Stennis Space Center Technology Development Needs

National Aeronautics and
Space Administration
John C. Stennis Space Center

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John C. Stennis Space Center

NASA's John C. Stennis Space Center (SSC) is located on the Mississippi Gulf Coast, just 45 minutes east of New Orleans, Louisiana. SSC is NASA's Center of Excellence for rocket propulsion testing and manages NASA's rocket propulsion test assets, including facilities at the Marshall Space Flight Center in Alabama, the White Sands Test Facility in New Mexico, and the Glenn Research Center Plumbrook Station in Ohio.

In addition to being the Center of Excellence for rocket propulsion testing, SSC also plays a lead role in remote sensing applications. The Earth Science Applications Directorate (ESAD) is part of NASA's Earth Science Enterprise (ESE). The ESE is dedicated to understanding the total Earth system and the effects of natural and human-induced changes on the global environment.

Propulsion Test Directorate (PTD)

The primary function of PTD is testing Rocket Engines and engine components. Most, but not all, of the rocket engines tested are cryogenic engines. Other types of propellants include RP1, Hydrogen Peroxide, and hybrid fuels. The harsh nature of the test environments creates a need for very specialized technologies for improving the test operations and resulting test data.

Earth Science Applications Directorate (ESAD)

The mission of the Earth Science Applications Directorate is to extend NASA geospatial science knowledge and technology to the solution of near term socioeconomic problems and enable the growth of a strong national commercial remote sensing industry. Part of the mission is to incorporate remote sensing technology into the everyday lives of U.S. businesses and citizens. To address end-user needs, the Directorate engages partners in the U.S. public and private sectors, including:

- Federal government agencies
- State, local and tribal governments
- Academic researchers
- Remote sensing
  - Instrument builders
  - Data providers
  - Value-added resellers
- Other, non-geospatial businesses
- Trade associations
- Not-for-profit companies and charities

Propulsion Test Directorate Technology Requirements

In order to meet mission requirements the Propulsion Test Directorate is looking for development of new technologies that can significantly increase the capabilities for improved rocket engine ground testing and safety, reduce overall propulsion test recurring costs, and/or increase reliability of ground rocket test facilities.

Sensors and Instrumentation. Due to the extremely harsh environments associated with rocket engine testing, sensors and instrumentation needed to obtain data from the tests must meet special requirements. The following descriptions are for types of sensors and instrumentation that could improve SSC test operations.

Sensors for Cryogenic Testing. Sensors that are capable of operating in LOX and/or LH2 cryogenic environments are needed to measure temperature, pressure and flow rates. The low end temperatures in these systems are 34R in LH2 to 160R in LOX. These systems can operate at high pressures (up to 12,000 psi) under high flow rate conditions: (2000 lb/sec (82 ft/sec) for LOX and 500 lb/sec (333 ft/sec) for LH2). Any type of sensor used in these systems must be able to operate in the above temperatures, pressures, and flow rate conditions. The following sensor features are needed:

a. Sensors should provide sub-millisecond response times.
b. Intrusive sensors must be rugged enough to handle the operating conditions but function with high accuracy (0.2%) and sub-millisecond response times.
c. Non-intrusion sensors that do not physically intrude into the measurement space. Non-intrusive flow rate measurement systems are of particular interest.

Specialized Measurement Technologies

a. There is a need for real time, on-line instrumentation for (real time) sampling and analysis of liquid oxygen-nitrogen mixtures in high pressure, high flow rate liquid oxygen (LOX) systems that also has the capability to detect the presence of other chemical species present in the LOX, which may have been introduced through the pressurization process.
b. There is an interest in the potential for Terahertz Sensors use in a cryogenic facility to monitor gaseous leaks by detecting invisible vapor clouds or to provide real time combustion measurements, and inspection of combustion devices with visualization of rocket engine combustion dynamics.
c. There is a potential for applications of high speed RF linked sensor systems in the test area. These systems could operate remotely and eliminate extensive cabling. The systems could not interfere with other electronic equipment and devices in the area.

Technologies for Monitoring Test Environments

a. Acoustics. New and innovative acoustic measurement techniques and sensors for use in a rocket plume environment are required that can accurately predict the acoustic levels using fewer measurements. New, innovative techniques based on energy density measurements rather than pressure measurements show promise as replacements for the older models.

b. Atmosphere. Accurate atmospheric transmission modeling is needed for high-temperature rocket engine plume environments. The capabilities should address both the losses from ambient atmosphere and localized environments, such as condensation clouds generated by cryogenic propellants that can be significant in certain wavelength regions for radiometric detectors located far from the rocket engine exhaust plume.

Plume Spectroscopy

a. There are requirements to develop enhanced methods and instrumentation for rocket plume spectral signature measurements. Emphasis is on developing data acquisition, analysis, display software, and systems to support infrared spectrometers, imaging systems, and filter radiometer systems. Overall system concepts should include instrument system calibration methodologies and data uncertainty analysis.

b. There is an interest in sensors and systems for detecting and measuring rocket plume constituents, and effluent gas detection. Rocket plume sensors of interest should be capable of determining gas species, temperature, and velocity for H2, O2, RP1, and hybrid fuels.

Other Propulsion Test Operation Technology Requirements

a. In addition to the measurement systems to facilitate test operations, there are several categories of technologies that have unique applications in test operations. The following are descriptions of some of the technologies that are of interest at SSC.

b. New propulsion systems using cryogenic fueled rocket engines are designed with advanced propellant requirements, which include special propellant conditioning methods such as densification. Improved methods are sought to meet these cryogenic propellant conditioning requirements for production and storage of densified propellants, such as sub cooled and slush hydrogen.

c. When using hydrogen as a rocket engine propellant, hydrogen from boiloff, or hydrogen exhaust from testing components cannot be vented to the atmosphere. Flare stacks are used to burn off this excess hydrogen during both standby and testing operations. New techniques for modeling and designing flare stacks are needed to develop flare systems possessing improved operational ranges, reduced cost for supplemental purge gas usage, and low environmental impact. These flare systems must operate over a wide range of hydrogen flow rates, which can span the range of a few cubic feet per minute to hundreds of pounds per second.

d. New innovative approaches to incorporating knowledge and information processing techniques (prepositional logic, fuzzy logic, neural nets, etc.) are of interest in an effort to support test system decision making and operations. Applications must operate statistically well on small and disparate data sources. The resulting products should be inferential, representative, and capture tacit and explicit knowledge. Statistic analysis must be supported.

e. Miniature front-end electronics are needed to support embedding intelligent functions onto sensors. Requirements include computational power comparable to a 200 MHz PC with 32 MB of RAM or similar non-volatile storage, analog I/O (at least two of each, with programmable amplification, anti-aliasing filters, and automatic calibration), digital I/O (at least eight), communication port for Ethernet bus protocol (one high speed and one low speed), support for C programming (or other high-level language), and development kit for PC. Physical size should not occupy a volume larger than 4”x 4”x 2”.

f. There is an interest in materials, including seals, valve materials, and coatings that can withstand long-term hydrogen peroxide operations. There is also a need for components for hydrogen peroxide service, including isolation valves, ball valves, and relief valves, which are designed for minimum number of sumps and seals, and clean flush-through.

g. There is a need for insulation materials for cryogenic (liquid oxygen and liquid hydrogen) tanks, pipes, and valves that are resistant to deterioration in an environment of intense sunlight, high humidity, and frequent, heavy rainfall. It must also maintain adhesion during thermal contraction and expansion associated with operational cycles of cryogenic propellants.

Earth Science Applications Directorate Technology Requirements

To meet mission requirements the Earth Science Applications Directorate is looking for the development of new technologies to enhance human and machine interaction in support of scientific, commercial, and educational application of remote sensing data.

There is also an emphasis on distributed and/or mobile teams in validation and verification exercises for the commercialization of remote sensing data that results in the development of end-to-end systems that use remote sensing data to produce information for end-user decision makers.

Another emphasis in the Earth Science Applications Directorate is development of technologies related to the carbon cycle. Changes in land management practices and additions of carbon dioxide and nutrients may enhance terrestrial carbon sinks significantly. The following are brief descriptions of some of the technologies of interest.

a. Tools for interpretation, visualization, or analysis of remotely sensed data
b. Qualitative and quantitative analysis tools and techniques for performance analysis of remotely sensed data.
c. Technologies that make earth science observations easy to use by practitioners in the areas of community growth and infrastructure, disaster management, environmental assessment, and resource management.
d. End-to-end systems that use remote sensing data to produce information for end-user decision makers.
e. Technologies related to the carbon cycle such as technologies capable of monitoring local and regional changes in soil / vegetation patterns and modeling their response to climate change.