NASA SBIR 2007 Phase I Solicitation

O2.02  Space Transportation Propulsion System and Test Facility Requirements and Instrumentation

Lead Center: SSC

Participating Center(s): GRC, MSFC

Ground testing of propulsion systems continues to be critical in meeting NASA's strategic goals. Relevant ground testing technologies and capabilities are crucial to the development, qualification, and acceptance process of validating cargo launch vehicles and human rated vehicles including Crew Exploration Vehicles (CEV), CEV Launch Systems, Cargo Launch Vehicle (CLV), and Lunar Surface Access Modules propulsion systems. The ability to quickly and efficiently perform system certification greatly impacts all space programs. Proposals are sought in the following areas:

Instrumentation and Sensors

NASA's Stennis Space Center (SSC) is concerned with expanding its suite of non-intrusive technologies that provide information on propulsion system health, the environments produced by the plumes and the effects of plumes and constituents on facilities and the environment. Current capabilities include non-intrusive optical methods of monitoring plumes for metallic contamination from erosion and wear, measuring the radiative and acoustic energies and as well as measuring the concentrations of environmentally sensitive species. SSC also requires facility health management technologies to monitor the physical health of testing infrastructure to improve the sustainability and reliability of the test facilities and components.

Engine Health Monitoring

Innovative, standalone sensors for non-intrusively measuring physical properties of rocket engine plumes. Measurements of interest include, but are not limited to, species, temperature, density, velocities, combustion stability and O/F measurement.

Plume Environments Measurements: Advanced instrumentation and sensors to monitor the near field and far field effects and products of exhaust plumes. Examples are the levels of acoustic energy, thermal radiation and final exhaust species that will effect the environment.

Facility Monitoring
Advanced instrumentation and sensors for process monitoring in high pressure 12,000 psi and high flow rate 100 lb/sec gas and cryogenic environments. Applications include cryogenic level sensing, fast response/high accuracy cryogenic temperature sensors. Facility response and analysis capabilities for monitoring facility structure, process systems and test article interaction. These include dynamic response, structural fatigue and pipe system health.

**Integrated System Health Management (ISHM) Capability for Rocket Engine Testing and Ground Operations**

ISHM capability is achieved by integrating data, information, and knowledge (DIaK) that might be distributed throughout the system elements (which inherently implies capability to manage DIaK associated with distributed sub-systems). DIaK must be available to any element of a system at the right time and within proper context. ISHM capability is measured by how well a system performs the following functions:

- Detect anomalies;
- Diagnose causes;
- Predict future anomalies/failures;
- Provide the user with an integrated awareness about the condition of every element in the system and guide user decisions.

The technologies of interest to this topic include:

- Algorithms/approaches/methodologies for anomaly detection;
- Approaches and methodologies for root-cause analysis to diagnose causes of anomalies;
- Approaches and methodologies for prediction of future anomalies;
- Architectures/Taxonomies/Ontologies (management of DIaK - where management implies distributed storage, sharing, processing, maintenance, configuration);
- Software environments that integrate contributing technologies in a modular plug-and-play fashion, adhering to a defined architecture/taxonomy/ontology;
- User interfaces to provide the user integrated system awareness;
- Intelligent elements (e.g., sensors, valves, pumps, etc.).

**Computational Modeling Tools and Methods**

Developing and verifying test facilities is complex and expensive. The wide range of pressures, flow rates, and temperatures necessary for engine testing result in complex relationships and dynamics. It is not realistic to physically test each component and the component-to-component interaction in all states before designing a system. Currently, systems must be tuned after fabrication, requiring extensive testing and verification. 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.

**Plume Environments**

Improved capabilities to predict and model acoustic and thermal energy produced by exhaust plumes and interaction/coupling with facilities. Exhaust constituents and far field buoyant plume modeling for environmental impact assessment.

**Component Design, Prediction and Modeling**

Improved capabilities to predict and model the behavior of components (valves, check valves, chokes, etc.) during the facility design process. This capability is required for modeling components in high pressure 12,000 psi, high flow 100 lb/sec cryogenic environments and must address two-phase flows.

**Process System Design, Prediction and Modeling**

Improved capabilities to predict and model process systems. The capability should incorporate the previous two areas to accurately model the process systems and test articles.