The new Vision for Space Exploration encompasses needs for innovative technologies in the areas of Space Human Factors and Food Systems. Operations in confined, isolated, and foreign environments can lead to impairments of human performance and behavioral health problems. Furthermore, the development of new vehicles for the human exploration of space provides the ideal opportunity to build the human element into the man-machine system at the outset, greatly simplifying activities and reducing the overall costs to the program. Additionally, significant advancements in food technologies will be needed for long-duration missions for both Lunar and Mars missions. Subtopic X12.01 Food and Galley seeks innovative technologies for providing shelf-stable food with a shelf-life of 3 - 5 years, new food packaging technologies that eliminate or minimize waste, and new technologies for on-orbit meal preparation and dining. Subtopic X12.02 Space Human Factors seeks models for predicting human performance in flight environments and activities, tools for designing and evaluating human interfaces, just-in-time information tools to aid astronauts in routine and emergency operations, as well as acoustic monitoring and abatement technologies for in-flight use.

**Subtopics**

**X12.01 Food Access Beyond Low Earth Orbit**

**Lead Center:** JSC  
**Participating Center(s):** JSC

Exploration missions beyond low Earth orbit greatly limit allowable consumables and require development of innovative low maintenance, reconfigurable, reusable, or self-sufficient food production. Since regularly timed resupply will not be possible for a Mars mission, all the prepackaged shelf-stable food, ingredients, and equipment to provide a complete diet for six crewmembers for more than three years will have to be provided at the beginning of the mission. Advancements are necessary to develop a combination of extended duration shelf-life stored foods augmented with fresh foods.

Safe, nutritious, acceptable, and varied shelf-stable foods with a shelf life of 3 - 5 years will be required to support the crew during future exploration missions to the Moon or Mars. Development of shelf-stable food items that use high-quality ingredients is important to maintaining a healthy diet and the psychosocial well being of the crew. Shelf-life extension may be attained through new food preservation methods and/or packaging. Once on the lunar or planetary surface, it may be possible to use bulk packaging of meals or snack items. These food products will require specialized processing conditions and packaging materials.
Current food packaging technologies represent a potentially significant trash-management problem for exploration-class missions to the Moon or Mars. New food packaging technologies are needed that minimize waste by using high barrier packaging with less mass and volume and/or by using packaging. Another opportunity would be development of a packaging material that can readily be reused by the crew to make objects of value to the space flight mission. All packaging materials must have adequate oxygen and water barrier properties to maintain the foods' 3 - 5 year shelf life.

Food preparation systems will be required to heat and rehydrate the shelf stable food items and to prepare meals from the processed and resupplied items. Technologies to support on-orbit crew meal storage, preparation, dining activities, and trash dispensing are being sought.

Food quality and safety are essential components in the maintenance of crew health and well-being. Efforts should be focused on control of food spoilage and food quality throughout the entire shelf life of the food. Effects of radiation on the stored food system quality are also needed. Food quality and safety efforts should be focused on identification and control of microbial agents of food spoilage, including the development of countermeasures to ameliorate their effects through food processing and food packaging.

X12.02 Long-Duration Space Human Factors

Lead Center: JSC
Participating Center(s): ARC

The long-term goal of this subtopic is to enable planning, designing, training, and executing long-duration human space missions that are up to 5 years without re-supply and real-time communications to Earth. Specifically, the focus of this subtopic is on the development of innovative crew equipment, technologies for human performance assessment/modeling/enhancement, and design tools for engineers to incorporate human factors engineering requirements into hardware and software. Proposals that aim at developing and addressing the following specific technology needs are solicited.

Technologies are needed for monitoring and maintaining human performance non-intrusively. Specifically, the technologies we seek are (1) minimally invasive and un-obtrusive devices and techniques to monitor the behavior and performance (physical, cognitive, perceptual, etc.) of individuals and teams during long-duration space flights or analog missions, as well as (2) embedded measures to detect significant changes in crew readiness to perform physical or cognitive tasks.

Methods and models are needed for predicting human performance. The particular technologies we seek are (1) methods and models for predicting effects on physical performance by encumbrances of clothing, space suits, etc., (2) models for predicting effects of physical environment (e.g., lighting, noise, temperature, contaminants) on human performance, (3) models to simulate and optimize interactions between humans and equipment/vehicle, (4) capability to implement time-delay algorithm and functionality into simulations for higher fidelity and effectiveness,
and (5) models for predicting performance due to the effects of cognitive changes.

Cost-effective and reliable tools are needed for aiding the design and evaluation of human-system interfaces for speed, accuracy, and acceptability. The particular tools we seek shall (1) provide automated analysis of computer-user interfaces for complex display systems to conduct objective review of displays and controls, (2) determine compliance with guidelines and standards, and/or (3) offer quantitative measures of the effectiveness of user interfaces for task-sensitive evaluations.

Tools are needed to facilitate user interface design for human computer interfaces, procedures, labels, and instructions. These tools shall assist the designer in incorporating contextual information such as the user’s task, the user’s knowledge, and the system’s limitations.

Tools are needed to build just-in-time system and operational information software that aid human users to conduct routine and emergency operations and activities. Such tools shall be either (1) effective and efficient job aids (e.g., "intelligent" manuals, checklists, and warnings) to support designing flexible interfaces between users and large information systems, or (2) methods for developing “facilitators” (procedures, labels, etc.) adapted for developing space vehicle and payload applications.

Acoustic monitoring systems are needed to accurately and autonomously monitor acoustic sound pressure and noise exposure levels in long-duration space vehicles. These technologies shall provide (1) acoustic sensor systems consisting of fixed and/or crew-worn transducers, (2) sound pressure level information as a function of frequency and/or time, (3) typical sound level meter and acoustic dosimeter functionality, and (4) the capability for autonomous operations and data transfer. Operation and data acquisition parameters of such systems shall be controllable either by ground personnel or the crew.

Innovative acoustic flight materials are needed for noise abatement. These materials shall function as acoustic absorbers, barriers, vibration isolators, dampers, spacecraft wall treatments, transparent containment, or combinations of these. These materials must be shown to satisfy space flight material requirements, such as off-gassing and flammability, and shall be easy to apply to hardware. The acoustic properties of these materials’ shall be demonstrated through absorption or transmission loss testing, or by other standard acoustic testing techniques.