Achieving space flight can be astonishing. It is an undertaking of great complexity, requiring numerous technological and engineering disciplines and a high level of organizational skill. Overcoming Earth's gravity to achieve orbit demands collections of quality data to maintain the security required of the range. The harsh environment of space puts tight constraints on the equipment needed to perform the necessary functions. Not only is there a concern for safety but the 2004 Space Transportation Policy directive that states that the U.S. maintains robust transportation capabilities to assure access to space. Given this backdrop, this topic is designed to address technologies to enable a safer and more reliable space transportation capability. Automated collection of range data, automated tracking and identification of objects, and instrumentation for space transportation system testing are all required. The following subtopics are required secure technologies for these capabilities.

**Subtopics**

**O2.01 Optical Tracking and Image Analysis**

*Lead Center: KSC*

*Participating Center(s): AFRC, MSFC*

**GPS or Radar-aided Autofocus**

Investigate using range information from radar, GPS, or other sources, for autofocusing long-range optics systems. Optical tracking provides valuable data during aerospace operations, but large distances between the target and the optical system can lead to distortions caused by atmospheric disturbances. Range information might be useful for a computer-controlled optical focusing system to decrease this distortion. The initial investigation will determine if this approach could be useful using one or multiple cameras, how it might be implemented, and if range information could be combined with other distortion-reduction techniques.

**New Optical Tracking Systems**

Investigate innovative and unconventional ways to use optical or hyperspectral imaging systems to visualize and track vehicles during launch and landing operations. Possibilities might include, but are certainly not limited to, unmanned aerial vehicle platforms or balloons. The system must be implemented unobtrusively in a spaceport environment. The initial investigation should result in a proof-of-concept demonstration in an appropriately scaled environment.
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.

**O2.03 Automated Collection and Transfer of Launch Range Surveillance/Intrusion Data**

*Lead Center: KSC*

*Participating Center(s): GSFC, MSFC*

Range surveillance is a primary focus of launch safety and often cost and schedule drivers as well. Launch delays due to difficulty in verifying a cleared range are common and will increase as development encroaches on existing spaceports and as spaceports are built in new areas. Proposals are sought for innovative sensors, instrumentation platforms, and communication technologies which expedite range clearance by providing real-time situational awareness for range operations such as launches, hazardous processing, and recovery.

Instrumentation platforms will provide mobile or transportable surveillance assets for broad area coverage to meet range needs. These platforms should be capable of a high degree of self-sufficiency and autonomy for unattended, long-term operations. During operations the platform must maintain stability so that instruments are not required to compensate for unique environmental characteristics surrounding the operations. Platforms may include, but are not limited to, Unpiloted Aerial Vehicles (UAV), High Altitude Airships (HAA), buoys, etc.

Instrumentation and sensors would include but not be limited to a wide spectrum of optical, infrared, Radio Frequency (RF), and millimeter wave. These would provide for the detection, recognition, and identification of persons and objects that have intruded areas of the range that must be cleared in order to conduct safe launch operations. In addition, multiple sensors and instruments may be used, or combined through the use of neural networks and data fusion, for accurate identification, and time and position of entities.

Centric and integrated communications schemes that adhere to widely accepted standards will enable a scalable architecture for range instrumentation that supports launch operations. Data rates and bandwidth requirements may vary greatly depending on instrumentation and sensors that are incorporated on a range. These constraints and the distributed nature of a range dictate the need to include multiple communication media such as free-space
optics, Wi-Fi, and terrestrial and space-based communications links in order to transport the collected data. Novel and innovative approaches to this architecture are sought.