NASA SBIR 2008 Phase I Solicitation

X12 Space Human Factors and Food Systems

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. Research and development activities in the Space Human Factors and Food Systems topic address challenges that are fundamental to design and development of the next generation crewed space vehicles. These challenges include: 1) understanding the requirements for information feedback to the crew and developing technologies to ensure these requirements are met, 2) building tasks and tools that are compatible with humans and that enable human performance consistent with mission success, and 3) providing extended shelf life foods with improved nutritional content, quality and reduced packaging mass. This Topic seeks methods for monitoring, modeling, and predicting human performance in the spaceflight environment. The Space Human Factors and Food Systems is seeking new Space Human Factors Assessment Tools and Advanced Food Technologies that utilize non-foil barriers and allow food processing or preparation in a reduced gravity and pressure environment.

Subtopics

X12.01 Space Human Factors Assessment Tools

Lead Center: JSC

Operations in confined, isolated, and foreign environments can lead to impairments of human performance. This subtopic seeks methods for monitoring, modeling, and predicting human performance in the spaceflight environment for accurate and valid human system integration into vehicle design and operations. In particular, the Space Human Factors Engineering Project within the Human Research Program is interested in obtaining timely and context-specific Human Factors (HF) incident data. Currently, space HF data come from crew debriefs. Such debriefs rely on retrospective recall, which could suffer delays of up to six months. Furthermore, opportunities to discuss HF issues in detail during these debriefs are limited. Consequently, the HRP sees the need to develop an automated human factors incident reporting tool.

Objective: Development of tool that assists the gathering and reporting HF incidents for long-duration space missions.

Requirements: In general, the tool will be used to help detect areas where HF can contribute to mission success, assess the effects of operational and hardware changes, and complement existing HF data sources for operations. Specifically, the tool shall meet the following requirements:

1. The crew shall have easy access to the tool at any time to eliminate the need for the crew to recall

information retrospectively.
2. An easy-to-use data gathering protocol with the following functionalities: Allow data to be entered either as text, audio, and/or video inputs,
3. It is desirable for tool to detect a system anomaly automatically and immediately record system status. At a minimum, however, the tool should provide an easily accessible event marker for the crew to mark the context and take a snapshot of the system and operator system status.
4. Provide a user-friendly automated data search engine for extracting meaningful incident information from the raw data. Examples of desirable search schemes include natural language, spatial, temporal searches, etc.

Phase 1 Requirements: The technical merit of the tool will be explored to evaluate feasibility. The Phase 1 report will include results of the evaluation/research/ or development of automated data mining technologies, definition of optimal data gathering protocol(s), and recommendations for optimal hardware/software design. Development of hardware and software algorithms is highly desirable.

Phase 2 Requirements: Development of a working tool prototype, with documentation of functionality and usability evaluation and testing.

X12.02 Advanced Food Technologies

Lead Center: JSC

The purpose of the Advanced Food Technology Project is to develop, evaluate and deliver food technologies for human centered spacecraft that will support crews on missions to the Moon, Mars, and beyond. 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. Concurrently, the food system must efficiently balance appropriate vehicle resources such as mass, volume, water, air, waste, power, and crew time. One of the objectives during the lunar outpost missions is to test technologies that can be used during the Mars missions. This subtopic will concentrate on two specific areas; food packaging and lunar outpost food preparation and food processing.

Non-Foil High Barrier Materials

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. New food packaging technologies are needed that have adequate oxygen and water barrier properties to maintain the foods' quality over a 3 - 5 year shelf life. The packaging must also minimize waste by using high barrier packaging with less mass and volume. The current flexible pouch packaging used for the thermostabilized and irradiated food items contains a layer of foil. Although the foil provides excellent oxygen and water barrier properties, it also contributes to added waste. Food packaging will be a major contributor to the trash on the lunar or Mars surface. One of the proposed methods to dispose of trash on the lunar or Mars surface is incineration. However, the foil layer will not incinerate completely and there will be ash formed. Two emerging food preservation technologies, high pressure processing and microwave processing, are being considered for future NASA missions. However, the current high barrier packaging material cannot be used for these processes. The material delaminates during high pressure processing and cannot be used in microwave processing. Hence, any food packaging material developed in response to this subtopic should be compatible with one or more of the following food preservation technologies: retort processing, microwave processing, and/or high pressure processing. In addition, the material should have an oxygen transmission rate that shall not exceed 0.06 $cc/m^2/24$ hrs/atm and a water vapor transmission rate that shall not exceed 0.01 $gm/m^2/24$ hrs as stated in the MIL-PRF 33073F specification.

Effect of Partial Gravity and Reduced Atmospheric Pressure

It will require approximately 10,000 kg of packaged food for a 6-crew, 1000 day mission to Mars. For that reason, it has been proposed to use a food system which incorporates processing of raw ingredients into edible ingredients and uses these edible ingredients in recipes in the galley to produce meals. This type of food system will require food processing and food preparation equipment. The equipment should be miniaturized, multipurpose and efficiently use vehicle resources such as mass, volume, water, and power. Food preparation may include gourmet kitchen appliances such as food processors or bread makers in addition to the standard stove and oven. Proposed food processing equipment may include a mill to produce wheat and soy flour, a soy milk/tofu processor, and a concentrator. The Moon's gravity is 1/6 of Earth's gravity. In addition, it is being proposed that the habitat will have a reduced atmospheric pressure of 8 psia which is equivalent to a 16,000 foot mountain top. These two factors will affect the heat and mass transfer during food processing and food preparation of the food. Heat transfer is required for proper microbial kill and to produce the desired texture and appearance of the food prior to consumption. At this pressure, the boiling temperature of water will be 181Â°F which has significant implications for preventing microbial contamination and to acceptable food quality. Prior to any design of food processing or preparation equipment, the effects of partial gravity and partial atmospheric pressure as it relates to fluid management, heat and mass transfer and chemical reactions must be determined. Once the effects are determined, methods to overcome these effects must be developed. All of this needs to happen prior to any fabrication of actual food processing or food preparation equipment that can be used in the Lunar Habitat.

The response to this subtopic should include a plan to either (1) develop food packaging technologies that respond the above requirements, or (2) develop a technology which will aid in determining the effects of reduced cabin pressure and reduced gravity and/or (3) develop a technology that will enable safe and timely food processing and food preparation in reduced cabin pressure and reduced gravity.

Phase 1 Requirements: Phase 1 should concentrate on the scientific, technical, and commercial merit and feasibility of the proposed innovation resulting in a feasibility report and concept, complete with analyses and top-level drawings.