



## **NASA SBIR 2016 Phase I Solicitation**

### **H10 Ground Processing**

Ground processing technology development prepares the agency to test, process and launch the next generation of rockets and spacecraft in support of NASA's exploration objectives by developing the necessary ground systems, infrastructure and operational approaches.

This topic 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.

A key aspect of NASA's approach to long term sustainability and affordability is to make test, processing and launch infrastructure available to commercial and other government entities, thereby distributing the fixed cost burden among multiple users and reducing the cost of access to space for the United States.

Unlike previous work focusing on a single kind of launch vehicle such as the Saturn V rocket or the Space Shuttle, NASA is preparing common infrastructure to support several different kinds of spacecraft and rockets that are in development. Products and systems devised at a NASA center could be used at other launch sites on earth and eventually on other planets or moons.

## **Subtopics**

### **H10.01 Improved Test and Launch Operations via Interface Design**

**Lead Center: KSC**

**Participating Center(s): SSC**

This subtopic seeks to improve ground and surface processing in both the operational and test environments through improved interface design concepts. A substantial portion of pre-launch processing involves the integration of spacecraft assemblies to each other or to the ground/surface systems that supply the commodities, power or data. Each assembly requires an interface that connects it to the adjacent hardware which includes flight critical seals or connectors and other components. The impact of these interface-driven tasks are of particular concern for surface systems where the additional work must be accomplished by crew performing Extra-Vehicular Activities (EVAs) or by purpose-built robotic systems.

The interfaces between payloads, boosters and ground/surface support equipment have historically been drivers of numerous delays and unplanned work prior to launch. The developmental impact of interface design and requirements development includes extensive design labor and validation for any new integrated launch system. Finally, the historical trend of having unique interface types for different launch systems has hampered recent

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efforts to establish a multi-user capability for existing launch infrastructure.

Development and adoption of improved, standardized interfaces holds the potential of reducing the cost and complexity of future space systems and their related design and implementation, which can increase the funding available for flight hardware and drive down the cost of government and commercial access to space.

Standardization of interfaces used during testing or launch processing also provides eventual benefits to autonomous servicing, a key space technology for future missions. Future in-space and surface servicing of multiple spacecraft/user types such as satellites becomes more feasible if a common interface approach can be developed and widely adopted.

Technologies sought for interface design are grouped in the following two focus areas:

### **Physical Interfaces**

- Modular architectures of expandable surface systems that minimize the adverse impact of interface connections.
  - Interfaces suitable for modular, reliable, cryogenic propellant liquefaction architectures that enable incremental system approaches for increasing capacities as needed.
  - Dust-tolerant interface approaches that drive highly reliable and/or autonomous connections.
- Development of earth based analog test hardware to test and validate these surface system interface concepts (module equipment interfaces and/or surface to vehicle interfaces).
  - Connector technologies including ports, disconnects or couplers that enable standardization across the industry for the transfer of cryogenic and storable propellants or other servicing fluids, power, and/or data for Governmental and Commercial launch providers and/or future surface system analog testing.
  - Interface concepts that simplify or standardize future Interface Requirements Documents (IRDs) or enable increased use of off-the-shelf hardware for future flight and exploration support systems.
  - Solutions that promote standardization of key payload to launch vehicle and subsystem interface standards to reduce the cost associated with analysis, design, configure, integration, and preparation of space systems for launch and reusability through standard servicing interfaces.
  - Novel concepts for adaptation of common interface architectures from relevant industries and the analysis and development required to adapt them to space and exploration architectures. Adaptation should include providing the relevant certification planning required for acceptance by government and industry.

### **Software/Data Interfaces**

- Concepts for embedded intelligence within interfaces that include software attributes to enhance the usage of interface data for tasks such as self-testing, diagnostics, configuration verification and/or management of the interface.
- Concepts for the use of industry standards and/or open source software to reduce or eliminate the need for dedicated interfaces by more efficiently managing system configurations. Software addressable interfaces conducting fault isolation and recovery, and decrease of software integration costs.
- Interface concepts that simplify or standardize future Interface Requirements Documents (IRDs) or enable increased use of off-the-shelf hardware for future flight and exploration support systems.

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, demonstrate the technical feasibility, and show a path towards a demonstration. Concept methodology should include the path for adaptation of the technology, infusion strategies (including risk trades), and business model. Identify improvements over the current state of the art for both operations and systems development and the feasibility of the approach in a multi-customer environment. Bench or lab-level demonstrations are desirable.

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Phase II Deliverables - Emphasis should be placed on developing and demonstrating the technology under simulated operational conditions with analog earth-based systems including dynamic events such as commodity loading, disconnect or engine testing. The proposal shall outline a path showing how the technology could be developed into or applied to mission-worthy systems. The contract should deliver demonstration hardware 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 5 or higher.

## **H10.02 Advanced Propulsion Systems Ground Test Technology**

**Lead Center: SSC**

**Participating Center(s): KSC**

Rocket propulsion development is enabled by rigorous ground testing in order to mitigate the propulsion system risks that are inherent in spaceflight. This is true for virtually all propulsive devices of a space vehicle including liquid and solid rocket propulsion, chemical and non-chemical propulsion, boost stage and in-space propulsion and so forth. It involves a combination of component-level and engine-level testing to demonstrate the propulsion devices were designed to meet the specified requirements for a specified operational envelope and over robust margins and shown to be sufficiently reliable, prior to its first flight.

This topic area seeks to develop advanced ground test technology components and system level ground test systems that enhance Chemical and Advanced Propulsion technology development and certification. The goal is to advance propulsion ground test technologies to enhance environment simulation, minimize test program time, cost and risk and meet existing environmental and safety regulations. It is focused on near-term products that augment and enhance proven, state-of-the-art propulsion test facilities.

In particular, technology needs includes producing large quantities of hot hydrogen, and develop robust materials, advanced instruments and monitoring systems capable of operating in extreme temperature and harsh environments.

This subtopic seeks innovative technologies in the following areas:

- Efficient generation of high temperature (>2500°R), high flowrate (<60 lb/sec) hydrogen.
- Devices for measurement of pressure, temperature, strain and radiation in a high temperature and/or harsh environment.
- Development of innovative rocket test facility components (e.g., valves, flowmeters, actuators, tanks, etc.) for ultra-high pressure (>8000 psi), high flow rate (>100 lbm/sec) and cryogenic environments.
- Robust and reliable component designs which are oxygen compatible and can operate efficiently in high vibro-acoustic, environments.
- Advanced materials to resist high-temperature (<4400° F), hydrogen embrittlement and harsh environments.
- Tools using computational methods to accurately model and predict system performance are required that integrate simple interfaces with detailed design and/or analysis software. SSC is interested in improving capabilities and methods to accurately predict and model the transient fluid structure interaction between cryogenic fluids and immersed components to predict the dynamic loads, frequency response of facilities.
- Improved capabilities to predict and model the behavior of components (valves, check valves, chokes, etc.) during the facility design process are needed. This capability is required for modeling components in high pressure (to 12,000 psi), with flow rates up to several thousand lb/sec, in cryogenic environments and must address two-phase flows. Challenges include: accurate, efficient, thermodynamic state models; cavitation models for propellant tanks, valve flows, and run lines; reduction in solution time; improved stability; acoustic interactions; fluid-structure interactions in internal flows.
- Improved capability for monitoring environmental conditions for ground and launch facilities supporting test and launch operations. Instrumentation should provide a remote sensing capability to measure atmospheric data with respect to altitude from 300 meters to at least 10 km. The technology must have a vertical measurement resolution of 150 m or smaller and a full vertical profile multiple times an hour in both cloudy and clear environments.
- Improved capability for cryogenic leak and fire detection to support ground test or launch operations.

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- Non-intrusive instrumentation for measuring rocket engine plume velocities including a volumetric assessment of plume extent, volume and turbulence.

For all above technologies, research should be conducted to demonstrate technical feasibility during Phase I and show a path towards Phase II hardware/software demonstration with delivery of a demonstration unit or software package for NASA testing at the completion of the Phase II contract.