NASA SBIR 2005 Phase I Solicitation

X13 Human Systems Integration

Long-term presence in space in confined, isolated, and foreign environments may lead to impairments of human performance and behavioral health problems. Proposals are sought in the areas of space human factors engineering such as physical, cognitive, and team performance; behavioral health and performance including psychosocial, neurobehavioral adaptation as well as cognitive task performance, and sleep and Circadian rhythms. The topics include, but are not limited to: design and verification tools that provide predictions of human-system performance; tools that facilitate designing human-system interfaces or environments; tools useful in verifying human-system requirements; psychological factors relevant to crew selection and performance; pre-launch and in-flight crew training systems; self-sufficient operations in case of emergency and without external resources; technology that can assist the mission control operations: design of workflow in vehicle maintenance, preparation checkout, and launch control.

Subtopics

X13.01 Space Human Factors Engineering

Lead Center: JSC
Participating Center(s): ARC

The long-term goal for this subtopic is to enable planning, designing, training, and carrying out human space missions of up to 5 years with crew independence, without re-supply and without real-time communications to Earth. Specifically, this subtopic's focus is the development of innovations in crew equipment; and the development of technologies for assessment, modeling, and enhancement of human performance; and the development of design tools for engineers to incorporate human factors engineering requirements into hardware and software. Proposals are solicited that seek to develop technologies that address these specific needs:

- Monitoring and maintaining human performance non-intrusively. Specifically, minimally invasive and unobtrusive 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. Embedded measures to detect significant changes in crew readiness to perform physical or cognitive tasks;
- Predicting human performance: methods and models for predicting effects on physical performance of
encumbrances of clothing, space suits, etc. Models for predicting effects of physical environment (e.g., lighting, noise, temperature, contaminants) on human performance. Models to simulate and optimize interactions between humans and equipment/vehicle. Capability to implement time-delay algorithm and functionality into simulation for higher fidelity and effectiveness. Models for predicting effects of cognitive changes on performance;

- Tools to aid in design and evaluation of human-system interfaces for speed, accuracy, and acceptability in a cost-effective and reliable manner: automated analysis of computer-user interfaces for complex display systems to conduct objective review of displays and controls, and to determine compliance with guidelines and standards. Quantitative measures of the effectiveness of user interfaces to be used for task-sensitive evaluations;

- Tools that facilitate the user interface design for human computer interfaces, and for facilitators such as procedures, labels, and instructions. Tools should assist the designer in incorporating contextual information such as the user's task, the user's knowledge, and the system limitations; and

- Tools to build just-in-time system and operational information software to aid human users conducting routine and emergency operations and activities. Such tools might include effective and efficient job aids (e.g., “intelligent” manuals, checklists, and warnings) and support for designing flexible interfaces between users and large information systems. Methods for development of “facilitators” (procedures, labels, etc.) adapted for the development of space vehicle and payload applications.

X13.02 Behavioral Health and Performance

Lead Center: ARC

Behavioral Health and Performance provides the necessary technology, techniques, capabilities, and knowledge that will support mission success, during human exploration flight and return to Earth. This will be accomplished by optimizing the behavioral health and performance of each astronaut and crewmember, and by mitigating psychosocial, neurobehavioral, sensorimotor, cognitive, and sleep chronobiology risks. Behavioral health and performance research contributes to medical standards, guidelines, and requirements and produces design tools and diagnostic measures for the Chief Health and Medical Officer, flight surgeons, and astronauts. The technical areas supported by this program include performance readiness, effective and efficient teamwork for pre-, in-, and post-flight expedition missions, and psychological selection validated criteria, tools, and procedures. Prolonged missions and the associated adaptation and de-conditioning due to microgravity, as well as significant time delays between Earth and the space environment increase the likelihood of serious crew conflict as well as behavioral health and performance decrements. Proposals are solicited that seek to develop core knowledge, predictive models, and enabling technologies that address these specific needs:

- Non-intrusively monitoring and maintaining human performance. Specifically, minimally invasive and unobtrusive devices and techniques to monitor the behavior and performance (physical, cognitive, perceptual, sensorimotor, etc.) of individuals and teams during long-duration space flights or analog missions. Embedded measures to detect significant changes in crew readiness to perform physical or cognitive tasks; and

- Monitoring and maintaining non-intrusively behavioral health. For example, self assessment tools for determining levels of stress, fatigue, conflict, and anxiety of an individual crewmember and training techniques for coping and on-board support tools for behavioral health.
X13.03 Systems Engineering and Requirements

Lead Center: JSC
Participating Center(s): ARC, KSC

The goal of effective Human Systems Integration challenges many areas of technology, including distributed data management and control, sensor interpretation, planning and scheduling, modeling and simulation, and validation and verification of autonomous systems. These various technology areas must eventually be integrated into a system-of-systems. Particular emphasis is placed on the following:

**System Engineering Tools**

Technologies, tools, and methodologies are needed that assure development activity is congruent with Exploration Mission capability requirements. Decision support tools are needed to help in the visualization of portfolio balance and clear representation of complex systems as well as a capture method for the interactions/interdependencies/interfaces between system elements.

**System Simulation Tools**

The ability to analyze, synthesize, and develop integrated function-based and simulation-based system architectures in support of Human Systems. Key to this requirement is either the further extension/enhancement of current available SE tools or acquisition/development of tools that will allow for system level concept development and concept simulation.

**System Integration Tools**

The ability to enable human system integration for exploration missions is strongly affected by the structure and architecture of the systems used to sustain and protect the crew. There is a need for the development and evaluation of control architectures and strategies for determining relative benefit, risk, and costs of the utilization of candidate system architectures. Tools for capturing state knowledge of the entire portfolio by project, including dependencies, maturity, and relationships to requirements are also needed.

Capability-based requirements methods require tools and methodologies that enable capture of current practice for information integration between ground-based systems, on-board systems, and crew systems; goal analysis; surveys of existing and proposed technologies; mapping of technology to tasks; prototyping; integrated testing and evaluation criteria; and development of experienced personnel.

**Integration Test Bed Tools and Applications**

Integrated ground tests for human exploration missions will provide a test bed for development of hardware, requirements, hardware acquisition strategies, novel system concepts, and management. Tools are needed that
provide techniques for real-time analysis; techniques for planning, scheduling, and conducting complex integrated mission simulations; tools to develop system-level mathematical models of missions; and systems engineering and analysis tools for mission architecture studies.

Human-System Integration for Manufacturing and Launch Site Operations

Human-System Integration of Manufacturing and Launch Site Operations addresses the following functional areas: Manufacturing, Spacecraft Processing, Launch Control, Landing and Recovery, Repair and Refurbishment, and Enabling Operations. Specific areas of interest include intelligent work instruction systems; maintainer/launch controller situational awareness; human/robotic maintainer on-board capability; reduced size ground crew training modules; and predictive labor requirement models.

Research should be conducted to demonstrate technical feasibility during the Phase 1 contract and show a path toward a Phase 2 hardware and software demonstration. The contractor will, when possible, deliver a demonstration unit of the monitoring instrumentation for NASA testing before the completion of the Phase 2 contract.