The Human Exploration and Operations Mission Directorate (HEOMD) provides mission critical space exploration services to both NASA customers and to other partners within the U.S. and throughout the world: assembling and operating the International Space Station; ensuring safe and reliable access to space; maintaining secure and dependable communications between platforms across the solar system; and ensuring the health and safety of our Nation's astronauts. Activities include ground-based and in-flight processing and operations tasks, along with support that ensures these tasks are accomplished efficiently and accurately, enables successful missions and healthy crews. This topic area, while largely focused on operational space flight activities, is broad in scope. NASA is seeking technologies that address how to improve and lower costs related to ground and flight assets, and maximize the utilization of the International Space Station. A typical flight focused approach would include:

- Phase I - Research to identify and evaluate candidate technology applications to demonstrate the technical feasibility and show a path towards a hardware/software demonstration. Bench or lab-level demonstrations are desirable.

- Phase II - Emphasis should be placed on developing and demonstrating the technology under simulated flight conditions.

The proposal shall outline a path showing how the technology could be developed into space-worthy systems. For ground processing and operations tasks, the proposal shall outline a path showing how the technology could be developed into ground or flight systems. The contract shall deliver a demonstration unit for functional and environmental testing at the completion of the Phase II contract and, if possible, demonstrate earth based uses or benefits.

Subtopics

H10.01 Ground Processing Optimization and Technology Infusion

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

This subtopic seeks innovative concepts and solutions for both addressing long-term ground processing and test complex operational challenges and driving down the cost of government and commercial access to space.
Technology infusion and optimization of existing and future operational programs, while concurrently maintaining continued operations, are paramount for cost effectiveness, safety assurance, and supportability.

Strategies to optimize and support changes in operations concepts should consider:

- The needs of geographically distributed and mobile teams.
- Efficient configuration changes to support operations of different customers.
- Protection of information for the different customers.
- Infrastructure availability.
- Increased situational awareness for operators.

Technology areas of Interest include:

- Strategies, technology innovations, and technology maturation of control room services to provide cost effective data handling and storage and standardized interfaces for data generated by dissimilar systems. Methods for rapid prototype of control and data systems software from engineering data, ensuring scalability of data presentation and streamlined communication, and methods to address and inform consumers of time delays in data transmission:
  - Cost effective solutions to connect control and data system software to facility models that provide for ease of use and maximize the return on investment for concurrent test and launch complex environments.
  - Approaches, such as a single console to perform command and control for a set of test resources or provisions for model-based diagnostic methods to provide rapid feedback on the test and launch complex environment state, can be explored.
- Methodologies for benchmarking, migrating, upgrading, and/or enhancing tools and control and data system architectures to lower the cost of technology infusion concurrently with the operational environment while reducing sustaining costs:
  - Focus should also be on system maintenance concepts for a highly COTS intensive environment to ensure configuration management and control, verification and validation approaches, technology refresh and security updates.
  - Innovative capabilities in information technology are required to provide robust and highly efficient information security for maintaining customer-specific intellectual property while providing a collaborative environment for launch and testing services.
- Optimization of ground controller and test conductor staffing and roles requirements through robust, innovative, and operator-infused simulation/training capabilities to efficiently train ground and test controllers in a collaborative environment. Objectives should focus on skills proficiency and maintenance for troubleshooting, decision making, and time management in critical situations.
- Migration of models used in the design and development of infrastructure to the operations/training phase (e.g., Model-Based System Engineering (MBSE) process).
- Cost effective solutions for operations automation including peer-to-peer planning, mixed initiatives,
elicitation of constraints and preferences, and system software integration. Focus should be on the use of standards and open source software enabling staff reduction, fault isolation and recovery methods, and decrease of software integration costs. Additionally, on understanding the interfaces of planning/mixed initiative systems with diagnostic systems, as diagnostic systems will inform the planning system of the available resources.

- Prognostic technologies to optimize component maintenance, support, mission and test planning, evaluation of system component redundancy, monitoring of performance and safety margins, and critical decision making.

Proposed concepts would benefit from clean, well-defined, unambiguous interfaces that account for configuration changes over the ground processing and test complex timeline; such proposals will receive higher consideration. All concepts must place an emphasis on how the interfaces in the system behave. Approaches to model, verify, and validate interfaces will be of interest.

For all above technologies, research should be conducted to demonstrate technical feasibility during Phase I and show a path toward Phase II demonstration, and delivering a demonstration package for NASA testing at the completion of the Phase II contract.

*Phase I Deliverables* - Research to identify and evaluate candidate technology applications to demonstrate the technical feasibility and show a path towards a demonstration. Concept methodology, infusion strategies (including risk trades), and business model. Identify improvements over the current state of the art and the feasibility of the approach in a multi-customer environment. Bench or lab-level demonstrations are desirable. The technology concept at the end of Phase I should be at a TRL of 4.

*Phase II Deliverables* - Emphasis should be placed on developing and demonstrating the technology under simulated mission conditions, including the mission of engine testing. The proposal shall outline a path showing how the technology could be developed into mission-worthy systems. The contract should deliver a demonstration unit for functional and environmental testing at the completion of the Phase II contract. The technology concept at the end of Phase II should be at a TRL of 7.

**H10.02 ISS Demonstration & Development of Improved Exploration Technologies**

**Lead Center:** JSC

**Participating Center(s):** ARC

The focus of this subtopic is on technologies and techniques which may advance the state of the art of spacecraft systems by utilizing the International Space Station as a technology test bed.

Successful proposals will address using the long duration environment of the ISS to demonstrate component or system characteristics that extend beyond the current state of the art by:
Increasing capability/operating time including overall operational availability.

Reducing logistics and maintenance efforts.

Reducing operational efforts, minimizing crew interaction with both systems and the ground.

Reducing known spacecraft/spaceflight technical risks and needs.

Providing information on the long term space environment needed in the development of future spacecraft technologies through model development, simulations or ground testing verified by on orbit operational data.

These demonstrations should focus on increasing the TRL in the following fields:

- Power generation and energy storage (e.g., regenerative fuel cells and battery).
- Robotics Tele-robotics and Autonomous (RTA) Systems.
- Communication and Navigation (e.g., autonomous rendezvous and docking advancements).
- Human health, Life Support and Habitation Systems (e.g. closed loop aspects of environmental control and life support systems).
- Science Instruments, Observatories and Sensor Systems.
- Nanotechnology.
- Materials, Structures, Mechanical Systems and Manufacturing.
- Thermal Management Systems (e.g., cryogenic propellant storage and transfer).
- Environmental control systems, including improved carbon dioxide removal.
- On-orbit trash processing/recycling.
- Radiation.
- Providing Engineering Motion Imagery "smart" imaging systems that reduce bandwidth but maintain high quality imaging in areas of interest; maintenance of window clarity on optical systems without creating a debris source; data storage and retrieval for instances when bandwidth is constrained or the rocket or spacecraft will not be retrieved; compression and/or modulation techniques to maximize efficiency of constrained telemetry downlinks; and imaging system components that are radiation and electromagnetic interference tolerant.

For the above technology subject areas, research should be conducted to demonstrate technical feasibility during Phase I and show a path toward hardware and/or material development as appropriate which occurs during Phase II and culminates in a proof-of-concept system.

Phase I Deliverables - Phase I Deliverables: Research to identify and evaluate candidate technologies applications to demonstrate the technical feasibility and show a path towards a hardware/software demonstration. Bench or lab-
level demonstrations are desirable. The technology concept at the end of Phase I should be at a TRL of 3-6.

*Phase II Deliverables* - Phase II Deliverables: Emphasis should be placed on developing and demonstrating the technology under simulated flight conditions. The proposal shall outline a path showing how the technology could be developed into space-worthy systems. The contract should deliver a demonstration unit for functional and environmental testing at the completion of the Phase II contract. The technology at the end of Phase II should be at a TRL of 6-7.