National Research Council: **Oct. 5, 2009**

Please find attached the Decadal White Paper submitted by the Aerospace Medical Association. It was vetted by our officers and several of our Constituent organizations. One of our Constituents, the Space Medicine Association (SMA), suggested other research priorities. Consequently, I took the liberty of asking them to also provide you with a White Paper that you should soon receive. Thank you.

Russell B. Rayman, M.D., MPH
Executive Director
Aerospace Medical Association

DECADAL WHITE PAPER

ARTIFICIAL GRAVITY

Submitted by the

Aerospace Medical Association
Oct. 5, 2009

Joan Vernikos, PhD
Former Director Life Sciences, NASA
540-829-2541
thirdage1@verizon.net

Russell B. Rayman, M.D., MPH
Executive Director
Aerospace Medical Association
703-739-2240, x-103
rrayman@asma.org

DECADAL WHITE PAPER

On behalf of the officers and members of the Aerospace Medical Association (AsMA), I would like to express our appreciation to you for giving us the opportunity to submit this white paper. AsMA is an organization of approximately 3,000 physicians, scientists, and flight nurses engaged in clinical aerospace medicine or related research.

It is our belief that the single most important challenge in space medicine remains microgravity. Over the previous five decades, scientists have defined the effects of microgravity and have worked hard on developing countermeasures. Unfortunately, these countermeasures are, at best, ameliorative to some degree, in some astronauts, and for some physiological systems. With limited effectiveness for missions as long as six months, it is most unlikely they would be any more effective over longer duration missions.

Some of the deconditioning problems identified are the functional deterioration of the musculoskeletal system, loss of blood volume, immune suppression, cardiac deconditioning, bone loss, and altered neurovestibular function.

Our responsibility is to have reasonable certitude that astronauts can return from long duration missions safely and in good health. It is, therefore, crucial that we increase our efforts on an aggressive research program to develop and validate effective microgravity countermeasures. Of all of the modalities we have investigated, it is our firm opinion that artificial gravity holds the most promise as the most comprehensive countermeasure.

Unfortunately, with the impending retirement of the space shuttle and the lack of a human-rated centrifuge on the International Space Station (ISS), there will be little, if any, opportunity to study artificial gravity inflight in the near future. In any event, considerable research needs to be carried out on the ground first in a systematic and sequential protocol to identify the most

efficient and effective prescription for the application of artificial gravity by centrifugation – how much, how often, how long, whether with or without exercise. Several preliminary results in the literature testing the value of centrifugation have been encouraging, but not coordinated.

We believe that ground research studies would not be particularly complex to design, would be affordable, and would provide valuable information once and for all. The research could best be done as a project in one or more bed-rest laboratories that have access to a human-rated centrifuge and the whole program should be coordinated as a national team effort. (Bed rest would be an analog for microgravity and the centrifuge an analog for artificial gravity.) The control group would remain at strict bed-rest for the duration of the protocol while the test group would be periodically exposed to a centrifuge run. For example, a cohort of controls and a cohort of test subjects would be confined to bed rest without or with centrifugation for a short period of time (eg. six days) and evaluated for effectiveness using a set of meaningful biomarkers for deconditioning. This short-term bed rest model could serve as a mechanism to screen in or out permutations of centrifugation intensity, duration, frequency and activity requirement for potential countermeasure effectiveness. Optimal permutations of the centrifugation protocols would then be tested and validated in relatively longer periods of bed rest where the standard Baseline Data Collection (BDC) used in space missions would be used to evaluate their countermeasure effectiveness. (The number of subjects and the length of time at bed rest could be determined by statisticians and scientists.) Various specific procedures could be added to evaluate cardiovascular, muscle, bone, balance, coordination, immune and metabolism function.

We hypothesize that the centrifuged groups would do significantly better than the control. Evidence that centrifugation might be a more effective countermeasure on the ground than

current inflight approaches will provide justification for an onboard centrifuge on the ISS within the next ten years needed to evaluate and validate the usefulness of artificial gravity as a countermeasure in space.

In summary, we believe that microgravity is the most compelling challenge for future long duration missions and exploration and that artificial gravity holds the greatest promise as a countermeasure. Consequently, we strongly recommend that aggressive research in this direction begin now.