Preferred form of presentation: Oral

Topic: Future Spaceflight Missions

Title: Addressing Human System Risks to Future Space Exploration

Authors: WH Paloski[1], DR Francisco[2], and JR Davis[2]

Institution: [1]Human Research Program and [2]Health and Medical Technical Authority, NASA Johnson Space Center, Houston, TX USA

Keywords:

Abstract (max. 500 words)

Introduction: NASA is contemplating future human exploration missions to destinations beyond low Earth orbit, including the Moon, deep-space asteroids, and Mars. While we have learned much about protecting crew health and performance during orbital space flight over the past half-century, the challenges of these future missions far exceed those within our current experience base. To ensure success in these missions, we have developed a Human System Risk Board (HSRB) to identify, quantify, and develop mitigation plans for the extraordinary risks associated with each potential mission scenario. The HSRB comprises research, technology, and operations experts in medicine, physiology, psychology, human factors, radiation, toxicology, microbiology, pharmacology, and food sciences. **Methods:** Owing to the wide range of potential mission characteristics, we first identified the hazards to human health and performance common to all exploration missions: altered gravity, isolation/confinement, increased radiation, distance from Earth, and hostile/closed environment. Each hazard leads to a set of risks to crew health and/or performance. For example the radiation hazard leads to risks of acute radiation syndrome, central nervous system dysfunction, soft tissue degeneration, and carcinogenesis. Some of these risks (e.g., acute radiation syndrome) could affect crew health or performance during the mission, while others (e.g., carcinogenesis) would more likely affect the crewmember well after the mission ends. We next defined a set of design reference missions (DRM) that would span the range of exploration missions currently under consideration. In addition to standard (6-month) and long-duration (1-year) missions in low Earth orbit (LEO), these DRM include deep space sortie missions of 1 month duration, lunar orbital and landing missions of 1 year duration, deep space journey and asteroid landing missions of 1 year duration, and Mars orbital and landing missions of 3 years duration. We then assessed the likelihood and consequences of each risk against each DRM, using three levels of likelihood (Low: ≤0.1%; Medium: 0.1%–1.0%; High: ≥1.0%) and four levels of consequence ranging from Very Low (temporary or insignificant) to High (death, loss of mission, or significant reduction to length or quality of life). Quantitative evidence from clinical, operational, and research sources were used whenever available. Qualitative evidence was used when quantitative evidence was unavailable. Expert opinion was used whenever insufficient evidence was available. **Results:** A set of 30 risks emerged that will require further mitigation efforts before being accepted by the Agency. The likelihood by consequence risk assessment process provided a means of prioritizing among the risks identified. For each of the high priority risks, a plan was developed to perform research, technology, or standards development thought necessary to provide suitable reduction of likelihood or consequence to allow agency acceptance. **Conclusion:** The HSRB process has successfully identified a complete set of risks to human space travellers on planned exploration missions based on the best evidence available today. Risk mitigation plans have been established for the highest priority risks. Each risk will be reassessed annually to track the progress of our risk mitigation efforts.

Presenting Author: William H. Paloski, Ph.D.

Institution: Human Research Program, NASA Johnson Space Center, 2101 NASA Parkway, Houston, TX 77058 USA

Contact: +1 281-244-7347; william.h.paloski@nasa.gov