical diagnosis. Because headache syndromes vary widely in presentation and risk profile, effective assessment requires a structured clinical approach that integrates targeted history, focused neurologic examination, and evidence-based indications for neuroimaging. This session provides AMEs with a practical diagnostic framework that forms the foundation for appropriate aeromedical decision making.
OVERVIEW: The presentation outlines a clinically driven approach to a patient with headache, aiming to distinguish between primary headache disorders from secondary causes. Core elements of the history, including onset pattern, tempo, associated neurologic symptoms, triggers, and modifying factors, will be reviewed to support accurate syndrome classification. A focused neurologic examination strategy will be presented, emphasizing high-yield findings that

differentiate benign from concerning presentations. Guidance will be provided on which clinical features mandate imaging, which scenarios allow imaging to be safely deferred, and how to avoid unnecessary studies. The session will also include selected case examples of imaging findings, illustrating how specific abnormalities influence diagnosis, aeromedical risk assessment, and disposition decisions. These concepts will then be applied to aviation-specific contexts, highlighting operational considerations that shape grounding or return-to-flight decisions. **DISCUSSION:** A structured, clinically rigorous approach enhances AME diagnostic accuracy and reduces variability in aeromedical decisions. By clarifying when imaging is needed, presenting real-world imaging examples, and linking diagnoses to risk, this session provides AMEs a foundation to care for this population and support certification pathways.

Learning Objectives

1. Differentiate primary from secondary headache disorders by applying a structured clinical approach that integrates targeted history, focused neurologic examination, and identification of red flag features.
2. Determine when neuroimaging is indicated in the evaluation of headache using evidence-based criteria.
3. Describe neurologic examination findings could suggest a secondary headache syndrome.

[43] HEADACHE TYPES AND PATHOPHYSIOLOGY FOR THE AME

Jumana Alshaikh

University of Utah, Salt Lake City, UT, USA

(Education - Program / Process Review)

BACKGROUND: Headache disorders are among the most common neurological complaints, affecting roughly 40% of the general population and a substantial proportion of aviation personnel. For aeromedical examiners (AMEs), accurate headache classification is essential because different headache types carry distinct implications for flight safety, required evaluation, and certification disposition. FAA guidance stratifies headache conditions by operational risk, yet diagnostic overlap, atypical presentations, and incomplete understanding of underlying mechanisms can complicate real-world aeromedical decision making. Strengthening diagnostic clarity can improve consistency in certification outcomes and help prevent unnecessary grounding or delays in return to duty. **OVERVIEW:** This presentation will review headache disorders most relevant to aircrew, with emphasis on tension-type headache, migraine with and without aura, cluster headache, and post-traumatic headache. Headache types will be presented using the FAA's headache guide alongside diagnostic criteria from the International Classification of Headache Disorders, 3rd edition (ICHD-3). Core pathophysiologic mechanisms such as trigeminovascular activation, cortical spreading depolarization, autonomic dysfunction, and neurobiological changes following head injury will be explained with attention to how they shape symptom patterns, prognosis, and aviation-specific considerations. Clinical examples will

illustrate how mechanisms influence risk, such as distinguishing migraine aura from neurologic red flags of aeromedical significance. **DISCUSSION:** By linking diagnostic features with underlying mechanisms and FAA-aligned certification pathways, this session aims to enhance AME competence in headache classification and aeromedical risk assessment. Improving diagnostic accuracy supports consistent, evidence-informed certification decisions, minimizes unnecessary deferrals, and promotes timely yet safe return to duty. Understanding these relationships also positions AMEs to better recognize when advanced evaluation is warranted and how different headache types intersect with operational performance requirements across aviation environments.

Learning Objectives

1. Differentiate common headache types encountered in aircrew based on clinical features.
2. Describe appropriate evaluation and management approaches for common headache syndromes.

[44] MANAGEMENT STRATEGIES FOR HEADACHE WITH CERTIFICATION IN MIND

Roger Hesselbrock

Federal Aviation Administration, Washington, District of Columbia, USA

(Education - Program / Process Review)

BACKGROUND: Headache disorders occur across all demographics and represent one of the most common neurologic conditions worldwide, ranking as the third leading cause of disability-adjusted life years. Their broad variability in clinical presentation and treatment response creates unique challenges for aeromedical assessment and disposition. Although therapeutic options for aviators are more restricted than those available in general clinical practice, many safe and effective aeromedically compatible treatments exist. This session will review practical aeromedical management strategies for headache disorders relevant to Aviation Medical Examiners and Flight Surgeons. Audience participation is encouraged. **OVERVIEW:** Headaches can present with a wide spectrum of severity from minor discomfort to profound functional impairment and often lack an identifiable underlying pathology. Predicting recurrence risk is inherently imprecise. While diagnostic evaluation for aviators mirrors that of the general population, treatment choices must be tailored to aviation-specific operational requirements, medication side-effect profiles, and regulatory constraints. The session will outline evidence-informed approaches to classification, evaluation, and management, with emphasis on aligning best clinical practices with aeromedical standards. **DISCUSSION:** From an aeromedical perspective, the primary safety concerns associated with headache disorders include the potential for sudden distraction, degraded performance, or in-flight incapacitation. A secondary concern involves the aeromedical implications of treatment modalities, particularly medications with sedative, cognitive, or physiological side effects. This presentation will provide a structured aeromedical framework for evaluating and managing headache disorders, highlighting

compatible and incompatible treatment options, risk-mitigation strategies, and practical guidance aimed at supporting safe and timely return-to-duty decisions.

Learning Objectives

1. Discuss aeromedical assessment methodology for aviators with headache disorders.
2. Identify aeromedically-acceptable and unacceptable headache treatments.
3. Identify resources available for headache disorder evaluation and management.

[45] AEROMEDICAL CERTIFICATION OF PILOTS WITH MIGRAINES AND OTHER HEADACHES; DESCISION CONSIDERATIONS IN AEROMEDICAL RISK ASSESSMENT

Ronan Murphy

Federal Aviation Administration, Washington, District of Columbia, USA

(Education - Program / Process Review)

INTRODUCTION: What may be considered an excellent clinical response to headache treatment may still warrant concern from an aeromedical perspective. The risk of incapacitation due to severe pain, visual symptoms, subtle cognitive symptoms, and potential medication side effects need to be considered, as well as the unpredictability of attacks. As presented elsewhere in this panel, many effective treatment strategies exist that help mitigate the risk. Understanding key concepts of aeromedical certification can help pilots and their treating providers optimize the path to safe certification. **OVERVIEW:** In 2021, 4.3% of adults aged ≥18 years reported being bothered a lot by headache or migraine in the past 3 months. Globally, headache disorders of any kind affect approximately 40% of the population. There is a wide variation in the frequency, severity and disabling features of headache syndromes. It should be no surprise that headaches are frequently encountered as an issue when assessing suitability for certification, however most headaches are mild and while uncomfortable, are not a significant safety concern. There are, however, a few individuals with symptoms that would be considered incapacitating in the aviation environment. Symptoms may be sudden and severe such as with pain or visual loss, or may be more subtle such as with migraine associated cognitive symptoms or “brain fog”. Under the Code of Federal Regulations: 14 CFR part 67, a pilot with a neurological condition that makes them unable to safely perform or may reasonably be expected for the duration of certification to make them unable to perform the duties of safely operating an aircraft, may not be certified by the FAA. Certification under Special issuance (SI) is possible if it can be assured that the pilot can safely perform the required duties without endangering the public. The aerospace environment is unforgiving, and such an event during flight or while controlling air traffic, could be catastrophic. This is a heavy responsibility for the certifying individual or authority. Fortunately, a structured framework to risk assessment and mitigation allows the vast majority of aviators (and Air Traffic Controllers) with headaches to safely fly. The majority of headaches are mild, non-disabling and may be reduced in severity and frequency significantly by safe and effective medications that themselves pose minimal risk to aviation safety. The FAA

encourages use of the “Conditions an AME Can Issue” or CACI headache worksheet to define cases where the risk is very likely low and/or sufficiently mitigated. Headaches that do not meet the CACI criteria may still be safe to certify through a special issuance (SI) process. This requires clinical judgement on the part of the treating provider and certifier to determine the ongoing risk and assure appropriate mitigation. Typically, an incapacitating migraine or aura would require an observation period of observation of up to two years before considering certification. This period may be shorter should there be evidence that initiation of an effective prevention has sufficiently reduced the risk of incapacitating migraine. This may be a challenge when the symptoms are more severe and less frequent, as a longer period of observation may be required to judge if the symptoms are controlled. **DISCUSSION:** Key practices to ensure safe and efficient certification include accurate history and documentation, e.g. with use of headache diaries, and early recognition of the potential benefits of preventative treatment in appropriate individuals with severe symptoms even when the frequency may be considered relatively low by a provider dealing with a non-aviator population.

Learning Objectives

1. Recognize importance of headache conditions in determining aeromedical risk in the aeromedical certification of airmen.
2. Recognize headache conditions for which the AME can issue certificate and which conditions must be deferred.
3. Note strategies to improve certification efficiency and minimize certification delays.

[46] EVOLVING SCIENCE OF AVIATION AND SPACE HEADACHE SYNDROMES

Kelsey Duncan

Case Western University, Cleavland, OH, USA

(Education - Program / Process Review)

BACKGROUND: Headache in the aerospace environment is heavily impacted by microgravity, pressure changes, and acceleration forces. The resulting headache syndromes pose unique operational and clinical challenges. Space-associated headache is among the most frequently reported neurologic symptoms during missions, often linked to cephalad fluid shifts and elevated intracranial pressure (ICP) in microgravity. As scientific and commercial spaceflight expand, understanding these mechanisms as well as their prevention and treatment is critical for mitigating performance decrements and safeguarding crew health. **OVERVIEW:** Headache pathophysiology across aerospace stressors represents a unique interplay of mechanisms and adaptations. In microgravity, cephalad fluid redistribution and venous congestion increase ICP, stretching pain-sensitive dura and activating trigeminovascular pathways. Elevated CO_2 aboard spacecraft promotes cerebral vasodilation and is strongly correlated with increased headache risk. At high altitude, hypobaric hypoxia induces cerebral vasodilation and interstitial edema, while acceleration forces transiently alter cerebral perfusion and venous outflow, all contributing

to the potential development of these unique headache syndromes. Diagnostic complexity arises from overlapping syndromes such as space motion sickness and VIIP (Visual Impairment Intracranial Pressure) disorders, as well as comorbid non-aerospace related headache conditions. Current countermeasures and mitigation strategies include CO_2 scrubbing to reduce vasodilatory effects, lower body negative pressure (LBNP) to restore venous return and mitigate cephalad fluid shifts, and optimized cabin pressure and oxygenation protocols to limit hypoxia-induced vasodilation. Pharmacologic interventions such as acetazolamide for altitude headache and analgesics tailored for spaceflight pharmacokinetics exist, though efficacy varies. Emerging approaches include individualized fluid and salt loading, ICP modulation via intermittent LBNP or thigh cuffs, and wearable ICP monitoring systems for real-time feedback. Research into targeted trigeminovascular pathway modulation and non-invasive neuromodulation devices offers promising future directions. **DISCUSSION:** Operationally, headache can degrade cognitive throughput, reaction time, and mission-critical decision-making. Clinically, these syndromes demand aerospace-specific algorithms integrating neurophysiology, environmental stressors, and mission constraints. Advancing this domain will refine aeromedical standards, enhance human performance, and inform countermeasure development for long-duration missions. This work supports widespread collaboration, bridging military and civilian sectors as spaceflight continues to expand. Future research priorities include real-time ICP telemetry, neurovascular imaging in microgravity, and pharmacologic interventions that preserve operational readiness while mitigating headache burden.

Learning Objectives

1. Describe the pathophysiologic mechanisms underlying space-associated and aerospace-relevant headache syndromes, including the roles of microgravity-induced fluid shifts, intracranial pressure changes, CO_2 exposure, hypoxia, and acceleration forces.
2. Identify diagnostic challenges and overlapping syndromes in the aerospace environment, and apply aerospace-specific evaluation strategies that integrate environmental stressors, neurophysiology, and mission context.
3. Evaluate current and emerging countermeasures to mitigate headache risk and preserve cognitive performance and operational readiness during high-altitude, microgravity, and spaceflight operations.

Monday, 05/18/2026, 2:00 PM

Governor's Hallway

[S-9] Interactive Presentation: STELLAR HAZE

Chair: Judith Hayes

Co-Chairs: Fred Hauser, Laura A. Cerbone

[47] CARDIAC ARRHYTHMIA RISK IN ASTRONAUTS DURING SPACEFLIGHT: THE NASA INTEGRATED CARDIOVASCULAR STUDY

Keval Patel[1], Felix Krainski[2], Michael Bungo[3], Benjamin Levine[2]

[1]University of Texas Southwestern, Dallas, TX, USA; [2]Institute for Exercise and Environmental Medicine, Dallas, TX, USA; [3]University of Texas Health Science Center Houston, Houston, TX, USA

(Original Research)

INTRODUCTION: Whether spaceflight is arrhythmogenic has been an important clinical question for the human space program. Cardiac structural and autonomic changes observed during long duration spaceflight may theoretically increase arrhythmia risk. We aimed to perform the most comprehensive to date quantification of the frequency and severity of cardiac arrhythmias before and during long-duration spaceflight and determine changes in indices of arrhythmia substrate through the novel application of advanced electrocardiographic (ECG) analysis of depolarization, repolarization, and refractoriness. **METHODS:** Thirteen astronauts (4 women) underwent 48-hour Holter monitoring: twice pre-flight, during Flight Day (FD)-14, 30, 75, 135, R-15 (15 days prior to return), and immediately upon landing. Arrhythmia burden was interpreted by a blinded, experienced electrophysiologist. **RESULTS:** Holter monitoring data demonstrated stable pre-flight quantification of supraventricular ectopic beats (SVEs) (Pre1: 116±345 vs Pre2: 36±49 beats/48 hr., P=0.366) and ventricular ectopic beats (VEBs) (Pre1: 265±907 vs Pre2: 167±513 beats, P=0.389). No significant differences in SVEs (Pre1: 116±345 vs R-15: 442±1492 beats, P=0.327) and VEBs (Pre1: 265±907 vs R-15: 442±1031 beats, P=0.392) were observed between any stage of spaceflight. There were no significant changes in late potentials, T-wave alternans (TWA), or abnormalities in myocardial repolarization at any stage. QT interval variability index, T-wave complexity, and spatial ECG parameters, also remained unchanged. **DISCUSSION:** Baseline arrhythmia burden is variable between astronauts. Long duration spaceflight does not appear to significantly alter arrhythmic substrate or arrhythmia frequency. These findings should be interpreted in the context of inter-individual variability in arrhythmia risk, susceptibility to atrial remodeling and fibrillation, and the unknowns of extended-duration spaceflight lasting longer than 6 months into deep space. More continuous arrhythmia monitoring may be warranted to evaluate the risk of arrhythmia development (particularly atrial fibrillation) in longer durations missions to deep space.

Learning Objectives

1. The audience will learn about the cardiovascular changes that occur in spaceflight that may contribute to the risk of arrhythmia development as well as our current understanding about how long duration spaceflight impacts arrhythmia risk.
2. The audience will learn about how arrhythmic burden is estimated and how advanced ECG analysis can be used to assess for changes in arrhythmia substrate.

[48] THE DIGITAL WET LAB: A HIGH-THROUGHPUT VIRTUAL SCREENING DECISION-SUPPORT WORKFLOW FOR LONG-DURATION SPACE MISSIONS

Ian Dadeboe[1], Heavenly Webb[2], Ashley Semier[2]

[1]University of Rochester Medical Center, Rochester, NY, USA; [2]Tillman J. Fretitta Family College of Medicine, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: Traditional pharmaceutical development relies heavily on wet-lab methodologies that are resource-intensive and historically slow, presenting a significant capability gap for long-duration space missions. As mission profiles extend to Mars and beyond, the potential exposure to novel pathogens or the immediate need for radiation countermeasures requires a more agile response system. Current operational constraints do not support extensive onboard experimental synthesis; therefore, a shift toward computational pharmacology is necessary to ensure rapid target identification and crew safety in planetary defense scenarios. **OVERVIEW:** This research provides a comprehensive review of High-Throughput Virtual Screening (HTVS) as an implementable computational decision-support process. HTVS is a scalable process capable of evaluating molecular libraries of over one million compounds against biologic targets. The project details the specific workflow for integrating Quantitative Structure-Activity Relationship (QSAR) machine learning, pharmacophore modeling, and molecular docking. A key focus is the CABS-dock protocol, which allows for the flexible docking of peptides to proteins without prior knowledge of the binding site. This specific capability addresses the challenge of analyzing novel space-based organisms where structural data may be incomplete. **DISCUSSION:** A High-Throughput Virtual Screening decision support workflow bridges the gap between limited spaceflight resources and the need for rapid, high-confidence therapeutic assessment by enabling computational evaluation of countermeasures, bypassing the need for onboard laboratory infrastructure. The operational significance of a digital wet lab is its ability to drastically accelerate the identification of potential countermeasures, enabling a rapid response capability that exceeds the pace of traditional wet-lab methods. This directly supports human performance and crew health by reducing time-to-countermeasure and preserving mission capability under medical uncertainty. Additionally, this workflow advances aerospace medicine by enabling the identification of protein targets and the repurposing of onboard medications as therapeutic candidates within mission-relevant timelines. Finally, this work underscores that implementing this capability requires collaboration across aerospace medicine, computational pharmacology, computational biology and mission operations.

Learning Objectives

1. The participant will be able to explain how high throughput virtual screening (HTVS) can be used to identify therapeutic candidates under the resource and time constraints of long-duration space missions.

2. The participant will be able to describe how flexible protein–peptide docking methods, such as the CABS-dock protocol, enable analysis of biologic targets when binding sites or structural data are incomplete and/or unknown.
3. The participant will be able to recognize how computational pharmacology workflows can function as a decision-support process in aerospace medicine to support crew health, mission continuity, and planetary defense.

[49] ULTRASOUND ASSESSMENTS OF LOWER EXTREMITY JOINT HEALTH AFTER 18 DAYS ONBOARD THE INTERNATIONAL SPACE STATION

Smarika Sapkota, Richard Meehan, Eric Hoffman, James Crooks, Elizabeth Regan

National Jewish Health, Denver, CO, USA

(Original Research)

INTRODUCTION: Microgravity exposure during spaceflight affects musculoskeletal loading and may adversely impact joint cartilage, tendons, and ligaments. Previous research reported increased collagen breakdown biomarkers during International Space Station (ISS) missions and cartilage loss in rodent studies. However, limited studies have been conducted to date to assess the impact of microgravity on the human joint structures. This observational pilot study aimed to determine the effects of spaceflight-related microgravity on human lower extremity joint structures using non-invasive ultrasound measurements and Power Doppler signal (PDI). **METHODS:** This study compared pre- and post-flight results from three Axiom-4 astronauts in 2025 who spent 18 days at the ISS. Quantitative ultrasound measurements were performed pre-flight and within 4 hours post-splashdown using a GE LOGIQe with a 12-LRS probe. Twelve bilateral anatomic regions were evaluated: hip, knee, and ankle (talus) cartilage depths; infrapatellar ligament and Achilles tendon thicknesses; and knee synovial fluid depths with and without pneumatic compression. PDI assessed inflammation. Paired statistical analysis compared pre- and post-flight measurements. **RESULTS:** No statistically significant differences were detected between pre- and post-flight measurements. Mean femoral cartilage depths remained stable (left: 3.5 vs. 3.7 mm; right: 3.9 vs. 3.9 mm), as did hip cartilage (left: 2.0 vs. 1.9 mm; right: 1.9 vs. 2.1 mm). Talus cartilage, infrapatellar ligament, and Achilles tendon measurements demonstrated minimal variation (p-values 0.06-0.70). Knee synovial fluid depths remained unchanged with and without compression (inflated-left: 4.7 vs 4.3 mm; right: 4.7 vs 4.8 mm). PDI revealed no inflammatory signals. All crew members performed 3-8 hours of cycling exercise during the mission. **DISCUSSION:** The absence of joint changes after 18 days onboard the ISS may be due to the short mission duration, protective effects of compressive loading exercises, and potential anti-inflammatory effects from NSAIDs ingested by crew members. Although this study did not demonstrate significant pre- and post-flight changes, musculoskeletal ultrasound shows promise for monitoring joint health in space and optimizing exercise protocols to prevent irreversible damage.

Learning Objectives

1. Describe the impact of microgravity exposure on lower extremity joint structures.
2. Recognize musculoskeletal ultrasound as a feasible, non-invasive modality to assess or monitor changes in lower extremity joint structures.

[50] N-ACETYLCYSTEINE IN SPACEFLIGHT HEALTH: CURRENT EVIDENCE AND FUTURE DIRECTIONS

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(Education - Tutorial / Review)

INTRODUCTION: Spaceflight exposes astronauts to chronic ionizing radiation and microgravity, leading to sustained oxidative and inflammatory stress that threatens health during long-duration missions. In addition to engineering countermeasures, N-acetylcysteine (NAC) is a safe and widely used antioxidant with emerging evidence supporting its potential protective effects against microgravity and radiation-induced physiological stressors. **TOPIC:** Oxidative stress is a common factor across several hazards of spaceflight, including microgravity and radiation, and is a known contributor to chronic conditions such as cardiovascular disease, cancer, and neurodegenerative disorders. NAC is a potent antioxidant agent which replenishes endogenous glutathione and is commonly used terrestrially, most notably in the treatment of acetaminophen toxicity. Beyond its favorable safety profile and extensive clinical use, animal and cell-line studies suggest that NAC may mitigate the detrimental effects of microgravity and radiation. Under simulated microgravity, NAC has been shown to reduce oxidative stress biomarkers, improve cell survival, and decrease markers of cellular senescence. In radiation models, NAC has been shown to protect against ionizing radiation-induced DNA damage and oxidative stress in mammalian cells and has been associated with improved wound healing in animal models. **APPLICATION:** Despite these promising preclinical findings, no published studies to date have evaluated whether daily NAC supplementation reduces biomarkers of oxidative stress in humans in either terrestrial or spaceflight environments. Given its favorable safety profile, widespread clinical utility, and encouraging preclinical data in the context of microgravity and radiation, NAC is a promising candidate for further investigation as a pharmacological countermeasure to the negative health effects of prolonged spaceflight. Future clinical studies may assess changes in oxidative stress and DNA-damage biomarkers in pre-flight and post-flight astronaut samples with and without daily NAC supplementation.

Learning Objectives

1. Understand the role of oxidative and inflammatory stress in the physiological challenges associated with spaceflight, including exposure to microgravity and ionizing radiation.
2. Review preclinical evidence suggesting that N-acetylcysteine may attenuate oxidative and inflammatory stress and related pathological responses in microgravity and radiation models relevant to spaceflight.

3. Identify gaps in current human research and the need for clinical studies evaluating antioxidant strategies, including N-acetylcysteine, in the spaceflight environment.

[51] ORAL BODY TEMPERATURE CHANGES DURING LONG DURATION SPACEFLIGHT

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(Original Research)

INTRODUCTION: Human body temperature, especially during exercise, may increase during spaceflight due to the decreased efficiency of heat removal from the lack of convection in microgravity. Previous work found that astronaut baseline resting temperature increased throughout long duration spaceflight when measured via heat flux thermometer placed on astronauts' foreheads. However, forehead readings may have been confounded from increased facial soft tissue thickness experienced during spaceflight cephalic fluid shifts. This study evaluates if forehead temperature measurements could be biased during spaceflight by assessing oral body temperature over long duration missions and comparing the results to published temperature measurements taken from the forehead. **METHODS:** US astronaut oral body temperatures were measured over the course of 6 month and one-year missions as part of standard medical exams during Expeditions 1 through 68. The six-month missions' oral body temperatures were compared to published forehead flux thermometer measurements over the course of a similar mission duration. **RESULTS:** There was no difference between terrestrial and spaceflight oral temperatures during both 6 month and 1 year ISS missions. When compared to forehead heat flux thermometer results, orally measured body temperatures were maintained while forehead measurements increased during spaceflight (p < 0.01) but showed a similar body temperature measurement to oral thermometers during preflight and postflight periods. **DISCUSSION:** If baseline body temperature increases during spaceflight, NASA requirements may unknowingly allow for decreased crew health and performance. Our study showed no change between preflight, spaceflight, and postflight oral body temperatures. These results may point to cephalic fluid shifts confounding previous work that showed increased forehead heat flux thermometer readings during spaceflight. Other methods of temperature analysis should be investigated, such as the use of temperature pills, Heart Rate Variability (HRV), and rectal thermometers and compared to oral and forehead flux thermometers to validate one of these two studies.

Learning Objectives

1. Inform audience on the differing methods of measuring human body temperature in zero-gravity and the potential complications of certain methods.
2. Demonstrate the superior accuracy of oral body temperature measurements in zero-gravity.

[52] CONTINUOUS GLUCOSE MONITORING DURING HUMAN SPACEFLIGHT: A COMPARISON WITH TERRESTRIAL BASELINES

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(Original Research)

INTRODUCTION: Small form-factor continuous glucose monitoring (CGM) allows researchers to monitor glycemia levels during human spaceflight. In healthy, non-diabetic adults on Earth the average CGM glucose is ≈98–99 mg/dL, with most readings expected to fall within the 70–180 mg/dL target range. The stress of launch and the physiological changes in microgravity might alter energy metabolism, yet it is unclear if glucose metabolism is affected in spaceflight. Methods Nine subjects participated across three different short duration orbital missions (Inspiration4, Polaris Dawn and Fram2) on SpaceX's Dragon spacecraft. Mission duration spanned 3-5 days. Most subjects wore a Dexcom G6 CGM during a pre-flight baseline period, during quarantine in the weeks before to launch, the flight itself and throughout the immediate postflight recovery period. For each stage we extracted the subject-level mean and median glucose values. Group-level averages (mean of subject-level means and medians) were calculated for combined pre-flight + quarantine (n = 7), flight (n = 9) and post-flight (n = 3) periods. Paired comparisons between flight and each terrestrial stage were made using subject-level differences and paired t-tests. **RESULTS:** Across all nine participants with flight data, the mean of subject-level glucose during flight was 112.2 ± 17.7 mg/dL and the mean of medians was 107.2 ± 17.9 mg/dL. All averages were well within the terrestrial target range. Individual differences in mean glucose between flight and pre-flight ranged from −34.9 to +28.9 mg/dL. Combining pre-flight and quarantine into a single baseline (n = 7) yielded a mean difference of −2.9 ± 22.5 mg/dL (p = 0.75). For the three participants with post-flight CGM data, flight mean glucose was 8.3 ± 5.3 mg/dL higher than post-flight values (p = 0.11). None of these comparisons reached statistical significance, and all medians followed the same non-significant pattern. **CONCLUSION:** Mean and median CGM glucose values during spaceflight were within normal terrestrial glycemic ranges and did not differ significantly from pre-flight, quarantine or post-flight baselines. While individual trajectories varied, the small mean differences (generally <10 mg/dL) and high inter-individual variability suggest that spaceflight does not systematically perturb glucose homeostasis in healthy individuals. The normative CGM benchmarks in non-diabetic adults support;the feasibility of using terrestrial glucose targets for astronauts.

Learning Objectives

1. Discuss the operational implications of using continuous glucose monitoring in astronaut selection and monitoring, including the applicability of terrestrial glycemic targets for healthy and potentially diabetic crew members during short-duration mission.

2. Interpret continuous glucose monitoring data across pre-flight, in-flight and post-flight phases and evaluate whether microgravity affects glucose homeostasis relative to terrestrial baselines.
3. Integrate continuous glucose monitoring results with pre-flight, in-flight and post-flight health data to assess astronaut metabolic resilience and to develop evidence-based countermeasures for future missions.

[53] SLEEP PRESERVATION IN TORPOR FOR SPACE MISSIONS

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(Education - Tutorial / Review)

INTRODUCTION: Torpor induction has been proposed as a potential strategy to mitigate the physiological, logistical, and resource constraints of long-duration space missions. While existing torpor concepts primarily focus on whole-body hypometabolism (to reduce energy consumption and potentially blunt the severity of radiation effects) comparatively little attention has been given to the preservation of restorative brain states such as sleep. Sleep disruption is a recognized risk factor for impaired cognitive performance, psychological health, and operational safety in spaceflight. Failure to consider sleep physiology during torpor may therefore represent a critical gap in current human torpor concepts. **TOPIC:** Proposed pharmacological torpor approaches frequently involve adenosine A1 receptor agonists, such as N6-cyclohexyladenosine (CHA), to induce metabolic suppression and hypothermia. However, CHA-associated cortical cooling produces electroencephalogram (EEG) slowing that may disrupt normal sleep architecture. Dexmedetomidine, an α2-adrenergic agonist, induces a sedative state with EEG features resembling non-rapid eye movement (NREM) sleep and has been proposed to suppress arousal during torpor. Sedation alone, however, does not replicate physiological sleep, which requires both NREM and rapid eye movement (REM) components. Experimental evidence suggests that periodic cholinergic augmentation (e.g. physostigmine) can induce REM-like states, raising the possibility of staged REM induction during torpor. Additional process considerations include optimization of drug delivery routes and selective regulation of brain temperature to reduce disruption of sleep-related neural activity. **APPLICATION:** This program and process review highlights sleep preservation as an under-recognised constraint in the development of human torpor protocols for spaceflight. Integrating sleep neurophysiology into torpor design may be essential for maintaining cognitive function, psychological health, and operational performance during prolonged missions. While the described approach remains conceptual and requires substantial validation, framing torpor as a combined metabolic and neurophysiological intervention may help guide future research priorities and support cross-disciplinary discussion within aerospace medicine and human performance communities.

Learning Objectives

1. [Participants will be able to] Identify key limitations in current pharmacological torpor protocols regarding disruption of normal sleep architecture and restorative brain states.
2. [Participants will understand] The importance of integrating NREM and REM sleep preservation into human torpor designs for maintaining cognitive and psychological health in long-duration space missions.
3. [The audience will learn about] strategies to preserve the neurophysiological state of sleep during pharmacologically induced torpor.

[54] MANUALLY-IMPLEMENTED REHYDRATION OF DEHYDRATED RED BLOOD CELLS IN REDUCED GRAVITY

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(Original Research)

INTRODUCTION: Previous parabolic flight investigations of red blood cell (RBC) rehydration have used small sample volumes and largely qualitative observations, with limited quantitative assessment of the physical performance of the rehydration process. Dual-chambered blood bags (DCBBs) containing freeze-dried RBCs and rehydration solution, separated by a pressure seal, are designed for extended storage at ambient temperatures. The shelf life is up to four years, providing a strategy for blood transfusion therapy in exploration spaceflight, particularly in the case of spaceflight anemia or traumatic blood loss. This study proposes that DCBBs can reproducibly achieve a pressure seal rupture pressure of 180-220 mmHg in reduced gravity. **METHODS:** A campaign of eight parabolic flights. were conducted to evaluate rehydration of DCBBs in reduced gravity (n=16). DCBBs were filled with an analog blood and rehydration solution to assess rehydration and physical performance during weightless intervals of parabolic flight. A “shoebox” glovebox containment system was used to enable interactive biomedical experimentation. Each glovebox was equipped with two 100 cc DCBBs, rehydration solution pressure sensors, an accelerometer, and a video recording camera. Rehydration procedures were conducted by Space Force and Air Force cadets using a standardized checklist-based protocol to quantify DCBB pressure seal rupture pressure, size of seal opening, in addition to bag manual pressurization technique to achieve seal rupture and rehydration. **RESULTS:** All DCBBs were successfully rehydrated without structural failure or leakage using the squeeze and twist technique. Seal rupture pressure was 191 ± 24 mmHg, and the post-rupture pressure seal gap measured 5.2 ± 0.9 cm. While prior reduced gravity studies utilized smaller sample volumes than 100 cc, this work enabled direct, quantitative assessment of DCBB performance during rehydration. **DISCUSSION:** This study represents the first quantitative evaluation of clinically relevant DCBB rehydration in reduced gravity, providing critical data on pressure seal rupture pressure and bag integrity during human performed rehydration. The results demonstrate that controlled rehydration and physical performance of these bags was consistently acceptable during reduced gravity. These findings support continued development of blood technologies for spaceflight and other resource-limited environments where reliability is essential.

Learning Objectives

1. The participant will be able to describe the mechanical performance of dual-chambered blood bags during red blood cell rehydration in reduced gravity.
2. The audience will learn about the feasibility of human-conducted red blood cell rehydration protocols during parabolic flight operations.

[55] AFFECTIVE RESPONSES DURING FIVE DAYS OF DEXMEDETOMIDINE-ASSISTED COLD-SLEEP FOR LONG DURATION SPACEFLIGHT

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(Original Research)

INTRODUCTION: Quasi-torpor, known as "cold-sleep", is an inducible state of metabolic suppression and mild hypothermia that has been proposed as a method to reduce resource demands and psychological stress (isolation, boredom, and circadian disruption) during long-duration spaceflight. While cold-sleep can reduce metabolic rate, the psychological effects remain unknown. We tested whether affective valence and arousal measured with the Positive and Negative Affect Schedule (PANAS) varied during a five-day dexmedetomidine-assisted cold-sleep protocol, hypothesizing no worsening across intervention days. **METHODS:** We enrolled six healthy volunteers (5 male, 1 female). Five received the cold-sleep intervention, and one served as a control. Participants received an oral loading bolus followed by an 18-hour dexmedetomidine infusion with external cooling, then a 2-hour sleep period and 4 hours of exercise and cognitive assessments including PANAS at hour 24. This cycle was repeated for five consecutive days. Positive Affect (PA) and Negative Affect (NA) were summarized descriptively, and valence (PA – NA) and arousal (PA + NA) were derived. Primary analysis used a repeated-measures ANOVA on participants with complete Day 1–5 data (n = 4). A secondary mixed-effects model included the early-withdrawal participant (n = 5). This study was approved by the University of Pittsburgh IRB and all participants provided written informed consent. **RESULTS:** Four participants completed all five days, and one withdrew after day 3 unrelated to the study. Two participants completed a post-study recovery PANAS. Valence ($p = 0.28$, $\eta^2 = 0.35$) and arousal ($p = 0.64$, $\eta^2 = 0.15$) showed no significant change across days 1–5. PA and NA showed no day-related trends within participants. Mixed-effects modeling including the partial-study participant showed no day effect (valence $p = 0.27$; arousal $p = 0.27$). Day 6 recovery assessments for the two participants were equivalent to day 5. The non-drug control qualitatively showed a similar pattern in valence, arousal, PA, and NA. **DISCUSSION:** Across five days of dexmedetomidine-assisted cold-sleep, participants showed no significant affective deterioration or recovery rebound. This evidence suggests that multi-day cold-sleep strategies are

psychologically tolerable and supports continued evaluation of metabolic suppression strategies to reduce crew stress and resource demands during long-duration spaceflight.

Learning Objectives

1. Participant will be able to recognize psychological challenges associated with prolonged isolation and limited environmental stimulation.
2. The audience will identify potential ways in which extended sleep or reduced wakeful exposure may mitigate psychological stress in confined environments.

[56] FEMALE REPRODUCTIVE HEALTH IN LONG-DURATION SPACE MISSIONS: CONTRACEPTIVE OPTIONS AND RESEARCH PRIORITIES

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(Education - Tutorial / Review)

INTRODUCTION: This tutorial addresses critical knowledge gaps in female reproductive health during extended spaceflight as NASA's Artemis program advances toward multi-year lunar and Mars missions. Topics covered include: (1) female reproductive physiology and the hypothalamic-pituitary-gonadal axis in microgravity, (2) current contraceptive modalities and their space-specific risks, (3) emerging menstrual management technologies, and (4) evidence-based research priorities for deep space missions. **TOPIC:** Currently, over 90% of female astronauts use continuous hormonal suppression for menstrual management, yet comprehensive data on long-term contraceptive use in microgravity remains limited. This review synthesizes evidence from human spaceflight studies, ground-based analogs including dry immersion, and animal models demonstrating that microgravity induces hypothalamic-pituitary-gonadal axis disruptions, enhanced follicular development with impaired luteal function, and uncertain effects on fertility preservation. Available contraceptive options include combined oral contraceptives, long-acting reversible contraceptives such as levonorgestrel intrauterine devices and subdermal implants, and non-hormonal menstrual devices. **APPLICATION:** Priority risks requiring clinical consideration include venous thromboembolism from combined estrogen-progestin contraceptives compounded by microgravity-induced hypercoagulability, bone mineral density loss, radiation-induced follicular DNA damage, and contraceptive pharmacokinetic uncertainties in space. This tutorial provides aerospace medicine practitioners with frameworks for evidence-based contraceptive counseling, supports autonomous reproductive health decision-making for female astronauts, and identifies critical research gaps requiring investigation before sustained deep space exploration missions.

Learning Objectives

1. Describe how microgravity affects the hypothalamic-pituitary-gonadal axis and ovarian folliculogenesis based on current spaceflight and ground-based analog evidence.
2. Compare risks and benefits of available contraceptive modalities for extended space missions, including thromboembolism, bone health, and fertility preservation considerations.
3. Identify critical research priorities and evidence gaps in female reproductive health necessary for developing comprehensive guidelines for multi-year deep space missions.

[57] GROUND-BASED EVALUATION OF DEHYDRATED RED BLOOD CELL BAG PRESSURE SEAL RUPTURE PRESSURES AND CHANNEL WIDTH

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(Original Research)

INTRODUCTION: Medical preparations for space missions have emphasized the need for reliable blood products to treat spaceflight anemia and trauma with blood loss. However, current transfusion protocols are constrained by limited blood storage capacity and shelf-life in an austere environment. Dual-chamber rehydration blood bags (DCBB), with dehydrated red blood cells (dRBC) separated from the rehydration fluid by pressure seals, offer a viable solution for providing shelf-stable blood for up to four years under ambient cabin conditions. Reliable initiation of rehydration, as indicated by DCBB pressure-seal rupture pressures and seal-channel width, was investigated for two DCBB sizes. **METHODS:** Eight 100cc and two 350cc DCBB;were stored, prepared, and tested at ambient temperature conditions. In each bag, one chamber contained lyophilized beetroot powder analog for dRBC, and the other chamber was de-aired, then filled with 100 mL or 350 mL of water analog rehydration solution. Chambers were separated by two pressure seals. DCBB were attached to a pressure transducer to measure rehydration fluid pressure. DCBB were rehydrated manually using handgrip compressions. After rehydration, the seal-channel width of each DCBB was recorded. **RESULTS:** For the 100cc DCBB group, primary seal rupture pressure was 235 ± 66 mmHg. For the two 350cc DCBB, the primary seal on one bag prematurely ruptured and was not recorded, while the second 350cc DCBB primary seal rupture pressure was 255 mmHg. Secondary seal rupture pressure was 370 ± 174 mmHg for the 100cc group and 188 ± 48 mmHg for the 350cc group. Seal-channel width was 5.8 ± 0.7 cm for the 100cc DCBB and 7.7 ± 1.1 cm for the 350cc DCBB. **DISCUSSION:** These ground-based results demonstrate favorable progress toward viable DCBB for terrestrial and spaceflight transfusion therapy. This study indicates attainable rupture pressures for both pressure seals in the 100cc and 350cc DCBB. Given the limited sample sizes, future investigations should prioritize expanding manual DCBB compression and, eventually, automated mechanical DCBB compression tests under simulated microgravity conditions, with ideal seal rupture pressures in the 180-220 mmHg range.

Learning Objectives

1. Understand the potential of dehydrated red blood cell (dRBC) bags for spaceflight health needs.
2. Appreciate the efficacy of manual compression initiation of dRBC rehydration.

[58] DETAILED GAIT ANALYSIS OF LOPING ON THE MOON USING BODY POSE SOFTWARE

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(Original Research)

INTRODUCTION: In previous studies by this research group, Apollo astronauts' speed of walking on the Moon was determined to be approximately one third of that on Earth. Astronauts thus quickly adopted alternative gait patterns to increase speed, including a unique Moon gait pattern: loping (alternating leg hopping). This is the first known project to perform detailed analysis of loping gait on the Moon from archived Apollo footage to help inform the upcoming Artemis lunar missions. **METHODS:** This project was determined to be IRB exempt by Baylor College of Medicine and NASA IRB. Body pose image analysis (OpenPose software) using a high-performance GPU was conducted on publicly available Apollo archival footage of astronauts walking on the Moon. OpenPose superimposes a 25-point stick figure for analysis. Percentage time of stance phase, swing phase, and airborne time (both feet off the ground) were measured. Speed of loping gait was estimated based on a reference object (size of shoe recorded and preserved in museums). Other metrics such as step length were collected. Mean ± SD, one-sample two-sided T-tests, and Bonferroni correction were calculated. **RESULTS:** OpenPose software was successfully used to analyze archived 50+ year-old Apollo footage of astronauts walking on the Moon. Of the 12 astronauts, data were collected on 8 male subjects. Data of;two astronauts from Apollo 12 were excluded due to camera breakage, and two additional subjects had limited footage (while serving as cameramen). Stance phase was 30.7 ± 8.2%(S.D.). Swing phase was 69.3 ± 8.2%(S.D.). Combined total of two;floating phases;was;44.4 ± 10.1%(S.D.). Preliminary estimate for speed of gait was 0.91 ± 0.12 M/sec. This compares to 0.4 M/sec walking on the Moon found in previous studies by this research group and a normal reference of 1.2 M/sec walking on Earth. **DISCUSSION:** Loping on the Moon is a unique gait involving alternative leg hopping. The speed of this gait approaches that of man walking on Earth. This adopted gait allowed astronauts to locomote about twice the speed of Moon walking.Understanding this gait could help with future studies on gait safety and fall prevention in future lunar missions.

Learning Objectives

1. The participant will be able to describe components of loping gait cycle on the Moon.
2. The audience will be able to compare loping gait on the Moon to walking and running on Earth.

[59] DESIGNING FOR SAFETY AND EQUITY: LESSONS FOR MIXED-GENDER SPACE MISSIONS FROM THE LIVED EXPERIENCES OF FEMALE SUBMARINERS

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(Original Research)

INTRODUCTION: Gender integration into high-risk, male-dominated, Isolated, Confined, and Extreme (ICE) environments poses unique operational, medical, and psychosocial challenges, lessons critical for future mixed-gender missions to Mars. This study explored the lived experiences of women serving aboard recently integrated U.S. Navy submarines to generate data-driven insights into both the potential behavioral health effects observed in mixed-gender crews and effective integration strategies for future space habitats. No prior in-depth qualitative study has been done. **METHODS:** This qualitative study used Colaizzi's seven-step phenomenological method, a systematic process of extracting significant statements from transcripts to identify emergent themes. The sample included 32 U.S. submariners (27 female, 5 male officers). Rigor was maintained via in-situ member-checking during interviews to validate captured experiences. Ethical approval was granted by the University of Colorado Boulder IRB (#25-0036). **RESULTS:** Nine primary themes emerged, categorized by operational impact and prevalence. Design/Ergonomics and equipment mismatch were near-universal finding; 91% (29/32) identified ill-fitting PPE (e.g., firefighting gear) as a primary safety and readiness risk. All participants (100%) cited leadership-driven meritocracy, rather than gender-specific training, as the critical factor for successful integration. However, most female officers reported "hyper-visibility," creating barriers to mentorship. Clinical findings revealed a significant reliance on self-managed care; >70% of female participants reported using menstrual suppression (amenorrhea) to navigate the confined environment and restrictive pregnancy policies. The presentation will detail the frequency distribution of all nine themes. **DISCUSSION:** Mixed-gender ICE success depends on a synergy of psychological safety and human systems integration. Ergonomic failures suggest a shift toward inclusive universal design, ensuring hardware accommodates all crew members rather than a male-centric standard. Operationally, leadership-established meritocracy is a vital lesson for deep-space crews; local command must serve as the primary architect of psychological safety to prevent stress and ensure professional identity takes precedence over gender. These findings underscore the need for a formalized reproductive health framework to mitigate clinical and mission risks during long-duration exploration.

Learning Objectives

1. Understand that leadership-driven culture and normalization, not merely gender-focused training, are the most effective means of mitigating minority stress and ensuring operational effectiveness in mixed-gender ICE crews.
2. Recognize that ergonomic failures in personal protective equipment and facilities for women represent a critical safety and operational readiness risk, urging a proactive universal design approach for future space habitats.

[60] MEDICAL READINESS AT OPERATIONAL SPACEPORTS: A REVIEW OF MEDICAL SYSTEMS SUPPORTING HUMAN SPACEFLIGHT

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(Education - Program / Process Review)

BACKGROUND: Human spaceflight launch operations represent high-consequence medical environments requiring preparedness for traumatic injury, toxic exposure, acute illness, and rapid physiologic stress. Historically, state-sponsored space programs embedded medical authority directly into launch operations. The expansion of commercial human spaceflight has introduced diverse medical support architectures. As launch cadence increases and additional spaceports become operational worldwide, understanding the range of medical and emergency response systems supporting human spaceflight has become increasingly important. **DESCRIPTION:** This program and process review describes medical and emergency response architectures at operational human spaceports supporting orbital and suborbital human spaceflight. Spaceports were included if they supported active or recent human spaceflight operations and had publicly available information describing medical, emergency medical services (EMS), or emergency response capabilities. Information was drawn from government and regulatory documents, national space agency publications, corporate mission disclosures, historical program reports, and reputable gray literature. Medical readiness was descriptively mapped across five domains: governance and medical authority, on-site medical capability, embedded physician presence, transport pathways, and access to definitive medical care. **DISCUSSION:** Medical readiness architectures varied across operational spaceports and clustered into three descriptive models: state-sponsored multi-layered systems, commercial evacuation-dependent systems, and hybrid commercial systems. State-sponsored spaceports commonly employed redundant, multi-tiered medical and prehospital frameworks integrated into launch operations. Commercial operations utilized more streamlined, mission-specific medical configurations, frequently relying on contracted prehospital assets, expeditionary recovery, and evacuation to civilian trauma centers. Observed differences reflected governance structure, mission profile, and geographic context rather than launch cadence alone. Across all models, effective medical readiness depends on coordination between aerospace medical teams, on-site emergency resources, and regional

medical systems. Mapping these cooperative frameworks also provides useful terrestrial analogs for planning sustained lunar and Martian exploration missions under constrained conditions.

Learning Objectives

1. The participant will be able to describe the range of medical and emergency response architectures supporting operational human spaceports and how these systems are organized across different governance and mission profiles.
2. The participant will learn about key medical readiness domains used to support human spaceflight launch operations, including governance structure, on-site emergency resources, physician integration, transport pathways, and access to definitive medical care.

[61] IMPROVING MEDICAL–ENGINEERING COMMUNICATION THROUGH A SPACE MEDICINE WORKSHOP SERIES

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(Education - Program / Process Review)

BACKGROUND: As human spaceflight advances toward longer and deeper missions, understanding how the body adapts to the space environment is increasingly critical. However, communication gaps between medical and engineering teams often limit the translation of physiological insights into spacecraft design and countermeasures. Bridging this gap is essential for human-centered spacecraft design, mission safety, and optimizing astronaut health and performance. **OVERVIEW:** Two voluntary workshop sessions [A]/[B] were offered covering space medicine topics and microgravity effects on multiple body systems at Embry-Riddle Aeronautical University (ERAU) to enhance cross-disciplinary knowledge of human physiology in space. Anonymous pre/post-workshop questionnaires assessed demographics, pre/post knowledge (7[A] / 10[B] number of questions), educational impact, workshop relevance, and feedback. Descriptive analysis was run on demographic and satisfaction questions. Knowledge gains were tested using a Mann–Whitney U test and Wilcoxon r for effect size. Sessions had 22[A] and 30[B] participants; 86%[A] / 83%[B] were engineering students, the rest aerospace physiology. Pre-test scores averaged 4.6(SD=1.29)[A] / 6.7(SD=2.6)[B]; post-test scores averaged 5.9(SD=1.4)[A] / 8.6(SD=1.9)[B]. These differences demonstrated statistically significant knowledge increases (W=84.4, p=0.001[A]; W=224.5, p<0.01[B]) with r= 0.40[A] / 0.39[B] indicating moderate effect sizes. Students overwhelmingly reported (Likert scale) in both sessions that material was clear (85% agreed/strongly agreed), they gained knowledge (88% strongly agreed), and would recommend the seminar (88% agreed/strongly agreed). All participants stated they would attend another session if offered. **DISCUSSION:** Results indicate

overall knowledge improvement, suggesting the workshop was engaging and relevant. Additional sessions are planned. Findings underscore the value of early interdisciplinary education in preparing future professionals to address physiological and environmental challenges of human spaceflight. By emphasizing collaboration between engineering and medical teams, the workshop promotes cross-sector integration, bridging academic, civilian, and potentially military domains to support safe and sustainable human presence in space. The workshop is intended to complement ERAU's engineering learning efforts and may inform future educational initiatives, with potential benefit to other institutions as well.

Learning Objectives

1. Understand interdisciplinary value: Attendees will learn how bridging communication between medical and engineering teams can enhance human-centered spacecraft design and astronaut health.
2. Interpret educational outcomes: Attendees will be able to evaluate how a space medicine workshop can effectively improve knowledge of spaceflight physiology and promote cross-disciplinary collaboration in aerospace education.

[62] IDENTIFYING TOP MARKER GENES AND ENRICHED PATHWAYS THROUGH ANALYZING WHOLE BLOOD TRANSCRIPTOMES FROM THE SPACEX INSPIRATION4 MISSION

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(Original Research)

INTRODUCTION: During space travel, genes related to immune functions might change their expression.The SpaceX Inspiration4 mission project offers a unique venture to investigate the immunological changes of human physiology resulting from space travel. In studying the NASA GeneLab repository whole-blood transcriptome datasets, I found that short-duration spaceflight caused noticeable alterations in immune-related gene expression upon applying machine learning methods and performing pathway enrichment analysis. **METHODS:** Processed datasets (OSD-569) for whole-blood RNA-Seq samples from four individuals collected at three pre-flight and four post-flight timepoints were investigated. Pre- and Post-flight gene expression alteration across multiple comparison groups was performed with Log2 Fold Change (Log2FC) values for highly variable expressed genes (variance cutoff = 0.001). Clustering and correlations for groups of samples were visualized using heatmaps. Machine learning models of Random Forest and Logistic Regression classifiers were employed to train the data, and model performances were evaluated by confusion matrices. Top candidate genes were identified as important features evaluated by the Random Forest algorithm. Top enriched pathways were produced by Enrichr. **RESULTS:** Correlation results show that pre- and post-flight samples have the most difference in their gene expression patterns. The significant expression changes happened at R+1 post-flight

stage. Although both machine learning models achieved high accuracy for classifying samples with high accuracy. Random Forest algorithm had better performance (0.92). Top 13 important features predicted by Random Forest model were reported. The top enriched pathway was "chemokine receptors bind chemokines," primarily driven by CXCL10, a gene known to mediate immune cell recruitment and involved immune signaling and stress responses. **DISCUSSION:** Machine learning models (Random Forest and Logistic Regression) were applied to whole blood transcriptomes expression data and predicted top biomarker gene CXCL10 involved in immune response pathways under the physiological stress in space. Integration of multi-omics data designed for space flight studies could enhance the power of analysis.

Learning Objectives

1. The participant will be able to see how bioinformatics can speed up the medical discovery process. The results reported in my study may be a good addition to the Space Omics and Medical Atlas (SOMA) database.
2. Top marker genes and their enriched pathways identified in my study could guide the future space flight experiments and the needs of monitoring astronaut health.

[63] A CLOSED-SYSTEM LUMBAR PUNCTURE DESIGN FOR MICROGRAVITY

Brandon Adams, David Mampre, Peter Alexandrov, Zoey Levinson

University of Florida, Gainesville, FL, USA

(Original Research)

INTRODUCTION: A lumbar puncture (LP) is often used as a diagnostic and therapeutic procedure for a wide range of conditions and also has application in the microgravity environment of human spaceflight. LP has been performed on astronauts post-flight in an attempt to answer lingering health questions, such as what causes spaceflight-associated neuro-ocular syndrome (SANS). However, the important characterization of cerebrospinal fluid dynamics during flight has not been performed due to operational constraints of the procedure. Technical difficulties of the procedure include infection, air entrance, and fluid management in microgravity. Despite these procedural challenges, as human exploration of space continues to increase in scope, the conditions that benefit from lumbar puncture will surely be encountered, and a way must be sought to overcome the risks to further our understanding of human health in spaceflight and increase our medical capabilities as we explore further from our home. **METHODS:** We developed a closed-system LP design by introducing an injection port between the typical needle-stylet lumbar puncture device and utilizing an electronic pressure transducer (eliminating gravity-based manometry). An initial validation of the new device was conducted by performing mock LPs utilizing an LP trainer with known fluid pressures. **RESULTS:** Closed-system LP was successfully demonstrated with no loss of fluid external to the system and no appreciable entrance of air. The new closed system showed accurate (r =.994) and precise (standard deviation = 0.375 mmHg) results when measuring pressures repeatedly in the typical

CSF range of 8-15 mmHg. **DISCUSSION:** This initial validation serves as the first step in testing a novel LP system that mitigates risks of conducting the procedure during spaceflight. An in-flight LP would enable the collection of vital data on intracranial pressure under microgravity. Development of custom equipment and in vivo testing are needed for further validation of the design.

Learning Objectives

1. A lumbar puncture is a versatile procedure that would provide vital information on intracranial pressures under microgravity and lingering health questions, such as SANS, if performed during spaceflight.
2. It is difficult to perform a lumbar puncture in microgravity due to concerns of infection, air entrance, and fluid management. However, a completely closed-loop device would mitigate these issues and make an in-flight procedure more viable.

[64] BRAIN MICROVASCULAR FUNCTION IN SIMULATED MICROGRAVITY IN MICE

Michele Moraes, Rachael Seidler, Orlando Laitano

University of Florida, Gainesville, FL, USA

(Original Research)

INTRODUCTION: The absence of gravitational hydrostatic pressure causes fluid to shift upward from the lower body. The brain presses against the cranial vault, which may contribute to structural and functional impairments, as to; the brain's microvessels. A major limitation to understanding the changes in brain structure and physiology induced by spaceflight stems from the logistical difficulties of studying astronauts. The hindlimb suspension (HLS) model enables controlled experiments in mammals to investigate the consequences of fluid shift in a microgravity analog, allowing the measurements of microvascular function in the brain. However, no prior study has directly measured cerebral microvascular function in models of microgravity. We hypothesize that HLS changes the dynamic of brain microvessel function, reducing microvascular cerebral blood flow in mice. **METHODS:** Brain microvascular function was assessed in C57BL/6 male mice, 10 days after the HLS (n=6) and in a normal-ambulation control group (CON, n=7). Mice were be positioned on a stereotaxic base equipped with an anesthesia mask delivering isoflurane. The skin from the top of the head was removed, and a 3mm opening was made manually in the left parietal bone, using a microdrill. In vivo microvascular function, in vessels from 4 to 25 mm, was assessed via intravital microscopy using an automated capture and analysis system. Data were analyzed using Student's t-test or a two-way ANOVA with Tukey's post hoc test. RESULTS: HLS reduces cerebral blood flow (CON: 234.1 ± 66.3 103µm/s/mm2, HLS: 140.4 ± 43.8 103µm/s/mm2, p=0.013), and induced reduction in microvessels density (CON: 140.2 ± 18.7 10-2mm/mm2, HLS: 103.7 ± 21.3 10-2mm/mm2, p=0.007), suggesting an apoptotic signaling, mainly for microvessels from 6 to 15 mm (FV: diameter x group, p=0.031). There were no differences in the perfused boundary-region, an

indication of damage to the glycocalyx. **DISCUSSION:** A short-term HLS led to an acute impairment in microvascular function with reduction in blood flow and microvascular density, possibly due to increased hydrostatic pressure, indicating potential changes in brain microvessels induced by microgravity during spaceflight.

Learning Objectives

1. Characterize the fluid shift in absence of gravitational hydrostatic pressure.
2. Discuss the impact of the fluid shift on brain microvessels.
3. To present, using an Earth-based model, potential alterations in cerebral microvessels induced by microgravity during spaceflight.

[65] MICROVASCULAR RESPONSES TO FLUID SHIFTS INDUCED BY 6° HEAD-DOWN TILT

Ketan Dhede[1], Pragnya Prusty[2], Michele Moraes[2], Isabella Abad[2], Sophia Larrade[2], Talha Soluoku[1], Aavash Adhikari[1], Orlando Laitano[2], Ashley Blackwell[1], Rachael Seidler[2]

[1]University of Nevada Las Vegas, Las Vegas, NV, USA; [2]University of Florida, Gainesville, FL, USA

(Original Research)

INTRODUCTION: Microgravity reduces hydrostatic gradients, driving headward fluid shifts that increase blood volume in the upper body, potentially mechanically stressing microvessel structure and endothelial function. This may degrade microvessel structure and function, including negative impacts on the glycocalyx. Placing participants in a 6° head-down tilt (HDT) position also creates cephalad fluid shifts. Here, we examined whether HDT-induced fluid redistribution alters glycocalyx-related microvascular structure and function. **METHODS:** Seventeen healthy adults (18–25 years; additional data collection is ongoing) completed sublingual sidestream dark-field microvascular imaging (GlycoCheck) and tetrapolar bioimpedance spectroscopy to quantify microvascular properties and segmental fluid redistribution. Measurements were taken following 30 minutes seated, 30 minutes supine, and 90 minutes of 6° HDT. Outcomes included (a) microvascular structure within the 4–10 μm vessel diameter range, including Perfused Boundary Region (PBR), a sensitive marker of glycocalyx thinning, and microvessel density; (b) microvascular function, including capillary recruitment capacity (CBV_RC) and microvascular blood flow (MBF); and (c) segmental body fluid redistribution, assessed via upper and lower body resistance (Rinf). **RESULTS:** HDT produced a significant headward fluid shift, with fluids moving upward toward the chest and head compared with sitting upright ($V = 0$, $p < 0.001$). However, no posture-related differences were observed in microvascular structural measures (PBR, $p = 0.49$; microvessel density, $p = 0.38$) or functional measures (CBV_RC, $p = 0.85$). MBF exhibited a trend-level change from seated to HDT ($p = 0.12$). Individual differences in fluid shift magnitude were not meaningfully associated with changes in microvascular outcomes (all $|\rho| < 0.20$). **DISCUSSION:** These findings indicate that acute HDT elicits robust systemic fluid redistribution without detectable changes in

sublingual microvascular structure or function within this exposure window. Longer-duration HDT and larger samples, with longitudinal monitoring across exposure and recovery, will be important for determining whether sustained or cumulative fluid shifts produce delayed glycocalyx-relevant microvascular adaptations.

Learning Objectives

1. Describe how 6° HDT produces headward fluid redistribution and how segmental bioimpedance indices (Rinf) quantify this shift.
2. Interpret glycocalyx and microvascular-related measures from sublingual imaging (PBR, microvessel density, CBV_RC, MBF), including how to contextualize null changes following acute HDT.

[66] EVALUATION AND MANAGEMENT OF MIDDLE EAR BAROTRAUMA IN ALTERNOBARIC ENVIRONMENTS

Justin Noble[1], Craig Kutz[2]

[1]U.S. Air Force Residency in Aerospace Medicine, Dayton, OH, USA; [2]KBR, Houston, TX, USA

(Original Research)

INTRODUCTION: Middle ear barotrauma (MEBT) is a well-documented phenomenon in diving and aviation physiology but remains poorly characterized in spaceflight environments. Current International Space Station extra-vehicular activity (EVA) tempo is infrequent; however, lunar and Martian exploration missions will include frequent extra-vehicular activity with rapid pressure transitions. The absence of validated tools or standardized clinical guidelines for evaluating and managing otic barotrauma in these contexts presents a threat to crew safety and mission success. **OBJECTIVE:** This project was initiated to evaluate existing literature for validated tools or clinical processes to assess and manage ear barotrauma in astronauts and to establish evidence-informed Return-to-Duty and Return-to-EVA guidelines applicable to diving, alternobaric research, and exploration environments. **METHODS:** A comprehensive literature review was performed using PubMed, NIH databases, and the Aeromedical Library of the U.S. Air Force School of Aerospace Medicine. Search terms included “ear barotrauma,” “aviation,” “diving,” “spaceflight,” “Eustachian tube dysfunction,” and “return to flight.” The authors reviewed over 4,400 abstracts. Inclusion required full-text availability and relevance to barotrauma management, evaluation tools, or operational medicine. **RESULTS:** No validated clinical tools or specific guidelines were identified for diagnosing or managing MEBT. Historical data indicate that even minimal pressure differentials (3–5 mmHg) can induce ear symptoms. Tympanometry and Teed’s classification remain the most objective tools for assessing middle ear status. Current spaceflight operations have mitigated decompression injury with long pre-breathe and gradual decompression protocols, but do not address barotrauma risk during high-frequency EVA cycles. This study collated current literature to develop potential clinical operations and treatment of ear barotrauma in alternobaric environments such as

spaceflight. Return-to-Duty involves a multimodal evaluation and treatment, including Teed grading, tympanometry (where available), pharmacologic management (pseudoephedrine, oxymetazoline, NSAIDs), and operational clearance criteria. Future research should focus on developing compact tympanometry devices, establishing time-to-recovery based on Teed's score, and on pharmacologic prophylaxis for barotrauma prevention in resource-limited environments.

Learning Objectives

1. Increase practitioner awareness of middle ear barotrauma in alternobaric environments.
2. Familiarize learners with common tools and practices for the evaluation of middle ear barotrauma.

[67] RESTING-STATE FUNCTIONAL CONNECTIVITY CHANGES IN VESTIBULAR AND SENSORIMOTOR NETWORKS FOLLOWING SHORT-DURATION SPACEFLIGHT

Pragnya P. Prusty[1], Seda Tasci[1], Sumire Sato[1], Robert C. Welsh[2], Alexander Stahn[3], Poppy Barsby[3], Marissa Rosenberg[4], Ayan Sengupta[5], Rachael D. Seidler[1]

[1]University of Florida, Gainesville, FL, USA; [2]University of California, Los Angeles, CA, USA; [3]Charité-Universitätsmedizin Berlin, Berlin, Germany; [4]Space Exploration Technologies, Hawthorne, CA, USA; [5]University of Nevada, Las Vegas, NV, USA

(Original Research)

INTRODUCTION: Spaceflight alters vestibular signaling and induces sensory reweighting, leading to changes in functional connectivity (FC) among sensory and motor brain networks. Studies of long-duration spaceflight and ground-based analogs such as head-down tilt (HDT) bed rest consistently demonstrate changes in FC within sensory (OP2) and motor networks, often linked to postural and mobility outcomes. Resting-state fMRI (rs-fMRI) studies suggest that altered gravity exposure drives adaptive changes in within-network connectivity that support sensorimotor recalibration. However, it remains unclear whether similar neural reorganization occurs following short-duration spaceflight. The present study examined pre- to post-flight changes in FC of a multisensory vestibular network and the sensorimotor network FC following short-duration spaceflight to characterize early neural responses to microgravity exposure. **METHODS:** Astronauts (n=4) from two commercial spaceflight missions (Fram2 and AX-4) underwent pre- and post-flight rs-fMRI. Functional images were preprocessed using SPM12 and CONN toolbox with standard motion correction, denoising, normalization, and smoothing. ROI-to-ROI (Region of Interests) FC was estimated across 148 regions using Fisher-transformed bivariate correlations. Analyses focused on within-network connectivity of five a priori networks: left and right OP2, the default mode network, and bilateral sensorimotor networks. Pre- to post-flight changes were assessed using paired statistical tests. **RESULTS:** Significant increases in within-network FC were observed in OP2 and sensorimotor networks, but not the

default mode network, following spaceflight. Across astronauts, L-OP2 showed a significant increase in within-network connectivity from pre- to post-flight (Pre: 0.18 ± 0.03; Post: 0.25 ± 0.05; $t(3) = 5.64$, $p = 0.01$, $d = 2.82$) with a similar increase observed in R-OP2 (Pre: 0.11 ± 0.02; Post: 0.13 ± 0.03; $t(3) = 3.87$, $p = 0.03$, $d = 1.94$). Within the sensorimotor network, L-SMN showed a significant post-flight increase in connectivity (Pre: 0.17 ± 0.02; Post: 0.20 ± 0.04; $t(3) = 3.36$, $p = 0.04$, $d = 1.68$), whereas R-SMN showed no change ($p = 1.00$). No significant pre to post-flight changes were observed in DMN within-network connectivity ($p = 0.64$).
DISCUSSION: These findings indicate that even a brief exposure to microgravity is sufficient to strengthen OP2 and sensorimotor networks, consistent with adaptive sensory reweighting.

Learning Objectives

1. The participant will be able to understand how short-duration spaceflight alters within-network functional connectivity in vestibular and sensorimotor brain networks.
2. The participant will be able to explain how changes in OP2 and sensorimotor network connectivity reflect early neural adaptation to microgravity.

[68] ULTRA-WIDEFIELD OCT-ANGIOGRAPHY ASSESSMENT OF CHOROIDAL INTERVORTEX ANASTOMOSES IN ASTRONAUTS: IS THERE VASCULAR REMODELING DUE TO SPACEFLIGHT?

Stephanie Tamayo[1], Sara Mason[2], Tyson Brunstetter[2]

[1]Naval Aerospace Medical Institute, Pensacola, FL, USA; [2]NASA Johnson Space Center, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: Spaceflight Associated Neuro-ocular Syndrome (SANS) remains a critical health risk for long-duration missions, yet its underlying mechanisms, particularly those involving the choroidal vasculature, are still not defined. Current clinical monitoring (e.g., standard optical coherence tomography [OCT]) is focused on the posterior pole and fails to image the vast majority of the choroid. This lack of visualization limits the ability to study potential venous outflow disruptions that may contribute to SANS. The recent identification of choroidal intervortex anastomoses (CIAs), structures associated with altered venous flow in terrestrial conditions, in some astronauts using specialized imaging may suggest a significant gap in current SANS monitoring. There is a need for a standardized approach to study this vasculature and determine if remodeling occurs due to spaceflight. **OVERVIEW:** This proposal presents a novel study utilizing non-invasive ultra-widefield OCT (UWF-OCT) with angiography (UWF-OCTA) to more completely examine choroidal vascular pre- and postflight in International Space Station astronauts. The protocol addresses the current gap by providing reproducible, high-resolution visualization of the central and peripheral choroid, specifically targeting CIAs and related venous features previously inaccessible via standard OCT. Terrestrially, these features are associated with altered choroidal venous outflow in conditions

such as idiopathic intracranial hypertension, serous chorioretinopathy, pachychoroid spectrum disease, and others involving congestion and/or redistribution of venous drainage. This study leverages UWF-OCTA capabilities to establish a quantitative method for assessing pressure- or flow-induced changes in the ocular drainage system in astronauts due to long-duration spaceflight. **DISCUSSION:** The proposed study aims to deepen our understanding of the vascular mechanisms underlying SANS, thereby supporting more accurate screening and risk stratification. By studying choroidal adaptation and venous redistribution, this work advances aerospace medicine by facilitating improved physiologic modeling of fluid shifts and intracranial pressure dynamics in microgravity, including during long-duration missions. Results may unlock clues to SANS pathophysiology, and if CIAs are confirmed to be associated with spaceflight, follow-on studies will seek evidence of similar vascular adaptations potentially occurring within the brain.

Learning Objectives

1. The audience will understand current ocular imaging protocols used on astronauts and their limitations in characterizing the choroidal vasculature.
2. The audience will learn about UWF-OCTA and how its use can advance physiologic understanding of SANS and intracranial vascular adaptations to microgravity.

Monday, 05/18/2026, 4:00 PM

Plaza A/B

[S-10] Panel: SIMULATOR ENVIRONMENT FOR CREWED LUNAR LANDING: DEVELOPMENT, ASSESSMENT, AND REFINEMENT

Chair: Torin Clark

Co-Chairs: Richard Folga

Panel Overview: *Through the Artemis program, NASA will be returning humans to the surface of the moon for the first time since Apollo. This panel will begin by introducing the potential challenges of crew lunar landing and then cover ongoing efforts to develop and evaluate an integrated motion-based human landing system vehicle simulator for training and research. The Navy's Kraken device has been integrated with NASA's Human Landing System Generic Reference Model simulator, including the development and refinement of motion cueing algorithms. The Kraken capsule module was configured as a single seat cockpit, which includes a head down display, set of Orion ER-7 controls, a large field of view out the window display, and SmartEye eye tracker system and associated analysis scripts to monitor and objectively quantify pilot attention. To assess and refine the motion cueing algorithm, a validation computational model for spatial orientation perception was simulated with Generic Reference Model trajectories of landing on the moon and associated motion cueing algorithm motions to compare model-predicted perceptions of vehicle motion. Finally, while these models have*

focused on passive motion perception, advancements have been made to integrate the pilot's understanding of vehicle dynamics into the model of spatial orientation perception to enhance motion cueing algorithm assessment. In preparation for Artemis, it is essential to appropriately replicate the sensations and experience of landing on the moon for astronaut foundational landing skills training, as well as applied interplanetary manual piloting spatial disorientation research.

[69] THE CHALLENGES OF PILOTED LUNAR LANDINGS AND THE NEED FOR APPROPRIATE SIMULATION

Torin Clark

University of Colorado-Boulder, Boulder, CO, USA

(Education - Program / Process Review)

BACKGROUND: As part of NASA's Artemis program, astronauts will land on the surface of the moon for the first time since Apollo. While the physics of landing humans on the moon has not changed in the last half century, the ability for motion-based simulators to replicate aspects of this highly challenging task has improved substantially. Here, we present the challenges of pilot lunar landings and motivate the need to for developing, assessing, and refining a simulator environment for research and training. **OVERVIEW:** It is well known that during gravity transitions, astronauts experience sensorimotor impairment. For upcoming missions returning humans to the moon, this is likely to pose functional risks for pilot lunar landings due to the risk of astronaut spatial disorientation. Extrapolating our understanding of astronaut spatial orientation misperceptions when returning to Earth after microgravity exposure, we might anticipate a risk for spatial disorientation during lunar landings. This is complicated by lunar gravity being approximately 1/6th the magnitude of gravity on Earth. Further, landing vehicles are likely to undergo unique vehicle motion trajectories, which could be exacerbated by difficulty in judging distances and terrain slopes on the moon particularly during terminal descent due to dust blowback of the lunar regolith from the descent engine thruster. This is made more challenging by the limited propellant allocated for landings, creating a rapid, high workload task. While recent astronaut landings on Earth have used parachutes, crewed lunar landings will require substantial, controlled maneuvers to avoid craters and other terrain hazards. This likely necessitates a more active role for astronauts to pilot their vehicle to the lunar surface safely. In preparation for this challenging task, it is essential to develop a motion-based simulator environment that appropriately replicates the motion perceptions and experience of landing on the moon. **DISCUSSION:** Here, we motivate and introduce the panel on motion-based simulation of piloted lunar landings. This includes the Navy's Disorientation Research Device (or Kraken) 6dof flight simulator, its motion cueing algorithms, eye-tracking system and analysis pipelines, and computational model of human spatial orientation to assess and help refine motion cueing necessary for piloted lunar landing.

Learning Objectives

1. [The audience will learn about...] the unique challenges of piloted lunar landing.
2. [The audience will learn about...] approaches to simulate piloted lunar landing using a motion-based simulator.

[70] DEVELOPMENT AND REFINEMENT OF A MOTION CONTROL ALGORITHM FOR SIMULATING HUMAN LANDING SYSTEM CLOSED LOOP OPERATION OF THE KRAKEN

Richard Folga[1], Cortland Etgen[2], Bradley Fairfax[2], Lynda Kramer[3], Torin Clark[4]

[1]Naval Medical Research Unit Dayton, Wright-Patterson AFB, OH, USA; [2]Naval Medical Research Unit Dayton, Dayton, OH, USA; [3]NASA Langley Research Center, Hampton, VA, USA; [4]University of Colorado Boulder, Boulder, CO, USA

(Education - Program / Process Review)

BACKGROUND: The Navy's Kraken device has evolved as a human orientation research platform employing flight simulation to drive 6DOF motion. Kraken has integrated NASA's Artemis Human Landing System (HLS) Generic Reference Model (GRM) simulator, supporting Human Research Program and Flight Operations Directorate foundational landing skills. Strategy for developing and refining the motion control algorithm (MCA) for HLS-Kraken integration will be described here. **OVERVIEW:** The Kraken was configured as a single seat cockpit with instrument display, Orion ER-7 (Metecs, LLC) rotational and translational hand controller, and a large field out the window display. Two GRM simulator instances were installed to support offline development/training and Kraken operations. The GRM sim provided vehicle state data to the motion calculation computer where tuned spherical washout and the MCA adjusted output motion data to the Kraken at 125Hz. Pilot control inputs were fed back to the GRM sim closing the loop. Nine versions of the MCA were incrementally introduced over ten months. Changes were based on improved utility for communication, perceptual analysis, identification of motion artifacts and elimination of unstable transitory states. Testing of the refined Kraken HLS MCA was referred to as 'Phase 1'. Phase 1 events were conducted with military trained test pilots (five active NASA astronauts and three civilian/former Navy) and one Army helicopter instructor pilot. Formal test plan execution consisted of seven single day events, including familiarization training flying the GRM simulation in a replica workstation followed immediately by flights in Kraken. In total there were 19 Kraken motion testing events, 293 individual landing runs (10% passive) for 22 hours of manned operation. Test sessions were 60% high thrust to weight and 40% low thrust to weight vehicle versions. The mean run duration was 4.5 minutes, with simulation/Kraken briefly paused in between landings to discuss performance and rate workload. **DISCUSSION:** The Kraken GRM MCA is instrumental in addressing aeromedical challenges of interplanetary space operations. Further refinements to the MCA will be based on crew state (deconditioned vs. earth adapted) and evolution of the Observer Model to guide motion perception expectations translated to discrete commands for Kraken to obey.

Learning Objectives

1. The participant will understand the technical integration of an in-development GRM HLS SIM into the Kraken offline and motion-based ecosystems and the process used to iterate the MCA.
2. The participant will understand the buildup process to the final 'refinement' of the MCA and formal test and evaluation of that refined MCA in Phase 1.

[71] DEVELOPMENT AND REFINEMENT OF A GAZE TRACKING SOLUTION FOR MANUAL PILOTING OF A MOTION BASED LUNAR LANDER SIMULATOR

Bradley Fairfax[1], Dain Horning[2], Richard Folga[2], Torin Clark[3]

[1]Naval Medical Research Unit Dayton, Wright-Patterson AFB, OH, USA; [2]Naval Medical Research Unit Dayton, Dayton, OH, USA; [3]University of Colorado Boulder, Boulder, CO, USA

(Education - Program / Process Review)

BACKGROUND: The Navy's Disorientation Research Device, or Kraken, has been coupled with NASA Artemis Human Landing System (HLS) Generic Reference Model (GRM) lunar lander simulator (SIM) to create a dynamic motion-based simulation environment supporting NASA's Human Research Program and Flight Operations Directorate foundational landing skills capability. Understanding the attention allocation for lander pilot trainees during high workload landing redesignations under manual control will be useful in assessing performance among other potential utilities. **OVERVIEW:** The Kraken capsule was configured as a single seat cockpit with head down display (HDD), set of Orion ER-7 controls (Metecs, LLC) consisting of a rotational and a translational hand controller, and a large field out the window display. Two NASA developed GRM SIM instances were used: one for offline development and training, and one dedicated to Kraken operations. Both the Kraken capsule and offline simulation lab were outfitted with a SmartEye Pro Dx 4 camera eye tracker system. Navy engineers and analysts developed custom MATLAB scripts and procedures to create an efficient post-run processing and analysis pipeline for GRM SIM SmartEye eye tracker data. This included procedures for organizing raw data into a consistent data file storage structure to enable efficient data processing and analysis, code for parsing Kraken data logs into individual runs according to timestamp files, methods for time-synching raw SmartEye data to GRM SIM and Kraken motion data, code for calculating and plotting derivatives of head position from SmartEye data, and code to generate heat maps to provide objective data visualizations to supplement subjective reports regarding effectiveness of display formats. **DISCUSSION:** The integrated NASA HLS GRM SIM into the Kraken ecosystem along with advanced eye and head position tracking has been extremely useful in both applied spatial disorientation research and foundational landing skills training development. Future use of the SmartEye system will include comparing larger data sets with varying participant backgrounds, to include deconditioned subjects undergoing spaceflight analog prior to Kraken flight.

Learning Objectives

1. The participant will learn the techniques developed for synchronizing data from three disparate systems (SmartEye, Kraken and GRM SIM) for post-run analysis.
2. The participant will understand the utility of processed SmartEye data to inform NASA GRM SIM developers, lunar landing skills training performance and SD researcher applications.

[72] EXPLORATION OF MODEL PARAMETERS FOR ASSESSMENT OF MOTION PERCEPTIONS GENERATED BY MOTION-BASED FLIGHT SIMULATORS

Nicole Rote, Torin Clark

University of Colorado, Boulder, CO, USA

(Education - Program / Process Review)

BACKGROUND: Motion-based flight simulators, such as the Disorientation Research Device (DRD, or Kraken), can provide a training environment for pilots of future lunar landing vehicles by replicating in-flight motion perceptions. As such, it is pertinent that the motion perceptions experienced in-simulator are similar to those experienced in-flight. Models of pilot spatial orientation, such as the well-validated Observer model [1], can be used to predict both in-flight and in-simulator perceptions to understand their differences [2]. Here we present an exploration of model parameters and assumptions for in-flight simulations including 1) adapted gravity level, 2) pilot knowledge of rigid body vehicle dynamics, and 3) differential gain weighting of accelerations within the vestibular portion of the Observer model to account for hyper-gravity tilt overestimation. **OVERVIEW:** The Observer model of spatial orientation was used to compare motion perceptions from lunar landing simulations completed at NASA Langley to motion perceptions created by the DRD. To address the first explored model parameter, several values for the astronaut adapted gravity level were explored, including Earth gravity, lunar gravity, and microgravity. The second model assumption was explored by simulating perceptions at both the pilot station and at the vehicle center of mass. Lastly, both identical and differential gains were explored within the Observer model, aiming to capture altered gravity environments. The perceptions of pitch tilt with the simulated adapted gravity level set to lunar gravity (0.1657g) resulted in a maximum pitch tilt of 12 degrees nose-down maximum compared to 1 degree nose-up with Earth-adapted gravity level (1g) for one landing. Simulations of motion perceptions at the pilot station resulted in inverse perceptions in pitch and roll compared to motion perceptions at the center of mass of the vehicle for a vehicle with a high thrust to weight ratio. Differential weighting resulted in sustained pitch nose-up perceptions for several landings. **DISCUSSION:** The exploration of model parameters is critical to quantify the impact of model assumptions and to enable motion perceptions in-simulator that best replicate the environment pilots will experience in-flight. Proper replication of sensations experienced by astronauts during lunar landings will be essential for foundational training for upcoming Artemis landings. [1] Clark et al. (2019) Prog Brain Res 248. [2] Dixon et al. (2019) Aerosp Med & Hum Perf 90(10).

Learning Objectives

1. This experiment outlines a method for assessing the motion perceptions created by motion-based flight simulators compared to in-flight motion perceptions using a spatial orientation model.
2. This experiment explores three model choices that can impact the resulting in-flight motion perceptions, including 1) adapted gravity level, 2) pilot's learning of vehicle dynamics, and 3) weighting of acceleration misperceptions for different planes of motion.

[73] CAPTURING SPATIAL (DIS)ORIENTATION PERCEPTION DURING ACTIVE VEHICLE AND LEARNED VEHICLE DYNAMICS

Aaron Allred, Sweta Alla, Torin Clark

University of Colorado Boulder, Boulder, CO, USA

(Education - Program / Process Review)

BACKGROUND: Spatial disorientation (SD) can lead to severe operational consequences, including loss of vehicle and/or loss of life. To develop countermeasures and investigate mishaps, existing work has developed theories and models that characterize how SD emerges during flight. These efforts have yielded computational models of spatial (dis)orientation perception, validated through psychophysical experiments. However, extant work is limited to examining perceptions during externally generated, often unpredictable passive motions. Such conditions differ from flight operations, where pilots are typically engaged in active control while using learned expectations of vehicle dynamics, both of which are expected to influence perceptions of self-motion and self-orientation. Therefore, models of SD may not generalize to aviation operations. **OVERVIEW:** Here, we advance models of spatial (dis)orientation perception to include the consequences of actively commanded motions and learned vehicle dynamics. From an 'observer' model formulation, we formulate model-based hypotheses that human perceptions of tilt will temporally differ between three flight-relevant conditions: passive motions with unknown vehicle dynamics, actively commanded motions, and passive motions with learned vehicle dynamics. To empirically validate these predictions, we empirically assessed perceptions of tilt during physical, tilt-based lateral motion. Here, subjects first experienced passive motions using prior subjects' commanded profiles, then actively administered motions via joystick inputs, and finally repeated passive trials unknowingly using identical profiles. Reports, actual motion, and observer-model predictions were compared to isolate condition-dependent differences. **DISCUSSION:** Our simulations reveal differences in perceived self-orientation and self-motion across conditions involving active control, passive motion with unknown vehicle dynamics, and passive motion with learned dynamics. Together, augmented observer modeling and the empirical quantification and validation of tilt perceptions represent key advances in modeling spatial (dis)orientation during flight. This work lays the foundation for understanding aviation spatial (dis)orientation mediated mishaps when pilots anticipate the sensory consequences of active motion and/or passive motion with learned vehicle dynamics, as well as the design of effective sensorimotor countermeasures, both for aviation and spaceflight contexts.

Learning Objectives

1. This effort produces augmentations to the observer model of spatial (dis)orientation perception to model pilot perceptions.
2. Perceptions during different combinations of active/passive flight, as well as between passive with and without anticipated vehicle dynamics. These differences demonstrate the importance of extending existing models during mishap investigations and future countermeasure development.

Monday, 05/18/2026, 4:00 PM

Plaza D

[S-11] PANEL: ONE FRAMEWORK, MANY DIAGNOSES: AEROMEDICAL RISK STRATIFICATION AND USAF WAIVER PATHWAYS

Chair: Kristin Vogt

Co-Chairs: Kevin Heacock, Amy Hicks

Panel Overview: *INTRODUCTION: Operational flying demands a consistent, diagnosis-agnostic approach to aeromedical risk, assessing incapacitation, subtle performance decrement (attention, judgment), the operational impact of relapse, and treatment consequences. Conditions as different as systemic vasculitis, venous thromboembolism (VTE), asthma, and anxiety converge on the same waiver questions: stability, predictability, acceptable therapies, objective functional testing, and a defensible risk-mitigation plan. This multidisciplinary USAFSAM Aeromedical Consultation Service (ACS) panel applies a unified risk framework across five high-yield aeromedical topics. TOPIC: The panel reviews USAF waiver standards and ACS evaluation pathways for: (1) granulomatosis with polyangiitis (Wegener's), emphasizing multisystem involvement, flare detection, and immunosuppression; (2) VTE risk stratification (provoked vs. unprovoked events, recurrence risk) and anticoagulation implications for aviation and ejection/trauma risk; (3) asthma in high-performance aircrew, focusing on objective pulmonary testing, exercise/altitude triggers, cockpit workload, and medication acceptability; (4) anxiety in USAF aircrew, emphasizing symptom patterns that drive risk (panic, avoidance, sleep disruption, cognitive load), treatment stability, and waiver-relevant impairment thresholds; and (5) obsessive-compulsive disorder (OCD), highlighting distraction risk from intrusive thoughts/compulsions, time-on-task impact, treatment response, and USAF waiver standards. A recurring focus is integrating objective data (labs, imaging, pulmonary function testing, performance indicators) into a practical aeromedical risk narrative. APPLICATION: A case report of a high-performance aviator with granulomatosis with polyangiitis anchors the session, highlighting the presentation, multisystem evaluation, treatment course, and aeromedical decision points for flare risk and therapy. Remaining segments are focused operational discussions: a VTE update on recurrence risk stratification; asthma guidance on objective testing and therapies; and considerations for anxiety and OCD on waiver-relevant symptoms,*

impairment, stability, and documentation elements that improve adjudication timelines. Attendees will gain a framework for translating clinical data into risk stratification, selecting acceptable monitoring strategies, and applying waiver standards consistently across systemic, cardiopulmonary, and anxiety-spectrum conditions.

[74] WITHDRAWN

[75] GRANULOMATOSIS WITH POLYANGIITIS: MULTISYSTEM INVOLVEMENT IN A FIGHTER PILOT

Artem Tkachenko, Luke Menner, Adam Young

U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, USA

(Education - Case Study)

INTRODUCTION: This case report describes a USAF fighter pilot diagnosed with granulomatosis with polyangiitis (GPA), highlighting the clinical course, treatment, and implications for flight safety. **BACKGROUND:** GPA is a rare autoimmune vasculitis causing necrotizing granulomatous inflammation of small and medium vessels with multi-organ involvement. Common manifestations include chronic sinusitis, nasal crusting, epistaxis, and saddle-nose deformity. Pulmonary disease may present with cough, hemoptysis, or dyspnea from nodules, infiltrates, or alveolar hemorrhage. Renal involvement often manifests as pauci-immune necrotizing or crescentic glomerulonephritis, producing hematuria and proteinuria. Neurologic, musculoskeletal, cardiac, and gastrointestinal systems may also be affected. Complications such as myocarditis, renal failure, or pulmonary hemorrhage pose critical flight safety risks due to potential in-flight incapacitation. **CASE PRESENTATION:** A 37-year-old male USAF fighter pilot presented with left ear fullness, hearing loss, nasal congestion, dry cough, hoarseness, periorbital swelling, and fatigue. Imaging and serologic testing confirmed GPA with myocarditis, reduced left ventricular function, pulmonary nodules, renal impairment, and tracheal wall thickening. Treatment with high-dose corticosteroids and rituximab induced rapid remission with marked improvement of symptoms, laboratory markers, and imaging findings. Persistent mild global hypokinesis and reduced ejection fraction were noted, but subsequent coronary angiography, Holter monitoring, stress testing, pulmonary function studies, and an altitude chamber evaluation were normal. Following extensive aeromedical evaluation, he was cleared to return to flying duties with restrictions to low-G aircraft. **DISCUSSION:** This case underscores the aeromedical challenges of GPA, as its multisystem nature can compromise flight safety. Airway manifestations such as subglottic or tracheal stenosis may worsen with altitude-related dehydration or pressure changes. Pulmonary involvement reduces gas exchange and hypoxia tolerance, affecting G-force resilience. Cardiac inflammation or dysfunction heightens risks of arrhythmia, decreased exercise tolerance, or sudden incapacitation. Given the unpredictable disease course and potential for relapse, affected aviators require ongoing specialist follow-up, rigorous surveillance, and individualized risk assessment before resuming flight operations.

Learning Objectives

1. The aeromedical community will better understand the pathophysiology and associated complications of granulomatosis with polyangiitis.
2. The aeromedical community will be equipped with mitigation strategies to reduce or detect complications of granulomatosis with polyangiitis that pose a flight safety risk.

[76] VENOUS THROMBOEMBOLISM: AN AEROMEDICAL UPDATE

Luke Menner, Christopher Keirns, Artem Tkachenko, Talib Ali

U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, USA

(Education - Tutorial / Review)

INTRODUCTION: Venous thromboembolism (VTE) poses a clinical challenge in determining the aeromedical risk associated with recurrent events and the need for extended anticoagulation in aircrew. **TOPIC:** Venous thromboembolism encompasses a spectrum that includes deep vein thrombosis (DVT) and pulmonary embolism (PE). VTE can be further classified as either provoked or unprovoked. The severity of symptoms depends on the location and extent of the thrombosis. DVT results in symptoms localized to the lower extremities, while PE may lead to sudden incapacitation. Additionally, chronic sequelae such as post-thrombotic syndrome and chronic thromboembolic pulmonary hypertension pose further aeromedical risks. Treatment for an acute first event consists of a time-limited course of anticoagulation. Following the completion of initial therapy, risk stratification may identify individuals who would benefit from extended anticoagulation. Over the past decade, multiple direct oral anticoagulants have been approved for the acute treatment of VTE and the prevention of recurrence. These agents have less burdensome monitoring requirements and may be associated with a decreased risk of spontaneous cranial and gastrointestinal bleeding compared to vitamin K antagonists. **APPLICATION:** Returning an aviator to flying duties after a VTE is challenging, given that recurrent events may result in sudden incapacitation. Identifying individuals at increased risk of recurrent events who may warrant extended anticoagulation is of paramount concern. Multiple factors, including risk of recurrence, complications, and need for extended anticoagulation, must be analyzed to properly adjudicate the reinstatement of an aviator to flying status after a VTE event. **RESOURCES:** Stevens SM, Woller SC, Kreuziger LB, et al. Antithrombotic Therapy for VTE Disease: Second Update of the CHEST Guideline and Expert Panel Report. Chest. 2021 Dec;160(6):e545-e608. doi: 10.1016/j.chest.2021.07.055.

Learning Objectives

1. Understand risk stratification of VTE in aircrew.
2. Understand long-term complications associated with VTE.

[77] ANXIETY DISORDERS IN USAF AIRCREW: AEROMEDICAL STANDARDS, TREATMENT STABILITY, AND WAIVER CONSIDERATIONS

Terry Correll

USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, Dayton, OH, USA

(Education - Tutorial / Review)

INTRODUCTION: Anxiety disorders are among the most common behavioral health conditions presenting in U.S. Air Force (USAF) aircrew. While many cases are mild and treatable, symptoms such as physiological hyperarousal, attentional disruption, avoidance behavior, and panic can degrade flight performance and mission readiness. The USAF Aerospace Medicine Waiver Guide delineates specific criteria for evaluating anxiety disorders, emphasizing symptom stability, absence of performance impairment, and resilience under operational stressors. DSM-5-TR anxiety disorder classifications—including generalized anxiety disorder (GAD), panic disorder, and specific phobia—provide the diagnostic framework used in aeromedical decision-making. This tutorial reviews these standards to assist clinicians in evaluating anxiety disorders in the aviation environment. **TOPIC:** The presentation outlines the diagnostic definitions of anxiety disorders (DSM-5-TR) and the aeromedical implications of each subtype. Key areas include: distinguishing transient stress reactions from diagnosable anxiety disorders; identifying panic features relevant to in-flight performance; understanding medication considerations (e.g., SSRIs) and the USAF's policies on psychotropic medications; and recognizing operationally relevant symptoms such as startle reactivity, workload intolerance, and fear-avoidance behavior. The USAF Waiver Guide requirements are reviewed in detail, including the need for symptom remission, stable functioning, documentation of treatment adherence, side-effect monitoring, and evidence that the aviator can tolerate high-demand operational environments. **APPLICATION:** Clinicians must evaluate whether symptoms interfere with situational awareness, cockpit workload management, or mission-critical tasks. This presentation provides practical guidance for determining treatment stability, documenting aeromedical risk, and preparing waiver packages aligned with USAF standards. Emphasis is placed on multi-disciplinary collaboration with behavioral health providers and flight medicine clinicians to ensure safe and evidence-based return-to-fly decisions.

Learning Objectives

1. Describe DSM-5-TR anxiety disorder classifications and the associated aeromedical implications.
2. Apply USAF Waiver Guide criteria when evaluating aircrew with anxiety disorders, including required treatment stability and monitoring.
3. Identify operationally relevant anxiety symptoms that may compromise flight safety and require ACS review.

[78] OBSESSIVE-COMPULSIVE DISORDER (OCD): AEROMEDICAL RISK, TREATMENT, AND USAF WAIVER STANDARDS

Ryan Peirson

U.S. Air Force School of Aerospace Medicine, Wright-Patterson Air Force Base, OH, USA

(Education - Tutorial / Review)

INTRODUCTION: Obsessive-Compulsive Disorder (OCD) presents unique challenges in the aerospace environment. Symptoms such as intrusive thoughts, compulsive checking, perfectionism, and cognitive rigidity may impair cockpit multitasking, increase task-saturation vulnerability, and degrade operational judgment. According to the USAF Aerospace Medicine Waiver Guide, OCD is a disqualifying condition requiring a waiver, with approval contingent upon symptom remission, functional stability, and absence of safety-relevant behaviors. DSM-5-TR criteria provide the underlying diagnostic structure. **TOPIC:** This presentation reviews OCD symptoms with direct aeromedical relevance, including compulsive checking rituals, intrusive harm-related obsessions, and contamination fears affecting mission performance. Distinctions between subclinical obsessive traits (common in aviators) and diagnosable OCD are clarified using DSM-5-TR definitions. The session details waiver criteria, including required treatment documentation, timeframes for medication stability, avoidance of prohibited medications, neurocognitive performance expectations, and criteria for referring to the Aeromedical Consultation Service (ACS). Flight-relevant impairment—such as prolonged pre-flight checking, rigidity during abnormal procedures, or intrusive thoughts disrupting task flow—is discussed with clinical examples. **APPLICATION:** Clinicians are guided through assessment strategies that differentiate adaptive cockpit conscientiousness from compulsive or intrusive patterns that compromise safety. The waiver process is outlined step-by-step, emphasizing functional assessment, treatment response, and documentation of operational reliability and stability. Special scenarios—such as OCD co-occurring with anxiety or depressive symptoms—are addressed in relation to waiver eligibility. CLEARED AFRL-2025-5702.

Learning Objectives

1. After this presentation, participants will be able to: Describe OCD symptoms with direct aeromedical relevance, including compulsive checking rituals, intrusive harm-related obsessions, contamination fears, and their potential impact on cockpit task flow and operational judgment.
2. After this presentation, participants will be able to: Differentiate subclinical obsessive traits common in aviators from diagnosable Obsessive-Compulsive Disorder, using DSM-5-TR definitions and functional impairment as the distinguishing criteria.
3. After this presentation, participants will be able to: Outline the USAF waiver process for OCD, including documentation requirements, treatment and medication stability expectations, neurocognitive performance considerations, and indications for Aeromedical Consultation Service (ACS) referral.

Monday, 05/18/2026, 4:00 PM

Plaza F

[S-12] SLIDE: THE COST OF EXPOSURE- HEALTH & PERFORMANCE

Chair: Joanna Nelms

Co-Chair: Brittany Neilson

[79] THE EFFECTS OF HEAT STRESS ON TRANSPORT HELICOPTERS AIRCREW PERFORMANCE

Ivan Gur, Idan Nakdimon, Sharon Itzhakov

Israeli Air Force Aeromedical Center, Tel Hashomer, Ramat Gan, Israel

(Original Research)

INTRODUCTION: Despite the low metabolic intensity of most flight activities, even the slightest cognitive impairment from heat and discomfort may affect flight performance. Meteorological measurements and simulated conditions have been shown extensively to correlate poorly with the real-life conditions of operational flight. We aimed to measure the cognitive impact of the heat exposure experienced during combat operations in transport helicopters. **METHODS:** Willing transport helicopter pilots and air support crews performed a Stroop test (defined as the primary outcome of this study) before and after an operational mission at different climate conditions. Secondary outcomes included the psychomotor vigilance test (PVT) and a subjective discomfort questionnaire before and after flight. Flying conditions, duration, mission type and thermal conditions (heat and humidity) were recorded for each flight. **RESULTS:** Data were analyzed from 34 sorties (n=18 pilots, n=16 crew chiefs) ranging from 45 to 110 minutes. Environmental monitoring confirmed significant heat strain variations, with Wet Bulb Globe Temperatures (WBGT) ranging from 22°C to 34°C inside the cabin. After controlling for mission duration and complexity, high heat strain (WBGT > 28°C) was significantly associated with reduced cognitive performance. Post-flight Stroop test results showed a 14% increase in interference reaction time (p < 0.01) and a 9% decrease in accuracy (p = 0.03) compared to baseline. Similarly, PVT mean reaction times slowed by 28ms (p < 0.01), with a concurrent increase in minor lapses (>500ms). Subjective discomfort scores significantly increased in correlation with WBGT (r = 0.72, p < 0.001). However, no significant correlation was found between the subjective discomfort scores and the decrements in Stroop or PVT performance (Stroop: r = 0.12, p = 0.45; PVT: r = 0.08, p = 0.61). While pilots consistently reported higher discomfort in hotter conditions, their self-perception of thermal strain did not predict the magnitude of their executive function or psychomotor degradation. **DISCUSSION:** This study demonstrates that the thermal burden encountered during routine

transport helicopter operations in Israel is sufficient to induce measurable deficits in executive function (Stroop) and vigilance (PVT), independent of mission fatigue or complexity.

Learning Objectives

1. Assess the specific impact of operational heat stress on executive function (inhibition control) and psychomotor vigilance in helicopter aircrews, independent of mission duration or complexity.
2. Recognize the dissociation between subjective thermal discomfort and objective performance degradation, and understand why self-assessment is an unreliable safety metric in high-heat flight environments.

[80] WITHDRAWN

[81] EFFECTS OF SIMULATED HYPOGRAVITY AND VIRTUAL REALITY ON PHYSIOLOGICAL VARIABLES AND MOTION SICKNESS SYMPTOMS DURING WALKING

Rosirene Gessinger[1], Juliana Herbert[1], João Castro[2], Joana Godinho[3], Adrian Rosa[4], Duarte Conchinhas[5], Thais Russomano[6], Alcyr Oliveira Jr.[7]

[1]Federal University of Health Sciences of Porto Alegre - UFCSPA, Porto Alegre, Brazil; [2]Pontifical Catholic University of Rio Grande do Sul (PUC-RS), Porto Alegre, Brazil; [3]Center for Aerospace Medicine Studies, Faculty of Medicine, University of Lisbon - CEMA, Lisboa, Portugal; [4]Center for Aerospace Medicine Studies, Faculty of Medicine, University of Lisbon, Porto, Portugal; [5]Center for Aerospace Medicine Studies, Faculty of Medicine, University of Lisbon, Lisboa, Portugal; [6]Center for Aerospace Medicine Studies, Faculty of Medicine, University of Lisbon, London, United Kingdom; [7]Federal University of Health Sciences of Porto Alegre (UFCSPA), Porto Alegre, Brazil

(Original Research)

BACKGROUND: Operational performance in lunar (0.2G) and Martian (0.38G) environments requires understanding how reduced gravity affects human physiological responses. Virtual reality (VR) has emerged as a tool to enhance sensory-motor engagement in simulations, potentially modifying cardiovascular and perceptual outcomes. **METHODS:** Thirty healthy adults completed 10-minute walks in six randomized conditions: Earth (1G), Lunar (0.2G), and Martian (0.38G), each with and without VR, using the AlterG antigravity treadmill. Systolic and diastolic blood pressure, heart rate, peripheral oxygen saturation, and end-of-trial symptoms were measured. Motion sickness susceptibility was assessed using the MSSQ. Analyses included repeated-measures ANOVA and marginal means comparisons. **RESULTS:** No significant effects of gravity condition or VR were found for systolic or diastolic blood pressure (p > 0.05). Significant interactions were observed for VR × Time (p = 0.03) and Condition × Time (p = 0.01). Heart rate remained higher in the Earth condition than in Lunar or Martian conditions at all time points (p < 0.001). In the VR × Time interaction, heart rate increased more rapidly

without VR, whereas VR delayed this rise. Peripheral oxygen saturation was slightly reduced with VR ($p = 0.01$). VR was associated with higher reports of fatigue, dizziness, and drowsiness, while the Lunar condition showed a greater association with nausea. MSSQ scores did not correlate with symptoms, indicating low baseline susceptibility to motion sickness among participants. **CONCLUSION:** Simulated hypogravity reduces cardiovascular demand during walking, and VR alters the temporal profile of this response by delaying heart rate elevation. These findings support the combined use of AlterG and VR as a feasible and informative platform for physiological assessment and for training strategies relevant to future lunar and Martian mission scenarios.

Learning Objectives

1. The participant will be able to describe how simulated hypogravity alters cardiovascular responses during walking and identify the physiological mechanisms underlying reduced heart rate demand in lunar and Martian gravity conditions.
2. The participant will be able to analyze how virtual reality modulates physiological and perceptual responses—such as heart rate dynamics, oxygen saturation, and motion sickness symptoms—during partial-gravity locomotion.
3. The participant will be able to evaluate the combined use of AlterG and virtual reality as an experimental and training platform applicable to astronaut preparation for future lunar and Martian missions.

[82] CONTRAST SENSITIVITY VIS-A-VIS VISUAL ACUITY AS MEASURES OF VISUAL ADAPTATION TIME POST DE-GOGGLING OF NIGHT VISION GOGGLE

Jeya Karthik, Vipin Sharma, Namita Choudhry

Institute of Aerospace Medicine, Indian Air Force, Bangalore, India

(Original Research)

INTRODUCTION: Night vision goggles (NVGs) enable aircrew to overcome the inherent limitations of human night vision and operate safely in low-light environments. Despite their operational advantages, NVGs impose visual constraints that must be clearly understood to define safe flying envelopes. Of particular concern is the effect of NVG display luminance — operating within the twilight to low-photopic range, on subsequent dark adaptation once the goggles are removed. This study aimed to estimate visual adaptation time (VAT) after de-goggling Gen-2++ NVGs under varying illumination levels, using contrast sensitivity (CS) and visual acuity (VA) as primary measures. **METHODS:** A prospective repeated-measures design was used involving 64 volunteers tested in NVG laboratories at two locations. Visual adaptation time was assessed following de-goggling under three ambient moonlight conditions: full moon (FM), half-moon (HM), and quarter moon (QM). CS was measured with the Pelli–Robson chart and VA with the USAF 1951 tribar chart. Log CS values and VA were also recorded under unaided and NVG-assisted conditions. **RESULTS:** The average recovery time post-de-goggling

of NVG for CS was 1 min 34 s for FM, 2 min 50 s for HF, and 4 min 01 s for QM conditions. The average recovery time for VA was 1 min 29 s for FM, 3 min 01 s for HF, and 5 min 32 s for QM conditions. The results of this study brought out that visual adaptation time post-de-goggling of Gen 2++ NVG increased significantly for both CS and VA with decreasing ambient moonlight illumination (P;< 0.001). This study also brought out that log value of;CS and VA under three ambient light illuminations decreased significantly with a decrease in illumination both during unaided eye and NVG usage. Post hoc analysis revealed that there was a significant difference in visual adaptation time in both CS and VA between all three ambient light conditions (P;< 0.001). **DISCUSSION:** This study has estimated the time for dark adaptation required after de-goggling NVG use in different ambient moonlight levels for Gen 2++ NVG using CS and VA charts. The values based on CS can be considered in terms of time required for the detection of objects while that of VA can be attributed to the time for recognition of the object. The visual adaptation time post-de-goggling of NVG is very crucial and critical during approach, landing, and taxiing on the runway under dim light conditions for the accomplishment of mission safety.

Learning Objectives

1. The findings in this study have operational implications in night flying with the usage of NVG, where a particular level of light would be required to get differentiate contrast between the objects seen through NVG and Contrast Sensitivity function is essential for target recognition by pilot.
2. Dark Adaptation from NVG vision to ambient moonlight conditions requires few minutes which is a concern for aerospace safety during approach/landing and taxiing the aircraft in night flying operations. Hence, the aircrew flying with NVG needs to be cautioned about the period of dark adaptation required after NVG usage.
3. The awareness of dark adaptation for aircrew post-degoggling of NVG should be incorporated as part of operational training in Aerospace Medicine.

[83] BLAST INJURY VERSUS OTHER ACUTE ACOUSTIC TRAUMA - DIFFERENCES IN SENSORINEURAL HEARING DAMAGE AND RESPONSE TO HYPERBARIC OXYGEN THERAPY

Ivan Gur[1], Yuval Nov[2]

[1]Israeli Air Force Aeromedical Center, Tel Hashomer, Ramat Gan, Israel; [2]University of Haifa, Haifa, Israel

(Original Research)

BACKGROUND: Acute acoustic trauma (AAT) is a prevalent occupational hazard in military aviation and combat operations, often resulting from gunfire or high-explosive ordnance. While Hyperbaric Oxygen (HBO) therapy combined with corticosteroids is a documented treatment for AAT, the distinct operational environment of blast exposure involves complex damage

mechanisms (shock waves, thermal injury) that differ from pure noise trauma. This study compared the auditory outcomes of HBO therapy in personnel sustaining blast injuries versus those exposed to non-explosive noise (e.g., gunfire). **METHODS:** We conducted a retrospective analysis of 387 active-duty military patients (598 ears) treated for AAT with a standard protocol of daily HBO (2.5 ATA for 90 minutes) and oral prednisone. Patients were stratified by mechanism of injury: "Blast" (explosion-induced, n=259 ears) or "Noise" (gunfire-induced, n=339 ears). The primary outcome was the change in high-frequency pure-tone average (HPTA) at 3000–8000 Hz. Secondary outcomes included changes in speech reception thresholds (SRT) and symptom resolution. **RESULTS:** Blast-exposed personnel presented with significantly worse baseline audiological metrics, including higher pure-tone averages (18 +- 11 dB vs. 12 +-9 dB, p < 0.001) and higher rates of abnormal otoscopy (95% vs. 87%, p = 0.003). Following HBO intervention, the blast group demonstrated significantly less auditory recovery, with a smaller improvement in HPTA (6+- 17 dB) compared to the noise group (10+-14 dB; p = 0.022). Post-treatment thresholds remained significantly poorer across all tested frequencies for blast victims. Despite reduced audiological recovery, subjective symptom improvement (tinnitus, hyperacusis) was frequently observed in the blast cohort. **DISCUSSION:** Blast-induced AAT represents a more severe and therapeutically resistant pathological entity than pure noise trauma, likely due to diffuse cochlear and retro-cochlear damage. While HBO remains safe and provides some benefit, its efficacy is significantly reduced in blast injuries. Operational medical planning should account for the lower likelihood of full auditory restoration in blast victims when assessing return-to-duty status for flight and combat personnel.

Learning Objectives

1. Differentiate the baseline clinical and audiological characteristics of blast-induced acute acoustic trauma compared to pure noise-induced trauma in military personnel.
2. Compare the therapeutic efficacy and prognostic limitations of Hyperbaric Oxygen (HBO) therapy for blast injuries versus non-explosive acoustic trauma to inform operational return-to-duty expectations.

[84] WITHDRAWN

Monday, 05/18/2026, 4:00 PM

Governor's 10

[S-13] SLIDE: SPACE SURGERY AND AI

Chair: Nereyda Sevilla Dusch

Co-Chair: Rahul Goel

[85] ROBOTIC AND TELEROBOTIC SURGERY FOR SPACEFLIGHT: CURRENT EVIDENCE, HUMAN PERFORMANCE CONSTRAINTS AND OPERATIONAL GAPS

Sukhbir Sira

National Health Service, United Kingdom, London, United Kingdom

(Original Research)

BACKGROUND: As human spaceflight extends beyond low-Earth orbit, surgical emergencies cannot rely on evacuation with communication latency limiting real-time Earth-based teleoperation. The objective of this review was to evaluate current evidence for robotic and telerobotic surgery in spaceflight-relevant conditions, with particular attention to human factors and operational gaps. **METHODS:** A structured literature review was conducted using MEDLINE, Embase and Cochrane Library, with searches executed by an information specialist. Controlled vocabulary addressing spaceflight, microgravity and validated spaceflight analogue environments were combined with terms relating to robotic, telerobotic, and autonomous surgical systems. Studies examining surgical task performance, communication latency, autonomy, human factors and spacecraft operational and safety constraints were included. Due to heterogeneity of study designs and outcomes, quantitative meta-analysis was not performed. **RESULTS:** Recent literature demonstrates increasing interest in robotic surgery for extreme and remote environments, with spaceflight cited as a future application. Despite advances in telesurgery and established damage-control practices in aeromedical environments, robotic surgical systems have undergone only limited demonstration in true microgravity, with no clinical validation for independent surgical intervention beyond sparse parabolic-flight or orbital experiments. Most systems remain dependent on teleoperation, despite documented degradation in performance with increasing latency, raising concerns for deep-space missions. Human factors namely cognitive workload, fatigue, skill retention and the impact of limited tactile feedback during robotic operation remain inconsistently assessed. Safety risks, such as sterility maintenance, fluid containment and contamination within closed spacecraft environments, are under-reported. Consequently, most proposed systems remain at low readiness levels, limiting their current contribution. **CONCLUSIONS:** Current evidence identifies significant gaps in microgravity validation, autonomy under communication latency, human-robot interaction, training of on-orbit surgical assistants and spacecraft-specific safety considerations. Addressing these gaps through high-fidelity simulation, carefully regulated cadaveric or analogue studies through an aerospace safety-lens represents a potential pathway to ensuring success of future robotic surgical systems

Learning Objectives

1. The participant will be able to describe the current evidence base for robotic and telerobotic surgery in spaceflight-relevant environments, including limitations related to microgravity, communication latency, and technology readiness.

2. The participant will be able to identify key human performance and human–robot interaction constraints that may affect the safety and feasibility of robotic surgical interventions during long-duration space missions.
3. The participant will be able to recognise critical operational and spacecraft-specific safety gaps that must be addressed before robotic surgical systems can meaningfully reduce medical risk in deep-space exploration.

[86] PERIOPERATIVE CARE OF THE SPACE SURGICAL PATIENT AS A HOLISTIC CONCEPT: AN INTEGRATED FRAMEWORK FOR THE PATIENT JOURNEY

Rowena Christiansen[1], Dora Babocs[2], Krishi Korrapati[3]

[1]The University of Melbourne Medical School, Melbourne, Australia; [2]Mayo Clinic, Rochester, MN, USA; [3]Rosalind Franklin University, Chicago, IL, USA

(Education - Program / Process Review)

BACKGROUND: As humanity plans for long-duration space missions to the Moon and Mars, the capability to manage surgical emergencies becomes mission-critical. Within the established field of space surgery, a comprehensive, systematic approach to perioperative care—the entire patient journey 'before-during-after' surgery—has not yet been established. This gap is significant: the space environment presents unique challenges that profoundly affect every phase of surgical care. A holistic framework is now needed to guide mission planning, equipment, training, and protocols for upcoming exploration missions where evacuation may not be feasible. **OVERVIEW:** The authors propose a novel systematic framework for holistic perioperative care in space. Using predicted key surgical presentations derived from NASA's Integrated Medical Model and other existing research, the framework applies a comprehensive process analysis across the complete 18-step perioperative journey. For each scenario and step, multi-disciplinary expert teams collaboratively assess what is currently known, identify critical knowledge gaps, determine and address unsolved problems. Solutions are systematically drawn from three knowledge domains—terrestrial perioperative medicine, established space medicine research, and analogous pre-hospital/austere environment medicine—considering space-specific challenges throughout. By synthesizing existing knowledge with innovative solutions tailored to unique spaceflight constraints, the framework leads to development of evidence-based, practical best-practice guidelines and step-by-step checklists for each perioperative phase, supporting optimal patient outcomes during spaceflight missions. **DISCUSSION:** This integrated approach to perioperative care in space advances aerospace medicine by providing a systematic methodology for addressing one of the most complex challenges in long-duration spaceflight. It supports cross-service, international, and military-civilian collaboration by establishing a common framework for developing surgical capabilities. By engaging multi-disciplinary teams—including health professionals, engineers, designers, and human factors specialists—this framework facilitates comprehensive problem-solving that addresses the full scope of perioperative challenges. Additionally, solutions developed for spaceflight may translate back to

terrestrial practice, particularly benefiting remote, austere, and resource-limited healthcare settings on Earth.

Learning Objectives

1. Participants will be able to describe the systematic framework for applying evidence-based perioperative care principles to long-duration spaceflight missions, including the three-phase structure and process analysis methodology.
2. The audience will be able to identify the three knowledge domains (terrestrial perioperative medicine, space medicine research, and pre-hospital/austere environment medicine) and explain how they contribute to developing space-adapted perioperative solutions.
3. Participants will be able to explain how risk-based surgical scenarios inform the development of perioperative guidelines and checklists for space missions, and discuss potential applications for improving terrestrial healthcare in resource-limited settings.

[87] VASCULAR TRAUMA IN LONG-DURATION SPACEFLIGHT: CHALLENGES, CURRENT CAPABILITIES, AND FUTURE DIRECTIONS

Dora Babocs[1], Krishi Korrapati[2], Jonathan Szeto[3], Georgios Tzavellas[4], Rowena Christiansen[5], Kimia Seyedmadani[6], M. Mark Melin[1], Todd E. Rasmussen[1]

[1]Mayo Clinic, Rochester, MN, USA; [2]Chicago Medical School at Rosalind Franklin University, Chicago, IL, USA; [3]University of Pennsylvania School of Medicine, Perelman, PA, USA; [4]Athens Medical Center, Athens, USA; [5]The University of Melbourne Medical School, Melbourne, Australia; [6]NASA Johnson Space Center, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: Humanity is preparing to return to the Moon and eventually launch a crewed mission to Mars. According to NASA's risk assessments, traumatic injuries represent one of the medical threats during long-duration space missions. Prolonged exposure to the space environment affects all; physiological body systems, increasing the likelihood of medical—and potentially surgical—emergencies arising from a variety of causes. The aim of this study was to review potential traumatic events that may necessitate vascular surgical intervention during human deep-space missions. **OVERVIEW:** A scoping review was conducted following the PRISMA;guidelines. Relevant literature published between 2000 and 2025, incorporating data from commercial, clinical, and military sources was reviewed. A structured search strategy was applied using Google Scholar, PubMed, the Defense Technical Information Center, the NASA Life Sciences Data Archive, and NASA Technical Reports. Out of the 246 total of 73 studies met inclusion criteria. We addressed the following NASA GAPs: CV-101: CV-102, CV-103, CV-202, CV-203, CV-301, CV4, EIHSO-201, EIHSO-301, EIHSO-501, EIHSO-701, EIHSO-8801, ExMC 4.07, ExMC 4.10:, Fracture 1, Med07, Med12, Medical-101, Sleep-101. **DISCUSSION:** As mission durations extend, the potential for vascular emergencies necessitates a tiered clinical

framework to prioritize surgical interventions. Traumatic injuries encountered during human space exploration are expected to range from minor microvascular damage to life-threatening hemorrhage requiring rapid intervention. Treatment options will include non-invasive, minimally invasive and open surgery. Surgical decision making will rely on available resources, ethics and expertise. While Tier 1 life-saving procedures like hemorrhage control are mission-critical, the management of Tier 2 and Tier 3 conditions—such as acute limb ischemia or carotid disease resulting from accelerated atherosclerosis—is significantly hampered by the lack of advanced imaging and sterile environments in deep space. Consequently, addressing these surgical concerns requires a shift toward aggressive pre-flight screening and the development of autonomous, minimally invasive endovascular technologies to manage vascular crises where Earth-based deferral is not an option. Therefore, integration of surgical considerations into mission operational planning is essential to ensure crew readiness and survival during future long-duration spaceflight.

Learning Objectives

1. Identify the spectrum of vascular traumatic events that may occur during long-duration spaceflight and their potential clinical impact on crew health and mission success.
2. Describe the limitations of current surgical and vascular intervention capabilities in deep-space environments, including constraints related to imaging, sterility, resources, and expertise.
3. Discuss future strategies for mitigating vascular trauma risk in space, including tiered clinical frameworks, pre-flight screening, and the role of autonomous and minimally invasive endovascular technologies.

[88] PIONEERING VASCULAR SURGERY IN SPACE: TRANSLATING TERRESTRIAL EXPERTISE AND USAGE OF ARTIFICIAL INTELLIGENCE FOR ON-BOARD CARE IN THE FINAL FRONTIER

Divy Kumar[1], Luis Guilarte[2], Rowena Christiansen[3], Kimia Seyedmadani[4], Georgios Tzavellas[5] and Dora Babocs[6]

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(Education - Program / Process Review)

BACKGROUND: As spaceflight moves from low Earth orbit to cis-lunar and Mars missions, medical care must shift toward crew autonomy. Communication delays, limited expertise, and constrained resources make real-time Earth-based surgical support impractical. Astronauts face higher risk of vascular emergencies from trauma, microgravity, radiation, fluid shifts, and altered hemodynamics. On Earth, vascular surgery has advanced toward minimally invasive approaches,

and in some contexts could be enhanced by artificial intelligence (AI). These technologies might help meet spaceflight challenges, but AI in vascular surgery has not been systematically evaluated for aerospace medicine. **OVERVIEW:** We conducted a scoping review using PRISMA guidelines to evaluate AI in vascular surgery through an aerospace lens. Literature from 2015-2025 was searched across PubMed, Scopus, Cochrane, and NASA archives and technical reports. Of 318 records screened, 28 met inclusion criteria and underwent independent review. Technologies across pre-, intra-, and postoperative phases were analyzed and mapped to seven NASA knowledge gaps. **DISCUSSION:** AI enables automated imaging analysis of vascular pathologies, such as risk estimation of abdominal aortic aneurysms (AAA) and deep venous thrombosis. Predictive outcome analytics support individualized care for peripheral artery disease, AAA, and postoperative complications, aiding treatment decisions and resource allocation. Decision support systems optimize intraoperative guidance, including fluoroscopy use, and enable patient monitoring through wearable and telemedicine platforms. Robotic interventional systems can shorten procedure times and reduce radiation exposure. AI tools also provide scalable training for crew medical officers under operational stress. Emerging frontiers in AI include integration with biometrics for chronic limb-threatening ischemia management, and natural language processing for extracting clinical documentation, further enhancing autonomous vascular care potential. However, challenges include algorithmic bias, limited standardization, and model hardware requirements. Studying AI in aerospace also informs low-resource and austere Earth environments with limited vascular specialist access. Lessons from spaceflight guide remote decision support, procedural guidance, telemedicine, and scalable training, improving capability in global, rural, and military settings across both local and international healthcare systems.

Learning Objectives

1. Explain the role of artificial intelligence in supporting autonomous vascular surgery during long-duration spaceflight.
2. Identify specific AI technologies applied in preoperative, intraoperative, and postoperative phases of vascular care.
3. Describe key challenges and considerations in implementing AI for vascular surgery in resource-limited or operationally constrained environments.

[89] THE EVERYWEAR MEDICATION TRACKING TOOL – AGILE APPROACH FOR ISS, ARTEMIS, AND BEYOND

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(Education - Program / Process Review)

BACKGROUND: Medication intake records during spaceflight missions have historically been collected during private medical conferences between crew surgeons and astronauts once per

week. The total time allotted for these medical conferences is approximately 15 minutes; medication intake reporting and recording constitutes only a small fraction of that time. This weekly reporting interval opens the data to recall bias by the crew, and current methods fail to capture timing of the medications as they are taken. Retrospective reviews of medication use have shown that medication intake may be underreported with this current approach. **DESCRIPTION:** The EveryWear Medication Tracking Tool is designed to enable real-time capture of medication intake and its context by astronauts. The tool is intended to assist in medication reconciliation for private medical conferences. The tool incorporates capability for capturing side effects and medication efficacy for applicable clinical indications. All captured data are time-stamped, facilitating the identification of potential medication-related issues by the crew surgeons or pharmacy staff. **DISCUSSION:** NASA and ESA collaborative process to develop and evolve the tool will be highlighted. During the initial deployment, crewmembers reported medication use in 33% of mission-weeks. As updates to the application and training have been made (based on crew, surgeons and pharmacists feedback), reporting rates have increased to 65% of mission-weeks in the 3 last increments. Exploration missions will necessitate greater crew autonomy. As a result, the use of the medication tracking tool will help inform the surgeons Earth-side about medical care during missions. Over time, data may reveal changes or patterns in dosing frequency, thereby informing pharmacokinetic research priorities. Additionally, these insights will contribute to evidence-based optimization of future medical kits.

Learning Objectives

1. Understand the importance of collecting medication use data near real time to optimize clinical management of crewmembers during mission and plan medication management for future crewmembers/missions.
2. Discover how EveryWear has been designed and continuously refined to support autonomous crewmember use.

[90] DO WE REALLY NEED A PHYSICIAN ON-BOARD? CAN WE SEND AN AI “DOCTOR” INSTEAD?

Lucas King

Canadian Armed Forces, Moose Jaw, Saskatchewan, Canada

(Education - Tutorial / Review)

INTRODUCTION: This presentation will discuss current clinical AI tool capabilities and how they may apply to austere and space medicine using audience participation and vignettes to consider future applications and risks of clinical AI and the role of physicians. **TOPIC:** Currently, the most common applications of clinical AI are (1) documentation support (ambient scribes that draft clinic notes), (2) evidence copilots (tools that retrieve and summarize clinical evidence with citations), and (3) intake/triage assistants (supporting decision-making to escalate care based upon red flags with human oversight). These tools are powered by large language models (LLMs), which generate text from patterns in training data. While formal AI clinical

decision-making tools are limited, consumer AI chatbots are being used widely by patients and clinicians to answer medical questions, despite the risk of hallucination, confident but incorrect answers, and inconsistent responses. **APPLICATION:** As these tools become more capable we may be faced with the question, "Do we really need a physician on-board?", particularly in austere environments and deep space. While the immediate response is "yes, ideally", even now there are many situations where a physician is not on-board. As such, a more nuanced framework is needed to determine when and why a physician is physically required, particularly once AI tools draft differentials and management plans and as human spaceflight moves beyond LEO, where communication delays become significant. What challenges, technological (e.g. computational power) and human factors (e.g. overconfidence in AI), will arise as AI becomes commonplace formally, as decision-making tools, and informally, as patients and clinicians use AI without monitoring? Attendees will participate in an interactive discussion to shape the direction of future frameworks and guardrails, including escalation rules and guidelines for use by allied health providers, to support safe and reliable implementation of clinical AI tools in austere and space medicine, as well as the future role of physicians.

Learning Objectives

1. Identify common clinical AI tools and Large Language Model (LLM) limitations.
2. Identify key risks to deploying clinical AI tools in austere and space settings.
3. Discuss guardrails for safe and reliable clinical AI implementation in austere and space settings.

Monday, 05/18/2026, 4:00 PM

Governor's 12

[S-14] SLIDE: AVIATION EVACUATION / ESCAPE

Chair: Taania Girgla

Co-Chair: Jeremy Berger

[91] ASSESSING AIRCRAFT EXHAUST CONTAMINANT INTRUSION INTO PORTABLE OXYGEN CONCENTRATOR OUTPUT DURING OPERATION NEAR AEROMEDICAL EVACUATION AIRCRAFT

Craig Nowadly[1], HoanVu Nguyen[2], Hayley Brawley[3], Cristina Muko[4], Edgar Hudson[5], William Wallace[6], Yazan Samara[6], Jeffrey Sweterlitsch[6]

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Lackland Air Force Base, TX, USA; [4]KBR, Houston, TX, USA; [5]JES Tech, Houston, TX, USA; [6]NASA Johnson Space Center, Houston, TX, USA

(Original Research)

INTRODUCTION: During aeromedical evacuation (AE), both patients and healthcare providers may be exposed to contaminants present in aircraft exhaust. Supplemental oxygen is often required and portable oxygen concentrators (POCs) offer a practical oxygen source in constrained, resource-limited AE environments. However, POCs could theoretically concentrate harmful compounds in ambient air during flight operations, creating a potential exposure pathway during AE. This study evaluated how POC operation influences concentrations of selected aircraft exhaust contaminants. **METHODS:** Nineteen contaminants identified in air samples collected around HH-60, C-130H, and C-17 aircraft were selected for testing. An airflow testbed was developed to simulate aircraft exhaust (1x), with a second configuration containing tenfold (10x) higher concentrations of these contaminants. Air from each testbed was directed into a chamber housing a continuously operating military-relevant POC model (SAROS 3000), and the resulting output oxygen stream was analyzed by gas chromatography mass spectrometry to quantify contaminant levels. **RESULTS:** Testbed contaminant concentrations were achieved as designed. During 1x testing, seven contaminants were detected in the POC oxygen output, while five appeared during 10x testing, with acetaldehyde, ethanol, and hydrogen present under both conditions. All outlet detections were low, near analytical limits. Several contaminants not included in the test panel (i.e., butane, isopropanol, methanol, propane, and tetrafluoroethane) were observed in the chamber atmosphere, but only a subset appeared in the outlet stream. All detected compounds declined despite continuous POC operation under contaminant exposure, with most clearing within 3 days and none remaining by day 7. **DISCUSSION:** This testbed represented a demanding environment for POC performance, with the device operating continuously for twelve days under sustained exposure to aircraft exhaust contaminants. No detected combustion contaminants in the POC oxygen outflow approached levels associated with known health hazards. Compounds that appeared in the outlet stream were limited to small molecules with three or fewer carbons or simple alcohols, and all cleared to undetectable levels during ongoing exposure. These findings suggest that pressure swing adsorption POC designs function safely when used in or near combustion environments typical of AE operations.

Learning Objectives

1. Describe how portable oxygen concentrator operation influences aircraft exhaust contaminant concentrations in the oxygen outflow during aeromedical evacuation.
2. Learn about the experimental testbed approach used to simulate aircraft exhaust exposure and quantify contaminants in POC oxygen output using gas chromatography mass spectrometry.
3. Summarize key findings regarding contaminant detection, clearance over time, and implications for safe use of pressure swing adsorption POCs in combustion environments typical of aeromedical evacuation operations.

[92] SAFEVAC: A FRAMEWORK FOR SAFE AERIAL MEDICAL AND CASUALTY EVACUATION OF HEMODYNAMICALLY UNSTABLE PATIENTS

Lonnie Petersen, Michael Tibbs

Massachusetts Institute of Technology, Boston, MA, USA

(Original Research)

INTRODUCTION: Hemorrhage represents the leading cause of preventable trauma death and comprises 88% of military aeromedical evacuations. Rapid transport under the golden-hour paradigm improves survival but must be balanced against flight-induced acceleration, vibration, and environmental stressors that can destabilize hemodynamically compromised patients. We introduce research to increase evacuation safety including patient monitoring, shock prediction algorithms, human in-flight testing quantifying acceleration susceptibility, and dose-response relationships between patient status and flight limits as a tool for risk-informed route planning. **METHODS:** The framework comprises five elements; 1) A machine-learning model that estimates hemorrhage severity from arterial waveforms with the Compensatory Reserve Measurement (CRM: 1.0=normovolemic, 0.0=decompensation) using 208 subjects undergoing LBNP-simulated hemorrhage. 2) Dose-response relationships between acceleration and hemorrhage from nine subjects undergoing LBNP during aggressive flight maneuvers. 3) Bayesian-Monte Carlo simulation quantifies decompensation probability under G given observed CRM. 4) Risk estimates define patient-specific flight envelopes specifying maximum permissible acceleration. 5) Route planning using path geometry produces flight-time versus patient-risk tradeoffs. **RESULTS:** Flight testing characterized hemodynamic responses across accelerations up to 2.0G combined with simulated hemorrhage up to >20% blood volume loss/50 mmHg LBNP. Dose-response modeling confirmed synergistic effects in which the combined effect exceeded either stressor alone. The CRM estimation model achieved strong predictive accuracy (R2;= 0.80). Safe flight envelopes were derived at warning (CRM<0.4) and critical (CRM<0.1) thresholds, with maximum permissible acceleration decreasing as hemorrhage severity increased. For one scenario, accepting 3% versus 13% decompensation risk increased flight time by 12%. **DISCUSSION:** This line of research provides the first comprehensive methodology connecting real-time hemorrhage assessment to patient-specific flight constraints. By quantifying the tradeoff between transport time and decompensation risk, the tool supports, but does not replace, medical decision-making. Applications include military casualty evacuation in contested airspace, civilian aeromedical transport, and autonomous platform operations, with real-time adjustment possible if patient status deteriorates

Learning Objectives

1. Understand why combined hemorrhage and acceleration exposure produces synergistic cardiovascular compromise exceeding either stressor alone, necessitating patient-specific flight constraints during aeromedical evacuation.

2. Learn how the Compensatory Reserve Measurement enables real-time assessment of hemorrhage severity and the derivation of patient-specific maximum G-force limits for safer aeromedical transport.
3. Recognize how probabilistic risk assessment quantifies the tradeoff between transport time and patient decompensation probability to support flight planning decisions.

[93] LATEST DEVELOPMENTS & TRENDS IN THE USE OF AI TOOLS IN SUPPORT OF AEROSPACE MEDICINE

Melchor Antunano

Federal Aviation Administration, Oklahoma City, OK, USA

(Education - Tutorial / Review)

Artificial intelligence (AI) is rapidly transforming aerospace medicine, evolving from experimental tools to integrated systems that enhance safety, performance monitoring, and autonomous care. In civil and military aviation, AI-driven models predict risk, support decision-making, and extend medical capabilities in remote or space environments. Machine learning (ML) algorithms now process large volumes of flight, environmental, and surveillance data to anticipate safety-critical events such as wind shear, aircraft anomalies, and physiological degradation. Embedded within safety management systems, ML-based anomaly detection and fatigue-monitoring tools have cut false alarms by about 35% and enabled earlier hazard identification, reducing incident rates. AI-assisted clinical decision engines empower flight surgeons and crew medical officers to manage mission-critical conditions where specialty care is limited. Applications for fatigue, performance, and human-factor monitoring integrate physiological, behavioral, and scheduling data to forecast fatigue up to 24 hours in advance and optimize crew rostering. AI-enhanced cockpit assistants combine multimodal data from aircraft and pilots to bolster situational awareness, lower cognitive load, and reduce human error—key goals in maintaining aeromedical fitness. In remote and spaceflight medicine, AI-driven diagnostic systems and chatbots are being tested to manage medical and psychological issues when communication with ground teams is delayed or impossible. Complementary biosensor and "digital twin" frameworks employ continuous physiological and operational data to model individual health trajectories, predict risk, and tailor aeromedical decisions across a career or mission. Emerging focus areas include explainable and ethically grounded AI, rigorous validation in operational conditions, and secure integration with existing health and safety systems. Ongoing challenges—such as data bias, privacy, and the need for human oversight—underscore that AI should function as an augmentative tool, reinforcing rather than replacing aeromedical expertise to safeguard aircrew health and mission performance.

Learning Objectives

1. The participant will be able to describe how artificial intelligence and machine learning are being applied to predict aeromedical risk and support clinical decision-making in aviation and spaceflight contexts.

2. The audience will learn about AI-driven tools for monitoring fatigue, cognitive performance, and other human factors that influence aircrew safety and aeromedical fitness.
3. The participant will be able to evaluate the emerging benefits and challenges of integrating AI-based monitoring and autonomous care systems into aeromedical and aerospace operational settings.

[94] BOUNDING ZERO EVENT RISK IN AEROMEDICAL SAFETY: APPLICATIONS OF THE RULE OF K

Stuart Mitchell[1], Anthony Tvaryanas[2]

[1]Aviation and Occupational Medicine Consulting, East Grinstead, United Kingdom; [2]N/A, Oklahoma City, Oklahoma, United States

(Original Research)

Introduction: Aeromedical safety assessments often rely on surveillance datasets in which no adverse outcomes are observed. While reassuring, zero-event observations do not imply zero risk, particularly for rare but high-consequence hazards such as pilot medical incapacitation or accidents associated with undisclosed medical conditions. Misinterpreting zero numerators can obscure latent system vulnerabilities. The Rule of K, derived from one-sided confidence interval theory, provides a conservative upper bound on the true event probability compatible with zero observed occurrences. This presentation demonstrates its application to bounding residual aeromedical risk. Methods: The Rule of K estimates an upper confidence limit for event probability as K/n, where n is the number of independent, event-free observations and K reflects the confidence level (K≈3 for 95%; K≈0.693 for 50%). Two applications were examined. First, medically related pilot incapacitation events reported to the UK Civil Aviation Authority (1990–2022) were analyzed, with no fatal accidents. Second, a modeled scenario evaluated latent, unmonitored risk from undisclosed depression among U.S. airline transport pilots by estimating cumulative latent exposure and applying the Rule of K to bound accident risk per flight hour. Results: Across 963 medically related in-flight incapacitation events with no fatal accidents, the 95% upper-confidence bound for an accident following incapacitation was ≤0.0031, with a 50% estimate of ≤0.0007. In the medical nondisclosure application, undisclosed depression represented a clinically silent cohort operating outside routine aeromedical surveillance. Using plausible assumptions for pilot population size, depression prevalence, nondisclosure rates, annual flight hours, and 15 years of event-free operations, the Rule of K yielded a conservative 95% upper-confidence accident risk of approximately;4.9×10^{-8} per flight hour, with a central estimate of;1.1×10^{-8}, representing the maximum plausible system-level risk attributable to flight hours accumulated by pilots with undisclosed depression. Discussion:;The Rule of K provides a transparent method for bounding aeromedical risk when adverse outcomes have not been observed. Applied to pilot incapacitation and undisclosed depression, it demonstrates how latent, unmonitored risk can persist despite reassuring safety records, supporting balanced risk communication and evidence-informed oversight.

Learning Objectives

1. Explain why zero observed adverse events do not imply zero aeromedical risk.

2. Apply the Rule of K to bound risk in aeromedical surveillance datasets with zero outcomes.

3. Interpret conservative versus central confidence bounds when communicating rare-event risk in aviation medicine.

[95] CHARACTERIZING EXHAUST EXPOSURE AROUND AEROMEDICAL EVACUATION AIRCRAFT DURING ENGINE-RUNNING GROUND OPERATIONS

Hoanvu Nguyen[1], Hayley Brawley[2], Andrew Branting[1], Cristina Muko[3], Edgar Hudson[4], William Wallace[5], Yazan Samara[5], Jeffrey Sweterlitsch[5], Craig Nowadly[2]

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(Original Research)

INTRODUCTION: Military personnel are routinely exposed to jet engine emissions containing combustion byproducts, particulate matter, and volatile organic compounds. Some tasks require maneuvering in proximity to running aircraft during engine running on/off (ERO) loading procedures. This study characterizes the composition of air contaminants present in typical work areas during ERO operations for aircraft commonly used in medical evacuation missions. **METHODS:** Air samples were collected at 50 m, 10 m, and inside aircraft with cargo bay doors open during ERO loading operations for the C-130H and C-17 (n=2 samples per position per aircraft). For the UH-60, samples were collected across flight, loading, and offloading events (n=2 per position). All sealed air canisters were analyzed via gas chromatography mass spectrometry using common air contaminant standards. All aircraft were operating on JP-8 fuel at the time of sample collection. **RESULTS:** 19 of the 123 analyzed compounds were detected across all collected air samples. All 19 appeared during C-130H operations, while 8 were detected around the C-17, and 5 around the UH-60. 5 contaminants were common to all three aircraft, with mean levels of acetone, carbon dioxide, carbon monoxide, and methanol highest near the C-130H, and acetaldehyde highest near the C-17. Additional detected compounds included several aldehydes, alcohols, and hydrocarbons such as 1,3-butadiene, acrolein, benzene, pentanal, propene, propionaldehyde, toluene, and trimethylsilanol. Ethanol, propene, and propionaldehyde appeared only near the fixed-wing aircraft, with higher values near the C-130H. Contaminant concentrations were broadly similar across sampling positions, although levels tended to be higher outside the aircraft than inside the cargo ramp. **DISCUSSION:** Sampling across the three aircraft identified a mix of combustion-related compounds, including species such as acetaldehyde that have been documented in earlier exhaust studies, as well as others like

1,3-butadiene, acrolein, and propionaldehyde that have not been well characterized in prior work. All measured combustion byproduct concentrations remained well below established occupational and emergency exposure limits. These data suggest that exposure to aircraft exhaust in the vicinity of running engines, including during ERO and similar operations, poses minimal health risk to personnel, particularly given the short duration of most tasks performed in these environments.

Learning Objectives

1. Recognize the common chemical contaminants in ambient air around operational jet engines for aircraft commonly used in medical evacuation.
2. Understand the toxicologic implications of exposures to various air contaminants in jet engine exhaust.
3. Appreciate differences in air contaminants found in aircraft exhaust between different aircraft.

[96] STUDY OF MORBIDITY PATTERNS AND DISABILITY TRENDS IN INDIAN CIVIL AVIATION PILOTS

Vijaya Vardhan Indluru

Indian Airforce, Delhi, India

(Original Research)

INTRODUCTION: The Indian civil aviation sector has witnessing remarkable growth over the past few decades, transforming into one of the fastest-growing aviation markets in the world. Along with this increase in civil pilot population proportionately. There were studies previously for the analysis of disabilities and morbidities of Indian civil pilot population. Recent morbidity patterns and disability trends analyzed in this study. **METHODOLOGY:** The data for this study was collected from medical assessment records of aircrew from 2020 to Jun 2025 from Medical Cell DGCA, India and analyzed. The source of data was hard copies of CA-35 and medical assessments in respect to permanent unfit cases, which were issued to pilots and ATCOs from Jan 2020 to Jun 2025. **RESULTS:** There were a total of 189 cases were made permanently unfit for flying due to medical reasons during this period. Majority of cases were due to deficiencies in the Ophthalmological system. (n=90, 47.61%) out of 189 were made permanently unfit due to Opthal system involvement. Lifestyle diseases like DM II (n=20, 10.58%) and cardiac diseases (n=16, 8.46%) are leading cause of morbidity in renewal cases. **DISCUSSION:** The overall morbidity cases are in decreasing trend on comparing with previous studies. But the disease patterns are similar with previous studies, most common cause of rejection in early medicals was Defective color perception, whereas during renewal cases most common cause was Type II Diabetes mellitus. A significant proportion of permanent unfitness cases are attributed to mental health disorders. **CONCLUSION:** Advancements in the medical field and improvements in national health standards have driven a significant decline in morbidity cases across Indian civil aviation, as shown by comparative analysis with prior data. There is a critical need to prioritize

psychological well-being within aviation medicine. It is imperative that the industry moves beyond physical health monitoring to implement more robust mental health support systems.

Keywords: Morbidity, Civil aviation, DGCA, Medical

Learning Objectives

1. The participants will able to understand morbidity patterns in Indian civil aviation.
2. The participants will able to understand importance of mental health in civil aviation.

Monday, 05/18/2026, 4:00 PM

Governor's 14

[S-15] SLIDE: MEDICINE RISK AND READINESS

Chair: Bethany Shivers

Co-Chair: Ferguson Scott

[97] U.S. ARMY FLIGHT SURGEON PROVIDER SHORTAGES

Sarah Snyder[1], Emily Hawker[2]

[1]U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, USA; [2]Medical Center of Excellence (MEDCoE), Fort Rucker, AL, USA

(Education - Program / Process Review)

BACKGROUND: A significant U.S. Army flight surgeon shortage exists in the aeromedical community at hospitals and clinics. Flight surgeon shortages pose an aeromedical risk by affecting the medical clearance process for U.S. Army aircrew. Flight physicals are electronically submitted at least annually on behalf of flight students, pilots, air traffic controllers, critical care flight paramedics, flight surgeons, aeromedical physician assistants, and aircrew to the Aeromedical Electronic Resource Office (AERO) at the U.S. Army Aeromedical Activity (USAAMA). All flight physicals are submitted by aeromedical providers for qualification (QI/QU) or disqualification (DQ). Only flight surgeons can approve and submit the aeromedical summaries (AMS) necessary for medically recommended waivers affiliated with a flight physical. A query of the Department of War AERO database was conducted to determine locations with the highest aeromedical workload for U.S. Army flight surgeons at Continental U.S. (CONUS) and Outside the Continental U.S. (OCONUS) hospitals and clinics. Data collected from the USAAMA Aeromedical Epidemiology Data Register highlighted medical centers with the highest flight physical encounter workload over three cumulative calendar years (CY), 2022 through 2024. **OVERVIEW:** U.S. Army pilots and aircrew require periodic medical clearance to complete their training and operational missions. The goals of the flight physical

workload query were to 1) collect and analyze data to determine which hospitals and clinics required the most flight surgeon support, and 2) determine the number of full-time equivalents (FTE) necessary to provide future aeromedical support to the facilities with the highest aeromedical workload. **DISCUSSION:** Identifying provider manpower gaps in aviation medicine clinics is essential to support the facilities with the most aeromedical demand. A total of 302 locations, 236 CONUS and 66 OCONUS, submitted flight physical encounters to the AERO database between CY22 and CY24. A total of 54,362 flight physical encounters, including long or short flight physicals and aeromedical summaries across all classes, were submitted to USAAMA for these three calendar years. Because a significant flight encounter workload excess exists to support the aeromedical community, at least 6 FTE flight surgeons should be distributed geographically across the highest aeromedical workload centers to reduce the manpower gap.

Learning Objectives

1. Identify the top 15 U.S. Army hospitals and aviation medical clinics that require the most aeromedical support to determine flight surgeon manpower gaps.
2. Determine the number of FTE flight surgeons required to support U.S. Army aviation medicine hospitals and clinics with the highest flight physical workload.
3. Educate the audience on the process of completing flight physicals at aviation medicine clinics via the AERO database for electronic transmission to USAAMA.

[98] CAVOK: LEVERAGING AEROSPACE MEDICINE BEST PRACTICES FOR TEACHING EMERGENCY MEDICINE OPERATIONS

Nick Tsipis

Virginia Tech Carilion School of Medicine, Roanoke, VA, USA

(Education - Program / Process Review)

BACKGROUND: Emergency Departments (EDs) are currently facing significant operational challenges due to overcrowding, resource constraints, and increasing patient complexity. Drawing on the advanced methodologies and best practices from aerospace medicine, there is a critical need for enhanced training curricula in Emergency Medicine (EM) to equip future leaders with the skills to navigate and manage these demanding environments effectively. Addressing these gaps now is crucial to ensure that EM graduates are prepared to deliver high-quality care in evolving clinical settings. **OVERVIEW:** The Virginia Tech Carilion Residency in Emergency Medicine (VTCEM) has developed an innovative Operational Leadership Curriculum aimed at bridging the existing gap in evidence-based operational training. This longitudinal curriculum leverages best practices from aerospace medicine and human performance to provide a comprehensive educational experience. Content is delivered by integrating best practices of aerospace/human performance into tiered, expanding spheres of operational contexts, from the level of the individual to the health system. The scalable SONAR

framework (See the patient, place Orders, create Note, And Review patients) leverages checklist principles for an individual provider's clinical operational flow. Evidence-based human performance literature is applied and integrated into didactic and simulation content related to resuscitation and team dynamics. Emergency Department-level operations content reflects principles of statistical modeling/data analysis, human factors, and organizational development perfected in the fields of aerospace and aerospace medicine. Residents learn the proven value of centralized operational command centers at the hospital and health-system level to optimize situational awareness and intra- and inter-facility patient and resource flow. By integrating simulation and didactic learning, the program addresses current and future needs, preparing EM professionals to lead in diverse operational contexts. **DISCUSSION:** The Operational Leadership Curriculum holds significant operational and clinical importance to equip EM professionals with the skills necessary for effective decision-making and leadership in high-pressure environments. This integration of aerospace best practices into EM training promises to set new standards for Emergency Medicine Operations, ensuring clinicians are well-prepared to face modern healthcare challenges.

Learning Objectives

1. Understand the Integration of Aerospace Best Practices in Emergency Medicine Training The audience will be able to identify key aerospace methodologies and their application in Emergency Medicine (EM) training, enhancing operational leadership skills to address complex clinical challenges in Emergency Departments.
2. Develop Competence in Using the SONAR Framework for Clinical Operational Flow Participants will acquire the ability to apply the SONAR framework, derived from aerospace principles, to improve decision-making and efficiency in clinical operations, thus optimizing patient care and resource management in high-pressure environments.
3. Evaluate the Impact of Centralized Operational Command Centers on Patient Flow and Situational Awareness Attendees will assess the benefits of centralized command centers, based on aerospace operational strategies, in enhancing situational awareness and intra-/inter-facility patient flow.

[99] RESEARCH PRIORITIES FOR ARMY AVIATION MEDICINE: A SURVEY OF COMBAT AVIATION BRIGADES

Thomas Summers

U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, USA

(Original Research)

INTRODUCTION: In an uncertain funding environment, it is critical that government aviation medicine research laboratories direct precious resources toward important capability gaps that are truly needed by aviation customers. In addition to "top-down" research priorities, important input can also be sought directly from operational aviators and aviation units. In 2025, we surveyed aviation leaders and commanders of U.S. Army Combat Aviation Brigades to

determine current operational aviation research priorities. **METHODS:** An online survey was created and hosted on the U.S. Army Aeromedical Research Laboratory website, consisting of one open-ended question asking for respondents' top aviation medicine research priorities. Potential respondents were notified by email. **RESULTS:** There were 42 responses to the survey. After 2 levels of response grouping, 6 research priority areas emerged: Aircraft seating comfort and crash protection (25 comments), helmets and head-supported mass problems (15), aviation medicine clinical issues (6), hearing protection (4), life support equipment (3), and enroute casualty care (3). **DISCUSSION:** Responses from operational aviation units provide important drivers for aviation medicine research program managers and researchers. Top areas of concern included aircraft seating and helmets—issues that are increasingly important in future conflicts involving longer flights, due to still-prevalent neck/back pain problems in rotary-wing aviation. Input from aviation medicine research stakeholders helps ensure that research is correctly aligned to operational needs.

Learning Objectives

1. Identify top U.S. Army aviation medicine gaps and priorities for use in planning and proposing applied aeromedical research.
2. Highlight factors leading to high priority aviation medicine research gaps.
3. Identify differences in aviation medicine research priorities for rotary-wing aviation compared to fixed-wing military aviation.

[100] WITHDRAWN

[101] CADMIUM EXPOSURE IN AIRCRAFT MAINTENANCE WORKERS - THE IMPORTANCE OF LIFESTYLE ASSESSMENT IN BIOMONITORING INTERPRETATION: A POSTER PRESENTATION

Coty Winn

USAFSAM, Beavercreek, OH, USA

(Education - Case Study)

INTRODUCTION: Cadmium is a toxic heavy metal regulated in industrial settings due to its association with renal dysfunction, pulmonary disease, and long-term bioaccumulation. Occupational health programs routinely monitor workers in high-risk environments; however, misattribution of exposure sources can lead to unnecessary operational disruption and significant financial impact. **BACKGROUND:** Three aircraft corrosion-control and painting personnel presented with elevated serum cadmium levels during routine surveillance. Despite strict adherence to personal protective equipment and no identifiable workplace breaches, operations were halted across multiple shops pending investigation. Elevated cadmium was ultimately traced to a shared non-occupational source, regular smoking of a particular brand of cigarettes,

which contain high cadmium levels. Biomarker reduction after smoking cessation reinforced the exposure source. **CASE PRESENTATION:** Three male aircraft maintenance workers in corrosion-control and paint operations were identified with elevated serum cadmium levels (>5 µg/L). All denied occupational protocol breaches, environmental risk factors, or dietary contributors, but all reported smoking the same brand of cigarettes. Case A (59 y/o): ⅓ pack/day; repeat level decreased with continued monitoring. Case B (50 y/o): ~1 pack/day; significant decline after smoking reduction. Case C (50 y/o): ½ pack/day; slight decline without behavior change. Routine labs and imaging were normal, and no renal dysfunction was found. Operations had been suspended prior to occupational medicine consultation. **DISCUSSION:** This case series demonstrates the risk of attributing elevated biomarkers solely to occupational exposure without comprehensive evaluation. Lifestyle factors, particularly tobacco use, can meaningfully contribute to biomonitoring results and must be considered prior to operational decisions. In this instance, premature shutdown of industrial processes resulted inavoidable mission and financial impacts. Occupational medicine involvement early in the decision chain prevents costly missteps and maintains mission readiness.

Learning Objectives

1. Identify Non-Occupational Sources of Heavy Metal Exposure: Recognize tobacco products as a significant cadmium exposure source in surveillance programs.
2. Apply Root-Cause Analysis in Exposure Investigation: Describe a systematic approach to evaluating elevated biomarker results, including history, occupational review, and lifestyle assessment.
3. Understand Operational Risk from Premature Industrial Shutdowns: Explain how delays in occupational medicine consultation may cause avoidable mission disruption and financial loss.

[102] MODERNIZATION: INTEGRATING AUTOMATION, POLICY, AND CLINICAL WORKFLOW IN AEROMEDICAL DECISION-MAKING

Barrett Campbell, Scott Salmon

U.S. Army Aeromedical Activity, Fort Rucker, AL, USA

(Education - Program / Process Review)

BACKGROUND: Aeromedical decision-making increasingly depends on timely synthesis of clinical data, regulatory policy, and operational risk. Across military and civilian aviation medicine enterprises, aeromedical practitioners often expend substantial effort locating, reconciling, and interpreting fragmented records before meaningful risk assessment can occur. This search-intensive workflow constrains consistency, traceability, and scalability at a time when aviation operations face growing complexity, evolving medical standards, and increasing expectations for transparency. Addressing these challenges requires rethinking how clinical records, policy derivation, and practitioner workflows; support aeromedical judgment.

OVERVIEW: This presentation describes a modernization effort that integrates automated record linkage, evidence-informed policy derivation, and workflow realignment to support aeromedical decision-making. Programmatic; linkage of; clinical records to aeromedical review processes; reduces manual retrieval and reconciliation. Policy logic is mutable and maintained using a centralized, structured data repository that supports consistent interpretation of aeromedical standards across conditions and contexts. Concurrently, the flight surgeon workflow is reoriented from searching and assembling information toward structured assessment, judgment, and risk communication. Rather than a single monolithic program, this effort represents an integrated set of aligned processes, each tailored to its function but designed to operate cohesively within a unified aeromedical decision framework. **DISCUSSION:** Operationally and clinically, this integrated process enhances decision-making consistency, improves timeliness, and strengthens the traceability of aeromedical recommendations. By shifting effort from record discovery to risk assessment, the framework better supports clinical reasoning, commander advisory roles, and defensible waiver determinations. Conceptually, the approach advances aeromedicine by demonstrating how automation and structured policy logic can augment professional judgment. Although developed within a specific organizational context, the principles are broadly applicable across Services, civil aviation authorities, and international aeromedical systems. The framework offers a basis for collaborative dialogue on predictive policy realignment and future-ready aeromedical processes that align clinical practice with evolving operational demands.

Learning Objectives

1. The participant will be able to explain how automated record linkage and structured policy logic can reduce search-intensive aeromedical workflows and support consistent, timely risk assessment and waiver decision-making.
2. The audience will learn about an integrated approach to aligning clinical records, policy derivation, and flight surgeon workflow to improve traceability, transparency, and operational relevance in aeromedical decisions.
3. The participant will be able to discuss how workflow realignment toward assessment and risk communication can enhance professional judgment while supporting scalable, defensible aeromedical practices across diverse aviation enterprises.

[302] AEROMEDICAL ASSESSMENT AFTER AORTIC VALVE REPLACEMENT IN AN AGRICULTURAL PILOT: A CASE REPORT

Maria Angelita Salamanca, Luis Felipe Arteaga

Civil Aviation Authority of Colombia, AeroCivil, Bogota, Colombia

(Education - Case Study)

INTRODUCTION: Cardiovascular surgery in pilots presents unique aeromedical challenges, particularly in high-demand operations such as agricultural aviation. This case report describes

the certification process for an agricultural pilot following a Bentall procedure, which includes aortic valve and ascending aorta replacement with coronary artery reimplantation. **BACKGROUND:** Aeromedical decision-making for agricultural pilots who have experienced a cardiovascular condition, must consider not only the pilot's medical condition after treatment and prognosis based on current scientific evidence, but also unique operational demands—such as aerobatic maneuvers, short-duration flights – and ;;other conditions such as flying over sparsely populated areas, to ensure an appropriate balance between regulatory flexibility and flight safety. **CASE PRESENTATION:** A 65-year-old agricultural pilot with a history of hypertension, dyslipidemia, and bicuspid aortic valve disease experienced a hypertensive angina crisis in October 2024. Diagnostic evaluation revealed severe aortic stenosis and dilation of the aortic root and ascending aorta. The patient underwent a Bentall procedure with a bioprosthetic valve. Postoperative recovery was uneventful, and cardiopulmonary rehabilitation was completed successfully. Follow-up assessments in 2025—including echocardiography (LVEF 76%), stress testing, 24-hour Holter monitoring, and ambulatory blood pressure monitoring—showed normal results without ischemia or arrhythmias. **DISCUSSION:** The Bentall procedure offers favorable long-term survival, with five- and ten-year rates of 93% and 89%, respectively. ICAO guidelines recommend a six-month observation period post-valve surgery before considering return to flight for asymptomatic individuals with normal hemodynamic and functional outcomes. Applying the "1% rule" for annual risk of sudden incapacitation, and considering the pilot's optimal functional status and absence of complications, the adjusted risk was deemed acceptable for single-seat agricultural operations. Operational factors such as brief G-force peaks (+3.2 G) were evaluated and found not to compromise hemodynamic stability. Risk mitigation included semi-annual cardiology follow-up and lifestyle adherence.

Learning Objectives

1. The audience will be able to evaluate a pilot after complex cardiovascular surgery under current scientific and technological advances, to return to operation under strict medical control and regulatory flexibility, provided that their functional status and risk profile meet aeromedical standards.
2. The audience will be able to analyze aeromedical decision-making for agricultural pilots by integrating post-treatment medical status and the specific operational demands of agricultural aviation (such as aerobatic maneuvers, short-duration flights, and operations in sparsely populated areas) to achieve an optimal balance between regulatory flexibility and flight safety.

Monday, 05/18/2026, 4:00 PM

Governor's Hallway

[S-16] INTERACTIVE PRESENTATION: MEDICINE AT THE EDGE

Chair: Carlos Navarro

Co-Chairs: Mauricio Galizia, Laura A. Cerbone

[103] WITHDRAWN

[104] FEASIBILITY OF OPERATIONAL SURVEY AND BLOOD SAMPLE COLLECTION TO EVALUATE POTENTIAL CARCINOGENIC EXPOSURES DURING CARRIER QUALIFICATION

Karl Kuersteiner[1], Michelle Harriman[2], Jacob Ross[2], Erin Hansen[2], Sara Robinson[2], Michelle Lane[3], Karl Kuersteiner[1], Jeffrey Rice[4], Bruce Waterman[5], John Steely[6], Diego Vicente[2]

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(Original Research)

INTRODUCTION: U.S. military service members experience higher cancer incidence rates than the general population, potentially linked to occupational exposures. Few studies have incorporated operationally embedded biological sampling to characterize carcinogenic exposures within shipboard environments. This feasibility study evaluated the logistical and operational viability of concurrent survey and biospecimen collection aboard a U.S. Navy aircraft carrier during carrier qualification (CQ) operations. **METHODS:** Over a 10-day embarked period, 50 Navy sailors participated in the Monitoring Analysis and Research in Nautical Environmental Risks (MARINER) study during CQ operations. Departmental location data, exposure-related surveys, and capillary blood samples were collected at four time points: within 24 hours of boarding and prior to the first shift (T0), after a work shift (T1), after a subsequent work shift (T2), and within 24 hours before ship egress (T3). Capillary dried blood spot samples were obtained using the Tasso T20 device and linked to survey data collected via offline electronic forms. Participants were stratified into higher-risk exposure groups (e.g., Engineering, Aviation Maintenance) and lower-risk groups (e.g., Medical, Admin). Under the Project for Military Exposures and Toxin History Evaluation in U.S. Service Members research network, biospecimens were transferred to the Murtha Cancer Center Research Program Biobank and the Data Tracking System (DTS) at Windber Research Institute under established regulatory agreements. **RESULTS:** Of the 50 enrolled sailors, five did not complete T0 sampling and were replaced. Complete blood sets were obtained at T0 and T2, with 48 collected at T1 (two missed due to watch schedule conflicts) and 49 collected at T3 (one participant off ship). Ninety-one percent of initial device collection attempts were successful, with 18 subjects requiring repeat application. Participants were evenly distributed between higher- (n=23) and lower- (n=27) risk groups. Overall, 99% of planned data and biospecimen collection was successfully completed, with optimal sample integrity and data security. **DISCUSSION:** This study demonstrates the feasibility of multi-time point biospecimen and survey collection aboard a Navy vessel during

CQ. The findings establish a framework for larger-scale shipboard projects combining exposure surveys and future biomarker analyses to identify potential carcinogenic risks in naval environments.

Learning Objectives

1. Understand the Feasibility of Operationally Integrated Biospecimen Collection Learners will be able to describe the logistical and operational challenges and solutions involved in conducting multi-time point biospecimen and survey collection aboard a U.S. Navy aircraft carrier during carrier qualification operations.
2. Identify Exposure Risks and Research Frameworks in Naval Environments Learners will be able to explain the significance of exposure-related surveys and biomarker analyses in identifying potential carcinogenic risks among U.S. military service members, as demonstrated by the MARINER study.

[105] DEVELOPING A MEDICAL CENTER-AIRLINE PARTNERSHIP MODEL FOR AIR AMBULANCE SERVICES

Wan Lin Chen

Taipei Medical University Shuang Ho Hospital, New Taipei City, Taiwan (Greater China)

(Education - Program / Process Review)

BACKGROUND: Air ambulance services require sophisticated integration of clinical care capabilities with aviation operational expertise. Traditional models typically involve established air medical transport operators with dedicated medical teams. However, academic medical centers with advanced critical care and telemedicine infrastructure often lack aviation medicine expertise, while newly established airlines possess operational capabilities but limited medical program development experience. This capability gap presents both challenges and opportunities for innovative partnership models that can expand access to air medical services in underserved markets. **OVERVIEW:** We describe the systematic development of a partnership framework between a tertiary medical center and a newly founded airlines to establish comprehensive air ambulance services. The medical center's telemedicine team, despite extensive critical care expertise, had no prior air medical transport experience. Over a structured multi-week collaboration period, we conducted capability gap analysis, defined complementary strengths, and developed an integrated operational model. Key development phases included: (1) assessment of medical center capabilities in critical care, telemedicine infrastructure, and clinical protocols; (2) evaluation of airline operational capacity, safety standards, and regulatory compliance; (3) identification of market needs and service delivery gaps; (4) creation of clinical-operational interface protocols; and (5) establishment of governance structures ensuring medical oversight and aviation safety integration. **DISCUSSION:** This partnership model addresses critical gaps in air medical service delivery by combining academic medical expertise with aviation operational capabilities. Key success factors include strong aviation medicine leadership to bridge clinical and operational domains, structured gap analysis methodology, and clear

delineation of responsibilities across medical and aviation spheres. This scalable model offers a blueprint for similar partnerships, potentially expanding air ambulance access in regions lacking established services. Future evaluation will focus on operational metrics, clinical outcomes, and sustainability of this innovative collaboration framework.

Learning Objectives

1. The participant will be able to (1) identify capability gaps and complementary strengths in medical center-airline partnerships.
2. (2) describe the systematic framework for integrating clinical expertise with aviation operations.
3. (3) apply this model to expand air ambulance services in their regions.

[106] WITHDRAWN

[107] INTERPLANETARY HEART HEALTH AS THE STANDARD, NOT THE EXCEPTION

Fariba Yazdanpanah

The University of Texas at Tyler, Tyler, TX, USA

(Education - Tutorial / Review)

INTRODUCTION: Cardiovascular health is a major concern in space medicine because microgravity, oxidative stress, circadian disruption, sympathetic hyperactivity, and cosmic radiation impair cardiac output, vascular integrity, and endothelial function. Yet no "Update Review" has integrated multidomain cardiovascular preventive strategies through advanced biomedical and lifestyle interventions in long-duration spaceflights or evaluated the adoption of such interventions using Rogers's Diffusion of Innovations (DOI) model. Current studies mainly emphasized reactive countermeasures rather than proactive prevention methods; therefore, there is still a gap in understanding how spaceflight stakeholders might adopt innovative approaches to protect cardiovascular health on long-duration space missions. **TOPIC:** This Update Review proposes an integrated, multidomain framework for cardiovascular protection in an extraterrestrial environment, incorporating lifestyle strategies of structured exercise, chrono-nutrition, optimized sleep, and antioxidant-rich diets with complementary biomedical approaches comprising the use of radiation-protective agents (e.g., melatonin, tempol), AI-assisted wearable diagnostics, mitochondrial-targeted therapies (e.g., elamipretide, NAD^+ boosters), and regenerative technologies such as CRISPR-Cas9 gene modulation, nanotechnology-enhanced stem cell therapy, and gene reprogramming. Given the pace of ongoing technological innovation, rapid translation from initial discovery to operational use is crucial to maintaining cardiovascular resilience during long-duration spaceflights. In line with Rogers's DOI model, the adoption of regenerative and AI-driven strategies will likely be advanced by innovators/early adopters; however, later adopters tend to favor established, low-risk interventions. **APPLICATION:** Building on previous studies, this review shifts the field from reactive countermeasures to a

proactive, innovation-driven model that requires diffusion from early adopters to widespread use, highlights the importance of collaboration between medical teams and space agencies, and proposes that early adoption of advanced regenerative biomedicine technologies by space agencies during the pre-exploration stage of targets (e.g., the Moon or Mars) will strengthen the foundation for predictive and preventive cardiovascular risk management, supporting human adaptation, resilience, and survival in interplanetary environments.

Learning Objectives

1. The participant will gain insight into the principal cardiovascular risk associated with long-duration spaceflight.
2. The audience will develop un understanding of how spaceflight stakeholders, together with clinical and operational health professionals, identify and implement advanced cardiovascular prevention technologies and practices to support the cardiovascular health of space crews in the pre-conquest phases of Moon and Mars missions.
3. The audience will learn about the value of applying the Diffusion of Innovation (DOI)-based framework to guide the strategic adoption of cardiovascular protective innovations, as well as the critical role of targeted communication with late adopters and laggards in improving the effectiveness of cardiovascular health prevention efforts in the aerospace healthcare context.

[108] POSTPARTUM RECOVERY AND PERFORMANCE IN WOMEN FOLLOWING SPACEFLIGHT: CURRENT EVIDENCE AND FUTURE DIRECTIONS

Nidhi Kakkar

Stockport NHS Foundation Trust, Stockport, United Kingdom

(Education - Tutorial / Review)

INTRODUCTION: As more women participate in long-duration space missions, understanding how spaceflight-induced physiological adaptations interact with postpartum recovery has become increasingly relevant. This tutorial will review the current evidence on how microgravity, radiation exposure, and operational stressors affect systems critical to postpartum health—including the musculoskeletal, cardiovascular, endocrine, and psychological domains. The session will provide an integrated overview of what is known, identify knowledge gaps, and outline research priorities for supporting safe and effective mission readiness in postpartum female astronauts. **TOPIC:** Spaceflight causes multisystem deconditioning that overlaps significantly with postpartum physiological demands. Microgravity induces muscle atrophy, bone loss, and cardiovascular remodeling—changes that parallel postpartum remodeling on Earth. Additionally, spaceflight-related endocrine disruption, particularly suppression of the hypothalamic–pituitary–gonadal axis, may influence lactation, menstrual resumption, and fertility. Psychologically, both environments challenge sleep, mood, and cognitive performance. Although no direct studies have examined postpartum women post-spaceflight, terrestrial

analogs (bed rest, immobilization, circadian disruption) suggest additive risks for delayed rehabilitation, reduced performance, and increased fatigue. This review synthesizes data from aerospace medicine, obstetrics, and rehabilitation sciences to describe the potential mechanisms and risks influencing postpartum recovery in women following spaceflight. **APPLICATION:** Understanding postpartum recovery in the context of prior spaceflight is critical for mission planning, medical policy, and occupational health. This tutorial will present practical guidance for aerospace medicine practitioners and mission planners, including recommendations for timing of post-flight pregnancies, rehabilitation protocols, hormonal and musculoskeletal monitoring, and psychosocial support strategies. Proposed research directions include longitudinal astronaut health surveillance, ground analog studies combining microgravity and postpartum physiology, and standardized readiness metrics. These approaches will help establish evidence-based guidelines to ensure safe return-to-flight and optimize performance for postpartum female astronauts in future lunar and Mars missions.

Learning Objectives

1. Describe the physiological adaptations to microgravity that may influence postpartum recovery in female astronauts, including musculoskeletal, cardiovascular, endocrine, and psychological factors.
2. Discuss the current evidence gaps and research priorities regarding the intersection of spaceflight physiology and postpartum health, including implications for mission readiness and astronaut performance.
3. Identify evidence-based strategies and operational considerations for supporting safe postpartum recovery and return-to-flight readiness in women following space missions.

[109] NURSING ROLES IN TELEMEDICINE TRIAGE FOR SPACEFLIGHT ANALOGS: PREPARING NURSES FOR REMOTE DECISION-MAKING

Christine Rincon

The Space Nurse, LLC, Royal Palm Beach, FL, USA

(Education - Tutorial / Review)

INTRODUCTION: Telemedicine is crucial for long-duration spaceflight and analog missions, yet nurses are not currently integrated into these areas. This tutorial will explore how nurses could apply their clinical, physiological, and communication assessment skills to remote triage scenarios. Students will learn a framework for evaluating symptom reports, vital signs, and dialogue patterns that may indicate escalation risk, drawing on evidence from telemedicine in extreme environments and astronaut healthcare. **TOPIC:** Nurses are skilled in synthesizing symptom reports, vitals, and communication cues, and can guide triage in isolated or extreme settings. This tutorial presents a conceptual framework linking these factors to escalation decisions, based on literature demonstrating telemedicine effectiveness in analog missions (Doarn et al., 2003), nurse-led remote monitoring (Schultz, 2023), and astronaut health

frameworks (Rivera et al., 2024; Urlings et al., 2024). Visual flowcharts will illustrate predictive thinking strategies for triage, highlighting how nursing judgment can enhance operational safety in future missions. **APPLICATION:** This tutorial will inform training programs to prepare nurses for remote triage in aerospace medicine. By recognizing which clinical features, communication patterns, and physiological signals indicate high-complexity cases, nurses can improve early detection of clinical risk, guide escalation, and optimize telemedicine interactions. The framework applies to analog missions, long-duration spaceflight, and other remote healthcare settings where telemedicine is critical. Attendees will gain actionable strategies for nurse training and operational readiness.

Learning Objectives

1. The participant will be able to describe how nurses can use clinical features, physiological signals, and communication patterns to guide remote triage and escalation decisions in spaceflight analog missions.
2. The audience will learn about a conceptual framework for nurse-led telemedicine, including identifying high-complexity cases and applying predictive thinking strategies in isolated and extreme environments.
3. The participant will learn how evidence from telemedicine and remote monitoring can inform nurse training and operational readiness for triage in analog and remote healthcare environments.

[110] BONE MINERAL DENSITY MEASUREMENT IN SPACE: CURRENT PORTABLE IMAGING CAPABILITIES AND AREAS OF FOCUS

Daniel Harwood[1], Moriah Thompson[2], Justin Yang[3]

[1]Cooper University Health Care, Philadelphia, PA, USA; [2]NASA, Houston, TX, USA; [3]Aegis Aerospace, Houston, TX, USA

(Education - Tutorial / Review)

INTRODUCTION: Bone loss is a significant concern for astronaut health and human systems risk management in space, with estimated losses in bone mineral density (BMD) of 1-1.5% per month in microgravity. Risk of fragility-related fractures at load-bearing sites such as the lumbar spine and proximal femur must be considered for proposed years-long missions, such as a three-year Mars journey. Currently, BMD is monitored via Dual X-Ray Absorptiometry (DXA) scans performed pre- and post-flight, but there is no procedure for evaluating BMD in-flight. When planning for increasingly long-duration spaceflight, the ability to monitor BMD in-flight would provide valuable information regarding astronaut bone health and fracture risk during missions. The objective of this project was to identify and evaluate currently available technology for performing portable BMD measurements, and provide recommendations for possible future investigation. **TOPIC:** Alternative imaging modalities for measuring BMD – as well as their respective accuracy, strengths, and weaknesses – were identified via literature review and

interviews with subject matter experts. There are currently three potential methods for evaluating bone density in-flight: 1) Dual Energy Subtraction (DES) radiography using a triple-layer flat panel detector; 2) Artificial intelligence analysis of traditional X-rays; and 3) Radiofrequency Echographic Multi Spectrometry (REMS). Recent DES radiography data has demonstrated 96% correlation with gold-standard DXA scans, whereas FDA-approved AI tools have shown only 62.8% sensitivity for identifying low BMD. REMS, which is an ultrasound-based technique, has demonstrated BMD measurement correlation coefficients of r=0.94 with DXA.
APPLICATION: The incorporation of BMD measurement as a functionality of existing imaging technologies may factor into trade-space analysis regarding which portable imaging modalities to include on a Mars mission. Based on available data and discussions with subject matter experts, DES radiography and REMS appear to be the most promising techniques in terms of accuracy and versatility. Both methods have limitations however – DES radiography does not yet have FDA approval for BMD measurement, and REMS has yet to be tested in-flight. Further investigation, including additional in-flight testing of both DES radiography and REMS, will be necessary to confidently use these portable methods as surrogates for DXA while in space.

Learning Objectives

1. The participant will learn about three methods for determining Bone Mineral Density in space which are currently being researched and are under development.
2. The participant will be able to understand the challenges of measuring Bone Mineral Density in space, and how portable X-ray and ultrasound technologies address these challenges.
3. The participant will learn about the relative accuracy of the three potential methods for Bone Mineral Density measurement in spaceflight.

[111] SPACE TRAVEL–ASSOCIATED ANAEMIA: CURRENT UNDERSTANDING AND IMPLICATIONS FOR HUMAN SPACEFLIGHT

Nidhi Kakkar

Stockport NHS Foundation Trust, Stockport, Manchester, United Kingdom

(Education - Tutorial / Review)

INTRODUCTION: Space travel–associated anaemia is a reproducible physiological adaptation observed during and after exposure to microgravity and is now recognized as a true reduction in circulating red blood cell mass rather than a transient plasma volume effect. This poster summarizes current understanding of space travel–associated anaemia, including underlying mechanisms, temporal characteristics, individual variability, operational consequences, and emerging countermeasures relevant to aerospace medicine and human performance. **TOPIC:** Advances in investigative techniques, including carbon monoxide rebreathing and biomarkers of heme metabolism, have demonstrated increased hemolysis early in spaceflight followed by sustained suppression of erythropoiesis. Contributing mechanisms include altered erythropoietin

signaling, skeletal unloading in microgravity, dysregulation of iron metabolism, radiation exposure, inflammation, and nutritional constraints. Evidence from International Space Station missions and terrestrial analogues such as head-down bed rest and immobilization models has refined understanding of anaemia onset, persistence, and recovery, with severity influenced by mission duration, sex, exercise load, and pre-flight iron status. **APPLICATION:** Space travel–associated anaemia has direct operational relevance due to its potential effects on aerobic capacity, fatigue, physical performance, and risk of orthostatic intolerance during re-entry and post-flight rehabilitation. These risks are amplified for exploration-class missions beyond low Earth orbit, where medical resources are limited and physical task demands are high. This poster reviews current and proposed mitigation strategies, including optimized in-flight exercise prescriptions, nutritional and iron management, routine hematologic monitoring, and potential pharmacologic support of erythropoiesis. Parallels with unloading-related and critical illness–associated anaemia on Earth are highlighted to support translational application across aerospace medicine, occupational health, and human performance optimization. **RESOURCES:** Additional information is available through peer-reviewed publications from International Space Station investigations, NASA Human Research Program reports, and contemporary reviews in aerospace medicine and physiology journals.

Learning Objectives

1. The participant will be able to describe the mechanisms, time course, and individual variability of space travel–associated anaemia during and after exposure to microgravity.
2. The participant will be able to explain the operational and human performance implications of space travel–associated anaemia for current and future human spaceflight missions.
3. The participant will be able to identify current and emerging countermeasures used to monitor, prevent, and mitigate space travel–associated anaemia in aerospace medicine practice.

[112] EXPLORING INDIVIDUAL SUSCEPTIBILITY TO DECOMPRESSION SICKNESS DURING EVA: A PERSONALISED MEDICINE APPROACH

Jessica Gamble[1], Bonnie Posselt[2], Peter D. Hodkinson[3], Thomas G. Smith[4], Richard S. Whittle[5]

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(Education - Tutorial / Review)

INTRODUCTION: Decompression sickness (DCS) arises from nitrogen gas bubble formation following decreases in ambient pressure and remains a significant hazard during extravehicular activity (EVA). Current mitigations address the “big four” factors (altitude, duration, workload, and prebreathe), as well as work on exploration atmospheres, to reduce population-level DCS

risk. However, most DCS risk estimates derive from US Air Force or government spaceflight studies conducted predominantly on healthy, young, white males. Individual susceptibility varies widely and is not captured by current risk prediction models, potentially placing some individuals at elevated risk while unnecessarily constraining others. With future lunar missions involving longer, more physically demanding EVAs undertaken by a small but increasingly diverse astronaut cohort, personalised decompression models could enhance safety and operational efficiency. **TOPIC:** Anatomical, physiological, and behavioural factors influence DCS susceptibility. Age-related increases in venous gas emboli (VGE) have been observed in hypobaric studies, possibly reflecting changes in vascular compliance and endothelial function. Body composition alters nitrogen kinetics, prolonging off-gassing in individuals with higher adiposity. Anatomical right-to-left shunts, particularly patent foramen ovale, are associated with increased risk of serious DCS. Physical exertion before or during decompression modulates VGE formation and DCS risk, while dehydration slows nitrogen elimination. Menstrual phases may affect susceptibility in women, although evidence remains mixed. Altered-gravity environments modify vascular loading and tissue gas kinetics, potentially shifting susceptibility during EVA. Biomarker studies demonstrate post-exposure inflammatory responses, and proteomic analyses suggest complex physiological effects beyond bubble formation. **APPLICATION:** Individualised DCS risk models and digital twins could support a personalised medicine framework for EVA planning. Tailoring prebreathe duration, exercise prescriptions, and recovery intervals to individual susceptibility could optimise EVA productivity while protecting higher-risk crew members. Wearable monitoring technologies may enable real-time assessment of exertion, hydration, and decompression strain for dynamic risk assessment. Such approaches may also translate to aviation and diving, although broader evidence from more diverse populations is required.

Learning Objectives

1. Explore anatomical, physiological, and behavioural factors influencing Decompression Sickness susceptibility.
2. Understand how these factors could inform a personalised medicine approach to Decompression Sickness risk management.
3. Recognise the potential of optimising decompression protocols to improve the efficiency and safety of lunar Extravehicular Activity.

[113] EVALUATION OF NOVEL 3D PRINTED SURGICAL TOOLS FOR LONG TERM SPACE MISSIONS

Ezra Myerson, Ezra Myerson, Sara Rothrock, Peter Lee

Brown University, Providence, RI, USA

(Original Research)

INTRODUCTION: Future prolonged human missions to the moon and Mars will increase the risk of medical events and may jeopardize astronaut lives and the success of future exploration

class missions. Volume and mass restrictions will limit the number and type of surgical instruments and equipment available. On demand additive manufacturing (3D printing) using multi-purpose renewable or recyclable material alongside innovative tool designs may help mitigate the lack of necessary surgical instruments. In this project, we evaluated novel designs for surgical tools made with recyclable plastics such as polylactic acid (PLA) and compared them to standard stainless steel instruments. **METHODS:** Pig feet were used to qualitatively compare the effectiveness of steel versus 3D printed PLA scalpel handles, needle holders, forceps, right-angle clamps, and retractors – basic instruments necessary for a simple open abdominal procedure such as an open appendectomy. Incisions were made in four pig feet, held open, and sutured using standard and 3D printed instruments to simulate the basic functions of each instrument as they would perform in a real surgery setting. All 3D printed instruments were created in Onshape and Solidworks. **RESULTS:** All 3D printed instruments were successfully used to perform the same basic tasks as their steel counterparts with minimal increase in difficulty and duration of use. From the selected tools for this experiment, stress whitening was observed for the scalpel handle and retractor locking mechanism and significant wear and tear with a noticeable effect on performance was observed for the needle holder jaws. **DISCUSSION:** The success of the PLA 3D printed instruments in the pig feet model demonstrates the potential application of 3D printed instruments in austere environments where the availability of surgical instruments are limited. Potential applications extend beyond spaceflight and include use in developing countries, wilderness medicine, forward operating medical sites, and remote or rural communities. More robust designs, expanding the type of instruments, and sterilization are next key areas for future research along with mechanical testing and experimenting with alternative filaments simulating processed materials available on the moon or mars. Validation surgeries on cadavers and animal models are key steps prior to practical human applications.

Learning Objectives

1. The audience will understand the potential success of using 3D printed surgical tools for surgeries in austere environments.
2. The audience will understand what improvements need to be made to further validate 3D printed tools as an alternative to stainless steel ones.

[114] MITIGATION AND MANAGEMENT OF ACUTE APPENDICITIS FOR LONG-DURATION SPACEFLIGHT: A SCOPING REVIEW

Saahil Golia[1], Micheal Kortz[2], Kaleigh Stabenau[3]

[1]Virginia Commonwealth University, Richmond, VA, USA; [2]University of San Diego, San Diego, CA, USA; [3]SpaceX, Los Angeles, CA, USA

(Original Research)

INTRODUCTION: Acute appendicitis poses a significant medical risk during long-duration spaceflight particularly for planned missions to the Moon and Mars. While appendectomy is the definitive treatment on Earth, microgravity, limited resources, communication delays, and restricted surgical expertise complicate operative care for these missions. Nonoperative management with antibiotics offers an alternative but carries risks of failure and recurrence. This scoping review evaluates terrestrial data to identify the breakpoint at which surgical management of uncomplicated acute appendicitis becomes more resource-efficient than medical management in long-duration spaceflight. **METHODS:** A systematic scoping review was conducted using the PubMed/NLM database with predefined keywords resulting in 76 studies meeting inclusion criteria. Extracted data included treatment success, failure and recurrence rates, complication rates, training requirements, spatial constraints, and estimated mass and resource demands relevant to spaceflight operations. **RESULTS:** In the adult population, annual incidence of acute appendicitis is estimated at 1.8–3.7 cases per 1,000. Medical management demonstrated initial success rates of 63–95% but acute failure rates of 5–27.3%, 1-year recurrence rates of 12.6–38%, and 5-year recurrence rates of 24–40%. Recurrent disease progressed to complicated appendicitis in up to 30% of cases. In contrast, laparoscopic appendectomy eliminated recurrence and demonstrated low complication rates of 0.8–3.02% for uncomplicated cases. **DISCUSSION:** Nonoperative management is feasible for shorter missions due to lower initial mass, training, and equipment requirements. However, as mission duration increases, recurrence risk and cumulative medical resource demands favor surgical capability despite higher upfront investment. Resource modeling suggests that for missions exceeding approximately 1.5 years, cumulative recurrence and resupply demands render medical management less resource-efficient than a single upfront surgical capability. These findings support mission duration medical planning and highlight the need for further research into surgical performance and crew training in spaceflight.

Learning Objectives

1. Compare the risks, recurrence rates, and resource demands of medical versus surgical management of uncomplicated acute appendicitis during long-duration spaceflight.
2. Identify the breakpoint at which surgical management of uncomplicated acute appendicitis becomes more resource-efficient than medical management in long-duration spaceflight.

[115] WITHDRAWN

[116] PIEZO1 AGONISM AS AN ADDITIONAL COUNTERMEASURE FOR SPACE BONE LOSS AND POTENTIAL MULTISYSTEM PROTECTION

Aki Takanami

Self-funded, Caen, France

(Education - Tutorial / Review)

INTRODUCTION: As lunar and Martian missions demand integrated countermeasures against multi-system microgravity deconditioning, long-duration spaceflight causes rapid bone loss, lower-limb muscle atrophy, and cardiovascular deconditioning. Current countermeasures remain only partially effective. For example, advanced resistive exercise combined with bisphosphonates preserves a substantial fraction of trabecular bone mineral density yet fails to fully prevent cortical and hip bone losses. Even non-weight-bearing bones, show density reduction, reflecting impaired osteoblast function, increased osteocyte apoptosis, and persistently elevated osteoclastic resorption. Artificial gravity would be ideal but is technically prohibitive, underscoring the need for pharmacological strategies that complement mechanical loading and help restore formation–resorption balance. **TOPIC:** Piezo1, a ubiquitously expressed mechanosensitive ion channel, is downregulated under simulated microgravity such as unloading or clinorotation, leading to impaired maintenance of skeletal stem cells through disruption of β-catenin–ATF4 signalling. Pharmacological activation of Piezo1 with agonists such as Yoda-1 restores mechanotransduction and increases trabecular bone volume in unloading models, suggesting pathway-level mechanical substitution. A combined bisphosphonate–Piezo1-targeting strategy could therefore rebalance bone remodeling by concurrently suppressing resorption and reinstating formation capacity, achieving an anabolic–antiresorptive synergy not attainable with single agents. Additional modulators, including Jedi-1, Jedi-2, and the antagonist Dooku-1, provide a toolkit for structure–activity optimization and translational evaluation. Because Piezo1 also regulates vascular endothelial migration and contributes to skeletal-muscle homeostasis, its pharmacological targeting could offer multi-system protection against spaceflight deconditioning, although potential risks such as calcium-overload-related cardiotoxicity and unknown spaceflight pharmacokinetics must be addressed. **APPLICATION:** A stepwise validation roadmap is proposed: ground-based unloading analogs followed by space-based rodent experiments to assess bone volume, muscle cross-sectional area, and pharmacokinetics, preceding human feasibility studies using biomarkers such as CTX, P1NP, and myostatin, with terrestrial applications in osteoporosis and sarcopenia.

Learning Objectives

1. The participant will understand key molecular mechanisms driving bone resorption and impaired formation at the cellular and signaling level during unloading.
2. The participant will describe Piezo1's role as a mechanosensitive ion channel in microgravity-induced bone loss.
3. The participant will understand why pharmacological countermeasures, including Piezo1-targeted agents, may be required alongside mechanical loading for long-duration space missions.

[117] POINT-OF-CARE ULTRASOUND (POCUS) IN AUSTERE ENVIRONMENTS AND IMPLICATIONS FOR FUTURE SPACE EXPLORATION

Hannah Lyons

Emory University, Atlanta, GA, USA

(Original Research)

INTRODUCTION: Point-of-care ultrasound (POCUS) has been heralded as the "modern day stethoscope," and presents an incredible opportunity to advance diagnostic efforts and ensure timely intervention, particularly in austere environments where advanced imaging is not available. Long-duration missions constitute the future of human spaceflight, and these missions necessitate compact, user-friendly, accurate medical imaging modalities. While POCUS technologies continue to advance at a whirlwind pace, there is no clear consensus across medical specialties about standardized training methods or integration into traditional diagnostic schemas and healthcare infrastructure. This systematic review investigates barriers and benefits to the application of POCUS in resource limited environments, ultimately providing a framework with which to conceptualize the integration of POCUS in future space missions. **METHODS:** This systematic review was conducted following PRISMA 2020 guidelines and included a literature search for studies on the application of POCUS in resource-limited environments. Inclusion criteria included publication in a peer reviewed, English language journal, study of point-of-care or bedside ultrasonography, as well as study of resource limited environments with primary focus on rural healthcare facilities and low- and middle-income countries. Studies were excluded if they were published before 2015, investigated ultrasonography in well-resourced settings, or were non-clinical in design. **RESULTS:** The initial search yielded 91 articles based on search criteria, and 42 studies were removed based on title and abstract. Most studies identified were small-scale and descriptive, and they were further sub-categorized into the fields of global health, rural medicine, or medical education to facilitate clear application to space as a distinct resource-limited setting. **DISCUSSION:** As the space industry pivots towards long-duration missions the application of portable medical imaging modalities like POCUS will prove essential. While ultrasound has been considered a core competency for NASA astronauts since 2006, there is no unifying approach for the integration of POCUS in terrestrial or space medical environments. This review indicates that user training, device durability, and diagnostic accuracy stand as barriers to the application of this technology in austere environments, and that further study should be dedicated to the use of telesonography.

Learning Objectives

1. Evaluate current literature on the implementation of point-of-care ultrasound (POCUS) in resource limited settings.
2. Apply the findings of ground-based studies on the clinical relevance and limitations of point-of-care ultrasound (POCUS) to human spaceflight.

[118] THE HUMAN ARCHAEOME AND ITS POTENTIAL RELEVANCE AND APPLICATIONS IN SPACE MEDICINE

Nina Purvis

National Health Service, Newcastle, United Kingdom

(Original Research)

INTRODUCTION: The human archaeome, the less abundant (1-2%) and understudied subpopulation of the microbiome, may be insightful and useful organisms in space medicine. Known for their extremophile existence in spaceflight, salt lakes and volcanoes; they also dwell in the human gastrointestinal tract, aerodigestive tract, urogenital tract, and on skin. Despite a largely bacteria-centric focus in microbiome research, archaea present a unique insight into challenges and opportunities for countermeasures in astronaut health. **METHODS:** A systematic literature review and thematic analysis. Databases searched: PubMed, NASA online archives, ESA online archives including cross-checking of reference lists. Search terms (1950-2025, English): (human archaeon OR human archaea OR human methanogen OR nitrososphaera OR haloarchaeon) AND (astronaut OR crew OR spaceflight OR mars OR moon OR analog* OR ICE). **RESULTS:** Pubmed search in December 2024 resulted in 303 abstracts to screen. NASA/ESA online archives resulting in 3 mission sources (Mars500, ISS twin study reports, Concordia). Major microbiome papers relating to human spaceflight were screened for archaeome analysis. Six publications met criteria for inclusion adhering to PRISMA and CASP 2018 guidelines. **DISCUSSION:** The breadth of archaeal diversity may be a result of diet and environment and so impacted by a long-duration exploration class mission. The abundance of archaea may be measured by a breath test, saliva or stool sampling, or skin scraping analysis - with possibility of in-flight monitoring. These organisms directly impact and interplay with other flora in the body, including the bacterial-archaeal hydrogen transfer and ability to form biofilms in the gut. These syntrophic relationships play a role in gut health, weight, infection and immunity. The archaeome is also shown to protect the body from atherosclerotic plaque-causing processes and has a role in activating immunity. Microbiota data was analysed from space agency missions, showing changes in temporal metabolic and immunological homeostasis of crewmembers. With the useful insights from spaceflight and analog microbiome research, these overlooked organisms should be investigated for adaptation and possibly utilised for their potential as radiation protection, ability to fight increased microbial virulence acting as “Archaeobiotics” and for Archaea-derived biodegradable polymers to create artificial blood vessels or disposable medical equipment.

Learning Objectives

1. Be introduced to the overlooked subpopulation of the microbiome, the archaeome, and its relevance and applications in astronaut health.
2. Assimilate a summary of the relevant literature pertaining to the human archaeome in astronaut health.
3. Consider the knowledge gaps and opportunities in research of the human archaeome in astronaut health.

[119] SPACE PORT OITA PROJECT: A CHALLENGE TO MEDICALLY SUPPORT COMMERCIAL SPACE FLIGHT IN A LOCAL AIRPORT IN JAPAN

Osamu Tokumaru

Oita University, Oita, Japan

(Education - Program / Process Review)

BACKGROUND: Recently, manned space flight has undergone a major paradigm shift from government-led to private-sector-led programs. The traditional space medicine so far has been “special” for professional astronauts who are physically and mentally healthy after rigorous selection and training. Anticipating the spread of commercial spaceflight in the future, it is necessary to establish a new health management system for a wide range of space travelers from children to the elderly with various health issues such as lifestyle-related diseases; i.e., a major paradigm shift is also essential in space medicine from "special” to "general.” The goal of the presentation would be to realize a society where everyone can safely go to space at ease.
OVERVIEW: Space travelers are exposed to extreme environments such as microgravity, cosmic radiation exposure, and closed environments as professional astronauts have been exposed. However, there is a big knowledge gap between special and general space medicine; medical issues critical in general space travelers were not targeted by special space medicine such as children, elderly with chronic diseases, and pregnant women. AsMA established a committee on commercial spaceflight to manage the health care for space travelers, which published the first of a series of scoping reviews of the health care of space travelers in October. The Japan Society for Aerospace and Environmental Medicine also established a new standing committee on health management of space travelers in cooperation with its US counterpart.
DISCUSSION: Japan's National Basic Space Plan (2022) clearly states "acceleration of commercial space activities." Accordingly, Oita Prefecture, located in south-western Japan, has formulated the "Spaceport Oita" project, taking advantage of its local airport with a 3,000-meter-class runway on the sea to successfully attract the only landing site in eastern Asia for a shuttle vehicle from a private space station. However, there is no system nor facility for health care of space travelers in Oita Prefecture at present. As an only national university with a medical school in the prefecture, Oita University has begun a medical preparation for the advent of the future commercial space flight era in corporation with the prefectural government.

Learning Objectives

1. The participant will be able to understand that even a medical community with a local airport participates a manned space program with an advent of era of commercial spaceflight.
2. The audience will learn about a paradigm shift of space medicine from “special” to “general.”

[120] ARTEMIS II CREW HEALTH SYSTEMS - FROM MISSION DESIGN TO OPERATIONS

Christopher Haas

NASA, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: The Artemis II crew health systems development started numerous years prior to the actual mission. In fact, the plans for the Orion spacecraft and its human systems integration requirements have over a decade of history at NASA. In this presentation, a focused review will be held on key lessons learned from the period covering medical system design, mission preparation and execution. **OVERVIEW:** These lessons will include a review of key milestones achieved and discussing how requirements for topics such as launch and landing day operations, medical system design, and life support systems, were ultimately translated into meeting the crew health and performance needs of the planned mission. **DISCUSSION:** These lessons learned will be discussed in the context of ongoing efforts to evolve the Artemis crewed missions from lunar orbital flight to lunar landings, and how medical operations teams can consider optimizing work more efficiently to support new vehicle programs in the future.

Learning Objectives

1. The participant will learn about significant milestones and achievements that enabled the crew health team to finalize plans for Artemis II.
2. The participant will be able to describe key lessons learned that came out of the conceptualization, design and implementation of crew health systems for Artemis II.
3. The participant will be able to identify ways to address challenges early on in program development, while maintaining the intended requirements baseline.

[121] BREAKING THE ALTITUDE BARRIER: INNOVATIVE STRATEGIES TO ENGAGE THE NEXT GENERATION OF AEROSPACE PHYSICIANS

Basil Spyropoulos[1], Philip Brady[2]

[1]Manitowoc County, WI, Manitowoc, WI, IL, USA; [2]Trinity College Dublin, Dublin, Ireland

(Education - Program / Process Review)

BACKGROUND: The future of aerospace medicine depends on securing a robust pipeline of talent, yet the field is currently losing the battle for awareness. Literature reveals that less than 20% of medical students recognize aerospace medicine as a distinct specialty and most curricula lack relevant content. Furthermore a persistent "military-only" misconception effectively screens out many civilian trainees who might otherwise be interested. (To wit, the number of AMEs is falling when it needs to increase.) To meet future needs the specialty must transition from passive recruitment to adopting a multi-faceted engagement framework that competes for student attention in a crowded landscape. **DESCRIPTION:** We evaluate modalities designed to dismantle barriers to entry. Among these we examine the utility of digital ecosystem leveraging. Tools such as content aggregators and real-time community platforms can enhance accessibility by bypassing traditional gatekeepers to directly engage digital native students. Also, institutional evolution is critical. The planned transition of the Civil Aviation Medical Association (CAMA) to the Civil Aerospace Medical Association is a primary case study. This evolution is not cosmetic but a necessary reflection of a changing industry where Aviation Medical Examiners

(AMEs) increasingly encounter commercial spaceflight participants. By aligning the organization's identity with this operational reality and promoting its established Space Medicine Subgroup the association bridges the gap between traditional aviation medicine and the modern aerospace domain. **DISCUSSION:** Promoting specialty awareness and robust workforce development requires a holistic strategy that integrates a broad spectrum of engagement modalities. Digital tools help mitigate accessibility barriers but must be anchored by institutions that project relevance. Also, the industry-wide pivot from "Aviation" to "Aerospace" acknowledges that the civil sector has expanded beyond the atmosphere. Aligning professional organizations with the actual trajectory of the field embodies the meeting theme of Relentless Progress. By mirroring industry changes civil organizations capture the interest of a generation inspired by spaceflight, correct the "military-only" misconception and help to secure an ample and diverse workforce for the Boundless Frontiers of the future.

Learning Objectives

1. Identify the specific systemic barriers preventing medical students from entering the field including curricular deficits and career misconceptions.
2. Describe how the modernization of organizational identity—exemplified by the shift from Aviation to Aerospace—aligns with industry evolution to attract civilian trainees.

[326] CLOSING THE TRAINING PERFORMANCE GAP: A STRUCTURED MODEL FOR RETENTION, RECALL, AND CERTIFICATION OF CABIN CREW FIRST AID TRAINING

Shagufta Hasnain, Narinder Taneja, Shilpa Khanna, Mithun Kumar, Manoj Kumar Nayak

Air India Ltd, Delhi, India

(Education - Program / Process Review)

BACKGROUND: Cabin crew serve as the primary first responders during in-flight medical events. Despite recurrent training requirements, first aid competency may be compromised by skill decay, variability in instructor delivery, and limited assessment of real-world performance. Traditional recurrent training often emphasizes knowledge exposure over long-term retention, recall under stress, and instructor standardization. A structured approach was developed to improve skill retention, recall, and instructional standardization. **OVERVIEW:** A structured enhancement program was implemented focusing on four key components: Retention and recall assessment using mannequin-based simulations integrated with Wi-Fi–enabled real-time performance dashboards; Certification of first aid instructors through a formal Train-the-Trainer (TTT) program; Trainer feedback metrics assessing instructional clarity, scenario facilitation, learner engagement, and error correction, and; Scenario-based training utilizing real in-flight medical emergency cases (e.g., syncope, cardiac arrest, seizures, hypoglycaemia). The overall training framework was externally validated through certification by an accredited Institute of Emergency Medicine. **DISCUSSION:** Preliminary observations demonstrated improved skill recall during scenario assessments, greater consistency in instructor delivery, enhanced learner

confidence, and improved realism of emergency response behaviours. Instructor feedback metrics enabled targeted remediation and standardization across trainers. An integrated model combining smart simulation, instructor certification, real-world scenarios, and external validation can enhance the effectiveness, credibility, and operational readiness of cabin crew first aid training programs. This approach supports patient safety, crew confidence, and regulatory defensibility in aviation medicine.

Learning Objectives

1. Describe a structured model for cabin crew first aid training that integrates simulation, real-world scenarios, instructor certification, and performance assessment.
2. Explain methods to enhance skill retention, recall, and instructor standardization in recurrent in-flight first aid training programs.

Evaluate the impact of structured training program and instructor feedback metrics on crew confidence, emergency response performance, and operational readiness.

[329] BUILDING MUSCULOSKELETAL RESILIENCE IN CABIN CREW: AN INTEGRATED WELLNESS FRAMEWORK

Shagufta Hasnain, Narinder Taneja, Brajamani Akoijam, Shilpa khanna

Air India Ltd, Delhi, India

(Education - Program / Process Review)

BACKGROUND: Cabin crew are routinely exposed to occupational demands that place sustained stress on the musculoskeletal system, including repetitive manual handling, prolonged standing, constrained postures, and variable in-flight conditions. These factors contribute to a high prevalence of work-related musculoskeletal disorders which remain a leading cause of discomfort, injury, and reduced work capacity in this population. Despite increasing recognition of these risks, musculoskeletal health strategies within the aviation industry are often reactive, fragmented, and focused primarily on injury management rather than prevention and long-term well-being. **OVERVIEW:** This paper presents an integrated framework for a musculoskeletal wellness program specifically designed to address the ergonomic and operational realities of cabin crew work. The framework draws on interdisciplinary principles from occupational health, biomechanics, ergonomics, and behavioural science to support a holistic approach to musculoskeletal health. Central to the framework is the integration of the Job Demands-Resources (JD-R) model and the Biopsychosocial approach, allowing for systematic consideration of physical workload, psychosocial stressors, individual capacity, and organizational support. Core components of the proposed program include structured risk identification, functional strength and mobility conditioning, task-specific ergonomics education, and supported self-management strategies facilitated through digital health tools.
DISCUSSION: By aligning individual physical capacity with job demands and organizational resources, the proposed framework promotes a shift from reactive injury management to

proactive musculoskeletal health promotion. Emphasis is placed on shared responsibility between cabin crew and airline systems, fostering a workplace culture that supports early risk mitigation, physical resilience, and sustainable health behaviours. This integrated approach has the potential to reduce injury incidence, enhance occupational well-being, and support workforce sustainability, offering a clinically relevant foundation to guide musculoskeletal wellness initiatives.

Learning Objectives

1. Identify the key occupational and ergonomic factors contributing to work-related musculoskeletal disorders among cabin crew.
2. Explain how the integration of the Job Demands-Resources (JD-R) model and the Biopsychosocial approach can inform the design of comprehensive musculoskeletal wellness programs in aviation settings.
3. Apply the proposed integrated framework to guide musculoskeletal health promotion, injury prevention, and workforce sustainability initiatives within aviation medicine and occupational health practice.

Tuesday, 05/19/2026, 2:00 PM

Plaza A/B

[S-17] PANEL: NASA'S EXPLORATION MEDICAL INTEGRATED PRODUCT TEAM (XMIPT) CONCEPT OF AN INTEGRATED MEDICAL SYSTEM FOR EXPLORATION MISSIONS

Chair: Moriah Thompson

Co-Chairs: Kelly Gilkey, Justin Yang

Panel Overview: *As NASA seeks to conduct missions to the Moon and eventually to Mars, crew will have an increased role in their own healthcare due to communication delay and distance from Earth. The objective of the Exploration Medical Integrated Product Team (XMIPT) of NASA's Mars Campaign Office is to develop technologies and capabilities that enable provision of medical care in this challenging new environment so that crews can execute their mission and return home safely. In this panel, the XMIPT will describe components of an integrated medical system for exploration missions that allows crew the ability to diagnose conditions using imaging hardware, treat with IV fluid, test for specific biomarkers, and access and record medical information. The first presentation will describe the health portal that allows crew access to their health information and the ability to record encounters during mission. Medical information that populates the health portal comes from a backend data architecture, the Crew Health and Performance Integrated Data System Platform (CHP-IDSP), that manages, stores, and pulls data from input devices. The next two presentations will showcase technology development and maturation efforts including the Mini Optical Coherence Tomography (OCT)*

device for spaceflight associated neuro-ocular syndrome (SANS) diagnostics and a Mini X-Ray device. The subsequent presentation will describe a novel, customizable biomarker detection platform that gives crew the ability for health monitoring and screening by detecting biomarkers for wide-spectrum clinical diagnosis and medical research. Finally, the XMIPT will present updates from the IV Fluid Generation Mini project which allows treatment of medical conditions via in-situ production of safe and shelf stable IV fluids on exploration missions.

[122] CHIRON EXPLORATION HEALTH PORTAL (CEHP) PROJECT UPDATES

Amanda Smith[1], Charles Sembroski[2], Robin Onsay[3]

[1]KBR, Houston, TX, USA; [2]CACI, Houston, TX, USA; [3]NASA, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: Inherent risks and limitations associated with future exploration missions mandate a paradigm shift in spaceflight medical operations. Crew will experience increased exposure to human spaceflight hazards, lack of evacuation capabilities, and absence of real-time communications with ground support. This asynchronous, increasingly Earth-independent mode of operations increases the in-flight Crew Medical Officer (CMO)'s need for autonomy in initiating and providing care, while also emphasizing the necessity for mutual awareness and coordination of medical care between crew members and care providers. In this new paradigm, a system is needed to enable the CMO, other crew members, and ground support to quickly, efficiently, and independently record and view medical data, make decisions, and relay important information. **OVERVIEW:** Today, the NASA electronic health record (EHR) is intended only for ground use and is not accessible to in-mission ISS crew for awareness and medical decision support. In addition, collecting, recording, and transferring medical data depends on manual processes and, especially during emergent situations, real-time communication with ground support. The Exploration Medical Integrated Product Team (XMIPT) and Spaceflight Software team have created and reviewed objectives, Concept of Operations, and preliminary high-level requirements, and are developing the Chiron Exploration Health Portal (CEHP) software to operate in an exploration (i.e., Lunar, Martian) environment. CEHP integrates with the Crew Health and Performance Integrated Data System Platform (CHP-IDSP) project, a back-end architecture that provides the foundation for in-flight informatics by collecting, storing, and integrating multiple sources of data generated by and around the crew. Capabilities of the CEHP software will provide crew access to their medical data in-flight, synchronize data with a ground EHR via medical store-and-forward communications and supply medical administrative tools for notifications and messaging medical operational support. Storing, reading, and writing medical data for crew and support staff across every phase of an exploration mission will be critical in enabling NASA's standard of healthcare during increasingly autonomous operations.
DISCUSSION: The CEHP's availability in-mission would provide increased access and awareness among the crew of their own health status and allow for more autonomous operations regarding healthcare in a delayed communication environment. Integration with the CHP-IDSP further enhances autonomous operations by streamlining data storage, transfer, and notifications, and supporting incorporation of medical decision support tools.

Learning Objectives

1. The audience will understand that the CEHP enables in-mission access to crew health data and supports increasingly autonomous care for exploration operations.
2. The audience will understand CEHP is being integrated into the Crew Health and Performance Integrated Data System Platform (CHP-IDSP) back-end system, providing a data architecture to facilitate access, promote decision tools, and provide meaningful insights to crew and to remote stakeholders during exploration missions.
3. The audience will understand the objective of the CEHP is to deliver a system that can store, read, and write medical data for crew and support staff across every phase of an exploration mission.

[123] HANDHELD OPTICAL COHERENCE TOMOGRAPHY (OCT) DEVICE FOR EXPLORATION MISSIONS

Steven Laurie[1], Jennyffer Smith[1], Katrina Carter[1], Tyson Brunstetter[2], Brandon Macias[2]

[1]KBR, Houston, TX, USA; [2]NASA, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: Since 2013, optical coherence tomography (OCT) has provided critical insight into the ocular structural changes that manifest during spaceflight, especially optic disc edema (ODE) and chorioretinal folds, key features of spaceflight associated neuro-ocular syndrome (SANS). The International Space Station (ISS) can accommodate OCT hardware despite its large mass and volume, necessity for real-time remote guidance from Earth, and need for a second crewmember to operate the device. During exploration missions, communication delays will limit use of real-time remote guidance, and smaller vehicles will demand reductions in medical hardware mass and volume. **OVERVIEW:** We established requirements to enable development of a "Mini OCT" device that is (1) self-operated, (2) does not require real-time communication with Mission Control, (3) allows for tracking of retinal and optic nerve head changes over time, and (4) collects data directly compatible with the current ISS OCT data. The current Mini OCT prototype arrived in the Cardiovascular and Vision Laboratory at NASA JSC in September 2025, is contained in a single device, removed 70 lbs. of mass, and reduced the volume by ~1/3 compared to the version on ISS, and incorporates automated data processing on the device, thus decreasing the data size transferred back to Earth. To validate the hardware and characterize the sensitivity of the Mini OCT to track changes in ocular structure, we will utilize both the ISS and a spaceflight analog on Earth. In Fall 2026, we will track ODE progression in 24 participants exposed to the spaceflight analog strict head-down tilt bed rest. In parallel, we will flight-certify the Mini OCT and deploy it to the ISS for a technology demonstration. **DISCUSSION:** This project will verify hardware functionality in weightlessness, validate inflight crew procedures, and compare the precision of the Mini OCT to quantify ocular changes to the gold-standard OCT device currently onboard the ISS. These efforts will lead to validation of the Mini OCT in tracking key findings of SANS, including ODE and chorioretinal folds, in

weightlessness on missions beyond the ISS, and enable continued monitoring of crew health on Artemis missions and future commercial space stations.

Learning Objectives

1. Understand why the OCT camera currently available on the ISS is not an option for use on exploration missions.
2. Learn how the Mini OCT camera overcomes these challenges and what approaches are being used to validate the camera for use on future exploration missions.

[124] USE OF A RADIOGRAPHIC TEST TOOL TO QUANTIFY X-RAY IMAGE QUALITY FOR SPACEFLIGHT APPLICATIONS

Ariel Tokarz[1], Chase Haddix[2], Jerry Myers[1]

[1]NASA, Cleveland, OH, USA; [2]Universities Space Research Association, Cleveland, OH, USA

(Education - Program / Process Review)

BACKGROUND: Medical imaging can be used to support quick and accurate diagnosis of conditions that may arise during spaceflight. A portable, handheld X-ray system is hypothesized to reduce the medical risk of long duration spaceflight missions but must provide high-quality images when used by minimally trained operators under spaceflight conditions. An image quality process was therefore developed to characterize system capabilities in the spaceflight environment of reduced gravity, confined space, and increased background radiation. **OVERVIEW:** The image quality process uses a standard, commercial computed and digital radiographic test tool to evaluate the image acquisition chain, including X-ray generation, X-ray exposure detection, image transfer between detector and software, and post-acquisition processing. Five elements in the test tool were used to characterize image quality for clinical detail: a line pair resolution test pattern, four measuring areas for homogeneity, a six-step copper wedge for dynamic range, a free area for signal normalization, and low-contrast test objects. Evaluation of these elements is anticipated to characterize any changes to system performance during spaceflight. Additionally, each component of the image acquisition chain was evaluated for different combinations of X-ray source and detector hardware from different manufacturers (combination n = 25). This supports the definition of system capabilities, and the selection of an X-ray system catered to the precise needs of a spaceflight mission. **DISCUSSION:** The image quality assessment process was used to recommend a portable X-ray system with high usability and performance for a spaceflight demonstration. The process will support the certification of portable X-ray systems for use in novel environments and is intended to identify any changes in exposure quality between environments (ex., from Earth to spaceflight). Using the image quality process developed to evaluate X-ray systems provides confidence that necessary clinical detail will be available if an X-ray is required in mission. Measures of dynamic range and signal normalization inform the system's robustness; quantification of maximum discernable spatial frequency identifies the smallest visible features of interest; signal homogeneity confirms that

clinical features are not obscured by artifacts from the X-ray system itself. Together, these measurements provide portable quality assurance for X-ray exposures.

Learning Objectives

1. Understand the image quality indicators used in the evaluation process, and the relevance of each to detail for an X-ray exposure in the spaceflight environment.
2. Be able to detail how the evaluation process may be used to evaluate new medical systems or operation environments.

[125] AUTONOMOUS MAGNETICALLY ENHANCED ELECTROCHEMICAL ENZYME LINKED IMMUNOSORBENT ASSAY INSTRUMENT FOR CREW HEALTH MONITORING

Jessica Koehne[1], Morgan Anderson[2], Milton Cordeiro[3], Victor Yeh[1]

[1]NASA, Mountain View, CA, USA; [2]Astrion, Mountain View, CA, USA; [3]Analytical Mechanics Associates, Mountain View, CA, USA

(Education - Program / Process Review)

BACKGROUND: As NASA's exploration advances beyond low earth orbit and towards Mars, technologies must be adapted for in-flight health monitoring without reliance on ground communication or ground analysis and with limited resupply. Therefore, the medical systems that are selected for such a mission must be compact, require few consumables and able to provide a variety of medical analyses with minimal intervention from crew. Our goal is to enhance Earth independent health monitoring capabilities by developing a microgravity compatible total analytical system capable of performing complex operations. **OVERVIEW:** Previously, we developed a magnetic bead based electrochemical ELISA (Mag-EC ELISA) sensor capable of detecting low concentrations of both protein and nucleic acid target analytes. The magnetic bead allows for localization of ELISA constructs onto a sensing electrode and provides the ability to magnetically enhance the measured electrochemical signal from the ELISA. We are now expanding on this development to generate a fully autonomous instrument capable of assembly and measurement of ELISAs within a microgravity compatible fluidic manifold. **DISCUSSION:** The Mag-EC ELISA instrument is broken down into three discrete fluidic manifolds each performing discrete operations. First, the reagent storage and processing module builds ELISA constructs, immobilization construct and detection construct. Next, the target processing module introduces the sample and builds the sandwich structure of the ELISA. Finally, the detection module carries the ELISA to the detector and measures the output of the ELISA. The Mag-EC ELISA instrument is being developed to support crew health monitoring for future Mars exploration but is versatile and can support additional science and environmental monitoring needs within NASA. Lastly, Mag-EC ELISA is a useful approach to biomarker detection in scenarios with limited resources or lab access, making it broadly applicable to a variety of space and terrestrial applications.

Learning Objectives

1. The audience will learn about the magnetically enhanced electrochemical enzyme linked immunosorbent assay (Mag-EC ELISA) under development for crew health monitoring on future Mars exploration.
2. The audience will learn about the development of autonomous fluidic modules to perform complex chemistry operations in microgravity.

[126] DEVELOPMENT OF AN INTRAVENOUS FLUID GENERATION DEVICE FOR EXPLORATION SPACEFLIGHT: IVGEN MINI

Courtney Schkurko[1], Justin Yang[2], Moriah Thompson[3], Alex Salimian[4], Alexandru Mezin[4], Brian Hromco[4], Kimesha Calaway[4]

[1]NASA, Cleveland, OH, USA; [2]Aegis Aerospace, Houston, TX, USA; [3]NASA, Houston, TX, USA; [4]Sierra Lobo Inc, Cleveland, OH, USA

(Education - Program / Process Review)

BACKGROUND: As spaceflight exploration missions increase in distance from Earth and duration, so does medical risk. Commercially available IV fluids have an expiration date that is shorter than the anticipated duration of a Mars mission. IV fluids are also estimated to contribute to treatment of a possible 30% of in-flight medical conditions. The ability to produce medical grade IV fluids from the potable water supply of an exploration vehicle or habitat could reduce overall medical risk and the mass/volume footprint of the in-flight medical system.
OVERVIEW: In 2021, NASA's Exploration Medical Integrated Product Team under the Mars Campaign Office began development of an Intravenous Fluid Generation Miniaturized (IVGen Mini) module. NASA's Glenn Research Center, with the help of Sierra Lobo, Inc., designed a fluid generation module that uses a peristaltic pump to flow potable water through a sterilized filter box to deionize and remove air bubbles, bacteria, and other particulates to create purified water. The fluid is then collected in a final sterilized product bag which contains a pre-measured amount of solid-salt powder to make 1L of 0.9% concentrated saline. The hardware was environmentally and functionally tested on the ground to verify requirements and validate safe operation in a spaceflight environment. IVGen Mini is manifested to launch on an upcoming cargo resupply mission to the International Space Station in 2026. Once on orbit, IVGen Mini will be demonstrated for use in the Life Science Glovebox, with a plan to down-mass fluid samples back to Earth for validation to US Pharmacopeia standards. **DISCUSSION:** Compared to terrestrial fluid inventory, the IVGen Mini system could result in an approximate 80% mass and volume savings for Mars-like exploration missions. Upon successful flight demonstration aboard the International Space Station, the design will be evaluated for infusion into future exploration mission medical system designs and mission operations which could come with additional unique challenges.

Learning Objectives

1. The audience will learn about the need for producing IV Fluid on exploration missions.
2. The participant will understand testing and certification of the IVGen Mini unit for the technology demonstration.

Tuesday, 05/19/2026, 2:00 PM

Plaza D

[S-18] SLIDE: G-FORCES VS THE HUMAN BODY

Chair: Bryan Funke

Co-Chair: Esther Kangas

[127] REPUBLIC OF SINGAPORE AIR FORCE HUMAN PERFORMANCE MAXIMISATION STRATEGY FOR FIGHTER AIRCREW

Maxz Ho, Benjamin Seah, Edwin Loh, Brian See

Republic of Singapore Air Force Medical Service, Singapore, Singapore

(Education - Program / Process Review)

BACKGROUND: A lethal fighter force is predicated on well-trained, healthy and cognitively superior aircrew operating at peak performance. By 2040, fifth-generation fighter operations will demand mastery of complex multi-domain missions, requiring physical conditioning, cognitive agility and psychological resilience. With Singapore's declining birth rate and increasingly sophisticated platforms, there is a clear impetus for a comprehensive approach to maximise aircrew performance. In 2024, RSAF set up the Human Performance Maximisation Working Group (HPM WG) to improve aircrew health, training performance and career longevity. To that end, the strategy is centered on peak physical and psychological conditioning featuring three key thrusts: Protect, Strengthen and Enhance. **OVERVIEW:** First, the RSAF seeks to protect and maximize the career longevity of fighter aircrew through reduction of occupationally-related musculoskeletal injuries. Prolonged temporary restrictions incur significant training costs, aircraft and instructor resources. Forward deployed sports therapists in operational flying squadrons seek to reduce barriers to early assessment, shape positive health-seeking behaviours and minimize restriction from duties in mild cases. Second, RSAF implemented targeted training programmes to strengthen fighter aircrew's fitness to improve core strength, prevent injuries and enhance G-tolerance. Sports nutritionists will support recovery through tailored micronutrient interventions. Third, RSAF Aviation Psychologists will incorporate sports psychology techniques into targeted training programmes to improve decision-making under high processing load and time pressure. **DISCUSSION:** The structured programmes will be introduced in a graduated approach, extending suitable initiatives to other flying vocations with challenging operating conditions and highly perishable skills. Measures of effectiveness include (a) tracking

reduction of flying restrictions due to occupationally-related MSK injuries, (2) tracking health indices and inflight performance data, and (3) measuring effectiveness of cognitive superiority skills through user feedback scores and psycho-physiological measurements. Early data will be analysed and presented. Through the integration of physical, physiological and cognitive optimization, this holistic approach positions the RSAF to meet the demands of future multi-domain operations, and may serve as a scalable model for other aviation communities.

Learning Objectives

1. Examine the operational challenges of sustaining peak fighter aircrew performance in the context of demographic constraints and 5th-generation multi-domain operations.
2. Evaluate potential applications of a structured human performance maximization strategy and its scalability to other military and non-military vocations.

[128] COMPONENT LOAD-SHARING AT INDEX AND ADJACENT LEVELS OF CERVICAL TOTAL DISC REPLACEMENT AND CONVENTIONAL FUSION DURING PLANNED AVIATOR EJECTION LOADING

Narayan Yoganandan[1], Hoon Choi[2], Balaji Harinathan[3], Tyler Rooks[3], Yuvaraj Purushothaman[2], Richard Lang[4], Paul Porensky[5]

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(Original Research)

INTRODUCTION: Head supported mass and high g-forces are known causes of cervical spondylosis and neck pain in military aviators. When surgery is the option, cervical total disc replacement (CTDR) is preferred over anterior cervical discectomy and fusion (ACDF) in civilians; however, they do not use helmets, and their spines are not subjected to high g-forces. CTDR designs are based on civilian needs. Their performance under high-g forces/dynamic loading is less known. The objective of the study was to determine spinal component loads of a design of an artificial disc for CTDR and ACDF in planned ejection loading and compare their spinal loading performances with the intact/native spine. **METHODS:** An intact mid-size male global human body consortium model was used. The finite element model was validated with existing whole-body human cadaver ejection loading test data. The model was seated in a fifth-generation aircraft seat, restrained using the harness system according to the general specifications of the aircraft (model and CTDR not specified per AsMA guidelines). The back of the helmet was in contact with the head restraint, and the Frankfort plane was horizontal prior to applying the nine-g planned ejection loading to the seat. Single level C5-C6 ACDF and CTDR spine models were developed following procedures used by our civilian and military surgeon authors. Peak vertebral body, disc, and facet loads representing spinal component load-sharing

were obtained at the index (C5-C6) and adjacent (C4-C5, C6-C7) levels for the native, ACDF, and CTDR spines. **RESULTS:** In the native, ACDF and CTDR spines, vertebral loads ranged from 1.1-1.3kN, 1.1-1.4kN, and 1.2-1.5kN, disc pressures ranged from 3.5-4.0MPa, 4.0-4.2MPa, and 3.7-4.2MPa, facet loads ranged from 357-468N, 374-488N, and 389-511N, respectively. Based on the native spine, normalized changes in disc pressures were greater in ACDF (up to 12%), while facet forces and vertebral body loads were greater in CTDR spines (up to 9.2% and up to 14%). **DISCUSSION:** Prior studies of dynamic axial loading;of head-neck cadaver specimens indicate that a compressive force of 3.7kN is associated with;50% probability of fracture for a 30-year-old cadaver subject. These preliminary findings show that the peak spinal loads are similar and below the fracture limit under planned aviation ejection loadings in all spines. Under the loading condition used in the study, CTDR may be an effective alternative to ACDF in aviators.

Learning Objectives

1. Comparison of biomechanical responses the native and ACDF spines during planned aviator ejection loading.
2. Comparison of biomechanical responses the native and CTDR spines during planned aviator ejection loading.
3. Comparison of biomechanical responses the ACDF and CTDR spines during planned aviator ejection loading.

[129] WITHDRAWN

[130] ASSESSMENT OF THE EFFICACY OF A COMPUTATIONAL MODEL FOR G-TOLERANCE PREDICTION

Samuel Stephenson[1], Karen Ong[1], Alanna Kennard[2], Rebecca Blue[1]

[1]University of Texas Medical Branch, Galveston, TX, USA; [2]New York University, New York, NY, USA

(Original Research)

INTRODUCTION: Reliably identifying layperson spaceflight participant G-intolerance risk enables opportunities for pre-flight interventions to reduce symptoms. Previously, limited validation of a predictive model developed by Kennard et al. demonstrated reasonable accuracy between model outcomes and participant G-tolerances. We utilized data from prior human centrifuge studies to test model discrimination between symptomatic and asymptomatic participants at +3.5Gz. **METHODS:** Data from prior human centrifuge studies with IRB approval, by Blue et al., were used for 10 symptomatic and 10 asymptomatic participants exposed to maximum +3.5Gz. Model input parameters were systemic vascular resistance, systemic arterial compliance, heart to mid-pupillary distance, heart-to-seat distance, and total blood volume. Blood volume was estimated via the Nadler formula and in parallel using ideal

body weight. The Kennard model estimated the predicted acceleration at G-induced loss of consciousness (G-LOC) for each participant. Cohort means were analyzed with Mann-Whitney U-tests. **RESULTS:** Mean predicted acceleration at G-LOC was +4.51Gz for the symptomatic cohort and +4.62Gz for the asymptomatic cohort (p>0.05) when estimating blood volume via the Nadler formula. When estimating blood volume with ideal body weight, mean predicted acceleration at G-LOC was +4.45Gz and +4.22Gz for the symptomatic and asymptomatic cohorts (p>0.05), respectively. Correlation coefficients with predicted G-tolerance were 0.98 for blood volume under both estimation methods, 0.85 for height, and 0.68 for weight. Correlation coefficients of age, mean arterial pressure, and cardiac risk factors to predicted G-tolerance were slightly positive. **DISCUSSION:** The model predicts reasonable participant G-LOC thresholds but did not identify significant differences in G-LOC thresholds between the symptomatic and asymptomatic cohorts. Height was positively correlated with predicted G-tolerance because it is used in blood volume estimation. This is inconsistent with prior centrifuge data showing inverse correlations with height. Model outcomes suggest strongest correlation between estimated blood volume and G-tolerance thresholds and may be a useful indicator for predicting spaceflight participant's G-tolerance. Future work is needed to identify best methods for quantification of participant's blood volume and to better refine model accuracy, potentially using volume estimates as a predictive factor.

Learning Objectives

1. The audience will learn about the relative importance of different input parameters for G-tolerance prediction models.
2. The participant will understand the future research work needed to improve and validate models for G-tolerance prediction.

[131] WITHDRAWN

[132] FLIGHT TEST VALIDATION OF THE MOBPHYSIOLAB FOR HIGH-G ENVIRONMENTS

Stefan Sammito[1], Daniel Moll[1], David Cyrol[1], Alexander Riel[2]

[1]German Air Force Centre of Aerospace Medicine, Cologne, Germany; [2]German Air Force Centre of Aerospace Medicine, Manching, Germany

(Original Research)

INTRODUCTION: The ability to monitor the physiological state of high-performance aircraft pilots during flight is crucial in assessing their mental and physical condition, especially during demanding flight missions and under high G-loads. For flight clearance of the Mobile Physiological Laboratory (mobPhysioLab) in a jet aircraft the system was used during live flight tests to assess its effectiveness in capturing the real-time physiological data from pilots after successful centrifuge testing. **METHODS:** In the used configuration the mobPhysioLab was able to measure ECG, respiration rate, oxygen saturation, skin conductance, body temperature,

and ambient conditions whereby additionally other parameters can be measured individually. This setup was attached to the test pilot and integrated into their flight suit. During three test flights, each lasting one to two hours, the system was worn by the Weapon System Office (WSO) as well as the Test Pilot. All of whom were male and experienced test aviators. The flight test campaign was carried out at the flight test facility in Manching, Germany on a Panavia PA-200 Tornado two-seater jet aircraft. The system was worn twice by the Weapon System Officer in the back seat and once by the pilot in the front seat. After each flight, the recorded data was paired with the aircraft flight recorder data (for ambient conditions) and examined for plausibility and completeness. **RESULTS:** The flight test results confirmed the mobPhysioLab's robustness and accuracy in capturing physiological data during high-G flight operations. Data comparison with the aircraft's internal measurement system showed high consistency, validating the mobPhysioLab's reliability. The device successfully recorded continuous, accurate data without impairing the flight, even under demanding physical conditions. **DISCUSSION:** The validation of the mobPhysioLab in-flight represents a significant step forward in the capability to do real-time monitoring of a pilot's workload and physiological state. The system's integration into the flight suit showed no adverse effects on flight safety, and the aircrew reported no issues with the equipment. These results pave the way for broader applications of the mobPhysioLab in other aircraft and operational settings, where real-time physiological data could be used to enhance pilot safety, optimize workload management, and improve overall human-machine interaction in high-performance aircraft.

Learning Objectives

1. The participant will understand how the mobPhysioLab performed during actual flight tests and its potential to provide reliable physiological data under extreme conditions.
2. To highlight the challenges of integrating a monitoring system, given the strict airworthiness requirements and the need to ensure that flight safety is never compromised.

Tuesday, 05/19/2026, 2:00 PM

Plaza F

[S-19] SLIDE: FROM ASSESSMENT TO SUPPORT - AIRCREW HEALTH IN THE DIGITAL ERA

Chair: Kathryn Hughes

Co-Chairs: Destiny Attewell

[133] PRELIMINARY EVALUATION OF THE RELATIONSHIPS BETWEEN AVIATION EXPOSURE AND MEDICAL OUTCOMES IN U.S. ARMY AIRCREW

Amanda Kelley[1], J. Andrew Atchley[1], Barrett Campbell[2], Ian Curry[1], David Holdsworth[1]

[1]US Army Aeromedical Research Laboratory, Fort Rucker, AL, USA; [2]U.S. Army Department of Aviation Medicine, Fort Rucker, AL, USA

(Original Research)

INTRODUCTION: Epidemiological studies of military rotary-wing aircrew have largely concentrated on specific conditions or diagnoses, and have estimated occupational hazard exposures using proxy variables such as age. In this study, we aim to link flying exposure, established over time, by specific airframes to aeromedical dispositions and health outcomes in order to inform aeromedical policy and provide evidence of the impact of rotary-wing flight on health. **METHODS:** Data were extracted from the U.S. Army Centralized Aviation Flight Records System (CAFRS) and combined with individual aviators' health outcomes as extracted from the U.S. Army Aeromedical Resource Office (AERO) database. For this analysis, we limited to rated aviators under the age of 55 years with 500 to 6000 cumulative flight hours. Variables of interest included flight hours by aircraft, further aggregated as cumulative hours by airframe (limited to Apache, Black Hawk, and Chinook); demographics; medical outcomes; and aeromedical dispositions. **RESULTS:** The filtered dataset included data from 10,889 pilots. Primary airframe (majority of hours) was identified for each pilot (Apache: n = 2,554; Black Hawk: n = 6,790; Chinook: n = 1,545). The most frequently cited diagnoses that coincided with a granted waiver overall were: obstructive sleep apnea, hearing loss, hypertension, head injury, and intervertebral disc disease. The correlations between cumulative flight hours by airframe type (Apache, Black Hawk, Chinook) and the presence/absence of the top five most frequently waivered conditions were explored. Cumulative Apache hours positively correlated with intervertebral disc disease (p < 0.001), Black Hawk with obstructive sleep apnea (p = 0.007), and cumulative flight hours across all airframes correlated with hearing loss (p < 0.001). **DISCUSSION:** The preliminary findings from this study support continued and detailed evaluation of aviation exposure in aircrew and the link between exposure and medical outcomes. While both data sources are limited in some capacity, there appears to be utility in assessment of time-series trends and relationships between variables in order to quantify occupational and operational risks. Results will illustrate whether prospective health interventions could possibly be targeted to aviators who have a certain level of flying time or if different airframes have disparate health outcomes.

Learning Objectives

1. Participants will learn about the relationships between medical conditions and flight exposure.
2. Participants will learn whether, and if so, to what extent, health outcomes may vary between exposure to various airframes.

[134] PSYCHIATRIC WAIVER OUTCOMES FOR NAVY AND MARINE CORPS PILOTS 2018-2025

Clark Noble, Stephanie Tamayo, Ames Larsen

U.S. Naval Aerospace Medical Institute, Pensacola, FL, USA

(Original Research)

INTRODUCTION: Aviation is a safety-sensitive occupation in which psychiatric symptoms may significantly affect aeromedical qualification and operational readiness. While limited prior data suggest high psychiatric waiver approval rates in naval aviation, no contemporary, multi-year analysis has been published. This study aimed to characterize psychiatric aeromedical waiver adjudication outcomes among U.S. Navy and Marine Corps aviators to provide a baseline for evidence-based aeromedical counseling. **METHODS:** A retrospective cohort study was conducted using data from the Aeromedical Electronic Resource Office (AERO), the Department of Defense central repository for Naval aeromedical dispositions. All psychiatric waiver submissions for designated Class I U.S. Navy and Marine Corps aviators from January 2018 through December 2025 were included. Applicants for initial qualification, Naval Flight Officers, aircrew, and air traffic controllers were excluded. Diagnoses were categorized using ICD-9 and ICD-10 codes and grouped by DSM-5 diagnostic categories. Final adjudication outcomes were classified as Waiver Granted (WG), Waiver Denied (WD), or Waiver Not Recommended at This Time (WNRATT). **RESULTS:** A total of 269 psychiatric aeromedical waiver submissions were identified. Overall, 279 submissions (87.4%) resulted in waiver approval, 13 (4.1%) were permanently denied, and 27 (8.5%) were adjudicated as WNRATT. Adjustment disorders (32.9%) and alcohol use disorders (32.3%) were the most prevalent diagnoses and demonstrated high approval rates (92.4% and 94.2%, respectively). Depressive disorders (81.6%) and anxiety disorders (78.6%) also showed high rates of return to fly. Conversely, trauma- and stressor-related disorders demonstrated the lowest approval rate (60.0%) and the highest proportion of WNRATT outcomes (35.0%). Annual submission volume trended upward over the study period, reaching a peak in 2025. **DISCUSSION:** The vast majority of psychiatric waiver submissions among Navy and Marine Corps pilots resulted in approval. These data suggest that most psychiatric conditions, when appropriately treated and stable, are not career-ending events. These findings are critical for flight surgeons to use in clinical counseling to reduce the stigma of mental health care, encourage earlier intervention, and ultimately enhance both aviator well-being and fleet operational readiness.

Learning Objectives

1. Describe contemporary psychiatric aeromedical waiver approval rates among U.S. Navy and Marine Corps aviators.
2. Apply waiver outcome data to improve counseling, reduce stigma, and support early mental health reporting in aviation settings.

[135] WITHDRAWN

[136] AEROMEDICAL SIGNIFICANCE IN (NEURO)PSYCHOLOGY - THEORY, DEFINITION, AND MODEL

Ryan Green[1], Marvin Acklin[2]

[1]Aerospace Neuropsychology Services, Layton, UT, USA; [2]Private Practice, Honolulu, HI, USA

(Education - Program / Process Review)

BACKGROUND: In aviation (neuro) psychology, the concept of aeromedical significance is frequently invoked in medical certification decisions. Yet, to my knowledge, there is no well-accepted theory, definition, or formal model that articulates what aeromedical significance is, how it should be operationalized, or how it can be applied reliably. This absence creates variability in interpretation, results in overreliance on diagnosis alone, difficulty translating data into operationally meaningful risk assessments, and difficulty making risk-mitigating treatment/monitoring recommendations. A structured framework of aeromedical significance is needed to align (neuro) psychological evaluation with the safety imperatives of aviation. **OVERVIEW:** A theory and definition of aeromedical significance is proposed that centers on the principle that even minor medical, psychological, or neurocognitive issues may have disproportionately large consequences in aviation. Conditions that are benign in everyday life may become hazardous in flight when they affect key, measurable (neuro)psychological constructs. Aeromedical significance is therefore defined not by diagnosis alone, but by functional impact, stability, and interaction with aviation stressors (e.g., fatigue, hypoxia, stress). A symptom, condition, treatment, or vulnerability (e.g., stress reactivity) is aeromedically significant when it has the potential to degrade operational performance, increase risk of sudden/insidious impairment, or undermine safe operations. **DISCUSSION:** A practical model of aeromedical significance integrates both binary (i.e., go-no-go) certification decisions and graduated risk judgments through at least the following: (1) pattern of impairment, including diffuse low-average performance or mild psychological vulnerabilities that may cumulatively increase risk; (2) severity of deficits in cognitive and psychological functions; (3) compensatory abilities; (4) stability and prognosis; and (5) stress reactivity and resilience. This framework conceptualizes aeromedical significance as a dynamic, context-dependent risk construct rather than a static medical label. By structuring (neuro)psychological interpretation, this model offers an opportunity for a reliable approach to risk determinations, certification, monitoring, and return-to-duty decisions, while preserving aviation's primary objective: flight safety.

Learning Objectives

1. The participants will be able to identify at least five critical factors in making risk determinations.
2. The participants will be able to conceptualize how the cumulative effects of multiple minor issues may result in risk to aviation safety.

[137] CHALLENGES IN AI AND DIGITAL TWINS FOR SPACEFLIGHT HEALTH

Shane Clark[1], Daniel Buckland[2]

[1]Duke University Hospital, Durham, NC, USA; [2]University of Wisconsin–Madison, Madison, WI, USA

(Education - Tutorial / Review)

Human spaceflight is entering a new era of longer missions and deeper exploration, creating unprecedented challenges for astronaut health. Space introduces unique stressors such as microgravity, radiation exposure, isolation, and resource limitations that make traditional medical support impractical. To address these risks, we need proactive, data-driven solutions. As human spaceflight ventures farther and longer, a new conversation is emerging at the intersection of AI, digital twins, and spaceflight health. These promising innovations include wearable sensors that enable real-time tracking of vital signs, hydration, and musculoskeletal strain. Digital twins, which are personalized physiological models, simulate health trajectories and predict responses to stressors, allowing early interventions. AI-powered decision support systems provide autonomous triage and predictive analytics, reducing reliance on Earth-based medical teams. Four subject matter experts in digital twins, AI, and human spaceflight were qualitatively interviewed, and their conclusions will be presented. This dialogue explores how computational tools can transform health monitoring, prediction, and prevention in extreme environments. Key challenges include data collection in space, regulatory frameworks, and aligning stakeholder needs. By fostering collaboration across disciplines, this discussion aims to shape a shared vision for the future of computational health in space, one that is proactive, personalized, and mission ready.

Learning Objectives

1. The participant will be able to describe how AI and digital twin technologies can enhance health monitoring, prediction, and prevention strategies during long-duration spaceflight missions.
2. The audience will learn about key challenges in implementing computational health solutions in space, including data collection limitations, regulatory considerations, and stakeholder alignment.

[138] AI RAG AUGMENTATION TOOL FOR SPACE MEDICAL CARE

Jeffrey Sutton, Ian Jamieson, Jackson Brougher, Jimmy Wu

Baylor College of Medicine, Houston, TX, USA

(Original Research)

INTRODUCTION: Future deep space missions, such as those to Mars, will face significant communication delays and blackouts, necessitating Earth-independent medical operations. While artificial intelligence (AI) offers autonomous support, standard large language models (LLMs) often rely on cloud computing and lack niche space medicine knowledge. This study evaluates a privacy-preserving, local AI architecture designed to augment clinical decision-making during autonomous missions. **METHODS:** We developed a retrieval-augmented generation (RAG) system capable of running offline on a standard laptop (Lenovo CPU). The system integrates a distilled, open-source LLM (Eomer/gpt-3.5-turbo) with a local vector database (Chromadb). We compared two configurations: a baseline Chat mode (LLM only) and a RAG mode grounded in specific NASA technical reports. The system was tested using the clinical scenario of venous thromboembolism (VTE) in spaceflight, assessing accuracy against known space medical capabilities and guidelines. **RESULTS:** The Chat model demonstrated strong general medical knowledge but was weak on space-specific context, incorrectly stating that no diagnostic capabilities exist in space and that anticoagulants are unsafe for astronauts. Conversely, the RAG system successfully retrieved and synthesized data from the uploaded NASA VTE report. It correctly identified valid onboard diagnostic options and appropriate treatment protocols. **DISCUSSION:** This proof-of-concept demonstrates that small, local RAG systems can effectively bridge the gap between general medical knowledge and space-specific constraints without reliance on Earth connectivity or heavy computing infrastructure. By tethering generative AI to verified documentation, this approach provides necessary guardrails against hallucination, enhancing crew autonomy and safety for long-duration exploration.

Learning Objectives

1. The audience will understand how retrieval-augmented generation (RAG) architecture addresses limitations of standard large language models in resource-constrained space environments.
2. The audience will learn about the clinical advantages of integrating local, open-source AI systems with verified domain-specific documentation for autonomous medical decision support during deep space missions.

Tuesday, 05/19/2026, 2:00 PM

Governor's 10

[S-20] PANEL: SECOND INAUGURAL SPACE SURGERY SYMPOSIUM 2025- REFLECTIONS AND RESULTS

Chair: Lisa Brown

Co-Chairs: Edson Oliveira

Panel Overview: *This panel endorsed by the Space Surgery Association reports on the main findings, points of discussion and where future research should be targeted from the second inaugural Space Surgery Symposium held at Johnson Space Center in April 2025. The*

introduction will be given by the Co-Convener of the Symposium, Professor George Pantalos, explaining the reasons behind the organisation of the Symposium and including a summary of the main topics discussed. Following this Dr Art Formanek, Anaesthesiologist, will present the most up to date research on Perioperative care and Spaceflight, with a focus on the gaps that exist in pharmacological management and ability to provide anaesthesia. The third presentation will be delivered by Dr Edson Oliveira, Neurosurgeon and ESA Medical Board Member on the Neurosurgical issues facing spaceflight and recent developments including SANS. The fourth presentation will be delivered by Dr Gordon Wisbach, General Surgeon and retired Captain within the US Navy on the application of Surgical and Military operations. A summation of the Symposium and the gaps identified for future research will be discussed in the final talk by the Co-Convener of the Symposium, Dr Danielle Carroll. This panel is the most up to date space flight information as it relates to Surgical conditions specifically and will present the results of the important symposium to a wider audience.

[139] 2025 SPACE SURGERY SYMPOSIUM: DEFINING AND IMPLEMENTING SURGICAL CAPABILITIES FOR EXPLORATION SPACE FLIGHT

George Pantalos[1], Danielle Carroll[2]

[1]University of Louisville, Louisville, KY, USA; [2]Brigham and Women's Hospital, University of Colorado, Boston, MA, USA

(Education - Program / Process Review)

INTRODUCTION: The need for surgical treatment in exploration spaceflight has been considered since 1967, when Yaroshenko and collaborators attempted surgical tasks during parabolic flight to identify challenges and demonstrate feasibility with adjustments of working in reduced gravity. Starting in 1983, eight symposiums have been organized to update and define future efforts needed. Being ten years since the last comprehensive symposium, the Space Surgery Association organized a new symposium to assess the current status and future of surgical capabilities for exploration spaceflight. **OVERVIEW:** A two-day symposium was held in April, 2025, at the NASA Starport Exchange adjacent to the NASA Johnson Space Center. Sessions initially presented the history, current medical/surgical capabilities, and lessons learned from global surgery and on battleships and submarines. The role of surgical physiology and perioperative care, anesthesia, robotics and AI for surgery was discussed. Finally, women's health, medical evacuation, management of medical data, developing medical technology, qualifying surgical technology for spaceflight, and lessons learned from remote military trauma care and from remote healthcare delivery were also considered. Thirty-five participants from six countries contributed 22 presentations followed by extended discussions of the presentations. The presentations included relevant experience from ground-based studies, parabolic flight, suborbital flight, and orbital spaceflight. Acknowledging that developing surgical capabilities is an interdisciplinary effort, the participants included astronaut physicians and engineers, test and process engineers, an anesthesiologist, physiologists, biomedical engineers, general, thoracic, neuro, and trauma surgeons, a women's health physician, and medical device developers from

academia, NASA, and the spaceflight industry. Twenty recommendations were identified for future activity. **DISCUSSION:** The development of surgical capabilities for exploration spaceflight will continue to be incremental as innovation of Earth-based technology increases. The ever-present challenges are the fundamental concerns for mass, power, volume, time, money, risk, and crew competence, which limit what can be accommodated on a mission to a Lunar or Martian base. As you will see in this session, that challenge was kept in mind in the presentations and discussions at the symposium. A detailed summary of the content of the symposium is in preparation to become publicly available from the NASA technical reports server (NTRS).

Learning Objectives

1. The audience will gain an understanding of the history and need to create surgical capabilities for astronaut healthcare during exploration spaceflight.
2. The audience will gain an appreciation for the diverse, interdisciplinary skills, resources, and activity to develop, test, and validate surgical capabilities for exploration spaceflight.

[140] PERI-SPACEFLIGHT PERIOPERATIVE CARE

Arthur Formanek

Mass General Brigham, Harvard Medical School, Boston, MA, USA

(Education - Program / Process Review)

BACKGROUND: As demand for commercial and professional spaceflight increases, the likelihood of an event demanding surgical or critical care in or immediately after spaceflight also increases. While no one would rationally advocate for an operative event peri-spaceflight, contingencies must be made in the event of an emergent situation. Unfortunately, the difficult nature of fully understanding the interactions of the physiologic changes of spaceflight with the stresses of anesthetic and critical care makes safe care of patients challenging, and we have a poor record of safely anesthetizing primates post spaceflight. **OVERVIEW:** Investigations into spaceflight physiology have increased our understanding of potential outcomes of anesthetic care, but much remains to be learned. Specifically, considerations for hypnotics, opioids, paralytics, pressors, and physical interventions must be taken into account given current knowledge of spaceflight physiology, environmental constraints, and limits in staff training. Upregulation or downregulation of receptors and systems such as acetylcholine receptors and autonomic nervous system components must be considered, as exposure to spaceflight may result in markedly different responses to medications. Likewise, resource availability, crew skillset, and practicality of remote guidance will guide techniques, such as type of anesthetic, airway control, and means of medications administered. Alterations in the neurologic system and neuromuscular junction have implications in choice of anesthetic regimen. Changes in pulmonary mechanics and airway physiology could make airway control and initiation of positive pressure ventilation challenging. Autonomic nervous system changes could result in large hemodynamic shifts and would guide pressor choice. Gastrointestinal motility alterations could increase the risk of aspiration and would affect the choice of airway control and level of

sedation administered. **DISCUSSION:** Further studies in spaceflight and terrestrial-based analogues are necessary to plan for safe anesthetic and critical care in and after spaceflight. Furthermore, identification and application of anesthetic analogues, such as multisystem atrophy, pregnancy, and gastrointestinal dysmotility, are necessary to understand possible reactions to common anesthetic interventions and formulate guidelines for safe care. Lastly, protocols taking these factors into account must be created to ensure a plan is present for when surgical pathology does present.

Learning Objectives

1. Describe key microgravity-related physiologic changes that increase peri-anesthetic risk.
2. Formulate an operationally realistic anesthetic strategy for peri-spaceflight scenarios, including monitoring priorities, agent selection, airway rescue planning, and aspiration mitigation.

[141] NEUROSURGICAL PATHOLOGIES IN SPACEFLIGHT: MICROGRAVITY EFFECTS, CLINICAL RISKS, AND MANAGEMENT CONSIDERATIONS

Edson Oliveira

Center for Aerospace Medicine Studies, Faculdade de Medicina, Universidade de Lisboa, Lisboa, Portugal, Portugal

(Education - Program / Process Review)

BACKGROUND: Long-duration spaceflight produces clinically meaningful alterations in human physiology that may affect the nervous system and, consequently, crew performance and mission safety. **OVERVIEW:** In a microgravity environment, cephalic fluid shifts are thought to contribute to intracranial pressure (ICP) changes, with potential downstream manifestations such as Spaceflight-Associated Neuro-ocular Syndrome (SANS). In parallel, spaceflight-associated stressors (e.g., sleep disruption and psychosocial strain) can influence neurocognitive performance, while spinal unloading may promote degenerative changes in vertebrae, intervertebral discs, and paraspinal musculature. Against this physiological backdrop, neurosurgical conditions of highest relevance to space medicine are those that can precipitate acute neurological deterioration, pose immediate life-threatening risk, or cause major functional impairment. Key entities include traumatic brain injury related to intra- or extravehicular accidents, acute intracranial hemorrhages capable of rapid mass effect and intracranial hypertension, elevated ICP with or without acute hydrocephalus, and traumatic spinal and spinal cord injuries whose susceptibility and progression may be modified by microgravity-induced spinal adaptations. **DISCUSSION:** Although no confirmed cases of acute neurosurgical emergencies have been reported during space missions, their time-sensitive nature and potential impact on crew capacity justify focused prevention strategies and further investigation. Terrestrial management of these conditions relies on high-resource, guideline-driven pathways—rapid neuroimaging (notably non-contrast CT), close neurological monitoring, ICP-directed

therapy when indicated, cerebrospinal fluid diversion for hydrocephalus, and timely surgical interventions such as hematoma evacuation, decompressive craniectomy, and spinal decompression/stabilization—providing a clinical baseline for identifying the adaptations required in spaceflight environments.

Learning Objectives

1. Explain how long-duration spaceflight and microgravity can affect the nervous system and link these effects to neurosurgical relevance.
2. Identify the neurosurgical conditions most relevant to space missions (e.g., TBI, intracranial hemorrhage, raised ICP ± acute hydrocephalus, spinal cord/vertebral injury) and outline the terrestrial, guideline-based management baseline (imaging/monitoring, ICP-directed therapy, CSF diversion, and key surgical interventions) as a framework for considering spaceflight adaptations.

[142] LESSONS FROM MILITARY SURGERY APPLICABLE TO THE DEVELOPMENT OF SPACE SURGERY

Gordon Wisbach

Navy Medicine Readiness & Training Command San Diego (NMTRC-SD), San Diego, CA, USA

(Education - Program / Process Review)

BACKGROUND: As human spaceflight progresses toward longer-duration missions beyond low Earth orbit, the capability to manage surgical emergencies in space becomes an increasing concern. Space surgery represents an extreme form of expeditionary medicine, characterized by isolation, confinement, limited resources, delayed communication, and the absence of evacuation. These constraints closely parallel those encountered in military and combat surgical environments, making military surgical experience highly relevant to the development of space surgical capability. **OVERVIEW:** Military surgery has demonstrated the effectiveness of mission planning and rehearsal, standardized operating procedures, and damage-control surgical principles in austere and high-risk settings. These approaches emphasize physiologic stabilization, simplified workflows, and decisive action when definitive care is not immediately possible. In the context of spaceflight, such principles support the prioritization of life-saving interventions over ideal anatomic repair and enable safe care with constrained equipment and personnel. Cross-training and task-based competency, long used in military medicine to extend surgical capability to non-specialists, offer a practical model for astronaut medical training. Crew resource management, including closed-loop communication and flattened hierarchies, further enhances team performance and safety during high-stress procedures. Military experience also underscores the importance of decision-making under uncertainty, ethical responsibility in isolated environments, and clear delineation of medical authority. Finally, structured after-action reviews and continuous performance improvement—core components of military surgical culture—provide a framework for iterative learning in an emerging field with limited operational

experience. Psychological resilience and stress management training, critical to maintaining surgical performance in combat settings, are equally essential for long-duration space missions. DISCUSSION: By adapting established military surgical lessons to the unique operational constraints of spaceflight, space surgery can evolve from a theoretical contingency to a feasible operational capability for future lunar, Martian, and deep-space exploration missions.

Learning Objectives

1. The audience will understand the parallels between military surgical protocols and that which can be used to inform spaceflight protocols.
2. The audience will understand the effect of team performance and its importance in managing complex medical and surgical scenarios in austere environments.

[143] 2025 SPACE SURGERY SYMPOSIUM: RESULTS, INSIGHTS, AND THE WAY AHEAD FOR SURGICAL CARE IN SPACE

Danielle Carroll[1], George Pantalos[2]

[1]Brigham and Women's Hospital & University of Colorado Boulder, Boston, MA, USA; [2]University of Louisville, Louisville, KY, USA

(Education - Program / Process Review)

BACKGROUND: The space missions planned for the coming years will bring many challenges in optimizing human health and performance for deep space exploration. Long-duration missions involving deep space transit and recurrent planetary surface operations will bring with them a catalog of possible medical events for which the terrestrial standard of care is surgical intervention. For these reasons, the Space Surgery Association held a Space Surgery Symposium in Spring 2025, with the goal of generating a specific and tailored list of strategic recommendations to guide the development of technologies, procedures, and processes for maximal timeliness and impact in the coming years. This presentation delineates and summarizes those recommendations. **OVERVIEW:** Over the course of the two-day symposium, 35 participants from various surgical or complementary specialties expressed diverse viewpoints and weighed in on a broad array of considerations impacting the provision of surgical care in the spaceflight environment. Based on this discussion, a summative list of recommendations and action items was generated. In total, 20 recommendations were generated, weaving surgical and engineering-based perspectives into a cohesive and well-rounded guide for future expansion of capabilities. These include topics such as leveraging artificial intelligence for diagnostic and procedural guidance, defining the minimum requirements for a surgical toolkit for exploration space flight, understanding the pharmacokinetics of drugs in altered gravity, evaluating and optimizing telementoring techniques for procedural guidance, and much more, while keeping an expeditionary medical perspective for the near future. **DISCUSSION:** As the global aerospace community moves toward long-duration missions to the moon and Mars with extensive surface exploration components, classical surgical pathology can and will arise in-mission. Neglecting to

plan for such contingencies will increase the risk of crew harm, permanent injury, and impairment of performance of the tasks necessary for mission success. A detailed synopsis of the symposium content is in process, with plans for public release from the NASA technical reports server (NTRS). With the symposium-generated list of recommendations as a guide, future research and development can yield the greatest potential impact on crew health and effectiveness to promote successful exploration-class missions.

Learning Objectives

1. The audience will gain an understanding of the role of a surgical perspective in informing technological development for optimal support of the injured patient in the deep space environment.
2. The audience will appreciate the ways in which surgical and engineering-based principles can be integrated to generate technologies that are capable of supporting crew health while also honoring the significant engineering design constraints intrinsic to the spaceflight environment.

Tuesday, 05/19/2026, 2:00 PM

Governor's 12

[S-21] PANEL: DEVELOPMENT OF THE ACCIDENT INVESTIGATION MENTAL HEALTH JOB AID: WHY, HOW, AND WHAT IT PROVIDES

Chair: Aric Raus

Co-Chairs: William Hoffman, Quay Snyder, Turan Kayagil

Panel Overview: *Aviation mental health (MH) has received increased scrutiny in recent years, reflecting both emerging research on healthcare-seeking behaviors among aviation professionals and heightened awareness following notable MH–related aviation events, including the Alaska Airlines and Germanwings incidents. However, accident investigators currently lack standardized methods to assess whether MH factors contributed to aviation incidents and may be uncomfortable addressing this factor without specialized training. This gap limits hazard identification, analysis, and the development of practical, evidence-based safety recommendations. To address these issues, the Accident Investigators' Mental Health Job Aid (AIMHJA) was developed by an international, multidisciplinary team of researchers. This panel provides the background and current approach to investigating mental health considerations in aviation incidents, describes the development of the AIMHJA, and examines how the Job Aid may help inform the incorporation of MH into aviation SMS. The first presentation describes current gaps in accident investigation processes with respect to MH identification and why existing investigative frameworks are insufficient. Next, panelists will review how aviation accident investigation organizations currently address MH considerations, given the limited number of investigators with specialized MH or human performance training. With this*

background information provided, the presentation will proceed to describing the resulting development of the Accident Investigation Mental Health Job Aid (AIMHJA), including its tiered structure and standardized design considerations, intended for use by non–mental health–trained investigators. The final presentation examines how information derived from the AIMHJA may be integrated into aviation Safety Management Systems (SMS), including its applicability across aviation's multiple domains, the implications of international implementation, and the use of aggregated data for long-term safety analysis. By providing a structured method for capturing MH considerations, the AIMHJA has the potential to support earlier identification of aeromedical risk patterns and inform proactive, preventative safety interventions. Together, this panel provides a structured, systematic approach to improving the identification of MH-related factors in aviation incidents and accidents, and offers a pathway to integrate those insights into proactive safety management.

[144] MENTAL HEALTH ASSESSMENTS IN ACCIDENT INVESTIGATION – WHY A TOOL IS ESSENTIAL FOR SAFETY ANALYSES

Quay Snyder

Aviation Medicine Advisory Service, Cantennial, CO, USA

(Education - Program / Process Review)

BACKGROUND: The mental wellbeing of all persons involved in aviation may have a role in the accident/incident chain of events. Accident investigators (AIs) serve a key role in identifying factors leading to negative unplanned outcomes that may be corrected to improve aviation safety. Most AIs do not have training in mental health (MH) issues and thus, this critical element is frequently not considered in mishap investigations. A tool for AIs to enable considering MH in aviation will enhance data collection, reporting and potentially implementing processes to improve operations safety. **OVERVIEW:** Several high visibility aviation mishaps attributed to negative MH of aircrew have recently captured the attention of the public and aviation professionals. The International Society of Air Safety Investigators (ISASI) convened a workshop in 2024 to address the role of MH in aviation safety and accidents. Although there was agreement among attendees that MH could be a key factor for not only pilots, but other aviation safety sensitive personnel (ASSP), most AIs felt that MH was not routinely considered in their investigations unless medical records or toxicology reports triggered further evaluation. Several barriers were identified. AIs lacked MH training and knowledge of appropriate questions to ask during interviews. They also indicated discomfort inquiring about MH issues. A standardized data collection format and reporting did not exist. To improve safety, a secure anonymized data repository with independent analysis and reporting is also needed. Development of an Accident Investigator's Mental Health Job Aid tool (AIMHJA) is the initial step in routine standardized data collection from all ASSPs during investigations. The AIMHJA is designed to be brief and easy to use in mishap investigations and alert the AI to seek further evaluation by a human factors/mental health professional if certain MH risk factors are identified in the initial investigation. **DISCUSSION:** This project seeks to overcome early barriers to evaluating the

critical role of MH in aviation mishaps and ultimately lead to international standardized analysis of MH factors that could be integrated into a Safety Management System.

Learning Objectives

1. Attendees will understand the current barriers that exist to exploring possible mental wellness compromises in aviation mishaps by investigators.
2. Attendees will be familiar with to role of an Accident Investigator's Mental Health Job Aid tool in mishap analyses and incorporation into a Safety Management System

[145] HOW THE NTSB INVESTIGATES HEALTH IN AVIATION ACCIDENTS

Turan Kayagil

National Transportation Safety Board, Washington, DC, USA

(Education - Program / Process Review)

BACKGROUND: The National Transportation Safety Board (NTSB) is an independent federal agency charged with investigating every civil aviation accident in the United States and significant events in other modes of transportation. The NTSB determines the probable causes of accidents and incidents and issues safety recommendations aimed at preventing future occurrences. The NTSB commonly investigates the health of vehicle operators and other persons of interest as part of investigating human performance. **OVERVIEW:** As the lead federal agency for safety investigations of US civil aviation accidents, the NTSB investigates approximately 1300 aviation accidents per year. Pursuant to statute, the Federal Aviation Administration participates as a party in those investigations. Most investigations involve general aviation and are led by a single NTSB investigator-in-charge (IIC). The NTSB employs physician medical officers and non-physician aviation human performance experts who may provide support to IICs upon request. NTSB Transportation Disaster Assistance specialists also may assist in communicating with families and securing medical evidence. Sources of investigatory health information may include certification records, medical records, autopsy and toxicology reports, recorded data, interviews, and other evidence. The NTSB has specific legal authorities to obtain and review such evidence. NTSB investigation and reporting of health information seeks to serve public safety with transparency, integrity, independence, and excellence, while appropriately protecting individual privacy. Conclusions about likely effects of medications and medical conditions on performance are made in context of accident circumstances, and any resultant safety recommendations are supported by facts of the case. **DISCUSSION:** Understanding how the NTSB investigates health in aviation accidents provides a foundation for discussing how proposed tools like the Accident Investigation Mental Health Job Aid might be incorporated into NTSB investigation processes. The NTSB's Chief Medical Officer will provide a basic overview of those processes.

Learning Objectives

1. Understand the role of the NTSB in US civil aviation accident investigations.
2. Understand how NTSB investigators collect and evaluate health information pertaining to vehicle operators and other persons of interest.

[146] DEVELOPING THE ACCIDENT INVESTIGATION MENTAL HEALTH JOB AID

Aric Raus

Embry-Riddle Aeronautical University, Kansas City, MO, USA

(Education - Program / Process Review)

BACKGROUND: Aviation mental health has become an important topic for flight safety and workforce well-being. High-profile events such as the Germanwings and Horizon Airlines incidents have drawn attention to the role of untreated mental health among aviation personnel. While awareness has grown, accident investigators lack standardized approaches for examining the influence of mental health in aviation events. Investigators also report hesitancy in addressing these issues due to the absence of an established approach and the sensitive nature of mental health discussions. Together, these challenges contribute to gaps in data collection, trend analysis, and safety recommendations. **OVERVIEW:** This presentation describes the development of the Accident Investigation Mental Health Job Aid (AIMHJA). The AIMHJA was designed through a six-round, modified Delphi process, conducted in 2025. An initial Phase 0 engaged an international team of aviation mental health and accident investigation researchers to identify research gaps, conduct a needs analysis, and establish the tool's initial design and question set. Phase 1 invited regulators, industry representatives, mental health practitioners, and aviation professionals to refine interview questions and guidance to best assess factors contributing to mishaps. Phase 2 engaged international air safety investigators to evaluate the AIMHJA's clarity, usability, and fit within investigation environments. Phases 1 and 2 each included two online questionnaires and one in-person session. Across the four questionnaires, 127 validated responses were received, with an additional 53 experts participating during two in-person sessions held at the 2025 Aerospace Medical Association and International Society of Air Safety Investigators annual meetings. **DISCUSSION:** Feedback across the phases refined the design, content, and language of AIMHJA by clarifying topic areas, optimizing wording, and integrating culturally sensitive language. The final AIMHJA consists of two linked but independent job aids. An initial Screening Tool helps investigators determine whether consultation with a mental health or human performance (MH/HP) expert may be warranted, while a secondary tool provides MH/HP experts with initial questions for follow-on interviews. Designed to balance structure with flexibility, AIMHJA integrates into existing investigative workflows, supporting the systematic consideration of MH/HP factors across military, civilian, and international investigation environments.

Learning Objectives

1. Describe the rationale for integrating mental health and human performance considerations into aviation accident investigations and the gaps AIMHJA is designed to address.
2. Explain the systematic, multi-phase Delphi methodology used to develop the Accident Investigation Mental Health Job Aid (AIMHJA).
3. Identify how the AIMHJA Screening Tool and Follow-on tool support consistent, culturally sensitive assessment of mental health–related human performance factors across diverse investigation environments.

[147] USING THE MENTAL HEALTH JOB AID TO INFORM AND STRENGTHEN SAFETY MANAGEMENT SYSTEMS

William Hoffman

Joint Integrated Clinical Medicine, 59th Medical Wing, Science and Technology, Ft Sam Houston, TX, USA

(Education - Program / Process Review)

INTRODUCTION: As aviation accident investigations increasingly recognize the relevance of mental health related human performance factors, structured and consistent methods for gathering this information are essential. The Accident Investigation Mental Health Job Aid provides investigators with standardized questions and guidance to explore these factors appropriately. Although the job aid was designed to support investigative practice, its structured outputs also create a potential pathway for improving system level learning by revealing when and how mental wellness related factors may influence safety and operational performance. **OVERVIEW:** This presentation explores how information collected through the job aid could, in the future, serve as a meaningful data source for Safety Management Systems (SMS) at both the operator and regulatory levels. The job aid generates nonclinical, contextual information that can highlight patterns in human performance influences including fatigue, stress, interpersonal dynamics, workload pressure, and other mental wellness related precursors that may otherwise remain undocumented. When aggregated and appropriately deidentified, these insights could support SMS processes such as safety policy and safety risk management by helping organizations recognize latent conditions, recurrent contributing factors, or breakdowns in organizational controls. Although full integration with SMS has not been implemented, the presentation outlines an exploratory framework for how such data could eventually inform safety policy, training, and organizational risk controls. **DISCUSSION:** By standardizing how investigators gather sensitive human performance information, the job aid creates the foundation for a future feedback loop into SMS that enhances system level visibility of mental wellness influences on safety. This session will discuss the opportunities and requirements for enabling such a feedback pathway, including privacy safeguards, deidentification needs, cross stakeholder coordination, and analytical approaches suitable for organizational and regulatory SMS functions. While conceptual at this stage, this work highlights how structured investigative data could, in time, strengthen proactive safety management and support a more complete understanding of human performance in aviation safety systems.

Learning Objectives

1. Describe what a Safety Management System (SMS) is and name its four components.
2. Describe how structured information gathered through the Mental Health Job Aid could eventually support SMS processes such as hazard identification, safety risk management, and safety assurance.

Tuesday, 05/19/2026, 2:00 PM

Governor's 14

[S-22] PANEL: BRINGING A RESEARCH PROJECT TO FRUITION: FROM CONCEPT TO JOURNAL PUBLICATION

Chair: Frederick Bonato

Co-Chairs: Douglas Boyd

Panel Overview: *INTRODUCTION In an academic setting, published research represents one of the benchmarks commonly used for peer recognition and career advancement. However, bringing a research project to fruition (i.e. a published manuscript) represents a complex multi-step process. While researchers schooled in this sphere receive training in this respect, this is less frequent for aerospace medicine professionals who have transitioned to a research path later in their career. TOPIC Herein, this Panel, sponsored by the Education and Training Committee, will discuss the multiple steps involved in taking a research project from a novel concept through to publication. APPLICATION Research starts with an idea/concept posed by the investigator. The first presentation will address how to determine if the idea is novel via a literature search and designing an appropriate experimental approach, data acquisition and analysis towards answering the question. In the second presentation, the issue of whether the research represents human subjects research and navigating the required approval process will be covered. In the third presentation, the past editor of the "Aerospace Medicine and Human Performance" journal will discuss statistical methods and statistical packages commonly used in aeromedical research projects. The following session, journal selection manuscript preparation, reference managers and the Editorial process for submitted papers will be discussed. In the final presentation, the manuscript review process will be addressed. Since, by far, the majority of manuscripts require at least one round of revision how best to respond to critiques towards getting a manuscript accepted will be addressed.*

[148] THE NUTS AND BOLTS OF A RESEARCH PROJECT FROM CONCEPT THROUGH TO EXPERIMENTAL DESIGN

Douglas Boyd

Embry Riddle Aeronautical University, Daytona Beach, FL, USA

(Education - Tutorial / Review)

INTRODUCTION: In an academic setting, published research represents one of the benchmarks commonly used for peer recognition and career advancement. However, bringing a research project to fruition (i.e. a published manuscript) represents a complex multi-step process. While researchers schooled in this sphere receive training in this respect, this is less frequent for aerospace medicine professionals who have transitioned to a research path later in their career. **TOPIC:** Herein, the author will discuss the steps involved in a research project from the germinating seed of an idea to data acquisition. **APPLICATION:** Research starts with an idea/concept posed by the investigator. One of the first steps is to determine whether this question has been addressed previously-this is important as priority in research is accorded more to novelty than a confirmation of older findings. Towards answering this question, various literature search platforms (e.g. PubMed, Google Scholar) will be discussed and how to bypass the fee required by some journals for non-subscribers. Consequently, selection of research methods which most directly answer the question posed will be addressed as well as data collection and analysis. Will research funding be required? Does the research lend itself to multiple experiment approaches to corroborate each other? What factors affect the population size needed? Importantly, is the allotted experimental time frame (including approvals for human subjects' research, research fund acquisition) within that achievable by the investigator? This presentation will segue to the next two where human subject research approval and statistical analyses are addressed.

Learning Objectives

1. Coming up with a novel research question which advances scientific knowledge.
2. What experimental design/methods are appropriate for the research question posed?
3. Recognition of experimental limitations.

[149] PREPARING AND SUBMITTING A MANUSCRIPT TO A SCIENTIFIC JOURNAL

David Newman

Aerospace Medical Association, North Palm Beach, FL, USA

(Education - Tutorial / Review)

INTRODUCTION: Publication in a scientific journal (such as Aerospace Medicine and Human Performance or Underwater and Hyperbaric Medicine) has potential benefits to one's career and can also contribute valuable information to others in one's field/specialty. Choosing the right journal to submit to is important—a decision that can depend on multiple factors, such as journal indexing, impact factor (or other metrics), the intended audience, whether or not the journal offers Open Access, and turnaround time. How does one maximize the chances of getting successfully published? Also, how can requests for revised manuscripts best be handled? **TOPIC:** This talk will address the following: 1) Appropriate journal(s) your work should be

submitted to, 2) Writing and formatting a submission, 3) Ethics committee approval (e.g., Institutional Review Board or Institutional Animal Care and Use Committee) 4) Use of generative AI, 5) The editorial process—including peer-review, 6) Corresponding with the journal office/editor. **APPLICATIONS:** Careful preparation prior to submitting a manuscript for consideration by a scientific journal is essential. After selecting a journal to submit to, following simple steps in preparing, submitting, and revising manuscripts can maximize the probability that a given manuscript will be accepted and published. Understanding and following the selected journal's instructions for authors is crucial. These guidelines are broadly applicable to many scientific journals.

Learning Objectives

1. Provide authors with a systematic approach to writing and submitting a manuscript for publication.
2. Acquaint authors with the editorial review process.

[150] STATISTICS FOR A SCIENTIFIC JOURNAL

Frederick Bonato

Manhattan University, New York, NY, USA

(Education - Tutorial / Review)

INTRODUCTION: In most research projects scientific rigor requires statistical testing of the data to draw any conclusion as to whether an endpoint has changed. Unfortunately, statistics is commonly given short shrift in in medical training. **TOPIC:** Herein, the author will give an overview of the types of data commonly generated in medicine studies, appropriate statistical tests and interpretation of their output. Exemplars drawn from published studies will be used for illustrative purpose. **APPLICATION:** Typically any research project will generate volumes of data requiring statistical analysis to determine whether a perceived change is real or anomalous. The type of statistical test used will be predicated partly on the question posed and whether data are parametric (normally distributed) or non-parametric. The following common research data scenarios are discussed (1) Do two/multiple populations differ in their average/median values for a particular parameter? Such differences can be tested using Students T test/ANOVA (parametric) or Mann-Whitney U (non-parametric) tests. (2) Is a population over-represented for a particular trait/parameter? This can be answered using proportion analyses (e.g. Chi-Square or logistic regression (for multiple variables)). Interpretation of statistical outputs to determine the strength of an association, confidence intervals and significance levels will be discussed. Finally, the suitability of various statistical packages for the non-statistician, medical professional in context of ease-of-use will be addressed.

Learning Objectives

1. Understanding that statistical tests depends on the type of data that are being analyzed.

2. Understanding the difference between parametric and non-parametric data and statistical tests.
3. Understanding the interpretation of statistical outputs--what do the data mean?

[151] NAVIGATING INSTITUTIONAL REVIEW BOARDS AND SURVIVING THE JOURNEY

Michael Wiggins

Embry-Riddle Aeronautical University, Daytona Beach, FL, USA

(Education - Tutorial / Review)

INTRODUCTION: Research involving human subjects is required by law to be reviewed and approved by an institutional review board (IRB). Understanding the requirements and ensuring your application contains the necessary information are the keys to success. **TOPIC:** Any research involving human subjects is required by law to be reviewed and approved by a qualified IRB to ensure that the rights and welfare of participants who volunteer in research activities are protected. IRBs are federally mandated by the Department of Health and Human Services to regulate this protection by the respective institution. This presentation will firstly define what constitutes human subjects research. Thereafter, the key components of the regulations governing human subjects research encapsulated in Title 45 of the Code of Federal Regulations (CFR) Part 46 (and based on the "Common Rule" and 45 CFR Part 46) will be described. These components set the basis for the review process. Noteworthy is that each institution has a unique process flow based on these components. Understanding both the regulatory requirements and navigating the institutions' specific process flow will minimize the applicant's effort/time in preparing/revising an application towards an expedient approval. **APPLICATION:** Attendees will learn how best to follow their institution's process for gaining approval in an expedient manner but at the same time protecting the rights, dignity, and safety of participants. RESOURCES: Office of Human Research Protections, U.S. Department of Health and Human Services, https://www.hhs.gov/ohrp/regulations-and-policy/regulations/45-cfr-46/index.html

Learning Objectives

1. What research constitutes human subjects research?
2. Definition of the "Common Rule"
3. How best to navigate the IRB application process.

Tuesday, 05/19/2026, 4:00 PM

Plaza A/B

[S-23] PANEL: BEYOND SPLASHDOWN: A JOINT-FORCE FRAMEWORK FOR ARTEMIS MEDICAL RECOVERY OPERATIONS

Chair: Benjamin Johansen

Panel Overview: *For the first time since 1972, humanity is returning to the moon. The success of the Artemis program depends not only on the journey there, but on the safe recovery of the crew post splashdown. To meet this challenge, a joint medical team from NASA, the Canadian Space Agency (CSA), the U.S. Air Force, and the U.S. Navy has spent the last several years developing the first modern Tactics, Techniques, and Procedures (TTPs) for medical support at recovery for exploration missions. This session explores the architectural development process for joint medical recovery operations for Artemis missions. This panel will detail the joint-force integration required to execute medical recovery in a maritime environment. Panelists will guide attendees through five critical pillars: Space Medicine Training: Introducing principles of space medicine to military medical teams and establishing a progressive training framework from the classroom to high fidelity contingency simulations. US Air Force Support: The role of the Human Space Flight Support Office (DET3) in translating NASA requirements into DoD capabilities and creating repeatable mission products. US Navy Operational Integration: Adapting LPD-class ship processes to meet NASA objectives, focusing on team cohesion and how these mission sets improve standard Navy medical readiness. International Partner Integration: A review of the CSA's medical operations structure and the logistical "lessons learned" that will benefit future international partners involved in medical recovery operations. Mission Execution: A summary of the integrated team dynamics, exploring the uniqueness of multiple agencies and multiple Navy medical teams operating on a single vessel to create a repeatable recovery process. The lessons from the Artemis framework are vital for any professional involved in a complex, high-stakes, multi-agency medical response.*

[152] FROM APOLLO TO ARTEMIS: BUILDING A JOINT-FORCE MEDICAL TRAINING FRAMEWORK FOR LUNAR RECOVERY OPERATIONS

Richard Scheuring, Chris Haas

NASA, Houston, TX, USA

(Education - Program / Process Review)

INTRODUCTION: It has been over 50 years since the US has launched humans to the moon and utilized military assets to recover them safely back on earth. The joint force medical team had a daunting task of compiling decades of lessons learned from ground based and maritime recovery operations into a new training framework for joint medical operations. **OVERVIEW:** NASA flight surgeons, in conjunction with the medical training teams from Johnson Space Center, the Navy Expeditionary Medical Training Institute (NEMTI) and 1st Air Force

Detachment 3 (Det 3) developed medical scenarios to train recovery forces to diagnose and treat realistic medical conditions after a nominal or contingency landing. The Det 3 team, acting as NASA's representative to the Department of War (DoW) forces, developed an online space medicine overview and familiarization course required for all medical personnel supporting mission operations. During the pre-NASA Underway Recovery Tests (URT), the team engaged with US Navy medical personnel in nominal recovery tabletop scenarios that defined roles and responsibilities for all team members. This training culminated in open water medical contingency simulations. The team extended this effort to include input from contractor and NASA engineers who designed the Orion spacecraft, vehicle seat, and Orion Crew Survival Suit (OCSS) to develop plausible mechanisms of injury that would require application of Advanced Trauma Life Support (ATLS®) principles both in open water medical care and within the medical bay of US Navy recovery ship. Mission success criteria was defined as the DoW medical forces meeting all medical simulation objectives. **DISCUSSION:** The Artemis II lunar mission represents the first crewed return to the moon in over 50 years. This mission required the development of new medical training to ensure successful management of nominal launch and landing medical scenarios and return of the crew. The training program philosophy, "crawl-walk-run," enabled DoW medical forces, previously unfamiliar with operational space medicine, to successfully demonstrate care and management of astronauts returning from lunar missions with a range of nominal and off nominal medical conditions.

Learning Objectives

1. The learner shall become familiar with the training approach developed by NASA and the Det 3 for return of nominal and contingency medical conditions for future lunar missions.
2. The audience shall apply principles of operational space medicine to on orbit medical conditions and post landing recovery of astronauts from short duration lunar missions.
3. Learners will understand plausible mechanisms of injury for crew members post landing in the Orion spacecraft.

[153] FROM MERCURY TO ARTEMIS: EVOLVING DEPARTEMENT OF WAR'S DOCTRINE FOR ASTRONAUT RESCUE AND RECOVERY

Brent Maney, Cady Blasser, Kristin Silvia

USAF, Patrick Space Force Base, FL, USA

(Education - Program / Process Review)

BACKGROUND: As a national strategic imperative, U.S. Space Command (USSC) is the combatant command charged with leading and synchronizing Department of War (DoW) support for all U.S. human spaceflight programs. 1st Air Force, Detachment 3 (Det 3) serves as the core of this mission and is the sole DoW entity, which is singularly focused on this task since its creation for Project Mercury in 1959. Det 3 was established to solve the unique problem of

rescuing astronauts from a complex vehicle in a hazardous, global environment, providing a continuum of care from the point of injury to definitive treatment. **OVERVIEW:** This presentation will detail how Det 3 translates NASA's complex requirements into tangible DoW medical rescue and recovery capabilities on behalf of USSC. We will outline the methodology used to build mission products, including response plans, standardized medical kits, and crew extraction procedures. This repeatable process is used to train and certify a global network of joint rescue and recovery forces providing the critical direction needed to execute a no-fail mission. **DISCUSSION:** The core of the discussion will focus on the evolution and codification of Tactics, Techniques, and Procedures (TTPs). We will provide examples of how TTPs refined during Commercial Crew Program operations have been institutionalized into formal training products. These validated processes were directly applied to prepare joint partners, including specialized Navy personnel, for the unique challenges of the Artemis missions. This deliberate transfer of knowledge ensures the DoW maintains a ready, integrated, and highly capable joint force to fulfill its strategic role.

Learning Objectives

1. Describe the strategic role of 1st Air Force Detachment 3 in executing U.S. Space Command's directive to provide a global DoW response for human spaceflight.
2. Identify specific mission products Detachment 3 develops to create a repeatable training process for joint rescue forces.

[154] NAVY MEDICINE: THE DEFINITIVE FORCE FOR ARTEMIS RECOVERY

Savannah Pounds

U.S. Navy, Encinitas, CA, USA

(Education - Program / Process Review)

BACKGROUND: Artemis II's manned mission to lunar space necessitates a modern at-sea recovery capability, a mission the U.S. Navy is uniquely positioned to lead, building on its historic partnership with NASA. The challenges of open-ocean recovery for astronauts returning from deep space demand a robust and medically sophisticated solution. This mission adapts the Navy's expeditionary expertise to the specific demands of human spaceflight, reaffirming its role as the nation's premier maritime medical and recovery force. **OVERVIEW:** Centered on the LPD-17 class amphibious transport dock, the Navy's contribution to the Artemis Recovery and Trauma Expeditionary (ARTE) mission integrates six specialized Navy medical teams. This force includes the ship's organic LPD Medical department; a Fleet Surgical Team providing afloat Role 2 surgical care; an Expeditionary Resuscitative Surgical System (ERSS) for austere surgery; En-Route Care (ERCS) teams for in-flight patient transport; Search and Rescue (SAR) Medical Technicians for hoisting operations; and a specialized undersea Explosive Ordnance Disposal (EOD) medical team for initial astronaut assessment and egress. This construct provides an unbroken chain of medical care from the capsule to a definitive surgical facility.

DISCUSSION: The U.S. Navy is the ideal force for future Artemis recoveries due to its unparalleled combination of maritime platforms and expeditionary medical expertise. The LPD is the cornerstone of this suitability, serving as a sovereign mobile hospital, airfield, and recovery station. Its advanced medical facilities and ability to launch and recover both aircraft and watercraft are unmatched. The true strength lies in the seamless integration of its diverse medical teams. This 'team of teams' model ensures a continuum of care from the open ocean to the operating room, a capability unique to the Navy. This effort creates a sustainable and repeatable template, solidifying the Navy's indispensable role in the future of human space exploration.

Learning Objectives

1. Describe how the LPD-17 class amphibious transport dock and associated Navy medical teams enable end-to-end medical support for Artemis II at-sea recovery operations.
2. Identify the roles of ERSS, ERCS, SAR Medical Technicians, and other specialized teams in providing a continuum of care from splashdown to definitive surgical capability during the Artemis Recovery and Trauma Expeditionary mission.

[155] ONE TEAM, ONE MISSION: INTEGRATING INTERNATIONAL PARTNERS INTO THE ARTEMIS JOINT-FORCE MEDICAL RECOVERY FRAMEWORK

Michael Greene[1], Raffi Kuyumjian[2]

[1]Canadian Space Agency, Houston, TX, USA; [2]Canadian Space Agency, Montreal, Quebec, Canada

(Education - Program / Process Review)

BACKGROUND: Artemis II represents the first international crew to make the journey from the Earth to the Moon. Nominal and contingency planning for recovery of the Artemis II crew following ocean splashdown involves coordinated medical and operational efforts across civil, military, and international organizations. Within the Artemis Recovery and Trauma Expeditionary Medical Team (ARTE), International Partner (IP) participation was a deliberate and essential component, involving specific considerations to establish a complete and repeatable medical recovery capability for Artemis II and future international exploration missions.
OVERVIEW: This presentation focuses on the integration of the Canadian Space Agency (CSA) medical team into Artemis II crew recovery operations. CSA medical operations are structured to support astronaut health across all mission phases within a multinational human spaceflight framework. This talk reviews the CSA medical operations structure, its established working relationship with NASA medical operations, and the processes used to integrate CSA flight surgeons into U.S.-led expeditionary recovery activities. International partner flight surgeon participation required coordination of roles, clinical workflows, standards of practice, and communication interfaces within a joint NASA–Department of Defense–U.S. Navy operational environment. Integration extended beyond clinical considerations to include an understanding of how medical roles and workflows interface with U.S. Department of Defense–

supported maritime recovery operations. These elements were progressively exercised and refined during Underway Recovery Tests (URT-10, -11, and -12), supporting effective participation by international medical personnel during recovery operations development, rehearsals, and mission execution. Additional unique considerations associated with international partner integration are reviewed, including security clearances, credentialing, badging, travel logistics, access to controlled information, and synchronization of agency-specific processes and contingency planning requirements. **DISCUSSION:** Lessons learned emphasize the importance of early coordination, clear role definition, and structured integration pathways to enable international medical teams to function effectively within U.S.-based operational constructs. The Artemis II experience establishes a foundation to help inform future international partner participation in crew recovery operations for subsequent exploration-class missions.

Learning Objectives

1. Describe how Canadian Space Agency (CSA) flight surgeons were integrated into Artemis II crew recovery operations within a multinational operational environment.
2. Identify key operational considerations and lessons learned unique to international partner medical integration that inform future exploration-class crew recovery missions.

[156] FORGING A TEAM: INTEGRATING MULTI-AGENCY MEDICAL EXPERTISE FOR ARTEMIS II CREW RECOVERY

Matthew Bidlack

U.S. Navy, Carlsbad, CA, USA

(Education - Program / Process Review)

BACKGROUND: As the first crewed lunar mission in over 50 years, the Artemis II splashdown recovery presented a novel challenge: assembling a cohesive medical team from disparate military, civilian, and international agencies. The success of this high-stakes recovery hinged not just on clinical skill, but on the ability to rapidly forge a unified team of experts from the U.S. Navy, U.S. Air Force, NASA, and the Canadian Space Agency. This is critical to aerospace medicine specialists as future space operations will increasingly rely on such complex, multi-agency partnerships to ensure mission success. **OVERVIEW:** The solution was a purpose-built training pipeline designed to build trust and create seamless team cohesion across all units. This effort began with foundational space medicine coursework and progressed through integrated, high-fidelity scenarios, including NASA's Neutral Buoyancy Lab and full-mission rehearsals at sea. This progressive training forged individual specialists—including seven distinct Navy medical commands operating alongside their interagency partners on a single LPD-class ship—into a single ARTE (Artemis Recovery and Trauma Expeditionary) Medical Team, capable of operating with a shared mental model under extreme pressure. **DISCUSSION:** The operational significance lies in the successful execution of the mission through the integration of multiple organizational cultures into one high-performing unit. The unique team dynamics achieved on the ship validated that military, civilian, and international medical personnel can be effectively

fused to support complex operations. This work advances aerospace medicine by providing a proven, human-centric "playbook" for building a joint expeditionary medical team. The development of a standardized training pipeline and its codification into tactical guidance establishes a repeatable and scalable framework, ensuring that the lessons learned from Artemis II will directly support the safety and success of all future crewed spaceflight recovery missions.

Learning Objectives

1. Describe team-building methods used to breakdown silos to fully integrate the ARTE Medical Team and ensure cohesive execution of the Artemis II recovery mission.
2. Explain efforts to codify the integration of military, civilian, and international medical personnel onto a single LPD-class platform to create a repeatable team-building process for future crewed spaceflight recovery missions.

Tuesday, 05/19/2026, 4:00 PM

Plaza D

[S-24] PANEL: AGING. IT AIN'T WHAT IT USED TO BE! THE GOOD NEWS ABOUT CARDIOVASCULAR RISK IN OLDER AIRCREW

Chair: David Holdsworth

Co-Chair: Norbert Guettler

Panel Overview: *"How should we manage the increasing medical risk associated with aging?" This is a vexed question in aerospace medicine. In most regulatory jurisdictions, the age of pilots is increasing. The advent of space tourism, also challenges the traditional paradigm of exclusively young, fit humans venturing beyond the confines of our atmosphere. Cardiovascular (cv) disease is degenerative and the risk of myocardial infarction and stroke rises inexorably, and exponentially, with age. Our panel will critique the traditional approach to screening for cv risk in older aircrew - a population-based 10-year risk score followed by individualised risk stratification using exercise stress testing (exercise ECG), functional (stress echo, stress MRI and nuclear perfusion) and anatomical imaging (coronary artery calcium scores (CACS) and CT coronary angiography). One clear challenge of the 10-year risk score is that, even with an optimal risk profile, the 1% risk threshold may be reached through age alone, at an age that is still consistent with commercial/military flying duties. We will address the increased risk of cardiovascular disease with age, and the related challenges that this risk is not equally distributed by sex, or by race. The ethical and political challenges will be explored further to encompass regulatory, legal and financial considerations of health screening in this older age group. New modalities, or forms of analysis, offer the potential to enhance the accuracy and precision of predicting aeromedically significant risk. However, it takes time to collect prospective clinical outcome data from new technologies. We will summarise the existing evidence for prognostic data : in exercise testing for peak capacity and in CACS, before*

introducing the role of 'standard' anatomical CT angiography and the future prospect of radiomic analysis of CT to yield data on coronary inflammation that may better predict the risk of hard clinical events. Aging is not only associated with increased risk of coronary artery disease, but also with higher incidence of arrhythmia and acquired valvular heart disease. We will present examples of specific age-associated pathology in electrophysiology and valvular heart disease. Panel presentations will conclude with a synthesis of the panel's approach to cv risk assessment in an asymptomatic population of older aircrew.

[157] AGE, A 'GLASS ALTITUDE' – THE TYRANNY OF 10-YEAR CARDIOVASCULAR RISK

David Holdsworth[1], Philip Laird[2], Lysette Broekhuizen[3], Thomas Syburra[4], Denis Bron[5], Olivier Manen[6], Gary Gray[7], Eddie Davenport[8], Norbert Guettler[9]

[1]British Army, Birmingham, West Midlands, United Kingdom; [2]Queen's University, Canada, Kingston, Ontario, Canada; [3]University Medical Centre, Utrecht, Netherlands; [4]Hopital de La Tour, Geneva, Switzerland; [5]Aeromedical Centre, Dubendorf, Switzerland; [6]Service de Santé des Armées (SSA), Paris, France; [7]Canadian Society of Aviation Medicine (Fellow), Calgary, British Columbia, Canada; [8]United States Airforce, Dayton, OH, USA; [9]German Air Force Centre of Aerospace Medicine, Cologne, Germany

(Education - Program / Process Review)

BACKGROUND: Assuring the medical risk of older pilots presents a challenge to international aviation authorities. Older pilots, both civilian and military, are typically the most experienced in the service, and will generally command the aircraft they operate. Age is commonly a protected characteristic in national employment law, and there is pressure not to restrict work on the basis of age alone. At the same time, age is a non-modifiable risk factor for cardiovascular disease and plays a major role in estimating the 10-year risk, upon which cv health screening is founded. **DESCRIPTION:** A basic tool of primary prevention in cardiovascular disease is the population-based risk calculator to estimate 10-year risk. Calculators of increasing sophistication and complexity have been developed to estimate risk based on age, sex, cardiovascular risk factors and sometimes also race and socioeconomic status. The challenge such estimates present to occupational risk management in aircrew is that even pilots with optimal/low-risk may exceed a 10%, 10-year (1% per annum) risk based on age in their early 60s, while they still have regulatory approval to fly commercially (age <65). We will present data demonstrating that asymptomatic, low-risk, non-smoking men, with no diagnosis of hypertension, dyslipidaemia or diabetes exceed the 1% annual risk threshold for a heart attack or stroke on the basis of age and sex alone ≤65 years. This challenge confronts low-risk pilots assessed by the Framingham hard-cv-outcomes score (low-risk men age 62), Reynolds risk score (low-risk men age 65), ASCVD score (low-risk white men aged 62, low-risk African American men age 64), QRISK-3 [UK] (low-risk white men aged 63, low-risk Pakistani men age 56). When comparing these international cv-risk scores, the European Society of Cardiology recommended SCORE-2 is an outlier: rating all low-risk men and women from Western Europe at less than a 10%, 10-year risk up until age 68-76. **DISCUSSION:** Age-related breaching of the regulatory threshold for aeromedical safety (1% pa) places considerable pressure on the medical approach to mitigating

this risk, with individual-focussed medical assessment. This is the topic we will address in the panel.

Learning Objectives

1. To understand the impact of age alone as a key determinant of cardiovascular risk and the implications for aeromedical safety.
2. To understand that a population-based cardiovascular risk calculator provides a useful estimate of risk, but that risk is not the same as disease.
3. To understand the important interaction of age with sex and race in cardiovascular disease risk.

[158] ARRHYTHMIAS, CONDUCTION DISORDERS, AND VALVULAR HEART DISEASE IN THE AGING PILOT

Norbert Guettler[1], Thomas Syburra[2], David Holdsworth[3], Olivier Manen[4], Lysette Broekhuizen[5], Denis Bron[6], Gary Gray[7], Philip Laird[8], Eddie Davenport[9]

[1]German Air Force Centre of Aerospace Medicine, Cologne, North Rhine-Westphalia, Germany; [2]Hopital de la Tour, Meyrin, Switzerland; [3]British Army, Oxford, United Kingdom; [4]Percy Military Hospital, Clamart, France; [5]University Medical Center, Utrecht, Netherlands; [6]Aeromedical Centre of the Swiss Air Force, Dübendorf, Switzerland; [7]Canadian Forces Environmental Medical Establishment, Toronto, Ontario, Canada; [8]Royal Canadian Air Force, Kingston, Ontario, Canada; [9]US Air Force School of Aerospace Medicine, Dayton, OH, USA

(Education - Program / Process Review)

BACKGROUND: The incidence of arrhythmias, including atrial fibrillation (AF), premature ventricular contractions (PVC), conduction disorders, and bradycardia increases with age. Therefore, investigation of these diseases is crucial for middle-aged and older pilots. Valvular heart disease (VHD) also becomes increasingly prevalent with age, particularly degenerative conditions such as aortic stenosis and mitral regurgitation. In older aircrew, these lesions may remain asymptomatic yet be aeromedically significant. Even minor abnormalities require detailed aeromedical risk stratification. **DESCRIPTION:** According to current guidelines, the diagnosis of AF should entail investigation for underlying cardiac and non-cardiac disease and risk factors. The presentation of AF with regard to symptomatology, arrhythmia burden, and thromboembolic risk is variable, and has to be considered for aeromedical decision. Such a variety of symptoms, arrhythmia burden and complications also exist for PVC; different forms, management and treatment indications will be discussed. In case of extreme bradycardia in a middle-aged or older pilot, evaluation must focus on the differential diagnosis between sick sinus syndrome or conduction disease, and high vagal tone. Further evaluations, for example by periodic echocardiography, other cardiac imaging, and ambulatory ECG will be discussed. Similarly, incidental detection of VHD—particularly aortic sclerosis, early stenosis, or mitral valve regurgitation requires focused interpretation. Licensing decisions must balance the functional impact of valvular lesions under high workload conditions, risk of progression, and

the potential for arrhythmias leading to sudden incapacitation. The role of advanced diagnostic testing will be addressed. **DISCUSSION:** The incidence of arrhythmias and conduction disorders increases in middle-aged and older pilots. In some diseases including AF, there is an additional association with endurance exercise. Aeromedical assessment requires systematic or opportunistic screening for certain arrhythmias; advantages and disadvantages of screening devices, modern treatment options, and aeromedical decision making will be discussed. Age-related valvular degeneration poses an emerging challenge in this demographic group of pilots. Screening strategies for VHD, including the role of periodic imaging and functional testing, need to be evaluated considering operational risk and progression kinetics. Valvular heart surgery (and transcatheter intervention) can restore fitness to fly but require careful post-operative aeromedical assessment to determine acceptable risk thresholds.

Learning Objectives

1. Learn examples of frequent arrhythmias in middle-aged or older pilots.
2. Learn differences in the management of arrhythmias in older age groups as compared to young applicants.
3. Understand the aeromedical relevance of age-related valvular heart disease in pilots and its implications for flight safety, valvular heart surgery and licensing decisions.

[159] ETHICAL, REGULATORY AND PRAGMATIC CONSIDERATIONS IN CARDIOVASCULAR SCREENING OF OLDER AIRCREW

Phil Laird[1], David Holdsworth[2], Lysette Broekhuizen[3], Thomas Syburra[4], Denis Bron[5], Olivier Manen[6], Gary Gray[7], Eddie Davenport[8], Norbert Guettler[9]

[1]Canadian Armed Forces, Kingston, Ontario, Canada; [2]British Army, Fort Rucker, USA; [3]-, Netherlands; [4]Swiss Army, Geneva, Switzerland; [5]Swiss Army, Switzerland; [6]., Paris, France; [7]Canadian Armed Forces, Toronto, Ontario, Canada; [8]US Air Force, Dayton, OH, USA; [9]., Germany

(Education - Program / Process Review)

BACKGROUND: The management of cardiovascular risk in older pilots is challenging. Newer tools make clinical risk prediction more precise but with added cost and complexity. A pragmatic approach is needed to balance clinical risk, employment law and fairness, medical ethics and cost. **DESCRIPTION:** Increasing age is an unmodifiable risk factor and has historically been used at least partially as a surrogate for risk of incapacitation due to cardiovascular and neurodegenerative causes. Certainly coronary artery disease, arrhythmias, valve disease and heart failure do increase in prevalence with age. Increasing age does not affect the risk of incapacitation equally between the sexes or across all races and in most jurisdictions, employment law quite rightly seeks to prevent discrimination based on age, sex and race This creates a tension which regulators must negotiate, and thus expert panels must consider. **DISCUSSION:** The current approach in asymptomatic aircrew is to use a risk score to trigger

individualized cardiovascular assessment at a pre-determined threshold. The validity of these risk scores remains a significant question. There is constant pressure to identify the ideal cardiovascular screening tests that would quantify the risk of an incapacitating event in a given period. Such a prediction, substantiated by evidence could be used regardless of age, sex and race, thus avoiding legal and political hurdles. Even for validated tests which accurately quantify risk, there are further ethical challenges. There is an important difference between clinical indications to rule out disease in a symptomatic patient, and occupational indications to continue flying; more so when there is a risk (albeit small) associated with testing. It is also important to consider who should pay for testing: the employer, regulator or pilot themselves. Implications, both clinical and financial, of incidental findings also need to be considered. Within this panel topic, we will review this topic from a regulatory and ethical standpoint and consider the perspective of regulator, employer and pilot.

Learning Objectives

1. The participant will gain an appreciation of key considerations in developing clinical recommendations for cardiovascular screening given complex legal and regulatory frameworks in different nations.
2. The participant will gain an appreciation of the potential downstream impacts of aircrew cardiovascular screening in terms and how these can be at least partially addressed in the policy development process.

[160] THE FINAL APPROACH: MAKING SENSE OF CARDIAC RISK IN THE AGING AVIATOR

Eddie Davenport[1], Gary Gray[2], David Holdsworth[3], Norbert Guettler[4], Lysette Broekhuizen[5], Thomas Syburra[6], Phil Laird[7], Denis Bron[8], Olivier Manen[9]

[1]US Air Force, Dayton, OH, USA; [2]Royal Canadian Air Force, Ottawa, Ontario, Canada; [3]British Army, Fort Rucker, AL, USA; [4]German Aerospace Centre, Colgne, Germany; [5]University Medical Centre, Utrecht, Utrecht, Netherlands; [6]Hopital de La Tour, Geneva, Switzerland; [7]Queen's University, Kingston, Ontario, Canada; [8]Fliegerärztliche Institut, Dubendorf, Switzerland; [9]Hôpital d'Instruction des Armées Percy, Paris, France

(Education - Program / Process Review)

BACKGROUND: Cardiovascular disease screening in the general population remains a subject of debate, and this complexity is amplified when applied to specialized groups such as athletes, tactical athletes, and aircrew members. Among aging aircrew, the challenge intensifies, and there is a critical need for a nuanced, evidence-based approach to assessing cardiac risk. Establishing a consensus on cardiovascular risk assessment in aging aviators, particularly from experts in aerospace cardiology, could significantly mitigate the risks of sudden incapacitation and enhance overall flight safety. Data from the previous presentations offer valuable insights that can be synthesized into a comprehensive, actionable framework for current practice and future research.
DESCRIPTION: This presentation will provide an in-depth overview of aeromedical

cardiovascular risk assessment among aging aircrew across seven nations, highlighting the variations and commonalities in their approaches. A coherent, consensus-based strategy, developed by an international aerospace cardiology working group, will be presented. Based on the latest evidence, the consensus holds that age should be used as a threshold for initiating additional evidence-based testing, rather than as a sole determinant of risk. Once an aviator reaches the defined threshold age, targeted cardiovascular evaluations—such as stress tests, echocardiograms, and advanced imaging—will be performed, accompanied by a clear schedule for follow-up assessments **DISCUSSION:** The issue of cardiac risk in aging aviators is both timely and critical, particularly for aeromedical examiners, flight surgeons, and aerospace health professionals. While individual aeromedical authorities (military, civilian, ground-based, and aircrew) may have differing methodologies for evaluating cardiac risk, a unified, evidence-based framework is urgently needed. Establishing this common foundation not only ensures that all aircrew—military and civilian—receive the best preventive care, but it will also help prevent potentially life-threatening events in flight and could pave the way for a safer future in aerospace operations.

Learning Objectives

1. The participant will be able to understand the nuances of screening for cardiovascular disease in older aircrew.
2. We will summarize the panel lectures and discussions into an actionable plan with consensus among experts regarding cardiovascular risk assessment in aging aircrew.

[161] MOVING ON TO PRECISE PREDICTION; SCREENING WITH CTCA

Lysette Broekhuizen[1], David Holdsworth[2], Philip Laird[3], Thomas Syburra[4], Denis Bron[5], Olivier Manen[6], Gary Gray[7], Eddie Davenport[8], Norbert Guettler[9]

[1]Central Military Hospital of the Netherlands, Utrecht, Utrecht, Netherlands; [2]University of Oxford, Oxford, United Kingdom; [3]University of Queen's, Kingston, Canada; [4]Hopital de la Tour, Geneva, Switzerland; [5]University of Basel, Basel, Switzerland; [6]Service de Sante des Armees, Clamart, Ile-de-France, France; [7]Canadian forces environmental medical establishment/ McGill University, Toronto, Ontario, Canada; [8]Wright Patterson Air Force Base, Dayton, OH, USA; [9]German air force center for aerospace medicine, Cologne, Germany

(Education - Program / Process Review)

BACKGROUND: Cardiovascular risk scores (CVRS) are usually validated from the age of 40 and older and have a lower predictive value in a young and healthy military population. This can lead to unnecessary restrictions where at the same time people with disease will be overlooked. Coronary artery calcium score (CACS) is a strong predictor of coronary events in asymptomatic adults, independent of traditional risk factors. The ACC/AHA recommend that CACS ‘should be’ considered in adults aged 40-75 with an intermediate 10-year risk (7.5%-20%). In younger patients there is a higher risk of false negatives due to missing non-calcified soft plaque disease.

Description: We will present cases from the Dutch SUSPECT study showing 211 asymptomatic military aircrew (median age 49.3 years (43.6–52.8), all men) with both clinically (CR-CAD) and aeromedically relevant (AR-CAD) coronary disease on CT coronary angiography (CTCA), who do not meet the 1% annual risk threshold for a heart attack or stroke according to various CVRS like the Reynolds Risk Score (RRS) and SCORE2. In SUSPECT, CR-CAD is defined as CACS ≥100 and/or a stenosis ≥50%. AR-CAD includes CR-CAD and/or a left main stenosis >30% or an aggregate stenosis ≥120%. The RRS was available for 76 participants (36%). CTCA performed better than traditional risk scores, as only two of six men with >10% risk had AR-CAD. Conversely, six persons with RRS <10% had AR-CAD, and enhanced screening based on risk scoring alone would not have identified these individuals. In total CR-CAD was found in 25 male aircrew (12%), with a CACS of ≥100 in 21 (10%) and a stenosis ≥50% in 10 (5%), including two with CACS 0. Two additional men had ≥120% aggregate stenosis, bringing total AR-CAD to 27 (13%). Discussion: CTCA appears to be more effective than RRS in identifying relevant CAD among asymptomatic, low-risk individuals in high-hazard occupations, however the significance of the anatomical findings for aeromedical risk reduction needs further determination.

Learning Objectives

1. Learn about pitfalls of the cardiovascular risk scores in middle aged pilots.
2. Discuss cases with a non high cardiovascular risk score who were positive for aeromedically relevant coronary disease on CTCA.
3. Learn what is known about the prognostic value of CTCA and understand how concepts like plaque burden and plaque composition can be used to further personalize cardiovascular risk.

Tuesday, 05/19/2026, 4:00 PM

Plaza F

[S-25] SLIDE: RUNNING ON EMPTY: FATIGUE, WORKLOAD AND METRICS

Chair: Ian Mollan

Co-Chair: Katarzyna Sowa

[162] IMPACT OF SLEEP QUALITY ON PAIN BURDEN, STRESS RESPONSE, AND MISSION RECOVERY IN FIGHTER PILOTS OF 5TH-GENERATION AIRCRAFT

Geoffrey Carl Rodriguez[1], Brian Stemper[1], Rachel Cutlan[1], Katherine Sherman[2], Hershel Raff[1], Keri Hainsworth[1]

[1]Medical College of Wisconsin, Milwaukee, WI, USA; [2]Clement J. Zablocki VA Medical Center, MILWAUKEE, WI, USA

(Original Research)

INTRODUCTION: Fighter pilots (FPs) of 5th-generation aircraft endure sustained G-forces, helmet weight, and restricted postures that increase cervical spine load and musculoskeletal pain. Sleep plays a critical role in pain modulation, stress resilience, and recovery, yet its operational impact in fighter aviation is poorly understood. The Pittsburgh Sleep Quality Index (PSQI) offers a multidimensional assessment of sleep disturbance that may identify modifiable factors affecting readiness. We hypothesized that poorer pre-flight sleep would correlate with greater baseline pain, elevated post-flight pain and stress, and slower recovery trajectories. **METHODS:** Twenty-three FPs (21 male, 2 female) completed the PSQI one day before scheduled flight training. Pain and stress intensity were self-reported using 0–10 numeric rating scales at baseline and for 14 consecutive post-flight days. Analyses compared baseline pain between good (≤4) and poor (≥5) sleepers, examined PSQI domain correlations with pre- and post-flight outcomes, and explored recovery phenotypes based on pain and stress trajectories. Statistical tests included two-tailed t-tests and Pearson correlations (p<0.05). **RESULTS:** Poor sleepers reported higher baseline pain (3.4±1.9 vs 1.4±1.4, p=0.01). Increased sleep latency, shorter duration, greater disturbance, and daytime dysfunction correlated with higher pre-flight pain. Sleep latency predicted elevated post-flight pain, while sleep disturbance predicted increased post-flight stress. Recovery duration for pain and stress were positively associated (p=0.009), identifying five recovery phenotypes ranging from rapid resolution to prolonged high-burden pain. Pilots with extended recovery exhibited greater neck pain disability and slower return to baseline function. **DISCUSSION:** Poor sleep quality is strongly linked to heightened pain, greater stress, and delayed recovery in fighter pilots. Sleep emerges as a modifiable operational health factor with direct implications for mission endurance and long-term musculoskeletal health. Early identification of high-risk aviators could guide sleep optimization strategies that sustain readiness, performance, and resilience across repeated flight demands.

Learning Objectives

1. Upon completion of this activity, participants will be able to describe the association between pre-flight sleep quality and baseline pain, post-flight pain intensity, stress response, and recovery duration in fighter pilots operating 5th-generation aircraft.
2. Upon completion of this activity, participants will be able to evaluate sleep quality as a modifiable operational health determinant and discuss its relevance to mission endurance, human performance optimization, and preventive strategies in military aviation populations.

[163] FLIGHT OUTCOMES UNDER HIGH WORKLOAD AND FATIGUE

Kathryn Feltman[1], Isaiah Persson[2]

[1]U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, USA; [2]U.S. Army Aeromedical Research Laboratory/Chickasaw Nation Industries, Fort Rucker, AL, USA

(Original Research)

INTRODUCTION: Maintaining safe flight requires managing tasks effectively. Even with automation, the aviator remains responsible for ensuring appropriate actions are being taken. This task can be challenging during mundane circumstances but can become exponentially more difficult when faced with additional stressors such as fatigue and high task load. As Army aviation introduces increasingly complex technology and operational environments, it is crucial to understand how each stressor impacts performance so that appropriate mitigation techniques can be used. Here we examined flight performance outcomes of a larger study where fatigue and workload were manipulated. **METHODS:** Eleven rated, U.S. Army active-duty aviators completed the study. Across 33-hours of sustained wakefulness, they completed four sets of flights within a UH-60 simulator. Each set included two different scenarios (high/low workload). Flights were designed to compare Session 1 vs. 3 and Session 2 vs. 4 outcomes, resulting in two sets of flight data. Linear mixed-effects models were used to evaluate the main effects of fatigue and workload and an interaction effect on performance outcomes. The performance outcome for Sessions 1 and 3 was the deviation from specified rate of closure while airspeed was used in Sessions 2 and 4. **RESULTS:** The comparison of Sessions 1 and 3 yielded a main effect of fatigue (session), $p = 0.045$, and interaction between session and workload, p < 0.001, on rate of closure. There was a faster rate of closure during high workload at Session 1, compared to low workload, Session 3. The opposite was found for the low workload conditions. Flight Sessions 2 and 4 also yielded a significant interaction between fatigue (session) and workload (high vs. low), p <0.001. Greater airspeed deviations occurred during the high workload condition of Session 2 vs. that in Session 4, while the opposite was seen between the low workload conditions. **DISCUSSION:** The worst performance was noted in the high workload condition during Session 3. This finding suggests that the experience of sleep deprivation amplified the effects of workload. However, for Session 4, when participants were the most sleep deprived, the worst performance occurred during the low workload condition. This may be indicative of a lack of engagement or motivation. The key finding, given the different outcomes related to workload, is that extreme fatigue seems to have the greatest impact on performance outcomes.

Learning Objectives

1. Define the concept of workload as applied to Army aviation.
2. Understand factors that impact pilot performance in Army aviation, such as workload and fatigue.

[164] WITHDRAWN

[165] BENCHMARKING FATIGUE IN UNITED STATES HELICOPTER AIR AMBULANCE PILOTS

Hannah Baumgartner[1], Justin Durham[2], Teena Sanders[2], Sarah Westrick[3], Cassie Hilditch[4]

[1]Federal Aviation Administration, Oklahoma City, OK, USA; [2]Cherokee Federal, Oklahoma City, OK, USA; [3]Wakeforest University, Wakeforest, NC, USA; [4]San Jose State University, San Jose, CA, USA

(Original Research)

INTRODUCTION: Helicopter air ambulance (HAA) pilots are exposed to fatigue risk due to on-call and shiftwork operations required for 24-hour emergency service. Previous research on fatigue in HAA operations has largely focused on European operators, many of whom operate through state-run emergency service providers. Most HAA services in the United States (US) instead operate as private companies, with a variety of company policies and environments that could differentially affect pilot fatigue. The current field study aimed to provide a benchmark for fatigue in US HAA operations to inform future fatigue management strategies. **METHODS:** US HAA pilots working 7-days-on, 7-days-off schedules were invited to participate in the field study. Data collection included 3 days pre-duty-block, 7 days on-duty-block, and 3 days post-duty-block. Pilots completed a 5-min psychomotor vigilance task (PVT), Karolinska Sleepiness Scale (KSS), and Samn-Perelli (SP) ratings at pre-, mid-, and post-duty times. Backward stepwise regression evaluated the contribution of potential covariates (e.g., sex) to retain in the analysis of primary dependent variables. Mixed-effects models with a random intercept of participant were performed to evaluate changes in PVT speed, PVT lapses, KSS scores, and SP scores across the 7-day on-duty-block and between phases of the schedule (pre-duty block, duty block, and post-duty block). **RESULTS:** One hundred and twenty pilots completed data collection from 21 different US HAA companies. Across the 7-day on-duty-block, PVT speed significantly decreased (p<0.001) and PVT lapses significantly increased (p<0.001), while KSS and SP ratings remained relatively stable. PVT performance (speed: p<0.001; lapses p<0.001), KSS (p<0.001), and SP (p<0.001) significantly degraded across the schedule phases, with worst outcomes during the post-duty-block. **DISCUSSION:** These results offer the most comprehensive assessment of US HAA pilot fatigue since the introduction of updated HAA regulations in 2014. Pilots demonstrated expected effects of accumulated fatigue across the 7 days on duty and showed poor post-duty-block recovery. These findings offer areas to target with fatigue mitigations, such as including the number of days on duty in pre-flight risk assessments. Future analyses will evaluate the effects of time-of-day across different schedule rotations.

Learning Objectives

1. Understand the unique fatigue risks faced by helicopter air ambulance pilots.
2. Understand the effects of cumulative fatigue on shift workers in air ambulance operations.

[166] HEART RATE VARIABILITY (HRV) RESPONSES TO ACUTE SLEEP DEPRIVATION AND COGNITIVE WORKLOAD IN A MILITARY FLIGHT SIMULATOR

Aleksi Lehmusaho[1], Jukka Koskelo[2], Taija Lahtinen[3], Tuomas Selander[4], Airi Kilpeläinen[5], Juha Hartikainen[1], Kerttu Huttunen[6], Tomi Laitinen[1], Tuomo Leino[7]

[1]University of Eastern Finland, Kuopio, Finland; [2]A-Clinic Foundation, Helsinki, Finland; [3]Centre for Military Medicine, Rovaniemi, Finland; [4]Kuopio University Hospital, Kuopio, Finland; [5]Oulu University Hospital, Oulu, Finland; [6]University of Oulu, Oulu, Finland; [7]Air Force Command Finland, Tikkakoski, Finland

(Original Research)

INTRODUCTION: Cognitive workload (CWL) and sleep deprivation both contribute to fatigue, a major source of human error in aviation operations, highlighting the need for pilots' real-time physiological monitoring. Pilots are frequently exposed to sleep deprivation and nocturnal operations. However, the evidence on the effects of sleep loss on cardiac autonomic stress responses in the aviation context remains limited. HRV is an established method for assessing dynamic changes in autonomic nervous system modulation. This study investigated the utility of HRV for detecting fatigue and real-time variations in CWL during acute sleep deprivation (ASD). **METHODS:** Six male student pilots participated in a sleep deprivation protocol involving up to 33 hours of continuous wakefulness. Data were collected in a Hawk flight simulator after 5, 22, and 29 hours of wakefulness (HoW) with HRV continuously recorded during simulator tasks. Each simulator session comprised flight phases with varying levels of cognitive demand. HRV metrics included mean RRI, time- (RMSSD, pNN50, SDNN) and frequency-domain indices (HF, LF, nHF, nLF, and LF/HF). CWL was assessed from data recordings by a flight instructor. Subjective sleepiness and mood were self-reported at each HoW using the Stanford Sleepiness Scale and the Profile of Mood States. The study was approved by the local ethics committee. **RESULTS:** During sleep deprivation, HRV tended to increase as a function of HoW, and during cognitively demanding tasks, HRV decreased. Linear mixed-model analyses showed that wakefulness duration had a significant main effect on two HRV indices (mean RRI, p<.001; RMSSD, p=.013) and on all scales of sleepiness and mood (p<.001). Flight phase had a significant main effect on CWL (p=.002) and on multiple HRV indices, including mean RRI (p=.006), RMSSD (p=.003), pNN50 (p=.011), HF (p=.003), nHF (p=.013), and nLF (p<.001). **DISCUSSION:** These findings extend prior research on the use of HRV to monitor CWL in military flight simulators and demonstrate that HRV sensitively captures short-term, real-time CWL variations under ASD. Sleep deprivation was associated with higher baseline HRV, independent of circadian influences. These results support the use of HRV indices for monitoring pilot CWL and sleep deprivation–related fatigue.

Learning Objectives

1. The audience will understand the utility of heart rate variability (HRV) for objective monitoring of pilots' cognitive workload during flight simulator tasks.
2. The audience will understand how acute sleep deprivation influences HRV responses in young military pilots.

[167] EFFECTS OF OCCUPATIONAL NOISE EXPOSURE ON SLEEP

Robin Dodge

U.S. Air Force, Boulder, CO, USA

(Education - Program / Process Review)

BACKGROUND: Aerospace medical professionals are likely familiar with the impact of noise exposure as it relates to hearing loss but may not be as familiar with the short-term effects of noise on sleep quality. This presentation will prepare human performance specialists with a broader understanding of how noise impacts our warfighters and highlights the need for further research specific to military aircrew operations. **OVERVIEW:** Though there is an abundance of literature addressing noise exposure during sleep, there is limited research that has been conducted on how occupational noise impacts sleep after exposure. Early research has indicated that long duration exposures as low as 50 decibels elicit a noise-stress response and that noise levels above 75 decibels are significantly associated with increased cardiovascular diseases, sleep disturbances, and decreased cognitive performance. Aircrew are exposed to anywhere from 75 to over 100 decibels in military aircraft, often for several continuous hours on multiple days a week. **DISCUSSION:** Inadequate sleep is not only a known performance inhibitor, but also one of the major risk factors for neurodegenerative disease, metabolic disorders, and poor mental health. Fatigue mitigation strategies that are focused on circadian disruption caused by variable flight schedules and rapid time zone changes are good steps towards improved performance and quality of life, but these only address a small part of the problem. Hearing conservation programs additionally miss an opportunity to target the full scope of noise exposure risks and need to expand to include mitigation efforts for other disorders related to noise exposure.

Learning Objectives

1. The audience will learn about how occupational noise exposure impacts sleep.
2. The audience will learn about how poor sleep impacts performance.
3. The audience will learn about the correlation between poor sleep and adverse health conditions.

Tuesday, 05/19/2026, 4:00 PM

Governor's 10

[S-26] SLIDE: MOTION SICKNESS AND SPATIAL DISORIENTATION

Chair: Stephen Vanderark

Co-Chair: Paul Chapell

[168] MOTION SICKNESS DESENSITIZATION

Jennifer Watne, Thomas Zeidlik

University of North Dakota, Grand Forks, ND, USA

(Education - Program / Process Review)

INTRODUCTION: Motion Sickness Desensitization training with civilian pilots using a fixed wing full motion simulator. **BACKGROUND:** Motion sickness is an unfortunate condition that is fairly common, especially in new pilots. Some students start their flight training either not knowing they suffered from motion sickness or did not realize it was as severe as they thought. With the combination of the cost of flight school, and for some having dreamed of being a pilot since they were a child, this can be a devastating and life changing condition to try and deal with. **OVERVIEW:** The military has had success for decades using motion sickness desensitization therapy utilizing spin training with a Barany chair. We have adopted the USAF Manual 11-403, (Aerospace Physiological Training program) which focuses on spin exposure to help desensitize a subject to motion sickness. The program has been built into a profile in our GAT III trainer and has been used successfully with 30+ subjects. **DISCUSSION:** The programs run over three consecutive days with each training session lasting about one hour. The spinning is done in ten-minute increments with ten-minute rest breaks in-between. The velocity of the yawing (spinning) is increased by 2-3 RPM for each session. The instructor has constant contact with the subject providing holistic treatment methods such as peppermint or ginger for symptoms of nausea, distractions by flying the simulated aircraft while it spins, comfort measures such as talking with the instructor, playing their favorite music over the headset, or having the subject visualize a place that brings them peace and comfort. Subjects are advised to continue exposing themselves for at least ten minutes, twice a week to abnormal motions to help the desensitization remain active. **CONCLUSION:** At this current time, there have been 30+ participants. Each participant has reported a level of improvement with the majority of the cases being able to do any activity with very little to no symptoms of motion sickness. This treatment has also shown that not only is the physical exposure important, but the mental component (the subject's ability to manage the symptoms, and to have the confidence to do so). At least half of the subjects admit their anxiety about motion sickness likely caused or greatly amplified their symptoms during situations they had previously experienced it.

Learning Objectives

1. Participants will get a brief review of the theories behind what causes motion sickness.
2. Participants will get an overview of how exposure to the training can physically and mentally improve the symptoms of motion sickness in those individuals affected.
3. Participants will get an overview of the outcomes that have occurred in 30+ subjects that have undergone this type of training.

[169] EFFECTS OF HELMET MOUNTED DISPLAY FORMAT AND SPATIAL AUDIO CUEING ON PILOT PERFORMANCE AND SPATIAL ORIENTATION MAINTENANCE

Henry Williams[1], Eric Geiselman[2], Thomas Schnell[3], Darci Gallimore[4], Kendra Carter[5], Dain Horning[5], Charles Powell[5], Logan Jarrett[5], Jonathan R. Byrne[1]

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(Original Research)

INTRODUCTION: Helmet mounted displays (HMDs) have the potential to improve pilot performance by visually providing flight and mission information regardless of where the pilot is looking. Spatial audio (SA) cueing can also present critical information, again independent of gaze direction. However these benefits may come with problems, such as visual clutter, altered scan patterns, and auditory distraction. This study was designed to compare three different HMD symbology formats, with and without SA attitude cueing, to determine how well they supported pilot performance during a collaborative combat aircraft battle management task, a missile evasion task, and recovery from unusual attitudes (UAs). **METHODS:** In NAMRU-D's Kraken, a Varjo XR-4 headset was integrated into a flight simulator to display three different off-axis HMD formats: 1) a simple display format (SDF) with airspeed, altitude, and an aiming reticle; 2) an arc-segmented attitude reference (ASAR), with all SDF elements plus attitude information, and 3) conformal attitude reference (CAR) with the SDF elements plus a conformal horizon line and longitudinal lines converging at zenith and nadir. A traditional head-up-display (HUD) appeared when looking on-axis for all display formats, and all were tested with and without a SA cue performing as a sky pointer. Twelve male pilots participated, and their tasks were to assign friendly aircraft to target enemy aircraft, then perform an evasive missile maneuver, then recover from a UA. **RESULTS:** Missile evasion performance was significantly better with SA cueing. UA recovery times (RT's) with ASAR and CAR were significantly faster than with SDF, but only if no SA cueing was provided. SDF RT's were significantly quickened with SA cueing. Subjective ratings of situation awareness, SD, workload, and preferred format favored both ASAR and CAR. SD ratings were significantly lower when SA cueing was provided. Participants were evenly split on their preferences for SA "On" or "Off", except for the SDF format, where 75% preferred SA "On". **DISCUSSION:** Overall, the combined objective and subjective measures favored ASAR and CAR, the two formats that presented off-axis attitude information. There was converging evidence that SA provided useful orientation cueing, particularly for SDF which provided no off-axis attitude information.

Learning Objectives

1. The audience will understand that providing off-boresight attitude information in a helmet mounted display can quicken recovery from unusual attitudes.

2. The audience will understand that spatial audio cueing can support spatial orientation maintenance.

[170] SPATIAL DISORIENTATION BEYOND THE HORIZON: CHARACTERIZATION IN CIVIL FIXED-WING PILOTS

Daniela Castro Quiroga[1], Diego Garcia Morales[2], Johana Giraldo Alzate[1], Alexandra Mejia Delgado[1]

[1]National University of Colombia, Bogota, Colombia; [2]Nationa University of Colombia, Daytona Beach, FL, USA

(Original Research)

INTRODUCTION: Spatial disorientation (SD), defined as the pilot's inability to correctly perceive the position, motion, or attitude of the aircraft or oneself relative to the Earth's surface, remains a persistent threat to aviation safety despite advances in aircraft automation and training. While SD has been extensively studied in military aviation, data on civil fixed-wing pilots—particularly in Latin America—are scarce. This study aimed to characterize SD in civil fixed-wing pilots, contributing to improved understanding and mitigation strategies in an evolving operational environment. **METHODS:** A cross-sectional descriptive study was conducted using an anonymous virtual survey administered to civil fixed-wing pilots. The survey collected sociodemographic data, flight experience, type of operation, characteristics and frequency of SD episodes, associated sensory illusions, severity, phase of flight, navigation rules, countermeasures, and perceived quality and recency of training. Each illusion was presented as an animation. **RESULTS:** The study included 106 civil fixed-wing pilots (mean age 39 years, SD 15.95; range 19–68), 91.51% of whom were male. Prior training in SD was reported by 84.9% of participants, mainly through classroom instruction and simulator exposure. 76.4% experienced at least one in-flight episode. The most common sensory illusions were runway width illusion (80.2%) followed by pitch-up/pitch-down illusion, leans, and linear vection (each 68.9%) and terrain slope illusion (67%). Training flights as students accounted for the highest proportion of events (41.51%). The most severe episodes occurred predominantly during approach and landing (35.85%), although most were minor. Instrument cross-checking was the most frequently reported mitigation strategy (51.89%). **DISCUSSION:** This study provides the first known characterization of SD among civil fixed-wing pilots using spatial illusion scenarios. Despite widespread training and modern operational environments, SD remains highly prevalent and pilots do not always recognize it. The most common illusions differ from previous studies in the military, probably due to the type of operation and aircrafts flown. These findings highlight the need to strengthen and standardize SD training and to develop innovative prevention strategies to support safe operations as aviation continues to expand toward new frontiers.

Learning Objectives

1. The audience will learn about the prevalence and most frequent sensory illusions associated with spatial disorientation in civil fixed-wing pilots, as identified through a cross-sectional survey.
2. Participants will be able to understand the relationship between training, operational context, and the occurrence of spatial disorientation in civil fixed-wing pilots.

[171] CORRELATIONS BETWEEN FATIGUE SYMPTOMS AND DYNAMIC VISUAL ACUITY USING LEGACY NVDS.

Bethany Dennis[1], Heather Robinson[2], Katherine Holderby[3], Erica Poole[4]

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(Original Research)

INTRODUCTION: Anecdotal reports suggest a preference for white phosphor night vision devices (NVDs); however, effects on sleep and visual performance relative to green phosphor remain unclear. Changes in Dynamic Visual Acuity (DVA) with fatigue and across phosphor types are poorly characterized. DVA—target identification during relative motion—was used to model operational conditions, and correlations between fatigue symptoms and DVA performance were examined to compare white and green phosphor NVDs. **METHODS:** In a pilot study, seven participants completed three 5-hour sessions across consecutive weeks under white phosphor NVD, green phosphor NVD, or no-NVD conditions. During each session, participants performed NVG-compatible visual and cognitive tasks. DVA was assessed four times per session using 20/30 Snellen E stimuli vibrating vertically at one of three randomized amplitudes, approximating rotary-wing vibration. Participants identified stimulus orientation, and DVA performance was quantified using a composite throughput metric derived from reaction time and accuracy. Subjective sleepiness and fatigue were repeatedly assessed using a visual analogue scale. **RESULTS:** Across all conditions and motion amplitudes, DVA throughput declined over time ($\Delta M = -0.27 \pm 0.24$). Mean throughput differed by condition, with lowest performance in the no-NVD condition ($M = 0.53 \pm 0.22$) and highest with green phosphor NVDs ($M = 0.76 \pm 0.26$). Increased motion demand further reduced performance, with the largest vibration amplitude yielding the lowest throughput ($M = 0.59 \pm 0.25$). Subjective fatigue increased over time, reflected by increased forgetfulness ($\Delta M = +52.43 \pm 20.55$) and sleepiness ($\Delta M = +65.14 \pm 18.24$), and decreased clear-headedness ($\Delta M = -44.43 \pm 14.92$) and alertness ($\Delta M = -58.43 \pm 13.46$). At session onset, DVA throughput at the largest amplitude showed marginal negative correlations with forgetfulness and sleepiness across phosphor conditions ($|r_s| = 0.66–0.73$, $p = 0.06–0.10$); by session end, a marginal negative association with clear-headedness persisted only for the green phosphor condition ($r_s = -0.66$, $p = 0.10$). **DISCUSSION:** Throughput declined over time across conditions, with green phosphor NVDs yielding the highest performance and increased motion demand producing the greatest impairment, while subjective fatigue increased and showed marginal negative associations with DVA throughput, warranting cautious interpretation given limited sample size and power.

Learning Objectives

1. Attendees will learn about dynamic visual acuity as a measure of visual performance.
2. Attendees will learn about the different photoreceptive cells of the human retina.

[172] VALIDATING THE MAASTRICHT ACUTE STRESS TEST FOR AVIATION (MAST-A): A RANDOMIZED CONTROLLED STUDY IN A VIRTUAL REALITY FLIGHT ENVIRONMENT

Danny van der Horst[1], Liscia Beenhakker[1], Antoin de Weijer[2], Arthur Rademaker[1], Elbert Geuze[2]

[1]Royal Netherlands Air and Space Force, Centre for Man in Aviation, Soesterberg, Netherlands; [2]Military Brain and Behaviour Centre, Utrecht, Netherlands

(Original Research)

INTRODUCTION: Military aviation demands optimal performance under stress. To investigate stress effects in controlled settings, a laboratory stressor is required that reliably elicits physiological and subjective responses while remaining suitable for inexperienced pilots. Naturalistic in-flight stressors are often highly procedural and therefore inappropriate for inexperienced pilots. The Maastricht Acute Stress Test (MAST) reliably induces stress responses but has not yet been validated in an aviation context. This study aimed to validate an aviation-adapted version of the MAST (MAST-A) embedded in a virtual reality (VR) flight environment. **METHODS:** Twenty military personnel participated in a single-blind randomized controlled trial. Participants were randomly assigned to either a stress condition receiving the MAST-A or a placebo condition. All participants completed two VR flights: a familiarization flight and an experimental flight. Subjective stress was assessed using a Visual Analogue Scale (VAS), and perceived workload was measured using the NASA Task Load Index (NASA-TLX). Physiological outcome measures are currently under analysis. **RESULTS:** Independent-sample t-tests revealed no significant differences between groups in VAS or NASA-TLX scores at baseline or during the familiarization flight, indicating comparable pre-stress conditions. During the experimental flight, participants in the stress condition reported significantly higher subjective stress ($M = 50.3$, $SD = 28.36$) than those in the placebo condition ($M = 21.7$, $SD = 13.87$), $t(18) = -2.87$, $p = .01$. Additionally, workload was significantly higher in the stress group ($M = 72.9$, $SD = 17.4$) compared with the placebo group ($M = 50.6$, $SD = 16.0$), $t(18) = -2.99$, $p = .008$. **DISCUSSION:** The absence of group differences during baseline and familiarization suggests that both groups entered the experimental phase with similar stress and workload levels and that the VR environment alone did not differentially induce stress. In contrast, the MAST-A elicited robust increases in subjective stress and workload during the experimental flight, supporting its suitability as a stressor in aviation research. Ongoing physiological analyses will determine whether these subjective effects are accompanied by corresponding physiological responses. If confirmed, the MAST-A may provide a controlled and ethically appropriate method for studying stress responses in aircrew and trainees.

Learning Objectives

1. The audience will learn about the development and validation approach of the aviation-adapted stress test, the Maastricht Acutre Stress Test (or MAST-A).
2. The audience will learn about the feasibility of implementing the MAST-A in a VR flight simulation environment.

[173] DEEP BRAIN STIMULATION FOR YOUNG ONSET PARKINSON'S DISEASE IN A MILITARY PILOT – A CASE REPORT AND AEROMEDICAL REVIEW

Ivan Gur, Hadar Lahav, Yuval Ben Dror, Livnat Amzaleg

Israeli Air Force Aeromedical Center, Tel Hashomer, Ramat Gan, Israel

(Education - Case Study)

INTRODUCTION: Parkinson's Disease (PD) is a progressive neurodegenerative disorder rare in young adults. While disqualifying in most high-performance aviation contexts due to motor symptoms and cognitive decline, Deep Brain Stimulation (DBS) offers a non-pharmacologic treatment alternative that may preserve flight status. However, DBS introduces unique aeromedical risks, including potential device malfunction under G-forces and the need to assess incapacitation risk in the event of stimulation failure. This report outlines the evaluation and waiver process for a fighter pilot with PD treated with DBS. **CASE PRESENTATION:** A 32-year-old male F-35 pilot presented with a resting hand tremor. Initially diagnosed with Essential Tremor, progressive symptoms and a positive FDOPA PET scan led to a revised diagnosis of Young Onset Parkinson's Disease. Pharmacologic treatment (Levodopa/Carbidopa, agonists) was attempted but provided insufficient control or caused unacceptable side effects. Consequently, the pilot underwent bilateral Subthalamic Nucleus (STN) DBS implantation. Post-operatively, the pilot demonstrated a resolution of all motor symptoms, becoming asymptomatic and ceasing all dopaminergic medications. A comprehensive aeromedical evaluation was conducted. Cognitive testing was within normal limits. A critical "device shut-off" test was performed: the pilot remained asymptomatic immediately following deactivation, with only minimal reduction in right-sided dexterity appearing after two hours, ensuring the ability to safely land an aircraft in the event of device failure. **DISCUSSION:** While the pilot's clinical status was excellent, the device manufacturer (Medtronic) advised against exposure to high G-forces due to the risk of device damage or lead displacement. This restriction precluded a return to fighter jets (F-35) or high-performance trainers. The annual risk of sudden incapacitation was deemed acceptable given the slow symptom recurrence observed during the shut-off test. A multidisciplinary board granted a waiver restricted to the transport array. To mitigate operational risk, the pilot is restricted to multi-crew aircraft with a qualified co-pilot. Mandatory quarterly surveillance by a movement disorder specialist was instated. This case demonstrates that with favorable response to DBS and strict platform restrictions, select aviators with YOPD can maintain a military flying career.

Learning Objectives

1. Describe the aeromedical challenges of Young Onset Parkinson's Disease (YOPD), including the balance between symptom control and medication side effects.
2. Discuss the implications of Deep Brain Stimulation (DBS) in the aviation environment, specifically regarding high-G exposure and device reliability.
3. Apply risk assessment strategies, such as device deactivation testing and platform restrictions, to determine flight eligibility for aviators with neuro-stimulators.

Tuesday, 05/19/2026, 4:00 PM

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[S-27] PANEL: DRIVING INNOVATION IN AEROMEDICAL RISK MANAGEMENT THROUGH AN AEROMEDICAL SAFETY COALITION

Chair: William Hoffman

Co-Chair: Quay Snyder

Panel Overview: *BACKGROUND: Aeromedical risk science is undergoing rapid transformation as health, performance, and operational data become increasingly integrated within civil aviation. This shift reflects a growing recognition that medical and human-performance factors contribute directly to safety outcomes and therefore deserve systematic attention within Safety Management Systems (SMS). In response, the Aeromedical Safety Coalition (ASC), established in 2024 as a partnership among airlines, unions, government agencies, researchers, and clinical leaders, aims to modernize aeromedical risk oversight through privacy-protected data sharing, collaborative governance, and independent scientific evaluation. OVERVIEW: This five-speaker panel presents current and emerging ASC initiatives that illustrate how coordinated aeromedical systems and new data streams can strengthen safety decision-making. The first presentation outlines ASC's founding mission, structure, and early achievements, showing how shared data and joint governance support consistent and evidence-based medical risk decisions across industry stakeholders. The second presentation introduces an approach for generating safety intelligence in data-sparse domains and describes how structured expert elicitation can be applied in aviation risk analysis. The third summarizes the first characterization study of pilot peer support programs among major U.S. airlines, highlighting how trusted peer pathways function as a medical risk control within SMS. The fourth presentation proposes an aeromedical extension of the FAA Aviation Safety Action Program to enable voluntary, protected reporting of medical-related safety concerns with an emphasis on trust and SMS integration. The fifth presentation examines advances in aeromedical safety risk assessment, including quantitative risk modeling methods and operational challenges associated with embedding medical risk within SMS frameworks. DISCUSSION: Together, these initiatives illustrate a maturing aeromedical safety ecosystem in which health and human-performance data are used as actionable safety information. ASC's work highlights the potential*

for shared data, harmonized governance, and specialty-specific risk intelligence to strengthen SMS processes, reduce preventable harm, and advance safety culture across U.S. commercial aviation.

[174] ADVANCING COLLABORATION AROUND AEROMEDICAL SAFETY

Travis Ludwig

Air Line Pilots Association, Washington, District of Columbia, USA

(Education - Program / Process Review)

BACKGROUND: The Aeromedical Safety Coalition (ASC) was formed in 2024 to address the lack of a coordinated and evidence-driven approach to integrating health and human performance into U.S. aviation safety risk management. ASC brings together airlines, unions, the FAA, health professionals, and safety experts to advance a shared mission focused on driving innovation in managing aviation safety risks related to mental and physical health through information sharing and systems-of-systems analysis. Its foundational goal is to elevate health and human performance as safety topics and reduce uncertainty surrounding medical-related risks within aviation operations. **OVERVIEW:** ASC seeks to strengthen Safety Management Systems by promoting both traditional Safety I approaches and forward-looking Safety II perspectives that enhance system resilience. Its mission includes improving hazard identification, supporting consistent medical risk interpretation, and expanding SMS-based education across diverse aviation organizations. Early ASC achievements illustrate the value of shared information, cross-sector collaboration, and structured governance. The coalition's working groups have established formal mechanisms for joint priority setting and consensus building, while its early research outputs, including the first characterization of pilot peer support programs across major U.S. airlines, demonstrate how collaborative data sharing can inform safety intelligence and support SMS functions. **DISCUSSION:** ASC's structure, mission, and emerging work collectively exemplify how aviation stakeholders can evolve toward a more integrated model of aeromedical risk oversight. By treating health and human performance as core safety imperatives and leveraging shared evidence, ASC provides a pathway for improving systemwide coordination, reducing preventable harm, and strengthening the safety and trust of pilots, air traffic controllers, and the flying public.

Learning Objectives

1. Identify ways that collaboration and information sharing can promote safer skies and healthier pilots and air traffic controllers.
2. Describe the Aeromedical Safety Coalition and describe its mission and roadmap.

[175] PROBABILISTIC MODELING OF AEROMEDICAL SAFETY RISKS

Kunal Sarkhel

MITRE Corp, McClean, VA, USA

(Education - Program / Process Review)

BACKGROUND: Assessing aviation safety risks associated with pilot medical impairment and medical nondisclosure is challenging due to limited empirical data, variability in clinical presentation, and the difficulty of directly observing non-compliant behavior. These constraints create significant uncertainty for aeromedical decision-makers and Safety Management Systems. To address this gap, a structured, quantitative approach is proposed to improve the understanding of medically related safety hazards and to provide a transparent framework for evaluating medical risk contributors. **OVERVIEW:** The approach integrates structured expert elicitation, behavioral modeling, and probabilistic risk assessment to characterize three domains: pilot medical nondisclosure, sudden medical incapacitation, and subtle or incomplete performance degradation. For medical nondisclosure, Bayesian structural equation models can identify factors influencing disclosure behavior, while simplified probabilistic models translate medical impairment into operationally relevant performance effects across cognition, action, perception, and sustainment. For sudden incapacitation, event trees can be constructed to model the progression from an unmanaged medical condition to in-flight incapacitation and subsequent operational outcomes. These trees represent conditional steps such as onset timing, phase of flight, recognition by the pilot monitoring, crew response, and the moderating role of aircraft automation. Probabilities can be informed by literature and structured expert elicitation and combined using Monte Carlo simulation to estimate order-of-magnitude risks per flight hour. Comparable event tree and Bayesian network structures can be applied to scenarios involving subtle performance decline and intentional inappropriate manipulation of flight controls, allowing the modeling of layered safety barriers such as monitoring, procedures, automation, and aircraft systems. **DISCUSSION:** This framework demonstrates how probabilistic modeling, supported by structured expert elicitation and behavioral analysis, can be applied to aeromedical safety questions to quantify uncertainty, improve transparency, and enable comparative assessment of medical risk drivers and mitigation strategies. Such an approach supports more consistent, evidence-informed aeromedical risk decisions and enhances SMS integration.

Learning Objectives

1. Describe how structured expert elicitation, behavioral modeling, and event tree based probabilistic analysis can be used to quantify aviation safety risk associated with pilot medical impairment and medical non-disclosure.
2. Identify how different categories of aeromedical safety risks and mitigations can be analytically compared using modeling results, while recognizing the assumptions and limitations of these methods.

[176] PILOT HEALTH AND AVIATION SAFETY INSIGHTS FROM PILOT PEER SUPPORT PROGRAMS AT MAJOR US AIRLINES

Elizabeth Ryan[1], Ty Dimeff[2]

[1]Aeromedical Safety Collaborative, McClean, VA, USA; [2]Soutwest Airline Pilots Association, Dallas, TX, USA

(Original Research)

INTRODUCTION: This presentation summarizes the Aeromedical Safety Coalition's first-of-its-kind study characterizing peer support programs across major U.S. airlines and examining their potential to serve as a safety risk control within Safety Management Systems. Peer support programs are increasingly recognized as vital pathways for pilot wellbeing, yet their safety value and operational characteristics have not previously been quantified at scale. **METHODS:** Using a mixed-methods design, the study conducted in-depth qualitative interviews with peer support program leaders at seven major U.S. airlines and applied structured expert elicitation to generate quantitative estimates in areas where empirical data are limited. Interviews explored call-handling processes, volunteer training, escalation and referral procedures, and innovations such as proactive outreach, program visibility in training environments, and expanded promotional strategies. Structured expert elicitation provided high-confidence estimates of program usage, outcomes, and operational features, representing the first quantitative characterization of these programs. **RESULTS:** Experts estimated with 90 percent confidence that 89 percent of peer support contacts resulted in positive health outcomes and 78 percent resulted in safety-relevant benefits, including improved pilot self-assessment of fitness to fly. Usage was estimated at 3 to 10 percent of pilots annually, with concerns most commonly involving family stress, negative life events, or job-related pressures. The study also identified variability across programs in operational structure, airline–union collaboration, volunteer vetting, and ongoing support mechanisms. **DISCUSSION:** Findings highlight both the widespread perceived value and the untapped potential of peer support programs as safety mitigations. Recommendations include expanding program awareness, integrating peer support presence into mandatory training, and enabling proactive outreach where appropriate. The study also identifies a significant opportunity for aviation leaders to strengthen these programs by incorporating them into Safety Management Systems and developing privacy-protected metrics that reflect their safety impact.

Learning Objectives

1. Describe the benefit of collecting privacy-protected data about PSPs and how they could improve aviation safety.
2. Identify key attributes of current PSP operations and drivers of effectiveness.

[177] EXPLORING A PROTECTED, VOLUNTARY MEDICAL SAFETY EVENT REPORTING PROGRAM TO ENHANCE AVIATION SAFETY INTELLIGENCE

Kathleen Berman[1], Ty Dimeff[2]

[1]MITRE Corp, McClean, VA, USA; [2]Soutwest Airline Pilots Association, Dallas, TX, USA

(Education - Program / Process Review)

BACKGROUND: Although system-generated data sources such as Flight Operational Quality Assurance have significantly advanced U.S. aviation safety over the past two decades, current datasets provide limited visibility into the role of human and health-related factors in safety events. To begin addressing this gap, this presentation introduces a voluntary and protected medical safety event reporting concept, envisioned as an aeromedical extension of the existing Aviation Safety Action Program. The proposal draws on insights from the Aeromedical Safety Coalition's cross-sector work on health and human-performance–related safety research. **OVERVIEW:** The proposed program provides a confidential and safety-focused mechanism to capture health-related contributors to operational events while maintaining strong protections consistent with labor–management expectations. Its design emphasizes voluntary participation, rigorous privacy and confidentiality safeguards modeled on established ASAP practices, and the use of trusted medical intermediaries. Integration into operators' Safety Management Systems would enable proactive, data-informed risk management by incorporating health factors that are currently invisible within system data streams. The presentation also outlines a prototype approach including an optional feature within existing ASAP reports to indicate when a medical factor was present. This interim step would allow assessment of adoption, generation of meaningful de-identified insights, preservation of pilot trust, and development of a foundation for a more fully realized program. **DISCUSSION:** Addressing this longstanding data gap has the potential to strengthen safety culture, enhance early identification and mitigation of health-related risks, and improve coordination of safety management activities across sectors. By elevating health as a legitimate component of aviation safety risk management, this approach offers new pathways for advancing SMS. The session will describe the conceptual model, key stakeholder considerations, and anticipated value for pilots, unions, airlines, and regulators as the aviation community evaluates this next step in safety innovation.

Learning Objectives

1. Describe the core components of a proposed medical safety event reporting program.
2. Learn about a proposed medical safety event reporting program with strong protections that will capture health-related contributors to operational events.

[178] METHODS FOR OBTAINING CRITICAL SAFETY INTELLIGENCE IN DATA-SCARCE ENVIRONMENTS

Ted Sienknecht

MITRE Corp, McClean, VA, USA

(Education - Program / Process Review)

INTRODUCTION: This presentation summarizes the methodology of the Aeromedical Safety Coalition's first-of-its-kind study characterizing peer support programs across major U.S. airlines and assessing their potential to function as aviation safety risk controls within Safety

Management Systems. Because empirical data on health and human performance contributions to safety are limited, the study applied Structured Expert Elicitation, a scientific method designed to generate high-confidence quantitative estimates in data-scarce environments. The effort is a case study in the application of this method in safety research. **OVERVIEW:** Aviation safety risk management is supported by a well-established set of tools and frameworks, and SMS emphasizes risk management as one of its four core pillars. However, many aviation safety decisions still lack sufficient data about complex sociotechnical interactions, the real-world effectiveness of risk controls, and the prevalence or impact of specific hazards. Structured Expert Elicitation provides a systematic approach to reducing this uncertainty. Other high-reliability industries, such as nuclear power and emergency response, have demonstrated that structured expert judgment can outperform traditional expert opinion by statistically combining estimates and accounting for cognitive biases. The method functions similarly to crowd-based estimation phenomena, where the aggregated distribution of judgments often approximates the true value. SEE strengthens this process by weighting experts based on demonstrated calibration and confidence, yielding quantitative outputs with reduced uncertainty. As with usability engineering, valuable insights can be generated with relatively small samples when the method is applied rigorously. **DISCUSSION:** By applying Structured Expert Elicitation to peer support programs, this study produces data not previously available for aviation safety risk management. The resulting estimates offer higher-confidence insights into how PSPs operate and how they may function as risk mitigations within SMS. These findings demonstrate the value of SEE as a tool for improving the quality, transparency, and consistency of aviation safety risk decisions, particularly in domains where traditional data streams are insufficient.

Learning Objectives

1. Describe the benefit of collecting quantitative data to inform safety risk management decisions for aviation safety.
2. Identify key attributes of methods for obtaining quantitative insights when actual data is not collected or currently collectable.

Tuesday, 05/19/2026, 4:00 PM

Governor's 14

[S-28] SLIDE: DEEP DIVE OF DI (DIAGNOSTIC IMAGING)

Chair: Kenneth Myers

Co-Chair: Rebeca Mendelsohn

[179] ULTRASOUND-GUIDED LUMBAR PUNCTURE WITH AI-BASED IMAGE LABELLING FOR INTRACRANIAL PRESSURE ASSESSMENT IN SPACEFLIGHT

Beatriz Saragoça[1], Francisco Santos[2], Zita Martins[3], Nuno Cruz Garcia[4], Edson Santos Oliveira[2]

[1]Center for Aerospace Medicine Studies, Instituto Superior Técnico, Universidade de Lisboa., Lisbon, Portugal; [2]Center for Aerospace Medicine Studies, Faculdade de Medicina, Universidade de Lisboa., Lisbon, Portugal; [3]Instituto Superior Técnico, Universidade de Lisboa., Lisbon, Portugal; [4]Center for Aerospace Medicine Studies, Faculdade de Ciências, Universidade de Lisboa., Lisbon, Portugal

(Original Research)

INTRODUCTION: As space exploration advances, concerns about astronauts' health during long-duration spaceflights arise, including Spaceflight-Associated Neuro-Ocular Syndrome (SANS), a condition affecting vision that may be related to increased intracranial pressure (ICP) caused by prolonged exposure to microgravity. To mitigate the risks of performing a lumbar puncture (LP) in space, we propose a technique that uses ultrasound (US) images from a portable probe, labelled by deep learning (DL) models, to identify anatomical structures. This approach builds upon a previously presented technique using a Needle Guidance System (NGS). Therefore, we investigated the feasibility of applying DL models to automatically segment lumbar spinal structures in real-time from portable US images. **METHODS:** Lumbar spine US videos, primarily in a paramedian longitudinal view, were acquired from eighteen volunteers and a phantom using a portable probe. Selected frames were manually annotated in 3D Slicer to create ground-truth masks of bone and ligamentum flavum for training Convolutional Neural Networks. U-Net and DeepLab networks with ResNet-50 and ResNet-101 backbones were pre-trained on the BUSI dataset and fine-tuned on our data, with data augmentation and hyperparameter tuning applied. Data were randomly divided by subject into training, validation, and test sets. An additional participant was selected to fine-tune and test a personalized model. An iOS application was developed to receive US images directly from the probe and apply the DL models in real time. **RESULTS:** The DeepLab model with a ResNet-50 backbone achieved the best segmentation performance, with average Dice coefficient, accuracy, and precision of 0.70, 0.97, and 0.67, respectively. After personalizing the model for the chosen subject, testing on that individual's data revealed improved results of 0.81, 0.99, and 0.84, respectively. The average processing time was 38 ms per image, confirming the feasibility of the network for real-time use. **DISCUSSION:** Noise from the portable probe made manual annotation challenging, highlighting the limitations of the Dice coefficient, which is highly sensitive to small boundary variations and may underestimate the actual segmentation quality. Nevertheless, this study demonstrated the feasibility of performing real-time segmentation of US images acquired with a portable probe, and the benefits of personalizing the models to the specific subject undergoing the LP.

Learning Objectives

1. Understand the challenges of interpreting spinal ultrasound images, especially distinguishing relevant structures from surrounding tissues and noise, for non-experts such as astronauts, and recognise the need for an automated detection system.
2. Identify lightweight Deep Learning architectures capable of accurately detecting relevant structures in real time and suitable for use on mobile devices.

3. Evaluate the potential benefits in labelling accuracy from fine-tuning and personalising the Deep Learning model to a specific subject, such as the astronaut designated to undergo Lumbar Puncture in microgravity.

[180] VENOUS ULTRASOUND LOW-FLOW COMPLEXITY ANALYSIS

Roxy Fournier

University of Waterloo, Waterloo, Ontario, Canada

(Education - Tutorial / Review)

INTRODUCTION: Extended exposure to gravitational unloading, whether in spaceflight or its terrestrial analogues (head-down tilt bed rest), profoundly alters cardiovascular and cerebrovascular physiology. Conventional ultrasound techniques have been extensively used to study these changes. For example, Doppler ultrasound has been previously used to demonstrate the change in blood flow of the internal jugular vein (IJV) in space, with recent findings of a fully occlusive thrombus in an ISS crewmember. However, Doppler does not fully characterize variations in flow patterns at different points inside the vessel. Additionally, the irregularity of the size and shape of vessels such as the IJV cannot be taken into account with this method. **TOPIC:** To overcome these limitations, we highlight a new modality called high frame-rate ultrasound (HiFRUS). HiFRUS utilizes plane wave transmission of at least two steering angles enabling precise velocity and direction vectors to be calculated along the vessel length. The resulting vectors, which we call vector flow imaging (VFI) can then be analyzed using circular statistics to interpret flow complexity at spatially distinct regions. We recently used VFI to examine how brief periods of microgravity during parabolic flight alters the IJV's flow profile, and how this profile might relate to the recent findings of fully occlusive thrombus in an ISS crewmember. **APPLICATION:** Analyses from our parabolic flight studies in May and November 2025 have shed more light on the mechanism of venous drainage in microgravity (0g) compared to the supine posture in Earth gravity (1g) using HiFRUS. In both conditions, blood flow followed a cyclic profile in close alignment with heart rate, consistent with the theory that venous outflow in the supine IJV is strongly regulated by pressure variations upstream and downstream of the vessel. We were also the first to analyze several new complex flow features in the IJV in parabolic flight, with a new data pipeline developed specifically for low-flow conditions. This included the vector concentration coefficient, wall shear rate, volume flow, bidirectionality, and vortex zones. This technique can be extended to answer questions related to the upstream causes and effects of IJV congestion during spaceflight and in disease models on Earth.

Learning Objectives

1. High frame-rate ultrasound of the internal jugular vein is a promising new modality for spaceflight monitoring of thrombosis risk.

2. High frame-rate ultrasound enables a full-field view of IJV blood flow, overcoming the limitations of Doppler ultrasound.

[181] THE EFFECTS OF DEEP LEARNING TOOL IMPLEMENTATION ON CARDIOTHORACIC ULTRASOUND CONFIDENCE AND COGNITION IN NOVICE LEARNERS

Katherine Lightfoot[1], Nhu-Nguyen Le[2], Victoria Hurd[1], Arian Anderson[3], Jamie Pospishil[2], Philippe Ayres[2], Jeffrey Olson[4], Matthew Riscinti[2], Allison Hayman[1]

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(Original Research)

INTRODUCTION: Point-of-care ultrasound (POCUS) is a critical diagnostic tool in austere, resource-constrained environments, yet POCUS performance is highly operator-dependent. Operator dependencies may be resolved with deep learning (DL) algorithm implementation by providing real-time anatomical labeling and image quality feedback. However, the effects of DL-enabled ultrasound on cognitive measures are incompletely characterized. The present study evaluated learner confidence, perceived workload, and system usability under DL-guided versus traditional ultrasound implementations, hypothesizing DL-guided instruction would improve learner confidence, decrease cognitive workload, and increase perceived usability. **METHODS:** 17 students and professionals in the STEM/healthcare fields with minimal ultrasonography/cardiothoracic experience were recruited to participate in this IRB-approved study and randomized to DL or traditional instruction. Participants performed five POCUS scans (right and left lung, parasternal long- and short-axis, apical 4-chamber) using a handheld ultrasound device (Butterfly IQ3). Surveys included pre-/post-intervention, NASA Raw Task Load Index, and System Usability Scale, assessing comfort, cognitive workload, and usability, respectively. Effects were assessed with Wilcoxon signed-rank tests, Welch's t-tests, and Mann-Whitney U tests. **RESULTS:** Self-reported comfort increased following cardiac and lung POCUS (cardiac: median 2 to 3, p=0.002; lung: median 2 to 4, p<0.001). Among workload subdomains, temporal demand was higher in the DL group compared to traditional instruction (DL median: 12.5, Traditional median: 6, p=0.037). No significant differences were observed between conditions in comfort, overall workload, remaining workload subdomains, or usability. **DISCUSSION:** DL-guided POCUS instruction significantly improved learner confidence without increasing overall cognitive workload or reducing usability. Increased temporal demand in the DL group may reflect influence of real-time AI feedback on perceived task pacing. These findings support feasibility of DL-assisted POCUS training in aerospace, military, and resource-limited environments and inform future studies evaluating performance outcomes and skill retention.

Learning Objectives

1. The participant will be able to describe how deep learning–guided ultrasound instruction influences novice learner confidence compared to traditional POCUS training methods.
2. The participant will be able to evaluate the effects of deep learning-assisted ultrasound guidance on perceived cognitive workload, including temporal demand, using the NASA Raw Task Load Index.
3. The participant will be able to interpret system usability outcomes for deep learning-enabled ultrasound platforms using System Usability Scale metrics in operational training contexts.

[182] DIAGNOSTIC RADIOGRAPHY FOR SPACEFLIGHT

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(Original Research)

INTRODUCTION: Missions of extended duration within and beyond low Earth orbit present unique challenges for in-flight medical care. Diagnostic imaging is a key medical capability. Leveraging recent technology advancements, we demonstrated the feasibility and diagnostic quality of portable digital radiography for human imaging and non-destructive testing of hardware during a 3-day polar-orbit mission. Specific aims included validating radiograph quality, operational feasibility, and image alignment in a microgravity environment. **METHODS:** 3 non-healthcare-specialist crewmembers were trained over two 2-hour practice sessions to use the battery-powered generator (MinXray) and spectral flat panel detector (KA Imaging), both FDA-approved and certified for spaceflight. A total of 21 exams were performed. Preflight and in-flight images were collected from an X-ray phantom, a Garmin watch, and; human participants (Peripheral: Hand, Forearm. Central: Chest, Abdomen, Pelvis). Pre- and post-flight DEXA scans for bone mineral density were obtained for future comparison with dual-energy radiographs obtained in space. **RESULTS:** Quantitative and qualitative analysis of the terrestrially-acquired human, electronics, and phantom control radiographs relative to inflight radiographs acquired on L+1 and L+3 showed no significant differences in contrast or spatial resolution, indicating good image quality despite the elevated background radiation of a polar orbit. Pre- and in-flight human radiographs were evaluated by board-certified radiologists in a blinded comparison and showed no difference in diagnostic quality. In-flight imaging for non-destructive testing of equipment showed internal components visible down to the sub-millimeter scale. Post-flight, the X-ray system continued to function nominally despite minor structural damage sustained during re-entry. Crew surveys rated radiography equipment and operational protocol as easy to use. **DISCUSSION:** This work successfully demonstrated an initial protocol for safe, rapid, and diagnostically adequate acquisition of radiographs by non-specialized crew in a weightless environment with elevated background radiation of a polar orbital flight. Future

analysis will focus on DEXA images and refinement of operational guidelines to better standardize alignment of three free-floating objects (emitter, subject, detector) to ensure distance and direction of X-rays, as well as expanding the portfolio of standardized diagnostic images.;

Learning Objectives

1. To understand the potential value of radiography as a clinical and research tool in spaceflight.
2. To convey the preliminary results of an initial protocol for radiography in microgravity.
3. To discuss limitations, knowledge gaps, and future directions to expand this diagnostic capability.

[183] SUITE RIDE MEDICAL DEVICE INTEGRATION: SUCCESSFUL ON-ORBIT AND ORBIT-TO-GROUND CONTINUOUS GLUCOSE MONITOR USE ON THE INTERNATIONAL SPACE STATION

John Marshall[1], Alex Rubin[2], S. Michelle Griffin[2], Melinda Hailey[2], Michael Harrison[3]

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(Education - Program / Process Review)

BACKGROUND: Commercial space will expand access to low earth orbit (LEO) for individuals with chronic diseases that were previously disqualifying. To date, no crewmember certified by the international partner community has flown with diabetes mellitus. Expanding orbital spaceflight to this medical community requires robust real-time glucose monitoring, clinical ground support, and reliable connectivity. With commercial space companies flying or preparing to fly missions, we describe technical features of the first real-time, delayed, and longitudinal glucose monitoring on a short-duration mission to LEO, thereby demonstrating a spaceflight management model for other chronic diseases. **OVERVIEW:** Continuous glucose monitors (CGM) were flown on an 18-day mission to the International Space Station. A smartphone was flown as primary CGM interfacing and transmitting device on and from orbit to ground. Hardware underwent flight certification including electromagnetic interference, materials, battery, and hazards testing. Additionally, glucose monitoring apps underwent network connectivity and down/uplink testing at the National Aeronautics and Space Administration's Joint Station Local Area Network lab. Crewmembers underwent procedural training for CGM app use and configuration. On orbit, high and low glucose alarm testing was performed between CGMs and on-orbit and ground smartphones. Glucose values were collected at 5-minute, 4-12 hour, and 24-hour frequencies via CGMs, apps, and ground-based servers. **DISCUSSION:** This payload completed its intended duration during the entire docked phase. Participating crewmembers donned, replaced, and doffed sensors without adverse incidents or malfunctions. On orbit, CGM sensors connected to smartphone devices and all high and low glucose alarms demonstrated functionality. Initially, there were difficulties with transmitting real time,

interstitial glucose values to principal investigators on the ground due to specific satellite outages. Glucose data was reliably transmitted from orbit to ground after satellite coverage issues resolved. Delayed and longitudinal glucose data were obtained via intermittent downlinks. This study successfully demonstrates the feasibility of using CGMs on orbit to monitor crewmembers with diabetes within the local station environment and provide telehealth support through real-time and longitudinal glucose data downlinked to ground servers and clinicians.

Learning Objectives

1. The participant will understand the complexity of networking real-time health monitoring data from orbit to ground.
2. The participant will understand recommended features and hardware for safe telehealth management of a potentially dynamic chronic condition on-orbit.

[184] A SPACE ANALOG HABITAT SURGICAL BAY--A MODEL FOR SPACE RESEARCH, EDUCATION, SIMULATION, AND TRAINING

Bindhu Oommen

Space Analog for the Moon and Mars at the University of Arizona Biosphere 2, Oracle, AZ, TX, USA

(Education - Program / Process Review)

BACKGROUND: As we prepare for deep space exploration and other-world habitation, we anticipate medical and surgical issues that will require treatment beyond our current capacity. For medical emergencies in low Earth orbit, stabilization and evacuation to Earth are reasonable. With longer returns from the Moon and Mars, medical capabilities must increase to manage severe clinical conditions. Advances in innovation, technology, training, and expertise have improved patient outcomes in medical and surgical care paradigms in military, expeditionary, remote and spaceflight medicine. However, care capabilities decrease with tightly constrained medical systems. In space, microgravity, differences in level of training of astronauts, as well as mass, volume, and power constraints limiting available area and diagnostic/treatment tools for care needs, all challenge management of severe medical and surgical conditions. **OVERVIEW:** It is critical to understand current and future capabilities and limitations in procedural and critical care surgery through surgical simulation, training, and education in small spaces applicable to any transit vehicle or habitat on the Moon or Mars. At the Space Analog for the Moon and Mars (SAM) at Biosphere 2 at the University of Arizona, our working group has begun and continues to grow a collaboration of space medicine and engineering professionals. We propose a comprehensive, compact, full-featured, low-resource, and readily deployable medical-surgical bay (“med bay) at an existing hermetically sealed and pressurized space analog and research facility. Focusing scope of care on general/trauma surgery and dental care, the med bay will be a testbed for research and ground-based experiments related to space medicine and surgery. The iterative med bay design process will be guided by NASA requirements and commercial needs,

incorporating contemporary technology and innovation. **DISCUSSION:** We describe our initial experiences with space surgery simulation at the analog habitat and anticipate expanding the project to encompass an entire system of care; that includes not only the structure, but investigates processes, systems, and outcomes. Beyond space medicine applications, there is potential for deployable med bays for use in the military, expeditionary medicine, and rural/remote environments. We present a demonstration of a surgical bay within a life support system that must consider and employ sustainable practices.

Learning Objectives

1. Understand the current limitations and needs of performing surgery in space.
2. Understand how investigating surgery for space in an analog habitat has earth applications.
3. Understand the need to incorporate sustainable practices in surgery not only for space but for earth.

Tuesday, 05/19/2026, 4:00 PM

Governor's Hallway

[S-29] INTERACTIVE PRESENTATION: FROM PHYSIOLOGY TO PERFORMANCE

Chair: Jaime Harvey

Co-Chairs: Corey Hart, Amos Meyers

[185] MICRO-RECOVERY BEHAVIORS IN CARRIER-BASED AVIATION: AN EMERGING CONSIDERATION IN AEROSPACE MEDICINE FOR COGNITIVE PERFORMANCE MANAGEMENT

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Embry-Riddle Aeronautical University, Daytona Beach, FL, USA

(Education - Tutorial / Review)

INTRODUCTION: Carrier-based aviation requires sustained cognitive performance during high task-density operations, often with minimal opportunity for formal rest or recovery (Cummings & Guerlain, 2007; Warm et al., 2008). While fatigue management, workload mitigation, and crew resource management are well-established focus areas within aerospace medicine, comparatively less attention has been given to micro-recovery behaviors, defined here as brief, self-initiated cognitive reset strategies occurring within seconds to minutes between task

demands (Hockey, 2013; Warm et al., 2008; Caldwell et al., 2019). Research from other high-performance domains suggests that short-duration recovery behaviors may support attentional stability (Hunter & Wu, 2016), error resistance (Albulescu et al., 2022), and cognitive resilience under sustained operational pressure (Hockey, 2013; Caldwell et al., 2019). **TOPIC:** Micro-recovery behaviors are defined as; short-duration cognitive or attentional strategies used to restore task readiness following periods of high workload without interrupting operational flow (Albulescu et al., 2022, Hockey, 2013; Warm et al., 2008). In the context of carrier-based aviation, examples may include controlled breathing, intentional attentional refocusing, procedural self-cueing, or brief posture adjustments during inter-task intervals. These behaviors differ from traditional fatigue countermeasures in both timescale and intent, operating below the threshold of formal rest while primarily targeting cognitive, rather than physiological, recovery (Warm et al., 2008). The compressed, high-consequence environment of carrier operations presents unique constraints in which even brief recovery opportunities may be operationally significant (Cummings & Guerlain, 2007). **APPLICATION:** This educational review introduces micro-recovery as a human factors construct in Naval aviation and examines its role in cognitive performance management. Incorporating micro-recovery into aviator training may enhance awareness and intentional use of effective strategies without adding procedural burden. Cockpit design, mission systems, and task pacing may influence the availability and effectiveness of these behaviors by shaping attentional demands. Positioning micro-recovery within aerospace medicine and human systems integration supports future research on cognitive resilience, workload adaptation, and error management in high-tempo maritime aviation.

Learning Objectives

1. The audience will be able to define micro-recovery behaviors and explain how they support sustained cognitive performance during high task-density naval aviation operations.
2. The audience will be able to distinguish micro-recovery behaviors from traditional fatigue countermeasures based on timescale, intent, and operational constraints.
3. The audience will learn how training, cockpit design, and task pacing can influence the availability and effectiveness of micro-recovery opportunities in carrier-based aviation.

[186] ANTHROPOMETRIC FACTORS EXPLAIN SEX DIFFERENCES IN HYPOXIA RECOGNITION TIME IN MILITARY AIRCREW

Benjamin Gebauer[1], Michael Nehring[1], Helmut Fleischer[1], Steffen Löck[2]

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(Original Research)

INTRODUCTION: Sex-based differences in aviation medicine remain understudied despite increasing female participation in military aviation. Hypoxia recognition training protocols lack analyses of demographic factors influencing recognition times. Understanding these effects is essential to optimize training and aviation safety guidelines. **METHODS:** Retrospective analysis of 19,255 hypobaric chamber trainings from 12,162 aircrew participants (10,861 males, 1,301 females) between 2002 and 2025. During mandatory training, participants underwent different altitude profiles: direct exposure at 25k ft or pressure breathing at 35k/43k ft before descent to 25k ft for hypoxia demonstration. Hypoxia recognition time (HRT) was recorded as the time until self-reported symptom recognition. Two linear mixed-effects models were used: Model 1 with sex, age, smoking status and altitude profile; Model 2 additionally including weight and height to assess whether anthropometric variables explain sex differences. **RESULTS:** In Model 1, female participants showed 3.3 s longer mean HRT than males (p < 0.001). Smokers had 2.7 s shorter mean HRT (p < 0.001). Pressure breathing profiles increased mean HRT by 8.2 s (35k ft) and 9.1 s (43k ft; both p < 0.001). Age was not significant (p = 0.453). In Model 2, the sex effect disappeared (p = 0.881). Both pressure breathing profiles increased mean HRT by 3.9 s (p < 0.001). Higher weight reduced mean HRT (-0.30 s/kg, p < 0.001), greater height increased it (+0.30 s/cm, p < 0.001), and age became significant (+0.10 s/year, p < 0.001). **DISCUSSION:** This study provides novel evidence on determinants of HRT in military aircrew. Apparent sex differences in HRT are fully explained by anthropometric characteristics rather than sex-specific physiology. Weight and height effects are consistent with differences in oxygen consumption and metabolic demands. Faster recognition in smokers likely reflect chronic adaptation to hypoxic stress. Pressure breathing likely delays hypoxia recognition by sustaining higher;oxygen saturation and thus prolonging the time until hypoxia symptoms emerge. These findings support personalized hypoxia training protocols based on individual anthropometric profiles instead of sex-based generalizations.

Learning Objectives

1. Recognize that apparent sex differences in HRT are explained by anthropometric rather than sex-based physiological factors.
2. Understand how individual body composition affects the ability to recognize hypoxia.

[187] ASSESSMENT OF PHYSIOLOGICAL STRESS USING HEART RATE VARIABILITY DERVIED FROM NOVEL WEARABLE DEVICES IN HIGH-ALTITUDE HYPOBARIC ENVIRONMENTS

Ju-Yun Hsu[1], Ke-Ting Pan[1], Chung-Yu Lai[1], Wun-Wei Huang[2], Xian-Zhong Jheng[3], Jhih-Wei Li[4], Yu-wen Liu[1], Kuei-Hei Lin[1], Yun-Chih Chen[5]

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(Original Research)

INTRODUCTION: High-altitude hypobaric hypoxia represents a primary physiological threat to pilots, as oxygen saturation declines, peripheral chemoreceptors trigger compensatory sympathetic responses such as increased respiration, heart rate (HR), and cardiac output. The aim of this study was to utilize the new wearable devices to record heart rate variability (HRV) objectively presented autonomic nervous system response and investigate physiological stress under hypoxic conditions. **METHODS:** Participants consisted of 10 military flight cadets who met Class I aeromedical standards, with a mean age of 24.6 years. They underwent altitude chamber training between March and November 2025 at the Aviation Physiology Research Laboratory, Taiwan. Continuous electrocardiographic (ECG) data were recorded using the QOCA ECG103 device to assess HRV during training. Following a 30-minute denitrogenation period, the simulated altitude was gradually increased to 30,000 feet (ft). Participants removed their oxygen masks and underwent hypoxia awareness training. The physiological parameters analyzed included the standard deviation of NN intervals (SDNN), the root mean square of successive RR interval differences (RMSSD), the low-frequency power (LF), high-frequency power (HF), LF/HF ratio, and HR. Data were extracted during the ascent phase under hypobaric normoxic conditions (HN) and during exposure to hypobaric hypoxia at 30,000 ft (HH). Comparisons between conditions were performed using SPSS version 29. **RESULTS:** During HN, the mean values of SDNN, RMSSD, LF/HF ratio, and HR were 64.13±20.41 ms, 35.15±16.41 ms, 1.20±1.23, and 93.34 beats per minute (bpm), respectively. The low-frequency (LF) and high-frequency (HF) power components used to calculate the LF/HF ratio were 604.89 ± 433.98 ms^2 and 692.45 ± 549.64 ms^2, respectively. During exposure to HH, both the LF/HF ratio and HR were significantly elevated to 1.48±1.44 ($p = 0.017$) and 98.91±11.66 bpm ($p = 0.005$), respectively. These findings indicate an acute activation of sympathetic nervous system tone under hypobaric hypoxic conditions. **DISCUSSION:** In our study, initial analysis indicated that all participants experienced significant elevations in LF/HF ratio and HR during HH, reflecting the sympathetic tone activation. This study demonstrates the operational applicability of artificial intelligence-enabled wearable ECG sensors for physiological monitoring in extreme chamber environments.

Learning Objectives

1. The participant will be able to describe the compensatory sympathetic activation and physiological stress responses in pilots during high-altitude hypobaric hypoxic exposure.
2. The participant will be able to evaluate the operational applicability of AI-enabled wearable ECG sensors for monitoring heart rate variability in extreme aeromedical training environments.

[188] DECOMPRESSION SICKNESS IN A MARINE F-35C PILOT: A CASE REPORT

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(Education - Case Study)

INTRODUCTION: This case report describes a Marine F-35C pilot who experienced symptoms of decompression sickness following integrated power package (IPP) failure during a training exercise. **BACKGROUND:** Decompression sickness (DCS) is often taught during initial aerospace medical training, yet it remains relatively rare in clinical settings leaving many providers inexperienced in the recognition, evaluation, and treatment of the condition. DCS can mimic a multitude of other diagnoses and, if left unrecognized or untreated, can have life-threatening consequences. A pertinent history and physical exam are essential, and a history of flying at cabin pressures greater than 18,000 ft should drive consideration of DCS as a primary diagnosis. Expedient treatment with supplemental oxygen and elevation of care to hyperbaric oxygen therapy depending on patient symptomatology are the gold standards of treatment protocols. **CASE REPORT:** The subject was a 38-year-old Marine F-35C pilot performing maneuvers during a large-scale training exercise. During straight and level flight his aircraft experienced an IPP failure causing cabin depressurization to 26,000 ft. The pilot completed a controlled descent over 2 minutes to 16,000 ft where cabin repressurization occurred to 8,000 ft. There was no IFE activation, and the pilot presented after-hours to the local MTF for evaluation causing a delay in ancillary personnel recall and definitive treatment. The pilot underwent hyperbaric therapy at a nearby U.S. Navy facility and demonstrated full symptom resolution at the conclusion of his treatment. He remained in non-fly status per Medical Standards Directory (MSD) for two weeks and was able to return to flying status without further delay. **DISCUSSION:** This case highlights several key considerations regarding the management of a decompression event and subsequent patient care, specifically involving military pilots. The first is proper notification following an event to ensure expedient medical assessment, initial treatment, and potential emergent transport available upon aircraft landing. Secondly, rapid recognition of symptoms and expedient delivery to definitive treatment facility is essential for symptom resolution and returning pilots to flying status. A recommendation is also made to include an updated Air Force clinical guideline workflow mirroring established Navy protocols for ease of record keeping, treatment plan, and investigation requirements.

Learning Objectives

1. The audience will learn about decompression categories and their treatment.
2. The participant will obtain a systematic approach to decompression event patient evaluation and common pitfalls.

[189] DETERMINATION OF HEIGHT-STANDARDIZED BODY COMPOSITION PARAMETERS ASSOCIATED WITH G TOLERANCE

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(Original Research)

INTRODUCTINON: Previous researches identified a positive association between pilots' G tolerance and body fat mass (FM), whereas the relationships with skeletal muscle mass (SMM) and fat-free mass (FFM) remain inconclusive. Rare studies have examined how regional body composition influences the G tolerance while accounting for height. This study aimed to normalize body composition parameters relative to height and explore their associations with G tolerance. **METHODS:** A total of 177 male flight cadets from Air Force in this study. Before high-G training, cadets underwent body composition analysis using an InBody 270. Parameters including FM, SMM, and FFM, were standardized by dividing height squared (m^2). Relaxed G tolerance (RGT) was assessed during the gradual onset rate training at 0.1 G/s, and data were analyzed using the SPSS software. **RESULTS:** Participants had a mean age of 23.4±1.6 years. They were categorized into five RGT groups: <4.0G (n=24, 13.6%), 4.0-4.5G (n=35, 19.8%), 4.6-5.0G (n=43, 24.3%), 5.1-5.5G (n=37, 20.9%), and >5.5G (n=38, 21.4%). Height (173.7±5.3 cm) was inversely correlated with RGT, while weight (72.1±10.0 kg) and BMI (23.9±2.8 kg/m^2) were positively correlated. Mean FM, SMM, and FFM were 14.2±5.6 kg, 32.8±3.9 kg, and 57.9±6.4 kg, respectively. All fat-related indices including FM, segmental FM, and percentage of body fat showed significant positive associations with RGT, which remained after height normalization. In contrast, crude SMM and FFM were not significantly related to RGT. Height-adjusted SMM demonstrated an increasing trend across the RGT groups, though the association almost approached statistical significance (P=0.093). Cadets with RGT > 5.5G showed higher height-standardized FFM (19.8±1.3 kg/m^2), notably in the upper limbs and trunk, while lower-limb FFM exhibited a similar but only borderline significant elevation. **DISCUSSION:** FM was positively associated with RGT among cadets with normal fat levels. After adjusting for height, SMM and segmental FFM were also linked to a higher G tolerance. Further large-scale studies are warranted to establish the optimal body composition profiles that may improve the G tolerance evaluation and guide pilot selection.

Learning Objectives

1. To understand the relationship between height-normalized body composition parameters (fat mass, skeletal muscle mass, and fat-free mass) and relaxed G tolerance in male flight cadets.
2. To evaluate how regional body composition (upper limbs, trunk, and lower limbs), after adjustment for height, contributes to variations in G tolerance during gradual onset rate training.
3. To analyze the implications of body composition normalization for improving G-tolerance assessment and informing future pilot selection and training strategies.

[190] SHEAR WAVE ELASTOGRAPHY ASSESSMENT OF TRAPEZIUS MUSCLE STIFFNESS IN EUROFIGHTER PILOTS BEFORE AND AFTER HIGH-G FLIGHTS

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(Original Research)

INTRODUCTION: Neck pain and musculoskeletal disorders represent a frequent operational issue in high-performance military aviation, particularly among fighter pilots exposed to sustained and repeated high +Gz acceleration. Objective tools to assess cervical muscle biomechanical adaptations in this population remain limited. Shear wave elastography (SWE) allows non-invasive measurement of muscle stiffness and may provide insight into flight-related musculoskeletal load and fatigue. **MATERIALS AND METHODS:** Ten Eurofighter pilots voluntarily partecipated in the study after providing written informed consent. Quantitative ultrasound was performed using shear wave elastography (Esaote MyLab 9 eXP) by a physician experienced in musculoskeletal ultrasound amaging. Measurements were obtained on the trapezius muscle with subjects in an orthostatic position and the neck in neutral alignment. Assessments were conducted immediately before and immediately after flight activity involving sustained +Gz loads between 5 and 8 G. Muscle stiffness was expressed in kilopascal (kPa) and calculated as the mean of four measurements obtained from superficial and deep muscle planes, with scans performed along the longitudinal axis of the muscle belly. In addition pilots completed the "Aircrew Neck Pain Survey" derived from the NATO Aircrew Neck Pain Panel, before and after flight. Statistical analysis was performed using the Wilcoxon signed–rank test for paired data. **RESULTS:** A statistically significant reduction in trapezius muscle stiffness was observed between pre-flight and post-flight measurements in all subjects ($p = 0.01$), indicating a consistent post-flight decrease compared with baseline values. No clear association was observed between changes in muscle stiffness and post-flight neck pain scores. **DISCUSSION:** The acute reduction in trapezius muscle stiffness following high-G exposure may reflect transient neuromuscular fatigue, short-term modulation of muscle tone or altered motor control following high-acceleration stress rather than structural muscle impairment. The absence of a clear association between stiffness variation and self-reported neck pain suggests that immediate post-flight pain perception may not directly mirror changes in muscle mechanical properties. In this context, shear wave elastography may represent a useful complementary tool for objectively assessing cervical muscle behavior and neuromuscular response in operational aviation settings.

Learning Objectives

1. The participant will be able to understand the role of shear wave elastography in the objective assessment of trapezius muscle stiffness in fighter pilots exposed to high-G flight.
2. The participant will be able to understand acute changes in cervical muscle stiffness following high-G exposure and their potential neuromuscular and biomechanical implications in operational aviation.
3. The participant will be able to understand the relationship between objective muscle stiffness measurements and self-reported neck pain in the immediate post-flight phase.

[191] PREDICTIVE MODELING FOR G-FORCE TOLERANCE ASSESSMENT IN MILITARY AVIATION TRAINING

Jia Hao Alvin Woo, Thevapriya Selvaratnam

Changi General Hospital, Singapore, Singapore

(Original Research)

INTRODUCTION: High-G tolerance testing is essential for fighter pilot training, yet current methods identify at-risk trainees only during expensive centrifuge testing. G-induced loss of consciousness during flight operations poses significant safety risks, including potential aircraft loss and pilot fatalities. This study developed a machine learning model to predict 8G rapid onset test failure using baseline clinical measurements and initial G-tolerance assessments.
METHODS: We analyzed data from 184 Republic of Singapore Air Force cadet trainees over two years who underwent 8G centrifuge testing (15-second duration). Baseline measurements included anthropometric data (height, weight, limb lengths), cardiovascular parameters (blood pressure, heart rate), hematological values collected during Pre-Employment Medical Screening and Annual Certification Examinations, and baseline G-tolerance levels (resting, straining, and maximal G-tolerance with anti-G straining maneuver) from initial centrifuge familiarization sessions. Feature engineering incorporated mean arterial pressure calculations accounting for hydrostatic pressure effects at 8G. Multiple predictive models were developed using logistic regression, Random Forest, and Support Vector Machine techniques with k-fold cross validation for model validation. One logistic regression model demonstrated optimal balance between sensitivity and specificity, prioritizing identification of all potential failures while minimizing false positives. **RESULTS:** The selected model demonstrated consistent performance across test datasets. In the first test dataset (n=24), accuracy was 70.8%, precision 50.0%, recall 100%, and F1-score 0.667. In a subsequent test dataset (n=19), accuracy was 68.4%, precision 40.0%, recall 100%, and F1-score 0.571. Significant predictive features from logistic regression included logarithmic platelet count, straining G-tolerance level, and white blood cell count. Shapley analysis identified additional contributors including mean arterial pressure, height, hemoglobin, and body mass index. **DISCUSSION:** This predictive model enables early identification of G-tolerance limitations before extensive centrifuge training begins. The model's high sensitivity ensures no at-risk trainees are missed, while accepting false positives is operationally acceptable given safety implications and training costs. Future work includes external validation and development of personalized G-tolerance training programs.

Learning Objectives

1. [The participant will be able to…] Identify baseline clinical and physiological measurements that predict G-force tolerance test failure in military aviation trainees.
2. [The audience will learn about…] machine learning approaches for early identification of at-risk pilots before expensive centrifuge training begins.
3. [The participant will be able to…] Evaluate the clinical utility of predictive models in optimizing G-tolerance training resource allocation and pilot safety.

[192] VARIATION IN HEART RATE VARIABILITY DURING MILD EXERCISE AND ITS ASSOCIATION WITH G TOLERANCE

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(Original Research)

INTRODUCTION: Exposure to G force leads to blood pooling in the lower extremities and triggers sympathetic activation to maintain cerebral perfusion. Previous studies have shown that the cardiac force index (CFI) measured during walking is associated with G tolerance. Heart rate variability (HRV), meanwhile, reflects autonomic regulation of cardiovascular function. Building on prior findings, this study further explores the relationship between HRV and G tolerance in addition to CFI. **METHODS:** This longitudinal study enrolled Air Force flight cadets as participants. Prior to high-G training, each cadet wore a BioHarness device to collect physiological data during resting and relaxed walking conditions. Recorded parameters included activity level, heart rate (HR), and heart rate variability (HRV), expressed as the standard deviation of normal-to-normal intervals (SDNN). The CFI was calculated as body weight multiplied by activity level and divided by HR. Relaxed G tolerance (RGT) was assessed using a gradual-onset run protocol. Statistical analyses were conducted using SPSS version 27.0 to examine the associations among CFI, HRV, and RGT. **RESULTS:** This study enrolled 40 participants with a mean age of 23.5±1.3 years, height of 174.8±6.0 cm, and body weight of 70.4±11.7 kg. The mean RGT was 4.9±0.9G, and 7 participants (17.5%) achieved an RGT greater than 5.5G. During the resting phase, the mean HR, CFI, and SDNN were 90.2±1.0 bpm, 0.019±0.021 kg*G*min/beat, and 60.2±18.7 ms, respectively. During relaxed walking, the mean HR was 115.8±10.0 bpm, CFI was 0.138±0.032 kg*G*min/beat, and SDNN averaged 26.8±16.4 ms. Participants with RGT >5.5G showed significantly lower walking-phase SDNN than those <5.5G (16.3±7.1 vs. 29.0±17.1 ms; p=0.020), with higher walking-phase CFI (0.146±0.016 vs. 0.137±0.035 kg*G*min/beat). **DISCUSSION:** In addition to CFI, walking-phase SDNN measured prior to high-G training was also significantly associated with RGT. These findings suggest that cardiovascular responses elicited by mild physical activity may serve as useful indicators for monitoring G tolerance. A key limitation of this study is that the BioHarness device provided only SDNN as the HRV data. Future research should incorporate additional HRV indices to better characterize the balance between sympathetic and parasympathetic activity in relation to G tolerance.

Learning Objectives

1. Interpret walking-phase SDNN as a heart rate variability (HRV) marker and relate CFI/SDNN to relaxed G tolerance (RGT).
2. Explain how walking-phase SDNN and CFI relate to relaxed G tolerance (RGT) and identify key measurement limitations and future HRV directions.

[193] CHANGES IN CARDIAC FORCE INDEX BEFORE, DURING, AND AFTER THE EXECUTION OF THE ANTI-G STRAINING MANEUVER IN MILITARY FLIGHT CADETS

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(Original Research)

INTRODUCTION: Former studies noted a positive correlation between walking cardiac force index (CFI) measured on the ground and pilots' G tolerance. Based on these findings, the present study aimed to monitor CFI fluctuations during the anti-G straining maneuver (AGSM) and to explore the relationship between CFI changes and AGSM performance scores before the high-G training. **METHODS:** Flight cadets from the Air Force Flight Training Command were enrolled in this longitudinal study. Physiological data were continuously collected using the BioHarness 3.0 system during the ground-based AGSM practice. CFI values were calculated for three phases-10 seconds before, 10 seconds during, and 20 seconds after AGSM execution-using this formula: CFI = weight × activity (or vertical acceleration) / heart rate (HR). AGSM performance was subjectively rated by aviation physiologists on a five-point scale (1 = poor to 5 = outstanding). Statistical analyses were performed using SPSS software to evaluate CFI dynamics and their associations with AGSM performance levels. **RESULTS:** A total of 45 flight cadets (40 males, 5 females) were analyzed. The distribution of AGSM scores were as follows: 37.2% scored 2, 51.2% scored 3, and 11.6% scored 4. The HR increased markedly during the 6-10 seconds of the AGSM (103.8 ± 19.5 bpm) and reached its peak within 1-5 seconds after completion (109.1 ± 19.4 bpm). The activity-based CFI (CFIa) rose significantly during the AGSM, remaining elevated for approximately 5 seconds post-execution. Conversely, the vertical acceleration-based CFI (CFIv) displayed an opposite trend. Participants with a higher AGSM performance (score = 4) showed significantly lower CFIa and CFIv values during the 10-second maneuver and in the 1-5 seconds following its cessation. **DISCUSSION:** This preliminary investigation identified a clear association between AGSM execution quality and ground-based CFI responses. Cadets exhibiting a superior AGSM performance demonstrated the distinctive cardiac effort patterns, likely indicating a more efficient cardiovascular regulation. These findings suggest that CFI, particularly when measured during the dynamic ground activities, may well serve as an objective physiological marker for assessing the AGSM proficiency and thereby offer insights into the individual differences in the G tolerance.

Learning Objectives

1. Understand how variations in CFI during AGSM relate to maneuver performance.

2. Identify the utility of CFI as a physiological indicator for evaluating AGSM proficiency and G tolerance.

[194] PREDICTABILITY OF PULSE WAVE FLATTENING FOR G-LOC USING ARTIFICIAL INTELLIGENCE METHODS

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(Original Research)

INTRODUCTION: When flying high-performance aircraft, high G-forces can lead to reduced blood flow to the brain and, as a result, to a "G-force induced loss of consciousness" (G-LOC). Unfortunately, this often leads to so-called Class A mishaps, resulting in the loss of the pilot and the aircraft. To date, there is no known valid physiological measurement method that can be used to clearly detect the occurrence of G-LOC in an aircraft shortly before or during G-LOC based on changes in vital sign parameters. The aim of this study was to determine whether computer learning or automatic algorithms can be used to reliably identify specific pulse wave changes in order to detect an impending G-LOC in advance. Methods: Data from a total of 86 long-arm human centrifuge runs in which the pilots experienced G-LOC were examined using automatic computer-assisted analysis of the respective pulse wave curves. This group was compared with a group of test subjects who did not experience G-LOC. The two groups were matched 1:1 in terms of age, country of origin, training type, and anti-G equipment. Methodologically, all pulse waves were analyzed in terms of their height using three different reference methods (30 pulse waves during 1.4 Gz, mean and median of all pulse waves) and in terms of height (90% to 20% of the reference method). The time around the G-LOC or, in the control group, the longest continuous pulse wave change over the entire centrifuge run was analyzed. **RESULTS:** Centrifuge runs with active flight profiles showed significantly longer pulse wave changes in the control group for all reference methods. In training runs that served to certify "high-G flight profiles" and were completed with the targeted use of "Anti-G straining maneuvers" (AGSM), the pulse wave flattening around the period of G-LOC was significantly longer in the G-LOC group than over the entire centrifuge run in the control group. There were no differences between the two groups across all runs. **DISCUSSION:** Even with algorithm-based analysis of pulse wave flattening, no significant pulse wave flattening could be identified, particularly for the mission-critical period of active aircraft control, that could be used as a predictor of impending G-LOC. However, the automatic analysis used here, possibly with the addition of further (vital sign) parameters, could represent a solution for future detection systems. The addition of further parameters would be desirable and is the aim of future studies.

Learning Objectives

1. The participants will learn to understand the physiologic background why pilots can be affected by G-force induced loss of consciousness (G-LOC).

2. The participants will understand the methods and computer algorithm of the presented examination to analyze the pulse wave curves and the results created in this study.

[195] PHYSIOLOGICAL PREDICTORS OF G-INDUCED LOSS OF CONSCIOUSNESS: A SYSTEMATIC REVIEW OF HUMAN CENTRIFUGE STUDIES

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(Original Research)

INTRODUCTION: Almost loss of consciousness (A-LOC) and G-induced loss of consciousness (G-LOC) remain critical threats for aircrew. Even brief gray-out or disorientation can compromise aircraft control. Multiple physiological sensors have been proposed for real-time warning, but evidence is scattered across small centrifuge studies. We aimed to map and appraise physiological monitoring approaches for A-/G-LOC detection and prediction.
METHODS: A systematic literature search was conducted, with 1345 records being screened. Studies were eligible if they (1) involved human participants, (2) used in-flight or centrifuge +Gz profiles, (3) recorded at least one psychophysiological signal, and (4) quantitatively related these signals to A-/G-LOC. Outcomes of interest were parameters that could predict or detect A-/G-LOC. Twenty-three studies met all criteria and were synthesized narratively. **RESULTS:** Participants were aircrew and volunteers. Sample sizes ranged from 6 to 141. All studies used centrifuge profiles with peak ≈+4 to +10 +Gz. Near-infrared spectroscopy (NIRS), examined in 11 studies, consistently showed decreases about 2–6 s before symptoms or G-LOC and identified individual "critical" saturation thresholds, with good discrimination but marked inter-individual variability. One NIRS study achieved ≈65% accuracy for prediction windows up to 3.5 s after high +Gz onset. Lower-limb surface electromyography (EMG), assessed in three studies, provided promising warning times: the best-validated gastrocnemius algorithm detected 7 of 8 G-LOC events 0.5–3 s before onset (sensitivity 87.5%, specificity 100%), whereas a small pilot using similar EMG features yielded 1–6 s warning but several false alarms. Temporal artery Doppler studies showed loss or reversal of forward flow a mean of ≈6 s (range 4–9 s) before blackout at low eye-level arterial pressures. EEG and ocular measures offered additional markers of incapacitation and delayed recovery but were evaluated offline in small samples.
DISCUSSION: Centrifuge research shows that cerebral oximetry, lower-limb EMG, and eye-level arterial pressure or flow are promising signals for A-G-LOC warning, but current models provide narrow warning windows, modest predictive performance, and almost no external validation. Future work should develop and prospectively test multimodal, individualized algorithms with standardized outcome definitions in operationally representative fighter pilot populations.

Learning Objectives

1. The participants will understand the main psychophysiological modalities that have been investigated for the short-term prediction or detection of A-/G-LOC in human centrifuge studies, such as NIRS, EMG, cardiovascular/ocular markers and EEG.
2. The participants will learn about the performance characteristics and warning times of key NIRS- and EMG-based algorithms for A-/G-LOC detection.

[196] PARADOXICAL REDUCTION IN G TOLERANCE WITH THE AGSM

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(Education - Case Study)

INTRODUCTION: Five trainee pilots have been identified for whom the Valsalva component of the AGSM impairs G tolerance compared with muscle tensing alone. **BACKGROUND:** The UK Royal Air Force requires all pilots to undertake centrifuge training prior to commencing Elementary Flying Training. Students are required to sustain +5Gz for 15s with no anti-G suit. Pilots failing to complete the training undertake a core and lower body physical training program followed by a further attempt in the centrifuge. Those failing a second time enter a personalised "G Reinforcement Training" (GRiT) program. This provides intensive G exposure and anti-G straining manoeuvre (AGSM) tuition for up to 4 weeks. 1-2 students enter this program annually. **CASE PRESENTATION:** During GRiT, some students experienced a significant reduction in G tolerance whilst performing a technically competent AGSM comprising both muscle tensing and breathing straining compared with muscle tensing alone. 5 students (median age 22, 4 male, one female) who repeatedly experienced G-LOC at or below +5Gz whilst conducting a full AGSM were able to complete the required G exposure using muscle tensing alone. **DISCUSSION:** During a Valsalva manoeuvre, increased intrathoracic pressure initially raises systolic blood pressure (SBP). The subsequent baroreceptor response causes a compensatory bradycardia and impaired venous return reduces cardiac filling, both contributing to a reduction in stroke volume. It is postulated that high vagal tone in these young and fit subjects exacerbates the parasympathetic response to the Valsalva. In such cases, the compensatory autonomic responses outweigh the initial contribution to SBP, leading to an overall reduction in G tolerance. Recognition of possible paradoxical reduction in G tolerance with the breathing straining component of the AGSM has 2 important consequences. Students appearing to be "G-intolerant" or "incapable" may be affected by this phenomenon. Amending their AGSM to omit a breath strain when operating at low G (up to +5Gz with no anti-G suit) potentially avoids unnecessary loss of such students from the training pathway. Wider awareness of this phenomenon may also improve flight safety by recognising this potential factor when assessing aircrew presenting with low G tolerance in flight.

Learning Objectives

1. The audience will recognise that the breathing straining component of the anti-G straining manoeuvre can paradoxically reduce G tolerance below +5Gz in the absence of a G suit.
2. The audience will gain practical appreciation of the competing physiological responses to the valsalva manoeuvre in the acceleration environment.

[197] FUNCTIONAL PERFORMANCE MODELING DURING NO-EXERCISE PERIODS IN SPACEFLIGHT ANALOGS

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(Original Research)

INTRODUCTION: Future Artemis missions will require astronauts to perform physically demanding tasks under challenging conditions. However, mission phases may limit access to exercise countermeasures due to operational priorities or hardware constraints. To assess the impact of no-exercise periods on task performance, we developed a functional risk model linking deconditioning duration to operational capability. **METHODS:** A literature review identified 31 head-down tilt bed rest (HDTBR; 2–90 days) studies reporting pre/post aerobic capacity (VO_2) values from non-exercise control groups. Isokinetic strength data were extracted from 7 bedrest studies for knee extensor strength (KES) and 4 studies for ankle plantar flexor (APF) strength (5–89 days). Additional data from NASA's Functional Mission Task (FMT) study related fitness metrics to simulated EVA task performance (capsule egress and incapacitated crew rescue) under varying load conditions (0–100% bodyweight). Nine generalized linear mixed models (GLMMs) were developed: three to quantify fitness decline over time, and six to relate VO_2, KES, and APF to each task. Models included fixed effects for fitness metrics, loading conditions, and their interactions, with subject-level random intercepts and time as a random slope. Validation included regression of predicted versus observed performance and cross-dataset comparisons. **RESULTS:** Without exercise, VO_2 declined by 5.1% per log(day+1) ($R^2 = 0.75$); KES decreased linearly by 0.73 Nm/day ($R^2 = 0.71$); APF declined proportionally to baseline strength and time ($R^2 = 0.62$). Performance models showed significant associations between reduced fitness and increased task times. For capsule egress, higher VO_2, KES, and APF were associated with faster completion times, with interaction effects indicating greater performance degradation under higher load conditions. For crew rescue, VO_2, KES, and APF were again significant predictors, with VO_2 showing the strongest relationship ($t = -17.81$, $p < 0.0001$). All models demonstrated high predictive accuracy ($R^2 > 0.60$). **DISCUSSION:** These models quantify the operational impact of deconditioning during no-exercise periods, underscoring the importance of high pre-flight fitness and early integration of exercise hardware in vehicle design. By linking fitness decline to functional performance, this approach translates physiological metrics into mission-relevant outcomes for risk trades and countermeasure planning.

Learning Objectives

1. The audience will be able to understand how aerobic capacity and lower-limb strength decline during no-exercise periods in spaceflight analogs.
2. The audience will learn about the modeling approach used to link fitness decline to EVA task performance under varying external loading constraints.
3. The audience will learn about how these models, and periods of no exercise, may help to inform operational risk trades and countermeasure planning.

[198] ARE HYPOXIA SYMPTOM SIGNATURES RELIABLE? IMPLICATIONS FOR HYPOXIA FAMILIARIZATION TRAINING

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(Original Research)

INTRODUCTION: In-flight physiological events, including hypoxic hypoxia, remain a threat to aviation safety. In the absence of onboard physiological monitoring, aircrew must rely on subjective hypoxia symptom recognition to detect impairment and act. Hypoxia familiarization training is designed to help individuals identify their personal "hypoxia symptom signature," under the assumption that symptoms are stable and reproducible within individuals across exposures. However, the consistency of these symptoms has not been prospectively evaluated using repeated exposures and within-subject reliability analyses. **METHODS:** Twenty-three healthy adults completed four sessions in a within-subjects design: one normoxia (20% O2) and three normobaric hypoxia exposures (9.7% O2; 20k-ft equivalent) in a Reduced Oxygen Breathing Environment. During each session, participants completed a Psychomotor Vigilance Task (PVT), provided live symptom reports, and completed the Hypoxia Symptom Questionnaire (HSQ). SpO2 and heart rate (HR) were continuously monitored. Symptom structure was examined using confirmatory factor analysis (CFA). Within-subject symptom consistency was assessed using cumulative link mixed models (CLMM) with intraclass correlation coefficients (ICCs) and individual-level Krippendorff's α. **RESULTS:** Hypoxia produced robust and repeatable physiological effects, including decreased SpO2 and increased HR, and significantly slowed median PVT reaction time relative to normoxia. In contrast, subjective symptom reporting showed substantial within-subject variability. Although CFA supported a three-factor symptom structure, dimension-level ICCs indicated poor to low-moderate reliability. Item-level analyses revealed that only a small subset of symptoms demonstrated good-to-excellent reliability. Commonly emphasized training symptoms showed poor reliability across sessions. Krippendorff's α indicated poor self-agreement for most participants, with only two individuals exhibiting highly stable symptom patterns. **DISCUSSION:** These findings challenge the assumption that most individuals present a stable hypoxia symptom signature through familiarization training. While hypoxia impairs physiological and cognitive functioning, subjective symptoms vary considerably across

exposures. Hypoxia training may benefit from a more flexible symptom recognition approach and multiple hypoxia exposures, allowing aircrew to develop broader expectations of symptom variability.

Learning Objectives

1. The audience will be able to describe the degree to which hypoxia symptoms are consistent within individuals across repeated exposures.
2. The audience will be able to discuss how hypoxia familiarization training might incorporate flexible symptom variability into instructional practice.

[199] ADDRESSING THE HIGH-NOISE COMMUNICATIONS AND PROTECTION IN ROTARY-WING AIRCRAFT FOR MEDICAL EVACUATION (MEDEVAC) PERSONNEL

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(Education - Program / Process Review)

BACKGROUND: Medical evacuation (MEDEVAC) personnel routinely operate in rotary-wing aircraft (e.g., UH-60 Black Hawk), where interior noise often exceeds 100 dBA due to rotor and engine noise, compounded by vibration and turbulence. These acoustic conditions degrade speech intelligibility, increase auditory workload, and hinder medical teams' ability to relay patient status, receive instructions, and maintain situational awareness during critical care tasks. These conditions emphasize the need to explore technologies that can better support communication in rotary-wing operations. Communication Earplugs (Commplugs/CEPs) systems, which include electronic earplugs/headsets for integrated protection and communication, emerge as a promising solution for MEDEVAC high-noise environments. However, CEPs are not currently listed in the Naval Air Systems Command Technical Manual (Allowance List). Overview: NAWCAD Auditory Performance Laboratory (APL) conducted structured evaluations to assess the suitability of Hearing Protection Devices (HPDs) in a simulated high-noise environment (e.g., 102 dBA F/A-18 cockpit noise). Assessments included Personal Attenuation Rating (PAR) and Modified Rhyme Test (MRT) speech-intelligibility measures. Results show foam canal ear tips CEPs performed nearly on par with the highest-rated devices, with PAR and MRT scores only 1.7 and 0.2% lower than Sound Guard and AWARE filtered 25 dB HPD earplugs, respectively. These findings indicate CEPs can support both hearing protection and effective communication for MEDEVAC personnel in rotary-wing operations. Discussion: Distributed Maritime Operations require MEDEVAC teams to deliver time-critical care across dispersed maritime and expeditionary units with limited access to centralized medical facilities. In these environments, communication demands can be elevated, creating conditions that encourage continued evaluation of technologies appropriate for rotary-wing medical environment. CEPs provide practical, high-value solution that balances attenuation with intelligibility. Adoption of CEPs on Allowance List would enhance communication

accuracy, improve coordination with aircrew, and strengthen mission outcomes. Beyond military applications, CEP integration has relevance for civilian air ambulance crews and international partners facing similar high-noise operational challenges, advancing aeromedicine and human performance across services, international, and military-civilian spheres.

Learning Objectives

1. Discuss the impact of high-noise rotary-wing environments on MEDEVAC communication accuracy, situational awareness, and delivery of medical care.
2. Evaluate the relative performance of hearing protection devices during simulated high-noise MEDEVAC operations.

[200] MILD HYPOXIA INCREASES VERTICAL TRANSLATION THRESHOLDS IN PATIENTS WITH UNILATERAL VESTIBULAR HYPOFUNCTION

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(Original Research)

INTRODUCTION: Hypoxia from breathing air with less than 14.3% O2 diminishes sensory, muscular, & cognitive function. We previously showed asymptomatic hypoxia-related reductions in vestibular function in healthy normal participants. We further characterize this susceptibility to hypoxic exposure by using patients with acquired unilateral vestibular loss (UVL). **METHODS:** 5 confirmed cases of UVL (ages 39-69) with no history of neurological, respiratory, cardiovascular disease, and no recent exposure to prolonged hypoxia prior to their testing were selected for Z-translation vestibular threshold testing with the fraction of oxygen set to 20.9%, 17.9%, 16.6% and 15.4% to mimic altitudes of 820 ft, 4000 ft, 6000 ft, or 8000 ft respectively. A five-question tool documented vestibular symptoms. Time- and altitude-related changes Z-translation thresholds, SpO2, and pulse were compared using 3 separate linear mixed effect models with a fixed-effect factor for SpO2 and random slopes and intercepts. P-values were calculated using Satterthwaite's approximation method. Informed consent was obtained in strict accordance with the ethical standards of The Ohio State University &amp Naval Medical Research Unit Dayton Institutional Review Boards and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. **RESULTS:** Spatial orientation illusions identical in character to those experienced during the acute vestibular event developed in the only participant who acquired the UVL from a non-surgical source whereas symptoms did not occur in the others with surgically-defined UVL. Breathing air with reduced oxygen led to significant reductions in SpO2 ($F(3,80) = 11.87$, $p = 1.63x10-6$, $f = .67$). Z- translation thresholds significantly increased in the hypoxic conditions ($F(3,88) = 8.29$, $p < 0.001$, $f = 0.530$). Further, greater reductions in blood oxygenation significantly predicted higher Z-translation

thresholds (estimated slope = 0.67cm/s/%, t (73.37) = -2.83, p = 0.006, R2c = 0.782). **DISCUSSION:** These results suggest vestibular function may be more susceptible to hypoxia than other sensory systems, especially in clinical cases of acquired UVL. Precautions &amp countermeasures may be warranted for those recovering from vestibular disorders who might experience reductions in blood oxygenation (e.g. aviation environments, deployments to higher altitude bases) while performing activities that require balance and/or accurate and precise spatial orientation.

Learning Objectives

1. Hypoxia affects vestibular function and can disrupt spatial orientation in patients with acquired unilateral vestibular hypofunction more than in healthy adults even years after clinical recovery.
2. Physicians who care for patients with vestibular disorders should provide counseling and accommodation regarding increased risks of disorientation and falling in those who might experience mild reductions in blood oxygenation.

[201] MITIGATING MOTION SICKNESS IN AVIATION: EXPLORING THE POTENTIAL OF BINAURAL BEATS AS A NON-PHARMACOLOGICAL INTERVENTION

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(Original Research)

INTRODUCTION: Motion sickness poses a significant challenge within the aviation community due to the unique and often dynamic environments of flight. The associated symptoms, including nausea and dizziness, can compromise safety and necessitate effective mitigation strategies. While pharmacological interventions offer relief, they are often accompanied by undesirable side effects such as drowsiness, potentially impacting pilot performance. Binaural beats, a non-pharmacological auditory stimulation technique involving the dichotic presentation of two tones with different frequencies, have demonstrated potential as a mitigation strategy for cybersickness. **METHODS:** This study employed a within-subjects design in which 27 participants (n = 27) completed three counterbalanced rotating chair tolerance tests separated by a minimum of seven days. The primary outcome measure was tolerance time, defined as the duration participants remained in the rotating chair before reaching a moderate level of nausea. During each test, participants wore headphones and were randomly assigned to one of three auditory conditions: (1) a silent control, (2) a 250 Hz binaural control tone, or (3) alpha frequency binaural beats (250 Hz in one ear, 260 Hz in the other). Secondary measures included physiological data (heart rate, respiration rate, and skin conductance level) and subjective symptom reports. **RESULTS:** No significant differences were observed in tolerance

time within the rotating chair paradigm across the three experimental conditions (F (2, 50) = 0.698, p = .502). Furthermore, physiological measures, including heart rate, respiration rate, and skin conductance level, exhibited comparable changes across conditions, suggesting similar levels of physiological stress. Consistent with these findings, subjective symptom reports did not significantly differ between conditions over time. These results suggest that binaural beats were not able to improve tolerance to vestibular stimuli or impact discomfort in the testing environment. **DISCUSSION:** Binaural beats are emerging as a potential tool for managing cybersickness and optimizing virtual reality experiences. However, the efficacy of binaural beats appears to be task-dependent, with limited impact observed during highly provocative vestibular stimulation. Further investigation is needed to determine the optimal applications of binaural beats, particularly in scenarios involving less intense motion, such as passenger flight.

Learning Objectives

1. To demonstrate that the process of applying a cybersickness intervention to a highly provocative vestibular environment.
2. To examine the effect of binaural beats in a motion environment.

[202] BIOMARKERS OF BRAIN NEURONAL INJURY EXIST IN SOME TACTICAL INSTRUCTOR PILOTS

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(Original Research)

INTRODUCTION: Neurofilament light (NFL) and glial fibrillary acidic protein (GFAP) are biomarkers for traumatic brain injury. Increased levels within Canadian tactical aviators are proposed to reflect the presence of brain injury. However, no evidence exists to demonstrate which sortie-related physical stressors may evoke expression of ;those biomarkers. Our objective was to investigate the relationship between NFL and GFAP blood serum levels with sortie profiles within U.S.A.F instructor pilots (IPs) across a two-week time period. **METHODS:** Following Institutional Review Board approval, IPs (n=46) provided venous blood samples and daily sortie information across a two-week time period. NFL and GFAP levels within venous blood were analyzed and compared against sortie descriptors including number of sorties, +Gz exposure, duration, and mean altitude. Three exploratory analyses were conducted to determine associations: 1) Tobit regression, 2) Bivariate correlation, and 3) Correlation with dummy variables. Due to the challenge of NFL and GFAP serum levels below the limit of detection, imputation methods were applied to handle censored values. **RESULTS:** Of the 46 IPs, 25 had measurable serum levels of NFL and 15 had measurable GFAP levels. Bivariate correlation analyses showed significant associations between daily NFL levels and daily sorties, mean altitude, and sortie duration (Day 12 NFL concentrations and total sorties: p=0.008). Bivariate correlation also suggested delayed responses between NFL levels and previous sortie stressors

(Day 8 NFL concentrations and Day 6 total sorties: p=0.013). No relationships were observed between sortie descriptors and GFAP. **DISCUSSION:** NFL serum levels suggestive of brain neuronal injury were associated with several sortie-related metrics in 25 of 46 IPs across a two-week time period. The time course between onset of neuronal injury to onset of measurable serum NFL levels may be several days. This, coupled with this study's design precludes analyses of cause and effect between individual sortie metrics with serum NFL levels. Future studies replicating sortie-induced physical duress, conducted within controlled laboratory environments are needed to identify whether neuronal injury can occur during high performance sorties, and if such injury manifests as increased serum NFL levels.

Learning Objectives

1. The audience will be able to identify Neurofilament Light (NFL) and Glial Flibrillary Acidic Protein (GFAP) as proposed biomarkers for brain neuronal injury.
2. The audience will be able to describe that physical duress occurring during high performance sorties were correlated with serum NFL concentrations.

[203] REAL-TIME ESTIMATION OF VISUAL CUE AVAILABILITY USING AIRCRAFT CONTROL DATA: TOWARD OBSERVER-BASED SPATIAL ORIENTATION MODELING

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(Original Research)

INTRODUCTION: Spatial disorientation (SD), especially unrecognized SD (Type I SD), is a major factor in fatal aircraft accidents, making research on its detection and mitigation critical for aviation safety. Observer-based spatial orientation models are a promising approach for predicting SD, but they require explicit information on the availability of visual cues, which is not directly measured during flight. This study proposes a machine learning-based method to estimate visual cue availability in real time using flight performance data. **METHODS:** Flight data were collected from eight adult participants performing a desktop flight simulator (Prepar3D®) task passing through ten targets with straight-and-level flight under two conditions: a good visual environment (GVE) and a degraded visual environment (DVE) which were designed to experimentally define the availability of external visual cues during flight. To emphasize reliance on external visual information and to simulate conditions in which flight instruments are not referenced, flight instruments were not displayed. This condition is also consistent with situations in which Type I SD may occur. Each task was repeated three times under both conditions. For analysis, we applied time-series decoding using a sliding window approach with a window size of 2.0 s and a step size of 0.1 s. Features were derived from altitude time-series data, calculating statistical measures (mean and standard deviation) within each window. Classification was performed using Support Vector Machines (SVM). Validation

employed leave-one-subject-out cross-validation to build a generalized model independent of individual differences. Performance was evaluated using accuracy and F1-score. **RESULTS:** The time-series classification accuracy exceeded 70% at 7.9 s after task onset and peaked at 83.3% (F1-score = 0.84) at 8.7 s, significantly higher than the chance level (50%, p = 0.001, permutation test). At this time, altitude profiles under DVE exhibited pronounced altitude loss compared to GVE. **DISCUSSION:** The results demonstrate that aircraft control behavior can be used to estimate visual cue availability before the completion of a flight task, using time-series analysis over short sliding windows to enable near real-time assessment. Although the experimental task was simple, the findings provide input to observer-based models supporting future pilot state estimation and SD prediction.

Learning Objectives

1. The audience will gain new insights into real-time spatial disorientation detection, particularly the potential of machine learning–based approaches for recognizing the flight environment in real time.
2. The audience will see degraded altitude control in a straight and level flight task under a DVE.

[204] US NAVY AIRCREW BODY COMPOSITION: METHODS AND SUMMARY STATISTICS FROM THE 2024 NAIRANSUR SURVEY AND FUTURE APPLICATIONS

Lori Basham[1], Brian Corner[2], Kenneth Ritchey[1]

[1]Naval Air Warfare Center Aircraft Division, Patuxent River, MD, USA; [2]Research and Engineering Development, LLC, CA, MD, USA

(Original Research)

INTRODUCTION: Anthropometric data for US Navy and Marine Corps (USN/USMC) aircrew has not been updated since the 1960s, and no body composition data on this population has been collected. These data gaps hinder the proper design of personal protective clothing and equipment (PPE), impacting warfighter safety, performance, and readiness. The primary objective of this study was to address these deficiencies by establishing the first modern, comprehensive body composition and anthropometric baseline for the active USN/USMC aviator and aircrew population. **METHODS:** As part of the 2024 USN Aircrew Anthropometric Survey (NAIRANSUR), body composition data were collected from a subset of 961 participants (173 females, 788 males). Key body composition parameters, including percent body fat, skeletal muscle mass, and fat-free mass, were measured using an InBody 770 Direct Segmental Multi-Frequency Bioelectrical Impedance Analysis device (InBody USA, Cerritos, CA). Standard anthropometric measurements (e.g., height, weight, waist circumference) were also taken by professionally trained anthropometrists. Data were analyzed to generate descriptive statistics, including means and percentile values, stratified by sex. RESULTS: This study successfully established a new statistical baseline for the body composition of naval aircrew. Key findings

include mean percent body fat values of 25.9%±7.7% for females and 17.1%±6.5% for males. The mean Body Mass Index (BMI) was 24.4±3.4 kg/m² for females and 26.2±3.1kg/m² for males. Comprehensive summary statistics were generated for over a dozen body composition variables and allometric indices, providing the first-ever normative dataset for USN/USMC aircrew. **DISCUSSION:** The summary statistics provide an essential baseline for developing appropriate PPE for the modern, mixed-sex aircrew force. A primary study limitation was the inability to control for pre-measurement conditions such as participant diet, hydration, and recent exercise. Therefore, while this dataset is unique, we recommend future research be conducted under more controlled conditions to further validate and refine these foundational results. The data is immediately beneficial to several product development and research efforts, but other applications for the data related to performance, health/injury risk, accession, and retention are being explored with collaborators.

Learning Objectives

1. Participants will learn that these findings fill a critical, long-standing data gap, and about the additional research applications where the data may be beneficial.
2. Participants will learn more about how bioelectric impedance analysis systems provide a cost-effective, inobtrusive, portable, and expeditious alternative to DEXA to obtain body composition data.

[205] MODELING OPERATOR SYNDROME AND PHYSIOLOGICAL DYSREGULATION IN MILITARY AVIATORS AND SPECIAL FORCES USING THE CUMULATIVE ALLOSTATIC LOAD FRAMEWORK

Reginald O'Hara[1], Bartley Frueh[2], Arkady Uryash[3]

[1]University of Texas El Paso, El Paso, TX, USA; [2]University of Hawaii, Hilo, HI, USA; [3]Mount Sinai Medical Center, Miami, FL, USA

(Education - Tutorial / Review)

INTRODUCTION: High-performance military aviators and Special Operations Forces (SOF) personnel are repeatedly exposed to multiple stressors, including blast exposure, sustained G-forces, hypoxia, sleep restriction, and cognitive overload, which cumulatively degrade health, neurocognitive function, and operational readiness. Current stress models describe isolated physiological systems but lack integrative, time-resolved metrics for assessing whole-body strain and recovery. **METHODS:** The Cumulative Allostatic Load (CALo) computational framework unifies five theoretical pillars: Allostatic Load, Adaptive Homeostasis, Reactive Scope Model, Complex Dynamical Systems, and Network Physiology Framework, into a dynamic model for quantifying cumulative stress. CALo introduces Dysregulated State (DS) days, defined as periods when one or more physiological systems exceed personalized adaptive thresholds derived from multiple data inputs. These include endocrine, immune, metabolic, cardiovascular, and autonomic biomarkers (e.g., heart rate variability, cortisol, cytokine ratios), integrated with

operational metrics such as flight duration, G-force exposure, and sleep disruption. **RESULTS:** CALo produces interpretable metrics, DS days, and predictive indices that link physiological dysregulation with mission-relevant outcomes. Preliminary modeling suggests that elevated DS-day counts correspond with reduced recovery efficiency, degraded flight performance, and early Operator Syndrome (OS) symptom clustering. Prototype equations quantify the recovery-to-load ratio and define threshold-based risk bands for predictive physiological modeling of flight-readiness assessment. **CONCLUSION:** CALo reframes chronic stress as a measurable, computationally tractable process integrating multisystem physiological with operational exposure data. The framework enables individualized stress monitoring, readiness forecasting, and recovery optimization across high-demand aviators and operators. Hence, CALo offers a testable foundation for Aerospace Medicine and Performance Physiology, providing new tools for predictive modeling of human resilience, mission readiness, and return-to-flight decisions.

Learning Objectives

1. The audience will be able to understand and describe how the Cumulative Allostatic Load (CALo) framework integrates five foundational physiological theories to quantify cumulative stress through the metric of Dysregulated State (DS) days in special forces and high-performance military aviators.
2. The participant will be able to identify and explain the role of physiological biomarkers and recovery metrics in the CALo's predictive model for assessing operational readiness, early dysregulation, and risk of Operator Syndrome (OS) symptom development.
3. The participant will be able to understand a simplified set of dynamical equations that link DS-day accumulation to the intensity, duration, and recovery rate associated with stress exposure.

[206] OPERATIONAL RISKS IN HIGH-FREQUENCY SHORT-HAUL OPERATIONS: COMPARING 6-SECTOR VS. 4-SECTOR DUTIES

Naoya Sawamoto

ALPA-Japan, Tokyo, Japan

(Original Research)

INTRODUCTION: Regional aviation operations are characterized by short-haul, high-frequency operations, yet the safety implications of super-multi-sector duties (e.g., 6 sectors per day) compared to standard multi-sector duties remain understudied. This study investigated whether 6-sector flight duties significantly increase safety risks compared to 4-sector duties. **METHODS:** We conducted a voluntary online survey among 26 pilots (15 Captains, 11 First Officers) at a regional airline in Japan between October 1 and October 31, 2025. Participants recorded subjective fatigue (Samn-Perelli 7-level Scale; SP), Situation Awareness (SA; 10-point Visual Analog Scale), operational error counts (including Undesired Aircraft States), and the necessity for special fatigue countermeasures during actual flight operations. Data were analyzed

using Generalized Linear Mixed Models (GLMM), including ordered logistic and Poisson mixed models, adjusted for age, position, workload (NASA-TLX), and baseline fatigue, utilizing Stata 17.0. The study received institutional ethics committee approval. **RESULTS:** In 6-sector operations, the predicted cumulative probability of experiencing severe fatigue (SP $\ge$6) increased by 34.2 percentage points compared to 4-sector operations. Similarly, the probability of severe SA degradation (SA $\le$4) rose by 26.9 percentage points ($p<0.001$). The odds of pilots requiring special countermeasures to maintain performance were significantly higher in 6-sector duties (Adjusted Odds Ratio 8.01; $p=0.049$). Furthermore, the incidence rate of operational errors increased by 46% (Incidence Rate Ratio 1.46; $p=0.044$) in 6-sector operations compared to 4-sector baselines. **DISCUSSION:** Six-sector operations appeared to be associated with reduced pilot alertness and situation awareness, alongside a statistically significant increase in recorded operational errors. The observed rise in fatigue levels and the increased reliance on compensatory countermeasures suggest that such rosters may impose higher demands on crew performance compared to standard schedules. These findings imply that Fatigue Risk Management System (FRMS) interventions could be valuable for further mitigating safety risks in high-frequency short-haul operations.

Learning Objectives

1. The audience will learn about the quantified increase in operational errors and severe fatigue risks associated with 6-sector flight duties compared to 4-sector duties.
2. The participant will be able to assess the impact of high-frequency short-haul operations on the degradation of pilot situation awareness.
3. The audience will learn about the increased necessity for pilot-initiated fatigue countermeasures during extended multi-sector operations.

[207] A SYSTEMATIC DESIGN APPROACH FOR UNOBTRUSIVE WEARABLE SENSOR SYSTEMS IN EXTREME ENVIRONMENTS

Alyvia O'Brien[1], Sarah Leary[1], Andrea Webb[2], Katya Arquilla[1]

[1]University of Colorado Boulder, Boulder, CO, USA; [2]The Charles Stark Draper Laboratory, Inc, Cambridge, MA, USA

(Original Research)

INTRODUCTION: Continuous, long-duration monitoring of human health and performance remains essential for crew safety and mission success in extreme environments, with wearable sensor systems (WSSs) as the leading technology to fulfill this need. However, recent literature highlights that current commercial off-the-shelf WSSs fit poorly, are uncomfortable, and overall provide suboptimal user experiences when applied to such operations. These shortcomings primarily stem from limited stakeholder input when deriving system requirements in the context of extreme environments. This work aims to address these gaps through a systematic design process that provides user-centered requirements of unobtrusive WSSs designed specifically for

extreme environments. To illustrate this approach, a case study is presented involving the fabrication of a wearable, textile-based electrocardiogram (ECG) sensor system. **METHODS:** Researchers followed the Sustainable Product Evaluation, Engineering, and Design process, a systems-engineering approach to designing and evaluating wearable technologies. First, Air Force personnel and researcher input, detailed in a separate work, helped define functional and design requirements for the WSS, which were then translated into design solutions and a preliminary design concept. Lastly, researchers used a physical fit model to guide prototype fabrication and modifications. **RESULTS:** The unobtrusive WSS must collect high-quality ECG data without negatively impacting a user's health, happiness, or productivity. Design requirements include avoiding inhibition of essential physiological systems; maximizing comfort, range of motion, and social wearability; minimizing garment displacement; and ensuring correct ECG placement. These requirements lead to design solutions relating to placement location, form factor, optimal tightness, material biocompatibility, and a seamless interface. The resulting design concept is a chest-mounted garment with shoulder straps, customizable through novel adjustment mechanisms. **DISCUSSION:** This work provides a repeatable design pathway for WSSs usable in extreme environments while also illustrating how the process translates stakeholder needs, tight environmental constraints, and human-factor considerations into specific design choices. Addressing these gaps will advance the use of WSSs in long duration missions in extreme environments and support future integration of artificial intelligence and machine learning.

Learning Objectives

1. Describe a systematic design process for developing an unobtrusive WSS specifically for continuous wear in extreme environments.
2. Recognize the importance of integrating stakeholder input into system requirement derivation to ensure that the WSS design concept is tailored for extreme environments.

Wednesday, 05/20/2026, 8:30 AM

Plaza A/B

[S-30] PANEL: DEVELOPMENT OF HERMES TO SUPPORT A CREW MEDICAL OFFICER DIGITAL ASSISTANT

Chair: Jimmy Wu

Co-Chair: Truong Le

Panel Overview: *This panel will discuss the accomplishments in development of the human health and performance data management platform, Hermes project, and its use in a crew medical officer digital assistant (CMO-DA) proof-of-concept demonstration in NASA's Lunar Command and Control Interoperability (LuCCI) testing environment. Multiple organizations supported by Translational Research Institute for Space Health (TRISH) and NASA conceived, developed, and implemented a CMO-DA on the Hermes platform to demonstrate autonomous*

medical capability during a simulated kidney stone scenario during a Martian transit mission. The first two presentations describe the efforts from two organizations funded by TRISH to develop the Hermes data management platform. The third presentation describes one organization's efforts in deploying Hermes in ground (e.g. LuCCI) and space based analog environments. The last two presentations describe NASA's effort, using Hermes as a network layer, to develop and demonstrate a CMO-DA in NASA's LuCCI environment. These combined activities were successful in achieving technical milestones that demonstrate the feasibility of providing autonomous medical capability to support human health and performance on deep space human spaceflight missions.

[208] HERMES: AN OFFLINE-FIRST, FHIR-BASED CLINICAL DECISION SUPPORT AND RESEARCH DATA PLATFORM FOR AUTONOMOUS MEDICAL OPERATIONS IN LONG-DURATION SPACEFLIGHT

Syed Gufran, Mir Suhail, Wahadat Jan, Chintan Patel, Sharib Khan

TrialX, Tarrytown, NY, USA

(Original Research)

INTRODUCTION: Future commercial and exploration-class space missions will rely on non-physician crews operating under prolonged communication delays. As missions extend farther from Earth, real-time medical support will be unavailable. Existing terrestrial healthcare standards such as HL7 FHIR are facility-centered and episodic, offering limited support for autonomous, continuous care under space-specific constraints including microgravity, radiation exposure, and constrained resources. There is a need for onboard systems that support structured medical decision-making, documentation, and delayed expert oversight. To develop and evaluate an offline-first clinical decision support system that enables non-physician spaceflight participants to perform protocol-driven medical assessment, AI driven workflows and limited condition management during extended communication delays, while supporting longitudinal health tracking and asynchronous flight surgeon review using FHIR-compatible data exchange. **METHODS:** An offline-first, HL7 FHIR compliant clinical platform (HERMES) was developed for use in low-connectivity environments Clinical protocols are implemented as structured, stepwise workflows incorporating standardized symptom assessments, condition triage, and intervention execution with progress tracking. A lightweight AI-assisted decision support layer analyzes symptoms in the context of patient history and mission-specific factors to recommend protocols and flag high-risk patterns. Embedded approval gates enable asynchronous flight surgeon consultation for predefined high-risk actions, with structured approval requests queued during connectivity gaps. **RESULTS:** All clinical events are stored locally as FHIR resources and synchronized upon connectivity. Environmental data integration via an edge-based MQTT interface was implemented as a proof of concept. A major challenge is representing space-specific concepts within the existing FHIR model. For example, modeling missions, inventories, environmental hazards, and unique medical risks does not map naturally to standard FHIR resources, requiring careful consideration of extensions, profiles, and structural adaptations.

Secondary challenges include managing offline-first synchronization and version conflicts. **DISCUSSION:** The prototype system successfully demonstrates the feasibility of offline-first, FHIR-compatible clinical decision support for autonomous, protocol-driven medical care by non-physician crews during extended communication delays. The system enables longitudinal health tracking, delayed expert oversight, and integration of environmental context, addressing key medical support gaps in future deep-space missions.

Learning Objectives

1. The participant will be able to describe the challenges of delivering autonomous medical care during long-duration spaceflight and explain why traditional facility-centered healthcare standards are insufficient under prolonged communication delays.
2. The participant will be able to explain how an offline-first, HL7 FHIR–based clinical decision support platform can enable protocol-driven medical assessment, longitudinal health tracking, and asynchronous flight surgeon oversight for non-physician spaceflight crews.
3. The participant will be able to identify key technical and modeling challenges associated with adapting HL7 FHIR for space-specific medical operations, including mission context, environmental hazards, and offline data synchronization.

[209] EJENTA HUMAN AND ENVIRONMENTAL RESEARCH MATRIX FOR EXPLORATION OF SPACE (HERMES)

Rachna Dhamija, Maarten Sierhuis

Ejenta, San Francisco, CA, USA

(Original Research)

INTRODUCTION: The Ejenta Human and Environmental Research Matrix for Exploration of Space (HERMES) system is a semi-autonomous platform to collect, analyze and act on biomedical data, and to enable a spaceflight participant, their medical providers and researchers access to the participant's medical history and data throughout their journey. **METHODS:** Ejenta adapted its existing earth-based platform to provide automated remote patient care for spaceflight. Each spaceflight participant has their own "intelligent agent" and devices that collect, display and store their individual data, which feed into a clinical dashboard that allows real time-monitoring by the in-flight crew, Mission Control and remote researchers on the ground. **RESULTS:** The platform allows data to be collected from numerous consumer wearable and medical kit devices (including vitals and point of care ultrasound), environmental sensors, and camera-based vital sign measurements. Personnel onboard and in Mission Control can use mobile and Web-based applications to view individual and population level data and to receive alerts about changes to an astronaut's health or to the vehicle environment. The HERMES software is containerized and designed to run on COTS computing devices that function without cloud connection to automatically collect and analyze astronaut data. Data can be transferred to networked edge computers on different space vehicles to ensure continuity of care across

missions. **DISCUSSION:** Ejenta will continue to add new devices and improve device integration and to increase the capabilities of intelligent agents to perform autonomous tasks and workflow automation. Our work highlights the need for standardized data interfaces for human health in spaceflight. By advancing a set of interoperable standards and APIs that span general health metrics, imaging modalities, and data collection and analysis, we can enable monitoring, preventative care, timely decision-making, and sustained well-being in space.

Learning Objectives

1. The participant will be able to describe how intelligent agents and containerized software enable autonomous medical monitoring and clinical decision support in spaceflight without cloud connectivity.
2. The participant will be able to discuss the necessity of standardized data interfaces and interoperable APIs for integrating diverse medical data streams and ensuring continuity of care across missions.

[210] HERMES IN-ORBIT AND GROUND DEMONSTRATIONS WITH AXIOM AND NASA

Rachna Dhamija, Maarten Sierhuis

Ejenta, San Francisco, CA, USA

(Original Research)

INTRODUCTION: Ejenta conducted two Technical Demonstrations (TDs), in-orbit and on the ground, to advance earth-independent medical operations using the Human and Environmental Research Matrix for Exploration of Space (HERMES) platform. **METHODS:** In collaboration with Axiom and the ISS National Lab, we demonstrated HERMES onboard the ISS. HERMES software containers were first installed on the onboard AWS Snowcone edge computer, via over the air (OTA) updates from Axiom's Mission Control. The software ran onboard with interrupted data communication to the ground. HERMES intelligent agents processed artificially generated data from wearables and sensors to simulate crew health monitoring, generating analytics and alerts for Axiom crew onboard and ground personnel. We expanded HERMES through a ground-based TD with NASA's Human Research Program in the Lunar Command and Control Interoperability (LuCCI) project. HERMES integrates with the LuCCI architecture to collect astronaut medical data (e.g., from the Butterfly Ultrasound) and to inform AI clinical decision support models. **RESULTS:** We successfully demonstrated HERMES on different edge hardware in varying scenarios. The in-orbit Axiom TD proved that HERMES could be delivered onboard via OTA and that intelligent agents could collect, process and act on the data to generate analytics, alerts and notifications. Ground personnel could view health data and alerts in near real-time, even despite Loss of Signal (LOS) events. By integrating HERMES software with large language models (LLMs), clinical decision support and machine learning models, we jointly demonstrated the Chief Medical Officer Digital Assistant (CMO-DA) for autonomous clinical decision support. **DISCUSSION:** The TDs advance the development of autonomous

medical operations for space and remote Earth environments. The Axiom TD illustrates how simulated data preserves scarce crew time. Future edge devices in space will support more advanced intelligent agent capabilities, such as automated workflow and interactive LLMs.

Learning Objectives

1. The participant will be able to explain how edge computing enables the deployment and operation of autonomous medical software in environments with interrupted or delayed communication.
2. The participant will be able to evaluate the use of "intelligent agents" and Large Language Models (LLMs) in providing automated clinical decision support for spaceflight crew members.

[211] AUTONOMOUS CLINICAL DECISION SUPPORT FOR EARTH-INDEPENDENT MEDICAL OPERATIONS: EVALUATING THE CREW MEDICAL OFFICE DIGITAL ASSISTANT (CMO-DA)

Ali Al[1], Truong Le[2], Doug Ebert[1], Jay Lemery[3], Joe Schmid[2], Maribeth Carpenter[4], Carlos De Los Santos[2]

[1]KBR, Houston, TX, USA; [2]NASA, Houston, TX, USA; [3]University of Colorado School of Medicine, Boulder, CO, USA; [4]The Aerospace Corporation, Houston, TX, USA

(Original Research)

INTRODUCTION: As exploration missions extend beyond Low Earth Orbit (LEO), communication delays and resource constraints render traditional ground-based medical support unobtainable, posing significant risks to crew health and well-being. This presentation evaluates the Crew Medical Officer Digital Assistant (CMO-DA), an AI-driven Clinical Decision Support (CDS) tool designed for autonomous medical operations, by showcasing a renal ultrasound and diagnosis in a resource-constrained, edge-computing environment. **METHODS:** The CMO-DA employs an agentic AI 'clinical' blackboard architecture, leveraging Google's MedGemma Large Language Model (LLM) and integrating with a Butterfly IQ3 portable ultrasound via Ejenta's integrated biomedical platform. For autonomous operations, the CMO-DA system ingested NASA's Autonomous Medical Officer Support (AMOS) training content, offering real-time, interactive guidance for image acquisition. A custom machine learning model then processed captured images to classify nephrolithiasis ("kidney stones"). **RESULTS:** The machine learning model demonstrated 98% accuracy on the validation dataset. The system successfully managed an entire clinical encounter, employing Natural Language Processing (NLP) for symptom analysis and differential diagnosis. Utilizing AMOS content, the CMO-DA offered verbal guidance to navigate anatomical challenges, securing diagnostic-quality images. The integrated classifier was then able to either confirm or exclude nephrolithiasis without Mission Control Center's (MCC) Flight Surgeon ground support. **DISCUSSION:** This proof-of-concept validated the feasibility of integrating Large Language Models (LLMs) and Computer Vision (CV) on

edge devices for Earth-Independent Medical Operations (EIMO). By combining Just-in-Time training with active AI guidance, CMO-DA demonstrated that high-fidelity medical decision-making is sustainable without cloud connectivity or MCC intervention.

Learning Objectives

1. The participant will be able to identify deep space constraints necessitating autonomous Clinical Decision Support.
2. The participant will be able to evaluate AI-integrated ultrasound for autonomous medical guidance in isolated environments.

[212] NASA HUMAN RESEARCH PROGRAM'S CONTINUE USING OF AI TECHNOLOGY TO MITIGATE EXPLORATION MEDICAL RISK

Truong Le[1], Jay Lemery[2], Josef Schmid[1], Ali Al[3], Maribeth Carpenter[4]

[1]NASA, Houston, TX, USA; [2]University of Colorado School of Medicine, Boulder, CO, USA; [3]KBR, Houston, TX, USA; [4]The Aerospace Corporation, Houston, TX, USA

(Original Research)

INTRODUCTION: National Aeronautics and Space Administration's (NASA) Human Research Program (HRP) Science Integration Office (SIO) strives to be a pioneering force in seamlessly integrating advanced medical Artificial Intelligence (AI) to safeguard crew health in deep space. HRP seeks to empower space professionals with intelligent AI tools to identify and mitigate crew medical risk by unlocking unparalleled insights for accelerated discovery and response. HRP's AI team continues to push the boundaries of what's possible as they develop the next evolution of health systems for deep-space exploration. **TOPIC:** By leveraging external partnerships, HRP SIO is able to enhance the understanding of the role AI plays in managing human system risks. HRP SIO is actively advancing proof-of-concept projects such as the innovative Crew Medical Officer Digital Assistants (CMO-DA). This initiative employs agentic AI tools and integrates space medicine-literate language models to supplement existing space condition/risk data sources, such as the probabilistic risk assessment tool, and NASA's Integrated Medical Evidence Library. In collaboration with data scientists from prominent technology firms such as Google, Microsoft and Ejenta, NASA was able to integrate the Butterfly Ultrasound (iQ3) device into a multi-vector data stream system. This integration successfully demonstrated the capability of providing real-time diagnostic functionality during a simulated space mission, confirming the ability to provide immediate medical support as part of a Clinical Decision Support System (CDSS). The application of the Butterfly Ultrasound, combined with AI guidance, facilitated the autonomous execution of complex medical diagnostics, thereby reducing the need for direct Earth-based intervention. The CMO-DA interoperability portfolio includes multi-vector data streams from Ejenta Translational Research Institute for Space Health (TRISH), the use of diagnostic and procedural support for ultrasound imaging developed in NASA's Autonomous Medical Officer Support (AMOS), the provision of

emergency procedure support and situational awareness for the Mission Control Center (MCC), as well as NASA establishing a Space Act Agreement (SAA) with UpToDate to use their data as part of the CDSS. This portfolio is designed to enhance the integration and utilization of various data sources and technologies for improved clinical decision support. Multi-vector data streams from Ejenta TRISH offer standardized, integrated multi-point data, facilitating more precise and timely health assessments. Diagnostic and procedural support for ultrasound imaging developed in AMOS which provides procedures capabilities to assist crew in diagnosing and managing medical conditions more effectively. Emergency procedure support and situational awareness for the MCC ensures that critical information is readily available during emergencies, enhancing decision-making and response times. NASA and UpToDate are collaborating on a SAA as part of the CDSS. This initiative aims to utilize their comprehensive medical knowledge database to provide the most up-to-date, evidence-based guidelines and recommendations. The goal is to improve CMO-DA model outcomes. **APPLICATION:** Continuing to employ agile techniques and refining the proof of concepts within the HRP AI strategy has facilitated the exploration of various AI approaches. This has enhanced our expertise and knowledge through collaborative efforts with both internal and external partners, as well as the involvement of HRP and its stakeholders.

Learning Objectives

1. The participant will be able to identify deep-space constraints that demand autonomous medical operations to maintain crew health and mission continuity when communication with Earth is limited.
2. The participant will be able to evaluate AI-driven devices for autonomous medical support in isolated environments.

Wednesday, 05/20/2026, 8:30 AM

Plaza D

[S-31] SLIDE: THE 10-YEAR ITCH AND THE ZERO-G STITCH

Chair: Sheyna Gifford

Co-Chair: Katherine Cortez

[213] CERVICAL SPINE DEGENERATIVE CHANGES IN FIGHTER PILOTS OVER A TWO-YEAR PERIOD

Rachel Cutlan, L. Tugan Muftuler, Narayan Yoganandan, Aditya Vedantam, Brian D. Stemper

Medical College of Wisconsin, Milwaukee, WI, USA

(Original Research)

INTRODUCTION: Fighter pilots frequently report neck pain, which is likely tied to the flight environment. During flight, fighter pilots are exposed to high magnitude accelerations while in non-neutral head positions as they scan the surrounding airspace. These loading conditions increase the stress on the cervical spine and may contribute to accelerated degeneration. The goal of this study was to quantify cervical degenerative changes in fighter pilots over the course of a 3-year study. **METHODS:** Wisconsin Air National Guard pilots of fifth-generation fighters gave informed consent and participated in bi-annual cervical spine MRI scans over a two-year period. Spine parameters (disc morphology, cord compression) were measured on sagittal and axial T2-weighted images and compared between timepoints using repeated measures ANOVA. **RESULTS:** Twenty-one fighter pilots (19M/2F; avg age (SD): 36(7) years) completed between two and four MRI scans. Posterior intervertebral disc height was reduced at the final scan compared to the initial scan (two-year period), specifically at C5-6 (p=0.09). Spinal canal occupation increased over time at C3-4, C4-5, and C5-6 (p's<0.15). This included thirteen posterior disc bulges with a notable increase in size and three new disc herniations which occurred over the span of 3-8 months. Older pilots tended to exhibit larger changes in C4-5 spinal canal occupation between scans (p=0.12). **DISCUSSION:** These results show possible degenerative consequences of the high acceleration experienced by fighter pilots, which include increased disc bulging. This is an important finding as disc bulges contribute to cord compression and nerve impingement, which may cause myelopathic/radiculopathy symptoms. Future work will include three additional time points of MRI scans and comparison to civilian spine degeneration rates. **DISCLAIMER:** The views expressed in this abstract are those of the authors and do not necessarily reflect the official policy or position of the Department of the Air Force, the DOD, nor the USG.

Learning Objectives

1. Understand the biomechanical load environment experienced by fighter pilots during flight training exercises.
2. Understand potential degenerative changes associated with repetitive exposure to the fixed-wing biomechanical load environment.

[214] BIOMECHANICAL CHARACTERIZATION OF GAIT PATTERNS UNDER HYPOGRAVITY CONDITIONS USING THE ALTERG® TREADMILL

Duarte Conchinhas[1], Fausto Pinto[1], Nelson Vinagre[1], Edson Oliveira[1], Thais Russomano[1], António Veloso[2], Filipa João[2]

[1]Faculty of Medicine University Lisbon, Lisbon, Portugal; [2]Faculty of Human Kinetics, Lisbon, Portugal

(Original Research)

INTRODUCTION: Future Lunar and;Martian missions require astronauts to perform mobility-dependent tasks in reduced gravity, yet the operational consequences of hypogravity on gait

mechanics remain insufficiently defined. While microgravity-related deconditioning is well documented, far less research has examined hypo-gravity locomotion, where altered spatiotemporal control may impact stability, movement efficiency, and EVA task performance. This study aimed to (i) characterize gait adaptations across Moon- and Mars-equivalent gravity levels and (ii) identify the biomechanical parameters most relevant to countermeasure and spacesuit design. **METHODS:** Thirteen healthy adults (18–35 yr; both sexes) completed consecutive 3-min walking trials at 3.2 $km \cdot h^{-1}$ on an AlterG® lower-body positive-pressure treadmill simulating Earth (1 g), Mars (0.38 g), Moon (0.20 g), and return-to-Earth conditions, performed with and without a 5% incline. Three-dimensional kinematics were captured using Xsens inertial sensors placed on the pelvis and lower limbs. Extracted metrics included step length, cadence, stance and swing duration, and hip/knee/ankle joint angles. Friedman tests with Wilcoxon post-hoc comparisons (Bonferroni-corrected) assessed condition differences. Ethics approval: Faculty of Human Kinetics, University of Lisbon (CEIFMH No. 3/2023). **RESULTS:** Simulated hypogravity produced marked gait alterations relative to 1 g. Under Lunar loading, step length increased 8.5%, swing duration 15.9%, and step frequency decreased 7.7%. Hip and knee range of motion rose 19.7%, ankle dorsiflexion decreased, and knee adduction increased 33.4%. Mars gravity elicited similar but smaller changes. No significant differences were observed between baseline and return-to-Earth trials. **DISCUSSION:** Decreasing gravitational load shifts gait toward slower, stability-oriented strategies with increased frontal-plane control. These adaptations highlight critical considerations for spacesuit mobility, partial-gravity exercise countermeasures, and EVA planning. Findings also inform terrestrial applications using body-weight-support systems in rehabilitation and athletic performance contexts.

Learning Objectives

1. Explain how Moon- and Mars-equivalent gravity influence spatiotemporal gait parameters (step length, cadence, swing/stance) and joint kinematics (hip, knee, ankle), and how these biomechanical changes may impact astronaut stability, task efficiency, and EVA performance in partial-gravity environments.
2. Identify the key biomechanical variables most affected by hypogravity—including increased frontal-plane control demands and altered joint mobility—and describe how these findings inform the design of effective countermeasure protocols and next-generation spacesuits to preserve mobility and reduce operational injury risk.
3. Discuss how hypogravity gait adaptations translate to terrestrial applications, including rehabilitation using body-weight-support systems, clinical gait retraining, and performance strategies for athletes requiring reduced-load locomotion, highlighting the shared neuromuscular challenges across spaceflight and Earth-based movement environments.

[215] A 10-YEAR-REVIEW OF BACK INJURY AMONGST RSAF FIGHTER AIRCREW

Feng Wei Soh[1], Jonathan Jia Jing Pong[2], Aaron Qi Han Chua[2]

[1]Changi General Hospital, Singapore, Singapore; [2]Republic of Singapore Air Force, Singapore, Singapore

(Original Research)

INTRODUCTION: Musculoskeletal back injuries pose a substantial occupational health risk to fighter aircrew potentially leading to prolonged or permanent flying restrictions. Beside unique operational stressors like high-G forces and life support equipment weight, general population risk factors may also be associated with such injuries in fighter aircrew. **METHODS:** A retrospective case-control study was conducted using data obtained from Republic of Singapore Air Force (RSAF) F-16 and F-15 fighter aircrew between 2014 and 2024. Cases were defined as aircrew diagnosed with musculoskeletal back injuries resulting in restriction from high-G or flying duties (n=26). There was a 1:3 ratio of cases to controls (n=78) based on gender, age, total flying hours, and platform type. Data on operational, lifestyle (current smoking status, alcohol use, exercise frequency, PHQ-9 and GAD-7 questionnaire scores), and clinical (BMI, blood pressure, LDL) variables were extracted from the RSAF annual health screening database for both groups. **RESULTS:** Aircrew with an elevated BMI ≥25.0 had significantly increased odds (OR: 4.08, p=0.019) whilst aircrew who regular exercised ≥3 times/week had significantly reduced odds (OR: 0.24, p=0.043) for musculoskeletal back injuries. There were no significant associations between musculoskeletal back injuries and hyperlipidaemia, hypertension, smoking, or alcohol use in the study. **CONCLUSION:** Common lifestyle factors are significantly associated with operationally relevant musculoskeletal back injuries in fighter aircrew. Understanding the interplay between general risk factors for such injuries and the unique stressors experienced by fighter aircrew will help flight surgeons develop effective preventative and management strategies for back injuries in fighter aircrew.

Learning Objectives

1. The audience will learn about the general population risk factors which may be associated with musculoskeletal back injuries in fighter aircrew
2. The audience will learn about general population risk factors which has to be taken into account when creating a holistic back injury preventative and management strategy for fighter aircrew.

[216] WITHDRAWN

[217] MORPHOLOGICAL PROPERTIES OF EXTENSOR AND FLEXOR MUSCLES OF US AIR FORCE FIGHTER PILOTS: IMPLICATIONS FOR SPINAL LOADS AND MODELING

Tyler Rooks[1], Narayan Yoganandan[1], Huy Truong[2], Jared Koser[2], Brian Stemper[2], Charles Weisenbach[3], Peter Le[4]

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(Original Research)

INTRODUCTION: Cervical muscles contribute to the posture, stability, and load carrying capacity of the head and neck under physiological and ejection scenarios. Any change in the properties of the muscle, e.g., area or distance of the center of gravity of the muscle to the spinal segment, changes the lever arm, and alters internal load sharing. Recent studies underscoring the earlier and greater prevalence of neck pain in military personnel than civilians have emphasized the need to develop musculoskeletal injury models (MSKI) to determine segmental neck loads for injury mitigation and prevention. Current MSKI models do not include muscle morphologies specific to the fighter jet pilots, in whom early onset of neck pain, spine degeneration, and cervical symptomatic degenerative spondylosis are well known. This study was designed to obtain muscle morphological data from a group of US Air Force fighter pilots. **METHODS:** Supine MRIs were taken after consent from nine pilots. Muscles were segmented on axial images at each inferior endplate from C2 to T1. Morphologies (cross-sectional areas, centroids, and muscle angulations) of flexor (longus capitis-LCAP, longus colli-LCO, sternocleidomastoid-SCM) and extensor (spinalis cervicis, semispinalis capitis and cervicis, multifidus) muscles were obtained. **RESULTS:** Mean age, stature, weight, BMI: 39±5years, 1.8±0.1m, 83±8kg, 27±2kg/m2. Flexors: across all C2 to T1 levels, mean areas, centroids and angulations: LCAP: 30-98mm2 20 -24mm, 110-1250, LCO: 69-122 mm2, 17-19mm, 102-1200, SCM: 106-540mm2, 43-57mm, 70-12350. Coefficients of variations were lowest for angulations (0.1), then centroids (<0.22), and area (0.36). Extensors had similar variations (not given due to word limits). Significant (p<0.05) differences were found between upper and lower cervical groups in different muscle groups. All level-specific areas, centroids, and angulations and statistical analysis will be presented. **DISCUSSION:** Areas, centroids, and angulations of flexor and extensor muscles obtained from MRIs at different levels of the cervical spinal column from a group of Air Force fighter pilots showed variations on both muscle type and action. These data can be used in MSKI models to predict realistic neck loads, stresses and strains, and anterior/posterior load-sharing for optimizing servicemember healthcare and readiness and assist in early prediction of excessive loads on specific neck segments/components that may contribute to neck pain.

Learning Objectives

1. Knowledge of the role of muscles on the osteoligamentous cervical column loads and implications spinal disorders such for neck pain.
2. Knowledge of the morphological properties of flexor (longus capitis, longus colli, and sternocleidomastoid) and extensor (spinalis cervicis, semispinalis capitis and cervicis, and multifidus) muscles of the spine.

[218] FEASIBILITY OF MENSTRUAL AND CONTRACEPTIVE DEVICE INSERTION AND REMOVAL AND JUST-IN-TIME TRAINING IN THE MICROGRAVITY ENVIRONMENT

Shawna Pandya[1], Kellie Gerardi[2], Begum Mathyk[3], Norah Patten[4], Aaron Persad[5]

[1]International Institute for Astronautical Sciences, Edmonton, Alberta, Canada; [2]International Institute for Astronautical Sciences, Jupiter, FL, USA; [3]International Institute for Astronautical Sciences, Tampa, FL, USA; [4]International Institute for Astronautical Sciences, Dublin, Ireland; [5]International Institute for Astronautical Sciences & University of Maryland Eastern Shore, Princess Anne, MD, USA

(Original Research)

INTRODUCTION: Medical devices for contraceptive and menstrual management have historically not been studied in space and space-like environments. In the current era of human spaceflight, as long-duration missions and commercial missions encompassing a wider demographic of astronauts become more prevalent, it is important to be prepared to address device complications as they occur in spaceflight, including managing subdermal contraceptive implants that become infected or migrate. Hormonal intrauterine devices (IUDs) can offer long-term contraceptive control and menstrual suppression in long-duration spaceflight, and be used to manage abnormal uterine bleeding (AUB), and may require placement over the course of a long-duration spaceflight, or need removal and replacement in spaceflight if dislodged, expelled, or expired. Additionally, it is possible that a crew medical officer may require IUD placement, necessitating placement by a non-medically trained crew member. **METHODS:** Physicians experienced in IUD placement and removal (n=2), and crew members (n=2) with no prior medical experience were tasked with IUD insertion and removal in microgravity conditions using plastic uterine models. The participants with no prior experience were trained in IUD insertion and removal on the ground and then guided in real-time in parabolic flight under the supervision of the experienced physicians. A physician (n=1) and non-medical layperson (n=1) were trained in the insertion and removal of an etonogestrel subdermal implant on the ground, and then tasked to perform the procedure in parabolic flight. **RESULTS:** All participants successfully completed IUD insertion and removal in ground conditions and in parabolic flight. Non-medical participants were able to complete IUD insertion in a single parabola with medical supervision. The physician was able to successfully insert and remove the etonogestrel implant, and the layperson was able to successfully insert the etonogestrel implant. **DISCUSSION:** This study, to our knowledge, marks the first time subdermal contraceptive implant and IUD insertion and removal were assessed in the microgravity environment. The success of this procedure in microgravity suggests that device complications, insertions and removals can successfully be managed in the microgravity environment, and that non-experienced practitioners can be trained to successfully perform the procedure under supervision.

Learning Objectives

1. By the end of this presentation, the audience will understand the relevance of studying intrauterine device and contraceptive implant insertion and removal in the microgravity environment.
2. By the end of this presentation, the audience will understand the relevance of studying just-in-time training for medical procedures for laypersons as they pertain to women's health. The nuances of procedural operations in the microgravity environment.
3. By the end of this presentation, the audience will understand the relevance of studying the nuances of procedural operations in the microgravity environment.

Wednesday, 05/20/2026, 8:30 AM

Plaza F

[S-32] SLIDE: BEYOND PRESSURE- HYPOBARIA & HYPOXIA

Chair: Tyson Brunstetter

Co-Chair: Munna Khan

[219] SELECTION OF A DECOMPRESSION MONITORING FRAMEWORK FOR LUNAR DEVELOPMENT EXTRAVEHICULAR ACTIVITIES AT NASA'S NEUTRAL BUOYANCY LABORATORY

Thomas Skinner[1], Kristi Ray[1], Ethan Stephens[2], Craig Kutz[1]

[1]UTMB/NASA Johnson Space Center, Galveston, TX, USA; [2]UTMB, Galveston, TX, USA

(Education - Program / Process Review)

BACKGROUND: Future lunar operations are expected to require higher volumes of extravehicular activities (EVAs). NASA's Neutral Buoyancy Laboratory (NBL) provides a high-fidelity; analog for partial microgravity and will be utilized in training astronauts for lunar operations. Historically conservative dive safety limits at the NBL have been adequate for Shuttle and ISS mission profiles, yet are increasingly restrictive for emerging lunar and exploration campaigns. Future operations may require dives longer than six hours and require variable suit pressures. As these operational envelopes expand, there is a need for a more precise and transparent method to characterize decompression stress, enabling informed decisions regarding acceptable exposure duration, incorporation of safety stops, or adjustment of existing limits. **OVERVIEW:** This presentation describes a multidisciplinary approach to evaluate decompression modeling for real-time monitoring of long-duration, shallow mixed-gas NBL suited operations. Two established decompression algorithms—the Bühlmann ZHL-16 model with Gradient Factors and the U.S. Navy Thalmann-derived model—were assessed specifically for their suitability as physiologic tools of decompression safety. Evaluation criteria included transparency of underlying mathematics, modeling of slow tissue compartments, control of

conservatism, mixed-gas capability, and reproducibility. Ultimately, Bühlmann ZHL-16 with Gradient Factors was chosen due to its publicly available equations, deterministic behavior, tunable conservatism, and alignment within the operational complexities of extended EVA analog activities. **DISCUSSION:** Implementation of a transparent, monitoring-focused decompression model at; NASA's NBL enables dive medical officers to directly assess; inert gas loading and decompression stress during extended EVA analog operations, particularly in slow tissue compartments that dominate long, shallow exposures. This approach focuses real-time medical decision-making by providing physiologic context for mission duration, suit pressure, workload, and individual variability. From an aeromedical governance perspective, use of a deterministic and auditable model aligns decompression risk management with established spaceflight safety principles, including traceability, reproducibility, and controlled adjustment of conservatism.

Learning Objectives

1. The audience will learn about a multidisciplinary approach to evaluate decompression modeling for real-time monitoring of long-duration, shallow mixed-gas NBL suited operations.
2. The audience will learn about two established decompression algorithms: the Bühlmann ZHL-16 model with Gradient Factors and the U.S. Navy Thalmann-derived model.

[220] INCIDENCE OF ALTITUDE DECOMPRESSION SICKNESS IN U-2 PILOTS FOLLOWING THE IMPLEMENTATION OF ENGINEERING CONTROLS TO REDUCE CABIN ALTITUDE: 2014-2025

Nathaniel Ford, Ki-Hyeok Lee, Patricia Manzur-Ballard

Beale Air Force Base, Beale AFB, CA, USA

(Original Research)

INTRODUCTION: The U-2 aircraft exposes pilots to reduced ambient pressure, placing them at risk for decompression sickness (DCS). Studies documenting DCS in U-2 pilots have demonstrated a high incidence of DCS cases at cabin altitudes of 29,500 ft (8,992 m). This led to the implementation of an engineering control to reduce the cabin altitude to 15,000 ft (4,572 m), known as the Cockpit Altitude Reduction Effort (CARE) package. New data is lacking on the incidence of DCS in U-2 pilots since installation was completed in 2014. This study assesses how rates of DCS have changed since the CARE package was implemented in the U-2 flight program. **METHODS:** A retrospective review of official U.S. Air Force medical and safety records was conducted to identify DCS cases from 2014-2025. U-2 fleet information was gathered to produce incidence rates, perform an odds ratio calculation, and generate a multivariate regression model. **RESULTS:** From 2014-2025, there were three documented cases of DCS in U-2 pilots flying in CARE-modified aircraft, one of which was severe. The DCS per flight incidence was 0.0088% in CARE-modified aircraft and 0.0180% in unmodified aircraft,

compared to historical rates of 0.0760%-0.2300%. This corresponds to 0.1897 cases per 10,000 flight hours in CARE jets. This period saw a reduced odds of DCS with an odds ratio of 0.073, a 99% confidence interval of 0.020-0.330, and p-value of 4.97E-11. This translates to an estimated 38 fewer cases than would have been expected under 1994-2010 conditions. A multivariate regression analysis including average flight hours per pilot and maximum cabin altitude in feet identified an R-squared value of 0.655, with coefficients of 0.0267 for average flight hours and 0.0002 for cabin altitude. **DISCUSSION:** The U-2 population experienced a significantly reduced incidence of DCS in 2014-2025 compared to 1994-2010. A significant portion of this improvement can be credited to the reduction in cabin altitude. However, a reduction in the average flight hours per pilot is also responsible for the reduction in DCS incidence. This improvement in DCS rates highlights the importance of engineering and administrative controls in maintaining crew health and operational capability in hypobaric environments.

Learning Objectives

1. Understand the Impact of Engineering Controls on DCS Incidence: Learners will be able to explain how the implementation of the Cockpit Altitude Reduction Effort (CARE) package, which reduced cabin altitude to 15,000 ft, significantly decreased the incidence of decompression sickness (DCS) among U-2 pilots from 2014-2025.
2. Analyze Contributing Factors to DCS Reduction: Learners will be able to identify and evaluate the factors contributing to the reduced incidence of DCS, including the reduction in cabin altitude and the decrease in average flight hours per pilot, using statistical findings such as odds ratios and regression analysis.

[221] GROUP SIZE AFFECTS TIME OF USEFUL CONSCIOUSNESS AND TIME TO RECOVERY DURING HYPOBARIC CHAMBER TRAINING

Yuval Steinman

Royal Netherlands Air and Space Force, Centre for Man in Aviation, Soesterberg, Netherlands

(Original Research)

INTRODUCTION: Given the inherent risks of hypoxia, it is important that aircrew promptly recognize the onset of its symptoms and are able to initiate appropriate recovery procedures within their time of useful consciousness (TUC). At 25,000 ft (7,620 m) the documented TUC during rapid decompression typically ranges between 1.5 – 2.5 minutes. However, hypobaric chamber instructors, at the Centre for Man in Aviation, noted that the time till recovery (TR) frequently exceeded the documented TUC and that it was longer in groups with more trainees. Therefore, the current study aimed to determine whether the number of trainees in the group influences TUC, TR, and hypoxia symptoms experienced during hypoxia awareness training. **METHODS:** In groups of 4 -12, 63 trainees with military and civilian aviation backgrounds underwent a hypoxia awareness training at a simulated altitude of 25,000 ft. TUC was defined as the point of cognitive impairment, assessed by failure to complete a simple arithmetic task. TR

reflected the time until voluntary O2-mask donning. A survival analysis was performed to determine the effect of group size. Symptoms and their timing were recorded using a predefined symptom list and video footage. **RESULTS:** Both the mean TUC and TR (224 ± 84 and 278 ± 87 respectively) significantly (p;< .001) exceeded the reported TUC during rapid decompression. A significant association was found between the number of trainees present in the chamber and both TUC (hazard ratio = 0.78, 95% CI [0.63, 0.958], p = .019) and TR (hazard ratio = 0.86, 95% CI [0.78, 0.96], p = .006). Each additional trainee decreased the likelihood; of cognitive impairment and O2-mask donning. Symptom manifestation and type did not differ significantly between group sizes. **DISCUSSION:** The observed increase in TUC and TR with group size may reflect physiological, environmental and behavioral influences. Despite these changes, symptom patterns remained consistent across all group sizes, suggesting that the training achieves its goal of symptom recognition.

Learning Objectives

1. The audience will be able to learn of the possible effect of group size on TUC.
2. The audience will learn about the hypoxia training procedure at the Centre for Man in Aviation.
3. The audience will be able to learn about other factors that may affect the time till recovery during hypobaric chamber training.

[222] PHYSIOLOGICALLY ADAPTIVE PERFUSION MODELING FOR DECOMPRESSION SICKNESS RISK IN PARTIAL GRAVITY

Hrudayavani Vellore[1], Peter Hodkinson[2], Richard Whittle[3]

[1]University of California, Davis, Davis, CA, USA; [2]King's College London, London, United Kingdom; [3]University of California Davis, Davis, CA, USA

(Original Research)

INTRODUCTION: Decompression sickness (DCS) poses significant risk to astronauts performing extravehicular activities (EVA) during planetary surface exploration. Current DCS risk prediction models rely on fixed perfusion assumptions and limited physiological variability, failing to account for perfusion redistribution in partial gravity, inter-individual variation in anthropometry, sex-based physiology, aerobic fitness, hydration state, or exercise-induced cardiovascular changes. As astronaut populations diversify and missions extend to planetary surfaces, individualized DCS risk prediction tools are essential. This study developed an adaptive cardiovascular-perfusion model for dynamic tissue nitrogen kinetics. **METHODS:** An individualized cardiopulmonary modeling framework was developed to simulate inert gas dynamics during EVA-relevant decompression profiles. The lumped-parameter, closed-loop framework resolves arterial-venous flow across six hydrostatically sensitive anatomical branches with integrated pulmonary gas-exchange. Tissue nitrogen kinetics use deterministic structure consistent with Tissue Bubble Dynamics Model (TBDM) heritage, stratifying compartments by

baseline half-time behavior and regional perfusion. Under steady-state, the model reproduces legacy half-time distributions; under dynamic conditions, fixed rate constants are replaced with branch-specific, perfusion-dependent kinetics driven by simulated cardiovascular responses. **RESULTS:** Testing encompassed cabin pressures of 10.2–14.7 psia, suit pressures of 4.3–8.2 psia, gravity levels from terrestrial to Lunar (0.16–1 g), and metabolic workloads spanning resting to moderate ambulation. Physiologic adaptation to prebreathe protocols (30–240 min), exercise countermeasures, workload, and altered gravity emerged through ventilation changes, perfusion redistribution, and tissue gas partial pressures. The model reproduced baseline inert gas uptake and elimination consistent with legacy half-time behavior while dynamically adapting tissue nitrogen kinetics in response to cardiovascular state and branch-specific perfusion. **DISCUSSION:** By integrating dynamic perfusion responses with individualized physiological parameters, we address critical gaps limiting current frameworks for planetary surface operations. Follow up work will focus on validation against legacy and exploration relevant datasets to establish quantitative confidence for operational applications.

Learning Objectives

1. Develop an individualized, adaptive cardiovascular-perfusion model for dynamic tissue nitrogen kinetics in exploration atmospheres.
2. Understand how individualized physiological parameters influence tissue nitrogen kinetics and decompression sickness risk in partial gravity environments.

[223] TEST OF PRESSURE: MEDICAL DECISION MAKING IN A CASE OF ALTITUDE CHAMBER DCS

Rebecca Mendelsohn[1], Robert Sanders[2]

[1]UTMB, KBR, and NASA, Houston, TX, USA; [2]NASA, Houston, TX, USA

(Education - Case Study)

INTRODUCTION: This case report illustrates the limitations of the “test of pressure” in differentiating a specific presentation of decompression sickness (DCS) in an altitude chamber participant. While commonly used in hyperbaric medicine to help rule out DCS in ambiguous cases, the test of pressure may not catch subtle or complicated cases of DCS. **CASE DESCRIPTION:** An altitude chamber participant in her 20s presented for evaluation of elbow and wrist pain approximately one hour after returning to ground level from a chamber flight. She had participated in a familiarization altitude chamber flight, in which she completed a pre-breathe protocol for 45 minutes and then had a gradual ascent on O2 up to 25,000 feet, before taking her mask down to experience altitude-induced hypoxia symptoms. After approximately four minutes, she put her mask back on, and the chamber slowly returned to ground level. On presentation to the clinic, she described feeling a “pinched nerve” sensation of her right elbow and wrist during the altitude chamber flight, which had not yet resolved. She was brought to the hyperbaric chamber for a test of pressure. She did not experience symptomatic resolution during the first 20 minutes of hyperbaric treatment at 60 feet but began experiencing improvement after

approximately 60 minutes of treatment on an Air Force Table 6. Her treatment course was continued on a Catalina Consolidated Table 3 and 11 until she experienced full symptomatic resolution. **DISCUSSION:** In hyperbaric medicine, a “test of pressure” is sometimes utilized to determine if a patient’s symptoms are compatible with DCS as opposed to alternate causes such as a musculoskeletal injury. Typically, a patient is brought to a depth of 60ft for 20 minutes, at which time, the patient’s symptoms are re-evaluated. If the patient experiences an improvement in symptoms, the test is considered positive, and the patient is treated for DCS. If the patient’s symptoms do not improve, the test is considered negative, and the patient is treated for alternate causes of symptoms. Our patient’s case demonstrates that the test of pressure can be insufficient for recognizing DCS, resulting in the possibility of missed treatment opportunities.

Learning Objectives

1. After this presentation, learners will be able to recognize limitations to the “test of pressure” as currently used in hyperbaric medicine.
2. After this presentation, learners will have a better understanding of the complexities of distinguishing decompression sickness from alternate causes in altitude chamber participants.

Wednesday, 05/20/2026, 8:30 AM

Governor's 10

[S-33] PANEL: BASIC AND APPLIED COLOR VISION RESEARCH IN AVIATION

Chair: Erica Poole

Co-Chair: Vincent Billock

Panel Overview: *Color vision is integral to aviation task performance across multiple domains, including target acquisition, camouflage segmentation, color-coded display interpretation, and signal light recognition. Conversely, aviation operational conditions can systematically alter chromatic information through factors such as optical filtering (e.g., laser eye protection), reduced viewing time, variable illumination, and increased cognitive workload, as well as observer-dependent factors including anomalous trichromacy. This panel examines the interaction between color-dependent task demands and aviation-specific constraints, with emphasis on how these factors differentially affect sequential stages of color processing—from detection and opponent-based discrimination to categorical identification—and, in turn, influence operational decision-making.*

[224] A CLOSER LOOK AT COLOR IDENTIFICATION IN COLOR-DEFICIENT OBSERVERS: MEANING AND APPLICATIONS IN AVIATION

Erica Poole[1], Jeffrey Rabin[2]

[1]Naval Medical Research Unit- Dayton, Wright Patterson AFB, OH, USA; [2]University of the Incarnate Word, San Antonio, TX, USA

(Original Research)

INTRODUCTION: Despite its apparent simplicity, color identification is a computationally demanding process dependent on hierarchical stages of visual processing. Detection establishes stimulus presence, discrimination reflects opponent-based differencing, and identification requires stable hue perception and categorical assignment; accordingly, identification is a higher-order and more vulnerable stage that can fail even when detection and discrimination are preserved. In operational environments, additional factors—viewing time, cognitive load, dynamic lighting, and optical filtering—increase the likelihood of identification failure. Here, we describe two assessments designed to probe the discrimination–identification interval in color vision deficiencies (CVDs). **METHODS:** Twenty CVD participants (12 deutan, 8 protan) were enrolled in an IRB-approved, double-blind, registered clinical trial. Subjects wore either color-correcting lenses (CCL) or neutral-density (ND) sham lenses for one week each, three hours daily. At the beginning and end of each week, participants completed the Cockpit Color Identification Test (CCIT) and Cone Contrast Naming Task (CCNT), with and without assigned lenses. The CCIT is a forced-choice, target-based color identification task scored by accuracy and reaction time. The CCNT extends the Cone Contrast Test by adding timed color naming and a luminance channel, yielding separate detection and identification scores (0–100) across randomized contrast levels. Results CCNT detection scores were high in both protanomal (95 ± 9.3) and deuteranomal (90 ± 10.4) participants, while identification was reduced (protans: 80 ± 35.5; deutans: 68 ± 19.9). Relative to color-normal observers, detection deficits were minimal in protans (−1%) but greater in deutans (−12.2%), whereas identification deficits were substantially larger in both groups (−20.9% and −38%, respectively). Consistent with these findings, increased anomaloscope matching range was associated with reduced identification accuracy, explaining 63% of performance variance ($R^2 = 0.63$). **DISCUSSION:** Results demonstrate dissociation between detection and identification in CVD, highlighting the vulnerability of color identification under chromatic uncertainty. The association between anomaloscope matching range and identification accuracy suggests that decision instability, rather than sensitivity loss alone, drives functional color errors. This dissociation is operationally relevant, as applied environments further tax identification processes, indicating that tasks probing the discrimination–identification interval may provide greater ecological validity for evaluating color-dependent performance and mitigation strategies in safety-critical settings.

Learning Objectives

1. Attendees will learn about the hierarchy required for color processing to take place.
2. The audience will be introduced to factors that can impact color perception.
3. Attendees will learn about how filters can change the appearance of colors.

[225] COLOR CODING AND RECODING: PRINCIPLES UNDERLYING DISPLAY ADJUSTMENT FOR LASER EYE PROTECTION AND COLOR VISION INDIVIDUAL DIFFERENCES

Vincent Billock[1], Bethany Dennis[1], Erica Poole[2], Michael Reddix[3]

[1]Leidos, Inc. at NAMRU- Dayton, Wright-Patterson AFB, OH, USA; [2]NAMRU-Dayton, Wright-Patterson AFB, OH, USA; [3]NAMRU-Dayton, Wright Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: Color coding on aviation displays assume that color appearance is relatively invariant between observers. However, within the population of aviation display users there are individual differences in color appearance which can be quite large, especially when considering differences between normal observers and observers with mild color vision defects (mCVDs) who are passed by screening exams. Similar shifts in color appearance are induced by colored filters, such as Laser Eye Protection (LEP), often employed at low altitudes and near airstrips. **METHODS:** Here we identify an approach to studying these shifts in color perception by measuring the spectral location of a special subset of colors known as unique and balanced hues. This has two virtues: (1) It is easy for the experimenter to set measurement criteria and it is easy for the subject to maintain these criteria. (2) The five unique and balanced hues are the zero-crossings and equibalance points of the human red-minus-green and blue-minus-yellow color opponent channels, which together determine color appearance. **RESULTS:** The color opponent channels can in turn be modeled as near-linear transforms of the cone photoreceptor spectral sensitivities. Using information about the unique and balanced hues, preretinal absorptions (like those induced by LEPs), and cone receptor spectral sensitivities in normal observers and mild color vision deficiencies, we can predict color appearance shifts induced by LEPs and CVDs. Compensatory shifts in display colors could then be induced to render color coding veridical for all kinds of users under multiple circumstances. **DISCUSSION:** The loss of chromatic saturation (perceived color purity) for color anomalous observers could be partially compensated for by projecting the spectral shifts to the edges of the display chromatic gamut. Funded by CDMRPL-19-0-DM190318.

Learning Objectives

1. The audience will learn about individual differences in color perception induced by both genetics and the aviation environment (e.g., Laser Eye Protection) and how this affects color coding on aviation displays.
2. The audience will learn about how aviation displays could be adapted to present color coding veridically despite individual differences in color perception.

[226] ROYAL CANADIAN AIR FORCE PILOT COLOR TASK SIMULATIONS: PERFORMANCE OF COLOR NORMALS

Mackenzie Glaholt[1], Sandra Mazur[2], Juleen Chen[1], Jeffery Hovis[3]

[1]Defence Research and Development Canada, North York, Ontario, Canada; [2]Univeristy of Waterloo, Waterloo, Ontario, Canada; [3]University of Waterloo, Waterloo, Ontario, Canada

(Original Research)

INTRODUCTION: A survey of the Royal Canadian Air Force (RCAF) fleet identified key pilot tasks that involve color discrimination. Analysis of the colorimetric data confirmed the need for an aircrew color vision standard. However, an empirical study was needed to determine the appropriate level of color vision to ensure aircrew can carry out their duties safely and efficiently. Accordingly, five task simulations were created for critical color vision tasks spanning multiple aircraft. Presently, we describe the task simulations and the performance of color-normal individuals. **METHODS:** The task simulations were two out-the-window viewing tasks (Signal Light Gun, SLG, and PAPI light discrimination) and three cockpit tasks (Tactical Radar, Weather Radar, and Indicator Button). Task simulations were displayed on an EIZO CG3146 HDR Reference Monitor. Sixty-seven color-normal participants (58.2% male; mean age 24.6 yrs, sd +4.7) with normal color vision as determined by the Rayleigh color match participated. The simulations were included in a 3-hour session that also included a variety of color vision tests. The simulations and test sequence were based on a random block design. Results: Performance is summarized using the median and the 95th percentile values. The 95th percentile values are in parentheses. PAPI simulation errors 0 (2); SLG errors 0 (1); weather radar response time 1.47 (2.32) sec and 0 (4) for the errors; tactical radar response time 0.74 (1.01) sec and 1 (7) for errors; Indicator task response time for blank versus yellow light 1.03 (1.37) sec and 0 (2.7) for errors; Indicator task response time for blank versus red light: 0.99 (1.27) sec and 0 (2.7) for errors; Indicator task response time for green to yellow text: 1.3 (1.73) sec and 1 (5) for errors; Indicator task response time for green to red text: 1.03 (1.33) sec and 0 (3.7) for errors. **CONCLUSIONS:** As expected, the number of errors on the out-the-window task simulations was small. Performance on the cockpit tasks was more variable. Comparison of these performance values with those of color-deficient individuals will allow the derivation of an aircrew color vision standard based on operational performance.

Learning Objectives

1. Attendees will understand the utility of PAPI lights.
2. Attendees will be familiarized with Military color standards.

[227] TRITAN COLOR VISION SCREENING RESULTS USING THE NEW FAA REQUIREMENTS

Jeffery Hovis[1], Sandra Mazur[1], Mackenzie Glaholt[2]

[1]University of Waterloo, Waterloo, Ontario, Canada; [2]Defence Research and Development Canada, North York, Ontario, Canada

(Original Research)

INTRODUCTION: The FAA recently introduced new color vision testing requirements. In addition to requiring computerized color vision tests, the FAA established test cut-off criteria for tritan deficiency that vary across tests. This presentation reports on the tritan failure rates for these newer tests among young adults. **METHODS:** Sixty-seven subjects with normal red-green color vision, as determined by the Rayleigh color match, participated in the study. The mean age was 24.6 yrs (sd +4.7). Visual acuity in the better eye was at least 6/6 and 6/9 in the other eye. Color vision was assessed with the CAD (blue-yellow failure, SNU >2.4), Waggoner Computerized Plates (tritan failure >2 errors), and the Innova Cone Contrast Test: Armed Forces Version (S-cone sensitivity failure <55). The Konan ColorDx CCTHD test was included, with a failure criterion for the S-cone stimulus of sensitivity 3 standard deviations below the mean (<0.50 log CS). **RESULTS:** 20.9% of subjects failed to meet the FAA criterion on at least one tritan test at the first session. The failure rates for the individual tests were 13.4% for the CAD, 0% for the Innova Rabin Cone Contrast (any eye), 0.0% for the ColorDx CCTHD, and 14.9% for the Waggoner Computerized Plates. 6.0% failed both the CAD and Waggoner tests. Of the individuals who failed at least one test at the first session, 64.3% passed all tritan tests at the second session, and of those who passed all tests at the first session, 15.1% failed at least one test at the second session. The percentage of failures for each test at the second session was 10.4% for the CAD, 2.99% for the Innova Rabin Cone Contrast (any eye), 0.0% for the ColorDx CCTHD, and 14.9% for the Waggoner Computerized Test. **CONCLUSIONS:** The variation in tritan failures across the tests reflects the varying levels of difficulty and stringency of the passing criteria. Although the combined prevalence of congenital and acquired tritan defects in the young adult population is not clearly established, failure rates exceeding 1% suggest that the FAA pass/fail criteria for tritan defects in the CAD and Waggoner tests may be too stringent.

Learning Objectives

1. Attendees will learn about the differences between S cones and the other two cone photoreceptors.
2. Attendees will learn about the FAA cut-off criteria.

Wednesday, 05/20/2026, 8:30 AM

Governor's 12

[S-34] SLIDE: BLASTS, BUBBLES AND BIOLOGICS: KEEPING THE HUMAN MACHINE FLIGHT READY

Chair: Roy Hoffman

Co-Chair: Matthew Carnal

[228] RAPIDLY GROWING THYROID MASS IN AN ARMY PILOT: A CASE REPORT

Kevin Anderson

28th Medical Group, Ellsworth Air Force Base, SD, USA

(Education - Case Study)

INTRODUCTION: This case report describes an Army pilot with a history of thyroid goiter who presented for rapid nodule enlargement, ultimately requiring hemithyroidectomy. **BACKGROUND:** Fast-growing masses of the head and neck area are concerning and can compromise such functions as swallowing and even breathing. Of special interest, thyroid masses can transform into cancerous growths and when coupled with concerns for airway compromise, require expedited evaluation. **CASE PRESENTATION:** We present a 44-year-old male CW4 Army National Guard C-12 pilot with 4,800 flying hours and a history of right-sided thyroid goiter who presented to his flight surgeon with a rapidly growing right-sided neck mass. Beginning in 2019, thyroid enlargement was noticed at his annual flight physical and fine needle aspiration noted a follicular neoplasm measuring 4x3x2 cm with low probability of malignancy. However, the two weeks leading up to present-day evaluation he endorsed rapid growth of his mass that caused intermittent extrinsic compressive symptoms of neck structures when lying flat. Urgent computed topography and general surgery consultation was completed. Tracheal deviation was noted with a cystic mass now measuring 6x6x8 cm and the decision was made to perform a right-sided hemithyroidectomy. Follow-up demonstrated normal thyroid function with no need for thyroid replacement medication and benign pathology. He continued flying duties throughout workup up until surgery and was cleared for continued flying in accordance with Army medical fitness standards based on general surgery, endocrinology, and aerospace medicine evaluation. **DISCUSSION:** Nodules of the head and neck space are extremely important to monitor, as several vital structures traverse this space and anatomical compromise can lead to harmful events. Furthermore, care should be taken to ensure timely treatment is performed. In this case, aviators provide an added layer of complexity due to their occupation, with risk factors spanning from acute airway obstruction in flight to career ramifications due to need for surgery and possible medication initiation. In this situation, outlooks are promising for the flier but provides medical personnel an example of multidisciplinary treatment between civilian and military providers for an area of the aeronautical medical literature that is sparse.

Learning Objectives

1. The audience will learn about thyroid goiter and its impact on medical standards and duty fitness.
2. The audience will grow an appreciation for acute head and neck pathology and expedited work-up, when necessary.
3. The audience will learn the implications of thyroid pathology and the importance of surveillance measures.

[229] PITUITARY MACROADENOMA IN A COMMERCIAL PILOT: A PATHWAY TO RECOVERY

Johan Sebastian Bedoya Saenz[1], Alexandra Mejia Delgado[2], Diego M Garcia[3]

[1]Universidad Nacional de Colombia, Bogota, Colombia; [2]AeroCivil (Colombian Civil Aviation Authority). Universidad Nacional de Colombia., Bogota, Colombia; [3]Universidad Nacional de Colombia., Bogota, Colombia

(Education - Case Study)

INTRODUCTION: Plurihormonal pituitary macroadenomas of PIT-1 lineage are rare benign tumors with significant aeromedical implications due to their potential impact on visual, neurological, and endocrine function. This case illustrates the aeromedical risk assessment and certification process following surgical treatment and residual visual sequelae in a commercial airline pilot. **BACKGROUND:** Pituitary macroadenomas may remain clinically silent until mass effect occurs. Immature PIT-1 lineage adenomas, classified by WHO 2022, account for approximately 0.9–1.5% of pituitary tumors and may exhibit aggressive behavior, hormonal hypersecretion, and visual field compromise. Civil aeromedical regulations (ICAO Annex 1 and Doc 8984) require strict multidisciplinary evaluation and follow-up prior to medical requalification. **CASE PRESENTATION:** A 35-year-old male commercial pilot with 2,484 flight hours and A320 and B737 type ratings presented with nonspecific ocular irritation. Brain MRI revealed a 30 × 25 × 22 mm functional PIT-1 adenoma compressing the optic chiasm. Transsphenoidal resection was performed in October 2023, with histopathology confirming plurihormonal expression of GH, TSH, and FSH. Postoperatively, multidisciplinary follow-up included neurosurgical, endocrinologic, and neuro-ophthalmologic evaluations. Endocrine function normalized without pharmacologic therapy, and serial MRI demonstrated stable residual tumor without progression. Visual assessment using Humphrey Field Analyzer showed a left supratemporal quadrantanopia with initial progression, followed by objective stability and gradual improvement on serial examinations. Based on tumor control, endocrine stability, and functional visual recovery without evidence of progressive impairment, the pilot was certified under special issuance. **DISCUSSION:** This case highlights the complexity of aeromedical decision-making in pilots with pituitary tumors and residual visual field defects. Timely surgical intervention and structured multidisciplinary surveillance allowed preservation of visual and endocrine function within operational limits. Continuous follow-up remains essential to ensure long-term safety and operational performance.

Learning Objectives

1. Identify the clinical manifestations and aeromedical risks associated with pituitary macroadenomas in flight personnel.
2. Outline the multidisciplinary requirements and criteria for the medical re-certification of a pilot following the surgical resection of a pituitary macroadenoma.

[230] WITHDRAWN

[231] NO ADRENALS? NO PROBLEM: ADDISON'S DISEASE WAIVER

Michael Yue

Naval Aerospace Medical Institute, Pensacola, FL, USA

(Education - Case Study)

INTRODUCTION: This case describes a former U.S. Marine Corps MV-22 pilot with primary adrenal insufficiency (Addison's disease) who, after medical disqualification and separation from service, was later granted a waiver by the Navy to fly as a civilian rotary-wing pilot operating Naval aircraft. **BACKGROUND:** Primary adrenal insufficiency is a rare endocrine disorder associated with fatigue, hypotension, electrolyte disturbance, and risk of adrenal crisis with sudden incapacitation. Because aviation environments limit immediate medical intervention and amplify stress-related cortisol demands, Addison's disease is disqualifying for military and civil flight duties. Military publications describe waivers as unlikely for all flight classes, and civil regulators typically only consider tightly restricted certification on a case-by-case basis. Consequently, aeromedical experience with adrenal-insufficient pilots is sparse, and guidance for conditional return to flight is limited. **CASE PRESENTATION:** A 30-year-old active-duty MV-22 pilot developed primary adrenal insufficiency and was ultimately medically separated. Over the subsequent years, he demonstrated excellent control on stable replacement medications, and documented adherence to sick-day rules. Seeking to return to flight, he underwent comprehensive aeromedical evaluation and endocrine consultation and was granted an FAA Class III waiver. He was later hired as a contractor at a naval squadron and pursued a return to military aviation. Based on his sustained stability and a detailed risk-mitigation plan, the waiver authority approved him as Navy Class I, Service Group 3, mandating dual-control, multi-crew aircraft, a qualified co-pilot on every flight, carriage of an emergency hydrocortisone kit, medical identification, and explicit stand-down criteria. **DISCUSSION:** This case illustrates that, in exceptionally well-controlled Addison's disease, individualized risk assessment, multi-crew operations, and robust contingency planning can reduce risk to an acceptable level for restricted flight duties. It underscores the value of waiver pathways that allow nuanced deviation from blanket disqualification while preserving safety. For aerospace medicine practitioners, this case provides a framework for evaluating high-risk endocrine conditions, highlighting key elements: objective disease stability, patient reliability, layered operational restrictions, and ongoing aeromedical and specialty follow-up.

Learning Objectives

1. Participants will be able to identify operational reasons why Primary Adrenal Insufficiency is generally disqualifying for flight status.
2. Participants will be able to describe what primary adrenal insufficiency is and why it can lead to sudden clinical deterioration.

[232] SPACEFLIGHT CONSIDERATIONS AFTER DIAGNOSIS WITH PITUITARY ADENOMA

Vasilis Mavratsas, Daniel Cox

UTMB, Galveston, TX, USA

(Education - Case Study)

INTRODUCTION: We present a hypothetical case of a female astronaut diagnosed with a pituitary macroprolactinoma after evaluation for amenorrhea. **BACKGROUND:** Pituitary adenomas are common intracranial tumors, with prolactinomas representing the most frequent hormonally active subtype. Although typically benign, prolactinomas can cause visual field compromise, endocrine dysfunction, and may require long-term medical therapy, all of which carry potential implications in operational environments. In astronauts, additional considerations include exposure to altered intracranial pressure dynamics, prolonged mission duration, limited in-flight diagnostic and treatment capabilities, and the need for sustained neurocognitive and visual performance. **CASE PRESENTATION:** A pre-menopausal female astronaut with no significant past medical history presented with three months of secondary amenorrhea. Physical examination revealed mildly decreased bilateral temporal visual fields. Laboratory testing demonstrated hypogonadotropic hypogonadism with suppressed luteinizing hormone and follicle-stimulating hormone levels and an elevated serum prolactin level of 221 ng/mL. Magnetic resonance imaging of the brain identified a macroadenoma of the pituitary consistent with a macroprolactinoma, without evidence of hemorrhage or acute compression. **DISCUSSION:** This hypothetical case illustrates the operational relevance of pituitary prolactinomas in astronauts. Potential aeromedical risks include visual field deficits, endocrine instability, tumor growth and mass effect, adverse effects of dopamine agonist therapy such as orthostatic intolerance or neuropsychiatric symptoms, and complications of surgical resection or gamma knife radiosurgery. In high-performance operational environments, even subtle visual or cognitive impairment may degrade situational awareness and mission safety. Determining return-to-flight eligibility requires careful, individualized, and multi-disciplinary consideration of the initial treatment response, tolerance of medical therapy or complications of surgical intervention, plans for surveillance, and the specific operational environment that the astronaut will return to.

Learning Objectives

1. The audience will learn about the aeromedical considerations of pituitary tumors in astronauts.
2. The audience will learn about the aeromedical risks associated with the treatment of pituitary tumors.
3. The audience will learn about the considerations for return to flight for an astronaut following diagnosis and treatment for a pituitary tumor.

[233] WITHDRAWN

Wednesday, 05/20/2026, 8:30 AM

Governor's 14

[S-35] Slide: GRAND ROUNDS: CARDIOLOGY AND OPHTHALMOLOGY CASES - TO THE HEART (AND THE EYES?) OF THE MATTER!

Chair: Thomas Jarnot

Co-Chairs: Julissa Mendoza, Matt Lindsay

[234] IN-FLIGHT SEROUS CHORIORETINOPATHY ON THE INTERNATIONAL SPACE STATION: A HYPOTHETICAL CASE

Andrew Lam, Samuel Stephenson

UTMB, Galveston, TX, USA

(Education - Case Study)

INTRODUCTION: This case report describes a hypothetical occurrence of serous chorioretinopathy in an astronaut with consideration of treatment, disposition, and prevention. **BACKGROUND:** Serous chorioretinopathy is the accumulation of exudative fluid below the retina. While commonly a self-limiting condition, it can substantially decrease visual acuity when it affects the macula. Though it also occurs on Earth, cases involving astronauts have identified a possible association with spaceflight-associated neuro-ocular syndrome. Due to the potential for spaceflight to induce serous chorioretinopathy, and given its risks for visual and mission impact, serous chorioretinopathy is a condition that warrants special attention in astronauts. **CASE PRESENTATION:** A middle-aged astronaut flew on a;6-month mission to the International Space Station. Prior to flight, all ocular imaging results were normal, and vision was correctable to 20/20. However, during standard on-orbit screening, the crewmember was found to have new choroidal thickening and a collection of peripheral subretinal fluid. Serous chorioretinopathy was diagnosed, and protocols for monitoring and treatment were followed throughout the remainder of the mission and post-flight. The subretinal fluid persisted upon landing but resolved within several months of return. The crewmember was eventually returned to flight with no permanent visual deficits. **DISCUSSION:** Serous chorioretinopathy is a unique type of retinal detachment whose pathophysiology may overlap with spaceflight-associated neuro-ocular syndrome. Given the risk of significant visual impairment, various treatment modalities and aeromedical disposition strategies have been developed to address this issue. Researchers are actively investigating candidate risk factors in the hope of identifying effective countermeasures. Overall, this fictitious case highlights a real yet manageable spaceflight-associated ocular condition whose relevance is becoming clearer over time.

Learning Objectives

1. Describe the typical management approach for an astronaut who is diagnosed with serous chorioretinopathy.
2. Appreciate the potential association between serous chorioretinopathy and spaceflight-associated neuro-ocular syndrome.

[235] WAIVER DECISION-MAKING AFTER OCULAR MELANOMA

Heather Foster

U.S. Air Force School of Aerospace Medicine, Dayton, OH, USA

(Education - Case Study)

INTRODUCTION: Choroidal melanoma is a rare but aeromedically significant diagnosis for aircrew, given its metastatic potential, risk of vision loss, and need for prolonged surveillance. **BACKGROUND:** Aeromedical disposition becomes more complex when post-treatment visual outcomes introduce both operational and medical risk considerations. We present a case illustrating long-term management, evolving ocular morbidity, and complex waiver decision-making in a senior military aviator. **CASE PRESENTATION:** A 48-year-old CV-22 pilot presented with one month of blurred vision of the right eye and was diagnosed with an amelanotic circumpapillary choroidal melanoma. Systemic staging was negative. He underwent I-125 brachytherapy, with tumor regression and low-risk cytogenetic features. The pilot had initial stability but developed profound vision loss (20/400) associated with radiation retinopathy, cystoid macular edema, and possible optic nerve injury a little over one year after treatment. Concern for neovascularization prompted denial of a flying waiver, with a recommendation to reassess once his condition stabilized. Over the following years, he developed additional post-treatment complications, including radiation-induced cataract, branch retinal vein occlusion with macular edema, and a horseshoe retinal tear, which required laser repair. He remains functionally blind in the right eye but retained a healthy left eye and adapted well to monocular vision. Serial abdominal MRIs, chest imaging, and laboratory surveillance have remained normal. He successfully obtained an FAA First-Class Medical Certificate with a Statement of Demonstrated Ability and has flown under SODA conditions without safety concerns. **DISCUSSION:** This case highlights key challenges in applying aeromedical standards to aircrew with treated ocular melanoma. Although monocular aviators may perform safely in controlled operational roles, post-radiation complications introduce dynamic risk requiring conservative disposition. Long-term oncologic surveillance, potential for painful neovascular glaucoma, and uncertainty regarding tumor-related optic damage further complicate decision-making. This case underscores the importance of individualized, risk-stratified assessment that integrates oncologic prognosis, visual function, operational role, and demonstrated safe performance, particularly as aircrew approach the final years of their service career.

Learning Objectives

1. The participant will be able to describe the aeromedical implications of treated choroidal melanoma in military aircrew, including long-term oncologic surveillance requirements and common post-radiation ocular complications that influence waiver decisions.
2. The participant will be able to apply a risk-stratified framework to waiver decision-making in monocular aviators, integrating oncologic prognosis, visual function, evolving ocular morbidity, operational role, and demonstrated safe performance.
3. The participant will be able to recognize the role of demonstrated safe performance and civilian aeromedical certification in informing military aeromedical decision-making for complex ocular cases.

[236] SINGLE-EPISODE ATRIAL FIBRILLATION FOLLOWING VASOVAGAL SYNCOPE IN A FIGHTER PILOT: AEROMEDICAL ASSESSMENT AND WAIVER CONSIDERATIONS

David Craig, Kyle Richardson, Cullen Pressley

Navy Medicine Operational Training Command, Pensacola, FL, USA

(Education - Case Study)

INTRODUCTION: This case report describes a fighter pilot with atrial fibrillation with rapid ventricular response precipitated by a vasovagal syncope event and elaborates on the unique considerations weighed in granting an aeromedical waiver for continued unrestricted flight. **BACKGROUND:** Atrial fibrillation results in the loss of atrial contribution to ventricular preload, impairing cardiac output and overall hemodynamic efficiency. The resultant decrease in exercise capacity and impaired tolerance to gravitational forces are serious concerns for aviators in high performance aircraft. The elevated risk of recurrence after initial episode of atrial fibrillation complicates the approach to aeromedical disposition. **CASE PRESENTATION:** The subject is a 41-year-old male SG1 F-5E pilot with over 2200 hours in a tactical aircraft and long-standing history of vasovagal syncope associated with phlebotomy. He suffered a similar syncope event watching his wife undergo intravenous line placement in the hospital with subsequent persistent heart palpitations. Upon evaluation in the emergency department, he was found to be in atrial fibrillation with rapid ventricular response and underwent successful TEE-guided cardioversion with 30-days of anticoagulation. He had a normal echocardiogram, myocardial perfusion study, and serial Holter monitoring on ensuing cardiovascular evaluation. Cardiac Electrophysiologist consultation deemed him low-risk for recurrence with initial dysrhythmia likely attributable to heightened vagal tone in the setting of reflex syncope. **DISCUSSION:** This case reviews the aeromedical concerns surrounding atrial fibrillation in flight, provides an overview of the aeromedical assessment and waiver process for atrial fibrillation, and highlights the influence of vagal tone on atrial arrhythmias. While the current subject's regular occupational exposure to forces causing large fluctuations in vagal tone draws some concern for risk of recurrence, his hours of flight without prior incident, his self-awareness of the symptoms of atrial fibrillation, and platform as an F-5E adversarial training pilot with the

ability to abort and land upon symptom onset, all were taken into account in order to more confidently recommend a waiver for return to SG1 unrestricted flight.

Learning Objectives

1. Understand the primary aeromedical concerns associated with atrial fibrillation in flight.
2. The audience will learn about current management guidelines for paroxysmal atrial fibrillation.

[237] QUADRICUSPID AORTIC VALVE IN A USAF PILOT

Ryan Bogart[1], Rosalinda Fitts[2]

[1]U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, USA; [2]U.S. Air Force, Wright-Patterson AFB, OH, USA

(Education - Case Study)

INTRODUCTION: This case study evaluates the aeromedical fitness of a senior pilot with a history of quadricuspid aortic valve, before and after surgical repair. **BACKGROUND:** Over a 17-year flying career, the pilot progressed from a diagnosis of bicuspid aortic valve with mild aortic insufficiency to quadricuspid aortic valve with severe insufficiency. He underwent bovine pericardial valve replacement and was subsequently provided a special issuance for FAA first class medical. Eleven months after surgical intervention, he was granted a waiver to fly KC-135s for the US Air Force. **CASE PRESENTATION:** The pilot was found at initial flight physical in 2007 to have a soft Grade 1/6 diastolic murmur, which led to a diagnosis of bicuspid aortic valve and aortic insufficiency on echocardiogram. He was granted a flying waiver, which was renewed in 2010, 2013, 2014, 2017 and 2020. He remained asymptomatic and continued with annual cardiology evaluation. TTE in November 2023 showed moderate-severe eccentric aortic insufficiency with a preserved EF 61% and a 4.6 cm ascending aortic aneurysm. CT angiogram showed 4.2 cm ascending aortic aneurysm. In May 2024, TEE showed progression to severe aortic valve regurgitation. Two months later, a Mayo Clinic evaluation revealed severe aortic regurgitation, holosystolic flow reversal in the abdominal aorta, LV EF 66%, and thoracic aortic aneurysm involving the aortic root (42-43 mm). Cardiopulmonary stress test showed increased ventricular ectopy including single PVCs, couplets, and multiple 3-5 beat runs of VT. In August 2024, the member had a Bentall root replacement, aortic valve replacement with tissue valve (29 mm Konect Resillia), and repair of ascending aortic aneurysm with Hemashield. Post-operative recovery was uneventful, including 3 months of anti-coagulation and cardiac rehabilitation. **DISCUSSION:** The USAF Aeromedical Consultation Service recommended the pilot be granted a 12-month waiver due to history of quadricuspid aortic valve with severe aortic insufficiency, status post valve replacement; mild thoracic aortic aneurysm, status-post aortic root repair and infrequent premature ventricular beats. Repeat CT aortography, transthoracic echocardiogram, 24-hour Holter monitor, and repeat electrocardiogram should be performed prior to waiver renewal consideration.

Learning Objectives

1. Identify the Aeromedical Risks and Mitigation Strategies for Pilots Diagnosed with Quadricuspid Aortic Valve: Learners will be able to explain the potential aeromedical risks associated with bicuspid and quadricuspid valves and ideal methods for surveillance.
2. Identify the Aeromedical Risks and Mitigation Strategies for Pilots Diagnosed with Aortic Insufficiency: Learners will be able to explain the potential aeromedical risks associated with aortic insufficiency, as well as activities and factors that increase the risk of severity progression.
3. Identify the Aeromedical Risks for Pilots with Prosthetic Aortic Valve Replacement and Ascending Aortic Root Repair: Learners will be able to explain the potential aeromedical risks associated with the presence of prosthetic aortic valve replacement (mechanical versus bioprosthetic) and ascending aortic root repair as well as indicated surveillance.

[238] SITUS INVERSUS IN A MILITARY AVIATOR: A CASE REPORT ON THE AEROMEDICAL CONSIDERATIONS

Trevor Scott[1], R. Tyler Williamson[1], Tiffany Carlson[1], Sarah Hasko[2]

[1]U.S. Army, Fort Rucker, AL, USA; [2]Guthrie Army Health Clinic, Fort Drum, NY, USA

(Education - Case Study)

BACKGROUND: Situs Inversus is a rare congenital condition where the major visceral organs are in a left-right mirror-image position of their normal anatomical location. A literature review in PubMed found only one aviation-related case of situs inversus in a commercial aviator. While often asymptomatic and discovered incidentally, the anatomical variation can present unique challenges in the aviation environment. The variant plays a role in dispositioning as different variants can drastically change the physiological effects. Variants exist on a spectrum and include situs inversus totalis, situs inversus incompletus, situs ambiguus (heterotaxy syndrome), and dextrocardia with situs solitus. **CASE PRESENTATION:** We present a case of situs inversus totalis in a 28-year-old service member who entered the military in 2017 with a known diagnosis of situs inversus with dextrocardia, also known as situs inversus totalis. Initial diagnosis was made with a chest x-ray at six months of age. He has remained asymptomatic, entering the Army with a medical waiver, and completing his initial term of service in 2020. He reenlisted in the Army in 2025 as a Warrant Officer candidate with the same medical waiver and subsequently applied for Army Aviation. Over the course of obtaining his aviation waiver, he obtained an electrocardiogram (ECG), echocardiogram, and Ziopatch. Testing confirmed diagnosis as expected along with an unspecified Right Bundle Branch Block (RBBB). Asymptomatic incomplete right bundle branch block with normal evaluation is not disqualifying for military service. **DISCUSSION:** This case highlights the unusual demands of flight surgeons facing unexpected anatomy. Although situs inversus totalis will not cause difficulty operating an aircraft, it may influence the way care is provided during emergencies. It is imperative that flight surgeons have pre-existing knowledge of known deviations for treatment purposes and expected findings. Auscultation, imaging, ECG findings, landmarks for procedures, etc., are all affected. In this case, the applicant's ECG demonstrated an abnormal P axis which is normal in dextrocardia. **CONCLUSION:** Flight surgeons should be trained in the expectations of anatomy

variations to include reviewing imaging and protocols. With careful evaluation and risk assessment, this condition is not necessarily a career ending diagnosis for an aviation candidate.

Learning Objectives

1. Differentiate between the anatomical variants of situs inversus (e.g. totalis, incompletus, and ambiguus) and evaluate their distinct physiologic implications for aeromedical dispositioning.
2. Apply aeromedical standards to the evaluation of incidental cardiac findings, such as dextrocardia with RBBB, to determine the necessity for structural cardiac imaging and eligibility for medical waivers.

Wednesday, 05/20/2026, 10:30 AM

Plaza A/B

[S-36] PANEL: BEHAVIORAL HEALTH & PERFORMANCE OPERATIONS AND RESEARCH AT NASA JSC

Chair: Stephen VanderArk

Co-Chair: Gary Beven

Panel Overview: *The Behavioral Health and Performance (BHP) Operations and BHP Laboratory teams at NASA Johnson Space Center are advancing capabilities critical to the next era of human space exploration. Together, these teams share a unified goal: to promote optimal behavioral health and performance of astronauts across all phases of mission execution. This goal is realized through a strong bi-directional integration of operations and research—operational experience guides research priorities, and research findings directly inform and strengthen clinical and operational practices with astronauts. As NASA progresses toward the Artemis missions and prepares for exploration beyond Low Earth Orbit, the BHP community is undertaking essential foundational work to support mission success in increasingly complex and demanding environments. This panel will highlight recent advancements and ongoing efforts across key operational and research domains that directly support exploration missions. Within the Space Medicine Division, BHP Operations plays a central role in astronaut selection, training, and behavioral healthcare services for astronauts and their families, as well as long-term surveillance of behavioral health outcomes following separation from NASA. In parallel, the BHP Laboratory conducts research across spaceflight and analog platforms to address behavioral health, team functioning, and sleep risks associated with future exploration missions. The panel will feature five presentations that blend educational and original research content. One presentation will provide an overview of recent BHP contributions to NASA's astronaut applicant screening process, highlighting collaborative advancements with the Astronaut Office to select Astronaut Candidates (ASCANs) likely to support future lunar and Mars missions. A second presentation will describe Expeditionary Skills Training being developed for newly selected ASCANs and for astronauts awaiting mission assignment. A third presentation will*

summarize data collected through the BHP Laboratory's contributions to the Human Research Program's Standard Measures initiative. A fourth presentation will describe emerging BHP Laboratory research efforts that contribute to the development of the new EVA/Lunar spacesuit. A fifth presentation will address BHP's occupational health surveillance of former astronauts, including key findings and the importance of this work in informing risk mitigation strategies for exploration astronauts.

[239] BEHAVIORAL COMPONENTS OF NASA'S 2025 ASTRONAUT SELECTION CYCLE

Gary Beven[1], James Picano[1], Alexa Baxley[2], William Ridgway[2], Thomas Williams[2], Anna Morgenthaler[2], GW Krauss[2], Victor Vergara[2]

[1]NASA JSC, Houston, TX, USA; [2]KBR, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: Behavioral suitability is a critical determinant of astronaut performance and mission success, particularly for exploration missions involving isolation, confinement, operational complexity, and communication latency. As NASA advances the Artemis program and prepares for sustained lunar operations and future Mars exploration, the behavioral demands placed on crews continue to evolve. Aerospace Medical Association (AsMA) attendees—especially those working in aerospace medicine, operational psychology, and human performance—benefit from understanding how contemporary astronaut selection processes address these demands. This topic is timely following the recent completion of NASA's 2025 astronaut selection cycle, which emphasized behavioral competencies required for deep-space missions beyond low Earth orbit. **OVERVIEW:** In 2025, NASA completed selection of its 24th class of astronaut candidates using a structured, multi-phase U.S. astronaut selection process designed to identify individuals best suited for the medical, psychological, and behavioral demands of long-duration spaceflight. More than 8,000 applications were received during this cycle. An initial subset of highly qualified candidates was invited to NASA Johnson Space Center (JSC) for preliminary screening, which included a first Astronaut Selection Board (ASB) interview, standardized medical examinations, and psychological testing. A smaller group advanced to a second and final phase involving comprehensive medical evaluations, in-depth behavioral assessments, psychiatric examinations, and a second ASB interview. From this process, 10 astronaut candidates (ASCANs) were selected to begin basic training in Houston in September 2025. This presentation will review the structure, content, and implementation of the behavioral components embedded within this phased selection process, as well as key lessons learned. **DISCUSSION:** The multi-phase behavioral selection framework enhances operational reliability by systematically integrating principles from operational psychology, aerospace psychology, and aerospace psychiatry within a high-stakes selection environment. When conducted by clinicians with direct spaceflight operations experience, this approach supports early identification of behavioral strengths, potential vulnerabilities, and team compatibility relevant to exploration mission environments. The process advances aerospace medicine and human performance by reducing behavioral and psychiatric risk across mission phases and by aligning selection criteria with evolving exploration-class mission requirements. Lessons learned

from NASA's 2025 astronaut selection cycle are applicable beyond the civilian space program and may inform behavioral selection practices across military, international, and commercial spaceflight organizations, supporting greater standardization and cross-domain collaboration within the aerospace community.

Learning Objectives

1. Describe the structure and rationale of the multi-phase behavioral evaluation process used during NASA's 2025 astronaut selection cycle.
2. Identify behavioral and psychological factors relevant to astronaut suitability for long-duration and deep-space missions.

[240] SHARPENING THE "RIGHT STUFF": EXPEDITIONARY SKILLS DEVELOPMENT IN ASTRONAUT CANDIDATE TRAINING

Alexa Baxley[1], Anna Morgenthaler[1], Rachel Passmore[1], Gregory Krauss[1], William Ridgway[1], James Picano[2]

[1]KBR, NASA Johnson Space Center, Houston, TX, USA; [2]NASA Johnson Space Center, Houston, TX, USA

(Education - Tutorial / Review)

INTRODUCTION: Spaceflight presents a range of unique and complex challenges to both individual and team functioning, which can impair performance and jeopardize mission success. These risks are expected to intensify during long-duration exploration missions, particularly those conducted farther from Earth and on smaller operational platforms. This presentation describes the current expeditionary skills training delivered by NASA's Behavioral Health and Performance Operations (BHP Ops) Group, designed to equip astronaut candidates (ASCANs) with the interpersonal, self-regulation, and leadership capabilities essential for the psychological and operational challenges of spaceflight. **TOPIC:** Preparing for spaceflight requires not only specialized technical expertise but also strong expeditionary skills to support effective team functioning in extreme environments. At NASA Johnson Space Center (JSC), the BHP Ops Group trains ASCANs in core expeditionary skills critical for long-duration mission success, including communication, leadership and followership, self-care/self-management, team care, and teamwork/group living. These skills help mitigate risks to team cohesion and mission performance by fostering effective communication, reducing interpersonal conflict, and strengthening crew dynamics. To ensure these skills are successfully applied during spaceflight, BHP Ops provides a comprehensive training approach that includes individualized developmental feedback informed by assessment and selection data, didactic instruction on behavioral performance risk areas, and real-time feedback on individual and team dynamics during expeditionary field exercises. Recent enhancements to the curriculum for the 2025 ASCAN class include integrated performance psychology content, expanded leadership training using both didactic and experiential methods, and personalized coaching to optimize operational

performance. **APPLICATION:** The current expeditionary skills training model offers practical insights for aeromedical professionals supporting small, high-performing teams operating in isolated, confined, and extreme environments. By leveraging the expertise of psychologists within the BHP Ops Group at NASA JSC, the program delivers targeted, operationally relevant training that enhances individual effectiveness, team resilience, and cohesion under high-stakes conditions.

Learning Objectives

1. The participant will be able to describe the core expeditionary skills essential for long-duration spaceflight and explain Behavioral Health and Performance Operations Group's role in supporting effective team functioning in extreme environments.
2. The participant will be able to Identify key components of NASA's Behavioral Health and Performance Operations training approach and discuss how these methods enhance individual and team optimization during space missions.

[241] SUMMARY RESULTS FROM THE ASSESSMENT OF PSYCHOLOGY IN EXTREME ENVIRONMENTS (APEX) STANDARDIZED SUITE

Suzanne Bell[1], Lauren Blackwell Landon[2], Sheena Dev[2], Jennifer Miller[3], Sydney Begerowski[2], Steven Anderson[2], Morgan Stosic[2]

[1]NASA Johnson Space Center, Houston, TX, USA; [2]KBR, Houston, TX, USA; [3]JESTech, Houston, TX, USA

(Original Research)

INTRODUCTION: Future space exploration missions to the Moon and Mars will require small teams of astronauts to work and live in an extreme circumstance including long-term isolation and confinement. While there has been extensive research in space and space analog settings, the characterization of behavioral health, interpersonal relationships, team functioning, and performance has been difficult due to small sample sizes. To address this, we administered and iteratively refined a standard suite of measures called the Assessment of Psychology in Extreme Environments (APEX) Suite to individuals and teams in isolation and used this data to characterize key behavioral health, team and performance risks over time. **METHODS:** Data were collected with the APEX Suite on 121 individuals in 40 teams living and working in isolated and confinement. The sample included astronauts in space for 150-350 days, and in terrestrial analogs from 45-240 days. The APEX Suite included a set of validated self-report measures, performance tests, and physiological biomarkers that quantify individual and team-level responses to the conditions expected for individuals and teams operating in long-duration, extreme environments. Data were harmonized across settings, allowing for analyses. **RESULTS:** We will present results examining key behavioral health, interpersonal relationships, team functioning and performance metrics over time in isolation, as well as a comparison of astronauts on the International Space Station with research analog astronauts. Example results include no

incidents of clinically elevated depression across the sample. For affect and stress, some temporal trends were observed, including a decrease in positive affect over time; however, negative affect and stress showed substantial interindividual variability and appeared to be more strongly associated with situational stressors than with duration in isolation. **DISCUSSION:** We will discuss the implications of our results for informing and prioritizing countermeasures for future exploration missions. We also will describe how research and operations can leverage the APEX suite to test the effectiveness countermeasures in small samples and prepare for future exploration-class missions.

Learning Objectives

1. The audience will be able to identify key behavioral health, interpersonal relationships, team functioning, and performance metrics for which there is evidence for change over time in isolation.
2. The audience will be able to describe how the harmonized data set generated from the APEX suite will help to inform and test countermeasure effectiveness.

[242] BEHAVIORAL HEALTH AND PERFORMANCE IN PLANETARY SURFACE EXTRAVEHICULAR ACTIVITY: OPTIMIZING COGNITIVE WORKLOAD AND PERFORMANCE MONITORING

Morgan Stosic[1], Steven Anderson[1], Suzanne Bell[2]

[1]KBR, Houston, TX, USA; [2]NASA Johnson Space Center, Houston, TX, USA

(Original Research)

INTRODUCTION: Surface extravehicular activity (EVA) is one of the most cognitively demanding operational contexts astronauts will encounter during the exploration era. Even subtle decrements in cognitive performance during EVA can pose substantial risks to crew safety and mission success if proper countermeasures are not in place. Accordingly, the NASA Human Research Program (HRP) has identified injury risk and performance degradation during surface EVA as critical concerns for future lunar and Mars missions. Addressing these risks requires the identification and validation of cognitive workload and performance measures that are (1) ecologically valid for the surface EVA environment, (2) sensitive to changes within high-performing astronaut-like populations, and (3) feasible for near-real-time or operational use when possible. **METHODS:** A suite of self-report measures, objective performance tasks, and nonverbal behavioral indicators of cognitive workload and performance were selected from the existing literature and systematically adapted for use in NASA surface EVA analog environments. These measures are presented and evaluated with respect to their ability to detect meaningful variation in cognitive workload and performance across key EVA-relevant factors, including EVA duration, EVA frequency, task demands, and suit parameters (e.g., suit pressure). **RESULTS:** Preliminary validation evidence will be presented from three recent surface EVA analog studies, including a non-suited and suited virtual/hybrid reality environment (APACHE)

and a suited gravity offload environment (ARGOS). Findings illustrate the relative sensitivity, strengths, and limitations of specific measurement approach across differing analog contexts and operational constraints. **DISCUSSION:** Implications for future surface EVA research are discussed, along with recommendations for refining and integrating cognitive workload and performance measures to support operational monitoring during planetary surface exploration. This work contributes to ongoing efforts to optimize astronaut safety and performance during increasingly complex and demanding surface EVA operations.

Learning Objectives

1. The audience will be able to learn about cognitive workload and performance measures that have applications to both operational and research settings to advance risk reduction research for future planetary exploration class missions.
2. The audience will be able to describe the strengths and limitations of different methodological approaches (e.g., self-reports v. performance tests v. nonverbal behavior indicators) for measuring cognitive workload and performance in EVA analog research settings.

[243] LONGITUDINAL MONITORING OF COGNITIVE FUNCTIONING AMONG FORMER ASTRONAUTS

Anna Morgenthaler[1], Victor Vergara[2], Thomas Williams[1], Wiliam Ridgway[1], James Picano[3], Sheena Dev[1]

[1]KBR, NASA Johnson Space Center, Houston, TX, USA; [2]GeoLogics, NASA Johnson Space Center, Houston, TX, USA; [3]NASA Johnson Space Center, Houston, TX, USA

(Original Research)

INTRODUCTION: The environment of space exposes astronauts to several factors that have been found in both human and animal models to degrade cognitive functioning over time. To date, research has primarily focused on the immediate or short-term postflight effects of spaceflight-related risk factors on cognitive performance and associated physiological brain changes. As a result, there remains a significant gap in the understanding and characterization of the long-term effects of spaceflight on cognitive performance across the lifespan of astronauts. **METHODS:** Through the Lifetime Surveillance of Astronaut Health (LSAH) program at NASA Johnson Space Center, neurocognitive testing was conducted with 96 former astronauts (82 male, 14 female) aged 49 to 89. Standardized neurocognitive measures were used to evaluate multiple cognitive domains and identify potential indicators of neurodegenerative disease. **RESULTS:** The majority of astronauts performed as well as or better than age- and education-matched norms across all domains of cognitive functioning tested. When looking at incidents of mild cognitive impairment (MCI) of astronauts within the 60-79 age cohort, they demonstrated relatively low incidence rates of MCI (60-69 [n=40] = 2.5%; 70-79 [n=37] = 5.4%). Within the 80-89 (n=8) cohort, 25% of participants demonstrated MCI, primarily affecting long-term verbal memory. The estimated rate of MCI in adults over the age of 65 within the general population is between

10-20%, indicating that astronauts may have a lower incidence of MCI until later stages of life. **DISCUSSION:** Our findings suggest that spaceflight and occupational exposure does not adversely impact the expected trajectory of cognitive aging. The results of neurocognitive testing suggest that astronauts maintain relatively high levels of cognitive reserve across the lifespan, which is protective against threats to neurocognitive decline. However, the higher incidence of MCI in the 80-89 age cohort to date is important to note and monitor, and more testing with astronauts in that age range is imperative to understanding neurocognitive changes after age 80. As such, longitudinal monitoring is essential to distinguish the impact of spaceflight and occupational exposure on the trajectory of normal cognitive aging. Finally, understanding and categorizing the impact of spaceflight on cognitive health over time aids in developing future countermeasures to mitigate the potential neurocognitive risks of deep space and longer-duration exploration missions to the Moon and Mars.

Learning Objectives

1. The audience will be able to describe the multiple risk factors related to spaceflight that impact the brain and cognitive functioning.
2. The audience will learn about the value of longitudinal neurocognitive monitoring in astronauts across the lifespan.
3. The audience will learn about the neurocognitive trajectory of aging in former astronauts.

Wednesday, 05/20/2026, 10:30 AM

Plaza D

[S-37] PANEL: WHEN THE AEROMEDICAL ASSESSMENT IS GOING FAR BEYOND THE MILITARY AND CIVILIAN REGULATIONS

Chair: Olivier Manen

Co-Chair: Jonathan Monin

Panel Overview: *In case of a medical situation which may impact the flight safety, the aeromedical decision is expected to reflect the current regulations applying to the aircrew category, some of them being accompanied by a practical guide. In the military, France has made the choice to have regulations with norms that are not detailed too much, some pathologies being described more than others. For civilian aircrew, the regulations of EASA have been imposed since 2013, presenting as a massive and increasing tome with regular updates as we observed in 2024/2025. Nevertheless, despite a European book of norms which will reach 150 pages very soon, many situations still remain unclear for AME to make a decision for aircrew. Consequently, it is important to carry out clinical studies regularly in the AeMC to highlight the key elements which take part in the decision and so have a role in the aeromedical prognosis. In this way, are the EASA rules exhaustive concerning coronary artery disease since the increasing use of coronary CT? As we have observed young adults among aircrew presenting with a past*

medical history of stroke, is this pathology clearly developed for the assessment? Is the diabetes issue limited to the possible hypoglycaemia risk of the treatment when talking about the flight safety? Finally, is the post-traumatic stress disorder a matter of concern for military aircrew only and the fitness management obvious for the aviation psychiatrist when reading the regulations? All these situations will be discussed through four presentations, all of them illustrated with an original clinical study. The last talk will make a synthesis about the link between the norms of the regulations and the decision-making process, with practical other examples of the daily aeromedical activity in our AeMC.

[244] CORONARY ARTERY DISEASE IN AVIATION MEDECINE: SHOULD THE ASSESSMENT FOCUS ON DETECTING PLAQUE OR ON PROGNOSIS?

Nicolas Huiban[1], Justine Esbrard[2], Mélanie Géhant[2], Erik Rebière[3], Laëtitia Marion[3], Jonathan Monin[4], François-Xavier Brocq[2], Olivier Manen[4]

[1]French Military Health Service, Toulon, Var, France; [2]French Military Health Service, Toulon, France; [3]French Military Health Service, Clamart, France; [4]French Military Health Service Academy, Clamart, France

(Original Research)

INTRODUCTION: Screening for coronary artery disease in asymptomatic individuals remains a challenge in aviation medicine, for which cardiac imaging tests have become essential tools in recent years. In the absence of validated recommendations, it is necessary to discuss relevant strategies, guided by the pursuit of a dual benefit: individual health and flight safety. **METHODS:** A descriptive single-centre, cross-sectional study with retrospective data collection was carried out between January 2020 and December 2025 in Sainte-Anne AeMC. The included patients had undergone anatomical study of the coronary artery network (CTCA and/or ICA) or a waiver procedure for coronary artery disease approved by the licensing authority, whether military or civilian. They were classified into four diagnostic categories: subclinical coronary artery disease, silent ischaemia, symptomatic chronic coronary syndrome and acute coronary syndrome. For each category, risk factors were collected at the date of the last fitness assessment prior to diagnosis. **RESULTS:** During this period, 40 patients were included, all male with a mean age of 54.4 years (sd 7.0), ranging from 28 to 67 years old and predominantly pilots (60% [95% CI :43.3-75.1]). Statistically, no significant difference was observed in the distribution of the risk factors according to the diagnostic categories: family history, active or former smoking, dyslipidaemia, high blood pressure, diabetes, obesity, number of risk factors, and the estimated coronary age in comparison to chronological age (MESA risk). Finally, only the chronological age (p=0.036) and the (ESC) SCORE 2 risk (p=0.0154) appeared significantly lower in the patients who had suffered from acute coronary syndrome. **DISCUSSION:** Neither traditional clinical and biological markers nor risk models seem discriminatory in the screening for coronary artery disease, whose progression profiles are difficult to predict. Cardiac imaging tests play a central role in the screening for high-risk individuals. Beyond the regulations that may require anatomical study of the coronary arteries, we discuss the relative added-values of calcium

scoring and coronary CT scan. With the aim of benefiting the patient and ensuring flight safety, one question seems to prevail: should we focus on detecting plaque or on prognosis?

Learning Objectives

1. The participant will understand that a prognostic approach based solely on traditional cardiovascular risk factors is largely insufficient.
2. The audience will learn that the most relevant prognostic approach is not based on strictly qualitative anatomical criteria.

[245] FITNESS ASSESSMENT IN AIRCREW WITH DIABETES, A RETROSPECTIVE STUDY

Erik Rebière[1], Nicolas Huiban[2], Gaëtan Guiu[3], Caroline Brescon[3], Laëtitia Marion[3], Olivier Manen[4], Jonathan Monin[4]

[1]French Military Health Service, Clamart, Hauts-de-Seine, France; [2]French Military Health Service, Toulon, France; [3]French Military Health Service, Clamart, France; [4]French Military Health Service Academy, Clamart, France

(Original Research)

INTRODUCTION: Diabetes poses a real challenge for the aviation safety due to the risk of in-flight incapacitation associated with hypoglycaemic medication but also the clinical and subclinical expression of chronic complications. The global prevalence of diabetes has continued to rise and has not spared aircrew members. **METHODS:** This is a monocentric retrospective study in which we included all aircrew members examined in Percy AeMC when they were referred to the civil or military authority for diabetes between 2010 and 2025. **RESULTS:** Our cohort consisted of 100 aircrew (85% pilots, mean age 52 +/- 11 yo, BMI 29.1 +/- 5.4 kg/m², waist circumference 109 +/- 10 cm), 91% with type 2 diabetes, 67% presenting with metabolic syndrome and 70% suffering from at least one additional comorbidity. Diagnosis was made in our AeMC for 37% of cases whereas only 20% of aircrew were diagnosed thanks to the regulatory screening, and the remaining cases were identified on clinical indication with suggestive symptoms or predisposing conditions. A first-line screening for complications was systematically performed by clinical interview and physical exam. Those with the greatest impact on flight safety were screened through additional investigations, even in asymptomatic aircrew members: retinopathy and other ophthalmological complications (100%), coronary artery disease (94%), nephropathy (66%) and peripheral artery disease (supra-aortic vessels 36%, lower limbs arteries 27%). After the evaluation, 68% of aircrew were declared fit to fly, but 97% had some limitations, mostly consisting in a close follow-up in an aeromedical center whereas 30% had a technical flight limitation (safety pilot required). Significant risk factors of unfitness decision included higher initial fasting blood glucose and HbA1c levels ($p<0.01$), type 1 or secondary diabetes ($p<0.01$), a treatment associated with hypoglycaemic risk ($p<0.01$) and a poorly controlled or complicated diabetes ($p<0.01$). **DISCUSSION:** Early detection and optimized management of diabetes are essential to preserve the flight safety. When supported by

a structured monitoring, a systematic screening for high-risk complications and the use of medication without any hypoglycaemic risk, the majority of aircrew can safely return to flying duties. However, many elements should be considered for limitations and sometimes unfitness decision.

Learning Objectives

1. The audience will learn about the specific population of diabetic aircrew with initial assessment and follow-up in our AeMC.
2. The audience will understand the impact of the disease, including its complications and treatments, on the decision-making process.

[246] STROKE IN AIRCREW MEMBERS: AEROMEDICAL ASSESSMENT AND RISK FACTORS OF UNFITNESS

Jonathan Monin[1], Erik Rebière[2], Gaëtan Guiu[2], Laëtitia Marion[2], Caroline Brescon[2], Nicolas Huiban[3], Olivier Manen[4]

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(Original Research)

INTRODUCTION: Stroke is a critical concern in aviation medicine due to its recurrence risk and potential for persistent sequelae, both of which may compromise flight safety. This study aims to characterize the population of aircrew members with a history of stroke. **METHODS:** We conducted a monocentric, retrospective study of all aircrew members (AM)—civilian and military, including pilots and other specialties— with a history of stroke who underwent evaluation at our Aeromedical Center (AeMC) between 2011 and 2025. **RESULTS:** The study included 83 AM (94% male, 64% civilian, 66% pilots; mean age 50.4 ± 13.2 years). Stroke type was ischemic in 94% of cases (including 26% transient ischemic attacks), and hemorrhagic in 6%. At diagnosis, the most common symptoms were motor deficits (55%), aphasia (33%), and visual disturbances (28%). Etiology remained undetermined in 55% of cases. During aeromedical assessment, MRI was performed in all cases (abnormal in 65%), alongside ophthalmological evaluation. Additional sequelae screening included EEG (48%), neurocognitive assessment (30%), and psychiatric evaluation (17%). Cardiovascular evaluation was composed of stress testing (96%), echocardiography (53%), Holter ECG (83%), and arterial Doppler ultrasound (36%). Finally, 66% of AM were declared fit to fly (mean interval from stroke to fitness decision: 15.6 ± 18 months), always with restrictions. The main predictors of unfitness were sequelae, particularly cognitive disorders and visual deficits ($p < 0.001$). Of the unfit AM, 31% were considered at high risk of recurrence. **DISCUSSION:** The aeromedical assessment after stroke largely aligns with French guidelines. However, to ensure optimal flight safety, systematic sequelae screening, including neurocognitive evaluation (via clinical

assessment +/- standardized testing) and visual examination, is essential. Recurrence risk, which depends on etiology, remains a key consideration in fitness determinations.

Learning Objectives

1. The audience will learn about the population of aircrew members with a past medical history of stroke.
2. The audience will understand how to screen for sequelae in aircrew members post-stroke.

[247] DIAGNOSIS, FOLLOW-UP, AND FITNESS ASSESSMENT OF MILITARY AIRCREWS WITH POST-TRAUMATIC STRESS DISORDER

Laëtitia Marion[1], Erik Rebière[2], Nicolas Huiban[3], Gaëtan Guiu[2], Caroline Brescon[2], Olivier Manen[4], Jonathan Monin[4]

[1]French Military Health Service, Clamart, Hauts-de-Seine, France; [2]French Military Health Service, Clamart, France; [3]French Military Health Service, Toulon, France; [4]French Military Health Service Academy, Clamart, France

(Original Research)

INTRODUCTION: Military aviators are exposed to potentially traumatic situations, particularly in flight and during overseas operations. Sometimes, aviators hide their symptoms for fear of a negative impact on their flight fitness, which can lead to a delay in diagnosis and treatment. **METHODS:** This is a retrospective study of aircrews examined by the aviation psychiatrist of our AeMC between January 2022 and December 2025. We focused on the characteristics of this population, including their service branches, the number of overseas deployments, the type of missions carried out, the follow-up, and the impact on fitness decision. **RESULTS:** The population was composed of 168 aircrews (82% men, 71% officers, 61% pilots, average age 35.6 ± 8.5 yo). 68% had no known psychiatric history. 11% of them suffered from post-traumatic stress disorder (PTSD), which was the 6th most frequent diagnosis, after anxiety disorders (39%), adjustment and depressive disorders (25%), and behavioral and personality disorders (12%). PTSD was often associated with anxiety disorders (68%). They were mainly pilots (74%), from the Army (79% $p<0.01$), helicopter pilots (81% $p<0.01$) without any distinction between attack and maneuver helicopters, with more frequent participation in overseas deployment (6.6 vs 3.2 $p<0.01$). They were more exposed to operational (84%) and in-flight events (68%) ($p<0.001$). Regarding the fitness decision, aviators with PTSD were more often referred to the French Military Aeromedical Board (58%, $p=0.038$), and 37% were declared fit to fly. **DISCUSSION:** We have shown that French Army helicopter pilots are more exposed to the risk of developing PTSD than other French military crewmembers, although there are more individuals in the Air Force. It seems linked to the types of missions and the characteristics of the flights. Indeed, these operations require helicopters to be in immediate proximity and within firing range of the targets, with frequent landings near enemy troops to deploy individuals or carry out medical evacuations. Finally, in France, the search and rescue

mission can also expose pilots to the risk of psychological trauma, due to weather conditions or flying over hostile areas (sea, mountains).

Learning Objectives

1. The audience will learn about the population of the French military aircrew suffering from post-traumatic stress disorder.
2. The audience will understand the importance of the aviation psychiatrist in terms of diagnosis, follow-up, and aeromedical fitness for PTSD.

[248] NORMS, REGULATIONS, AND DECISION-MAKING-PROCESS: DO WE REALLY ABIDE BY THE RULES FOR THE FITNESS ASSESSMENT?

Olivier Manen[1], Nicolas Huiban[2], Erik Rebière[3], Laëtitia Marion[3], Caroline Brescon[3], Gaëtan Guiu[3], Jonathan Monin[4]

[1]French Military Health Service Academy, Clamart, Hauts-de-Seine, France; [2]French Military Health Service, Toulon, France; [3]French Military Health Service, Clamart, France; [4]French Military Health Service Academy, Clamart, France

(Education - Program / Process Review)

BACKGROUND: In case of a medical problem in aircrew, the fitness decision depends on multiple parameters, including but not as an exhaustive list: the statistical risk of in-flight medical event, the global situation (disease, treatment, comorbidities, psychological consequences), the flying experience, and regulations to be applied. In a changing world, there have been a decrease in the acceptance of professional constraints but also unfit decisions by aircrew who may use their medical condition in the most favourable way. Consequently, it is necessary to question about the real place of regulations in the decision-making process. **OVERVIEW:** In the daily aeromedical activity of Percy AeMC where 11,000 expertises (45% military, 55% civilian) are performed every year, regulations are a central issue in the discussions. First, the content of the examination when very minimalist may worry the AME for the assessment. Second, the very administrative forms and procedures of EASA may occult the medical aspect of these examinations. The need to refer to the medical assessor of the licensing authority for some situations may be inadequate, particularly when the national administrative system is quite slow whereas pilots are under pressure. The official guide also in the military may be insufficient, discordant, or absurd. The civil and military duality to consider the long-term prognosis may bother AME who must develop additional resources when aerobatics does not appear in the regulations, when some statutory limitations seem inadequate or when pilots are asking for LAPL fitness, all of that for pathologies with no clear aeromedical follow-up officially described. **DISCUSSION:** A perfect regulatory system does not exist of course, and in case it does AME would have not their role any longer, acting as simple underling people with no need for critical sense. However, the more regulations aim to be precise and complete, the more they bring new questions and perplexity feelings depending on the wording choices and

missing recommendations. Through many clinical examples from the real-life experience, the author will explain why to issue an aeromedical certificate is to reach an acceptable compromise between official regulations, flight safety, and individual interest.

Learning Objectives

1. The audience will learn about the limits of the official regulations regarding the aeromedical assessment and the decision-making process.
2. The audience will learn about the way to find a compromise between regulations, and all other parameters that are part of the situation, to take the best fitness decision in aircrew.

Wednesday, 05/20/2026, 10:30 AM

Plaza F

[S-38] PANEL: HIGH ALTITUDE, HIGH STAKES; EXPLORING THE RISKS INVOLVED IN HIGH ALTITUDE PARACHUTING OPERATIONS'

Chair: Bonnie Posselt

Panel Overview: *BACKGROUND: Interest is growing among various militaries to conduct parachute operations from higher altitudes and more frequently. In contrast to routine activities in pressurized aircraft, parachutists and dispatchers will be exposed to extreme altitudes for prolonged periods, often with the addition of exercise. This operating environment poses many physiological challenges that are not addressed sufficiently in traditional Aerospace Medicine equipment or training standards. OVERVIEW: This panel will start by reviewing the high-altitude parachuting (HAP) environment and associated specific physiological risks before focusing on necessary requirements for a suitable oxygen system. The challenges of integrating an appropriate oxygen system with flight equipment worn by parachutists will also be explored. In addition, the audience will learn about recent research conducted investigating Decompression Sickness risk with repeat exposures to inform improved safety and efficiency of HAP operations. Throughout the panel, existing gaps in current knowledge will be identified, aiming to better direct future research efforts and co-ordinate effective collaboration. DISCUSSION: Addressing the specific challenges and hazards of High-Altitude Parachuting is critical to inform setting appropriate requirements for oxygen systems and flight equipment needed to adequately protest users. Aerospace Medicine expertise in HAP operations is vital to mitigate risks to life and to optimize human performance in such a demanding aerospace environment.*

[249] PHYSIOLOGICAL CHALLENGES OF HIGH-ALTITUDE PARACHUTING

Joseph Britton

Royal Air Force, Henlow, Bedfordshire, United Kingdom

(Education - Tutorial / Review)

INTRODUCTION: Exposures to high altitude in pressurized aircraft are commonplace, with aeromedical hazards being well appreciated and largely mitigated for. In comparison, high altitude parachuting represents a greater challenge, more similar to that encountered by early aviation pioneers. Despite operating in one of the most demanding aviation environments, the physiological challenges experienced in high altitude parachuting are less well explored and understood. **TOPIC:** The challenges of exposure to altitude in most aviation operations are primarily addressed by the presence of a pressure cabin. The requirement to jump from an unpressurised aircraft at high-altitude exposes parachutists to hypobaria, hypoxia, decompression sickness, gas expansion, and cold stress. The impact of these hazards increases with jump altitude, but also with various factors such as duration of exposure, physical workload, health status, age, and the presence and performance of an oxygen system. These hazards will affect operational performance as well as being safety critical. Furthermore, individuals involved in parachuting operations can be separated by degree of risk into three main occupational groups; aircrew, parachutists, and dispatchers. This presentation will explore the differences between these three groups, and how these differences affect the well-known physiological challenges of altitude applied to high altitude parachute operations. How the possible mitigations available to these groups differ will also be discussed as well as identifying knowledge gaps that require further research. **APPLICATION:** The challenges of high-altitude parachuting are less well represented in aerospace medicine literature than those involved in fixed or rotary wing operations. This presentation will highlight the known risks and differences between groups, as well as define altitude risk boundaries for parachuting operations. This will set the scene for detailed discussions about the mitigations for these risks in the following presentations.

Learning Objectives

1. The audience will gain an awareness of the unique physiological challenges of high altitude parachuting in comparison to aircraft operations.
2. The audience will understand the different challenges faced by different occupational groups involved in high altitude parachuting.

[250] OXYGEN SYSTEM REQUIREMENTS FOR HIGH-ALTITUDE PARACHUTING

Nicholas Green

Royal Air Force, Henlow, Bedfordshire, United Kingdom

(Education - Tutorial / Review)

INTRODUCTION: High altitude parachuting presents some of the most demanding physiological challenges in aviation, with high levels of physical activity being carried out in

unpressurised conditions. National and international standards have existed for many decades for oxygen systems in high-performance aircraft, but the threats from hypoxia and decompression sickness are arguably greater in parachuting operations and yet there are no established standards for parachuting oxygen systems. **TOPIC:** Oxygen system requirements typically describe the required breathing flow performance to be delivered by the system, including mask cavity pressure swings during inhalation and exhalation, in addition to the oxygen concentration to be provided at relevant altitudes, and other factors including the need for a backup system, and performance in very cold conditions. Increased work of breathing may influence the users' ability to perform physical tasks, and also influences the risk of inboard leakage, leading to hypoxia and failure of pre-oxygenation used to mitigate decompression sickness. While standards designed for high-performance combat aircraft applications have been used in system procurement, some have questioned their relevance in this setting, on the assumption they are too stringent. However, given the physiological challenges associated with parachuting and air dispatch, it may be that these standards are actually not rigorous enough. **APPLICATION:** There is a lack of evidence concerning the physiological requirements of parachutists and air dispatchers in terms of ventilatory demand on which to base standards. The decompression sickness risk in personnel involved in parachuting operations is incompletely understood. Pre-oxygenation times for these individuals, and the effects of breathing less than 100% oxygen in some phases of parachute descent have not been explored and should be the target for future research in inform the development of parachute oxygen standards.

Learning Objectives

1. The audience will learn about which aspects of parachutist physiological demand have the greatest influence on oxygen system performance.
2. The audience will learn what future research is needed to inform the development of parachute oxygen system standards.

[251] TEST AND EVALUATION OF OXYGEN SYSTEMS FOR HIGH-ALTITUDE PARACHUTING

Matthew Landells

RAF Centre of Aerospace Medicine, Henlow, Bedfordshire, United Kingdom

(Education - Tutorial / Review)

INTRODUCTION: High altitude operations expose parachutists and dispatchers routinely to multiple physiological hazards as detailed in this panel. An effective oxygen delivery system is critical to mitigate many of these. However, there is considerable variability in how oxygen systems are tested, validated and integrated across user groups. This tutorial aims to summarize current best practice and commonly experienced issues in order to support safer, evidenced based usage of oxygen systems in high altitude parachuting operations. **TOPIC:** A parachuting oxygen system commonly consists of multiple sub-components including an oro-nasal mask, demand regulator, console or pre-breathing system and portable bailout bottle which must function as an

integrated system across a range of physiological and operational conditions. Test and evaluation should take place across multiple stages. Firstly, uncrewed testing should assess performance of the regulator, mask and oxygen sources(s) across a range of representative simulated breathing demands, thermal conditions and pressure changes. This data will inform risk and medical ethics for future crewed testing which should aim to assess performance with a range of human subjects as well as qualitative aspects of end-user experience. Finally, test and evaluation should assess how the oxygen system is integrated with existing aircraft and personal equipment, usability and reliability under real-world environment conditions and risk of system displacement or failure following exit from the dispatch aircraft. An inherent limitation to evaluating parachuting oxygen systems is that evidence concerning the specific physiological requirements or parachutists and air dispatchers is currently lacking. **APPLICATION:** Completing all stages of testing allows for accurate assessment of oxygen system performance and assurance that it will adequately protest users from the physiological hazards of high-altitude parachuting operations. Where system limitations or potential failure models are identified, this is still of benefit to aeromedical specialists in informing operational risk assessments, proposing equipment usage restrictions and standard operating procedures. Future work in this area should aim to develop accepted standards for the testing and certification of such systems.

Learning Objectives

1. The audience will learn about recommended aspects of uncrewed and crewed parachuting oxygen system testing required to advise on performance and potential aeromedical risk.
2. The audience will learn why high altitude HAHO/HALO operations present particular performance challenges for a potential oxygen system.

[252] INTEGRATION OF OXYGEN SYSTEMS FOR HIGH-ALTITUDE PARACHUTING

Alasdair Mackay

RAF Centre of Aerospace Medicine, Henlow, Bedfordshire, United Kingdom

(Education - Tutorial / Review)

INTRODUCTION: High altitude parachuting exposes operators to severe hypobaria, extreme cold and high physical workload while outside the safety of a pressurized cabin. Oxygen delivery systems mitigate hypoxia, but must integrate with the parachutist's equipment ensemble to avoid physiological compromise or mechanical failure. This presentation focuses on equipment integration risks specific to high altitude high opening (HAHO) operations. **TOPIC:** Parachuting from lower altitudes usually involves brief exposure to environmental stressors and requires limited protective clothing and equipment. In contrast, operators conducting HAHO jumps are exposed to potentially hypoxic altitudes for an extended period of time and may require oxygen delivery for prolonged periods after exit. The oxygen system must provide reliable protection from hypoxia while integrating with increased equipment bulk, including thermal clothing, gloves, body armor, communications equipment and navigation aids. It must not prevent routine

or emergency procedures, restrict visual field, or degrade communication. Military HAHO operations can impose a high cognitive burden limiting capacity to test, adjust or troubleshoot complex systems. This presentation will discuss human machine interface design, including simple operation with gloved hands, resistance to inadvertent actuation and rapid confirmation that breathing gas is being delivered. Flow indication should be interpretable in low light and adverse conditions, remain visible with the fitted mask and eyewear, and avoid reliance on fine colour discrimination. Trials should include representative clothing, gloves and mission equipment as well as physical activity. The presentation will also discuss how parachute opening physics at high altitude can differ from low altitude. Reduced air density increases terminal velocity, so opening shock may be higher. Mannequin drop testing of the full assembly can assess dislodgement, mask seal disruption, hose disconnection and snag hazards. Representative acceleration test pulses can be estimated using a range of features such as likely aircraft speeds, parachute opening delay, exit altitude and mass. **APPLICATION:** Integration should be assessed as a whole system, ensuring compatibility with other equipment and preserve the operator's ability to conduct routine and emergency drills. This presentation will outline design and test considerations that support aeromedical clearance and safe introduction of an oxygen system for HAHO use.

Learning Objectives

1. The audience will understand how high-altitude operations change oxygen system integration compared with low altitude parachuting.
2. The audience will be able to identify test and human factors measures that reduce integration risk.

[253] HIGH ALTITUDE PARACHUTING TRAINING AND TRIALS AT 25,000 FT

Desmond Connolly, Tim D'Oyly, V. C. Edwards, Vivienne Lee

QinetiQ, Farnborough, Hampshire, United Kingdom

(Original Research)

INTRODUCTION: Out latest study showed that the risk of decompression sickness (DCS) amongst parachutist despatchers at 25,000 ft is exacerbated by physical activity, advancing age, and higher denitrogenation altitude (15,000 ft), but early repeat exposure incurs less decompression stress than expected (fewer venous gas emboli, VGE). Blood biomarkers suggest systemic inflammation and neuroinflammatory responses. The findings will be reviewed briefly before presenting new data, exploring potential mitigations to more intensive decompression stress. **METHODS:** In our latest study, eleven subjects (23 to 41 yrs) each undertook four chamber ascents to 25,000 ft pressure altitude breathing 100% oxygen, compromising two ascents on each two successive days, with same-day ascent separated by three hours or breathing air at ground level. Activities at altitude simulated despatcher levels of exertion. Exposure to 25,000 ft followed denitrogenation for 60 min at 8000 ft and was interrupted after 15 min by

bounce recompression to 10,000 ft for 15 min. VGE loads were monitored at 15-min intervals using 2D + Doppler echocardiography. Kisman integrated severity scores were calculated. Blood sampling compromised three morning baselines (B1-B3) and four post ascent samples (A1-A4), for hematology serum protein and plasma microparticles, aiming to validate and extend previous findings. **RESULTS:** Of 44 planned ascents, 42 completed uneventfully with limb pain DCS curtailing one experiment during the third ascent (incidence 2.3%). VGE loads and Kisman scores were substantially lower on repeat relative to initial daily ascents (x2 [3, N=10] = 14.45, P = 0.0024). Innate immune cell counts increased post-ascent, neutrophils particularly after initial ascents and monocytes after repeat ascents. Baseline morning monocyte counts increased progressively, by 20% at B2 and 40% at B3 (F[2, 16] = 4.61, P = 0.026). **DISCUSSION:** DCS incidences of 2.3% is no greater than predicted for exposures to 25,000 ft at rest, following 60 min of denitrogenation. Daily repeat exposures provoked few VGE, with the propensity to 'bubble' regenerating overnight. Protein and microparticle biomarkers are being assayed, to evaluate any associated inflammatory stress. Nonetheless, this altitude profile appears comparatively benign, potentially enabling repeat daily, and successive day ascents, thereby adding considerable value to intensive training and trials deployments.

Learning Objectives

1. The audience will understand the interplay of the key risk factors that drive the overlying risk of decompression sickness during high altitude parachuting at 25,000 ft.
2. The audience will learn how mitigations other than duration of denitrogenation might also influence the response to decompression stress and, hence, likelihood of decompression sickness.

Wednesday, 05/20/2026, 10:30 AM

Governor's 10

[S-39] PANEL: OPERATIONAL BASED VISION ASSESSMENT (OBVA) RESEARCH PANEL

Chair: Marc Winterbottom

Co-Chairs: Marc Winterbottom, Eric Seemiller

Panel Overview: *The objectives of the 711th Human Performance Wing, Human Effectiveness Directorate, Operational Based Vision Assessment (OBVA) Laboratory are to 1) provide quantitative data defining the visual performance capability that will contribute to mission success; 2) evaluate human performance with the use of vision correction, enhancement, and protective technologies and provide recommendations for operational based vision standards and waiver criteria; and 3) uncover strategies (training, engineering) to improve vision performance and optimize mission performance. The OBVA Lab has teamed with multiple organizations to accomplish these objectives, several of which are participating in this panel. The presentations in this panel will address operational vision research on several topics: 1)*

individual differences across color tests used for aeromedical vision screening; 2) examine meaningful differences in smooth pursuit biomarkers based on normative and longitudinal data; 3) the effect of sleep deprivation on eye movement biomarkers; 4) the use of real-time eye-tracking and hidden Markov Modeling (HMM) to detect visual stress patterns over time during flight task performance (simulated air refueling); and 5) vision standards recommendations for KC-46 Boom Operators using new remote vision system (RVS) stereoscopic display technology.

[254] INDIVIDUAL DIFFERENCES IN COLOR TEST THRESHOLDS REVEAL STRUCTURED VARIATION IN L–M CONE WEIGHTING

Kassandra Lee[1], Eric Seemiller[1], Marc Winterbottom[2], Steven Hadley[2]

[1]KBR, Beavercreek, OH, USA; [2]711th Human Performance Wing, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: Cone contrast tests (CCTs) are widely used to quantify color vision across clinical and operational settings, including aeromedical vision screening for commercial and military aircrew, yet results frequently differ across instruments. These discrepancies may reflect test-specific design features or stable, physiologically meaningful individual differences in cone-opponent processing. Clarifying the structure of these variations is essential for interpreting color test outcomes and understanding how different tests capture distinct aspects of color vision. **METHODS:** Fifty-one observers completed three CCTs (Konan, Innova, NCI) and the Colour Assessment and Diagnosis (CAD) test, which measure L-, M-, S-cone, and red-green (RG) and blue-yellow (BY) thresholds, respectively. Analyses used run-level and eye-specific data to evaluate reliability and shared variance across tests. A subject-level principal component analysis (PCA) characterized individual differences in color vision, followed by clustering to identify structured subgroups. A consistency analysis then compared PCA patterns for individuals with stable versus mixed pass/fail outcomes across tests targeting the same cone axis. **RESULTS:** Across the four color vision tests, 69.6% of observers showed at least one pass–fail disagreement, indicating that the instruments do not classify individuals consistently. Despite this, within-test reliability was high, suggesting that the differences reflect meaningful variation in what the tests measure rather than measurement noise. Analysis of individual differences suggested possible reasons for these discrepancies, including variation in overall color vision and differences in L–M cone weighting that influenced how observers performed across the different test formats. **DISCUSSION:** Color vision tests can differ in what they are actually testing. Letter-based CCT tests present static chromatic letters on a luminance pedestal and are more susceptible to luminance intrusion and hardware limitations, whereas the CAD uses dynamic luminance noise to isolate chromatic mechanisms. As a result, the tests often disagree on who passes or fails. Importantly, these disagreements were structured: individuals who produced mixed pass/fail patterns also differed in their underlying L–M cone weighting. For aeromedical screening, conflicting outcomes across tests are expected and informative, not signs of poor

reliability. Results emphasize they should be interpreted with awareness of the mechanisms each test engages.

Learning Objectives

1. Identify key sources of variability in color test performance, including test-specific factors and individual differences in cone-opponent weighting.
2. Understand how multivariate analyses (PCA, clustering, consistency analyses) reveal structured patterns of variation across observers for several commonly used color vision screening tests.

[255] MAKING SENSE OF CHANGES IN OCULOMOTOR BIOMARKERS

Eric Seemiller[1], Eleanor O'Keefe[1], Danae Johnson[2], Daniel Hartling[2], Marc Winterbottom[2]

[1]KBR, Beavercreek, OH, USA; [2]711th Human Performance Wing, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: To track a moving target, the human eye engages a complex eye movement circuit known as smooth pursuit. Because the broad neural circuity relies on feedforward and feedback relationships, quantitative biomarkers of smooth pursuit can provide a powerful snapshot of the overall health of the nervous system. Changes in these biomarkers can potentially indicate injury or fatigue and may be useful when making fitness-for-duty decisions. To do that, one must understand what constitutes a clinically meaningful change. Here we present the results of three studies to make sense of how these biomarkers change. **METHODS:** To establish a baseline of day-to-day variation, six adults ran a smooth pursuit-based neurological health screening protocol (neuroFit ONE) as many times as feasible over the course of 8 months. Descriptive statistics were computed at the individual and group level. Additionally, we measured the before-and-after changes in these biomarkers for 53 individuals who completed a 1-hour critical care aeromedical transport (CCAT) simulation and for 17 individuals who participated in a 3-hour aerial refuelling simulation. **RESULTS:** We determined that the criterion for a meaningful change was +/- 1.96 times the standard deviation of each biomarker, indicating the change is <5% likely due to noise and suggesting a statistically valid change in the biomarker. Following the CCAT simulation, 13% of participants had meaningful reductions in biomarker performance, while 10% actually had meaningful improvements. Following the longer aerial refuelling simulation, all participants had decreased biomarkers, with 30% exceeding the criterion. **DISCUSSION:** By establishing longitudinally based criteria for what constitutes a clinically meaningful change in the biomarker, the user can make an estimation that a change is unlikely to be attributed to normal variation in the operator and more likely due to a change in the operator state. We demonstrated two use-cases that show how these biomarkers might be used in the operational aviation environment, while highlighting substantial individual variation in responses. Eye movement tests, such as the neuroFit ONE, may enable objective metrics of

Airmen and Guardian medical readiness. This research can be used to establish actionable criteria to support the development of new aeromedical readiness metrics.

Learning Objectives

1. Attendees will understand how smooth pursuit biomarkers can provide an overall snapshot of brain health and fatigue.
2. Attendees will learn to make clinically relevant decisions about meaningful changes in smooth pursuit biomarkers.

[256] OCULOMETRIC ASSESSMENT OF ACUTE SLEEP DEPRIVATION IN MILITARY AVIATORS

Chris Aura[1], Dorion Liston[2], Eric Seemiller[3]

[1]U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, USA; [2]neuroFit, Inc., Mountain Home, CA, USA; [3]KBR, Beavercreek, OH, USA

(Original Research)

INTRODUCTION: Fatigue is a leading cause of injury and mishaps for Warfighters. Whereas physiological effects of fatigue are well-documented, it is unclear whether functional signs can be measured reliably and non-invasively. We explored whether oculometrics could quantify the effects of fatigue in a small sample of aviators. **METHODS:** Eight U.S. Army aviators underwent 34 hours of sustained wakefulness, beginning at 9 AM on the first experimental day. During the 34-hour period, participants were engaged in several simulated tasks related to military aviation (e.g., shooting simulator, etc.). Oculometric and computer-based cognitive assessments were completed at five time points: baseline (one to seven days prior to sleep deprivation), and four experimental time points at 1 PM, 10 PM, 3 AM, and 11 AM. Completion of the 5-minute, 45-trial oculometric assessment produces 10 raw z-scored smooth pursuit eye-movement metrics (e.g., initiation latency, steady state gain, etc.), and one z-scored summary metric called nFit. This study was approved by the U.S. Army Medical Research and Development Command (USAMRDC) Institutional Review Board (IRB). **RESULTS:** Baseline oculometric performance was typical of a healthy adult population (mean nFit: -0.44, STD: 1.06). Oculometric performance declined during the period of sleep deprivation for all individual metrics and nFit. Relative to baseline, significant impairment in nFit occurred by the 10 PM time point. Using linear regression, we measured the rate of fatigue-related impairment in each of the metrics. **DISCUSSION:** Consistent with previous studies, smooth pursuit eye movements show robust signs of acute sleep deprivation. The vector of fatigue-related impairment rates can be used to detect fatigue and quantify its magnitude. One limitation associated with eye tracking under fatigue is behavioral complications (i.e., droopy eyelids, heavy blinking, inattention) which could be quantified separately. Oculometric tests may enable objective metrics of Warfighter medical readiness and potentially provide objective feedback to adapt mission planning to optimize performance and lethality.

Learning Objectives

1. Attendees will learn about oculometrics.
2. Attendees will learn about the impact of sleep deprivation fatigue on oculometrics.

[257] DETECTING TEMPORAL DYNAMICS OF VISUAL FATIGUE THROUGH HIDDEN MARKOV MODELING IN SIMULATED AERIAL REFUELING

Katharine Woodruff[1], Eric Seemiller[2], Eleanor O'Keefe[2], Marc Winterbottom[3]

[1]Collins Aerospace, Madison, WI, USA; [2]KBR, Beavercreek, OH, USA; [3]711th Human Performance Wing, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: Visual fatigue and stress from prolonged stereoscopic three-dimensional (S3D) display use pose challenges for aviation operations and system design. Traditional analyses using subjective surveys and group-averaged eye metrics provide static summaries of fatigue and may obscure dynamic temporal progression of fatigue states and individual compensatory strategies. Hidden Markov Modeling (HMM) offers temporal granularity by identifying behavioral states and their transition patterns, revealing visual stress patterns over time. This investigation employs HMM to uncover latent fatigue states and their non-linear progression patterns during long-duration exposure to misaligned displays. **METHODS:** Fifteen participants performed a simulated aerial refueling task using an S3D display. Participants performed the task for 3-hour blocks during 3 visits. To further induce visual fatigue, the stereoscopic scene cameras were vertically misaligned at one of three magnitudes during each visit (0°, 0.21° and 0.41°). Subjective symptoms of visual fatigue and stress were collected hourly, while eye-tracking data was recorded binocularly using a remote eye-tracker. **RESULTS:** HMM revealed three behavioral states of eye movements. State 1 presented high saccade rates, lower blink rates and durations, and larger pupil dilation. State 2 had higher blink rates and durations, smaller pupil dilation, and lower saccade rates compared to state 1. State 3 had the lowest saccade rates, smallest pupil dilation, and highest blink rates and durations. Most features showed stable state persistence across all alignment levels, with transition matrix diagonal probabilities (i.e., remaining in the same state) greater than 75%, indicating that states tend to be self-maintaining. However, in the moderate misalignment condition, an inverted-U fatigue response emerged where moderate misalignment triggered increased state-switching compared to the zero and high misalignment conditions. Pupil size, saccade amplitude, and vertical/horizontal vergence remained stable with lower state-switch transition probabilities. **DISCUSSION:** The HMM analysis captures temporal dynamics of behavior state switching, enabling a path to future real-time fatigue detection, versus traditional group comparisons. This approach could inform adaptive cockpit display systems that alert operators of visual stress and adjust stereoscopic parameters when fatigue is detected. Future work will identify individual state-switching patterns related to vision tests from aeromedical screening that may predict aircrew susceptibility to fatigue.

Learning Objectives

1. Identify eye-tracking features that may serve as sensitive biomarkers for visual fatigue modeling by examining differential state emissions (how features characterize each state) and state transition probabilities.
2. Evaluate how Hidden Markov Modeling provides superior analysis of physiological signals compared to traditional statistical approaches by capturing continuous state emissions and transition probabilities, revealing non-linear temporal dynamics.

[258] KC-46 RVS 2.0 BOOM OPERATOR AEROMEDICAL VISION STANDARDS RECOMMENDATIONS

Marc Winterbottom[1], Eric Seemiller[2], Eleanor O'Keefe[2], Matthew Ankrom[2], Lance Kielbaso[2], Jason Russi[2], Charles Bullock[1], Steven Hadley[1]

[1]711th Human Performance Wing, Wright-Patterson AFB, OH, USA; [2]KBR, Beavercreek, OH, USA

(Original Research)

INTRODUCTION: The redesigned KC-46 remote vision system (RVS) 2.0 was intended to solve a number of deficiencies of the original RVS 1.0 design. In previous research, operator binocular vision status (e.g., stereo acuity, phoria, fusion range) was found to be a limiting factor for simulated refueling performance with the RVS 1.0 design. The purpose of this investigation was to determine whether the RVS 2.0 design might require similar aeromedical vision screening considerations, or alternatively, whether the design improvements could enable less restrictive aeromedical vision standards. The relationship between standard Air Force vision tests and new computer-based vision tests and simulated RVS 2.0 refueling performance was evaluated. **METHODS:** Fifty-one participants, including 18 active-duty boom operators, were recruited for this study. All participants completed a comprehensive vision test battery: Optec 2300 Armed Forces Vision Tester (vertical and horizontal phoria, near and far visual acuity and stereoacuity); computer-based vision tests (visual acuity, contrast sensitivity, stereoacuity, horizontal and vertical fusion range). The neuroFit ONE (nFit) smooth pursuit eye movement test was also used. Vertical and horizontal cover tests were also performed by a licensed optometrist. The air refueling simulation consisted of a prototype RVS 2.0 stereoscopic display and FlightSafety International Vital 1150 image generator. Participants were asked to maneuver the boom to make contact with various types of simulated receiver aircraft as quickly as possible while avoiding contacts outside the receptacle (COTRs). **RESULTS:** Several of the nFit metrics were correlated with unintended COTRs (e.g., steady state gain, $r = -0.33$, $p = 0.02$). The Optec far phoria test also correlated with COTR rate ($r = 0.4$, $p = 0.01$). No other vision metrics were correlated with simulated refueling performance. **DISCUSSION:** Unlike with the RVS 1.0, only far phoria was correlated with refueling performance while using the RVS 2.0 design concept. Notably, however, smooth pursuit eye-movements were related to simulated refueling performance. These results suggest that less restrictive vision standards are appropriate for KC-46 Boom Operators, increasing the pool of eligible operators for this critical weapons platform and that smooth

pursuit eye-tracking metrics may provide a valuable new tool to assess aircrew medical readiness.

Learning Objectives

1. Attendees will learn about the relationship between standard vision metrics (e.g., Optec 2300) and simulated air refueling performance for two remote vision system design concepts (KC-46 RVS 1.0 vs. 2.0).
2. Attendees will learn about the relationship between new computer-based vision tests (e.g., digital stereo acuity, smooth pursuit eye movement tests, etc.) and simulated air refueling performance for two remote vision system design concepts (KC-46 RVS 1.0 vs. 2.0).

Wednesday, 05/20/2026, 10:30 AM

Governor's 12

[S-40] PANEL: CADETS AT THE CONTROLS: FLEXIBLE AEROMEDICAL READINESS ACROSS AIR AND SPACE

Chair: Jaime Harvey

Co-Chair: Jennifer Giovannetti

Panel Overview: *This panel highlights how future aerospace medicine and human performance professionals at the United States Air Force Academy (USAFA) are being prepared to understand and support the diverse operational environments of pilots, parachutists, and space operators, each with distinct physiological hazards that demand flexible approaches to aeromedical readiness. Four USAFA cadet-authored abstracts illustrate this range: Basic Freefall Parachuting, where peer-led risk management protocols mitigate physiological complications and optimize performance in high-stress environments; the Cadet Soaring program, which contrasts the limited physiology exposure of cadet student pilots with the advanced situational awareness and human-performance monitoring required of cadet instructor pilots in tandem-seat glider cockpits; comparative training demands between Powered Flight and the competitive Collegiate-level Flying Team, where cadets encounter different levels of physiological stress and emergency preparedness; and the Azimuth program, which immerses future Space Force officers in space physiology and microgravity through parabolic flight and astronaut instruction; and These programs demonstrate how aerospace medicine professionals must adapt their support to the unique hazards of each operational domain, from hypoxia recognition in aviation to vestibular disturbances in spaceflight and physiological risk management in parachuting. Foundational to the Academy's role as a "cadet leadership laboratory", all of these programs are cadet-run, with cadets instructing and safeguarding their peers, a structure that develops leadership while sustaining an impressive safety record across high-risk aviation and space training. For attendees, the panel offers timely insights into how physiology education is embedded early in operational training, how cadets apply*

human-performance principles in real-world contexts, and how these lessons inform broader aerospace medicine practice, ensuring that operational support remains both flexible and rigorous across the US Air Force and Space Force.

[259] BASIC FREEFALL PARACHUTING: CADET-LED MANAGEMENT OF PHYSIOLOGICAL RISK AND PERFORMANCE

Hannah Grover

U.S. Air Force Academy, United States Air Force Academy, CO, USA

(Education - Program / Process Review)

BACKGROUND: The United States Air Force Academy (USAFA) is referred to as a "leadership laboratory" for cadets. From leading in the classroom to training events to airmanship programs, cadets employ leadership styles to develop fellow cadets into leaders of character. A unique aspect of USAFA is the peer instruction present in airmanship programs, including Basic Freefall Parachuting. This presentation aims to inform military and civilian aerospace medicine professionals about the risk controls used by cadet instructors to help students overcome mental limitations while safeguarding against physiological complications. **OVERVIEW:** The program currently has mitigation strategies that enable cadet instructors to identify indicators of physiological risk both before jump day and on jump day. Before jump-day operations, cadet instructors: (1) leverage the wingman concept to detect deviations from personality baselines; (2) confirm mental preparedness through repetition of BOLD FACE emergency procedures (EPs) and hanging harness exams (3) perform on jump day, a pre-jump risk-management (RM) assessment and matrix; (4) brief cadet students on how to recognize parachutists' in-flight physiological emergencies. **DISCUSSION:** The standardized training package—wingman personality baselines, emergency-procedure repetition with hanging-harness evaluations, crew resource management "gauge of the human" assessments, environmental factor reviews, and hypoxia briefs with breathing techniques—reduces physiology-related impairment by harnessing cadet-led instruction to optimize performance at the jump door. Together, these elements create a comprehensive risk-assessment framework that integrates human factors, physiology, and environmental conditions into observable, repeatable steps, providing a standardized pathway to optimize operational human performance. The program's reliance on peer leadership rather than specialized equipment makes these risk management protocols easily exportable across U.S. Services, partner nations, and civilian high-risk training environments. This model offers a common template for applying human-performance research to operational decision-making across diverse aerospace contexts.

Learning Objectives

1. Participant will be able to recognize how cadet led instruction and standardized physiological checks reduce impairment risk during freefall operations.

2. Audience will learn about the integrated risk assessment framework that combines human factors, physiology, and environmental conditions into observable, repeatable steps.

[260] SOARING: CADET-LED PROGRESSION FROM STUDENT TO INSTRUCTOR PILOT

Caroline Friedrick

U.S. Air Force Academy, United States Air Force Academy, CO, USA

(Education - Program / Process Review)

BACKGROUND: The U.S. Air Force Academy's (USAFA) soaring program is unique because cadet instructors teach fellow cadets in a tandem-seat glider, a form of unpowered glider-pilot training known at USAFA as "Soaring." In this configuration, the instructor sits behind the student and cannot see the student's face, posture, or breathing patterns. Due to basic soaring students receiving no physiology or human-performance training, cadet instructors must detect performance decline using only indirect cues. This cadet-to-cadet instructional model highlights how cockpit design, training level, and limited visual access shape human-performance monitoring and risk—making the program directly relevant to aerospace medicine professionals. **OVERVIEW:** The USAFA soaring program places cadet instructors in tandem seat gliders with cadet students, requiring instructors to monitor performance without direct visual access to the student. Basic soaring students receive no physiology or human performance training, while instructor upgrade cadets receive only introductory exposure. This creates a training gap in which cadet instructors must detect physiological or cognitive decline using indirect cues alone. Comparing AM 251 (student) and AM 461 (instructor upgrade) highlights how cockpit configuration and limited physiology education affect early recognition of performance degradation—an area with implications for current and future aeromedical risk management practices. **DISCUSSION:** The tandem seat cockpit prevents cadet instructors from observing facial color, breathing patterns, or visible distress, forcing them to rely on indirect indicators such as inconsistent control inputs, abnormal energy management, or disrupted scan patterns. For inexperienced cadet instructors with minimal physiology training, this creates an operational vulnerability in detecting hypoxia, overload, or task saturation. This cadet-to-cadet model exposes a critical gap between physiology knowledge, cockpit visibility, and instructional responsibility. Understanding how early aircrew detect impairment without direct visual cues can inform improved physiology education, workload monitoring strategies, and human performance training for novice aviators. This identified gap supports refinement of early-stage aeromedical curricula and risk recognition tools. The challenges identified in USAFA soaring apply broadly to tandem seat aircraft, early aircrew training, and peer instruction environments across U.S. Services, partner nations, and civilian glider or flight training programs. Insights from this comparison can guide shared approaches to human performance monitoring, mishap prevention, and physiology related risk management in diverse aviation communities.

Learning Objectives

1. Participants will be able to describe how physiological training, situational awareness expectations, and performance monitoring abilities differ between AM-251 and AM-461.
2. Participants will be able to explain how limited visibility in a tandem-seat glider alters an instructor's ability to detect physiologic impairment.

[261] POWERED FLIGHT: CADET-LED ASSESSMENT OF PHYSIOLOGICAL DEMANDS IN COMPETITIVE AND TRAINING ENVIRONMENTS

Samuel Brown

U.S. Air Force Academy, United States Air Force Academy, CO, USA

(Education - Program / Process Review)

BACKGROUND: The United States Air Force Academy (USAFA) offers multiple airmanship pathways that build foundational skills and introduce cadets to relevant physiological stressors. The Powered Flight course and competitive Flying Team serve different cadet populations, developing physiological readiness for their missions and demands. Understanding these differences is essential for optimizing preparation and reducing aeromedical risk. **OVERVIEW:** Powered Flight and USAFA's Flying Team prepare cadets for safe, disciplined aviation, contributing readiness in different ways. The Flying Team delivers rigorous physiological training through high-workload flying, demanding task-saturation scenarios, and instruction that include hypobaric chamber and hypoxia exposure, and structured physiology lessons. These experiences mirror the physiological and cognitive stresses cadets could face in military aviation. In contrast, the Powered Flight Program is an introductory course designed to familiarize cadets with basic aircraft handling, checklist discipline, and decision-making—but its physiological training requirements are moderated. Powered Flight should still incorporate deliberate physiological education—such as fatigue awareness, spatial disorientation cues, and stress management—to better align with USAF expectations and improve preparedness. Both programs function distinctly: Powered Flight introduces aviation fundamentals, while the Flying Team cultivates refined skills under realistic physiological stress. **DISCUSSION:** The Flying Team and Powered Flight operate under fundamentally different physiological demands. Flying Team members fly more frequently, execute complex profiles, and experience higher workload and task saturation, increasing their exposure to physiological stressors. A 2024 Flying Team incident involving symptoms consistent with hypemic hypoxia—recognized early and managed safely due to the crew's training—illustrates the operational importance of timely impairment detection. Although this event occurred in a competitive flying environment, similar physiological vulnerabilities could arise in any early aviation program. Comparing these two programs highlights a gap in early physiology education. The Flying Team's structured exposure to hypoxia, workload stress, and aeromedical instruction equips cadets to recognize and respond to performance decline, while Powered Flight cadets receive minimal physiology preparation. Lessons from USAFA's programs can inform other Service academies, partner nation training pipelines, and civilian collegiate flying teams. Strengthening baseline physiology education

across these environments can improve early impairment recognition, enhance safety, and support long term aviator development.

Learning Objectives

1. Participants will be able to describe the operational, physiological, and training differences between Powered Flight students and members of USAFA's Flying Team.
2. Participants will be able to understand how the airmanship programs mentioned contribute to cadet's preparation for operational Air Force Aviation.

[262] SPACE OPERATIONS: CADET-LED PHYSIOLOGICAL PREPARATION THROUGH THE AZIMUTH PROGRAM

Jordan Martinez

U.S. Air Force Academy, United States Air Force Academy, CO, USA

(Education - Program / Process Review)

BACKGROUND: With military operations expanding more frequently into the space environment, physiology and aerospace medicine must have the capability of supporting individuals within that domain. To ensure mission success, Space Force personnel require a deep understanding of the physiological environment they operate in. The Azimuth program at the U.S. Air Force Academy directly addresses this emerging necessity. Azimuth is a 2-week program that largely instructs future Space Force officers on valuable topics in their upcoming career. Throughout the cadet-led course, cadets will immerse themselves into the spaceflight concepts, neutral buoyancy, rocket building, and zero gravity. **OVERVIEW:** Cadets pursuing a Space Force career are required to take Azimuth over the summer receiving instruction from NASA astronauts, space medicine physicians, aerospace physiologists, and an assortment of various subject matter experts in the space domain. Through these engagements, cadets are introduced to a broad set of topics including space systems engineering, military space operations, and the physiological effects of weightlessness and microgravity. To reinforce the concepts and address the gaps in microgravity exposure, the Azimuth program provides an opportunity for cadets to experience parabolic flight. Completing these flights allows cadets to directly observe and experience vestibular disturbances, motion sickness and numerous other physiological effects that are essential to understanding the limitations and advantages of the operational environment as a Space Force officer. and advantages of the operational environment as a Space Force officer. **DISCUSSION:** Operationally, Azimuth enables future Space Force officers to understand and mitigate the risks associated with the physiological space environment, perceive challenges with human integrated systems in space, and effectively communicate their needs with aerospace medicine professionals within a space environment. Azimuth provides a path forward for application of physiology concepts taught traditionally to a limited population in a classroom setting, to a broader force that oversees the execution of missions in, from and to space. This program allows for meaningful advancements in aerospace medicine by bridging gaps in engineering, operations, and physiology of spaceflight. Azimuth's

collaborative structure reinforces its relevance not only to the physiology and space community, but to an international aerospace stage.

Learning Objectives

1. Participant will be able to describe the key physiological stressors of the space environment and explain how Azimuth prepares future Space Force officers to recognize and mitigate them.
2. Audience will learn about the role of parabolic flight, microgravity exposure, and expert instruction in building early human performance awareness for cadets entering space domain operations.

Wednesday, 05/20/2026, 10:30 AM

Governor's 14

[S-41] SLIDE: GRAND ROUNDS: NEUROLOGICAL CASES - SEIZURES, MASSES, AND HEMORRHAGES...OH MY!

Chair: Jonathan Elliot

Co-Chairs: David Navel, Chris Grace

[263] INTRACRANIAL HEMORRHAGE AFTER HIGH-G EXPOSURE IN A RESEARCH PARTICIPANT: A CASE REPORT

Justin Noble, Steven Fosmire

U.S. Air Force, Dayton, OH, USA

(Original Research)

INTRODUCTION: This case report describes a hemorrhagic cerebrovascular event temporally associated with high-G centrifuge exposure in a research participant with a history of Sjögren's syndrome (SS). **BACKGROUND:** Exposure to high gravitational (G) forces is known to affect cardiovascular and cerebrovascular function, but intracranial hemorrhage (ICH) related to such exposure is very rare. While ICH has been infrequently reported after exposure to high-G events, it has not previously been documented following centrifuge exposure. Autoimmune diseases like Sjögren's syndrome can cause systemic vasculitic changes, which may increase vascular fragility. No cases were found linking Sjögren's syndrome and spontaneous hemorrhage in high-G flight regimes. **CASE PRESENTATION:** A 40-year-old female centrifuge research participant presented with a focal seizure and loss of proprioception in her right lower extremity several hours after completing a centrifuge session involving exposure to +9G forces.

Neuroimaging showed a 2 cm hemorrhagic lesion in the left parietal lobe. Notably, she has a history of Sjögren's syndrome and Raynaud's phenomenon, both mild and untreated. Extensive vascular imaging found no aneurysm, arteriovenous malformation, or structural vascular abnormalities. Despite an initially stable recovery, she later experienced recurrent seizures and a progressive increase in lesion size, ultimately requiring emergent craniotomy for hematoma evacuation. Postoperative recovery was good, with resolution of neurological deficits and seizure activity. **DISCUSSION:** No previous cases of intracranial hemorrhage in association with centrifuge activities have been identified. The combination of autoimmune-related vascular weakness and transient, extreme cerebrovascular stress likely contributed to vessel rupture. While high-G exposure is usually well tolerated by healthy individuals, underlying systemic or autoimmune disorders may raise the risk of vascular injury. Recognizing these potential interactions is crucial for risk stratification in centrifuge and high-performance aviation research environments.

Learning Objectives

1. Recognize cerebrovascular risks of high-G exposure and the potential amplifying role of autoimmune disease.
2. Discuss implications for screening, waiver decisions, and return-to-high-G activities in research and operational settings.
3. Describe key pathophysiologic mechanisms by which +Gz forces alter cerebral perfusion and contribute to potential vascular injury in individuals with underlying conditions.

[264] THE HIDDEN CHECKLIST: MANAGING DISCREET BEHAVIORAL CONCERNS IN POST-TBI AVIATORS

Stephanie Tamayo, Tracey Kim

Naval Aerospace Medical Institute, Pensacola, FL, USA

(Education - Case Study)

INTRODUCTION: Behavioral health and neurocognitive sequelae following traumatic brain injury (TBI) in military aviators present complex challenges for aeromedical disposition. This case highlights the evaluation process and ongoing concerns in a Navy pilot with moderate TBI, persistent neurocognitive symptoms, and self-reported problematic pornography use. **BACKGROUND:** Aviators with moderate TBI require a comprehensive, multidisciplinary assessment to determine fitness for return to flight. Frontal lobe injuries may result in subtle neuropsychiatric symptoms, including impulse control issues, mood disturbance, and cognitive impairment. Behavioral symptoms such as problematic pornography use, warrant careful aeromedical risk assessment. Importantly, the evaluation process is designed to identify both risk and resilience, allowing for individualized consideration of waiver eligibility. **CASE PRESENTATION:** A 29-year-old right-handed Navy pilot sustained a moderate TBI in late 2024 after a syncopal event aboard a ship, resulting in a nondisplaced occipital fracture and frontal lobe contusion. He underwent inpatient TBI rehabilitation and reported resolution of most

physical and cognitive symptoms. However, during psychological assessment, the pilot disclosed an "on and off issue with pornography," with increased use during periods of isolation post-injury, and a pre-injury pattern of viewing pornography while waiting to fly. The pilot expressed concern about his ability to control this behavior. Notably, there was no formal evaluation or diagnosis of a behavioral addiction or impulse control disorder by the psychologist, and the issue remains under consideration for further disposition. **DISCUSSION:** This case underscores the importance of thorough behavioral health and neurocognitive assessment in aviators post-TBI, particularly when self-reported behaviors raise concerns about impulse control. The lack of formal evaluation of the pilot's pornography use highlights a gap in current aeromedical assessment protocols. Ongoing multidisciplinary evaluation, including targeted assessment of behavioral symptoms, is essential to inform safe and equitable aeromedical disposition. This case illustrates the need for clear guidelines and structured follow-up for behavioral health concerns in the context of TBI in aviators, while also emphasizing that a path to waiver and return to duty remains possible with appropriate assessment and management.

Learning Objectives

1. Describe the clinical presentation and multidisciplinary evaluation process for aviators with moderate traumatic brain injury (TBI), including the identification of subtle behavioral health concerns.
2. Discuss the current understanding, diagnostic criteria, and treatment strategies for problematic pornography use and its relevance in the aviation population.
3. Analyze the aeromedical implications of behavioral health symptoms post-TBI and review available waiver guidance across military branches for managing impulse control and behavioral disorders in aviators.

[265] THE HEADACHES OF AVIATION

Charles Bergdolt[1], Ryan Baxter[2], Merwan Faraj[1]

[1]U.S. Navy, Pensacola, FL, USA; [2]U.S. Navy, Beaufort, SC, USA

(Education - Case Study)

INTRODUCTION: This case report describes an ejection-seat aircraft naval flight officer (NFO) who developed worsening positional headaches later found to be caused by a Grade I pilocytic astrocytoma, successfully resected with complete recovery and no neurologic deficits. **BACKGROUND:** Although low-grade Astrocytomas have favorable prognoses, craniotomy carries a non-trivial risk of postoperative epilepsy. A recent Danish cohort evaluating seizure incidence following craniotomy for astrocytoma found cumulative risks of approximately 16% at one year and 29% at five years. While these values exceed the commonly referenced 1% operational aeromedical threshold, risk varies significantly by tumor biology, patient age, tumor grade, and completeness of resection. When interpreted using the USAFSAM AMRAAM, the patient's individualized risk profile aligns with a low operational risk category appropriate for consideration of return to flight. **CASE PRESENTATION:** A healthy NFO in his 30s presented with several weeks of pounding bilateral frontal headaches lasting hours, exacerbated by

position, poorly responsive to NSAIDs, and relieved by emesis. Imaging and subsequent pathology confirmed Grade I pilocytic astrocytoma. He underwent craniotomy and gross-total resection. At nine months post-operation, MRI demonstrated no residual or recurrent tumor. The patient was cleared by Neurology, Neurosurgery, Physical Therapy, Occupational Therapy, Speech Therapy, and Neuropsychology, all confirming normal cognitive, motor, and operationally relevant performance. He holds no critical phase-of-flight pilot duties but fulfills essential NFO responsibilities. **DISCUSSION:** Eligibility for return to aviation duties should be contingent upon operational role, mission requirements, international operations, and individualized seizure risk. This case demonstrates how clinical context with critical analysis should be used for operational optimization. Risk management tools enable a comprehensive risk-benefit analysis that transcends initial diagnostic concerns to bolster mission accomplishment. Individualized pathology, post-operative recovery trajectory, and structured risk-assessment tools can support return-to-flight decisions in aircrew with unsettling pathology. This highlights the importance of critically analyzing individual medical scenarios, such as intracranial neoplasms, when seeking to make return-to-flight decisions.

Learning Objectives

1. Describe the clinical presentation, diagnostic evaluation, and management of a Grade I Pilocytic Astrocytoma in an active duty aircrew member.
2. Discuss the postoperative seizure risk following craniotomy for low-grade Astrocytoma and explain how risk varies based on tumor character and resection.

[266] RETURN TO HIGH-PERFORMANCE FLIGHT AFTER MENINGITIS AND ENCEPHALOCELE REPAIR

Caroline McDowell[1], Michael Yue[1], Emily Elliott[1], Keith Roxo[2]

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(Education - Case Study)

INTRODUCTION: This case describes a U.S. Navy fighter pilot who developed pneumococcal meningitis and, on follow-up, was found to have an anterior cranial fossa encephalocele. He underwent an endoscopic repair and was subsequently evaluated for return to high-performance flight. **BACKGROUND:** Serious neurosurgical and otolaryngologic conditions in aviators are rare but pose significant aeromedical challenges. Skull base encephaloceles and cerebrospinal fluid (CSF) leaks pose risks of recurrent meningitis, pneumocephalus, and barotrauma during tactical jet operations. Published data on return to flight after skull-base repair in aviators are extremely limited, with no standardized aeromedical pathway. This case illustrates the multidisciplinary management, risk assessment, and waiver process leading to successful consideration for return to high-performance flight following meningitis secondary to sinus disease and skull-base CSF communication. **CASE PRESENTATION:** A previously healthy 35-year-old Navy fighter pilot presented with acute Streptococcus Pneumoniae meningitis requiring intubation and intensive care. He was successfully treated. After full neurologic

recovery, imaging revealed chronic sinus disease and a right anterior cranial fossa encephalocele with concerns for a possible CSF leak. He underwent endoscopic repair and a multilayer skull base repair with a nasoseptal flap graft. Postoperative recovery was complicated by a Pseudomonas aeruginosa infection, successfully treated with targeted antibiotics. Follow-up ENT and neurosurgical evaluations confirmed complete healing without an active CSF leak. Neurology and neuropsychology testing showed no residual deficits. **DISCUSSION:** Aeromedical risk assessment centered on barometric stress, potential for recurrence, and neurologic integrity. This case illustrates that with close coordination between neurosurgery, otolaryngology, neurology, neuropsychology, and aerospace medicine specialists, selected aviators with prior meningitis and encephalocele repair may be considered for return to high-performance flight while maintaining mission safety and readiness.

Learning Objectives

1. At the conclusion of this activity, participants should be able to perform a structured aeromedical risk assessment for high-performance aircrew recovering from meningitis and skull-base repair.
2. At the end of this activity, participants should be able to explain how surgical repair methods, healing timelines, and postoperative complications influence aeromedical risk and waiver considerations.

[267] HIGH-ALTITUDE SEIZURES AND HIGH-STRESS WORK: A CASE OF DIAGNOSTIC DILEMMAS IN A C-130 CREW CHIEF

Larissa Brandenburg, Craig Mills, Emily Elliott

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(Education - Case Study)

INTRODUCTION: Our case highlights considerations in seizure semiology, evaluation, treatment, and aeromedical risk assessment when new-onset seizures arise in an operational aviation setting. **BACKGROUND:** Seizures occurring in aviation environments present unique diagnostic and operational challenges, yet the literature on seizure triggers specific to the flight environment remains limited. Factors such as relative hypoxia, circadian disruption, sleep deprivation, and operational stress may influence seizure threshold. This case describes a previously healthy C-130 crew chief with new-onset seizures occurring exclusively during high-altitude flight, temporally associated with in-flight sleep or sleep onset, raising questions regarding flight-related precipitants and aeromedical risk assessment. **CASE PRESENTATION:** A 29-year-old crew chief suffered two seizures during C-130 flights. Both seizures occurred while flying in a pressurized aircraft at around 28,000 feet, while the patient was napping. Levetiracetam was prescribed by the ER but stopped one month later after a normal specialist workup. Ten months later, he had a second seizure while flying in the same conditions, for which he was restarted on levetiracetam. He had approximately fifteen uneventful flights

after the initial event; however, he did not sleep on any of those flights. Both events are described as bilateral tonic-clonic convulsions with post-ictal confusion. A grounding physical was submitted. **DISCUSSION:** Although evidence is limited, some theoretical associations within the aviation environment could lower the seizure threshold. In this case, the association of his two focal to bilateral tonic-clonic events occurring during high altitude C-130 flights allows for exploration to understand the potential of some of these factors as seizure threshold lowering in someone with epilepsy.

Learning Objectives

1. Describe the diagnostic approach to new-onset seizures occurring in an aviation environment, with attention to seizure semiology, differential diagnosis, and evaluation when events occur exclusively during flight.
2. Discuss potential flight-related factors that may lower seizure threshold—including relative hypoxia, circadian disruption, sleep deprivation, and operational stress—and how these factors may interact in high-altitude military aviation.
3. Apply aeromedical risk assessment principles to determine implications for flight status, treatment decisions, and operational safety in aircrew experiencing seizure events.

Wednesday, 05/20/2026, 2:00 PM

Governor's 10

[S-42] SLIDE: IN & OUT: BREATHING SYSTEMS, HYPOXIA AND PERFORMANCE

Chair: Paul Newbold

[268] CEREBRAL EFFECTS OF OSCILLATORY VS STEADY-STATE OXYGEN EXPOSURE

Kelsey Rose Duncan, Hannah Boehringer, Jackson Pollard, Lisa Damato, Michael Decker

Case Western Reserve University, Cleveland, OH, USA

(Original Research)

INTRODUCTION: Inspiration of increased oxygen concentration (FiO2), widely used to mitigate risk of hypoxia, has been shown to paradoxically reduce global cerebral blood flow (CBF) and alter cortical activity. Recent studies have shown that exposure to oscillatory state oxygen delivery may exacerbate those physiological sequalae. This study sought to assess the potential impact of exposure to oscillatory FiO2 upon cortical brain activity. **METHODS:** Healthy participants (n=21) were randomized to exposure to either Oscillatory (Osc) or Steady-State (SS) FiO2 across three study visits. Cognitive testing was performed pre- and post-exposure. Sleep and fatigue were recorded across the duration of the study using validated

assessments and wearable devices. Oxygen was delivered via non-rebreather masks at FiO2 levels ranging from 21% to 100%, with oscillatory exposures alternating ± 15% around target levels. Participants were monitored by EEG and completed an intermittent pegboard task during oxygen exposure. **RESULTS:** Data from 21 individuals was usable for analysis (Osc: n=11; SS: n=10). Sleep duration, subjective sleepiness, fatigue, and mood state did not differ between groups. Reaction times on the Line Orientation Task improved post-exposure in both groups (Osc: p = 0.006; SS: p = 0.02), however both groups demonstrated decreased correct responses (Osc: p = 0.012; SS: p = 0.29). EEG revealed greater desynchronization during pegboard task performance in alpha (p=0.026 within the anterior region at 35% FiO2) and beta bands, indicating heightened cortical engagement. This finding was more prominent in the Osc group. In the SS group, average EEG, quantified with Hilbert analyses remained consistent across increasing FiO2 levels whereas the Osc group showed a modest upward trend, plateauing at FiO_2 80%. This resulted in more statistically significant variations in cortical synchrony between increased FiO2 levels and the 21% room air baseline in the Osc group. **DISCUSSION:** Exposure to oscillatory FiO2 induced more pronounced neurophysiological changes than steady-state exposure, supporting a mechanistic link between dynamic oxygen delivery, impaired CBF and cortical activity. Increased EEG synchrony and lower cortical engagement associated with higher FiO_2 levels in the Osc group may reflect reduced perfusion and decreased neural activity due to hyperoxia-induced vasoconstriction with associated regional specificity.

Learning Objectives

1. Describe the physiological effects of oscillatory versus steady-state inspired oxygen concentration on cortical brain activity and cerebral blood flow.
2. Analyze EEG findings to explain how dynamic oxygen delivery influences cortical engagement and cognitive performance in healthy individuals.

[269] EFFECTS OF HYPOXIA, HYPERVENTILATION AND EXERCISE

Aiden Coffey[1], Ross Pollock[1], Malik Alsharif[1], Daniel Gwyer[2], Panus Choocheepwattana[1], Peter Hodkinson[1]

[1]Kings College London, London, United Kingdom; [2]Guy's and St Thomas' NHS Foundation Trust, London, United Kingdom

(Original Research)

INTRODUCTION: The individual effects of hypoxia, hypocapnia and exercise have been described. During flight, these conditions can be experienced simultaneously but this has not been adequately studied. The potential interaction of these variables is important to understand in the context of in-flight physiological monitoring. The aim of this study was to assess for interaction effects of exposure to hypoxia, hyperventilation and exercise. **METHODS:** Healthy participants (n=10, age: 26.7±4.1y, sex: 5M, 5F) undertook four normobaric exposures to simulated mean sea level;(MSL), 8000ft (2438m), 12500ft (3810m) and 14000ft (4267m). They

exercised at three workloads (rest, 30W, 120W) for four minutes initially with normal ventilation (NV) and then followed with hyperventilation (HV) at double minute ventilation (Ve). After each workload condition, a hypoxia symptom questionnaire was completed. There was continuous monitoring of pulse oximetry, end-tidal gases and respiratory flow. From this, Ve, peripheral oxygen saturation (SpO2), end tidal oxygen (PetO2) and carbon dioxide (PetCO2) were analysed for the final minute of each condition. Data were analysed using linear mixed-effects models, with fixed effects for altitude, ventilation and workload (α=0.05). Data stated as mean ± 95% confidence interval. The study was approved by the Kings College London Research Ethics Committee. RESULTS: For both PetO2 and PetCO2 (mmHg), there was an interaction effect between altitude and workload during NV (PetO2 p=0.0014; PetCO2 p=0.0031) but not HV. For both NV and HV, SpO2 showed no interaction effect. During NV, PetO2 decreased with altitude and this fall was exaggerated with 30W exercise: MSL 108.6±3.5 vs 104.6±4.6, 8000ft 71.7±4.5 vs 67.8±4.3, and 14000ft 48.7±4.6 vs 46.8±4.5 (rest and 30W, respectively). Conversely, PetO2 increased from 30W to 120W at 12500ft 51.2±2.8 vs 58.1±3.5 and 14000 ft 46.8±4.5 vs 54.3±4.9 (30W and 120W, respectively) with NV but not with HV. **DISCUSSION:** These results show that the physiological response to altitude and exercise during hyperventilation differs to normal breathing. This suggests that ventilation state should be considered when interpreting end-tidal gas data, and failure to do so risks misinterpretation. This is particularly important for interpretation of in-flight physiological monitoring data due to the potential of hyperventilation during flight.

Learning Objectives

1. The audience will learn about the physiological response to hypoxia, hyperventilation (hypocapnia) and exercise.
2. The audience will learn about physiology of gas exchange in the lung under different conditions relevant to aviation.

[270] INFERRING RESPIRATORY ENVIRONMENTS THROUGH THE RESPIRATORY CHALLENGE INDEX TO CHARACTERIZE BREATHING AND COGNITIVE LOAD COMPENSATION

Szilard Beres, Nicholas Napoli, Victoria Ribeiro Rodrigues

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(Original Research)

INTRODUCTION: Respiratory impairment elicits non-linear adaptive search behaviors, reflected in systematic compensatory changes in breathing pattern and timing as stress increases (e.g., hypoxia). We evaluate whether these behaviors persist under respiratory loads during concurrent tasks, and how they relate to cognitive demands and mechanical cost of breathing. Recently, detecting these non-linear changes has required 5–10 minutes of data, delaying recognition of altered respiratory control and its cognitive impact and limiting timely

countermeasures. We demonstrate minute redistributions of temporal changes (5-10 seconds) in cognitive decline and respiratory control, enabling detection on timescales relevant for operational monitoring and intervention. **METHODS:** The experimental design included graded loads representing no, medium, and high impairment, incorporating chest wall and abdominal restriction, airflow resistance, and pressure threshold loading (participants, N=19). Respiratory signals, including airflow, ribcage and abdominal respiratory belts, and esophageal pressure were recorded alongside a psychomotor vigilance task (PVT) to quantify cognitive performance based on response time. The Respiratory Challenge Index characterizes non-linear adaptive search behaviors derived from transitional phases of the breath cycle (pre-/post-inhalation and exhalation) using noninvasive ribcage and abdominal belts. **RESULTS:** Larger Respiratory Challenge Index (RCI) values were strongly associated to the three slowest responses per subject when compared to the fastest, indicating reduced cognitive resource availability and breathing effectiveness. Under medium and high load conditions, RCI values were significantly higher for slow than fast PVT responses (medium load: 0.86 ± 0.09 vs. 1.46 ± 0.16, p = 0.003; high load: 1.00 ± 0.10 vs. 1.50 ± 0.17, p = 0.022). Index values greater than healthy breathing also showed increased mechanical demand, with work of breathing per liter rising (cmH2O) (medium load: 20.9 ± 0.94 vs. 30.2 ± 0.66, p < 0.001; high load: 20.17 ± 0.58 vs. 30.8 ± 0.77, p < 0.001). **DISCUSSION:** Near–real-time tracking of respiratory search behavior enables in-flight, closed-loop monitoring of cognitive risk and breathing patterns during respiratory stress, supporting timely countermeasures and on-the-fly tuning of avionic life-support. Furthermore, we will extend the respiratory challenge index to hypoxia and other extreme environments.

Learning Objectives

1. The audience will learn that the best discriminator for determining respiratory distress is to evaluate non-linear compensatory changes in breathing patterns, which statistically infers to Work of Breathing effectiveness (e.g., shifts to higher work of breathing per liter) and decreases in cognitive performance.
2. The audience will learn how cognitive resources shift and are redistributed during concurrent breathing challenges and cognitive task demands, leading to tradeoffs in the control of respiratory compensatory mechanics and task performance.
3. The audience learn how to utilize the Respiratory Challenge Index and interpret their values to indicate when respiratory distress occurs in extreme environments (e.g., increased mechanical demand, hypoxia).

[271] EFFECTS OF REPEATED BACKUP OXYGEN SYSTEM ACTIVATIONS ON RESPIRATION

Frank Robinson[1], DeAnne French[2], Dan Warkander[2], Gary Ellis[2], Ryan Everidge[2]

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(Original Research)

INTRODUCTION: Tactical aircrew rely on complex life support systems (LSS) to provide physiological support during flight. Disruptions to the supply of breathing gas or increases in breathing resistance in the LSS may disrupt respiration and lead to physiological symptoms. Automated backup oxygen systems (ABOS) are designed to ensure a consistent supply of breathing gas in the event of an LSS issue, but transitions to the ABOS are not seamless. LSS failure may be accompanied by changes to the delivery pressure or content of breathing gas, which then change again upon activation and deactivation of the ABOS. This study explored whether such changes during ABOS activation may have unintended effects on respiration. **METHODS:** Sixteen participants completed this study at Wright-Patterson AFB, OH. Participants breathed through a CRU-103 flight regulator supplied with breathing gas via the Hypoxia-Ventilation Research Device. Participants flew a flight profile four separate times in a hypobaric chamber under different ABOS activation conditions: control, repeated activations on the ground only, repeated activations at altitude only, and repeated activations throughout the profile. We captured objective measures of respiration during and shortly after each simulated ABOS activation. **RESULTS:** We analyzed respiratory responses during and after ABOS activations separately within each test condition. During ABOS activations at altitude, we observed several interactions such that the respiratory responses varied across condition and over time, particularly for end-tidal CO2 ($F(1, 11) = 39.79$, $p < 0.001$, $\eta p2 = 0.78$), maximum mask pressures ($F(1, 11) = 6.31$, $p = 0.029$, $\eta p2 = 0.37$), and minute ventilation ($F(1, 9) = 9.14$, $p = 0.014$, $\eta p2 = 0.50$). We observed similar results when ABOS activations occurred throughout the profile. Effects largely dissipated after each activation, but differences in end-tidal CO2 may linger. **DISCUSSION:** ABOS plays an important role in ensuring minimum gas supply to aircrew. However, repeated ABOS activations may have brief effects on respiration. The implications of these changes are unclear. Future research should investigate possible changes to ABOS activation parameters to minimize respiratory disruption.

Learning Objectives

1. The participant will be able to describe the purpose and operation of the ABOS.
2. The audience will learn about the potential effects of repeated ABOS activations on aircrew.

[272] OPERATIONAL SIGNIFICANCE AND EVALUATION OF CLINICALLY SYMPTOMATIC CHRONIC RESPIRATORY ALKALOSIS (CSRA) IN AEROSPACE MEDICINE

Jan Stepanek, Jeremy Cohran, Karen Breznak, Karen Ong

Mayo Clinic, Scottsdale, AZ, USA

(Education - Program / Process Review)

INTRODUCTION: Clinically symptomatic respiratory alkalosis (CSCRA) is a frequent but underrecognized contributor to operational performance degradation in aircrew and other high-reliability personnel. Often precipitated by workload, task saturation, stress, hypoxic

environments, or environmental factors, CSCRA will produce neurologic, cardiopulmonary, autonomic and cognitive symptoms that directly affect flight safety. Despite its relevance, evaluation pathways in aerospace medicine frequently emphasize psychogenic etiologies, leading to delayed recognition of physiologic contributors (root causes). This presentation examines the operational significance of symptomatic respiratory alkalosis and outlines a pragmatic clinical evaluation framework applicable to aerospace medicine practice. **OPERATIONAL SIGNIFICANCE:** Symptoms associated with respiratory alkalosis—including lightheadedness, dyspnea, paresthesias, visual disturbance, and impaired concentration—may mimic anxiety, vestibular disorders, or hypoxic events. In operational environments, these symptoms can degrade situational awareness, decision-making, and task execution, particularly during high workload or contingency operations. Failure to recognize CSCRA may result in inappropriate aeromedical disposition, unnecessary grounding, or recurrent in-flight symptoms with failure to find underlying root causes. **CLINICAL EVALUATION:** A structured approach integrating symptom characterization, operational context, and physiologic assessment is essential. Standardized symptom screening tools, such as the Nijmegen Questionnaire, may assist in identifying clinically relevant symptom patterns. Objective evaluation should focus on confirming acid–base status via arterial blood gas analysis and identifying underlying possible driving pathology (sleep disorders, right to left shunting, diaphragmatic dysfunction etc), including hypoxia, metabolic stressors, or ventilatory responses. Differentiating physiologic respiratory alkalosis from functional breathing disorders is critical for targeted management and return-to-duty decisions. **CONCLUSION:** Recognizing and systematically evaluating CSCRA enhances diagnostic accuracy, supports appropriate aeromedical decision-making, and mitigates operational risk. Incorporating standardized symptom assessment with focused physiologic evaluation provides a practical framework for aerospace medicine practitioners.

Learning Objectives

1. Understand the operational impact and physiological manifestations of symptomatic respiratory alkalosis.
2. Apply a structured clinical evaluation approach applicable to aerospace medicine settings.

[273] HUMAN LUNGS ASSESSMENT USING FEV1/ FVC DURING SIMULATED PUSH PULL MANEUVERS OF AN AIRCRAFT PILOT

Munna Khan, Kashif IK Sherwani

Jamia Millia Islamia (Central University), New Delhi, India

(Original Research)

INTRODUCTION: Modern high-performance (MHP) aircrafts can develop 7 to 9 Gs (or more) within 1 second and significantly increases risk of Gravity (G) induced loss of consciousness (G-LOC), especially during a push-pull maneuver (PPM). Ratio of Forced expiratory volume in 1

second (FEV1) and Forced Vital Capacity (FVC) is a key measure of lung function used to assess a pilot's fitness for operation of MHP aircrafts during the PPM. Anti-G straining maneuver (AGSM) is a technique used by pilots to counteract PPM effects, involving specific respiratory actions related to human lung capacity (HLC). The FEV1/ FVC directly related to HLC considered a key indicator of airway obstruction. Therefore, an attempt has been made to assess HLC by measuring ratio of FEV1/FVC. **METHODS:** The PPM was simulated using tilt table keeping head down and legs up of human volunteers as Push. Inversion of human body keeping head up and legs down simulated as Pull. The 19 healthy subjects were enrolled with age range from 21 to 27 years and RMS Helios 401 PC based spirometer used to measure lung parameters Forced Vital Capacity (FVC) and FEV1. The data was recorded during four distinct positions: sitting, supine, Push, and Pull positions. Artificial Intelligences (AI) Ridge Regression (RR) and Support Vector Regression (SVR) techniques were applied using python software. Calculated values of Ratio FEV1 and FVC were used to plots various graphs for BMI, Sitting, Supine, Head up, and Head down positions to assess HLC. **RESULTS:** The range of FEV1/FVC ration were found to be 0.66-1 and 0.7-1 in Head down and head up positions respectively. Various analysis showed a 10.70% drop in FVC capacity when transitioning from the sitting position to the Push position compared to Pull position. The difference was obtained as 12.27 % in the FVC capacity during simulated PPM using tilt table. **DISCUSSION:** The results shows the FEV1/FVC ratio greater than 0.70 for human subjects indicating healthy HLC. Most of the subjects lowered FEV1/FVC ratio during head down positions (Push) as compared to head up positions (Pull). Similarly results were obtained for supine positions as compared to sitting positions. The results may be used to refine fitness assessments of an of aircraft pilot during high-G maneuvers.

Keywords: Aircraft pilot, Push-pull maneuver (PPM), Human lung capacity (HLC), Lung parameters, FEV1/FVC ratio.

Learning Objectives

1. Simulation of Push Pull maneuvers of aircraft pilot using tilt table.
2. Assessment of human lung capacity by measuring FEV1/FVC ratio.

Wednesday, 05/20/2026, 2:00 PM

Governor's 12

[S-43] PANEL: THE HUMAN FACTORS OF AEROSPACE SAFETY AND MISSION SUCCESS

Chair: Brian Musselman

Co-Chair: Marc Shepanek

Panel Overview: *BACKGROUND: The most versatile, creative component of an aerospace crewed activity is the human in the loop. It is also the most challenging, as humans are impacted by the entire system. These impacts can be felt in the areas of nutrition, performance, sleep, and*

social connection. Advanced technologies, like Artificial Intelligence (AI) may be or assistance, but they may result in additional demands on the human. This panel will address these topics and more. Air and spacecraft propulsion systems are not expected to function without fuel or power. Computer systems require routine updates and often need temperature and climate-controlled environments in which to operate. Human beings need design consideration of their own. Unfortunately, perhaps, it is not possible to redesign a human the way it is possible to reconfigure a jet engine or computer chip. So, how can we make sure that we get the best of human performance for the mission? Integrate human factors into hardware, software and mission design. OVERVIEW: We have assembled five excellent presentations addressing nutrition, sleep, social connection and dynamics, training and performance and the use of AI, as they relate to aerospace human safety and mission success. DISCUSSION: Integrating the role of humans from the start improves performance, helps assure mission success, and ultimately saves lives. When operating at optimum, humans are capable of performing with partial information, analyzing unanticipated data, integrating previously unconsidered options, working with previously unplanned resources, including people, and functioning outside of hardware design parameters. Physical elements are needed for any crew: air (gas mixture, pressure, temperature, humidity), potable water, food (healthy and desired), comfortable quarters (for work, recreation or sleep), sound (ambient and ability to communicate), light (for work). For extended missions, designs need to include support for rest, recreation, sleep, social interaction, and training. Continued advances in artificial intelligence promise help in some if not all of these areas, but it too needs to be designed and implemented with the human in mind.

[274] THE IMPORTANCE OF SLEEP FOR MENTAL HEALTH

John Caldwell

Coastal Performance Consulting LLC, Yellow Springs, OH, USA

(Education - Program / Process Review)

INTRODUCTION: Over the past decade, a substantial amount of research has shown that suboptimal sleep is associated with a host of adverse health outcomes including cardiovascular disease, diabetes, weight gain and obesity, systemic inflammation, neurocognitive deficits, and increased overall mortality risk. In addition, chronically sleeping less than 7 h per night has been found to elevate the likelihood of poor mental health. **TOPIC:** Optimal adult health requires 7–9 hours of sleep per night, and failure to obtain this amount is associated with numerous disease states—physical as well as psychological. Sleep alterations are observed in nearly all mental health conditions, with the severity of restriction and disruption correlating to greater adverse effects. Sleep consists of alternating cycles of two distinct phases: non-rapid eye movement (NREM) sleep, important for bodily repair and memory stabilization, and rapid eye movement (REM) sleep, critical for brain repair and emotional processing. From a mental-health perspective, insufficient REM sleep is particularly problematic, since during REM, key emotion-regulation circuits (the amygdala, striatum, hippocampus, as well as the insula- and medial-prefrontal cortex) are highly activated, while at the same time, the brain's main noradrenaline center—the locus coeruleus—is virtually silent. This creates a low-stress environment in which the emotional charge of memories is reduced, preventing psychological distress and supporting

emotional well-being. When this process is disrupted, the result is dysregulation characterized by exaggerated reactivity to stimuli, reduced self-control, and impaired risk/benefit assessment capacity (e.g., overvaluation of rewards and undervaluation of risks). Evidence suggests that such changes contribute to the development of numerous psychiatric conditions, including bipolar disorder, schizophrenia, PTSD, anxiety, depression, alcoholism, and antisocial/aggressive behavior. Furthermore, there is a bidirectional relationship between mental disorders and sleep, such that each significantly impacts the other, creating a destructive vicious cycle. **APPLICATION:** Adequate sleep has long-been considered important from a fatigue-management standpoint. However, it is now apparent that sleep is also vital for health maintenance. Ensuring our pilots routinely obtain a minimum of 7 hours of sleep is crucial for both operational and personal safety!

Learning Objectives

1. The audience will understand the impact of sleep on overall health outcomes.
2. The audience will understand the importance the two phases of sleep (REM and NREM) on physical and behavioral health.
3. The audience will learn how disordered sleep may have adverse impacts on the operational performance of pilots.

[275] INTEGRATED AI-DRIVEN BIOMEDICAL AND HUMAN-FACTORS ARCHITECTURE FOR AUTONOMOUS CREW HEALTH IN MARS-CLASS MISSIONS

Carlos Salicrup Diaz

Aerospace Medicine Clinic, Mexico City, México, Mexico

(Education - Program / Process Review)

BACKGROUND: Mars-class missions eliminate real-time medical support due to 4–22-minute communication latency, limited clinical payload, restricted diagnostics, and the absence of evacuation capability. These constraints require crews to operate with unprecedented medical and performance autonomy for extended durations. As exploration missions move beyond low Earth orbit, traditional aeromedical models—designed around continuous ground support—are insufficient to manage cumulative physiological degradation, behavioral health risks, and system instability. Addressing autonomous medical capability, sustained human performance, and safe human–AI integration is therefore immediately relevant to AsMA attendees as agencies transition toward independent human exploration architectures. **OVERVIEW:** This program review describes a mission-agnostic architecture integrating artificial intelligence, biomedical sensing, and human-factors engineering to enable autonomous crew health management and sustained performance in deep-space missions. The system combines machine-learning medical decision support, continuous multimodal physiological surveillance, behavioral analytics, and autonomous environmental control. These components are unified through a digital-twin physiology framework that supports predictive risk detection, intervention prioritization, and

adaptive countermeasure deployment within strict resource constraints, addressing current and future gaps in Earth-independent medical operations. **DISCUSSION:** Operationally, the architecture enables early detection and management of cardiovascular, immunologic, neurovestibular, musculoskeletal, and behavioral health risks through continuous biosensing, point-of-care diagnostics, and predictive modeling. Clinically, it advances aeromedicine by shifting from reactive care to anticipatory, closed-loop health management supported by AI-driven forecasting and countermeasure optimization. Human performance is enhanced through AI-based monitoring of sleep–wake regulation, fatigue accumulation, cognitive drift, stress markers, and interaction dynamics, with real-time recommendations for workload redistribution, circadian-adaptive scheduling, and behavioral mitigation while preserving crew autonomy. System safety and reliability are strengthened through AI-enabled environmental monitoring, predictive maintenance, and autonomous regulation of life-support parameters to minimize fault propagation. Human-factors–informed interface design supports safe human–AI teaming, reduces cognitive workload, and enhances situational awareness in time-critical environments. The architecture supports cross-Service, international, and military–civilian applications by leveraging common principles applicable to spaceflight and other austere operational settings.

Learning Objectives

1. The audience will be able to identify the primary operational constraint that necessitates autonomous medical systems for Mars-class missions.
2. The audience will be able to describe how AI-enabled systems advance clinical aeromedicine during long-duration exploration missions.
3. The audience will be able to recognize system features that support sustained human performance while preserving crew autonomy.

[276] THE UPS AND DOWNS OF NUTRITION AND SUPPLEMENTS IN AVIATION HUMAN PERFORMANCE

Walter Dalitsch

FAA Alaskan Region, Anchorage, AK, USA

(Education - Program / Process Review)

BACKGROUND: Besides oxygen and water, food substances are required for not only the survival but also the performance of the human being, both on the ground as well as in the air. **OVERVIEW:** Aviation is an endeavor that requires the maximum possible output from performance. This includes not just physical capabilities, but importantly, mental – including, but not limited to reasoning, judgment and decision-making. These skills require the very human-specific functioning of the brain's frontal lobe. **DISCUSSION:** Nutrition and associated supplements can impact frontal lobe functioning both positively and negatively. This presentation will review some of the most current concepts of nutrition and supplements within the context of human performance in aviation, both physical and mental.

Learning Objectives

1. The audience will learn the positive and negative impacts of nutrition in aviation human performance.
2. The audience will become more informed of misleading advertising used for nutritional supplements and energy drinks.

[277] HUMAN RESILIENCE THROUGH CONNECTION: CREW NETWORK SUPPORT AS A CORE BEHAVIORAL HEALTH STRATEGY.

Diego Garcia, Alexandra Mejia-Delgado, Johana Giraldo Alzate

National University of Colombia., Bogotá, Módulo, Colombia

(Education - Program / Process Review)

BACKGROUND: Behavioral health is a critical determinant of mission readiness, safety assurance, and sustained human performance across aerospace and other high-risk operational domains. While sleep, exercise, nutrition, and workload management are routinely addressed, supportive social connection remains inconsistently defined, implemented, or measured as a formal component of behavioral health systems. As operations grow more complex, longer in duration, more cognitively demanding, and increasingly socially constrained, there is a need to operationalize social support as a deliberate, mission-enabling strategy rather than an informal or incidental resource. **OVERVIEW:** This programmatic review examines structured social contact pathways as a resilience-supporting process. Drawing from aerospace medicine, human and organizational performance, behavioral health initiatives, and operational experience, it explores how the intentional design of peer support networks, mentorship structures, communication architectures, and organizational trust mechanisms can address persistent gaps in behavioral health support. Particular attention is given to trust-building processes that strengthen psychological safety, reporting confidence, and help-seeking behaviors, as well as the role of behavioral health literacy in improving shared understanding, informed decision-making, and early recognition of risk. Practical frameworks are presented for integrating crew network support into existing human performance and readiness systems. **DISCUSSION:** Structured social contact pathways have important operational and clinical implications, functioning as protective factors against burnout and performance degradation in high-demand environments. By framing social connection as a system-level intervention, this review examines the strengths and limitations of supportive social networks within complex sociotechnical systems and their alignment with human-systems integration and resilience engineering principles. The concepts discussed are applicable across military, civilian, and international contexts, supporting evidence-based strategies that enable interoperability, cultural adaptability, and sustained human performance critical to mission success.

Learning Objectives

1. Learners will be able to describe how structured social contact pathways—including peer support networks, mentorship structures, and communication architectures—contribute to resilience, safety assurance, and sustained human performance in high-demand operational environments.
2. Learners will be able to evaluate the role of organizational trust mechanisms and behavioral health literacy in strengthening psychological safety, reporting confidence, and early help-seeking behaviors within aerospace and mission-critical teams.

[278] LEVERAGING NUTRITION FOR PERFORMANCE OPTIMIZATION

Annette Sobel

Self employed, Lubbock, TX, USA

(Education - Tutorial / Review)

INTRODUCTION: Performance optimization is a multifactorial acute and chronic physiological indicator of acute and chronic nutritional status. This educational presentation will provide a concise overview of lessons learned in the extreme settings of the war fighter environment. **TOPIC:** The topic of warfighter performance optimization through nutrition and nutritional supplements was reviewed extensively by the Uniformed Services University of the Health Sciences and Defense Advanced Research Projects Agency (DARPA) scientists, resulting in a number of operational recommendations that have been implemented. Traditional military and special operations communities have measurable improved outcomes. **APPLICATIONS:** The interventions and environmental parameters parallel those anticipated in aerospace, high altitude, diving and hyperbaric medicine, and we believe these parallels may be helpful in operational patient and physician education, training and rehabilitation. In particular, these actions may have substantial impact on preventative medicine and injury prevention. Also, these approaches augment monitoring patient susceptibility to acute and chronic diseases as well as mental health effects due to overuse.

Learning Objectives

1. The audience will be able to identify key components of performance optimization provided through nutrition and biomarkers that can be used to assess impact on performance.
2. Attendees will be knowledgeable of the physiological effects of specific targeted supplements.

Wednesday, 05/20/2026, 2:00 PM

Governor's 14

[S-44] PANEL: HIV INFECTION: AEROMEDICAL IMPLICATIONS, NEUROPSYCHIATRIC RISK, CASE STUDY, AND THE USAF WAIVER PROCESS

Chair: Kevin Heacock

Co-Chairs: Kristin Vogt, Amy Hicks

Panel Overview: *INTRODUCTION: Human Immunodeficiency Virus (HIV) is now a chronic, highly manageable condition; however, it continues to carry significant aeromedical implications for U.S. Air Force aircrew. While modern antiretroviral therapy (ART) reliably achieves viral suppression and preserves long-term health, USAF waiver determinations still emphasize neurocognitive performance, medication tolerability, psychiatric stability, and the absence of AIDS-defining conditions. Cultural and generational shifts—including decreasing HIV stigma, variable condom use, increased PrEP availability, and contemporary changes in sexual behavior—affect how service members perceive risk, disclose exposure, and engage in sexual-health counseling, directly influencing testing, adherence, and aeromedical management. TOPIC: This panel reviews USAF HIV waiver requirements, including durable viral suppression, stable ART regimen, preserved CD4 count, absence of opportunistic infections, and an Aeromedical Consultation Service (ACS) evaluation. Particular focus is placed on HIV-Associated Neurocognitive Disorders (HAND), which—even with viral suppression—may impair executive function, attention, or psychomotor speed in ways relevant to aviation safety. ACS evaluation pathways are outlined, including indications for formal neuropsychological testing, ART side-effect review, adherence verification, and monitoring for viral "blips." APPLICATION: A case of an HIV-positive aviator with concurrent syphilis infection is presented to illustrate the aeromedical impact of co-occurring infections. Discussion includes evaluation for neurosyphilis, transient cognitive or mood symptoms, serologic follow-up, and how co-infections influence ACS interpretation, risk stratification, and waiver timelines. Attendees will gain an operationally grounded framework for applying waiver-guide criteria, identifying neurocognitive or psychiatric red flags, interpreting viral and serologic data, and addressing cultural and generational factors when counseling flyers. The session aims to improve waiver submission quality, enhance clinician confidence in HIV-related aeromedical management, and strengthen readiness across diverse aviation populations.*

[279] NEUROPSYCHIATRIC AND BEHAVIORAL COMORBIDITY IN HIV INFECTION: CLINICAL AND AEROMEDICAL CONSIDERATIONS

Terry Correll

U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, Dayton, OH, USA

(Education - Tutorial / Review)

INTRODUCTION: Aircrew diagnosed with Human Immunodeficiency Virus (HIV) face a complex combination of medical, neurocognitive, and psychiatric considerations. Contemporary antiretroviral therapy (ART) allows HIV-positive aviators to maintain excellent health and operational readiness; however, HIV infection carries increased risks for depression, anxiety, trauma- and stressor-related symptoms, neurocognitive impairment, and medication-related neuropsychiatric side effects. The USAF Waiver Guide emphasizes evaluating neurocognitive performance, mood stability, and emotional adjustment prior to determining aeromedical suitability. This presentation highlights neuropsychiatric comorbidities associated with HIV and their relevance in the aeromedical environment. **TOPIC:** We will review the neuropsychiatric conditions most frequently associated with HIV infection, including major depressive disorder, generalized anxiety disorder, trauma- and stressor-related symptoms, substance use disorders, and HIV-associated neurocognitive disorder (HAND). Special relevance will be placed on differentiating primary psychiatric illness from HIV-related neuroinflammation, opportunistic CNS disease, and ART-related impacts. Attendees will gain a clear understanding of how HIV-related psychiatric conditions interact with operational performance and may impact waiver determinations. **APPLICATION:** Aerospace clinicians must recognize the impact of HIV-associated neuropsychiatric symptoms on flight safety, decision-making, and mission performance. Early identification, evidence-based treatment, and close collaboration with infectious disease specialists are essential. Aircrew may be returned to flying duties when stable on guideline-based therapy, cognitively intact, adherent to treatment, and free from impairing psychiatric or neurocognitive symptoms. This review will outline practical strategies for evaluating aviators with HIV, providing optimal care, and preparing high-quality waiver submissions consistent with USAF standards and aeromedical best practices.

Learning Objectives

1. Understand the neuropsychiatric comorbidities most commonly associated with HIV infection and their relevance to aviation safety.
2. Describe the USAF aeromedical considerations and necessity for cognitive/psychiatric evaluation requirements for aircrew diagnosed with HIV infection.

[280] BEHAVIOR, RISK PERCEPTION, AND IDENTITY IN HIV EVALUATION FOR AIRCREW

Ryan Peirson

U.S. Air Force School of Aerospace Medicine, Wright-Patterson Air Force Base, OH, USA

(Education - Tutorial / Review)

INTRODUCTION: Aircrew operate within an occupational system that shapes how they understand sexual risk, engage with prevention methods, and respond to HIV related testing and diagnosis. Although the Air Force screens personnel for HIV on a routine schedule and requires self-reporting of outside diagnoses, these structural features do not eliminate the psychological factors that influence exposure, reporting, and follow-up. Instead, they shift the relevant

questions. The central issues for clinicians are how aircrew perceive risk, how emotional and situational factors influence sexual decision making, and how identity and occupational meaning shape reactions to a diagnosis that may affect flying status. **TOPIC:** This tutorial reviews established findings from behavioral science and HIV prevention research with specific attention to features that apply to aircrew. Topics include risk perception, decision making under stress or isolation, personality factors associated with risk taking, and the ways in which prevention tools such as PrEP can alter perceived vulnerability. The session also examines stigma, shame, avoidance, and the psychological burden of diagnoses that intersect with a high accountability profession. These factors may not change the frequency of required testing, but they can influence exposure patterns, timing of care, the accuracy of sexual histories, and the emotional and occupational impact of a positive result. **APPLICATION:** Application to aeromedical practice includes approaches to interviewing, framing of sensitive questions, understanding delayed or partial disclosure, and anticipating the psychological responses that may accompany new diagnoses. The session aims to provide clinicians with a practical framework for integrating behavioral and psychological factors into consultation, documentation, and collaboration with flight medicine teams. CLEARED AFRL-2025-5701

Learning Objectives

1. The participant will be able to describe how risk perception, decision making, stigma, and professional identity influence sexual behavior, disclosure experiences, and psychological responses to HIV diagnosis among aircrew, even within systems of mandatory testing and reporting.
2. The participant will be able to recognize how mandatory HIV surveillance and reporting requirements alter patterns of disclosure, distress, and health seeking behavior in aircrew, shaping the psychiatric context in which HIV related aeromedical evaluations occur.
3. The participant will be able to apply a behavioral and psychiatric framework to interpret HIV exposure narratives, prevention behaviors, and psychological adjustment in aircrew, complementing aeromedical risk assessment, neuropsychological evaluation, and certification decision making.

[281] REVIEW OF THE USAF HIV WAIVER GUIDE: AEROMEDICAL STANDARDS, NEUROCOGNITIVE EVALUATION ADN OPERATIONAL IMPLICATIONS

Henrik Close

USAFSAM Aeromedical Consultation Service, Wright-Patterson AFB, OH, USA

(Education - Tutorial / Review)

INTRODUCTION: Human Immunodeficiency Virus (HIV) is now a chronic and highly treatable condition; however, in the U.S. Air Force, HIV infection remains a designated medical condition requiring careful waiver adjudication due to potential implications for neurocognitive performance, treatment stability, and operational reliability. The U.S. Air Force Aerospace

Medicine Waiver Guide provides standardized criteria for assessing HIV-positive aircrew, emphasizing durable viral suppression, preserved immune function, medication tolerability, psychiatric stability, and absence of AIDS-defining conditions or opportunistic infections. This presentation provides a comprehensive review of the HIV waiver-guide section and its practical application for clinicians supporting flying and special-duty populations. **TOPIC:** Core waiver elements—including minimum CD4 thresholds, viral load requirements, ART regimen stability, monitoring intervals, and documentation requirements—will be discussed in depth. Particular attention will be given to HIV-Associated Neurocognitive Disorders (HAND), which remain a primary aeromedical concern even in virally suppressed individuals. The waiver guide outlines criteria for when neurocognitive screening, full neuropsychological testing, or Aeromedical Consultation Service (ACS) referral is required; these pathways will be reviewed step-by-step. **APPLICATION:** Attendees will leave with a strengthened ability to interpret the waiver guide, prepare high-quality submissions, identify red-flag findings requiring ACS referral, and counsel aircrew regarding adherence, monitoring, and the operational significance of viral suppression. This session aims to increase consistency and accuracy in HIV waiver determinations across the aviation enterprise.

Learning Objectives

1. The participants will be able to summarize the key components of the USAF HIV Waiver Guide, including clinical stability requirements, immune criteria, ART stability, and ACS evaluation pathways.
2. The audience will be capable of identifying which neurocognitive, psychiatric, and treatment-related red flags impact HIV waiver approval and require ACS evaluation.

[282] ASSESSMENT OF NEUROCOGNITIVE AND PSYCHOLOGICAL FUNCTIONING IN USAF AIRCREW WITH HIV

Monica Malcein

USAFSAM Aeromedical Consultation Service, Wright-Patterson AFB, OH, USA

(Education - Tutorial / Review)

INTRODUCTION: The neurocognitive landscape for individuals living with HIV has evolved significantly with the advent of combination antiretroviral therapy (ART). The widespread use of ART has been associated with a marked decrease in the incidence of more severe neurocognitive deficits, although a number of reports document a continued, substantial prevalence of milder impairment on testing in the setting of HIV infection even among patients with viral suppression in community settings. These changes can manifest across various cognitive domains, potentially affecting critical skills necessary for safe and efficient flight operations. Additionally, individuals with HIV are at a higher risk for psychiatric disorders which can impact functioning and require careful assessment to determine overall risk. **TOPIC:** Given the potential for subtle cognitive decline in individuals who are HIV+, even with adequate viral suppression, pilots and aircrew

with HIV are seen at the ACS for initial waiver evaluation and for follow-up. The initial evaluation in the Neuropsychiatry branch includes clinical interviews with psychiatry and psychology, intellectual/neurocognitive testing and psychological assessment. Follow-up evaluations include only neurocognitive testing, unless there are co-morbid psychiatric or other conditions. A total of 20 flyers, including pilots and other aircrew positions, have been evaluated and followed at the ACS since 2018. All were administered a measure of intellectual functioning (MAB-II,) a computerized neuropsychological screening exam (MicroCog), and measures of psychological functioning at the initial evaluation. Follow-up appointments include repeated measures of neurocognitive functioning and clinical neuropsychological measures. We present qualitative findings and descriptive summaries of findings on measures of neurocognitive and psychological functioning in this group of individuals with a history of HIV followed at the ACS. We discuss aeromedical implications and offer recommendations for assessing this population. **APPLICATION:** Attendees will gain a greater understanding of the neurocognitive and psychological functioning of USAF aircrew with HIV, assess the utility of repeated testing, and provide guidance for aeromedical assessments.

Learning Objectives

1. Understand the key components of a standardized neuropsychological evaluation for USAF aircrew with HIV.
2. Gain a greater understanding of neurocognitive functioning over time in the USAF aircrew population compared to the general population.

[283] NEUROLOGIC AND COGNITIVE EFFECTS OF HIV AND OTHER COMMON CO-OCCURING DISEASES

Aven Ford

USAFSAM Aeromedical Consultation Service, Wright-Patterson AFB, OH, USA

(Education - Case Study)

INTRODUCTION: This case report describes an aviator with known history of HIV on adequate treatment and a remote history of treated syphilis who was found on subspecialty review to have laboratory evidence for syphilis recurrence and exam evidence of neurosyphilis. **BACKGROUND:** The first aeromedical waiver for HIV infection in a USAF aviator was granted in 2019. Since then, the Aeromedical Consultation Service (ACS) has continued to recommend waivers for aviators with adequately treated HIV who are tolerating and compliant with treatment, do not have any evidence for AIDS defining illness, and have no evidence for neurologic or cognitive disease. The most feared aeromedical outcome of concern is the development of HIV-associated neurocognitive syndrome (HAND). The aeromedical-risks associated with HAND are largely related to subtle neurocognitive deficits in the areas of attention, working memory, executive function, and information processing speed; and subtle fine motor problems that may affect gait or upper extremity coordination and rapid alternating movements. In addition to the direct effects of the HIV virus, there may be neurologic impact

from co-occurring/opportunistic infections and treatments. **CASE PRESENTATION:** A non-rated airman in his early 20s was diagnosed with HIV Stage 1 and early syphilis in 2019 (pos TP ab and RPR 1:32). He was started on Biktarvy for HIV and treated with IM one time Penicillin G 2.4 million units in clinic for his syphilis. Repeat RPR in 3 months was 1:2, indicating adequate response to treatment. However, repeat RPR a year later was 1:32, without reported re-exposure, but unfortunately no further evaluation or treatment was initiated. 6 months later, on neurologic exam he had diffuse hyperreflexia, clonus at the ankles, and a mild decrease in position sense in the left big toe. In the setting of syphilis treatment failure this was felt to represent neurosyphilis and inpatient evaluation and treatment were initiated. Lumbar puncture was unremarkable, but the decision was made to complete the full treatment for neurosyphilis. He tolerated treatment well and currently has no complaints. **DISCUSSION:** HIV and co-infections may have a myriad of neurologic manifestations and careful evaluation and treatment are required.

Learning Objectives

1. Review the neurocognitive aeromedical risks associated with HIV, including HIV-associated neurocognitive syndrome (HAND).
2. Explain the risks associated with co-occurring/opportunistic infections and treatments.

Wednesday, 05/20/2026, 4:00 PM

Plaza B/C/E/F

[S-45] PANEL: 16TH ANNUAL RAM BOWL

Chair: Allen Parmet

Co-Chair: Rebecca Blue

Panel Overview: *The 16th Annual RAM Bowl features participants from the Air Force, Navy, Army, Mayo Clinic, UTMB and Hyperbaric Fellows competing for the Louis H. Bauer Trophy. Aerospace Medicine Residents are required to demonstrate multiple competencies to satisfy the requirements of ACGME and ABPM and serve as specialists in the field. Multiple tools are available for developing appropriate didactic knowledge in aerospace medicine, public health, epidemiology, biostatistics and health care management. Residents participate in a college bowl format that test aerospace medicine competencies including the flight environment (atmosphere, radiation, vibration, acceleration, and microgravity), clinical aerospace medicine, aircraft and space vehicle systems/operations, accident investigation, historical events, aerospace physiology, human factors, ergonomics, medical standards, Federal Aviation Administration regulations, passenger transport, restraint and escape, cockpit resource management and aeromedical transportation. Questions are divided into toss-up and bonus questions. Multiple rounds of competition will lead to the selection of an individual victor and awarding of the Louis H. Bauer Trophy to the top team, sponsored by the American Society of Aerospace Medicine Specialists.*

[284] 16TH ANNUAL RAM BOWL

Allen Parmet[1], Rebecca Blue[2], Joanna Nelms[3], Rahul Suresh[4], Roy Allen Hoffman[5], Alex Garbino[6], Walter III Dalitsch[7], Mary Cimrmancic[8], John Barson[9]

[1]University of Southern Californai, Kansas City, MO, USA; [2]University of Texas Medical Branch, Galveston TX, TX, USA; [3]Texas ANG, Austin, TX, USA; [4]Johnson Space Center, Houston, TX, USA; [5]US Navy, Pensacola, FL, USA; [6]Geocontrol NASA/Houston, Houston, TX, USA; [7]FAA, Anchorage, AK, USA; [8]Marquette University, Milwaukee, WI, USA; [9]US Army, Atlanta, GA, USA

(Education - Program / Process Review)

The 16th Annual RAM Bowl features participants from the Air Force, Navy, Army, Mayo Clinic, UTMB and Hyperbaric Fellows competing for the Louis H. Bauer Trophy. Aerospace Medicine Residents are required to demonstrate multiple competencies to satisfy the requirements of ACGME and ABPM and serve as specialists in the field. Multiple tools are available for developing appropriate didactic knowledge in aerospace medicine, public health, epidemiology, biostatistics and health care management. Residents participate in a college bowl format that test aerospace medicine competencies including the flight environment (atmosphere, radiation, vibration, acceleration, and microgravity), clinical aerospace medicine, aircraft and space vehicle systems/operations, accident investigation, historical events, aerospace physiology, human factors, ergonomics, medical standards, Federal Aviation Administration regulations, passenger transport, restraint and escape, cockpit resource management and aeromedical transportation. Questions are divided into toss-up and bonus questions. Multiple rounds of competition will lead to the selection of an individual victor and awarding of the Louis H. Bauer Trophy to the top team, sponsored by the American Society of Aerospace Medicine Specialists.

Learning Objectives

1. The session will enable participants to prepare for ABPM examinations in Aerospace Medicine.
2. Attendees will receive an intense review of Aerospace and Preventive Medicine

Thursday, 05/21/2026, 10:00 AM

Governor's 12

[S-46] PANEL: CRITICAL CARE AT HIGH ALTITUDE: SYNERGY OF MOUNTAIN RESCUE AND AIR AMBULANCE

Chair: Allen Parmet

Co-Chair: Aaron Parmet

Panel Overview: *The very high-altitude environment of Summit County, Colorado, home to the nation's highest ICU, Level III Trauma Center, and HEMS base, presents unique aeromedical challenges. The altitude ranges from 9000 feet (2900 m) to over 14000 feet (4350 m) and temperatures from minus 25C to over 40C. This panel will showcase the integrated response of Flight for Life Colorado, Summit County Rescue Group, and St. Anthony Summit Hospital through five compelling case studies. These scenarios will illustrate the interactions of high-altitude illness, mountain trauma, and the challenges of terrain in severe weather in a county that has 4.5 million annual visitors. Cases will highlight the physical, physiological, and meteorological complexities inherent to mountain rescue, aeromedical patient care, and interdisciplinary collaboration in high-stakes, austere settings.*

[285] VERY HIGH ALTITUDE AVALANCHE RESCUE AND SURVIVAL-AGAINST ALL ODDS

Aaron Parmet

St. Anthony Summit Hospital, Frisco, Colorado, Keystone, CO, USA

(Education - Case Study)

This presentation examines the extraordinary survival of a fully buried snowmobiler in an avalanche at 11,500 feet (3500m) on Shrine Mountain. A mission profile perfect for SAR and HEMS deployment partnerships was forced by conditions into a ground-based rescue. The patient endured outlier duration extended burial, suffering significant hypoxia and hypercapnia at high altitude making survival remarkable. Successful extraction by Summit County Rescue Group and subsequent hospitalization at St. Anthony Summit Hospital underscore the critical role of coordinated ground efforts when air support is unavailable. We will analyze the unique survival despite overwhelming odds, physiological challenges of high-altitude burial.

Learning Objectives

1. The participant will become familiar with the medical conditions caused when an individual is caught in an avalanche.
2. The participant will understand the urgency and nature of Search and Rescue (SAR) for avalanche victims due to time critical progression in order to prevent a fatal outcome.

[286] WET CLOTHES AND CLIFFED OUT AT 14,000 FEET

Kristin Lodmill[1], Lindsay Wiebold[2]

[1]Flight for Life, Frisco, CO, USA; [2]Summit County Rescue Group, Frisco, CO, USA

(Education - Case Study)

A father and son become stranded on a technical ridge near 14,000ft (3400m) only dressed in wet t-shirts and shorts. A coordinated response between Summit County Rescue Group and Flight for Life inserted 4 rescuers on the far side of the summit who worked overnight to reach the patients, stabilize the situation, and collaboration with CANG HAATS hoist deals with high winds and high dust to extricate. Rescuers are further confounded by altitude, night, and weather conditions limiting helicopter operations. Flexibility is the key to safe and successful rescue.

Learning Objectives

1. The participant will understand the impressive inability of naïve tourists to recognize the need to dress appropriately for weather conditions at high altitude.
2. The participant will understand the complexities of coordinated rescue operations under the adverse conditions of high altitude, mountainous terrain and severe weather.

[287] TAKING HAPE UPHILL

Lindsay Wiebold[1], Maggie Clark[2]

[1]Summit County Rescue Group, Frisco, CO, USA; [2]Flight for Life Colorado, Frisco, CO, USA

(Education - Case Study)

This presentation details the complex, multidisciplinary rescue of a critically ill High Altitude Pulmonary Edema (HAPE) patient from over 12,000 feet (3700m) in challenging terrain and weather, occurring at night. This case was particularly unique as the patient had a history of previous HAPE episodes, highlighting a compelling physiological outlier. Initial aeromedical operations were hampered by severe wind conditions, forcing ground rescue crews to undertake an arduous uphill extrication of the patient to a suitable landing zone. This case study will explore the critical coordination between ground rescue, wilderness EMS, and aeromedical teams, illustrating the profound logistical and medical challenges of high-altitude rescue, the impact of adverse weather on care delivery, and the innovative solutions employed to ensure patient survival in an austere mountain environment.

Learning Objectives

1. The participant will understand the physiologic condition of High Altitude Pulmonary Edema, its signs and symptoms.
2. The participant will understand the treatment for HAPE.
3. The participant will understand the unique reasons for exposing this HAPE victim transiently to higher elevations in order to effect rescue.

[288] WHEN YOU CAN FLY IN BUT NOT OUT: HIGH ALTITUDE WINTER HEAD TRAUMA

Maggie Clark

Flight for LIfe Colorado, Frisco, CO, USA

(Education - Case Study)

This presentation details the critical rescue of an ice climber with severe head injury on Mount Lincoln (14,295 ft), exemplifying challenges of high-altitude critical care and interagency collaboration. Initial SAR requested mutual aid from Summit County Rescue Group (SCRG) for technical extraction and Flight for Life (FFL) for critical care. FFL and SCRG rescuers hiked in through challenging winter conditions to access the patient, providing advanced life support. As SCRG lowered the patient, deteriorating weather grounded the FFL helicopter necessitating creative solutions to reach St. Anthony Summit Hospital (SASH) for stabilization before critical care transport to a tertiary facility. This case highlights rapid critical care deployment in austere environments, indispensable SAR and FFL coordination, and adaptive strategies amidst unforeseen environmental obstacles.

Learning Objectives

1. Participant will understand clinical concerns for a trauma case at high altitude.
2. Participant will understand the coordination issues between component rescue organizations in the high altitude wilderness setting.

[289] CRITICAL DECISION MAKING IN HIGH-ALTITUDE AEROMEDICAL RESCUE

Erixson Moore[1], Aaron Parmet[2]

[1]Air Methods, Frisco, CO, USA; [2]St. Antony Summit Hospital, Summit County Rescue Group, Frisco, CO, USA

(Education - Case Study)

Critical decision-making inherent in high-altitude aeromedical rescue. We will highlight a unique operational scenario involving the Summit County Rescue Group (SCRG) and Flight for Life (FFL) that demanded forethought, coordination, and rapid problem-solving in a dynamic high altitude rescue mission. This presentation will explore the intricate interplay between ground rescue, wilderness medical expertise, and aeromedical transport in an evolving emergency situation. We will delve into the critical "right calls" made under pressure, the resources leveraged, and the innovative strategies employed to overcome significant logistical, environmental, and medical hurdles.

Learning Objectives

1. The participant will understand the Aeromedical rescue decision process.
2. The participant will understand the multiple inputs to the decision process, include the helicopter pilot's ultimate go/no go decision to fly.

Thursday, 05/21/2026, 1:30 PM

Plaza A/B

[S-47] SLIDE: STONES, SALTS, AND SPACE SUITS

Chair: Samantha King

[290] A RETROSPECTIVE ANALYSIS OF MAGNESIUM ALTERATIONS IN HUMAN SPACEFLIGHT

Thomas Diaz[1], Edward Ashworth[2], Ganeev Singh[3],

[1]The Johns Hopkins Hospital, Baltimore, MD, USA; [2]University of Basel, Basel, Switzerland; [3]Scripps Mercy Hospital San Diego, San Diego, CA, USA

(Original Research)

INTRODUCTION: Magnesium is essential for neuromuscular function, cardiac conduction, ATP metabolism, and bone integrity. A recent systematic review found increasing serum magnesium and urine magnesium in human spaceflight, along with abrupt magnesium changes on landing day. The present study provides the most up-to-date assessment of magnesium homeostasis inflight using biochemical data through 2025 from NASA's Lifetime Surveillance of Astronaut Health (LSAH) program. **METHODS:** This retrospective cohort study included astronauts with serum or urinary magnesium values collected before, during, or after spaceflight. Deidentified individual data were provided by NASA LSAH, alongside corresponding serum and urine creatinine values. Descriptive statistics were calculated, and linear mixed-effects models evaluated temporal and sex-related differences. **RESULTS:** 99 astronauts (28 female) at the International Space Station between 2000 and early 2025 contributed 2,890 data points, with the longest inflight duration being 199 days. During flight, ten astronauts were hypomagnesemic (<1.82 mg/dL), one astronaut was hypermagnesemic (>2.20 mg/dL), and the remaining 88 astronauts remained within normal limits. Inflight serum magnesium increased over time ($p=0.048$), with no significant difference between sexes ($p=0.107$). Inflight daily urinary magnesium was unchanged over time ($p=0.293$) but was independently lower in females ($p=0.026$). Among astronauts who were hypomagnesemic inflight, 31% had a FEMg > 2%, suggesting inappropriate renal magnesium losses. Inflight serum creatinine remained stable, indicating that renal magnesium loss may be unrelated to glomerular filtration ($p=0.088$). **DISCUSSION:** These findings suggest that although inflight serum magnesium may increase over time, some astronauts may be at risk of hypomagnesemia potentially due to renal magnesium losses. Possible confounding factors include sex differences, bone and tissue loss, countermeasures, dietary and fluid shifts, electrolyte interactions, and neurohormonal changes. As data are limited to approximately six months inflight, more longitudinal measurements are necessary to determine if magnesium homeostasis is progressively altered and whether magnesium supplementation is warranted.

Learning Objectives

1. Describe longitudinal changes in serum and urinary magnesium during spaceflight.
2. Evaluate the prevalence of hypomagnesemia among astronauts during spaceflight and assess for need for nutritional supplementation.
3. Interpret fractional excretion of magnesium (FEMg) values to determine potential magnesium wasting during spaceflight.

[291] VALIDATION AND OPERATIONAL UTILITY OF THE NIJMEGEN QUESTIONNAIRE FOR IDENTIFYING CLINICALLY SYMPTOMATIC CHRONIC RESPIRATORY ALKALOSIS (CSCRA)

Javin Patel[1], Karen Breznak[2], Jeremy Cohran[2], Blake Langlais[2], Jan Stepanek[2]

[1]Mayo Clinic Alix School of Medicine, Scottsdale, AZ, USA; [2]Mayo Clinic, Scottsdale, AZ, USA

(Original Research)

INTRODUCTION: Clinically symptomatic chronic respiratory alkalosis is a common but frequently underrecognized contributor to symptoms in operational and aerospace medicine settings, often occurring in the context of workload, stress, hypoxia or task saturation. The Nijmegen Questionnaire (NQ) has historically been used to identify hyperventilation syndrome but has not been evaluated as a screening tool for physiologic acid–base disorders. This study evaluates the diagnostic performance of the NQ in identifying clinically confirmed respiratory alkalosis and assesses its operational utility for aerospace medicine practitioners. **METHODS:** A retrospective chart review was conducted of patients evaluated between April 2022 and October 2025. After exclusions, 535 patients were included. A positive Nijmegen score (≥23) was compared with arterial blood gas, which confirmed primary or secondary respiratory alkalosis. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated. Subgroup analyses by age and sex were performed. **RESULTS:** For primary respiratory alkalosis, a positive NQ demonstrated a sensitivity of 63%, specificity of 28%, PPV of 73%, and NPV of 20%. For secondary respiratory alkalosis, there was a sensitivity of 80%, specificity of 36%, PPV of 12%, and NPV of 95%. Additionally, diagnostic performance varied significantly by age and sex. **DISCUSSION:** In aerospace medicine, rapid differentiation between physiologic respiratory alkalosis and functional or anxiety-related symptoms is essential for aeromedical decision-making. The Nijmegen Questionnaire demonstrated utility as an adjunctive screening tool, particularly for excluding secondary respiratory alkalosis given its high sensitivity and NPV. In operational environments where symptoms may be episodic and diagnostic resources are limited, the NQ provides a quick, standardized method of symptom assessment that may guide targeted physiologic evaluation and support timely return-to-duty decisions.

Learning Objectives

1. To evaluate the operational applicability of the Nijmegen Questionnaire as a screening adjunct for respiratory alkalosis in aerospace medicine.
2. To explore the diagnostic performance of the Nijmegen Questionnaire and determine its validity.

[292] URINARY OXALATE EXCRETION IN ASTRONAUTS DURING LONG-DURATION SPACEFLIGHT: AN EXPLORATORY ANALYSIS

Stephanie Smith[1], Juliana Villanueva-Congote[2], Nathaniel Hansen[3], Raeann Dalton[4], Evelyn James[4], Jay Buckey[5], Daniel Wollin[3], David Watson Sobel[4]

[1]University of Minnesota Medical School, Minneapolis, MN, USA; [2]Mass General Hospital, Boston, MA, USA; [3]Brigham and Women's Hospital, Boston, MA, USA; [4]Maine Medical Center, Portland, ME, USA; [5]Geisel School of Medicine at Dartmouth, Hanover, NH, USA

(Original Research)

INTRODUCTION: Spaceflight and prolonged exposure to microgravity can increase the risk of renal stone development. Most available evidence indicates that these stones are predominantly made of calcium oxalate. Prior work has focused on hypercalciuria from increased bone resorption as a mechanism of stone formation in astronauts, however, little research has assessed the role of hyperoxaluria. In this study, we explored the relationship between urinary oxalate, urinary calcium, diet, and mission phase during long-duration spaceflight. **METHODS:** Dietary calcium and oxalate intake, 24-hour urine parameters, and daily dietary intake logs from 12 astronauts (11 men, 1 woman) who completed ≥160-day spaceflights were obtained from the Lifetime Surveillance of Astronaut Health Repository and the Life Sciences Data Archive and subsequently analyzed. Two sets of mixed-effects regression analyses were conducted to assess differences in urinary calcium and oxalate, adjusting for daily intake of calcium and oxalate across mission phases. This study used human subject data collected previously under protocols approved by the NASA Institutional Review Board. We received ethics approval for use of this data. **RESULTS:** Calcium intake was higher pre-flight than in-flight (p<0.05), while oxalate intake was stable between pre- and in-flight periods (p>0.05) and decreased post-flight (p<0.01). Despite this, both urinary calcium and oxalate were elevated in-flight compared with pre- and post-flight levels (p<0.01 and p<0.05, respectively). Only 30% of astronauts demonstrated persistent hypercalciuria (>250 mg/day) beyond flight day 163. Hyperoxaluria (>40 mg/day) was observed in 50% of astronauts in-flight. After adjustment for dietary calcium and oxalate, urinary oxalate remained elevated in-flight by a mean of 10.6 mg/day. **DISCUSSION:** Hyperoxaluria persists during long-duration spaceflight and appears largely diet-related, even with stable calcium intake. Unlike urinary calcium, elevated oxalate levels remain throughout the in-flight phase. In-flight symptomatic nephrolithiasis poses serious challenges due to limited diagnostic and therapeutic resources, threatening crew health and operational continuity. Oxalate handling may be a key, and potentially modifiable, determinant of stone risk in space. Given the importance of reducing renal stone risk, dietary oxalate

mitigation, including astronaut menu modifications, should be considered for future long-duration missions.

Learning Objectives

1. The audience will learn about the relationship between urinary calcium, urinary oxalate, diet, and mission phase during long-duration spaceflight.
2. Participants will be able to understand general trends in urinary calcium and urinary oxalate across mission phases for astronauts.
3. The audience will learn about how calcium and oxalate metabolism in microgravity increases risk of renal stone formation.

[293] DIETARY FACTORS ASSOCIATED WITH HYPEROXALURIA AND CALCIUM OXALATE SUPERSATURATION DURING LONG DURATION SPACEFLIGHT

Nathaniel Hansen[1], Juliana Villanueva-Congote[2], Stephanie Smith[3], Raeann Dalton[4], Evelyn James[4], Jay Buckey[5], Daniel Wollin[1], David Sobel[6]

[1]Brigham and Women's Hospital, Boston, MA, USA; [2]Mass General Hospital, Boston, MA, USA; [3]University of Minnesota Medical School, Twin Cities, MN, USA; [4]Maine Medical Center, Portland, ME, USA; [5]Geisel School of Medicine at Dartmouth, Hanover, NH, USA; [6]Maine Medical Center, Portland, MA, USA

(Original Research)

INTRODUCTION: Spaceflight has been shown to increase the risk of urinary stone disease. However, urinary oxalate, a key determinant of calcium oxalate (CaOx) stone formation and supersaturation of CaOx, has not been previously characterized in this setting. Given oxalate's central role in kidney stone pathogenesis, we conducted an analysis to identify dietary and metabolic factors associated with increased urinary oxalate excretion and CaOx supersaturation during long duration spaceflight. **METHODS:** Dietary and 24-hour urine parameters from 10 male and 2 female astronauts during 160+ day spaceflights on the International Space Station consuming controlled diets, were analyzed. We analyzed paired dietary and urinary data to identify dietary factors associated with urinary oxalate and CaOx supersaturation in-flight. Dietary intake data were averaged by subject and collection period to generate mean daily intakes of calcium, oxalate, water, potassium, animal protein, magnesium, phosphorus, and sodium. To identify the dietary factors most strongly associated with each urinary outcome while accounting for repeated measurements within subjects, we applied a LASSO regression within a linear mixed-effects framework. **RESULTS:** For urinary oxalate, higher dietary oxalate (β = 9.33) and magnesium intake (β = 5.04) were strongly associated with increased urinary oxalate levels, whereas higher calcium intake (β = −3.09) was inversely associated. Smaller positive effects were observed for animal protein (β = 0.31) and water intake (β = 0.11). In the model evaluating dietary predictors of CaOx supersaturation, higher dietary oxalate (β = 0.73) and

animal protein (β = 0.34) intake were positively associated. In contrast, greater water (β = −0.44) and calcium intake (β = −0.31) were inversely associated. **CONCLUSIONS:** Prior work on stone formation in space has focused on microgravity-induced bone resorption driving hypercalciuria, with comparatively little focus on drivers of hyperoxaluria and other dietary factors affecting CaOx supersaturation. High oxalate diet appears to drive hyperoxaluria, as well as low calcium diet, likely from decreased enteric binding of oxalate with calcium. Increased dietary calcium and fluid intake reduce CaOx supersaturation. Symptomatic nephrolithiasis can jeopardize mission objectives and crew safety, and developing further dietary countermeasures and novel spot urinary measurements to reduce risk is essential for long duration spaceflight.

Learning Objectives

1. Participant will be able to understand the role that diet plays on kidney stone development in space.
2. Participant will be able to understand how fluid intake affects kidney stone development.

[294] REASSESSING THE EVIDENCE ON SPACE RADIATION AND CANCER RISKS

Dana Levin[1], Matt Mackay[2], Chris Mason[2], Meg Everett[3], Jon Steller[3]

[1]Vast, Long Beach, CA, USA; [2]Cornell University, New York, NY, USA; [3]Vast Inc., Long Beach, CA, USA

(Original Research)

INTRODUCTION: Space radiation is typically considered within the context of the linear no-threshold model (LNT). LNT assumes there is no safe radiation dose, that all damage is cumulative, and exposure dose is linearly correlated with cancer risk. However, increasing evidence suggests this model may be too simplistic. While high radiation doses are clearly correlated with linear increases in cancer risk, lower doses and dose rates do not consistently follow this trend. More interestingly, astronauts, air crews, and nuclear shipyard workers appear to have static or lower overall rates of cancer relative to controls. A similar pattern is also seen in populations exposed to low doses of other types of radiation. In human biology, exposure to a low-level noxious stimulus often induces an adaptive response through a process called hormesis. If radiation risk follows a hormesis model rather than LNT, space missions, even exploration class ones, may be less constrained by radiation. It also may lead more broadly to new therapeutic modalities. **METHODS:** We undertook a systematic review of relevant epidemiological and experimental literature to evaluate the evidence for cancer risk and radiation hormesis in individuals exposed to space and space analogous radiation. **RESULTS:** While existing data are not yet sufficient to justify changing operational standards or regulations, there does appear to be a consistent epidemiological signal suggestive of a threshold dose for radiation cancer risk Some controlled studies also demonstrate that low-dose proton exposure appears to protect human cells against subsequent heavy ion damage likely mediated through NRF2/ERK signaling. Our review also identified upregulated proteins in in-vitro models that are

recapitulated in astronaut RNA profiles post-flight. **DISCUSSION:** In light of these findings we propose a research program integrating multi-omic NGS analyses, organoid models, long-term monitoring for astronaut health, and drug screens. The goals are to better assess the effects of radiation on space crew, more appropriately characterize and convey risk, and identify compounds that may activate protective pathways. Such therapeutic compounds could reduce radiation risk and improve health outcomes for terrestrial and extraterrestrial humans.

Learning Objectives

1. What are the types of radiation, and which are most applicable to space flight.
2. Understand the Radiation hormesis model vs. linear no threshold (LNT) model.
3. Trends in available data are not always consistent with the LNT model.

[295] EVALUATION OF ANTICIPATORY CUES TO MITIGATE ENTRY MOTION SICKNESS DURING SIMUALTED ASTRONAUT POST-FLIGHT LANDINGS

Torin Clark, Priyanka Vasu, Taylor Lonner

University of Colorado, Boulder, CO, USA

(Original Research)

INTRODUCTION: Following extended exposure to microgravity, astronauts returning to Earth experience entry motion sickness, with symptoms that can be amplified by passive wave motions during splashdown. Previous research found that visual plus anticipatory cues significantly reduce nausea during wave-like motion as compared to a control group. This raises the question as to whether these benefits could be due to anticipatory cues in isolation. We aim to develop and evaluate a promising countermeasure for mitigating motion sickness by providing only anticipatory cues about self-motion one second in the future. **METHODS:** This study, approved by the IRB at CU Boulder, has a within-participants experimental design in which 15 participants are exposed to wave-like motion and provided with no cues of self-motion, a combination of visual and anticipatory cues, and just anticipatory cues in a counterbalanced order. Wave-like motion is simulated using the Tilt Translation Sled, via roll-tilt and lateral translation, and is followed by a recovery period. Anticipatory cues involve displaying a human figurine against a black background on a Meta Quest 2 VR headset. Participants verbally rate their motion sickness symptoms every minute, through the Motion Illness Symptoms Classification scale, along with the severity of general discomfort and nausea. A pre-established stopping criteria of two consecutive minutes of moderate nausea is employed. Performance assessment measures include Psychomotor Vigilance Test, a spaceflight-relevant, operational task of a piloted planetary landing simulator, and standing balance task. Outcome data is analyzed using an ANOVA or a non-parametric equivalent for the different conditions. **RESULTS:** Time course of participant survival (proportion of participants that had not dropped out due to sustained moderate nausea) is compared across the three experimental conditions. Previous research on participant survival found that only 33% of the control group could

withstand an hour of wave-like motion compared with 90% of the visual plus anticipatory cues group ($p = 0.017$). **DISCUSSION:** Using ground-based paradigms to simulate post-flight water landings, we experimentally assess the incidence, severity, and time course of motion sickness. Evaluating the role of anticipatory cues in the drastically increased survival percentage helps ascertain the most efficient VR countermeasure to mitigate motion sickness.

Learning Objectives

1. The participant will understand the significance of spaceflight driven motion sickness on operational performance, and its consistence with the sensory conflict theory.
2. The participant will learn about the different visual countermeasures that are being developed to help reduce the incidence and severity of entry motion sickness and mitigate sensorimotor and cognitive impairment.

Thursday, 05/21/2026, 1:30 PM

Plaza D

[S-48] PANEL: SYNERGY OF INTERDISCIPLINARY TEAMS IN BOUNDLESS FRONTIERS: BEST PRACTICE PROTOCOLS EMULATING MARY F FOLEY

Chair: Marian B Sides

Co-Chairs: Donna Fearon, Nora Johnson

Panel Overview: *This panel perpetuates the multidisciplinary legacy of Mary F Foley and her influence on engaging interdisciplinary teams for best practices in aerospace medicine. The conceptual framework of the panel will profile the dynamics of professionals who are academically qualified in two or more disciplines, and whose world of work embraces practice in interdisciplinary teams. These highly accomplished panel participants include Dr. J Karen Klingenberger, MD, MPH, MS, BSN, FAsMA, Col. USAF (ret). Dr Philip Brady, MB, BCh, BS, MinstP, MRCPsych, MCPsychl., Robin Bruce, FN, BSN, RN, Dr Elizabeth G Damato PhD, APRN-CNP, CPNP-PC and Dr Rowena Christiansen MEmergHealth, MBA, MBBS, BAHons, LLB, FAsMA, FAsHFA. The qualities and virtues that shape these distinguished leaders will be portrayed by exemplifying highlights and examples of collaboration, that involve interactive communication, integrating their expertise to create a unified plan, with shared goals that influence each other, for synergistic results and outcomes. Participants will address five key questions, including: 1. What inspired you to cross disciplines or add a discipline to your existing practice? 2. What impact has your multiple careers had on the quality of your practice? 3. How have your diverse skill sets influenced your decision making in client care? Provide examples; 4. How has synergistic collaboration on interdisciplinary teams, in your experience, improved patient care outcomes? 5. What is your vision for the future with respect to multidisciplinary qualifications, and interdisciplinary team initiatives? This event will offer illuminating insights, and strategies on developing and clarifying critical thinking thought*

processes. Panel discussion will describe unique patterns of multidisciplinary qualifications, and the synergistic characteristics of the interdisciplinary team experience. The deliberations of these trailblazing panelists will demonstrate blended problem-solving strategies, promote creativity by encouraging novel ways of approaching problems, bringing professionals with multiple academic disciplines together to achieve a common synergistic goal. This panel will leave legacies that offer valuable lessons in perpetuating the advancement of knowledge and development of collaborative solutions that can be applied in real world challenges, in austere environments. This panel will offer mentoring opportunities for career path and leadership development for AsMA membership.

[296] FROM TEAM AEROSPACE TO DEEP SPACE: BUILDING HIGHLY EFFECTIVE INTERDISCIPLINARY TEAMS

J. Karen Klingenberger

Virginia ANG, Williamsburg, VA, USA

(Education - Tutorial / Review)

INTRODUCTION: Mary "Bunny" Foley's legacy reflects what aerospace medicine demands at its best: deep technical competence paired with genuine cross-disciplinary collaboration. She treated operational physiology, cutting-edge research, and lived experience in extreme environments as mutually reinforcing. As we push further into austere, resource-limited contexts, her example is a practical model for how multidisciplinary preparation strengthens judgment, education, mentorship, and mission resiliency. **TOPIC:** My aerospace practice was shaped by U.S. Air Force operational experience in combat-support environments, where decision-making is time-critical, information is incomplete, and consequences are immediate. As a pilot and aircraft commander, I depended on aerospace medicine to keep crews safe, effective, and mission-capable. My role as a senior flight surgeon placed me on the other side of that relationship: responsible for rapid clinical decisions that had operational implications. Across these positions, I learned that outcomes improve when teams share a common operational picture and treat medical, human performance, and mission requirements as an integrated system. Early nursing training, in a whole-person approach to health, reinforced the importance of understanding the full context of a patient's history and environment, not just the presenting problem. Subsequent experience in policy development added a governance lens: how standards, accountability, and communication structures either support or undermine effective operational outcomes. **APPLICATION:** Interdisciplinary team performance is not accidental; it can be trained, structured, and reinforced through clear doctrine and daily practice. Operational organizations have long relied on integrated models—such as "Team Aerospace"—to align clinicians, operators, and leadership around shared goals, common language, and transparent decision pathways. That same approach is directly relevant to space exploration, security, and commercialization, where health, performance, and mission success are tightly coupled and where evacuation, specialist support, and redundancy may be limited or unavailable. Looking forward, this presentation argues for deliberate training pathways and team frameworks that build shared mental models, clarify roles and escalation routes, and normalize frequent cross-functional collaboration. Emulating Foley's principles means treating multidisciplinary expertise

as a capability to be developed—so future space teams can deliver individualized care while maintaining operational resilience in the most demanding environments.

Learning Objectives

1. At the conclusion of this session, participants will be able to describe how synergistic multidisciplinary collaboration in operational settings provides the optimum platform to develop a critical systems approach to ensure exploration, security and commercialization of space.
2. At the conclusion of this session, participants will be able to identify the essential characteristics of interdisciplinary teams; shared operational goals, integrated training opportunities, clear policies, frequent collaboration of all team member.

[297] FROM CLINICAL JUDGMENT TO OPERATIONAL GOVERNANCE: INTEGRATING PSYCHIATRY AND AEROMEDICAL DECISION-MAKING IN THE SPACEFLIGHT DOMAIN

Philip Brady

Trinity College Dublin, Dublin, Leinster, Ireland

(Education - Tutorial / Review)

INTRODUCTION: Spaceflight operations require decision-making at the intersection of human physiology, cognition, operational constraints, and governance. In practice, behavioural health, aeromedical assessment, and organisational decision frameworks are often treated as adjacent rather than integrated domains. This fragmentation limits the ability of aerospace teams to anticipate risk, maintain performance, and manage uncertainty across international and high-consequence environments. **TOPIC:** My professional trajectory spans clinical psychiatry, aeromedical examination, experimental and mathematical physics, military operational medicine, and international governance. Early training in physics emphasised systems modelling, signal interpretation, and non-linear responses to stressors. As an Aeromedical Examiner and operational psychiatrist, I observed parallel challenges in aviation and spaceflight, including cognitive load, threat perception, fatigue, and decision-making under regulatory and operational constraint. Across military, civil aviation, and commercial spaceflight contexts, the same human performance issues are often framed differently by clinicians, engineers, regulators, and commanders. These disciplinary silos obscure shared risk rather than managing it.
APPLICATION: Applying a systems-based, interdisciplinary framework across international aerospace environments has improved risk communication, aeromedical decision-making, and alignment between clinical judgment and operational governance. Integrating psychiatric expertise with aeromedical standards, physical constraints, and leadership structures strengthens shared mental models and supports earlier identification of human performance degradation. This approach improves the consistency, transparency, and defensibility of decisions affecting flight safety and mission readiness. Looking ahead, this work highlights the need for intentional

development of interdisciplinary competence in space medicine, ensuring that clinical training, aeromedical decision-making, and governance structures are prepared to support increasingly complex spaceflight activities.

Learning Objectives

1. The participants will be able to identify how psychiatric assessment, aeromedical standards, and governance interact in aerospace decision-making.
2. The participants will be able to recognise the impact of fragmented clinical, operational, and governance processes on human performance risk in aerospace environments.

[298] SYNERGY IN ACTION: THE VALUE OF NURSES AND INTERDISCIPLIARY COLLABORATION IN THE ADVANCEMENT OF AEROSPACE HEALTH CARE

Robin Bruce

Colorado Council of Black Nurses Inc., Denver, CO, USA

(Education - Tutorial / Review)

INTRODUCTION: As evidenced by the pioneering accomplishments of Mary Frances Foley, RN, nurses make extraordinary advances in medicine, drive innovation, and are determinants of healthcare policy. However, the recognition of these accomplishments have generally gone unrecognized if not minimalized. Fortunately, the recent embrace of nurses by the space industry is noteworthy and sure to accelerate rapid advancements in both health care and industry.
TOPIC: This presentation highlights one nurse's trials and triumphs to bring the industries of healthcare, medicine, education, and aerospace together to work synergistically to maintain optimal health for all during this new space age. In doing so, she has advanced the recognition of nurses in the medical and aerospace arenas as an invaluable and irreplaceable, professional member of the interdisciplinary workforce team. As an advocate for nurses in space, Robin Bruce RN, has steadily chiseled away at space industry "isms," breaking multiple barriers originally through a global Space Expo initiative for youth that brought together industry experts to inspire our next generation to discover their place in space future. Currently, her work focuses on closing critical gaps in aerospace education. She has both hosted and served on national and international panels that bring together interdisciplinary experts to contemplate space health implications not only in deep space, but on Earth and every atmosphere in between. She has engaged colleges and universities to fathom adding aerospace to Nursing program curriculum, spearheading certificated offerings, an entire Aerospace Nursing program equipped with the first (to her knowledge) Space Nursing simulator, and new aerospace degrees on the horizon. She has broken barriers in boardrooms, serving in director positions of pioneering space, aerospace, and Nursing organizations, founded several Space Nursing programs, and she's not done yet!
APPLICATION: In this live narrative, Robin Bruce RN brings the profession of Nursing to the forefront of space exploration and habitation. Her uncharted space nursing journey serves as an inspiration for industries to collaborate outside of their disciplines to forge strong

interdisciplinary teams that benefit from the contributions and influence of nurses in reaching aerospace goals.

Learning Objectives

1. The audience will learn how to identify interdisciplinary teams to incorporate aerospace into Nursing curriculum.
2. The participant will be able to apply aerospace principles into everyday nursing practice.
3. The audience will recognize opportunities to collaborate with nurses to reach aerospace goals.

[299] FROM SILOS TO SYNERGY: INTERDISCIPLINARY TRAINING AS A FOUNDATION FOR AEROSPACE PHYSIOLOGY

Elizabeth G Damato

Case Western Reserve University, Hudson, OH, USA

(Education - Tutorial / Review)

INTRODUCTION: The depth and breadth of Aerospace Physiology cannot be described by a singular expertise, as is common with many other disciplines. Aerospace physiologists address diverse topics ranging from human factors and nutrition to neurophysiology and hypergravity. Yet there is no national licensing, nor consensus of fundamental knowledge or skills, that Aerospace Physiologists should possess. That gap of a nationally recognized standard of training, academic degree, or competencies enables almost any person to self-declare as an Aerospace Physiologist. **TOPIC:** My inspiration to delve into the aerospace realm was driven by emerging and unanswered questions related to human resiliency in extreme environments. I began collaborating with Aerospace Physiologists across multiple agencies to consider possible mechanisms underlying “Physiologic Events” in aviators. I soon realized the focus of each person’s formal education was reflected in their almost singular (versus multidisciplinary) approach to understanding Physiologic Events. Those trained as engineers thought the culprit was “work of breathing.” Those trained as sports scientists blamed fatigue, while nutritionists focused on poor diet, hypoglycemia or even dehydration. It became clear that no single discipline could adequately explain or address these physiologic events, prompting a deliberate shift toward integrated, multidisciplinary training. That process reshaped my foundational knowledge of human physiology, with an emphasis on neural structure and function, cognition, communication processes, and human performance. **APPLICATION:** During a 3-year journey of structured training, I sought input from renown aerospace and high-altitude scientists, clinicians, and biomedical engineers. My training included key coursework from the first two years of medical school, a fellowship course in electroencephalography, and laboratory work using a hypobaric chamber and MRI systems. This interdisciplinary training paradigm enabled me to conduct research aimed at pressing issues in the cockpit. Stakeholders and study sponsors identified the need for formal training of individuals seeking a career in aerospace physiology, resulting in the

establishment of a Masters of Aerospace Physiology multidisciplinary training program. This experience reflects the interdisciplinary legacy of Mary F. Foley, demonstrating how crossing professional boundaries strengthens both aerospace practice and education.

Learning Objectives

1. The audience will recognize the limitations of siloed training in aerospace physiology and human performance.
2. The participant will be able to describe how structured interdisciplinary education can improve operational decision-making and safety outcomes.

[300] SYNERGY OF INTERDISCIPLINARY TEAMS IN BOUNDLESS FRONTIERS: CLINICAL AND OPERATIONAL LESSONS FROM SPACE HEALTH PRACTICE

Rowena Christiansen

The University of Melbourne Medical School, Victoria, Victoria, Australia

(Education - Tutorial / Review)

INTRODUCTION: Mary F. Foley's legacy exemplifies the power of multidisciplinary training and synergistic collaboration in advancing aviation and aerospace medicine. As human activity expands into increasingly extreme and resource-limited environments, particularly in spaceflight, the ability to integrate diverse clinical, operational, educational, and leadership skill sets within interdisciplinary teams is essential to ensuring safe, effective, and ethical health care delivery. **TOPIC:** This presentation profiles the multidisciplinary career of an Australian clinician whose practice integrates emergency medicine, aviation medicine, space health, disaster and emergency response, medical education, and health systems leadership, underpinned by formal training in law, business, and the humanities. Cross-disciplinary engagement was driven by repeated exposure to complex operational environments, rural and remote medicine, aeromedical retrieval, disaster response, and long-duration spaceflight planning where clinical decision-making intersects with governance, ethics, resource management, and international collaboration. The integration of legal, managerial, educational, and humanistic perspectives alongside clinical expertise enables systems-level thinking, enhanced risk assessment, and creative problem-solving in high-risk, time-critical, and resource-constrained settings. Examples from space health education and research illustrate how this breadth supports informed prioritisation and ethical judgement when conventional pathways of care, evacuation, or specialist support are unavailable. **APPLICATION:** Drawing on experience within multidisciplinary and international teams, this presentation highlights how synergistic collaboration improves patient safety, operational resilience, and innovation in emerging domains such as space medicine. Effective team structures characterised by shared mental models, clear communication, role flexibility, and mutual respect across disciplines enable adaptive responses to novel clinical challenges. Looking forward, the presentation advocates for deliberate cross-disciplinary training pathways and team-based frameworks to support future

space exploration, ensuring that health systems evolve in parallel with expanding human activity beyond Earth. In emulating Mary F. Foley's principles, interdisciplinary teams remain central to advancing clinical excellence and safeguarding human health in boundless frontiers.

Learning Objectives

1. Participants will be able to describe how multi-disciplinary training supports decision-making in operational and spaceflight environments.
2. The audience will gain an awareness of how to identify key characteristics of effective inter-disciplinary teams in aerospace medicine.
3. Participants will gain insights into how to apply principles of synergistic collaboration to future space health challenges.

Thursday, 05/21/2026, 1:30 PM

Plaza F

[S-49] SLIDE: AND THE BEAT STILL GOES ON...AND ON AND ON

Chair: Warren Silberman

Co-Chair: Dacia Boyce

[301] SUBCLINICAL CARDIOVASCULAR DISEASE RISK STRATIFICATION IN AIRCREW USING PREDICTIVE ECG ARTIFICIAL INTELLIGENCE

Wiaam Elkhatib[1], Daniel Sykora[2], Darshankumar Raval[2], S. Michael Gharacholou[1]

[1]Mayo Clinic Hospital, Jacksonville, FL, USA; [2]Mayo Clinic Hospital, Rochester, MN, USA

(Original Research)

INTRODUCTION: Aircrew require regulatory medical screening which includes an electrocardiogram (ECG) and face unique occupational cardiovascular risks. Artificial intelligence (AI) algorithms are revolutionizing healthcare screening but remain underexplored in high-risk occupational cohorts. We investigated the efficacy of a proprietary, validated ECG-AI algorithm in cardiac age and subclinical heart failure evaluation in aircrew. **METHODS:** We retrospectively studied asymptomatic aircraft pilots assessed at a tertiary care hospital. The cohort comprised of 205 pilots (median age 52 years, 91% male). ECG AI-predicted cardiac age (years), sex, diastolic dysfunction grade (0-3), and heart failure with reduced ejection fraction (HFrEF; left ventricular ejection fraction [LVEF] <35%) probabilities were collected. AI-predicted values were compared to actual patient data via medical record review. Adjusted

models were performed. Inter-rater reliability was studied between AI-prediction versus diastolic grade. This study received approval from the Mayo Clinic Hospital IRB. No animal subjects were involved. **RESULTS:** Mean biologic age resembled AI-predicted cardiac age (52.3 vs 53.6 years, p=0.038). Mean AI probability of male sex was 90% in male (n=187) and 7% in female (n=18) pilots (p<0.001). 52 pilots had an available echocardiogram (median echocardiogram-ECG time 62 days [IQR 993 days]). 4 had diastolic dysfunction (3 with grade 1 and 1 with grade 3) with excellent AI-predicted diastolic dysfunction grade concordance (Kappa=1.00, p<0.001). No pilots had HFrEF (mean LVEF 61.4%±5.1%, range 45%-71%). For every 10% increase in the ECG AI-predicted probability of HFrEF, an unadjusted measured LVEF decrease was demonstrated (3.9%, p=0.005). Age and sex adjusted models for HFrEF, however, displayed loss of significance (3.8%, p=0.934). **DISCUSSION:** Pilot biologic age closely reflected ECG AI-predicted cardiac age. Diastolic dysfunction grading between ECG-AI and measured showed excellent agreement. ECG-AI probability of HFrEF was appropriately low, showing directional correlation of reduced LVEF probability with measured LVEF. Limitations included sample size and the retrospective nature of study. ECG-AI algorithms demonstrate good performance in screening for subclinical cardiac disease in aircrew for risk stratification. Further study could optimize high value care and screening in this unique population.

Learning Objectives

1. Artificial intelligence algorithms remain underexplored in high-risk occupational cohorts like aircrew, with ECG-AI algorithms demonstrating acceptable performance in this occupational group.
2. Pilots display an overall low prevalence of significant cardiovascular disease including heart failure and appropriate cardiac age relative to biologic age.

[302] Moved to “Medicine Risk and Readiness”, Monday, May 18, 4 p.m.

[303] PACEMAKER IMPLANTATION IN MILITARY AIRCREW: TWO CASE REPORTS WITH SUCCESSFUL RETURN TO FLIGHT DUTY

Denis Bron[1], Lysette Broekhuizen[2], Gary Gray[3], Philip Laird[4], Norbert Guetler[5], Thomas Syburra[6], David Holdsworth[7], Olivier Manen[8], Eddie Davenport[9]

[1]Aeromedical Centre Swiss Air Force, Duebendorf, Switzerland; [2]Department of Cardiology, University Medical Center Utrecht and Central Military Hospital, Utrecht, The Netherlands, Utrecht, Netherlands; [3]Canadian Forces Environmental Medical Establishment, Toronto, Ontario, Canada; [4]Canadian Forces Environmental Medical Establishment, Toronto, Ontario, Canada; [5]Germain Air Force, Cologne, Germany; [6]Hospital de la tour, Geneva, Switzerland; [7]MA DPhil DAvMed FRCP RAMS, Henlow, United Kingdom; [8]Centre universitaire des Saints Pères, Toulon Cedex 9, France; [9]Retired USAF Cardiologist, Wright Patterson Air Force Base, OH, USA

(Original Research)

BACKGROUND: Pacemaker (PM) implantation in active military aircrew presents a unique aeromedical challenge, particularly regarding performance under increased G-forces. **CASE PRESENTATION:** Two male military pilots aged 62 and 61 years with high-grade AV blocks were detected on resting ECG during routine aeromedical examination. One pilot was asymptomatic: the other reported reduced exercise capacity during sport activities. Cardiovascular risk factors were well controlled; slightly increased cholesterol levels were detected in both cases. 24-hour Holter ECG documented a complete intermittent AV block lasting 14 seconds in the first pilot and a complete permanent AV block with associated sinus dysfunction leading to a maximum pause of 8.8 seconds in the second. Transthoracic echocardiography and cardiac MRI with adenosine stress excluded ischemic origin and structural heart disease in both cases, including sequelae of myocarditis or necrosis, with no fibrosis findings. Management and Outcome: Both pilots received dual-chamber pacemakers in summer 2025. Following completion of post-implant cardiological follow-up, both successfully completed stress testing in the centrifuge up to a maximum of 6G without complications. The PM systems functioned without any adverse effects. Both pilots were granted fit;to fly for PC-7 aircraft with a qualified pilot on board. **CONCLUSION:** These cases demonstrate that return to military flight duty is possible following PM implantation with careful evaluation and successful centrifuge stress testing.

Learning Objectives

1. Pilots are getting older and pacemaker implantation may become necessary.
2. Primary cardiac disease prevention by reducing cardiovascular risk factors is essential.
3. In cases of pacemaker implantation in pilots and for subsequent revalidation of fitness to fly, a cardiologist network can provide valuable support.

[304] PARTIAL ANOMALOUS PULMONARY VENOUS RETURN (PAPVR) AS A RARE CAUSE OF RIGHT HEART STRAIN IN A HELICOPTER PILOT DIAGNOSED BY COMPUTED TOMOGRAPHY

Daniel Veit[1], Kai Nestler[1], Hans-Juergen Noblé[1], Norber Guettler[1], Martina Grundwald[1], Paul Martin Bansmann[2], Lennart Stroeker[1], Josef Ehling[1]

[1]German Air Force Centre of Air and Space Medicine, Cologne, Germany; [2]Radiology Department, Hospital Porz, Cologne, Germany

(Education - Case Study)

INTRODUCTION: In our case a young helicopter pilot showed ecg abnormalities during a periodic medical examination (PME). Further imaging detected PAPVR where oxygen enriched blood flows from the pulmonary veins into the right atrium, leading to abnormal right heart strain. By a frequency of 1% of all heart defects, this is a rare anatomical variant that can remain

clinically asymptomatic for a long time. **BACKGROUND:** PAPVR can remain asymptomatic for a long time and is often seen associated with syndromal diseases. Symptoms of PAPVR include syncopal events, which carry a high risk of sudden inflight incapacitation. There is no case in literature describing the impact of PAPVR on avation medicine. Literature: Dillmann J et al Imaging of Pulmonary Venous Developmental Anomalies. AJR 2009. **CASE PRESENTATION:** A 42-year-old helicopter pilot underwent a PME that showed abnormalities in ECG. Additional echocardiography showed significant dilated right heart chambers. CT-Angiography (CTA) revealed a lung vein miss-connection as well as an atrial septal defect (ASD) as the cause of the right heart strain. The pilot was referred to a specialized cardiac surgery department, where the vein misconnection and the ASD were successfully operated using the 'Warden procedure'. After cardiac rehabilitation medical follow up examinations already showed no remaining functional impairment 6 month after the surgery. As the operation was successful with fast and complete cardiac functional rehabilitation the prognosis for taking on flying duties is excellent according to our cardiologic specialists. The pilot is currently fully reintegrated into his unit, but is not yet cleared to fly. A decision on his fitness to fly will be made at the earliest one year after the surgery and after a new interdisciplinary assessment including actual imaging and functional testings. **DISCUSSION:** Pilots undergo regular medical check-ups due to the exposed nature of their workplace and the stresses of flight which are remarkable higher in a military setting. Modern imaging comes into focus in the event of abnormal findings. CTA combines low radiation exposure with very high resolution and is a safe and highly accurate diagnostic tool in the hand of an experienced diagnostician. Our case underscores the importance of reliable imaging, in aviation medicine, in this case from the perspective of an active military helicopter pilot.

Learning Objectives

1. Understand the relevance of ECG screening and the options of additional diagnostic tools.
2. Understand rare causes of right heart strain like PAPVR as well as frequent causes like pulmonary embolism.
3. Understand the relevance of advanced computed tomography imaging in aviation.

[305] MISSION-SPECIFIC FEASIBILITY OF CARDIOPULMONARY RESUSCITATION IN COMMERCIAL SPACEFLIGHT: A SIMULATION-INFORMED OPERATIONAL MODEL

Lydia Johnson Kolaparambil Varghese[1], Jan-Jakob Völlering[2], Felix Liebold[3], Gonçalo Torrinha[4], Gerrit Jansen[1], Manuel Michno[5], Konstantinos Vergos[6]

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(Original Research)

INTRODUCTION: Commercial suborbital and orbital spaceflight increasingly includes non-professional participants with heterogeneous medical risk. Sudden cardiac arrest is rare but mission critical. CPR in microgravity is constrained by loss of anchoring, restricted cabin geometry, limited crew capacity, and environmental stressors (notably CO_2 accumulation), yet the literature remains technique-centric rather than mission-decisional. **METHODS:** We synthesized quantitative and operational evidence on CPR in microgravity and analogs, and the first in-orbit CPR evaluation (Polaris Dawn, 2025). Manual techniques and mechanical compression systems were abstracted for compression depth/rate compliance, rescuer workload, and operational constraints. We developed a simulation-informed, feasibility model with three domains, Biomechanical (B), Operational (O), and Sustainability (S), built from weighted, normalized components (compression quality and anchoring; geometry/deployability/training; duration, transition success, resource endurance, and post-ROSC support). Overall feasibility was computed as: $F = 100 \cdot (B^{\alpha} \cdot O^{\beta} \cdot S^{\gamma})$ (α=0.40, β=0.35, γ=0.25). A safety floor enforced $F = 0$ when effective compressions or minimal sustainment were unattainable. The model was applied to parabolic, suborbital, commercial orbital, and long-duration profiles. **RESULTS:** Manual CPR exhibited rapid performance decay and failed sustainability thresholds, limiting it to brief bridging. Mechanical compression preserved biomechanical performance but reduced feasibility through deployment and power/stowage constraints, environmental penalties (CO_2 rise), and crew task loading. A recurrent failure mode emerged: scenarios with technically adequate compressions (and potential ROSC) frequently remained operationally infeasible because post-ROSC care requirements exceeded available mission resources, lowering S despite preserved compression quality. Model outputs therefore stratified CPR as bridging-only in suborbital flight, conditionally feasible in orbital missions with pre-staged mechanical compression plus anchoring and environmental control, and feasible in long-duration missions with integrated resuscitation and post-ROSC systems. **DISCUSSION:** CPR in commercial spaceflight is a mission-dependent systems capability, not a universal onboard standard. This model provides quantitative, auditable requirements to guide spacecraft design, crew training, and medical certification.

Learning Objectives

1. The participant will be able to evaluate the biomechanical, operational, and sustainability constraints that determine whether cardiopulmonary resuscitation is feasible across suborbital, orbital, and long-duration spaceflight missions.
2. The participant will be able to apply a simulation-informed feasibility model to assess when manual or mechanical CPR may provide clinical benefit versus false reassurance in commercial spaceflight environments.
3. The participant will learn how post return-of-spontaneous-circulation care requirements influence mission-level medical decision-making, spacecraft design, and crew training in aerospace operations.

Thursday, 05/21/2026, 1:30 PM

Governor's 10

[S-50] SLIDE: CRITICAL SKILLS: COMMERCIAL SPACE AND ANALOGS

Chair: Thomas Hoffman

Co-Chair: Ferguson Scott

[306] PRE-FLIGHT, HANDS-ON MEDICAL SKILLS TRAINING FOR NON-PHYSICIAN CREWMEMBERS: THE UTHEALTH HOUSTON ASTRONAUT MEDICAL TRAINING PROGRAM

Samuel Beger, Eric Power, Nicolas Heft, Samuel Beger, Kris Lehnhardt

McGovern Medical School at the UTHealth Science Center at Houston, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: As human spaceflight expands to include longer missions, deep space exploration, and increased commercial participation by individuals with less rigorous health screening, medical events are more likely to occur in space. Many crews will not include a member with formal medical training. To address this gap, UTHealth Houston developed a pre-flight, hands-on medical training program for non-physician astronauts. The curriculum emphasizes medical procedures and clinical decision-making relevant to spaceflight while accounting for the operational constraints of an austere environment. **OVERVIEW:** UTHealth Houston astronaut medical training sessions are taught by board-certified physicians at a large, urban academic medical center and Level I trauma facility. Training includes hands-on experience with real patients and focuses on high-yield spaceflight skills such as point-of-care ultrasound, laceration and wound repair, intravenous cannulation, and urinary catheterization. Additional instruction covers airway management, including intubation, treatment of common dental and ocular problems, and selected invasive procedures in intensive care settings. The educational approach emphasizes recognition of medical problems, execution of appropriate treatments or procedures, and adaptation to the spaceflight environment. Training is delivered over five days using in-hospital clinical exposure, simulation-based scenarios, and structured skills stations led by experienced clinicians. Real-time feedback is provided to improve confidence, competence, and procedural skill acquisition. With over a decade of implementation, the program has supported training for more than 60 NASA astronauts and astronaut candidates. Commercial spaceflight organizations have also recognized the value of this hands-on training model. Past participants report improved confidence in recognizing medical emergencies and performing critical procedures during spaceflight. **DISCUSSION:** Training non-physician astronauts in essential medical skills is a key component of modern space exploration and aligns with future space medicine priorities. This program offers a scalable model to enhance crew medical capability. As missions expand in access, complexity, duration, and distance, experiential medical training will play an important role in improving crew safety and mission success across governmental and commercial sectors.

Learning Objectives

1. The audience will learn about the rationale for hands-on medical training of non-physician astronauts in the context of expanding spaceflight participation.
2. The audience will be able to identify core medical skills emphasized in an astronaut medical training program and their relevance to the spaceflight environment.
3. An individual interested in creating a similar program would better understand how to prepare non-clinicians to identify and treat relevant medical issues in an austere environment.

[307] TRAINING ONCE IS NOT ENOUGH: PREDICTABLE SKILL DECAY AND IN-FLIGHT SUSTAINMENT FOR EXPLORATION-CLASS MISSIONS

Anushka Gupta[1], Tooba Tahir[2], Dhivyashree Bangaru-Raju[3], Deepasaree Bangaru-Raju[4], Carole Dangoisse[5]

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(Education - Tutorial / Review)

INTRODUCTION: Long duration exploration missions will require astronauts to independently manage medical and technical emergency procedures without real time ground support. Terrestrial data demonstrates that skill fade begins within weeks, yet current astronaut training relies heavily on pre-mission practice. This review examines evidence showing how existing knowledge on risk of skill fade can inform countermeasures for exploration class missions. **TOPIC:** Across studies, measurable skill decay was found to occur between 1 to 3 months of non-use with complex psychomotor procedures showing the steepest decline. Airway management proficiency deteriorated rapidly: intubation performance worsened after several months without practice and emergency cricothyrotomy skills were found to decline at 1 month, with 0% of participants meeting passing criteria by 6 months. Surgical skills such as laparoscopy degraded within 4 months, with demonstrable declines in force control and instrument precision. Cognitive knowledge decayed more slowly but was insufficient to maintain procedural accuracy. Four countermeasures provided consistent benefit: 1) low dose, high-frequency practice, which maintained 91% retention at six months for vascular access skills and >90% CPR retention at 7-10 months, 2) rapid-cycle deliberate practice, 3) feedback-rich simulation and 4) booster sessions at 1-3 month intervals, aligned with known decay curves. **APPLICATION:** These findings highlight a significant operational challenge for spaceflight. Without deliberate in-flight sustainment, critical skills may fall below competency thresholds before the first onboard emergency. Countermeasures may include embedding scheduled monthly or bimonthly microsimulation for medical and technical tasks, including VR with haptic feedback, using compact feedback-capable training devices to compensate for instructor absence and employing

AI-guided onboard refresher modules. Competency tracking systems could be used to monitor decline and trigger targeted retraining. Although no studies were conducted in microgravity, decay patterns across terrestrial analogues were highly consistent, suggesting that skill loss in space is predictable and can be mitigated with structured sustainment rather than increased pre-mission intensity alone. These results provide a data driven framework for designing in-flight training that preserves procedural competence and mission safety for the duration of exploration-class missions.

Learning Objectives

1. The participant will be able to describe the time course and severity of procedural skill decay for medical and technical tasks relevant to long duration spaceflight with emphasis on high risk psychomotor skills.
2. The participant will be able to evaluate evidence based countermeasures, including low dose high frequency practice, simulation and booster training for mitigating skill fade during exploration class missions.
3. The participant will be able to apply terrestrial skill decay data to inform the design of structured in flight training and competency sustainment strategies for spaceflight operations.

[308] SUSTAINING HUMAN PERFORMANCE IN COMMERCIAL SPACEFLIGHT: OPERATIONAL INSIGHTS FROM AXIOM SPACE ASTRONAUT MISSIONS

Rahul Goel, Lucie Low

Axiom Space, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: As human spaceflight transitions from a government-only endeavor to a mixed commercial ecosystem, understanding and sustaining human performance has become an urgent priority for aerospace medicine. Performance decrements related to microgravity, circadian disruption, workload, and sensorimotor adaptation directly affect mission safety and operational readiness. With the International Space Station (ISS) approaching retirement and commercial missions introducing more heterogeneous crews, there is a timely need to generate operationally relevant performance data that can inform medical standards, risk mitigation strategies, and performance sustainment across aerospace domains. **OVERVIEW:** Axiom Space has conducted research-focused Astronaut Missions and is developing a commercial space station to support sustained access to low-Earth orbit (LEO). Across four ISS missions (Ax-1 through Ax-4), more than 150 research projects have been completed, with nearly half focused on human performance–relevant domains. These efforts include investigations of cognitive performance, attention, workload, sleep, fatigue, sensorimotor function, and multimodal physiological monitoring. Collectively, these missions provide near-term continuity of performance research during the LEO transition while enabling participation by new investigator

communities. **DISCUSSION:** The operational and clinical significance of this work lies in its direct applicability to performance monitoring, fatigue risk management, countermeasure development, and mission planning for increasingly diverse crews. Early results—reflected in nearly two dozen peer-reviewed publications from the first two missions—demonstrate how commercial spaceflight missions can generate meaningful human performance data in operationally realistic environments. These findings advance aeromedicine and human performance by extending evidence-based insights beyond traditional astronaut cohorts, supporting the development of performance standards relevant to exploration, commercial, and analog extreme environments. Our mission supports dual-use and international collaboration by engaging government agencies, academic institutions, and private partners across multiple nations. This presentation will highlight selected findings and outline opportunities for investigators to engage in future missions to the ISS or to our station, strengthening academic and international collaboration during the evolving commercial LEO era.

Learning Objectives

1. The audience will learn about how commercial human spaceflight missions generate operationally relevant human performance data to inform aerospace medical standards, fatigue risk management, and countermeasure development during the LEO transition.
2. The presentation will help identify opportunities for investigators and international partners to engage in future commercial ISS and LEO station missions to advance human performance research across diverse crew populations.

[309] FURTHER ANALYSES OF COMMERCIAL SPACEFLIGHT BIOMEDICAL DATA

Mark Shelhamer[1], William Queale[1], Arya Kazemnia[2], Elia Showalter[3]

[1]Johns Hopkins University School of Medicine, Baltimore, MD, USA; [2]Johns Hopkins University, Baltimore, MD, USA; [3]Bryn Mawr School, Baltimore, MD, USA

(Original Research)

INTRODUCTION: Biomedical studies have been carried out by the crews of several commercial orbital spaceflights. These studies span a range of disciplines, including sensorimotor function, cognition, and physiological monitoring. Analysis of these datasets have been presented by the respective investigators. Here, a new analysis of the sensorimotor data is presented, along with an exploratory investigation that examines combined data from multiple disciplines. **METHODS:** 1) The sensorimotor project examines otolith asymmetry, manifest by vertical or torsional binocular alignment. Misalignment is a manifestation of otolith asymmetry, which has been connected to susceptibility to space motion sickness (SMS). 2) For the multivariate study, physiological parameters were acquired by wearable sensors and include measures of heart rate, physical activity, sleep, and skin temperature. Data were acquired from (among others) Inspiration4 (I4, September 2021), Polaris Dawn (PD, September 2024), and Fram2 (F2, April 2025). **RESULTS:** 1) Sensorimotor. Analysis is based on the hypothesis that

adaptive behavior in preflight data demonstrates an adaptive capability that is later expressed in adaptation to spaceflight. The test looks for a pattern in preflight ocular-skew data: a zig-zag or alternating pattern that indicates trial-to-trial corrections. This pattern is more prevalent in those subjects without SMS. With a suitable threshold, 3 of 4 non-SMS subjects were scored correctly, and all 8 with SMS. 2) Multivariate analysis. As a general measure disruption between body systems, we derive Functional Entropy (FE), which quantifies "discordance" or "misalignment" between various physiological parameters, relative to preflight baselines. This initial use of FE makes use of the available physiological measures, with sporadic sampling and uncertain measurement reliability. The results show a dramatic spike in FE at the time of launch and orbital entry, and substantial ongoing peaks in those crew who had SMS. Those same subjects also exhibited other forms of "discomfort" during the flight, as assessed by viewing publically available cabin video. **DISCUSSION:** Entropy measures might capture essential features of "good" and "bad" spaceflight adapters, which raises the possibility of flagging undesired deficient adaptation and intervening appropriately.

Learning Objectives

1. Understand how preflight vestibular testing might forecast inflight astronaut performance and wellbeing.
2. Understand how entropy can capture functional alignment of body systems and their disruption in spaceflight.

[310] A STRUCTURED AEROMEDICAL EVALUATION OF THREE SPACE ANALOGUE MISSIONS: A FLIGHT SURGEON'S PERSPECTIVE

Gaurab Ghosh[1], Angad Pratap[2], Yashvir Singh Dahiya[1], Sowgandhi Chaturvedula[1], Punyashlok Biswal[1], Polash Sannigrahi[3], Stuti Mishra[1], Anirudh Srikant[1]

[1]Institute of Aerospace Medicine, Indian Air Force, Bengaluru, India; [2]Indian Space Research Organisation, Bengaluru, India; [3]No. 1 Aeromedical Training Centre, Indian Air Force, Hindon, Ghaziabad, India

(Original Research)

INTRODUCTION: The challenges of human spaceflight necessitate robust ground-based simulations. While many analogue missions exist, a standardized framework for evaluating their effectiveness from aeromedical and human factors point of view is crucial for operational preparedness for real spaceflight. This paper presents a comparative analysis of three distinct space analogue missions carried out in India in 2025, from the perspective of a flight surgeon. **METHODS:** Three analogue scenarios were evaluated: an 18-hour Crew Module Simulation Trial, a 10-day lab-based Isolation and Confinement mission, and a 10-day high-altitude, resource-critical analogue mission. A standardized, statistically validated rating scale (Cronbach's alpha – 0.82) was prepared for the assessment. This multi-faceted scale examines a space analogue mission from the perspective of relevance, research objectives, fidelity of the

induced stressors, human factors and crew safety at all times of the mission. The researchers and flight surgeons who participated in all three missions were asked to rate each mission based on the rating scale. **RESULTS:** The 10-day lab-based analogue mission proved the most suitable, overall, in simulating isolation, operational protocols, and possessed a strong safety culture. The 18-hour Simulation Trial appropriately simulated confinement and mission protocols. The high-altitude mission was effective in providing stressors of an extra-terrestrial exploration. **DISCUSSION:** Analogue missions are valuable, cost-effective research modalities, but lack an ideal model. This structured evaluation provides a novel perspective of analysing different ground-based space analogue experiments and demonstrated the importance of standardizing assessments across contextual, human, and safety factors. The high safety scores in controlled facilities contrasted sharply with the low safety scores in the remote field environment, highlighting a critical need for mandated safety audits in future, especially in cases where the analogue habitats are outsourced.

KEYWORDS: human spaceflight programme, space analogue missions, aeromedical assessment, checklist, flight surgeon

Learning Objectives

1. Understand the human factors considerations and the standards of human space research testbeds while designing a space analogue mission.
2. Ensures optimal resource utilisation and safety of both analogue crew and ground crew, especially in private analogue missions which can be resource-critical or safety-critical.

[311] MAGSBH: A MULTI-AGENTIC AI GOVERNANCE SYSTEM FOR BEHAVIORAL HEALTH IN ANALOG ASTRONAUT ICE MISSIONS

Susan Jewell[1], Emmy Jewell[1], Sebastian Valence[2], Surabhi Sonawane[3], Madhumitha Srinivasan[4], Raúl Mariani Galarza Galarza[5], Krys Strand[6]

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(Original Research)

BACKGROUND: Isolated, confined, and extreme (I.C.E.) mission environments pose significant behavioral health, cognitive, and team dynamics risks during long-duration spaceflight and spaceflight-relevant training. Conventional psychological support models are limited by delayed communication and a lack of contextual immediacy. The Multi-Agent Governance System for Behavioral Health (MAGSBH) was developed to provide ethically governed, human-in-the-loop behavioral support through a decentralized, explainable artificial intelligence architecture. **METHODS:** MAGSBH was implemented and evaluated during seven MMAARS Virtual Analog Astronaut missions involving 35 trained participants organized into

seven five-person crew teams. All participants were graduates of the MMAARS Virtual Analog Astronautics Training Program and operated under standardized mission protocols emphasizing the MMAARS 5xCs (Communication, Collaboration, Cooperation, Cohesion, Conflict Resolution) and 4xPs (Physical, Physiological, Psychological, Philosophical/Spiritual). The system employed a TRIAD multi-agent architecture consisting of KIRK (ethical governance), EVE (non-clinical wellness support), and SpaceGuardianGPT (individual cognitive reflection), operating under established MMAARS governance frameworks. Data sources included structured crew interactions, reflective journals, mission debriefs, and behavioral self-assessments. **RESULTS:** Across all virtual missions, MAGSBH demonstrated operational feasibility and stability within mission workflows. Crews showed improved communication clarity, reduced conflict escalation, enhanced workload distribution, and stronger team cohesion during high-demand mission phases. Participants reported improved emotional regulation and decision pacing. AI behavior remained strictly non-clinical, autonomy-preserving, and explainable. **CONCLUSIONS and FUTURE WORK:** This completed virtual-mission study demonstrates that a decentralized, ethically governed, multi-agent AI system can support behavioral health and team stability in spaceflight-relevant training environments. Future phases will extend validation into MMAARS in-person analog astronaut missions across multiple fidelity levels, including desert, underwater, high-altitude, and parabolic flight analogs, to assess transportability across physical and environmental stressors.

Learning Objectives

1. Describe the role of a multi-agent, human-in-the-loop governance system in supporting behavioral health, cognitive performance, and team functioning during isolated, confined, and extreme analog astronaut missions.
2. Identify key behavioral, psychosocial, and operational indicators used to assess feasibility, usability, and crew acceptability of artificial intelligence–enabled behavioral health support systems in spaceflight-relevant environments.
3. Discuss ethical and human factors considerations, including governance constraints, crew autonomy, and informed consent, when integrating multi-agent artificial intelligence systems into behavioral health monitoring for analog astronaut research.

Thursday, 05/21/2026, 1:30 PM

Governor's 12

[S-51] PANEL: NEUROPSYCHOLOGICAL ASSESSMENT OF AVIATORS

Chair: Joe Wood

Co-Chairs: John Heaton, Ryan Green, Justin Bunn, Kevin Heacock, Monica Malcein

Panel Overview: *This panel will focus on the use of neuropsychological tests for the selection and retention of aviators. The initial presentation will outline key elements of the ACS*

Neuropsychiatry evaluation process, emphasizing the role of individualized psychological test batteries anchored by an internal normative dataset of more than 2,000 evaluations. The second presentation will discuss the use of the Personality Assessment Inventory (PAI) to objectively assess USAF pilots and aircrew for a broad range of mental health symptoms and diagnoses that could impact flight safety and performance, along with establishing normative data. Next will be a presentation discussing the importance of attention in aircrew and describing the utilization of a measure of vigilance (CPT-II) during aeromedical evaluations. The fourth presenter will discuss neurocognitive changes over the lifespan of aviators. The final presentation will discuss the importance of using aviation-specific norms in assessing aircrew.

[312] ASSESSMENT OF AVIATORS WITH ADHD

Joe Wood

USAFSAM, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: Attention is the ability for focused behavior and is a precondition for most mental activities. Pilots are expected to have intact attention to safely fly. Many individuals with mental health disorders experience some decrease in their abilities to focus and concentrate. ADHD, a neurodevelopmental disorder usually diagnosed in childhood, is disqualifying for flying duties primarily due to its symptom pattern that includes sustained difficulties in attention and working memory and resulting negative impact on academic and job performance. For aviators with this condition, neuropsychological tests can be employed to assess for potential decrements in attention. One such test is the Continuous Performance Test-II (CPT-II), a computerized neuropsychological assessment tool commonly used to measure sustained attention and impulsivity. The CPT-II requires individuals to respond to specific target stimuli and inhibit responses to non-targets over a sustained period, generating indices such as omission errors (inattention), commission errors (impulsivity), reaction time, and reaction time variability. In the context of a broader ADHD evaluation, often involving collateral interviews and academic transcripts, the test can be a useful supplementary tool. **METHODS:** Aviators evaluated at the ACS between 2020-2025 for a diagnosis of ADHD and given the CPT-II were included for this study. There were seven aviators who met criteria. Six of seven were male (85.71%) and the mean age was 28.71. Three were flight surgeon applicants, two were trained loadmasters, one was a pilot applicant, and one was a trained Combat Systems Officer. **RESULTS:** Of those with ADHD diagnoses, 2 of 7 (28.57%) received a waiver. Of the key indices on the CPT-II, mean scores were as follows: Omission Errors: 1.71, Commission Errors: 13.71, Hit Reaction Time: 397.30, Hit Reaction Time Standard Deviation: 4.61, and Detectability: 0.73. **DISCUSSION:** Intact attentional capabilities are a necessary component for any aircrew duty. For individuals with a history of an ADHD diagnosis or attentional difficulties, the CPT-II and other neurocognitive tests can be useful additions in a comprehensive evaluation.

Learning Objectives

1. The audience will understand the importance of attention in aviators.

2. The audience will be provided guidance and norms for conducting ADHD evaluations utilizing the CPT-II.

[313] APPLIED NEUROPSYCHIATRIC TESTING IN USAF AVIATION: CURRENT PRACTICES AND PROGRAM-LEVEL TRENDS

John Heaton

USAFSAM, Wright-Patterson AFB, OH, USA

(Education - Program / Process Review)

BACKGROUND: The Aeromedical Consultation Service (ACS) Neuropsychiatry Branch supports aeromedical risk assessment and return-to-flying decision-making for United States Air Force aviation through comprehensive psychological evaluation. Accurate characterization of cognitive and psychological functioning is essential to aeromedical judgment, particularly when integrating individual clinical findings with established norms and standards. **DESCRIPTION:** This presentation outlines key elements of the ACS Neuropsychiatry evaluation process, emphasizing the use of individualized psychological test batteries tailored to clinical presentation, occupational demands, and aeromedical context. These evaluations are supported by an internal normative dataset of more than 2,000 neuropsychological and personality assessments spanning multiple cognitive and psychological instruments. To provide context beyond ACS evaluations, findings from the Medical Flight Screening–Neuropsychiatry (MFS-N) program are also reviewed. Baseline data from over 52,000 pilot applicants are used to describe current trends in cognitive and psychological performance among this population. **DISCUSSION:** Descriptive findings from both ACS and MFS-N illustrate how neuropsychiatric testing is applied across different points in the aviation continuum, from baseline testing during the initial flight physical to ACS evaluation. Together, these programs demonstrate the value of integrating individualized assessment with large-scale normative data to inform aeromedical judgment. This overview highlights how structured testing, interpreted within appropriate clinical and operational context, supports consistent, defensible decision-making and reflects continued refinement in the application of neuropsychiatric evaluation within USAF aviation.

Learning Objectives

1. Describe the structure and clinical rationale of the ACS Neuropsychiatry evaluation process, including the role of individualized psychological test batteries and internally derived normative data in aeromedical risk assessment.
2. Explain how baseline neuropsychiatric screening data from the Medical Flight Screening–Neuropsychiatry (MFS-N) program and referral-based ACS evaluations together inform aeromedical judgment across different stages of the aviation continuum.

[314] PERSONALITY ASSESSMENT INVENTORY (PAI) NORMATIVE DATA FOR A CLINICAL SAMPLE OF USAF PILOTS AND AIRCREW

Justin Bunn

U.S. Air Force, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: The assessment of human characteristics relies on comparing an individual to a representative sample, allowing for standardized comparisons of traits like personality. Air Force aviators and aircrew constitute a highly selected and distinguished occupational group operating in potentially high-risk professions. There are often challenges in assessing these individuals utilizing nationally representative norms because scores, while appearing "average" for the general population, may not be truly representative of their functioning, making the establishment of normative data specific to this population essential for accurate psychological assessment. **METHODS:** This study is a retrospective review of 374 United States Air Force (USAF) pilots and aircrew who were evaluated at the Aeromedical Consultation Service (ACS) for a waiver recommendation following a mental health diagnosis. All participants underwent a comprehensive battery of cognitive and psychological assessments, which included the Personality Assessment Inventory (PAI). Descriptive statistics were used to analyze the PAI data for the combined sample, as well as for subgroups based on gender and grade (enlisted/officer). The sample includes 325 (86.89%) male and 49 (13.11%) female aviators and aircrew with 284 (75.93%) officer and 90 (24.07%) enlisted. **RESULTS:** Descriptive statistics, including means and standard deviations, for all PAI clinical, treatment, and validity scales will be reviewed for this unique cohort of military aviators. Normative data are provided for the combined sample and are also stratified by gender and military grade. Comparisons between these aviator-specific norms and the general population norms are highlighted to illustrate key differences in the baseline personality profiles. **DISCUSSION:** The results indicate that USAF pilots and aircrew present a distinct personality profile on the PAI when compared to the general population. The establishment of this aviator-specific normative dataset provides a more accurate and sensitive baseline for assessing psychological fitness for duty. Using these norms, aeromedical evaluators can better detect subtle but significant changes in a pilot's psychological functioning, improving the reliability of the waiver process and ultimately enhancing operational safety.

Learning Objectives

1. The audience will learn about the limitations and potential risks of using general population psychological norms with specialized populations comparative to USAF pilots and aircrew.
2. The participant will understand the value of population-specific normative data for evaluating aviators and aircrew.

[315] EXPLORING NEUROCOGNITIVE PERFORMANCE AND ASSESSMENT IN USAF PILOTS ACROSS AGE GROUPS

Monica Malcein

USAFSAM Aeromedical Consultation Service, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: Many cognitive functions are known to decline with age in the general population, although less is known about military pilots, a select group generally of better physical and mental health. For neuropsychological measures, standard scores are typically age-corrected to account for cognitive decline considered normal, although applying this correction can remove useful information. As flight operations pose high cognitive demands, even mild decrement in performance that might be considered normal age-related change could have aeromedical significance. **METHODS:** Analyses were conducted on test scores of USAF pilots referred to the ACS requiring a waiver for flight status. 321 pilots were evaluated 2013-2024, divided into age groups: 20-29 (N=34), 30-39 (N=151), 40-49 (N=122) and 50-59 (N=14). Performance across age groups was examined on subtests and index scores of the MAB-II, a measure of intellectual functioning. The MAB-II produces standardized scores, which are corrected for age. To further assess for change in functioning, raw scores on subtests were also compared. **RESULTS:** These USAF pilots had a FSIQ of 125, VIQ of 120 and PIQ of 127, consistent with findings in pilots not referred for clinical evaluation. FSIQ and VIQ were not significantly different across age groups. Mean PIQ increased from standard score of 124.8 in the 20's group to 129.7 in the 40's group. Raw scores indicated that pilots maintained the same level of performance across age groups on a number of subtests, without the expected decline seen in the general population, resulting in increased standard scores. Subtle declines were observed in the older pilots, on average, when raw scores were examined. **DISCUSSION:** Findings provide information on the cognitive profile of military pilots across age cohorts referred for clinical evaluation. Standard scores suggest that verbal functioning remains, but that performance scores increase across age groups. Looking at raw scores, it is evident that there are subtle changes in some areas with increased age. Given that even mild decrements in performance could have aeromedical implications, assessment may be enhanced by removing age-corrections. Understanding of the distribution of neuropsychological testing scores among trained pilots across the age span could improve aeromedical evaluation process.

Learning Objectives

1. Describe patterns of neurocognitive performance across age groups of USAF pilots referred for clinical evaluation as measured by both age-corrected standard scores and raw scores.
2. Explain why removing age-corrections from standardized test scores may improve the aeromedical evaluation process for pilots.

[316] EXECUTIVE FUNCTIONING IN PROSPECTIVE PILOTS ASSESSED FOR ADHD

Ryan Green

Aerospace Neuropsychology Services, Layton, UT, USA

(Original Research)

INTRODUCTION: Attention-Deficit/Hyperactivity Disorder (ADHD) affects approximately 5–7% of children and 2–5% of adults worldwide, with a substantial proportion pursuing safety-sensitive occupations, including aviation. ADHD is associated with atypical development and functioning of frontostriatal and frontoparietal networks, particularly involving the dorsolateral prefrontal cortex, anterior cingulate cortex, and related white-matter pathways. These systems support executive functions such as sustained attention, inhibitory control, working memory, planning, task monitoring, and adaptive problem solving. Neuropsychological studies consistently demonstrate that individuals with ADHD may exhibit subtle but meaningful executive inefficiencies. In aviation operations, executive functioning is critical for managing workload, prioritizing tasks, monitoring errors, responding to unexpected events, and maintaining safety margins under time pressure. Executive functioning failures are implicated in the majority of aviation accidents and incidents. Current Federal Aviation Administration (FAA) evaluations for individuals with ADHD do not require comprehensive, performance-based executive functioning assessment in the initial screening, potentially limiting the detection of aeromedically relevant cognitive vulnerabilities. **METHODS:** This study examined prospective aviators evaluated at a U.S. private aviation neuropsychology practice between 2023 and 2025. 187 individuals underwent aeromedical neuropsychological evaluation. Of these, 102 individuals (55%) were referred due to a history of ADHD. Standardized cognitive and executive functioning measures were reviewed, with emphasis on task monitoring, organization, impulsivity, and problem solving. **RESULTS:** Among individuals evaluated for ADHD, 53 of 102 (52%) demonstrated lower performance on one or more executive functioning measures. Deficits were commonly observed in task monitoring, organization, impulse control, and problem solving. **DISCUSSION:** Intact executive functioning is essential for aviation safety. The absence of robust executive functioning requirements in initial FAA ADHD evaluations may allow some aeromedically significant deficits to go undetected. These findings support consideration of additional executive functioning assessment during initial screening of aviators with ADHD.

Learning Objectives

1. Participants will understand the neurobiology and neuropsychology in individuals with ADHD.
2. Participants will understand the high prevalence of lower executive functioning scores in prospective pilots.
3. Participants will understand the importance of intact executive functioning skills to maintain aviation safety.

Thursday, 05/21/2026, 1:30 PM

Governor's 14

[S-52] SLIDE: GRAND ROUNDS: STONES, CROHN'S, AND MORE - A POTPOURRI OF CLINICAL CASES

Chair: Sonya Heidt

Co-Chairs: John Marshall, Caleb James

[317] MEDICAL RISK ASSESSMENT AND OPERATIONAL IMPACTS OF NEPHROLITHIASIS IN A HYPOTHETICAL MALE SPACEFLIGHT CREWMEMBER

Brian Rodriguez[1], Daivd Reyes[2], James Locke[2]

[1]University of Texas Medical Branch, Galveston, TX, USA; [2]NASA, Clear Lake, TX, USA

(Education - Case Study)

INTRODUCTION: Pre-flight aeromedical assessment aims to identify, characterize, and mitigate spaceflight associated medical risks. Physiologic alterations in microgravity result in a cephalad fluid shift, bone resorption, and other changes. These physiologic changes have been shown to produce urinary effects that may increase the risk of renal stone formation, including; hypercalciuria, hypocitraturia, low urinary pH and decreased urine volume. To date, 22 US crewmembers have experienced a total of 36 urinary calculi. A single in-flight stone occurred in a Russian cosmonaut aboard the Salyut 7 in 1982, however the stone passed spontaneously. Still, renal stones are of great concern due to the potential for sudden incapacitation and mission impacts. This presentation examines the aerospace medical and operational implications of nephrolithiasis using a hypothetical case study to inform risk assessment and countermeasure development. **CASE DESCRIPTION:** A hypothetical middle-aged male astronaut is chosen to participate as a prime crewmember for a long duration mission. He is a veteran astronaut, having completed prior long-duration missions. Prior to the flight, he was found to have a 3.5 mm renal calcification on routine screening. Of note, he has a prior history of renal stone 5 years ago which was successfully treated. **DISCUSSION:** Success of current and future spaceflight missions relies on astronauts' operational capability. Probabilistic risk assessments identify symptomatic renal stones as an incapacitating medical event which could require medical evacuation. As we transition to longer duration missions outside of low-Earth Orbit, on the surface of the Moon and Mars, renal stones may become an increasingly important risk due to the difficulty of evacuation. For all crewmembers, there must be an individualized assessment of baseline risk, which is the strongest predictor for future risk in-flight. Currently, all astronauts are screened before and after spaceflight– to assess and mitigate renal stone risk. In addition, other countermeasures such as exercise to reduce in-flight bone loss, and administration of potassium citrate may be useful in reducing the risk of developing renal stones.

Learning Objectives

1. The audience will gain an appreciation for potential aeromedical considerations of renal stones in spaceflight.
2. The audience will gain an appreciation for the impact preflight screening to crew health and mission success.

[318] INTEGRITY UNDER PRESSURE: CERTIFYING CREWMEMBERS FOR SPACEFLIGHT AFTER INGUINAL HERNIA REPAIR

Christine Schwartz, Ethan Stephens

UTMB, Galveston, TX, USA

(Education - Program / Process Review)

INTRODUCTION: Although inguinal hernia repair is common and generally low-risk terrestrially, unique considerations arise in the spaceflight environment. This case describes a hypothetical astronaut diagnosed with an inguinal hernia and explores post-surgical factors relevant to spaceflight medical certification. **BACKGROUND:** Astronaut medical certification requires rigorous evaluation to ensure that crewmembers can safely perform mission-critical tasks in extreme operational environments. Medical conditions that pose a risk of acute incapacitation, impaired mobility, or increase need for in-flight medical intervention are of particular concern. Guidance regarding return to spaceflight following hernia repair remains limited. The biomechanical demands of spaceflight, including microgravity-related fluid shifts, resistive exercise, and alternobaric environments (such as extravehicular activities), necessitate individualized medical assessment. **CASE PRESENTATION:** A middle-aged male crewmember presents with a symptomatic, reducible right inguinal hernia. He has had no prior abdominal surgeries and maintains excellent physical conditioning despite symptoms. The crewmember undergoes a laparoscopic right inguinal hernia repair 18 months prior to recertification for spaceflight. He undergoes an uncomplicated surgery and is cleared for return to unrestricted duty. At the time of recertification, the crewmember demonstrates no limitations in his exercise routine or during training. **DISCUSSION:** Recertification after inguinal hernia repair requires a multidisciplinary approach that integrates surgical outcomes, functional performance, and mission-specific risk analysis. Key considerations include surgical approach and materials used, risk of contralateral hernia formation, risk of recurrence in the spaceflight environment, healing timeline, risk of post-op or in-flight complications, and the ability to safely perform extravehicular activities requiring sustained engagement of the abdominal wall. This case highlights both aeromedical and post-surgical considerations relevant to spaceflight recertification following inguinal hernia repair.

Learning Objectives

1. Describe post-operative factors following inguinal hernia repair that may increase the risk of recurrence, pain, or functional limitation during spaceflight training and mission execution.
2. Outline appropriate long-term monitoring and follow-up strategies for crewmembers recertified after abdominal wall surgery to mitigate operational risk over successive missions.

[319] DIETARY RIGIDITY AND ALTITUDE INTOLERANCE IN A MILITARY PILOT FOLLOWING A STRICT CARNIVOROUS DIET

Sandra Salzman, Tatiana Villalobos

U.S. Air Force, Dayton, OH, USA

(Education - Case Study)

INTRODUCTION: Nutritional adequacy is vital for sustaining performance under hypoxic stress. Extreme diets may impair metabolic flexibility and elevate aeromedical risk. **BACKGROUND:** A 31-year-old active-duty pilot developed acute mountain sickness during a high-altitude climb despite excellent conditioning and no prior history of altitude intolerance. He followed a carnivore diet for six years, consuming over 4 g/kg/day protein with minimal carbohydrates. **PRESENTATION:** During ascent of Mt Kilimanjaro (~12,000-ft), he developed joint pain, fatigue, tachycardia, headache, confusion, and anuria, requiring 2-week admission for acute mountain sickness and high-altitude renal syndrome. Labs showed elevated ketones, uric acid, hypernatremia, mild metabolic alkalosis, and reduced eGFR (45 mL/min/1.73 m^2). Cardiopulmonary and vestibular exams were unremarkable. His carnivorous diet relied on gluconeogenesis, likely reducing glycolytic ATP synthesis during hypoxia, lowering oxidative efficiency, and triggering earlier altitude intolerance than peers. Severe carbohydrate restriction limits substrate-switching metabolism in low-oxygen conditions, increasing fatigue and cognitive decline. Nutritional counseling on nutrient balance, protein intake limits, and carbohydrate introduction was initiated. After eight weeks, laboratory values normalized, and the pilot returned to fly. **DISCUSSION:** Aviators often adopt “optimization” diets that may unintentionally deplete metabolic reserve needed for endurance, cognition and hypoxia tolerance. Experimental hypobaric studies show early hypoxia suppresses glycolysis while increasing reliance on fatty-acid oxidation and TCA-linked pathways, underscoring the importance of metabolic flexibility. In this case, prolonged carbohydrate elimination with very high protein intake may have reduced rapid glycolytic energy availability and increased renal solute burden, impairing adaptation during ascent. Although exogenous ketosis may improve oxygenation in controlled settings, such findings do not apply to carbohydrate-absent, high-protein diets. Long-term restrictive, protein-heavy diets may limit metabolic flexibility and reduce tolerance to acute hypoxic stress in otherwise healthy aviators. Incorporating routine dietary assessment into aeromedical evaluations may identify patterns affecting hydration, energy availability, or physiologic resilience supporting safer cognitive and physical performance during high-altitude or decompression events.

Learning Objectives

1. Recognize how restrictive diets can impair hypoxia tolerance and operational performance.
2. Explain the physiologic role of metabolic flexibility in ATP production under hypoxia.
3. Apply dietary screening and counseling strategies within aeromedical evaluations.

[320] CROHN'S DISEASE IN A MILITARY AVIATOR: A CASE REPORT

Eliezer Bar-Meir[1], Joshua Sullivan[1], Amanda Pouncey[1], Christopher Ulm[2]

[1]U.S. Army, Ft. Rucker, AL, USA; [2]U.S. Army, Fort Gordon, GA, USA

(Education - Case Study)

INTRODUCTION: This case report describes a military aviator diagnosed with Crohn's disease following an evaluation for bilateral ankle swelling with predominantly extra-intestinal manifestations. **BACKGROUND:** Crohn's disease is a chronic transmural inflammatory bowel disease that can affect any part of the gastrointestinal tract. It presents unique aeromedical challenges due to its unpredictable course, extra-intestinal manifestations, and frequent need for immunomodulatory therapy and other treatment contraindicated in the aviation environment. The condition is disqualifying for military aviators when active disease or required medications compromise flight safety. Early diagnosis and appropriate management are critical for aeromedical disposition decisions. **CASE PRESENTATION:** A 27-year-old male Army aviator presented in February 2025 with bilateral ankle swelling after NSAID use. Workup revealed proteinuria, hypoalbuminemia, anemia, and an elevated ESR. Initial referrals to nephrology and rheumatology led to a diagnosis of inflammatory polyarthropathy. Nephrology noted chronic diarrhea, prompting gastroenterology referral. In September 2025, a positive fecal calprotectin led to endoscopic evaluation, in October 2025 which demonstrated findings suggestive of ulcerative colitis. However, biopsy revealed granulomatous inflammation on antral and colonic biopsies, confirming Crohn's disease. The patient was treated with budesonide with temporary symptom resolution. He is currently being considered for biologic therapy as of this writing. **DISCUSSION:** This case highlights several important considerations for Crohn's disease from an aviation perspective. Extra-intestinal manifestations may precede overt gastrointestinal symptoms, requiring high clinical suspicion. Pathologic findings (granulomas) are diagnostic even when endoscopic appearance suggests ulcerative colitis. Aeromedical concerns include unpredictability of disease flares during flight operations, and medication side effects. Military and FAA medical certification for Crohn's disease involves nuanced medical decision making and fitness evaluations. While the Air Force and Army allow specific maintenance therapies like mesalamine and sulfasalazine, the Navy categorically prohibits Crohn's patients from flight roles. The FAA may issue certification based on individual medical review, requiring stable conditions and approved treatments.

Learning Objectives

1. Recognize the clinical hallmarks of Crohn's disease that impact aeromedical fitness, including extra-intestinal manifestations that may present before gastrointestinal symptoms.
2. Understand the aeromedical waiver requirements for inflammatory bowel disease across military services, including required documentation, medication restrictions, and criteria for flight status consideration.

[321] HEREDITARY HEMOCHROMATOSIS IN AN AVIATION APPLICANT: A CASE REPORT AND AEROMEDICAL DISPOSITION

Jinyong Bae, Michael Emerson, Carlos Lopez Aquino

U.S. Army, Fort Rucker, AL, USA

(Education - Case Study)

INTRODUCTION: Hereditary Hemochromatosis (HH) is an autosomal recessive disorder of the HFE gene, characterized by unregulated intestinal iron absorption, leading to systemic iron accumulation. The prevalence of this genotype is approximately 1 in 200 to 400 in non-Hispanic whites in North America. Clinical manifestations typically present after age 40 but can vary significantly depending on the clinical penetrance. Untreated HH poses a moderate aeromedical risk due to potential end-organ damage, most commonly in the form of cardiomyopathy, hepatic cirrhosis, and diabetes. This case discusses the diagnosis, management, and aeromedical disposition of an asymptomatic aviation applicant with HH. **CASE DESCRIPTION:** A 32-year-old active-duty military male presented for an initial U.S. Army Class 1 flight physical. His history was significant for an episode of gastroenteritis and chest pain in 2019, during which significant transaminitis was noted (ALT 254; AST 309) alongside elevated ferritin (5706 ng/mL). Subsequent genetic testing confirmed the patient was homozygous for the HFE C282Y mutation, confirming HH. Evaluation included a standard echocardiogram, Holter monitor, and maximal exercise stress test. MRI demonstrated hepatic iron overload while Fibroscan showed no significant fibrosis. He was managed with therapeutic phlebotomy to maintain ferritin levels near 150 ng/mL. **DISCUSSION:** Aeromedical disposition for HH varies significantly by agency. The FAA allows HH as a Conditions Aviation Medical Examiners Can Issue (CACI) if the pilot is asymptomatic, without end-organ damage, and maintains ferritin ≤150 ng/mL. Conversely, the U.S. Air Force generally considers HH disqualifying for initial Flying Class I applicants with no waiver potential. The U.S. Army considers waivers on a case-by-case basis and requires rigorous internal medicine and cardiology review. In this case, while the Integrated Disability Evaluation System recommended an unrestricted waiver for Army service, the initial flight physical was deferred pending further cardiac stratification. **CONCLUSION:** This case highlights the importance of including iron panels in the workup of unexplained fatigue or abdominal symptoms in aviation personnel. Early detection allows for phlebotomy intervention before irreversible end-organ damage occurs. While disqualifying in some services, successful management of HH can allow for waiver consideration in select military aviation candidates and FAA applicants.

Learning Objectives

1. Identify the clinical presentation and necessary diagnostic workup for Hereditary Hemochromatosis in aviation personnel.
2. Compare the aeromedical waiver dispositions for Hemochromatosis across the U.S. Army, Navy, Air Force, and Federal Aviation Administration (FAA).
3. Discuss the aeromedical safety implications of untreated iron overload regarding incapacitation risk.

Thursday, 05/21/2026, 1:30 PM

Governor's Hallway

[S-53] INTERACTIVE PRESENTATION: FROM COCKPIT TO CLINIC

Chair: Charles Mahakian

Co-Chairs: Joseph Berto DeRouchey, Kenneth Myers

[322] WITHDRAWN

[323] HEALTH CONCERNS PREVENTING NAVAL AVIATORS FROM HEALTH-RELATED NON-DISCLOSURE

Matthew Lindsey

Naval Aerospace Medical Institute, Pensacola, FL, USA

(Original Research)

Health-related nondisclosure among aviators is a persistent aviation safety concern, yet the specific medical conditions withheld from Naval Flight Surgeons and the reasons for nondisclosure remain poorly characterized. This cross-sectional epidemiological study surveyed 274 Naval Aviators and Naval Flight Officers at the Naval School of Aviation Safety to identify the prevalence, types, and motivations behind undisclosed medical conditions. Participants represented a broad range of aviation experience, platforms, and designations. Overall, 43.5% of respondents reported withholding at least one medical condition from their flight surgeon. Among those with undisclosed conditions, 94.5% believed their symptoms did not pose a safety-of-flight risk. Statistically significant nondisclosure was identified across multiple medical domains, with the highest rates observed in psychiatric (77.6%), miscellaneous symptoms (62.5%), medication or supplement use (58.3%), internal medicine (56.5%), and neurological symptoms (55.6%). Within these categories, specific conditions such as mood swings (90.9%), suicidal ideation (83.3%), anxiety (80.8%), depression (76.6%), low testosterone (77.7%),

GERD (62.5%), headaches (73.3%), and dizziness (55.6%) were most likely to be withheld. Gastrointestinal symptoms—including constipation (66.7%), blood in stool (50%), and diarrhea (50%)—also demonstrated high nondisclosure rates. Orthopedic symptoms were frequently reported but less often withheld, though neck pain (38.5%) and back pain (32.9%) remained significant. Ophthalmologic, ENT, dermatologic, and cardiology symptoms showed lower but still meaningful nondisclosure rates. These findings reinforce that nondisclosure among Naval Aviators is both common and medically diverse, extending well beyond traditionally suspected areas such as mental health. The data suggest that aviators selectively disclose conditions they believe will not threaten flight status while withholding symptoms perceived as potentially grounding, stigmatizing, or difficult to detect during routine flight physicals. Understanding these patterns is essential for improving aeromedical trust, refining waiver education, and strengthening human-factor risk mitigation in military aviation. Further research should explore targeted interventions to reduce nondisclosure and enhance the aviator–flight surgeon relationship.

Learning Objectives

1. Describe the prevalence and patterns of health related nondisclosure among Naval Aviators and Naval Flight Officers.
2. Identify the medical domains most commonly withheld from flight surgeons, including psychiatric, neurologic, gastrointestinal, and medication related conditions.
3. Compare disclosure rates across demographic variables such as aviation platform (rotary vs fixed wing), years of service, and aviator vs NFO designation.

[324] MENTAL HEALTH CERTIFICATION IN AVIATION: CERTIFICATION OUTCOMES AND ASSESSMENT TIMELINES FOLLOWING REFERRAL TO THE UK CIVIL AVIATION AUTHORITY

Payam Ghoddousi[1], Peter Hodkinson[2], Ross Pollock[2], Anthony Cleare[2]

[1]UK Civil Aviation Authority, London, United Kingdom; [2]King's College London, London, United Kingdom

(Original Research)

BACKGROUND: Mental health concerns among pilots and air-traffic controllers (ATCOs) can affect both operational safety and individual wellbeing. Despite this, many aviation professionals avoid care or withhold disclosure because they believe that reporting a mental health condition will result in loss of certification. Quantifying actual regulatory outcomes could help address this. The aim of this study was to characterise certification outcomes and assessment timelines for pilots and ATCOs referred to the UK Civil Aviation Authority (CAA) following disclosure of a mental health condition, to assess actual regulatory impact. **METHODS:** A retrospective observational study was performed on 147 Class 1 and 3 mental health related referrals to the CAA during 2024. The study used anonymised, non-identifiable data and did not require ethics

board review or individual consent. Data extracted from medical records included demographic details, diagnoses (primarily affective, anxiety-related, and stress-related disorders), referral pathways, certification outcomes, and assessment timelines. A one-sample binomial test, Friedman, Wilcoxon signed-rank test and Mann-Whitney U test were used to examine the study hypotheses: i) most applicants would receive a favourable certification outcome, and ii) delays would be concentrated in specific stages of the certification process, indicating potential bottlenecks. **RESULTS:** Of the 147 applicants (67 initial, 80 renewal), 94 % received favourable outcomes (fit unrestricted or with limitations), exceeding the 50 % reference proportion (p<0.001). The longest delay in the aeromedical assessment process occurred between initial contact with an Aeromedical Examiner and referral to the CAA (median 76 days), identifying a key bottleneck in the certification pathway. The need for a psychiatri assessment was associated with longer overall timelines (U=222.5, p<0.001). **DISCUSSION:** Most applicants retained or regained certification, contradicting perceptions of a punitive regulatory approach. This finding is relevant to both aeromedical and aviation professionals, providing reassurance that the majority of applicants (94% in this cohort) return to duty. Improved transparency and communication of real-world certification outcomes may help reduce fear-driven healthcare avoidance and encourage earlier engagement with aeromedical services, thereby supporting a timely and safe return to certification for safety-critical aviation personnel.

Learning Objectives

1. The audience will be able to describe real-world aeromedical certification outcomes following disclosure of common mental health conditions in pilots and air-traffic controllers, and how these compare with prevailing perceptions of regulatory impact.
2. The audience will be able to identify key stages in the UK mental health aeromedical certification pathway where delays most commonly occur and consider the implications for applicant engagement and regulatory transparency.

[325] NEXT-GENERATION FIGHTER JETS REQUIRE NEXT-GENERATION PILOT SCREENING: AI-ENHANCED WHOLE-BODY MRI FOR INTEGRATIVE AEROMEDICAL RISK STRATIFICATION

Josef Ehling, Kai Nestler, Hans Noblé, Daniel Veit

German Air Force Center of Aerospace Medicine, Cologne, Germany

(Original Research)

INTRODUCTION: The German Air Force has performed MRI-based screening for pilot candidates since 2001. Since 2016, high-resolution head and spine 3-Tesla MRI produced over 4,500 standardized datasets. In 2025, an AI-enhanced whole-body MRI protocol was established, enabling turbo-fast sequences, assisted feature extraction, and integrated analysis, allowing inclusion of abdomen, pelvis, and dental screening. This study evaluates the impact of AI-enhanced MRI on diagnostic accuracy, screening efficiency, and aeromedical relevance.

METHODS: 518 consecutive applicants (17–40y) were retrospectively analyzed for a period of 12 months between 09/2024 and 08/2025. The AI cohort comprised 247 candidates (22.7±4.7y) and was compared to a conventional MRI cohort of 271 candidates (22.4±4.3y). MRI datasets were assessed for findings across neurological, vascular, musculoskeletal, abdominal/pelvic, and dental systems. Neurological and musculoskeletal detection rates were compared to prevous data (Kühn et al;2022). Findings were categorized into four aeromedical relevance groups (I: disqualifying; II: follow-up required; III: incidental; IV: normal variant). Welch's t-test, χ^2-tests, and regression analyses were applied. **RESULTS:** Mean scan time decreased from 62:58±5:07 min to 42:04±1:18 min (33% reduction by AI-boosted MRI, t=87.2, p<0.0001). Detection rates improved due to higher spatial resolutions and contrast: white matter hyperintensities 28.7% vs. 14.4%; pineal cysts 34.8% vs. 11.6%; developmental venous anomalies 4.9% vs. 2.3%; cavernomas 1.6% vs. 0.6%; other brain findings 17.8% vs. 9.8%; intervertebral disc abnormalities 7.6% vs. 4.9%. MRI-based assesment of liver cysts or hemangiomas (15.4%), urinary tract obstruction (4.0%), and retained wisdom teeth (9.7%) was initally carried out by the AI-enhanced protocol and thus not comparable to prior data. Findings categorized by aeromedical relevance ranged from 34.8% (normal variant) to 1.6% (disqualifying). **DISCUSSION:** AI-enhanced whole-body MRI improves diagnostic accuracy, screening efficiency, and detection rates. Faster acquisition enables additional abdomen, pelvis, and dental screening, providing a true all-in-one solution. Importantly, the reduced scan time allows higher throughput of young applicants, critical given rising recruitment demands. This approach supports data-driven aeromedical risk stratification and represents a key step toward next-generation pilot selection and operational readiness.

Learning Objectives

1. Due to faster scanning times, improved diagnostic accuracy, and greater efficiency, AI-enhanced MRI may become a critical tool for high-throughput pilot screening, supporting flight safety, meeting increasing recruitment demands, and enabling selection of next-generation fighter pilots.
2. Technical improvements in accelerated detection of incidental findings with AI-enhanced MRI versus aeromedical relevance.

[326] Moved to "Medicine at the Edge", May 18, 4 PM

[327] OCCUPATIONAL NOISE, AUTONOMIC IMBALANCE, AND SLEEP DISRUPTION ACROSS MILITARY ROLES: IMPLICATIONS FOR PERFORMANCE AND FLIGHT SAFETY

Shih-En Tang[1], Shu-Yu Wu[2], Ke-Ting Pan[2], Kun-Lun Huang[3], Yu-Cheng Lin[4], Hong Hau Wang[5], Chung-Yu Lai[2], Shih-Yu Lee[2], Yu-Ju Chen[2]

[1]National Defense Medical University; Tri-Service General Hospital; Medical Affairs Bureau, Ministry of National Defense, Taipei, Taiwan (Greater China); [2]National Defense Medical University, Taipei, Taiwan (Greater China); [3]National Defense Medical University, Taiepi, Taiwan (Greater China); [4]Tri-Service General Hospital Songshan Branch, Taipei, Taiwan

(Greater China); [5]Tri-Service General Hospital Songshan Branch, National Defense Medical University, Taipei, Taiwan (Greater China)

(Original Research)

INTRODUCTION: Sustained occupational noise may impair sleep and autonomic regulation—key determinants of vigilance, reaction time, and operational/flight safety. We profiled duty-role differences in noise perception, perceived stress, autonomic balance, and sleep quality in noise-exposed military personnel. **METHODS:** Cross-sectional study of 70 active-duty personnel with long-term workplace noise exposure: maintenance (n=13), pilots (n=23), mechanics/operations (n=20), and administrative/other (n=14). Measures included workplace-noise perception items, Perceived Stress Scale (PSS), Pittsburgh Sleep Quality Index (PSQI; poor sleep >5), resting HRV-derived sympathetic (SNS) and parasympathetic (PNS) indices, and urinary 8-OHdG and TEAC. **RESULTS:** Workplace noise was reported by 57.14% overall and was highest in mechanics/operations (85.0%) vs maintenance 61.54%, pilots 43.48%, and administrative/other 35.71%. Raising voice at 1 m occurred in 28.57% overall and peaked in mechanics/operations (55.0%) vs maintenance 30.77%, pilots 13.04%, and administrative/other 11.76%. HRV showed sympathetic predominance in pilots and mechanics/operations. In pilots, SNS was usually >2 (often +3 to +4) with PNS suppression (−1 to −3). Maintenance showed the most stable autonomic balance (SNS and PNS largely within −2 to +2). Administrative/other showed mild SNS activation (SNS typically +1 to +2) with reduced PNS. Mechanics/operations showed strong SNS predominance despite lower perceived stress on PSS. PSQI indicated best sleep in maintenance, moderate impairment in pilots (prolonged sleep latency and daytime dysfunction), and mild-to-moderate impairment in mechanics/operations with sleep fragmentation; administrative/other showed mild impairment. Weekly exercise frequency correlated with PNS (r=0.247, p=0.044). Urinary 8-OHdG and TEAC did not differ by role. **DISCUSSION:** Distinct autonomic–sleep phenotypes across noise-exposed roles identify actionable human-performance and flight-safety risks, especially for pilots and mechanics/operations. Role-tailored surveillance, fatigue/sleep risk management, and structured fitness to enhance vagal recovery may improve readiness and safety; future work should add objective noise dosimetry and longitudinal performance outcomes.

Learning Objectives

1. The participant will be able to describe duty-role differences in perceived workplace noise, HRV-derived autonomic balance (SNS/PNS), and sleep quality (PSQI) among noise-exposed military personnel.
2. The participant will be able to identify higher-risk operational groups (pilots and mechanics/operations) showing sympathetic predominance and sleep impairment relevant to vigilance, reaction time, and flight safety.
3. The participant will be able to apply role-tailored countermeasures, including noise surveillance/dosimetry, fit-tested hearing protection, fatigue and sleep risk management, and structured fitness programs to enhance vagal recovery and readiness.

[328] AN EXPLORATION OF ASSOCIATIONS BETWEEN FLYING EXPOSURE AND ILLNESS: CHARACTERIZATION OF THE RISK OF BACK PAIN IN U.S. ARMY ROTARY-WING PILOTS

J. Andrew Atchley[1], Amanda Kelley[1], Ian Curry[1], Barrett Campbell[2], David Holdsworth[3]

[1]U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, USA; [2]School of Army Aviation Medicine, Fort Rucker, AL, USA; [3]U.S. Army Aeromedical Research Laboratory, Fort Rucker, USA

(Original Research)

INTRODUCTION: To-date, no studies have explored the association between occupational flying exposure and clinical diagnoses that may result in flying disqualification or career termination. We present a novel dataset created by linking the U.S. Army Centralized Aviation Flight Records System (CAFRS) to the Aeromedical Resource Office (AERO) database and record of waivers. We have exploited this dataset to characterize the prevalence of back pain (BP), its association with different aircraft, and with medical waivers. **METHODS:** All records were accessed from CAFRS (2010-2024) for pilots ≤55 yrs. Records were filtered for rotary-wing pilots (Apache, Black Hawk, and Chinook). Records from both AERO (listing all clinical diagnoses) and the waiver database were accessed for the same period. We identified all diagnoses, magnetic resonance imaging (MRI) investigations, and surgical interventions for back pain and explored interactions with aircraft type. Statistical measures for association were corrected for multiple comparisons. **RESULTS:** 10,889 pilots were identified (Apache n= 2,554; Black Hawk n= 6,790; Chinook n= 1,545). Mean age (±SD) was 39.2±7.0 years. 10,372(95.7%) were male. 10,842 pilots had ≥1 clinical record, and 4,484 (41%) pilots had a record in the waiver database. 5,485(50.6%) ;pilots sought medical attention for BP. 771(7.1%) required MRI of the spine, and 52(0.5%) required surgical intervention. BP was more common in Apache pilots (Apache n= 1,367 [53.9%]; Chinook n= 794 [51.5%], Black Hawk n= 3,324 [49.1%]; X2 = 17.0, p< 0.001). BP was associated with an increased likelihood of waiver (BP: 2,368(43%) vs. no BP: 1,290 [24%], p< 0.001) and suspension (BP: 368 [7%] vs. no BP: 167 [3%], p< 0.001). **DISCUSSION:** We report, for the first time, the prevalence of a medical condition, and frequency of waivers, in association with occupational exposure. This has been made possible by the combination of three databases for the same population, an occupational database (CAFRS), a clinical database (AERO), and the database of medical waivers. We selected back pain for the first exploration, as it is the most prevalent medical condition in this population. This analysis serves as a template, which can be followed to assess the impact of all conditions in U.S. Army aviators.

Learning Objectives

1. Attendees will appreciate the importance of assessing the association between occupational flying exposure and illness.

2. Attendees will recognize the potential of linking the occupational, clinical, and waiver databases to understand the interaction of occupational exposure and pilot health.

[329] Moved to "Medicine at the Edge", May 18, 4 PM

[330] PRE-SELECTION MRI AS A PREDICTOR OF CERVICAL SPINE DEGENERATION IN FIGHTER PILOTS: A 10-YEAR PROSPECTIVE FOLLOW-UP STUDY

Tuomas Keskimölö[1], Tuomas Honkanen[1], Jaro Karppinen[2], Roope Sovelius[1], Liisa Kerttula[3], Niko Murto[3], Tuomo Leino[4]

[1]Finnish Defence Forces, Helsinki, Finland; [2]University of Oulu, Oulu, Finland; [3]Helsinki University and Helsinki University Hospital, Helsinki, Finland; [4]National Defence University, Helsinki, Finland

(Original Research)

INTRODUCTION: Fighter pilots are exposed to repeated high +Gz-forces with simultaneous head movements while wearing helmet-mounted equipment. Spinal intervertebral disc (IVD) degeneration accompanied with disability is reported as the most common reason for aeromedical limitations among Finnish Air Force (FINAF) fighter pilots. All FINAF fighter pilot candidates undergo full-spine MRI before selection, but decision making is largely based on clinical experience rather than evidence-based criteria. The aim of the study was to assess whether pre-selection MRI can provide prognostic value for cervical spine degeneration at the 10-year follow-up. **METHODS:** Fifty-six male FINAF fighter pilots were enrolled and underwent cervical spine MRI at baseline and at a 10-year follow-up (52 completed). Two musculoskeletal radiologists evaluated the images for cervical degenerative changes including IVD degeneration (Pfirrmann classification), IVD herniations, facet joint arthrosis, uncovertebral arthrosis and foraminal stenosis. Spearman rank correlation was used to determine whether baseline degenerative findings predicted severity at follow-up. **RESULTS:** The prevalence of IVD degeneration, IVD herniations, facet joint arthrosis, uncovertebral arthrosis, and foraminal stenosis increased during the follow-up, and further analyses focused on these degenerative findings. Across the cervical spine, correlations between baseline and follow-up MRIs were found for IVD degeneration (ρ=0.44, p<0.001), facet joint arthrosis (ρ=0.40, p=0.004) and uncovertebral arthrosis (ρ=0.32, p=0.022). Level-specific analyses showed positive correlations at all six levels for IVD degeneration, at four levels for facet joint arthrosis, at three for uncovertebral arthrosis, at two for IVD herniations and at none for foraminal stenosis. **DISCUSSION:** The presence of IVD degeneration, facet joint arthrosis and uncovertebral arthrosis at baseline appears to predict more advanced degeneration at the 10-year follow-up. This likely reflects the progressive and non-regressive nature of arthrosis and IVD degeneration. As within-person stability of degenerative findings is expected over short follow-up periods, it is noteworthy that cervical spine status already at age 20 can have predictive value for the condition at age 30. Given the relatively short duration of fighter pilot careers, degenerative

findings identified on pre-selection MRI should be considered when evaluating fighter pilot applicants.

Learning Objectives

1. Describe typical early MRI findings of cervical spine degeneration in young fighter pilots and their expected progression over a 10-year period.
2. Explain how cervical MRI findings obtained at the point of military flight training selection can inform long-term aeromedical risk assessment.

[331] WHEN THE CENTRIFUGE FIGHTS BACK: A CASE OF VERTEBRAL COMPRESSION FRACTURE DURING CENTRIFUGE TRAINING

Christina DeInnocentiis[1], Lindsay Kingston[1], Miles Brooks[2]

[1]Nellis Air Force Family Medicine Residency, Las Vegas, NV, USA; [2]Kunsan Air Force Base, Kunsan Air Force Base, Korea, Republic of

(Education - Case Study)

INTRODUCTION: This case report details the onset of a vertebral fracture in an Air Force flight surgeon with a history of ankylosing spondylitis after undergoing centrifuge training. **BACKGROUND:** High-G flight simulation places specific physiologic, musculoskeletal, and performance demands on the body. Flight surgeons complete centrifuge training so they can fly safely in their assigned squadrons' aircraft and in order to assess, counsel and make informed medical decisions for their aircrew. This training has been associated with injuries, including case studies of pneumomediastinum, rib fractures, and a case of vertebral compression fracture in a patient who was found to have underlying osteopenia. **CASE PRESENTATION:** A 37 year old Active Duty Air Force flight surgeon candidate with a history of well-controlled ankylosing spondylitis underwent routine centrifuge training with exposure to 9Gs during the Aerospace Medicine Primary course. The patient had acute onset of low back pain during the F-16 profile which persisted for several weeks. X-ray evaluation of the patient's spine revealed a mild compression fracture of L5 vertebral body. A DEXA scan revealed normal bone mineral density, and laboratory results from two months prior to injury showed normal calcium and vitamin D. The patient was treated conservatively. **DISCUSSION:** This case highlights the importance of individualized injury risk assessment during +Gz training, particularly in personnel with underlying spinal disease. Altered spinal biomechanics resulting from inflammatory diseases such as ankylosing spondylitis may increase fracture susceptibility despite normal bone density and disease control. Current Air Force Medical Standards Directory instruction disqualifies patients with ankylosing spondylitis who have severe pain or functional limitations; allowing for waivers for well controlled patients such as the flight surgeon outlined in this case. Although centrifuge training is essential for flight surgeons to support aeromedical decision making, the risk of fracture in training and during a potential ejection event, when the axial spine is exposed

to upwards of 12Gs, raises concerns for assigning patients with underlying spinal conditions to ejection seat aircraft.

Learning Objectives

1. The participant will be able identify the physiologic stresses associated with high G exposure on the axial spine.
2. The audience will learn about the pathophysiology leading to the increased risk of spinal fractures associated with inflammatory spinal disease.
3. The participant will understand the implications of inflammatory spinal conditions on aircrew operating in ejection seat aircraft.

[332] CLAY-SHOVELER'S FRACTURE IN A FAST JET PILOT: A CASE STUDY

Brent Barker[1], David McGinness[2]

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(Education - Case Study)

INTRODUCTION: This case report describes a military fast jet pilot who experienced Clay-shoveler's fracture at T7 following repeated high +Gz manoeuvres. **BACKGROUND:** Fast jet aircrew are exposed to substantial musculoskeletal stress due to repeated high-G manoeuvres, rapid head movements, and prolonged cervical loading. While cervical discogenic injuries are more commonly reported, spinous process avulsion injuries such as Clay-shoveler's fractures remain under recognized in aviation medicine. Clay-shoveler's fractures, avulsion injuries of the spinous processes, are rare among aviators but clinically relevant in the context of repetitive high-G exposure. Fast jet aircrew are particularly susceptible due to the mechanical loads of aerial manoeuvres. **CASE REPORT:** A 49-year-old male fast jet pilot presented with acute upper back pain following repeated high-G manoeuvres. Clinical evaluation and MRI identified a low-grade Clay-shoveler's fracture at T7, with associated interspinous ligament strain. Conservative management with temporary flight cessation, physiotherapy, and a structured rehabilitation program led to full recovery. The patient returned to unrestricted flight duties at six weeks. **DISCUSSION:** This case highlights the biomechanical vulnerabilities of the cervical-thoracic spine in fast jet pilots and underscores the importance of targeted prevention, ergonomic optimization, and neck-strengthening protocols in mitigating injury risk.

Learning Objectives

1. Upon completion of this activity, participants should be able to recognize the clinical presentation, bio-mechanical mechanism, and diagnostic imaging findings of a Clay-shoveler's fracture in fast jet pilots exposed to repetitive high-G maneuvers,

distinguishing it from more common cervical spine pathologies such as discogenic injuries.
2. Upon completion of this activity, participants should be able to outline an evidence-based conservative management and multidisciplinary rehabilitation approach for stable Clay-shoveler's fractures in high-performance aviators, including appropriate timelines for return-to-flight duties and preventive strategies to reduce future cervical-thoracic injury risk.

[333] RECURRENT ALTEROLATERAL HIP PAIN AS PRESENTING SYMPTOM OF RARE GRADE 2 SYNOVIAL SARCOMA OF THE LEFT GLUTEUS MINIMUS IN UAS PILOT: A CASE REPORT

Nicole Thatcher

U.S. Navy, Jacksonville, FL, USA

(Education - Case Study)

INTRODUCTION: This case report describes an incidence of synovial sarcoma of the left hip in a UAS pilot. **BACKGROUND:** Synovial sarcoma is an uncommon high grade tumor, comprising up to 10% of soft tissue sarcomas; furthermore, gluteal synovial sarcomas are exceedingly rare. They comprise many subgroups, with variable treatment recommendations and prognoses dependent on staging and subtype. Early recognition and involvement of multidisciplinary care teams contribute to improved outcomes, as management is multimodal and involves chemotherapy, radiation, and surgical treatment. **CASE DESCRIPTION:** The case subject was a 30 year old male MQ-4 Triton pilot, with over 1300 flight hours and prior experience flying P-8 Poseidon. He presented with longstanding history of left hip pain which began following a hard landing and over wing aircraft egress 18 months prior. Despite multiple courses of physical therapy, the pain had progressively worsened. Tenderness of the tensor fasciae latae and pain with passive internal rotation was noted on exam at the time of initial presentation. MRI showed a 5.8 by 3.7 by 7.9 cm lobulated septated mixed signal mass in the left gluteus minimus, and US-guided biopsy revealed FNCLCC Grade 2 synovial sarcoma. Subsequent MRI with contrast showed interval growth and involvement of the gluteus medius as well. He underwent chemotherapy with doxorubicin & ifosfamide every three weeks for six cycles, with follow up CT demonstrating reduction in size of the mass. He is currently scheduled to undergo preoperative radiation therapy and surgical resection. **DISCUSSION:** This case illustrates the importance of maintaining suspicion for possible occult malignancy in patients with musculoskeletal pain unresponsive to conservative management. Early involvement of multidisciplinary care teams (e.g. medical and radiation oncology, orthopedic oncology, case management) ensures expedited care and optimization of treatment plan and subsequent outcomes. Side effects of treatment, survival rate, risk of recurrence and distant metastasis are important factors in determining short and long term flight duty limitations, aeromedical disposition, and follow up requirements, as are aircrew role and platform.

Learning Objectives

1. The audience will learn about the potential presenting features, prognosis, and multidisciplinary treatment recommendations for gluteal synovial sarcoma.
2. The audience will explore the potential impact of synovial sarcoma diagnosis and treatment on the short-term aeromedical disposition and flight duty limitations on aviators with this condition, in both manned and unmanned aerial system platforms.
3. The audience will learn about the risk of recurrence, distant metastasis, and mortality of synovial sarcoma, and examine the current requirements for follow up monitoring and long-term aeromedical disposition in manned and unmanned platform aviators with synovial sarcoma.

[334] A REVIEW OF THE CLINICAL PRESENTATION OF IN-FLIGHT ALTITUDE DECOMPRESSION SICKNESS (DCS)

Alexander Wrigley

UK Royal Navy, Portsmouth, United Kingdom

(Original Research)

INTRODUCTION: 'Altitude DCS' and 'sub-atmospheric DCS' are terms for pathology relating to the evolution of bubbles, predominantly of nitrogen, in the body, secondary to a reduction in ambient air pressure, either at altitude or within a hypobaric chamber. Pains (DCS Type I) are widely understood to be the commonest presentation of Altitude DCS, with neurological manifestations (DCS Type II) being rare. However, this clinical presentation is based on data from hypobaric chamber studies rather than from in-flight rapid decompressions. A literature review was conducted to ascertain if the clinical presentations of in-flight physiologically significant decompressions in published cases conformed to the widely accepted picture of DCS Type I pain and skin symptoms. **METHODS:** A literature search was conducted to identify case reports/series of aeroplane occupants, medically examined for DCS after physiologically significant decompression in flight. Papers were discounted if there was a lack of accessible detail to confirm adherence to the search inclusion criteria, or to be able to be categorise cases appropriately. **RESULTS:** 6 papers met the inclusion standards of the literature search, in which were identified 11 cases of DCS Type II (or DCS Type I & II), and 7 cases of aircraft occupants being asymptomatic. All the cases of DCS Type II included neurological signs and/or symptoms. No aircraft occupants were diagnosed solely with DCS Type I. **DISCUSSION:** This literature search supports a clinical presentation of in-flight Altitude DCS that is distinct from that commonly reported during/after hypobaric chamber profiles, with DCS Type II neurological signs and symptoms predominating. This perceived difference could be related to the practice of pre-breathing 100% Oxygen before chamber-based altitude training. Alternatively, it could be related to a reluctance amongst aircrew to report what they perceive as minor DCS Type I symptoms during/after flying, or to aviators' difficulty distinguishing DCS Type I from other causes of pain and skin symptoms when undertaking flying operations. If this

difference is genuine, it could inform the training of aircrew, high-altitude parachutists and Flight Surgeons, regarding the common types of DCS symptoms to look out for.

Learning Objectives

1. Understand the mechanism by which Decompression Sickness (DCS) can occur in the aviation environment (i.e. in flight and in the hypobaric chamber), and that there are different clinical presentations of DCS.
2. Understand that, while DCS Type I is widely thought to be the commonest presentation of Altitude DCS, a search of the literature suggests DCS Type II (or DCS Type I and II combined) may be the more frequent presentation in cases of in-flight DCS.
3. Understand that the apparent dominance in the literature of DCS Type II symptoms, in cases of in-flight DCS, may not be accurate and could be related, for example, to under-reporting of DCS Type I symptoms by aircrew.

[335] NEW ONSET WORK-RELATED ASTHMA IN TWO NAVY SUBMARINERS

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(Education - Case Study)

INTRODUCTION: We describe two submariners with new-onset asthma associated with multiple submarine missions. **BACKGROUND:** Submariners work in enclosed environments for extended periods. Nuclear submarines employ unique methods to generate oxygen and remove carbon dioxide and other air contaminants during prolonged submersion. **CASE PRESENTATION:** Case #1: A 33-year-old never-smoker with no personal/family respiratory history noted new-onset cough while deployed on a 45-day submarine mission. Three weeks later, he deployed on a 90-day submarine mission. His symptoms worsened, now with dyspnea. Two months later, he deployed for a third (90-day) submarine mission. During this mission, an electrical fire disabled the automatic oxygen generator, requiring use of oxygen-generating chlorate candles, creating a low oxygen environment for most of the deployment. Two months later, he deployed on a fourth mission (120 days), with worsening cough, dyspnea, and new-onset wheezing. The oxygen generator again malfunctioned, requiring oxygen-generating candles with a persistent strong amine odor. Subsequent evaluation with methacholine challenge showed new-onset asthma requiring daily treatment.bCase #2: A 45-year-old smoker with no personal/family respiratory disease history noted new-onset dry cough following three 90-day submarine deployments. During his third deployment, the oxygen generator malfunctioned, prompting use of oxygen-generating candles. A carbon dioxide scrubber malfunction triggered a sustained amine leak. Subsequent pulmonary function testing showed a 13% bronchodilator response, indicating new-onset asthma that required regular inhaler use. **DISCUSSION:** New-onset respiratory symptoms during multiple submarine missions raised concerns for work-related

asthma. Monoethanolamine is used in submarines to scrub excess airborne carbon dioxide. Asthma has been linked with occupational exposure to amines, chemicals with both irritant and immune-sensitizing properties. Other airborne hazards aboard submarines may include aldehydes, acrolein, ozone, nitrogen oxides, refrigerants, and volatile organic compounds. Submariners live and work continuously in low oxygen and high carbon dioxide environments. They may experience smoke exposure from confined space fires and ionizing radiation exposure from nuclear reactors or weapons. These cases underscore the need for systematic tracking and studies of submarine air quality and respiratory disease risks to submariners.

Learning Objectives

1. Understand the range of airborne hazard exposures experienced by nuclear submariners.
2. Understand the potential causal associations between airborne submarine exposures and respiratory diseases.

[336] TENSION PNEUMOTHORAX FOLLOWING A RECREATIONAL SKYDIVE: A CASE STUDY WITH OPERATIONAL IMPLICATIONS FOR AEROSPACE MEDICINE

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(Education - Case Study)

INTRODUCTION: This case describes a tension pneumothorax in a healthy individual following a tandem skydive. **BACKGROUND:** Musculoskeletal traumas are the most common survivable skydiving injuries; internal organ damage or pneumothorax is rare and infrequently described in medical literature. Tension pneumothorax is a life-threatening emergency that requires prompt recognition and intervention. This case emphasizes diagnostic challenges and the importance of considering internal thoracic pathologies in activities involving pressure changes and deceleration forces. **CASE PRESENTATION:** A healthy 24-year-old female with no history of smoking or pulmonary disease completed her first tandem skydive. Considerable harness adjustment was required for her small stature, but ascent, jump, descent, and landing were unremarkable with no discomfort or traumatic impact. Shortly after landing, she developed shortness of breath and mild pleuritic chest pain. Symptoms worsened over 24 hours, and urgent care evaluation revealed a left-sided tension pneumothorax, prompting transfer to the emergency department and chest tube decompression. Computed tomography showed a previously unknown 12x6 mm pulmonary bleb in the superior segment of the left lower lobe near the major fissure. She underwent video-assisted thoracoscopic surgery (VATS) with mechanical pleurodesis and left lower wedge resection, and recovered completely without complications or recurrence. **DISCUSSION:** Pneumothorax is a rare but important consideration post-skydive in those presenting with dyspnea or chest pain, particularly without classic risk factors or a clear

mechanism of injury. In these patients, diagnosis may be delayed, resulting in potentially life-threatening consequences. Factors leading to pneumothorax in this case may involve improper harness fit and asymmetric load distribution, opening shock of parachute deployment, and reflexive glottic closure, all contributing to a rapid increase in thoracic stress and alveolar damage. Accurate classification of pneumothorax etiology is especially critical in military and aerospace populations, where medical documentation may influence career eligibility. First-time pneumothorax in these populations may warrant preventive imaging or evaluation for occult risk factors to guide risk mitigation. Although the relative contribution of harness fit cannot be definitively determined, this case also highlights the requirement for adequate harness fit and tension.

Learning Objectives

1. The audience will be able to consider the clinical presentation and diagnostic considerations for pneumothorax following recreational or tandem skydiving in patients without classic risk factors or impact trauma.
2. The audience will learn about potential biomechanical and physiological factors, such as harness fit, parachute deployment forces, and reflexive glottic measures that may contribute to pneumothorax in skydiving and their relevance to civilian and military operational safety.

[337] CHANGES IN LUNG FUNCTION IN HIGH PERFORMANCE FIGHTER PILOTS WITH POSITIVE PRESSURE VENTILATION

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German Air Force Centre of Aerospace Medicine, Cologne, Germany

(Original Research)

BACKGROUND: Military pilots in high-performance aircraft (HPA) are exposed to considerable gravitational forces (G-forces), which can reach up to +9 Gz. These G-forces can lead to loss of consciousness (G-LOC) and impair lung function. Positive pressure ventilation during G-load (PBG) is used to increase G-tolerance and reduce lung problems. Given the limited data on long-term effects, this retrospective study aims to evaluate the effects of PBG on the lung function of fighter pilots over a long observation period. **METHODS:** The study retrospectively analyzed clinical data from 1,838 German military pilots who were examined between 1972 and 2024. This included HPA pilots with PBG (n = 231), HPA without PBG (n = 965) and pilots of fixed-wing aircraft (n = 642), who served as a control group without relevant Gz exposure and without PBG. Forced vital capacity (FVC), forced expiratory volume in the first second (FEV1) and FEV1/FVC ratio were analyzed from the respective initial and final examinations. **RESULTS:** All lung function parameters decreased over the follow-up period (mean 19.7 years) in all three groups. For both FVC and FEV1, HPA pilots with PBG showed a smaller decrease than the group of fixed-wing pilots; this was only greater for FEV1/FVC.

However, the absolute values at the last examination were comparable. A multiple regression analysis showed that older age and aircraft type (wing > jet without PBG > jet with PBG) were significant predictors of changes in FVC and FEV1. **DISCUSSION:** The lung function of HPA pilots with PBG did not deteriorate significantly more than that of other pilots. Age proved to be the primary factor for the change in lung function. Despite a greater decline in the FEV1/FVC ratio in PBG users, there was no significant impairment of FEV1. Thus, no clinically relevant negative effects of PBG on lung function can be determined with the present study. PBG remains an effective and safe measure to increase G-tolerance. The strengths of the study include the long follow-up period and the large sample size.

Learning Objectives

1. The participants will understand the impact of positive pressure breathing on the pilot during high performance aircraft flying.
2. The participants will be able to understand the results of this study on future discussion on the impact of positive pressure breathing on the pilot.

[338] EXPANDING MEDICAL DIAGNOSTICS FOR SPACEFLIGHT: FLEXIBLE NASOPHARYNGOLARYNGOSCOPY

Tara Nibhanupudy[1], Taani Girgla[2], Amran Asadi[3], Brita Mittal[4], David Wexler[5]

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(Education - Program / Process Review)

BACKGROUND: Otolaryngology (ENT) symptoms of low severity are common in short and long-duration spaceflight. In considering extended-duration missions, there is an increased risk of high consequence upper aerodigestive tract conditions, including airway obstruction and dysphagia. Future crew medical officers will need to provide an expanded range of care for ENT conditions of varying urgency using on-site skills and resources. One modern diagnostic technique, flexible nasopharyngolaryngoscopy (NPL), enables detailed inspection of the nose and throat for both routine and emergency scenarios in a highly efficient manner. **OVERVIEW:** NPL is routinely accomplished in an awake patient by a trained individual. The technique can be readily adapted for crew medical kits or future habitats, with attention given to stabilization of the examiner and the subject. Using a 2.5mm diameter scope, NPL can be performed with topical anesthetic or a simple lubricant. The flexible scope is introduced into the nasal passage and advanced along the nasal floor. At 7 cm, the nasopharynx is reached and the scope is flexed downward to visualize the oropharynx and hypopharynx/larynx. Through an open glottis during inspiration, the subglottis and trachea are inspected. A thorough upper airway exam can be accomplished in 1-2 minutes by an experienced provider. Additionally, endotracheal intubation

over a flexible scope is an important technique in management of the high-risk difficult airway, although additional training, expertise, and patient preparation would be required for safe performance during spaceflight. **DISCUSSION:** NPL offers a feasible, efficient, comprehensive upper airway assessment, using readily learned skills and reusable equipment of modest mass, volume and power requirement. In an important first step, NPL has previously been self-administered on commercial astronauts in orbital spaceflight, with successful visualization of the larynx. Besides utility in evaluating urgent airway issues, NPL can also be used as a multimodal endoscopic tool for investigation of persistent non-urgent conditions, i.e., persistent nasal obstruction, identifying an epistaxis source, middle ear effusion and barotrauma, deep pharyngeal discomfort, or vocal changes. In this presentation we will review NPL technique, precautions and typical findings, with attention to spaceflight lessons learned from execution on Polaris Dawn and potential future applications.

Learning Objectives

1. Review the technique, precautions and typical findings of the flexible nasopharyngolaryngoscopy exam (NPL).
2. Review lessons learned from execution of NPL in orbital spaceflight, and highlight potential applications for a long or extended-duration spaceflight setting.

[339] WITHDRAWN

[340] LOSS OF AGSM CAPABILITY FOLLOWING OSA SURGERY: A FIGHTER PILOT CASE STUDY

Hong-Hau Wang[1], Shih-En Tang[2], Yu-Cheng Lin[1], Yu-Juei Hsu[1], Yu-Hao Huang[3], Pin-Huei Lai[3], Chung-Yu Lai[4], Shih-Yu Lee[5], Shu-Yu Wu[5]

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(Education - Case Study)

INTRODUCTION: We report a fighter pilot with severe obstructive sleep apnea (OSA) who was unable to tolerate continuous positive airway pressure (CPAP), underwent staged upper-airway surgery, and subsequently experienced Anti-G Straining Maneuver (AGSM) limitation influencing aeromedical disposition. **BACKGROUND:** OSA threatens flight safety via impaired vigilance. Disposition requires objective evidence of disease control plus confirmation of mission-critical functional performance; PAP is preferred when tolerated because efficacy/adherence are quantifiable, whereas surgery may have variable outcomes and postoperative functional constraints. **CASE PRESENTATION:** A male fighter pilot in his early

30s with hypertension and BMI 28.9 presented with habitual snoring and daytime sleepiness. Baseline polysomnography (May 2024) showed severe OSA (AHI 59.3/h; SpO2 nadir 71%) with nasal obstruction (hypertrophic rhinitis, septal deviation). Lifestyle/weight control and CPAP were attempted, but pressure intolerance prevented sustained use. He underwent staged multilevel surgery: transoral upper-airway surgery with uvulopalatopharyngoplasty (Aug 2024) and septal/turbinate surgery (Feb 2025). Symptoms improved, but postoperative upper-airway discomfort and functional limitation prevented effective AGSM. After aeromedical evaluation, duties were reassigned from high-performance fighter operations to a lower-G platform. **DISCUSSION:** Symptom relief after OSA surgery may not equate to high-G readiness. Return-to-fly decisions should integrate objective sleep metrics with standardized functional assessment aligned to platform demands (e.g., AGSM capability) and address postoperative pain/tightness, altered laryngeal/upper-airway coordination during forced expiratory straining, and deconditioning. Early multidisciplinary planning with clear documentation requirements (repeat sleep testing, symptom/alertness assessment, and treatment adherence metrics when applicable) supports timely, defensible disposition while maintaining flight safety.

Learning Objectives

1. The participant will be able to describe aeromedical risks of severe OSA in fighter operations, including impacts on vigilance and high-G task performance.
2. The participant will be able to identify required documentation for aeromedical disposition of OSA, including objective sleep metrics, symptom/alertness assessment, and treatment adherence evidence when applicable.
3. The participant will be able to explain how postoperative upper-airway limitations can impair AGSM and inform risk-based assignment from high-G fighters to lower-G platforms.

[341] WITHDRAWN

[342] VITAMIN D DEFICIENCY RISK ASSESSMENT IN OPERATIONAL MILITARY MEDICINE

Sarah Avila[1], Carol Henderson[2]

[1]California State Air National Guard (left active duty July 2025), Rocklin, CA, USA; [2]711 Human Performance Wing, USAFSAM, Wright Patterson AFB, OH, USA

(Original Research)

BACKGROUND: Vitamin D deficiency is common among military personnel, particularly those in operational environments with limited sunlight, irregular schedules, and high cognitive demands. Civilian guidelines do not adequately address these occupational risks. Early symptoms such as fatigue, mood disturbance, and musculoskeletal pain are nonspecific and often overlooked, affecting readiness. This study developed a domain-based framework to identify deficiency risk, support decision-making when laboratory testing is limited, and guide preventive

supplementation. **METHODS:** A qualitative observational approach was used, drawing on symptom patterns noted by an embedded physician in Intelligence, Surveillance, and Reconnaissance (ISR) units. These observations were supplemented by a four-decade literature review of physiological, behavioral, environmental, and occupational determinants of vitamin D status. Twenty-seven risk factors were identified and organized into seven domains based on modifiability. Each factor was scored for relevance and modifiability, producing a three-tier priority system. A cumulative scoring method stratified individual risk and established thresholds for empiric supplementation. **RESULTS:** The framework integrated 27 risk factors: 12 from clinical observations and 15 from literature. Composite scoring classified 13 factors as high priority and 14 as moderate. High-priority risks included limited outdoor exposure, restrictive clothing, inadequate diet, latitude above 37°N, endocrine/metabolic disorders, and darker skin pigmentation. ISR personnel demonstrated a high prevalence of deficiency-related symptoms, with laboratory testing confirming widespread low serum 25(OH)D, including cases of osteomalacia and fractures. A practical operational rule emerged: individuals with ≥3 risk factors, including ≥1 high-priority factor, should be considered high risk and candidates for empiric supplementation. **CONCLUSIONS:** This domain-based, risk-tiered framework is the first tailored to operational military environments. It provides a practical tool for early identification and intervention where diagnostic testing is limited. By integrating modifiable and non-modifiable risks, the model enables clinicians to prioritize supplementation and preventive strategies that enhance readiness and resilience. Validation across diverse operational settings is needed to refine thresholds and strengthen clinical utility.

Learning Objectives

1. The audience will be able to use the provided framework to learn proactive Vitamin D screening and supplementation strategies tailored to the demands of operational environments, where early signs of deficiency may be subtle and access to diagnostic resources may be limited.
2. The audience will learn how to utilize the framework to guide operational and command-level changes that offered the greatest benefit with minimal operational disruption to enhance performance and reduce preventable health risks related to Vitamin D deficiency.
3. The audience will be able to assess which common presenting clinical symptoms suggest Vitamin D deficiency in at-risk military populations.

[343] AEROMEDICAL EVALUATION AND CLEARANCE IN AN ASYMPTOMATIC WOMAN WITH HEMOGLOBIN M (SASKATOON VARIANT) AND CHRONIC METHEMOGLOBINEMIA

George Khludenev, Clayton T. Cowl

Mayo Clinic, Rochester, MN, USA

(Education - Case Study)

INTRODUCTION: Aeromedical certification relies heavily on the use of objective measures of oxygenation to assess a pilot's fitness for flight. Aviators with certain hemoglobinopathies may present with cyanosis and reduced SpO2 measurements, despite otherwise healthy cardiopulmonary physiology and normal PaO2 levels when measured using co-oximetry in an arterial blood gas analysis. **BACKGROUND:** In the case of hereditary Hemoglobin M disease, this effect is due to the presence of methemoglobin, which exhibits abnormal light absorption properties at the wavelengths used by standard 2-channel pulse oximeters (660 and 940 nm) and produces falsely elevated carboxyhemoglobin measurements. The incongruency between objective evidence suggesting marked hypoxemia and an unremarkable clinical evaluation can complicate the flight safety assessment, and rather limited aeromedical literature exists to offer clarity in such situations. Accordingly, providing aeromedical flight clearance to individuals with hemoglobin M disease remains a challenge. **CASE REPORT:** A healthy, 19-year-old woman with a known diagnosis of Hemoglobin M, Saskatoon variant, was denied aeromedical clearance by the Federal Aviation Administration (FAA) due to concerns of hypoxemia. Despite an active lifestyle and no cardiopulmonary symptoms, she presented with recorded SpO2 measurements in the 50%'s on room air and a subtle, but visible cyanosis, associated with her otherwise asymptomatic hereditary methemoglobinopathy. Further evaluation revealed normal pulmonary function testing and normal resting arterial blood gas analysis; therefore, no specific treatment was indicated or pursued. Once all relevant aeromedical concerns were addressed, an appeal was submitted to the FAA Federal Air Surgeon's Office where the case was ultimately granted aeromedical certification approval. **DISCUSSION:** This case highlights the importance of recognizing the limitations of standard pulse oximetry as a screening tool in individuals with asymptomatic, hereditary methemoglobinopathies. When tested appropriately using arterial blood gas analysis and co–oximetry, these individuals exhibit normoxia and typically do not suffer from any kind of cardiopulmonary impairment related to the diagnosis. Raising awareness about such presentations should help avoid unnecessary disqualification on the basis of this condition.

Learning Objectives

1. The audience will learn how rare, congenital hemoglobinopathies can lead to chronically low pulse oximetry readings despite preserved physiologic function.
2. The participant will demonstrate appropriate aeromedical evaluation of individuals with diagnosed hemoglobin M disease for Federal Aviation Administration safety clearance.

[344] PELVIC FLOOR DYSFUNCTION INCIDENCE AMONG U.S. AVIATION ACTIVE-DUTY MILITARY PERSONNEL

Kaila Vento, Nicole McCloughan, Ian McIver, Charles Weisenbach

Naval Medical Research Unit-Dayton, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: Pelvic floor dysfunction (PFD) is inclusive of symptoms and disorders relating to abnormal pelvic floor function and pain. Some of these symptoms, including chronic pelvic pain, can disqualify pilots and aircrew from flight duties. However, a significant knowledge gap exists regarding the prevalence of PFD within the military aviation population. Therefore, we examined the PFD incident counts and rates in aviation active-duty USA personnel from 2016-2025. **METHODS:** The Defense Medical Epidemiology Database (DMED) was searched for ICD10 codes associated with PFD. These included dysfunction of pelvic region (M99.05), organ prolapse (N81.84 - Pelvic muscle wasting, and N81.89 - Other female genital prolapse), urinary incontinence (N39.x), and rectal incontinence (R15.x) to determine incident counts (n) and rates (per 1,000 person-years [p-yrs]) among active-duty US military aviation personnel. Data on counts and rates were separated by sex with subcategories of branch, grade, and occupation (NAMRUD IRB25-0016). **RESULTS:** Between 2016-2025, the occurrence of PFD reported among USA active-duty military pilots and aircrew were 14,113 male (41.81 per 1,000 p-yrs, n = 337,512) and 7,909 female (309.05 per 1,000 p-yr, n = 25,591) cases. The highest rates were observed among Army (Total: 101.01 per 1,000 p-yrs; Male: 81.07 per 1,000 p-yrs, Female: 374.83 per 1,000 p-yrs) compared to Navy (Total: 55.14 per 1,000 p-yrs), Air Force (Total: 49.95 per 1,000 p-yrs), and Marine Corps (Total: 44.55 per 1,000 p-yrs) and female Army (374.83 per 1,000 p-yrs). For enlisted personnel, highest rates were seen among junior Air Force (36.82 per 1,000 p-yrs) and senior Navy (67.45 per 1,000 p-yrs). For officers, highest rates were seen among Army (Junior: 92.84 per 1,000 p-yrs, Senior: 124.75 per 1,000 p-yrs). **DISCUSSION:** Pelvic floor dysfunction affects all pilots and aircrew, with women experiencing higher rates, possibly attributed to pregnancy and childbearing. Rates were higher among men and women Army pilots and aircrew compared to other services. This may be possibly attributed to aircraft type, with Army primarily flying rotary wing aircraft known for high levels of whole-body vibration exposure. These findings underscore the importance of pelvic floor health and educational programs to increase awareness among pilots and aircrew.

Learning Objectives

1. Understand the PFD incident count and rate among US military pilots and aircrew.
2. Consider the implications of PFD treatment options and platform-specific care.

Thursday, 05/21/2026, 3:30 PM

Plaza A/B

[S-54] SLIDE: SAFETY FOR ALL MY FRIENDS!

Chair: Ryan Mayes

[345] U.S. ARMY AVIATION SAFETY: FY 2025 YEAR IN REVIEW

Jennifer Benincasa, Sean O'Connell

U.S. Army Combat Readiness Center, Fort Rucker, AL, USA

(Original Research)

INTRODUCTION: Discuss (FY) 2025 statistics and analysis for USA Class A aviation mishaps including Human Factors Analysis. **METHODS:** FY2025 data was obtained from the USA Combat Readiness Center database (ASMIS2.0) for Class A thru C manned and Class A unmanned aviation mishaps and reviewed for human factors as determined by the Safety Investigation Boards. **RESULTS:** In the manned aircraft category, Army aviation experienced 5 Class A flight mishaps in FY25, with a mishap rate of 0.66 mishaps per 100,000 flight hours, which is a decrease from the FY24 rate of 1.90. Closure of the training gap in unanticipated right yaw/Loss of Tail Rotor Effectiveness training, that manifested at the end of FY23 and continued into FY24, also returned the Class A mishap rate below 1.0 per 100,00 flight hours, making it the third best Class A Mishap rate in recorded history of Army Aviation. The Class A-C flight mishap rate of 10.33 is primarily driven by the increase in Class C mishaps, which many were only a single overlooked procedural step from being a Class A mishap. Mishap analysis points to a combination of reduced mid-level aviator experience and insufficient training management. In FY25, unmanned systems (UAS) saw an uptick in the Class A mishap rate from 1.56 in FY24 to 4.42 in FY25, though still remaining below the 5-year average of 6.06 for Class A mishaps per 100,000 flight hours. Army Aviation restructure with an emphasis on UAS continues to present several safety considerations that affect manned and unmanned aviation. **DISCUSSION:** In FY25, Army Aviation experienced the third lowest Class A mishap rate in its recorded history. The increase in Class C mishaps continues to be the primary driver of the increased Class A-C mishap rate, which were only “inches and seconds” from being Class A mishaps. The most significant trend involves a procedure or checklist not followed correctly. There were 5 Class A mishaps reported in FY25 with 9 reported fatalities given approximately 755,349 flight hours flown. There were 3 UAS Class A mishaps in FY25. Human error continues to be the leading factor in Army Class A Flight mishaps.

Learning Objectives

1. Discuss the reasons for the decrease in Army Class A mishap rates and increase in Class C mishap rates compared to previous years. Discuss the gap in mid-level aviator experience in Army Aviation and organizational training gaps with their impacts on current and potential future mishap trends.
2. Describe how the Army Aviation restructuring and emphasis on UAS presents new and increasing safety considerations that will affect manned and unmanned aviation in an already congested airspace.
3. Human error remains the primary causal factor in manned aircraft mishaps. Discuss human factors that have been involved in FY25 Class A Flight mishaps (manned and unmanned).

[346] SAFETY CENTRES: YEAR IN REVIEW - UK MILITARY AVIATION SAFETY AND AIRCRAFT ACCIDENT INVESTIGATION

Matthew Lewis

Royal Air Force Centre of Aerospace Medicine, Henlow, United Kingdom

(Education - Tutorial / Review)

BACKGROUND: The purpose of this presentation is to identify the primary causal factors, survival and injury outcomes, and crew escape system performance findings from UK military aviation accidents. The analysis centered on both human and technical causal factors. **OVERVIEW:** Aircraft accident data were obtained from military aircraft accident databases and the casual factors and injury outcomes were analysed. In the reporting period there were two Category 5 accidents (Class A Mishaps) resulting in the loss of a Spitfire aircraft from the Battle of Britain Memorial Flight and a Royal Navy Merlin helicopter. The Spitfire crashed in a field shortly after take-off due to a technical malfunction. The Merlin, with three people on board, ditched in the English Channel during a night training exercise after having taken off from HMS Queen Elizabeth aircraft carrier. Two of the crew were able to successfully escape from the aircraft but the right-hand seat pilot was fatally injured. In addition, a significant parachuting accident was identified and is also discussed. In this incident the service personnel sustained significant injuries having been unable to deploy their main parachute canopy. During the post-accident investigation, it was identified that anthropometry limitations and a strength test evaluation are required to safely operate the parachute system. **CONCLUSION:** UK military accident rates have shown a gradual reduction over the past ten years. Human factors and technical malfunctions persist in being the major causes of aircraft accidents and in particular were responsible for the loss of a vintage aircraft and a current modern rotorcraft. Anthropometry and strength testing limitations need to be introduced for parachutist where previously the were none.

Learning Objectives

1. The audience will learn about the UK military's efforts to utilise aviation accident data to develop proactive intervention strategies to prevent future accidents in an effort to preserve human life and aircraft losses.
2. Understand the importance of how aircrew equipment design and function is critical to aircraft accident survival.

[347] CREW RESOURCE MANAGEMENT ANALYSIS OF 245 INVESTIGATION REPORTS IN INDONESIA FROM 2007 TO 2024

Inne Yuliawati[1], Budi Sampurna[1], Tjhin Wiguna[1], Imam Subekti[1], Widura Imam Mustopo[2], Aria Kekalih[1], Hervita Diatri[1], Wawan Mulyawan[1]

[1]Universitas Indonesia, Jakarta, Indonesia; [2]Universitas Jayabaya, Jakarta, Indonesia

(Original Research)

INTRODUCTION: Pilot errors research have been dominated by psychological and physiological contribution such as medical condition and cognitive function. However, the psychosocial contribution such as of Crew Resource Management that includes communication and teamwork had less attention. **METHODS:** This was a cross-sectional study design with secondary data from the investigation reports published by the National Transport Safety Committee (NTSC) from 2007 until 2024 in Indonesia, downloaded from https://knkt.go.id/investigasi between August 12–31, 2024. The inclusion criteria was pilot-error related investigation reports. Internal validation was conducted with the NTSC investigators. Statistical analysis using non-parametric tests was carried out to assess the association between Crew Resource Management and pilots errors consisted of Perceptual, Skill-based and Decision errors. **RESULTS:** A total of 245 investigation reports were downloaded, amounting to 253 aircrafts with eight aircrafts involved in near collisions, and 186 pilot-error related investigations were selected as subject analysis. Pilots who experienced a precondition of Crew Resource Management had a 1.90 times higher risk (95%CI 1.03 – 3.51) for perceptual errors compared to pilots who did not have precondition of Crew Resource Management. Other than that, pilots who experienced a precondition of Crew Resource Management had a 2.13 times higher risk (95%CI 1.18 – 3.86) for decision errors compared to pilots who did not have precondition of Crew Resource Management. **DISCUSSION:** Crew Resource Management was significantly associated with perceptual and decision errors. Crew resource management is crucial in aviation safety for its component in communication and teamwork is a beneficial approach to mitigate pilot error.

Learning Objectives

1. This study aids in understanding that Crew Resource Management is crucial in aviation safety for its component in communication and teamwork.
2. This study aids in understanding that effective Crew Resource Management training is a beneficial approach to mitigate pilot error.

[348] FLIGHT SAFETY IMPLICATIONS OF PHYSIOLOGICAL EPISODES: A NATO PERSPECTIVE

Ryan Mayes[1], Laetitia Bertrand[2], Erik Frijters[3], Nicholas Green[4], Tom Holthe[5], Vivienne Lee[6], Karsten Lindgaard[7], Stefan Sammito[8], Alessandro Scagliusi[9], Adrian Smith[10], Roope Sovelius[11]

[1]U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, USA; [2]French Health Military Service, Avord, France; [3]Royal Netherlands Air and Space Force, Soesterberg, Netherlands; [4]RAF Centre of Aerospace Medicine, Bedfordshire, United Kingdom; [5]FSAN/Norwegian Armed Forces, Oslo, Norway; [6]QinetiQ PLC, Hampshire, United Kingdom; [7]Danish Medical Command, Vojens, Denmark; [8]German Air Force Centre of Aerospace Medicine, Cologne, Germany; [9]Flight Test Center - Aerospace Medicine Department, Rome, Italy; [10]RAAF Institute of Aviation Medicine, Edinburgh, Australia; [11]Finnish Defence Force Aeromedical Centre, Helsinki, Finland

(Education - Program / Process Review)

BACKGROUND: From around 2010, many nations reported an increasing occurrence of Physiological Episodes (PhysEps) among aircrew of high-performance aircraft. These PhysEps do not appear to be due exclusively to the classic causes of hypoxia or G-induced loss of consciousness (G-LOC). In order to facilitate international information sharing and create a consensus understanding of PhysEps, a North Atlantic Treaty Organization (NATO) working group was formed in 2018, comprising 10 NATO and partner nations. **OVERVIEW:** The NATO PhysEp group has previously presented its findings and recommendations; PhysEps are commonly multifactorial and often represent a normal physiological response to an abnormal and challenging environment. The group has also presented its "exposure matrix" for PhysEps, which describes the impact of each exposure of potential interest in the high-performance aviation environment. From this analysis it has identified knowledge gaps and research priorities. Finally, the group has presented its envisioned "end state" for how to mitigate the impact of PhysEps in high-performance aviation. This presentation extends on that work by describing the flight safety implications of PhysEps; this is a critical translational element from aerospace medicine and physiology professionals to aircrew. **DISCUSSION:** Historically, aerospace physiology training has focused on recognizing and/or mitigating the most hazardous exposures in the high-performance aviation environment. This focus is deserved; exposures such as hypoxia and high Gz are, by themselves, sufficient to incapacitate aircrew and may lead to catastrophic outcomes. These primary threats to safety have been extensively addressed (but not eliminated) through engineering, research, training, and procedural mitigations. The remaining physiologic drivers of PhysEps are unlikely to be catastrophic on their own. However, an uncontrolled aircrew response to PhysEps may represent a significant hazard that may be more dangerous than the PhysEp itself. Procedures for responding to PhysEps should address potentially catastrophic causes first. If these causes have been addressed but aircrew symptoms persist, procedures should allow for physiologic recovery to the greatest extent possible before executing critical phases of flight. Examples of how to implement this recovery phase will be discussed.

Learning Objectives

1. The audience will be able to discuss basic findings of the NATO PhysEp group.
2. The audience will be able to describe flight safety implications of PhysEps for aircrew.

[349] A BUCKET OF BOLTS? AN EXAMINATION OF HELICOPTER MISHAPS AND EQUIPMENT FAILURE FOR ALL CAUSE MISHAP ATTRIBUTION

Thomas Powell, Tim Sprott

U.S. Air Force, Albuquerque, NM, USA

(Original Research)

INTRODUCTION: Recent high-profile rotary wing mishaps such as the inflight breakup of the Hudson River tourist helicopter have called into question the inherent safety of rotary-wing aircraft. In 2020, the National Commission on Military Aviation Safety (NCMAS) revealed a

large data set examining mishap causes for military aircraft from FY 2013 through FY 2018. This large data set, in conjunction with the NTSB data set from the same range of civilian aircraft mishaps provides for illuminating data about equipment failure as the primary cause of rotary-wing mishaps and how this compares to complex fixed-wing aircraft. **METHODS:** The mishap aircraft data set for USN and USAF rotary-wing aircraft for the NCMAS was examined for Class A mishaps resulting in loss of life or total loss of aircraft where the primary cause was found to equipment failure. This was compared to the publicly available NTSB Accident Investigation data set for all fatal aviation mishaps involving rotary-wing aircraft in the United States during the same time frame. **RESULTS:** For the NCMAS dataset 55 episodes of Class A mishap were involved in rotorcraft resulting in 37 destroyed aircraft. Maintenance causes and equipment failure were found to be the primary cause for 17 out of 55 (27%) mishaps. In the NTSB data, 22 out of 121 (18%) fatal mishaps in the civilian rotorcraft fleet were directly attributable to equipment failure. This mishap rate is slightly lower than the number of USAF and USN fighter aircraft lost to mechanical failure over the same timeframe (34%) but greater than the rate of tanker/transport aircraft lost to equipment failure (10%). **CONCLUSION:** Although rotorcraft have a reputation for mechanical unreliability, their mishap rate due to equipment failure is in line with that of other complex aircraft, particularly when examined against other military aircraft. Greater emphasis on maintaining safety of flight critical systems such as gearboxes and engines is necessary for long-term safety of the rotary-wing fleet. For flight surgeons, emphasis on ensuring clean maintenance areas and minimizing maintainer and crew fatigue could be a key preventative for equipment failure mishaps.

Learning Objectives

1. Individuals attending this presentation will be able to understand the vulnerabilities inherit in modern rotorcraft systems.
2. Individuals attending this presentation will be able to understand main causes of rotorcraft mishaps across the military and civilian fleets and how equipment failure contributes to mishaps.
3. Individuals viewing this presentation will be able to better appreciate why greater preventative maintenance and more robust design will be able to save lives in rotorcraft aviation.

[350] LEADERSHIP UNDER CONDITIONS OF OPERATIONAL COMPLEXITY: A PRELIMINARY QUALITATIVE ANALYSIS OF CVN SENIOR MEDICAL OFFICERS

Michael Kukenberger, Clark Noble, Rebecca NeSmith

Naval Aerospace Medical Institute, U.S. Navy, Pensacola, FL, USA

(Original Research)

INTRODUCTION: The Senior Medical Officer (SMO) aboard a nuclear-powered aircraft carrier (CVN) occupies one of the most demanding leadership roles in operational medicine.

SMOs are responsible for the health and readiness of up to 7,000 personnel in a constrained, high-risk environment while coordinating across medical departments, ship leadership, operational units, and external systems. Despite extensive clinical training, limited evidence-based leadership preparation exists for the complexity of this role. This study examines leadership behaviors associated with effective SMO performance in high-stakes operational settings. **METHODS:** This qualitative study uses the critical incident technique. Semi-structured interviews were conducted with seven current and former U.S. Navy CVN SMOs who described recent leadership situations they experienced as effective or less effective. Interviews were recorded, transcribed, de-identified, and analyzed using inductive thematic analysis. Data collection is ongoing, with a planned sample of 25–30 SMOs. **RESULTS:** Five leadership themes emerged. First, effective leadership required alignment of formal authority and domain expertise, with SMOs retaining decision accountability while integrating distributed input. Second, humility functioned as a coordination behavior that enabled information sharing and joint problem solving without undermining authority. Third, leadership failures most often occurred at organizational and professional boundaries rather than from technical deficiencies. Fourth, SMOs described the protective use of authority to constrain system-level risk, often involving unpopular but safety-preserving decisions. Fifth, leadership was temporally dynamic, shifting across planning, execution, and recovery phases. Leadership challenges differed when operating within the medical department versus across organizational boundaries, reflecting multi-team system demands. **DISCUSSION:** SMO effectiveness appears driven less by clinical expertise alone and more by adaptive leadership capabilities for complex operational systems. Successful SMOs balance authority and expertise, use humility to enable coordination, and adjust leadership behaviors based on timing, risk, and boundary conditions. These findings inform leadership training that complements clinical preparation for carrier-based and other high-reliability medical environments.

Learning Objectives

1. Identify five leadership behaviors associated with effective CVN SMO performance.
2. Distinguish leadership demands within departments versus across organizational boundaries in complex operational settings.

Thursday, 05/21/2026, 3:30 PM

Plaza D

[S-55] PANEL: UV-C DISINFECTION IN AEROSPACE OPERATIONS: CURRENT EVIDENCE, APPLIED RESEARCH, AND OPERATIONAL BOUNDARIES

Chair: Kris Belland

Co-Chair: Charles DeJohn

Panel Overview: *Brief Background Statement: Given AsMA 2023-01 resolution supporting the continuous use of airborne Ultraviolet-C (UV-C) disinfection technologies, this timely update is critical to a rapidly changing and advancing field. UV-C was rapidly adopted during the COVID-19 pandemic as emergency mitigation tools in aviation and healthcare. As aviation moves beyond crisis response, there is a need to reassess UV-C using current scientific evidence, operational experience, and international aviation health frameworks. This session places UV-C in the context of modern aerospace medicine and long-term infectious disease preparedness. PANEL/WORKSHOP DESCRIPTION: This panel provides an evidence-based update on UV-C disinfection in aerospace and aviation-adjacent operations. Panelists will review recent laboratory and operational data on airborne and surface UV-C applications, including upper-room, in-duct, and emerging far-UV approaches. Discussion will address effectiveness, safety, engineering controls, maintenance requirements, and known operational limitations. Audience engagement will be encouraged through moderated discussion and case-based questions. Relevance, Timeliness, and Real-World Application: As UV-C transitions from an emergency intervention to a proposed long-term control measure, aerospace medicine professionals are increasingly asked to provide informed guidance on its appropriate use. This session aligns UV-C with High Reliability Organization principles and the Swiss Cheese layered risk-mitigation model, positioning it as a complementary, not standalone, control alongside ventilation, filtration, vaccination, surveillance, and operational measures. Attendees will gain a practical understanding of where UV-C adds value, where its limits lie, and how to apply this knowledge in real-world operational decision-making.*

[351] UV-C DISINFECTION UPDATE: EVIDENCE, OPERATIONAL EXPERIENCE, AND EVOLVING AVIATION HEALTH INTEGRATION

Kris Belland

Aerospace Medicine Strategic Consultation (AsMSC), PLLC, Keller, TX, USA

(Education - Tutorial / Review)

INTRODUCTION: Building on prior Aerospace Medical Association presentations that examined ultraviolet-C (UV-C) disinfection as a pandemic-era mitigation strategy, this presentation provides a focused update on how the evidence base, operational experience, and aviation health integration have evolved in the post-pandemic period. The intent is continuity, not reinvention, updating earlier findings with new data and real-world implementation lessons. TOPIC: Recent laboratory, field, and operational studies evaluating airborne and surface UV-C applications will be reviewed, including upper-room UV-C, in-duct systems, and emerging far-UV technologies. Emphasis will be placed on effectiveness against respiratory pathogens, refinements in engineering controls, human exposure considerations, maintenance and monitoring requirements, and operational constraints observed in aviation and aviation-adjacent environments. **APPLICATION:** What is new since 2022–2023 is the accumulation of multi-year operational data, improved dosimetry and exposure modeling, clearer differentiation between near-field and room-scale effectiveness, and increasing alignment with consensus safety

guidance, allowing UV-C to be discussed less as an emergency intervention and more as a mature, supplemental risk-mitigation layer. Technology makes UV-C low risk, with low power consumption, providing design optimization within aircraft cabins. These updates are framed within international aviation public health principles advanced by the International Civil Aviation Organization Collaborative Arrangement for the Prevention and Management of Public Health Events in Civil Aviation (CAPSCA). UV-C is positioned within a High Reliability Organization framework as a complementary control that reinforces, but does not replace, ventilation, filtration, vaccination, surveillance, and operational measures. The presentation further aligns with the scientific and educational missions of the Aerospace Medical Association through ICAM and ICASM, and with the global professional perspective of the International Academy of Aviation and Space Medicine. The objective is to provide aerospace medicine professionals with a credible, evidence-based update that naturally extends earlier AsMA UV-C work and supports informed decision-making as aviation moves toward sustainable infectious disease resilience.

Learning Objectives

1. Describe how post-pandemic operational data, improved dosimetry, and exposure modeling have refined the effectiveness and safety profile of airborne and surface UV-C disinfection in aviation and aviation-adjacent environments.
2. Explain how UV-C disinfection functions as a supplemental risk-mitigation layer within a High Reliability Organization framework, aligned with International Civil Aviation Organization CAPSCA guidance and complementary to ventilation, filtration, vaccination, and surveillance.

[352] LATEST ADVANCES IN UV-C DISINFECTION (2023–2025)

Charles DeJohn

DeJohn AeroMed, LLC, Oklahoma, OK, USA

(Education - Tutorial / Review)

INTRODUCTION: Ultraviolet-C (UV-C) disinfection has advanced rapidly over the past three years, transitioning from largely experimental or pilot-scale use toward increasingly standardized and field-validated deployment. Accelerated by the COVID-19 pandemic, recent research has shifted emphasis from proof of germicidal efficacy to real-world performance, safety, verification, and integration into environmental control systems. This presentation summarizes key developments from 2023–2025 that illustrate the maturation of UV-C technologies across air, surface, and water disinfection domains. **TOPIC:** Recent advances in UV-C research have focused on refining wavelength-specific performance, safety characterization, and measurement rigor. Far-UV-C (222 nm) has moved beyond laboratory studies to evaluations in occupied spaces, with multiple investigations demonstrating substantial reductions in airborne infectious virus under realistic conditions. These studies emphasize engineering considerations such as

spectral filtering, fixture geometry, dose distribution, and in situ exposure verification rather than reliance on theoretical safety assumptions alone. Comparative research between 222 nm and conventional 254 nm UV-C has clarified efficacy and risk tradeoffs relevant to continuous or intermittent use in occupied environments. In parallel, UV-C light-emitting diode (LED) technology has progressed significantly. Improvements in output power, wall-plug efficiency, and device lifetime have expanded the practical feasibility of LEDs, particularly at 280 nm, while enabling new form factors and system designs not achievable with mercury-based lamps. **APPLICATION:** In building and healthcare environments, upper-room germicidal ultraviolet (GUV) and HVAC-based UVGI systems have benefited from consolidation of professional guidance and standards. Updated CDC/NIOSH recommendations and the introduction of ASHRAE Standard 241 (Control of Infectious Aerosols) have positioned UV-based air disinfection as a recognized engineering control, with clearer expectations for design, testing, and exposure management. In water and wastewater treatment, full-scale demonstrations of 280 nm UV-LED reactors have achieved multi-log microbial inactivation with audited fluence delivery, marking a transition from laboratory feasibility to early commercial deployment. Within healthcare settings, surface disinfection has evolved toward targeted and automated UV-C approaches, including early use of autonomous or AI-enabled systems to improve delivered dose and workflow integration. Collectively, these applications reflect a shift toward implementation quality, verification rigor, and standards-aligned deployment of UV-C technologies.

Learning Objectives

1. Describe recent advances (2023–2025) in UV-C disinfection technologies, including far-UV-C and UV-C LEDs, with emphasis on real-world performance, safety verification, and engineering controls rather than laboratory efficacy alone.
2. Apply current standards and guidance to evaluate when and how UV-C can be appropriately integrated as an engineering control in air, surface, and water disinfection across healthcare and built environments.

[353] OPTIMIZING UV-C PATHOGEN MITIGATION FOR MILITARY AVIATION AND AEROMEDICAL EVACUATION

Eric Robinson

Naval Aerospace Medical Research Lab (NAMRL) Naval Aerospace Medicine Research Unit (NAMRU-D), Dayton, OH, USA

(Education - Tutorial / Review)

INTRODUCTION: Military aviation and aeromedical evacuation operations present complex infectious disease risk profiles driven by confined cabin environments, variable ventilation, high personnel density, and the transport of acutely ill or injured patients. These operational realities challenge traditional infection-control approaches and motivate exploration of supplemental mitigation strategies that can function within aviation constraints. **TOPIC:** This presentation

provides a measured review of current evidence regarding ultraviolet-C (UV-C) pathogen mitigation efficacy, with particular focus on recent advances in UV-C light-emitting diode (LED) technology. Laboratory findings and early operational research related to aerosolized and surface-associated pathogens relevant to military and expeditionary settings will be summarized. Emphasis will be placed on key system performance considerations, including wavelength selection, dose delivery, power efficiency, durability, and integration challenges within constrained aircraft platforms. Known limitations, uncertainties, and data gaps will be explicitly identified. **APPLICATION:** Rather than asserting operational effectiveness, this presentation outlines a proposed research approach to better characterize UV-C application in military aviation environments. Specifically, we propose evaluating UV-C exposure profiles within the MV-22 Osprey across multiple patient and passenger cabin configurations to assess spatial dose distribution, potential shielding effects, and compatibility with existing airflow and mission requirements. This work reflects ongoing and planned research activities at the Naval Medical Research Unit Dayton (NAMRU-D) and is intended to inform future study design, risk-benefit assessment, and evidence-based decision-making. UV-C is presented as a potential complementary element within layered infection-control strategies for military aviation and aeromedical evacuation, with emphasis on rigorous evaluation prior to any operational consideration.

Learning Objectives

1. Describe the infectious disease risk factors unique to military aviation and aeromedical evacuation, and explain why supplemental mitigation strategies such as UV-C are being explored within constrained aircraft environments.
2. Identify key performance, integration, and research considerations for UV-C LED systems in military aviation platforms, including wavelength selection, dose distribution, durability, and known limitations requiring further study.

[354] PROPOSED ANIMAL MODEL EVALUATION OF OCULAR SAFETY THRESHOLDS FOR PROLONGED UV-C EXPOSURE IN MILITARY AVIATION ENVIRONMENTS

Erica Poole

Naval Aerospace Medical Research Laboratory (NAMRL) Naval Aerospace Medicine Research Unit Dayton (NAMRU-D), Dayton, OH, USA

(Education - Tutorial / Review)

INTRODUCTION: As ultraviolet-C (UV-C) technologies are increasingly explored for mitigating airborne pathogen transmission in occupied military aviation environments, rigorous biological safety evaluation is required before any operational consideration. Extended-duration exposure scenarios relevant to aviation and aeromedical evacuation introduce safety questions that are not fully addressed by existing short-term or non-occupancy data. **TOPIC:** This presentation outlines a proposed animal research framework to evaluate ocular safety associated

with prolonged, low-level UV-C exposure. The study will utilize young male guinea pigs (Cavia porcellus), an established ocular research model with a well-characterized visual system and mature retinal development at birth. Although guinea pigs do not perceive UV-C wavelengths, their ocular anatomy and corneal response characteristics support evaluation of biological injury thresholds independent of visual perception. The research will focus on light-emitting diode (LED) UV-C sources spanning the 220–280 nm wavelength range, with emphasis on 265 nm, reflecting emerging engineering approaches to disinfection. **APPLICATION:** A within-subject control design is proposed using monocular occlusion via tarsorrhaphy, allowing each animal to serve as its own control. Exposure scenarios will model realistic operational durations of up to eight hours per day over a four-week period. Acute ocular assessment will be conducted following the initial exposure using slit lamp examination, with predefined humane endpoints guiding early euthanasia and tissue harvest if abnormalities are observed. Exposure enclosure design will be informed by UV-C exposure profiles within the MV-22 Osprey across multiple patient and passenger cabin configurations, enabling translation of worst-case distance and irradiance conditions to the animal model. The goal is to generate foundational safety data to inform future risk assessment and system design while prioritizing personnel safety.

Learning Objectives

1. Explain why extended-duration UV-C exposure in occupied military aviation environments requires dedicated biological safety evaluation, particularly for ocular risk not addressed by short-term or non-occupancy data.
2. Describe the rationale and design features of an animal model used to assess ocular safety during prolonged, low-level UV-C exposure, including wavelength selection, exposure duration, and control methodology.

Thursday, 05/21/2026, 3:30 PM

Plaza F

[S-56] SLIDE: CIRCUIT BREAKERS; SEIZURE RISKS, STROKE WAIVERS & BRAIN STIMULATORS

Chair: Kapil Ojha

Co-Chair: Sheena Dev

[355] PERIMESENCEPHALIC NON-ANEURYSMAL SUBARACHNOID HEMORRHAGE IN A NAVAL AVIATOR

Merwan Faraj[1], Brianna Sheridan[2]

[1]U.S. Navy, Pensacola, FL, USA; [2]U.S. Navy, Fort Worth, TX, TX, USA

(Education - Case Study)

INTRODUCTION: This case report describes a naval pilot who experienced a perimesencephalic non-aneurysmal subarachnoid hemorrhage (PN-SAH), a benign bleed involving the cisterns of the midbrain and pons. Differentiating PN-SAH from aneurysmal SAH is essential because the two conditions carry different prognostic and aeromedical implications. **BACKGROUND:** PN-SAH is a subarachnoid hemorrhage in the absence of an identified source such as an aneurysm or vascular malformation, and is known for its excellent prognosis, low complication rate, and rare recurrence. Unlike aneurysmal SAH, which carries significant morbidity and higher seizure risk, PN-SAH typically has;a benign clinical course. These differences directly influence aeromedical disposition, return-to-flight timelines, and long-term monitoring requirements in military aircrew. **CASE PRESENTATION:** A naval aviator developed an acute, severe headache during a Valsalva-type event after several days of upper respiratory symptoms. CT imaging showed a cisternal perimesencephalic hemorrhage with no aneurysm. MRI and MRA were unremarkable aside from transient spinal dural enhancement. The aviator had no neurological deficits, hypertension, or prior neurological disease. Serial imaging demonstrated complete resolution of the hemorrhage. Clinical evaluations throughout follow-up remained normal. **DISCUSSION:** Standard Navy aeromedical policy typically restricts aviators with spontaneous SAH from flight duties for two years because of recurrence and seizure risk. However, PN-SAH's benign medical course and low recurrence rate support a shorter observation period. After one year of stability, multidisciplinary review, and resolution on imaging, the aviator received a waiver and returned to flight status. This case emphasizes the operational importance of distinguishing PN-SAH from aneurysmal SAH to avoid prolonged grounding. It also highlights the need for continued research on neurocognitive and seizure outcomes in aircrew with PN-SAH to refine evidence-based waiver guidance.

Learning Objectives

1. The participants will be able distinguish perimesencephalic non-aneurysmal subarachnoid hemorrhage from aneurysmal subarachnoid hemorrhage in aviators and understand its waiver implications.
2. The participants will be able to describe recurrence and seizure risk in perimesencephalic non-aneurysmal subarachnoid hemorrhage and the rationale for modified aeromedical disposition timelines.
3. The audience will learn about the causes and pathophysiology of perimesencephalic non-aneurysmal subarachnoid hemorrhage.

[356] SEIZURE RISK IN U.S. AIR FORCE FLYERS WITH AEROMEDICAL WAIVER FOR STROKE

Allan Ward, Aven Ford, Joseph Connolly, Jared Haynes

U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: Transient ischemic attack (TIA) and cerebrovascular accident (CVA) can be career-ending events for US Air Force (USAF) personnel on flying status. Current USAF post-stroke observation periods required for aeromedical waiver consideration are based on general population studies, which may overestimate the seizure risk in USAF flyers who demonstrate complete clinical recovery, especially those whose stroke etiology is identified and corrected. This study investigated the incidence of post-stroke seizure in USAF flyers with medical waiver for TIA or CVA, using longitudinal clinical data from the USAF waiver database and DoD medical surveillance repositories. **METHODS:** The USAF AIMWTS database was queried using validated ICD 9/10 stroke and seizure codes to identify flyers with TIA/stroke waivers adjudicated between years 2001 and 2024. Case demographics, stroke event date, stroke type, and associated risk factors were extracted from the aeromedical summaries. Last known clinical encounter date and seizure event data were obtained by querying longitudinal surveillance and pharmacy databases for the presence of validated ICD 9/10 codes for stroke and seizure diagnoses and/or antiseizure medication prescriptions. The study protocol was approved by the USAF 711th HPW IRB. **RESULTS:** AIMWTS query identified 277 flyers (84.8% male, 15.2% female; 67.5% Guard-Reserve, 30.3% Active Duty) with unprovoked TIA/stroke. 140 (50.5%) cases were ischemic type, 51 (18.4%) hemorrhagic, 52 (18.8%) TIA, 28 (10.1%) cryptogenic. 14 (5.1%) participants experienced a post-stroke seizure, of whom 10 experienced early seizures (<24 hrs), and 4 had late seizures (>24 hrs). Avg time to late seizure was 4.3 months. The total time at risk for the cohort was 2,034.7 years. Overall seizure incidence was 6.9 events per 1,000 person-years, 5.0 events per 1,000 person-years for early seizure and 2.1 events per 1,000 person-years for late seizure. **DISCUSSION:** Among this cohort of 277 USAF flyers presented for medical waiver for TIA or stroke, who lack residual neurocognitive deficits and severe epileptogenic imaging findings, the overall late seizure incidence is considerably lower than previously published rates in general population studies. Current USAF medical standards for post-stroke observation periods may be too conservative for flyers who meet criteria for waiver consideration.

Learning Objectives

1. The participant will be able to identify the primary risks associated with stroke in personnel on flying status.
2. The participant will review the current USAF aeromedical waiver standards for stroke and requirements for aeromedical waiver consideration.
3. The participant will learn the observed early and late seizure rates for TIA and stroke in this cohort.

[357] CEREBELLAR ATAXIA INDUCED BY HIGH-G LOADS IN A MILITARY PILOT WITH FUNCTIONAL PICA ENDING OF THE VERTEBRAL ARTERY AND ITS AEROMEDICAL RELEVANCE

Marcus Wichlitzki, Josef Ehling, Jan Stier, Hans Juergen Noble, Daniel Veit

German Air Force Centre of Air and Space medicine, Cologne, Germany

(Education - Case Study)

INTRODUCTION: Military jets are increasingly agile and capable of producing significant Gz-loads and G-onsets. Neuroanatomically regular blood supply of the cerebellum and the brainstem is guaranteed via two vertebral arteries (VAs) both converging in the basilary artery (BA). Functional PICA (Posterior Inferior Cerebelli Artery) ending is a rare anatomic variant, that carries a risk for insufficient blood supply which can lead to sudden inflight incapacitation. **BACKGROUND:** There are no cases that describe the impact of PICA-VA in aviation medicine. PICA is a critical artery for blood supply due to its potential risk of sudden inflight incapacitation. Literature Searls DE et al Symptoms and signs of posterior circulation ischemia in the New England Medical Centre posterior circulation registry. Arch Neurol. 2012 Cerebral hemodynamics and brain oxygen changes related to gravity-induced loss et consciousness in thesus monkeys C.C. Tran'et al. Neuroscience Letters 338 (2003) 67-71. **CASE DESCRIPTION:** A 26-year-old military pilot passed the first steps in regular flight training. Shortly after he switched to a T-38C, he noticed symptoms of vertigo and ataxia in positive GZ-forces with high G-onsets. Counter measurements showed no effect. The pilot was transferred to our specialized medical center for further evaluation. 3-Tesla MRI showed a functional PICA ending of the left VA and a subtle hyperintensity of the left cerebellar hemisphere. We performed several testings in our flight-physiologic center, including centrifuge rides. The cerebellar ataxia was reproducable when performing more then 5Gz, below the pilot was asymptomatic. In terms of aviation medicine, a limit of +4 Gz was imposed, with the requirement to use dual controls and no approval for jet-powered aircrafts. Furthermore, regular checks by means at each follow-up examination are required. **DISCUSSION:** The PICA is the last exiting branch of the VA before connecting to the BA. PICA ending describes the VA with an aplastic V4 segment. PICA-VA configuration is crucial as it is a critical vascular artery affecting the posterior circulation with insufficient capacity of compensation in blood supply. Especially in military pilots the cerebellar functions are of special interest. Vertigo and disorientation are typical symptoms pilots can experience during training and in challenging flight situations. In this case a cause was found after advanced MRI imaging of the brain.

Learning Objectives

1. Understand and recognize vascular supply of the cerebellum and recognize anatomic variants.
2. Understand the relevance of cerebellar functions for vertigo and ataxia.
3. Learn about neuroanatomic imaging and its impact on flight medicine.

[358] PREVALENCE OF NEUROLOGIC & MENTAL HEALTH DISORDERS IN U.S. NAVAL AVIATORS: A RETROSPECTIVE COHORT STUDY

G. Merrill Rice[1], Steven Linnville[2], Tina Luse[3], Jonathan Erpenbach[4], Stephanie Larocco[5]

[1]Naval Safety Command, Norfolk, VA, USA; [2]Naval Medical Research Unit-Dayton, Dayton, USA; [3]DHA Public Health, Portsmouth, USA; [4]Naval Safety Command, Norfolk, USA; [5]Battelle Memorial Institute, Columbus, USA

(Original Research)

INTRODUCTION: Recent media and public attention have linked the Naval tactical aircraft accelerative environment to potential neurologic and mental health issues, but epidemiological research on tactical aviators is limited. This study reports the current prevalence of selected neurologic and mental health disorders among naval tactical aviators and non-tactical aviators. **METHODS:** A retrospective cohort-designed study was performed on 10,661 active-duty naval aviators identified within the Naval Fleet Training Management and Planning System. Their unique identification codes were then associated with all available military electronic health records within the Military Health System Data Repository for certain neurologic and mental health International Classification of Diseases (ICD) codes from October 2000 through December 2024. **RESULTS:** 8,598 active-duty naval aviators met inclusion criteria. Compared to tactical aviators, helicopter aviators had higher odds of behavioral health disorders overall (odds ratio [OR] 1.29, 95% confidence limits [CL] 1.10-1.52), adjustment disorders (OR 1.35, 95% CL 1.09-1.68), and post-traumatic stress disorder (PTSD) (OR 1.82, 95% CL 1.02-3.25). Reconnaissance aviators had higher odds of behavioral health disorders overall (OR 1.37, 95% CL 1.17-1.60), adjustment disorders (OR 1.5, 95% CL 1.22-1.85), PTSD (OR 1.84, 95% CL 1.05-3.22); and anxiety (OR 1.33, 95% CL 1.05-1.70) compared to tactical aviators. No significant differences were observed between these cohorts for selected neurologic conditions. **DISCUSSION:** Accelerative exposures in tactical naval aviation differ and are generally far lower than those seen in sports involving repetitive head impacts. Advances in medical imaging and neuro-biomarkers now make it possible to examine this population for potential subclinical neurologic changes.

Learning Objectives

1. The audience will learn that tactical Naval Aviators have less risk of behavioral health disorders compared to their non-tactical counterparts and no elevated risk of selected neurologic disorders.
2. The audience will understand that accelerative exposures from repetitive head impacts during various sports activities are different and in general far less than accelerative exposures during extreme tactical aviation maneuvers.

[359] TRAINING IN AEROSPACE MEDICINE IN INDIA - A REVIEW

Vipin Sharma[1], Nataraja MS[2]

[1]Nil, Bangalore, India; [2]Indian Air Force, Bangalore, India

(Education - Program / Process Review)

BACKGROUND: Training in the field of Aerospace Medicine in India has been conducted at the Institute of Aerospace Medicine, at Bangalore, India, for more than five decades. It started with a two-year Diploma in Aviation Medicine in 1968 and graduated into a two-year MD Programme in Aviation Medicine in 1978. The three-year MD Aviation Medicine was started in the eighties and the MD in Aerospace Medicine in 1997. **OVERVIEW:** The training programme has kept pace with the developments in the field of Aerospace Medicine and has trained professionals who now function as specialists in Aerospace Medicine in India and abroad. With the advent of fast jets, the facilities for human centrifuge training and Spatial Orientation training were added for training of aircrew and its effective implementation was ensured by Aviation Medicine specialists. With the use of Night Vision Devices (NVDs) in helicopter & transport flying, NVG training found its way into the curriculum. Similarly, the developments in Space Medicine have resulted in changes in the way Space Medicine is taught at the Institute. The inclusion of Remotely Piloted Aircraft Systems (RPAs)/ Unmanned Aerial Vehicles (UAVs), need for Crew/ Cockpit Resource Management (CRM)/ Human Factors training, Aircraft Accident Investigation training, Civil Aviation Medicine training, Clinical Aerospace Medicine training, Hyperbaric Medicine training, use of Applied Biostatistics have all been elements that have been added and have been refining training content, expanse and depth. It has also necessitated modular training and use of scalable resource materials with students & teachers. With the future developments of commercially useable hypersonic platforms, suborbital long-range human flights, 6th generation fighter aircraft, prolonged & sustained aerial operations and aeromedical support to wars fought over distant lands, have raised issues that need to be addressed as specific training modules in future modifications of the training programme. **DISCUSSION:** The paper will discuss the past, present & future of the training of Aerospace Medicine in India. The need for collaboration in Aerospace Medicine training is fast becoming an imperative, from being just an option. The standardisation of methodology and uniform objectives appears to be an imminent goal.

Keywords: Aerospace Medicine, Postgraduate Training

Learning Objectives

1. Understand the need for a constant need-based updation of training in Aerospace Medicine.
2. Appreciate the felt need for international collaboration in Aerospace Training.

Thursday, 05/21/2026, 3:30 PM

Governor's 10

[S-57] PANEL: ASAMS AEROSPACE MEDICINE BOARD EXAM REVIEW SESSION

Chair: Amy Kreykes

Co-Chair: Thomas Jarnot

Panel Overview: *This review session for the American Board of Preventive Medicine – Aerospace Medicine Examination is hosted annually by the American Society for Aerospace Medicine Specialists (ASAMS) at the AsMA Scientific Meeting. The session is comprised of 4 review topics (approximately 20 minutes per topic) presented by the 4 ACGME Accredited Aerospace Medicine Residencies as follows: 1) Aerospace Impacts on Human Physiology, United States Army; 2) Acceleration and its Effects on the Aerospace System, United States Air Force; 3) Spatial Disorientation: A Rapid Review, University of Texas Medical Branch; 4) High-Yield FAA Medical Disposition, United States Navy The ASAMS Board Review session provides a high-yield opportunity for Aerospace Medicine physicians in the process of recertifying, or Aerospace Medicine residents who will be taking their boards for the first time to be exposed to board-like questions in an interactive session with experts in the field.*

[360] REVIEW OF AEROSPACE IMPACTS ON HUMAN PHYSIOLOGY

Julissa Medoza[1], Soyna Heidt[2]

[1]U.S. Army, Redstone Arsenal, AL, USA; [2]U.S. Army, Fort Rucker, AL, USA

(Education - Program / Process Review)

BACKGROUND: Understanding the aerospace environment's effects on human physiology is paramount for Aerospace Medicine professionals. The flight and spaceflight environments expose human physiology to unique stressors that can impair performance, and/or threaten life and safety. Medical screening, diagnosis, and treatment for aircrew, astronauts, and passengers are predicated on the depth and breadth of knowledge for aerospace clinicians. This 22-minute high-yield session provides a targeted review of the impacts on normal human physiology resulting from exposure to the aerospace environment by organ systems. This session is specifically tailored for the high-yield concepts to first-time Aerospace Medicine board test-takers as well as those seeking to maintain their board certification through the Longitudinal Assessment Program. **OVERVIEW:** In the aviation environment, stressors such as vibration, noise, acceleration forces and spatial disorientation, can significantly affect major organ systems. Clinicians must understand the effects of changing pressure, motion, temperature, gravity, and gas physiology on the human body to effectively screen, diagnose, and treat aircrew, astronauts, and passengers for missions or commercial flights. Deep understanding of these effects helps develop policies, training and countermeasures to prevent as well as to respond to in-flight medical emergencies. Aerospace medicine specialists must be involved in the full spectrum of flight planning and operations to promote the safest environment for the crew and passengers and risk mitigate adverse medical circumstances. **DISCUSSION:** The roles for aerospace medicine specialists are advancing beyond the clinical realm. However, preventive screening and clinical medicine remain the crux of the profession. Comprehensive medical evaluations identify conditions that could impair performance or pose sudden incapacitation risks. Participants will understand how human body systems respond to aerospace exposures specifically related to hypobaric, hypoxic, and microgravity environments. This session will also review common medical diagnoses and associated treatments related to hypobaric, hypoxic, and microgravity

environmental exposures. This material is relevant to military and civilian aerospace medicine specialists.

Learning Objectives

1. Understand how human body systems respond to aerospace exposures specifically related to hypobaric, hypoxic, and microgravity environments.
2. Recognize common medical diagnoses and associated treatments related to hypobaric, hypoxic, and microgravity environmental exposures.

[361] REVIEW OF ACCELERATION AND ITS EFFECTS ON THE AEROSPACE SYSTEM

David Navel, Caleb James

U.S. Air Force, Wright-Patterson AFB, OH, USA

(Education - Program / Process Review)

BACKGROUND: Aerospace Medicine professionals must be familiar with the complex environment imposed on the aerospace system, including the forces applied to the airframe and human occupants. All assessments must account for acceleration to best determine the operator's suitability for flight and the safety of an airframe. This presentation prepares human performance practitioners to speak to the different facets and effects of acceleration in the aerospace environment in relation to the forces of flight, hydrostatic force, impulses and vibration. **OVERVIEW:** Acceleration is necessary for movement. In flight, sustained acceleration can exceed normal terrestrial experiences, causing significant physiological challenges through hydrostatic forces that can lead to loss of life. In mishaps, transient acceleration drives mortality, and survivability depends on engineering the system to buffer the elements of acceleration as it rapidly acts on the human operator. In both, acceleration can act upon the aerospace system and the human operator to create vibrations with potentially harmful and deleterious effects on human performance and flight safety. Understanding all facets of force and how they relate to the operator is critical to promoting human performance and ensuring the safety of the system, airframe and aircrew alike. **DISCUSSION:** Acceleration, both in its static and transient forms, is a constant concern with flight and remains a challenge human performance within the aerospace system. Participants will leave with a greater understanding of acceleration and its effects on clinical and operational work within Aerospace Medicine, both military and civilian, as providers seek to better care for their population and ensure the future safety of flight systems. This session directly addresses a known gap identified by residents across services and strengthens joint service readiness for the Aerospace Medicine board examination.

Learning Objectives

1. Ensure aerospace medicine practitioners understand the principles and physics of acceleration as it applies to sustained acceleration, transient acceleration, and vibration.

2. Review the effects of acceleration on aircrew as it applies to civilian and military operations.

[362] SPATIAL DISORIENTATION: A RAPID REVIEW

Amy Kreykes

University of Texas Medical Branch, Galveston, TX, USA

(Education - Program / Process Review)

BACKGROUND: Spatial disorientation (SD) remains a common cause of aviation accidents – accounting for up to 10% in general aviation (90% of which are fatal). Military mishaps caused by spatial disorientation incur a significant cost: both loss of crew and monetary. Even experienced and current pilots can be subject to spatial disorientation. The importance of educating Aerospace Medicine specialists and pilots how to recognize and prevent spatial disorientation remains paramount. **OVERVIEW:** This session will provide a rapid review of Spatial Disorientation. The presentation will discuss spatial disorientation categorization (Type I, II, III) and pathophysiology. It will highlight high-yield SD illusions with audience participation, reviewing common visual and vestibular illusions. Specifically, size and shape constancy, leading to illusions with wide, narrow, and sloping runways; somatogravic inputs (head-up illusion) and somatogyral inputs (graveyard spiral and Coriolis illusions) will be reviewed. **DISCUSSION:** Teaching Aerospace Medicine specialists and aviators the pathophysiology of spatial disorientation as well as steps for recognition and prevention are critical to prevent aviation mishaps. This rapid review will provide a brief overview of the pathophysiology behind common spatial disorientation illusions applicable to civilian and military aviation both domestically and abroad.

Learning Objectives

1. Understand common runways illusions caused by shape and size constancy.
2. Understand the difference between somatogravic and somatogyral vestibular illusions and the pathophysiology behind each.

[363] HIGH-YIELD FAA MEDICAL DISPOSITION REVIEW

Jonathan Elliot, Matthew Lindsey

U.S. Navy, Pensacola, FL, USA

(Education - Program / Process Review)

BACKGROUND: FAA medical disposition and the Conditions Aviation Medical Examiners Can Issue (CACI) represent recurring knowledge gaps among aerospace residents despite the high frequency of these topics on ABPM Aerospace Medicine board examinations. Aerospace

medical specialists operate across military–civilian boundaries. A solid foundational understanding of FAA regulatory pathways is essential for clinicians who support civil aviation, interface with the National Airspace System, or prepare residents for board certification. Addressing these gaps ensures alignment with evolving FAA policy, enhances ABPM aerospace board exam readiness, and strengthens cross domain aeromedical competency. **OVERVIEW:** This session provides a focused, high yield review of FAA disposition categories including Issue, CACI, and Special Issuance. Special Issuance triggers including insulin use, coronary artery disease, atrial fibrillation, and neurologic events are contrasted with CACI eligible conditions to reinforce rapid differentiation. The review directly targets current training gaps identified by Navy RAM residents and faculty. **DISCUSSION:** Operational and clinical mastery of FAA disposition logic improves risk assessment, enhances regulatory literacy, and strengthens the ability of aerospace clinicians to support civil aviation stakeholders. This review enhances aeromedical decision making by providing a standardized, reproducible framework for interpreting FAA medical policy, improving board performance, and reinforcing cross domain competency. The content supports interoperability across Services and between military and civilian aeromedical systems, aligning with AsMA's mission to integrate global aerospace medical practice.

Learning Objectives

1. Differentiate between Conditions Aviation Medical Examiners Can Issue (CACI) and Special Issuance pathways, particularly for common triggers such as insulin use, coronary artery disease, atrial fibrillation, and neurologic events.
2. Describe the main FAA medical disposition categories and apply this framework to enhance aeromedical decision-making and risk assessment for civil aviation stakeholders.
3. Explain how a comprehensive understanding of FAA disposition logic improves ABPM board examination readiness and strengthens cross-domain competency between military and civilian aeromedical systems.

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[S-58] PANEL: AEROMEDICAL ETHICS PANEL

Chair: Mark Mavity

Co-Chairs: Bill Tarver, Robert Holmes, Billy Hoffman, Krishi Korrapati

Panel Overview: *Aerospace medicine may present an array of potential ethical dilemmas to aviation medicine physicians and other aeromedical professionals that may arise out of conflicts between the interests, rights, and responsibilities of those within our profession, individual patients/aircrew, private employers, governmental certifying agencies, and society at large. The hierarchy of current medical and aeromedically-specific ethical guidelines are reviewed. Recent relevant articles of ethical interest from the medical literature from the preceding year are reviewed and highlighted in the areas of aerospace medicine, public health policy, clinical*

conduct, and the evolving role of artificial intelligence in the medical field. Online medical ethic apps are addressed as educational and reference tools. Case studies are presented for open audience discussion, thereby addressing the application of a variety of relevant ethical conflicts in the current practice of aerospace medicine.

[364] AEROMEDICAL ETHICS PANEL

Mark Mavity

EHE Health, McLean, VA, USA

(Education - Tutorial / Review)

Aerospace medicine may present an array of potential ethical dilemmas to aviation medicine physicians and other aeromedical professionals that may arise out of conflicts between the interests, rights, and responsibilities of those within our profession, individual patients/aircrew, private employers, governmental certifying agencies, and society at large. The hierarchy of current medical and aeromedically-specific ethical guidelines are reviewed. Recent relevant articles of ethical interest from the medical literature from the preceding year are reviewed and highlighted in the areas of aerospace medicine, public health policy, clinical conduct, and the evolving role of artificial intelligence in the medical field. Online medical ethic apps are addressed as educational and reference tools. Case studies are presented for open audience discussion, thereby addressing the application of a variety of relevant ethical conflicts in the current practice of aerospace medicine.

Learning Objectives

1. The audience will explore the process of ethical decision-making and its impact upon the practice of aerospace medicine.
2. The audience will learn about the current foundational resources which form the framework of current medical ethical guidance, particularly the ASAMS Ethical Guidelines as they relate specifically to the practice of aerospace medicine.
3. The audience will be encouraged to provide thought and attention to the ethical issues impacting the practice of aerospace medicine via the review of recent ethical articles in the medical literature and specific case discussions.

[365] AEROMEDICAL ETHICS PANEL: ETHICAL GUIDELINES

Mark Mavity

EHE Health, McLean, VA, USA

(Education - Tutorial / Review)

The five principle documents of the World Medical Association's ethical guidelines are reviewed, including recent updates. United States ethical guidelines from the American Medical Association and the American Osteopathic Association are reviewed. Aeromedically-specific ethical guidelines, principles, and practices as outlined in AsMA's Bylaws, Policies and Procedures Manual, AMHP editorial policy on the use of human subjects, ASAMS ethics guidelines, and ASAMS expert witness position statement are reviewed. Duties to patients; duties to other physicians, health professionals, and students; duties to society; and duties as a member of the medical profession are addressed in the above guidelines.

Learning Objectives

1. The audience will learn about the most current foundational resources which form the hierarchal ethical framework in the practice of medicine.
2. The audience will review the aeromedically-specific ethical guidelines developed by the American Society of Aerospace Medicine Specialists, and the accompanying policy on expert witness testimony.

[366] AEROMEDICAL ETHICS PANEL: ETHICAL ARTICLES OF INTEREST

Robert Holmes

U.S. Air Force, Joint Base Andrews, MD, USA

(Education - Tutorial / Review)

The year's medical literature is reviewed for relevant articles of ethical interest. Special interest is given to the topics of obligations for providing inflight medical care, conducting research, the roles and risks of artificial intelligence, public health policies, and unique military medical ethical concerns.

Learning Objectives

1. The audience will review recent articles in the medical literature with relevance to the full scope of practice of aerospace medicine.
2. The audience will learn of the evolving medical ethical landscape posed by trending public policies and the emerging impact of advanced technologies in the practice of medicine.

[367] AEROMEDICAL ETHICS PANEL: MEDICAL ETHICS MOBILE APPS

William Tarver

NASA, Round Mountain, TX, USA

(Education - Tutorial / Review)

The DoD's Medical Ethics Center and the King's College of London Centre of Medical Ethics online applications are reviewed. Subjects include: Philosophical Foundation of Ethics, Philosophy of Medicine in the Military Context, Prioritization of Care and Triage in Emergencies, Legal and Ethical Considerations, Informed Consent, Confidentiality and Privileged Communication, Physician and Patient Relationship, Conscience Clauses, End of Life Care, Technology and Ethics, Reproductive Ethics, Public Health Ethics, Care of Vulnerable and Marginalized Patients, and Research Ethics.

Learning Objectives

1. The audience will learn about existing mobile applications that are available as teaching and reference aids for medical ethical issues.
2. The audience will learn about additional medical ethical resources via from the USUHS Griffith Institute's DoD Medical Ethics Center.

[368] AEROMEDICAL ETHICS PANEL: CASE DISCUSSIONS

Mark Mavity[1], Billy Hoffman[2], Krishi Korrapati[3]

[1]EHE Health, McLean, VA, USA; [2]U.S. Army, Ft Sam Houston, TX, USA; [3]Chicago Medical School, Rosalind Franklin University, Chicago, IL, USA

(Education - Case Study)

Case discussions elicited from the ASAMS members and our AsMA constituent organization colleagues are presented for open and interactive discussion and debate amongst all Panel session attendees to explore and relevant ethical principles and courses of action.

Learning Objectives

1. The audience will apply ethical principles in a participatory discussion of an aeromedically-relevant case involving the roles of peer support programs and medical review officer responsiblities in regards to public health safety in the commercial aviation environment.
2. The audience will apply ethical principles in a participatory discussion of an aeromedically-relevant case involving the potential role of incorporating AI into medical decisions on interplanetary space missions.

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[S-59] PANEL: ADVANCED AEROSPACE MEDICINE FOR INTERNATIONAL MEDICAL OFFICERS (AAMIMO) GRAND ROUNDS

Chair: Steven Nordeen

Panel Overview: *AAMIMO Grand Rounds consists of 6 clinical case presentations. Each case is presented by current AAMIMOs who will review the clinical case, diagnosis, treatment pathway and current policies from different agencies. The aviator's aeromedical disposition and waiver or special issuance outcome (if applicable) will be discussed. These unique case presentations describe clinical aviation medicine as well as policy updates for common medical and/or mental health conditions encountered in the practice of Aerospace Medicine.*

[369] BEYOND THE EYE EXAM: TRUST AS A DIAGNOSTIC DIMENSION

Veronika Polackova[1], Biplab Bhowmick[2]

[1]Czech Republic, USAFSAM, Wright-Patterson AFB, OH, USA, [2]India, USAFSAM, Wright-Patterson AFB, OH, USA

(Education - Case Study)

INTRODUCTION: This case describes a military sub-sonic jet pilot, who intentionally concealed an ophthalmic disorder due to fear of permanent grounding. **BACKGROUND:** Accurate aeromedical decision-making relies not only on clinical examination and diagnostic testing, but also on complete and honest disclosure by aircrew. Proper diagnostics may be particularly challenging when historical data are incomplete or withheld. **CASE PRESENTATION:** A 35-year-old subsonic jet pilot in the Czech Air Force with >1300hrs of total flight underwent a routine aeromedical ophthalmologic examination. An incidental retinal scar was identified near the superior temporal retinal artery of the left eye, associated with a mild reduction in uncorrected visual acuity (20/25) and a small monocular visual field defect. No corresponding abnormalities were documented in prior medical records, and no historical fundus photographs were available for comparison. The pilot denied any previous visual symptoms, ophthalmologic or systemic disorder. Based on available information, the finding was interpreted and concluded as a residual scar following presumed chorioretinitis. The pilot continued flying duties under regular ophthalmologic follow-up without progression. After five years of continuous follow-up by the same flight surgeon, the pilot eventually disclosed a prior episode of central serous retinopathy (CSR) treated with retinal laser photocoagulation at a private clinic, which he had intentionally concealed due to fear of permanent grounding. **DISCUSSION:** CSR is a common self-limited retinal disorder in otherwise healthy individuals 20 to 50 years of age. Changes in the retinal pigment epithelium lead to elevation and distorsion of the neurosensory retina, usually in the fovea, degrading visual acuity. Although most cases resolve spontaneously in several months, longer recovery times are not uncommon with significant risk of recurrence worsening the visual performance. This case highlights the limitations of diagnostic testing in

absence of accurate clinical history and demonstrates how non-disclosure can lead to misinterpretation of findings. Also, highlights the key concerns for paramount aeromedical consequences endangering aircrew health and the aerospace safety. Trust between aircrew and flight surgeon is essential. Establishing a confidential and supportive relationship is critical to ensure accurate diagnosis, appropriate risk assessment, and flight safety.

Learning Objectives

1. Recognize how incomplete medical disclosure by aircrew can lead to diagnostic dilemma and misinterpretation of ophthalmologic findings.
2. Describe the aeromedical implications and consequences of central serous retinopathy and retinal laser treatment in military jet pilots.
3. Emphasize the role of trust and effective physician–aircrew communication and bond in accurate aeromedical risk assessment and ensure aerospace safety.

[370] AEROMEDICAL MANAGEMENT OF AN ANOMALOUS RIGHT CORONARY ARTERY IN A MILITARY PILOT

Col. Elsedawy[1], Capt. Aldalabih[2], Lt. Al Ma'aytah[2]

[1]Egypt, USAFSAM, Wright-Patterson AFB, OH, USA, [2]Jordan, USAFSAM, Wright-Patterson AFB, OH, USA

(Education – Case Study)

INTRODUCTION: This case study presents the aeromedical evaluation and operational disposition of a military pilot diagnosed with an anomalous right coronary artery (RCA), emphasizing cardiovascular risk management and return-to-flight considerations in military aviation. **BACKGROUND:** Congenital coronary artery anomalies are uncommon but clinically significant in aircrew due to their association with myocardial ischemia, malignant arrhythmias, and sudden cardiac death, particularly under high physiologic stress. Anomalous RCA with an interarterial course between the great vessels poses increased risk during high-G or high-workload flight. Aeromedical assessment following surgical correction requires careful integration of cardiology findings, operational demands, and waiver criteria to ensure flight safety. **CASE PRESENTATION:** A 38-year-old male military pilot was identified with a positive treadmill stress test during routine annual screening. He was asymptomatic, with normal electrocardiogram and echocardiographic findings. Coronary computed tomography angiography demonstrated an anomalous RCA originating from the left coronary sinus and coursing between the ascending aorta and pulmonary trunk with significant compression. The pilot underwent successful RCA re-implantation surgery in November 2023. Postoperative recovery was uncomplicated. Serial cardiology and aviation medicine follow-up revealed no angina, dyspnea, or arrhythmias, with preserved left ventricular systolic function. Follow-up coronary angiography in August 2024 confirmed normal coronary anatomy and a patent re-implanted RCA without residual stenosis. **DISCUSSION:** This case highlights the aeromedical implications of anomalous coronary anatomy in military aircrew and the importance of early

detection through routine screening. Successful surgical correction and comprehensive post-operative evaluation allowed the pilot to meet established aeromedical waiver criteria. The case demonstrates that, with appropriate intervention, surveillance, and operational restrictions, selected aircrew with corrected coronary anomalies may safely return to flying duties. This reinforces the value of structured waiver processes and long-term cardiovascular monitoring to balance mission readiness with flight safety.

Learning Objectives

1. Identify the aeromedical risks and operational implications of anomalous coronary artery anatomy, including indications for restriction, further evaluation, and referral in military aircrew.
2. Apply aeromedical waiver and return-to-flight principles following surgical correction of coronary artery anomalies, integrating cardiology findings with mission and flight safety considerations.

[371] AN INCIDENTAL FINDING WITH AEROMEDICAL SIGNIFICANCE: RIGHT HEMIDIAPHRAGM EVENTRATION IN A FIGHTER PILOT

Maj. Faidz[1], Maj. Xiong[2]

[1]Malaysia, USAFSAM, Wright-Patterson AFB, OH, USA, [2]Taiwan, USAFSAM, Wright-Patterson AFB, OH, USA

(Education – Case Study)

INTRODUCTION: This case describes a fighter pilot in whom right hemidiaphragm eventration was incidentally identified. **BACKGROUND**: Diaphragmatic eventration is an abnormal elevation of a portion or the entire hemidiaphragm due to thinning or absence of functional muscle fibers while maintaining normal anatomical attachments. In adults, the condition is most often identified incidentally and is frequently asymptomatic, with many individuals demonstrating normal pulmonary function at rest. A limited number of case reports have suggested the incidence is less than 0.05%, with a predominance in men. Although generally considered benign in the civilian population, it may pose a risk of incapacitation for military pilots. **CASE PRESENTATION**: A 30-year-old male fighter pilot was incidentally found to have a right elevated hemidiaphragm, during a routine annual aeromedical examination with X-ray imaging. The pilot was completely asymptomatic, with no reported respiratory, gastrointestinal, or exercise-related complaints. Comprehensive diagnostic workup and physiological tests were conducted, including multiple imaging studies, lung function testing and assessments in an altitude chamber and centrifuge. Surprisingly, all examinations demonstrated near-normal findings, with preserved diaphragmatic movement and pulmonary function. Despite the absence of clinical symptoms, diaphragmatic eventration may pose potential aeromedical concerns in high-performance flight. **DISCUSSION**: Hemidiaphragm eventration, though typically asymptomatic and benign, carries unique aeromedical implications in high-performance

aviators. The diaphragm is critical for ventilation and contributes to G tolerance. Structural abnormalities may impair respiratory mechanics, reducing ventilatory reserve under +Gz forces. In this case, the pilot remained asymptomatic with preserved pulmonary function and normal diaphragmatic motion. However, this condition necessitates careful aeromedical evaluation, considering operational risks such as decreased G tolerance and increased respiratory workload in pressure-breathing environments. Functional compensation may support waiver eligibility, but close monitoring is essential. This case underscores the importance of integrating clinical findings with operational demands in determining fitness for flying duties.

Learning Objectives

1. To identify the potential aeromedical implications of hemidiaphragm eventration, particularly in high-performance aviators exposed to +Gz forces and pressure-breathing environments.
2. To emphasize the need for comprehensive physiological assessment including imaging and pulmonary function testing in determining aeromedical disposition in asymptomatic aircrew.
3. To ensure aerospace medicine clinicians are aware of the criteria for waiver consideration in cases of diaphragmatic abnormalities.

[372] FROM ALLERGY TO IMMUNITY: SUBLINGUAL IMMUNOTHERAPY FOR JAPANESE CEDAR POLLINOSIS IN AN AIR TRAFFIC CONTROLLER

Lt.Col. Cabreros[1], Maj. Tadokoro

[1]Philippines, USAFSAM, Wright-Patterson AFB, OH, USA, [2]Japan, USAFSAM, Wright-Patterson AFB, OH, USA

(Education – Case Study)

INTRODUCTION: This case report describes successful sublingual immunotherapy (SLIT) in a military air traffic controller (ATC) with Japanese cedar pollinosis. **BACKGROUND:** Japanese cedar pollinosis is highly prevalent in Japan, and seasonal pollen exposure may pose aeromedical risks even in newly arrived individuals. Allergic rhinitis can impair concentration, alertness, and task performance, while sedating antihistamines may further compromise aviation safety. SLIT is an established disease-modifying treatment for allergic rhinitis with a favorable safety profile; however, its use in aviation personnel is limited. **CASE PRESENTATION:** A male Japan Maritime Self-Defense Force ATC officer in his early 30s presented in August 2023 with worsening seasonal nasal symptoms, affecting daily life and operational performance. Japanese Allergic Rhinitis Clinical Grading indicated moderate disease (sneezing 1/3, rhinorrhea 2/3, and nasal obstruction 2/3). Specific IgE confirmed Japanese cedar sensitization (class 3). SLIT was initiated with CEDARCURE® 2,000 JAU once daily and was escalated to 5,000 JAU maintenance dose without adverse effects. Mild pruritus was managed with Levocetirizine, later switched to fexofenadine. On December 18, 2024, SLIT was recognized as requiring restriction

from aviation duties, and the patient was placed on Duties Not Including Flying (DNIF) status, coinciding with non-operational assignment. By March 2025, symptoms improved markedly (sneezing 0/3, rhinorrhea 1/3, nasal obstruction 0/3). Aeromedical evaluation in June 2025 supported conditional return to operational duties with precautions, including avoidance of duties for four hours post-dose and monthly evaluation. Follow-up through December 2025 showed complete resolution without adverse events. **DISCUSSION:** SLIT provided disease-modifying control of allergic rhinitis without sedation or systemic reactions. Compared with subcutaneous immunotherapy and chronic antihistamine use, SLIT represents a lower-risk and practical long-term option for aviation personnel. While the Federal Aviation Administration and U.S. Air Force allow aircrew and ATC to utilize immunotherapy under specific conditions, to our knowledge this is the first reported case of SLIT use in active aviation personnel, demonstrating safe and effective use under structured aeromedical supervision.

Learning Objectives

1. Recognize the aeromedical impact of Japanese cedar pollinosis on cognitive performance and operational duties.
2. Describe safe administration of SLIT in aviation personnel under structured medical oversight.

[373] N/A

Thursday, 05/21/2026, 3:30 PM

Governor's Hallway

[S-60] INTERACTIVE PRESENTATION: AT THE EDGE OF HUMAN CAPABILITIES

Chair: Emmanuel Urquieta

Co-Chairs: Rebecca Mendelsohn, Dacia Boyce

[374] WITHDRAWN

[375] THERE IS NO IMOI IN TEAM: LEVERAGING TEAM-BASED INVESTIGATIVE METHODS IN SPACEFLIGHT ENVIRONMENTS

Liam D. Brennan, Katie B. Stubits, Jenna Korentsides, Toni C. Butler, Thomas Meyer, Joseph R. Keebler, Scott K. Ferguson, Elizabeth H. Lazzara

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(Education - Tutorial / Review)

INTRODUCTION: With the continued growth of commercial space operations, further efforts are required to investigate team performance in spaceflight environments, particularly as failures in team processes represent non-trivial risks to safety and success. In an effort to advocate for the investigation of teams within spaceflight environments and educate researchers on approaches, models, and techniques by which to do so, the following work explores two subjects of interest from the team sciences; these include: input-mediator/moderator-output-input (IMOI) models and team synchrony. **TOPIC:** MOI models (Illgen et al., 2005) have become a staple of teams' science (Landon et al., 2019) but remain rarer within the isolated, confined, and extreme environments literature (Golden et al., 2018). While this approach has been slowly incorporated into investigations of spaceflight environments (Käosaar et al., 2021), these have failed to step beyond traditional psychological constructs and variables. By going beyond existing frameworks and examining individual physiological variables alongside team-level constructs, researchers have the opportunity to provide more nuanced insights into the sociotechnical systems surrounding spaceflight environments. Considerations surrounding IMOI models and examples of potentially relevant physiological variables will be discussed. Team synchrony refers here to the overarching approach of investigating shared changes in behavioral, cognitive, and physiological variables (DeChruch et al., 2010; Kazi et al., 2019; Mayo et al., 2021). While team synchrony has become more feasible as an investigative method, due to advancements in wearable sensor technologies (Salas et al., 2015), efforts are underway to incorporate measures of physiological synchrony into spaceflight environments for team monitoring (Nemmi et al., 2025). These advancements, while valuable, fall short of the potential afforded by more integrated approaches. Considerations surrounding the current state of team synchrony in spaceflight environments and examples of potential advancements possible with integrated measures will be discussed. **APPLICATION**: By working to incorporate these approaches, models, and techniques from the team sciences, researchers can better understand the nature and substance of team operations in spaceflight environments, in particular during long-duration missions and amongst increasingly civilian-comprised astronaut teams.

Learning Objectives

1. The audience will learn about input-mediator/moderator-output-input (IMOI) models as employed in teams' science literature. Considerations surrounding IMOI models and examples of potentially relevant physiological variables in spaceflight environments will be discussed.
2. The audience will learn about team synchrony as employed in teams' science literature. Considerations surrounding the current state of team synchrony in spaceflight environments and examples of potential advancements possible with integrated (i.e., behavioral, cognitive, and/or physiological) measures will be discussed.

[376] TRANSCRANIAL ELECTRICAL STIMULATION TARGETS TO ENHANCE SPACEFLIGHT OPERATIONAL PERFORMANCE

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(Original Research)

INTRODUCTION: Transcranial electrical stimulation (tES) may be applied to improve operational performance or as a useful adjunct to pharmaceutical management of symptoms. We identify potential tES targets for specific spaceflight-related concerns and sample protocols to improve astronaut vigilance, motor learning, and sleep. **METHODS:** Reviewed literature relating to non-invasive brain stimulation for spaceflight and known spaceflight-associated brain alterations in order to identify candidate tES targets and create sample protocols to enhance operational performance. **RESULTS:** Stimulation of the primary motor cortex (M1) (tDCS, 1mA);can enhance procedural learning by priming the development of internal models of movement. Neuromodulation over F3 and F4 (tACS, 0.5-1.2 Hz) may boost slow-wave sleep and enhance memory consolidation. Anodal direct current stimulation over F3 (tDCS, 2mA) may be beneficial in fatigue mitigation (e.g., vigilance). **DISCUSSION:** Frontal lobe stimulation is versatile with potential benefits in memory, cognition, mood, sleep, attention, and learning. Direct current stimulation of the primary motor cortex (M1) could enhance crew training for complex, procedural tasks (e.g., robotic arm manipulation) especially when combined with cerebellar stimulation. Data regarding vigilance, appetite, and pain are more limited but neuromodulation may provide some benefit. Some limitations of tES include providing only superficial stimulation, individual variability, and minimal consensus on parameters. However, given its portability and reassuring safety profile, targeted tES offers the potential to optimize terrestrial crew training and spaceflight performance. Looking ahead, tES can theoretically be applied in-flight to autonomously manage symptoms (e.g., appetite loss), post-flight to accelerate reversal of maladaptive brain changes (e.g., neurovestibular), or prophylactically (e.g., optimizing sleep).

Learning Objectives

1. Evaluate the potential of targeted tES to specific frontal lobe regions for enhancing terrestrial crew training and optimizing spaceflight performance by potentiating its effects on motor learning, mood regulation, sleep quality, and attentional processes.
2. Explore potential applications of in-flight tES to facilitate crew recovery in preparation for landing, and post-flight for autonomous deployment on planetary surfaces.

[377] FACTORS AFFECTING AVIATOR PERFORMANCE ACROSS DIFFERENT OPERATIONAL ENVIRONMENTS

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(Original Research)

INTRODUCTION: U.S. Army aviators are required to perform a wide range of flight tasks across diverse operational environments. Combat and non-combat environments (e.g., training centers) differ in skill level, cognitive engagement, and training to optimize overall aviation performance. These environments can differ significantly in levels of task saturation, degraded visual environments (DVE), and weather conditions. These factors contribute to cognitive overload and underload, reducing cognitive engagement including situational awareness, attention, and decision-making, thus increasing the likelihood of mishaps. Given these risks, it is essential to understand how frequently aviators experience these conditions and how it affects performance outcomes critical for mission safety and success. **METHODS:** A cross-sectional survey was conducted to assess prevalence of factors affecting current U.S. Army aviators and impacts on performance. Participants reported perceived experiences of fatigue, boredom, and environmental factors across three operational environments: combat deployments, non-combat deployments, and combat training centers. Demographics and flight experience were included. Descriptive and comparative analyses were used to identify differences across operational environments. **RESULTS:** A total of 44 aviators completed the survey (Female = 11). Total flight hours ranged from 1 (50-200) to 5 (1501+) on a Likert scale, with a mean of 4 (SD = .9) and majority reported the UH-60 as their primary airframe (79%). Aviators reported experiencing communication issues (53.6%) most frequently during combat deployments. Respondents indicated that these communication issues negatively impacted their performance. In non-combat deployments, the most frequently occurring stressor reported was weather issues (43.3%). Respondents also reported negative impacts on performance. Finally, respondents indicated task saturation was most frequently experienced in combat training centers (38.1%); however, it did not significantly impact performance. **DISCUSSION:** The findings reveal that aviators experience different stressors across operational environments. Additionally, respondents reported that these factors have significant effects on performance in combat and non-combat deployments. Future research will examine how specific factors can be improved to mitigate mishaps in high-risk operational environments.

Learning Objectives

1. How do different operational environments differ in challenges that impact aviator performance?
2. Understand key factors that contribute to decrements in aviator performance while in flight.

[378] ENHANCING PILOT SELECTION: INTEGRATING TEMPERAMENT, FLUID INTELLIGENCE, AND OCULOMOTOR MEASURES OF ATTENTIONAL CONTROL

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(Original Research)

INTRODUCTION: Efficient attentional control and response inhibition are critical for flight safety and effective pilot performance, particularly under high cognitive workload. Oculomotor tasks provide objective markers of these processes. In an aviation context, fluid intelligence may support processing speed and rapid decision-making, whereas temperament traits may reflect stability and regulation of behavior over time. The present study examined whether fluid intelligence and temperament relate to distinct aspects of oculomotor performance in pilot candidates. **METHODS:** Pilot candidates (N ≈ 103) completed prosaccade and antisaccade tasks under gap and overlap conditions. Median saccadic latencies, latency variability, and derived oculomotor indices (e.g., the gap–overlap effect) were analyzed. Fluid intelligence was assessed using Raven's Advanced Progressive Matrices (TMZ). Temperament traits were measured with the Formal Characteristics of Behavior–Temperament Inventory (FCB-TI), yielding six dimensions: Briskness, Perseveration, Sensory Sensitivity, Emotional Reactivity, Endurance, and Activity. Hierarchical regression models were used to examine associations between individual differences and oculomotor outcomes. **RESULTS:** Fluid intelligence (TMZ) was significantly associated with shorter saccadic latencies in cognitively demanding conditions, particularly in antisaccade and prosaccade overlap tasks, as well as with a reduced gap–overlap effect (all p < .05). These findings indicate a relationship between fluid intelligence and the speed and efficiency of attentional disengagement. Temperament traits did not predict median saccadic latencies; however, they showed limited and task-specific associations with latency variability, suggesting a possible link to temporal stability of performance. These effects were weaker and less consistent than those observed for fluid intelligence. **DISCUSSION:** The findings suggest that fluid intelligence and temperament are related to different aspects of pilot performance. Fluid intelligence primarily supports response speed and efficiency under high cognitive load, whereas temperament traits may reflect stability and regulation of performance over time. This distinction highlights that oculomotor measures can capture complementary components of cognitive control relevant to aviation, supporting a multidimensional approach to pilot assessment and selection.

Learning Objectives

1. The participant will be able to distinguish how fluid intelligence and temperament relate to different oculomotor indicators of attentional control relevant to pilot performance.
2. The audience will learn about the use of pro- and antisaccade eye movement measures as objective indicators of inhibitory control and attentional disengagement in pilot candidates.
3. The participant will be able to describe how oculomotor, cognitive, and temperament measures may complement each other in pilot assessment and selection.

[379] REMEMBERING THE FUTURE: WHY PROSPECTIVE MEMORY MATTERS IN FLIGHT AND HOW TO ASSESS IT UNDER AERONAUTICAL CONSTRAINTS

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(Education - Tutorial / Review)

INTRODUCTION: In aviation, memory is usually considered as recalling past knowledge, procedures, or prior experience. Yet, safe and efficient flight operations also rely on a future-oriented form of memory: remembering to perform intended actions at the appropriate moment. This cognitive function, called prospective memory (PM), is essential for managing checklists, delayed procedures, system monitoring, responding to unexpected events, and task resumption in the cockpit. Failures of PM frequently result in omission errors, which can have significant operational consequences, including degraded performance and potential safety risks. Despite its critical role in piloting, PM remains underrepresented in aerospace medicine education and human factors training. **TOPIC:** PM involves remembering to carry out intended actions in the future. Successful PM depends on executive functions, attention, and working memory, all of which are continuously engaged during flight operations. To study PM in operationally relevant contexts, flight simulator tasks can be employed in research, with either trained pilots or recruited participants. In these tasks, participants are asked to remember and execute predefined intentions embedded within a simulated flight scenario while concurrently performing standard piloting tasks. Simulator-based assessments provide objective measures such as omission errors, execution timing, and accuracy, while enabling systematic manipulation of task complexity, environmental factors, and physiological constraints, making them a powerful tool for advancing both research and applied human factors studies in aviation. **APPLICATION:** Aeronautical constraints are likely to alter PM and, as a result, affect pilot performance and safety. Hypoxia is particularly relevant, as it has been shown to impair executive functions, attention, and temporal processing— cognitive processes that are central to PM. Even moderate levels of hypoxia may reduce a pilot's ability to maintain intentions, detect relevant cues, or execute actions at the correct moment. Evaluating PM under hypoxic conditions using flight simulators is therefore highly relevant, as it allows researchers to assess human performance under realistic physiological stress, and inform the development of effective mitigation strategies. Integrating PM assessment into aerospace medicine and human factors practice supports a more comprehensive understanding of pilot cognition and operational safety.

Learning Objectives

1. The audience will learn about the concept of prospective memory, including its distinction from retrospective memory, its role in executing future intentions, and its critical importance for safe and effective piloting during complex flight operations.
2. The audience will learn about methods to assess prospective memory in aviation research, including the use of flight simulator tasks for pilots or participants, and the

evaluation of event-based and time-based prospective memory under realistic operational conditions.
3. The audience will learn about methods to assess the effects of aeronautical constraints, particularly hypoxia, on prospective memory.

[380] A CASE STUDY ON PHARMACOLOGICAL RISK AND HUMAN PERFORMANCE DURING LONG-HAUL FLIGHTS

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(Education - Case Study)

INTRODUCTION: From a pharmacological perspective, medication use invariably begins with an expectation: to relieve symptoms, control a health condition, or restore physiological balance. However, this therapeutic expectation is seldom examined in relation to the context in which the drug is consumed. Air travel, although commonly perceived as part of everyday life, introduces a distinct physiological environment that calls for a reconsideration of pharmacological treatment beyond the prescription itself. In this context, pharmacokinetics emerges as a central focus, as physiological changes become determining factors for both the individual and the active pharmaceutical ingredient. **BACKGROUND:** Basic and clinical pharmacology have long recognized that the human body is not static in its interaction with medications. From the moment a drug enters the organism, a series of chemical processes are initiated and modulated by individual determinants. Despite this, during air travel it is frequently assumed that tablets, injections, or transdermal patches behave in the same manner as they do at ground level, as if altitude neither altered essential metabolic functions nor influenced expected absorption. In reality, the environment exerts a far greater influence than is commonly acknowledged. **CASE PRESENTATION:** This case study describes a clinical scenario involving passengers and flight crew who continue their usual pharmacological treatments during long-haul flights. Upon boarding the aircraft, these individuals maintain their medication regimens with the expectation of achieving the same therapeutic effects previously experienced on the ground. **DISCUSSION:** This scenario highlights the pharmacological risks associated with flight-related factors, which cannot be adequately analyzed without recognizing the importance of ensuring that time spent in the cabin is both safe and comfortable for passengers and crew. Across the various phases of pharmacokinetics, recurrent alterations arise due to conditions such as mild hypoxia, dehydration, and circadian desynchronization, rendering drug responses unpredictable. The aeronautical environment thus modifies not only the organism receiving the treatment, but also the behavior of the drug itself and, consequently, the therapeutic effects involved.

Learning Objectives

1. After participating in this session, participants will be able to understand how physiological changes associated with long-haul flights—such as mild hypoxia,

dehydration, and circadian disruption—can alter pharmacokinetic processes and modify expected therapeutic drug responses.
2. The audience will be able to recognize how altered pharmacological responses at altitude may influence human performance, including attention, cognitive function, and decision-making, in both passengers and aircrew during prolonged flight operations.
3. Participants will be able to identify the importance of informed medication use and contextual awareness in the cabin environment, highlighting pharmacokinetics as a key element for supporting patient autonomy and reducing preventable pharmacological risks during long-haul flights.

[381] WITHDRAWN

[382] ADVANCING WEARABLE PHYSIOLOGICAL MONITORING IN EXTREME ENVIRONMENTS THROUGH MILITARY STAKEHOLDER INPUT AND OPERATIONAL TESTING

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(Original Research)

INTRODUCTION: Physiological monitoring has long been essential for assessing human health and performance in extreme environments. Although wearable sensor systems (WSS) enable continuous data collection, their adoption in operations remains limited. Moreover, few systems are tested in their environments, hindering iterative improvements. This work aims to identify challenges in WSS design and adoption through stakeholder engagement, and test a previously developed prototype in an operationally relevant environment to guide future design iterations. **METHODS:** Qualitative insights were gathered from researchers at the 711th Human Performance Wing. These discussions highlighted a lack of user-centered design and reliability challenges in current WSS, particularly during operational use. To contextualize these findings, a previously developed prototype was incorporated into the study. This prototype consists of a chest strap with woven textile electrodes for electrocardiography (ECG), foam padding, and hook-and-loop fastening. It was evaluated against gold standard ECG during human centrifuge and altitude chamber testing to assess signal quality in operationally relevant conditions. **RESULTS:** Challenges identified from stakeholder discussions included poor fit, discomfort due to bulky electronics, limited usability, and insufficient power management for long-duration missions. Stakeholders emphasized the need for adjustable designs, simplified interfaces, novel power solutions, and embedding electronics directly into textiles. Centrifuge and altitude chamber testing demonstrated that the prototype could acquire ECG data, but motion artifacts reduced signal quality during acceleration. The prototype was widely adjustable, but a one-size-fits-all approach limited usability. While the fabric was considered lightweight, breathable, and

non-irritating, its flexibility likely exacerbated motion artifacts. **DISCUSSION:** User-centered, environment-specific WSS design is critical for advancing physiological monitoring in operations. Stakeholder engagement revealed that comfort, fit, and usability are as essential as signal quality and power efficiency. While the prototype showed promising performance at rest, motion robustness and usability remain key challenges and was improved in the follow-on designs. This iterative design process represents a step toward developing operationally feasible WSS for physiological monitoring in extreme environments.

Learning Objectives

1. The audience will learn the basic principles of user-centered design, such as comfort, usability, and acceptance.
2. The audience will learn the trade-offs between user requirements (e.g., comfort) and technical requirements (e.g., signal quality).

[383] INTEGRATING THE HUMAN SUB-SYSTEM IN HIGH PERFORMANCE AIRCRAFTS: APPLIED ANTHROPOMETRICS AS THE FOUNDATION FOR FLIGHT SAFETY AND OPERATOR PERFORMANCE

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(Original Research)

INTRODUCTION: Combat Aircraft Systems need to be ready for man-unmanned teaming (MuM-T) and multi domain operations. Hence, aircrew tasks are shifting from aircraft operation to battle management and cockpit environments undergo marked changes to support the increased integration of the human element as “on-site” battle-manager and decision making “subsystem”. Pilots will use the support of Artificial Intelligence (AI), Augmented and Virtual Reality (AR and VR) and MuM-T to assert and maintain the operational advantage. Anthropometrics provide a reliable base for optimum man-machine fit, supporting operator performance while maintaining and enhancing flight safety. **METHODS:** We digitized aircraft cockpits to obtain 3D-representations including seat-index-points, consoles, flight controls, and ranges of movement with laser/white light 3D-scanning systems. Critical poses were defined with pilots and flight instructors and digitally recreated as RAMSIS manikins to obtain reaching spaces, minima/maxima in eleven anthropometric measures, and seating/head positions, pilot line-of-sight, and visibility and accessibility of information and control elements. **RESULTS:** Five cockpits have been digitized and analyzed. Based on the data, eleven anthropometric measures were derived and new criteria were identified for optimum pilot-system fit. **DISCUSSION:** Enhancing flight safety in challenging environments depends on optimal integration of the human sub-system. Integration begins with valid and digitally available anthropometric data. 3D-scanning and digital representation form the base for enhanced human-

system fit. Revised criteria can improve personnel availability and retainability. Enhanced pilot–airframe fit is a key to flight safety, workload management, and improvement of man-machine interaction in military aircraft. Linking the results to personnel recruitment may enable digitalized fitting of aircrews, enhancing and optimizing flight safety and performance. Future cockpit-designs can be derived from current results, underlining the need for state-of-the-art digital ergonomic analyses. Applying the results may prevent/mitigate discomfort, neck/back pain, and motion sickness and enable mastering modern man-machine interfaces and cognitive demands in modern air warfare.

Learning Objectives

1. Participants will understand how anthropometrics and digital aircrew fitting enhance performance and flight safety in integrated combat aircraft systems, providing the base for man-machine interaction and -teaming.
2. The participants will learn how modern anthropoemtrics methods can impove the performance of war fighters in modern aircrafts.

[384] WITHDRAWN

[385] A PRELIMINARY STUDY COMPARING MOTION SICKNESS SEVERITY ACROSS DIFFERENT INTERVENTION TIMES OF THE APRL MANEUVER

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(Original Research)

INTRODUCTION: The APRL maneuver, a focused vocalization technique, can reduce motion sickness symptoms. Its effectiveness at different stages of the symptom development remains unclear. This study aimed to determine whether the timing of APRL implementation during the motion sickness provocation differentially influences the symptom severity in the aircrews. **METHODS:** This interventional study enrolled the Air Force aircrew as participants. Prior to exposure, participants completed the Motion Sickness Susceptibility Questionnaire (MSSQ) to assess their susceptibility during childhood and adulthood. Participants were then seated in a motorized rotating chair and exposed to rotational stimulation at 20 r.p.m. Motion sickness was induced via Coriolis stimulation through repeated head flexion and extension. Each 1-minute rotation trial included three head movements, followed by a 1-minute rest during which symptoms were evaluated using the Motion Sickness Symptom Rating (MSSR) scale. Five

rotation trials were conducted. Participants were assigned to three groups: control without APRL (n = 36), early-APRL (n = 19, first three trials), and late-APRL (n = 25, fourth and fifth trials). MSSR scores were analyzed using SPSS to compare symptom severity across the groups. **RESULTS:** Eighty participants were analyzed, including five females (6.3%). The three groups did not differ significantly in height, body weight, BMI or MSSQ scores. In the first trial, the mean MSSR scores were similar across the no-APRL, early-APRL, and late-APRL groups (3.5±4.0, 2.0±2.3, 2.2±2.2; p=0.530). By the third trial, scores modestly increased in the early-APRL group (3.3±4.3) but rose more in the late-APRL group (5.0±5.2). After APRL initiation in the fourth trial, scores in the late-APRL group decreased to 4.4±5.0, whereas the early-APRL group, no longer performing APRL, increased to 4.4±5.7. This trend persisted in the fifth trial. The no-APRL group consistently had higher MSSR scores, rising from 3.5±4.0 to 9.2±7.4 (p for trend < 0.001). APRL implementation and timing significantly influenced the symptom severity (interaction p=0.008). **DISCUSSION:** This study provides preliminary evidence that APRL maneuver timing influences self-reported motion sickness severity. However, outcomes were based solely on a subjective assessment. Future studies should incorporate objective physiological measurements to further explore the effects of the APRL maneuver.

Learning Objectives

1. The participant will be able to describe how the APRL maneuver reduces motion sickness symptoms and explain the differential effects of implementing this technique at various stages of motion sickness development.
2. The audience will learn about the impact of intervention timing on motion sickness severity by comparing early versus late implementation of the APRL maneuver in rotational chair experiments.

[386] EFFECTS OF HYPERBARIC EXPOSURE ON PERCIEVED VERTICAL ORIENTATION

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(Original Research)

INTRODUCTION: The perceived orientation of gravity is essential for divers to return safely to the surface from the sea. On the ground, the perceived vertical orientation is biased when the body is tilted; however, adding visual reference flames can eliminate the perceived bias. Such flames can improve performance on mental rotation tasks (MRTs), which estimate spatial recognition ability. Under hyperbaric environments exceeding 41 ATA, which is equivalent to a depth of 400 MSW, the performance of MRTs deteriorated even when these flames were added. These results suggest that perceived bias may exist when divers operate in deep-sea environments. Nevertheless, the relationship between hyperbaric exposure and perceived bias has not been investigated. Therefore, this study examined the effects of hyperbaric exposure on perceived vertical orientation using the subjective visual vertical (SVV) task, which estimates the

perceived direction of gravity. **METHODS:** For the SVV, participants were required to judge whether a luminous rod at the center of a computer display was tilted to the left or right relative to gravity. The SVV was carried out twice throughout a simulated 200 MSW (21 ATA) saturation dive training: pre- or post-diving (1 ATA) and 21 ATA. Furthermore, SVV was measured in two postures: upright and with the head tilted 45°to the left (tilted). Six male saturation divers (mean ± SD: 37.08 ± 5.71 years) participated in this study. In this study, the angle of the rod at which the participants' left-right judgement changed, which is the subjective point of equivalence (PSE), was used to evaluate perceived biases. **RESULTS:** In this study, the PSE of Tilted condition shifted in the direction opposite to the body tilt at both 21 ATA and 1 ATA. Additionally, the shift in the PSE at 21 ATA tended to be larger than that at 1 ATA. Furthermore, for the upright condition, the PSE at 21 ATA significantly shifted to the right, whereas the PSE at 1 ATA showed no lateral shifting. **DISCUSSION:** The results of our stindicatetede the hyperbaric expos interferes with red perceived vertical orientation aion, even when the body is not tilted.

Learning Objectives

1. Understand how human perceptual system changes under hyperbaric environment such as deep-sea condition.
2. Find out the subjective visual vertical task can estimate human perceptual system without any physiological experimental methods.

[387] IMPACT OF ACUTE FLIGHT TRAINING STRESS ON CARDIOVASCULAR HEALTH: A PILOT STUDY

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(Original Research)

INTRODUCTION: Student pilots experience unique acute stressors during flight training that may influence both physiological and psychological health. Acute stress has been shown to affect cardiovascular function, including vascular endothelial health. Using near-infrared spectroscopy (NIRS) to assess vascular endothelial function, this study tested the hypothesis that acute stress from a single flight training session would reduce cardiovascular function, as indicated by a diminished post-occlusive reactive hyperemic (PORH) response. Understanding these acute responses may provide insight into how flight training stress influences cardiovascular health in student pilots. **METHODOLOGY:** In a repeated-measures, within-subjects pilot study, three healthy student pilots [2 men, 1 woman; 18 ± 0.0 years] from Embry-Riddle Aeronautical University were assessed before and after a routine flight training session. NIRS was used to quantify relative changes in tissue oxygenation (StO_2) in the brachioradialis muscle. The Hokanson Rapid Cuff Inflation (RCI) system induced temporary arterial occlusion to evaluate the PORH response. Subjective stress was assessed pre- and post-flight using a single-item stress questionnaire (SISQ). **RESULTS:** Following a single flight training sortie,

two participants demonstrated modest reductions in peak hyperemic StO_2 (−3.03% and −6.63%). The reoxygenation slope during reperfusion was reduced in two participants (−34% and −31.5%). Two of the three participants also showed a decrease in PORH area under the curve (AUC), with the largest individual reduction being 17.5%. Mean AUC decreased by approximately 9% from pre- to post-flight. Self-reported stress levels varied individually, with no consistent pattern observed. **DISCUSSION:** These preliminary findings suggest that acute flight training may be associated with modest reductions in peripheral vascular endothelial function. Ongoing data collection in a larger sample is needed to confirm feasibility and determine whether acute flight training stress consistently impairs endothelial function. Ultimately, these findings may help clarify how flight training stress contributes to cardiovascular disease risk in pilots.

Learning Objectives

1. The audience will be able to identify acute flight training-related stressors that may affect vascular function and oxygen delivery.
2. The audience will be able to explain how near-infrared spectroscopy (NIRS) and post-occlusive reactive hyperemia (PORH) are used to assess vascular responsiveness.
3. The audience will be able to describe what a post-occlusive reactive hyperemia (PORH) response indicates about vascular function.

[388] WITHDRAWN

[389] IDENTIFYING ESSENTIAL KNOWLEDGE FOR EXPLORATION SATURATION DIVING: A MULTI-METHOD APPROACH TO TRAINING MANUAL DEVELOPMENT

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(Education - Program / Process Review)

BACKGROUND: Saturation diving is a method in which divers remain in a pressurized environment until their body tissues are fully saturated with inert gases at ambient pressure. Exploration Saturation Diving (ESD) applies saturation diving to scientific or personal exploration. After peak activity in the 1960s and 1970s, interest in undersea habitation is reemerging as commercial organizations develop new habitats for research and tourism. Additionally, ESD has proven highly useful as a spaceflight analog. For example, the National Aeronautics and Space Administration Extreme Environment Mission Operations project, or NEEMO, generated human factors, operations, and training data applicable to planetary exploration. Future Exploration Saturation Divers (e.g., aquanauts) will require structured training and demonstrated proficiency in human factors topics prior to saturation exposure. **DESCRIPTION:** This study employs a multi-method approach, including the Mission Essential

Competencies (MEC) framework and Training Needs Assessment (TNA), to identify and prioritize essential human factors topics for inclusion in ESD education. MECs were first defined across five mission phases: transit to and from an undersea habitat, habitation, excursion diving, scientific diving, and intra-habitat science. For each MEC, supporting competencies, required knowledge, skills, and prior experiences were identified. These MECs were then thematically clustered to generate a consolidated list of necessary human factors competencies for aquanauts. Each competency subsequently underwent a TNA to identify the additional knowledge, skills, and experiences an open-water certified diver must acquire to achieve aquanaut-level competencies. **DISCUSSION:** This analysis sought to identify human factors knowledge required for safe and competent aquanaut performance, and to inform the development of an ESD training manual or textbook. From the MEC analysis, six thematic areas emerged: mission planning and operational preparation, safety systems and risk management, habitat systems operations, diving resource management, excursion diving and scientific field operations, and developing the Exploration Saturation Diver. Collectively, these domains constitute the foundation of human factors education in an aquanaut training program. The results support the development of a competency-based training manual or textbook to serve as a foundational resource for future aquanauts.

Learning Objectives

1. Analyze the human factors challenges associated with exploration saturation diving.
2. Identify the essential human factors knowledge, skills, and experiences required to train a competent exploration saturation diver.

[390] EARLY CAREER DEVELOPMENT OF CERVICAL SPINE DEGENERATIVE CHANGES IN PILOTS OF FIFTH-GENERATION FIGHTER AIRCRAFT

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(Original Research)

INTRODUCTION: The association between flight training, cervical spine degeneration, and functional disability in fighter pilots has not been clearly defined. **METHODS:** Twenty-three fighter pilots of fifth-generation fighter aircraft received a series of pain questionnaires to understand the character and modifiers of their neck and back pain, flight history questionnaires, anthropometry measurements, and MRI scans. Random Forest analysis identified factors most associated with neck pain-related disability according to the Neck Disability Index (NDI). **RESULTS:** After average pain, sleep quality, and central sensitization, cervical spine degenerative changes were most associated with disruption of daily activities such as reading, concentration, and driving; spine degenerative changes were more strongly associated with NDI

than any flight history or anthropometry factors. Our prior studies identified that cervical spine degenerative changes were significantly associated with post-flight reductions in extension, axial rotation, and lateral bending ranges of motion, indicating that degeneration has a primary role in limiting pilot head-neck motions during flight. Analysis of cervical spine MRI scans in fighter pilots compared to controls, and split by age group (20s, 30s, 40s), revealed a trend wherein pilots had significantly increased total cervical spine degeneration and size/number of cervical spine disc bulges, along with significantly reduced average disc height compared to age-matched civilians. Interestingly, these disc-related changes were most pronounced for pilots in their 20s compared to age-matched civilians, and civilian disc degeneration scores approached fighter pilots for older age groups. Other metrics such as foramen stenosis followed more gradual development and progression trends for pilots that outpaced civilians in their 20s to 30s to 40s. **DISCUSSION:** These trends represent a unique temporal characterization of cervical spine disc degeneration in fighter pilots, wherein a majority of disc degenerative changes occurred early in in their military flight careers (approximately <5 years). Those changes then remain somewhat consistent for the remainder of their careers.

Learning Objectives

1. Understand differing characteristics of cervical spine degeneration in fighter pilots compared to age-matched civilians.
2. Understand factors that are most associated with neck pain-related disability in fighter pilots.