National Space Biomedical Research Institute
Team: Human Factors and Performance Team – Team Executive Summary
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Background/Scope
Many factors impact an astronaut's ability to perform optimally in space or on the lunar surface. The Human Factors and Performance Team (HFP) works to improve daily living and keep crew members healthy, productive and safe during missions. Overall Team aims are to reduce performance errors and mitigate habitability, environmental and other behavioral factors that pose significant risk to mission success. Team members are examining ways to improve training, automation and information displays, performance assessment tools, sleep, work schedules, environmental conditions, lighting for optimal alertness and performance, nutrition, and food storage/handling to assure healthy food.

Goals
HPF goals are to: (1) reduce the risks associated with poor human-centered design and integration, including issues of habitability, information presentation and task design; (2) reduce the risks associated with sleep loss, circadian desynchronization, fatigue and workload by characterizing, quantifying and modeling the effects of spaceflight and other mission schedules on sleep and circadian rhythms of both ground and space/lunar crews; (3) reduce the risk of inadequate nutrition and inefficiencies in the food system; and (4) reduce the risks to health and performance from behavioral and environmental factors. The HFP works to resolve and manage the risks associated with each of these four broad areas to optimize physical, neurobehavioral and task performance, for both the individual and the mission team. In addition, the HFP (5) supports developing the NASA Human Health Systems Standards for the Constellation Program, including Orion, the crew exploration vehicle for lunar and Mars exploration. HPF objectives are driven by the Human Research Program's (HRP) Program Requirements Document, the HRP Program Plan, and the Integrated Research Plan (IRP). The major risks within the HRP IRP that relate to the HFP include: 5.0 Risk factor of inadequate nutrition; 6.0 Risk of inadequate food system; 13.0 Risk of adverse health effects from lunar dust exposure; 19.0 Risk of error due to inadequate information; 20.0 Risk associated with poor task design; 21.0 Risk of reduced safety and efficiency due to poor human factors design; 27.0 Risk of performance errors due to sleep loss, circadian desynchronization, fatigue and work overload.

Support of NASA Needs
The HFP focuses on Constellation Program needs, specifically the near future use of Orion, intermediate future of lunar exploration, and the long-term future of Mars exploration. Earth-based labs, analog operations, worldwide astronaut training facilities, and the immediate use of the International Space Station all provide environments to study countermeasures needed for Orion, lunar and Mars exploration. Although the general structure of Orion has been established, issues of information display, human-centered design and robotics-human interaction need to be resolved to make the best use of Orion's limited environment. The Team's research is highly relevant to development of the Constellation Program's food handling and storage; interior lighting; workload in spacecraft or with ground control, extravehicular activities (EVA), or lunar habitats; and NASA policies for duty hour limits, sleep schedules and quality of sleep as relates

to environmental, individual or other influences. Lunar sorties and long-duration stays must take into account the human in the design of the lunar habitat; the semi-autonomous nature of the mission; the multi-agent team that includes humans (ground and flight) and automated tools/operators, nutritional and food requirements; sleep, fatigue and performance issues; and countermeasures for sleep loss and fatigue as well as mitigation for elements such as lunar dust. Human factors, sleep, circadian rhythms, nutrition and behavioral health-related performance issues studied on the lunar surface will provide the final validation before Mars exploration.

Deliverables

Anticipated deliverables include: (1) specific recommendations for the wavelength and intensity of artificial environmental lighting in the Earth and space/lunar crew habitat; (2) recommended light-dark schedules for crew members and Earth-based support; (3) specifications for EVA visor, habitat window and vehicle window light transmission characteristics; (4) recommended work-rest policies to facilitate maintenance of alertness and performance during extended-duration missions and those that require extended wake and/or work at adverse circadian times for both Earth and space/lunar crews; (5) mathematical modeling tools to evaluate the impact of actual work-rest/sleep-wake schedules, light-dark schedules, and individual differences on the alertness and performance of crew members and to implement countermeasures; (6) necessary research and tool development required to assess performance and inform the human health system standards; (7) documentation of the effects of lunar dust exposure on health and performance; (8) specifications for nutritional goals and food storage and handling; and (9) recommendations for human-centered design of habitats.

Cross-Links

The HFP links closely with the Neurobehavioral and Psychosocial Factors and the Sensorimotor Adaptation Teams. The Team shares a common interest with the Smart Medical Systems and Technology Team in innovative methods to resolve high-technology problems. The HFP Team works closely with two of the six elements in the Human Research Program: the Space Human Factors Engineering and Habitability Element in the Division of Habitability and Environmental Factors and the Behavioral Health and Performance Element in the Space Medicine Division. Through these elements, HFP also works with stakeholders in the Constellation Program, the Astronaut Office, and Space Medicine.

Enabling Capabilities and Gaps

Team strengths include the capability to inform and support the NASA Human System Standards (Volumes I and II) for crew health and habitability; a focus on risk prevention and mitigation, individualized modeling; and development of practical countermeasures that can be delivered for use in the near term. The HFP Team has just been re-organized and new gaps have emerged. Current gaps are defined in the following three questions: (1) What is the relationship of sleep loss, circadian desynchronization, fatigue and work load to performance in spaceflight, and what countermeasures and policies are required to mitigate this risk? (2) What are the guidelines for appropriate task automation and effective allocation of tasks between humans and automation to increase performance, efficiency and safety? (3) What requirements and technologies will enable NASA to provide the crew with a safe, nutritious and acceptable food system while efficiently balancing appropriate vehicle resources such as mass, volume and crew time in exploration missions?

Earth-Based Benefits

The HFP Team countermeasures have extensive Earth-based benefits in many safety-sensitive operations. The sleep and circadian biology work, including countermeasures, have applications for individuals with selected clinical affective or sleep disorders, or otherwise healthy individuals who travel across multiple time zones, work night shifts or rotating shifts, or work extended schedules, such as individuals in the military, transportation, industrial, security and healthcare sectors. The research will also directly impact people who are chronically exposed to poor artificial lighting, including nighttime shift workers, elderly in nursing homes and those who spend the majority of their waking hours in an environment under nocturnal conditions or without sunlight. The Team is designing pharmacological, environmental and scheduling systems to counteract or prevent circadian disruption and associated health problems. The nutrition and physical fitness countermeasures against muscle wasting and loss of muscle strength have broad applicability and are in use for burn patients and elderly or handicapped individuals confined to bed in nursing homes. The nutrition countermeasure to radiation-enhanced colon cancer has direct application to diet recommendations to protect against colon cancer, the second leading cause of death from cancer in the United States. In addition, individuals exposed to radiation as part of cancer therapy can benefit from the results of this research program. The lunar dust related work has application to Earth environments with different aerosol contaminants. Finally, the human-factors design work is applicable to every work environment.