



NASA STTR 2019 Phase I Solicitation

T13.01 Intelligent Sensor Systems

Lead Center: SSC

Technology Area: TA4 Robotics, Telerobotics and Autonomous Systems

Advanced Instrumentation for Rocket Propulsion Testing

Rocket propulsion development is enabled by rigorous ground testing in order to mitigate the propulsion system risks that are inherent in spaceflight. Test articles and facilities are highly instrumented to enable a comprehensive analysis of propulsion system performance. This subtopic seeks to develop advanced instrumentation technologies which can be embedded in systems and subsystems. The goal is to provide a highly flexible instrumentation solution capable of monitoring remote or inaccessible measurement locations, all while eliminating cabling and auxiliary power. It is focused on near-term products that augment and enhance proven, state-of-the-art propulsion test facilities. Rocket propulsion test facilities within NASA provide excellent test beds for testing and using the innovative technologies discussed above. The technologies developed would be capable of addressing multiple mission requirements for remote monitoring such as vehicle health monitoring.

Intelligent wireless sensor systems have the potential for substantial reduction in time and cost of propulsion systems development, with substantially reduced operational costs and evolutionary improvements in ground, launch and flight system operational robustness. Sensor systems should provide an advanced diagnostics capability to monitor test facility parameters including simultaneous heat flux, temperature, pressure, strain, and near-field acoustics. Applications encompass remote monitoring of vacuum lines, gas leaks and fire; where the use of wireless/self-powered sensors to eliminate power and data wires would be beneficial. Nanotechnology enhanced sensors are desired where applicable to provide a reduction in scale, increase in performance, and reduction of power requirements.

Sensor systems should have the ability to provide the following functionality:

- Measure of the quality of the measurement.
- Measure of the health of the sensor.
- Sensor systems should enable the ability to detect anomalies, determine causes and effects, predict future anomalies, and provides an integrated awareness of the health of the system to users (operators, customers, management, etc.).
- Sensors are needed with capability to function reliably in extreme environments, including rapidly changing ranges of environmental conditions, such as those experienced in space. These ranges may be from extremely cold temperatures, such as cryogenic temperatures, to extremely high temperatures, such as those experienced near a rocket engine plume. Collected data must be time stamped to facilitate analysis with other collected data sets.
- Sensor systems should be self-contained to collect information and relay measurements through various means by a sensor-web approach to provide a self-healing, auto-configuring method of collecting data from

-
- multiple sensors, and relaying for integration with other acquired data sets.
 - The proposed innovative systems must lead to improved safety and reduced test, and space flight costs by allowing real-time analysis of data, information, and knowledge through efficient interfaces to enable integrated awareness of the system condition by users.
 - The system provided must interface with existing data acquisition systems and the software used by such systems.
 - The system must provide NIST traceable measurements with capability for in-place calibrations.
 - The system design should consider an ultimate use of space flight qualified sensor systems, which could be used for multi-vehicle use.Â Â

Subtopic is relevant to the development of liquid propulsion systemsÂ and verification testing in support of the Human Exploration and Mission Operations Directorate. Supports all test programs at Stennis Space Center (SSC) and other propulsion system development/test and launch facilities. Potential advocates are the Rocket Propulsion Test (RPT) Program Office and all rocket propulsion test programs at SSC.Â

The expected Technology Readiness Level (TRL) range at completion of the project is 3-6.Â

References:Â

- Fernando Figueroa, Randy Holland, David Coote, "NASA Stennis Space Center integrated system health management test bed and development capabilities," Proc. SPIE 6222, Sensors for Propulsion Measurement Applications, 62220K (10 May 2006);
- J. Schmalzel ; F. Figueroa ; J. Morris ; S. Mandayam ; R. Polikar, "An architecture for intelligent systems based on smart sensors,"Â IEEE Transactions on Instrumentation and Measurement (Volume: 54 , Issue: 4 , Aug. 2005)
- S. Rahman, R. Gilbrech, R. Lightfoot, M. Dawson, "Overview of Rocket Propulsion Testing at NASA Stennis Space Center," NASA Technical ReportÂ SE-1999-11-00024-SSC
- David J. Coote, Kevin P. Power, Harold P. Gerrish, and Glen Doughty. "Review of Nuclear Thermal Propulsion Ground Test Options", 51st AIAA/SAE/ASEE Joint Propulsion Conference, AIAA Propulsion and Energy Forum, (AIAA 2015-3773)
- H. Ryan, W. Solano, R. Holland, W. Saint Cyr, S. Rahman, "A future vision of data acquisition: distributed sensing, processing, and health monitoring,"Â IMTC 2001. Proceedings of the 18th IEEE Instrumentation and Measurement Technology Conference. Rediscovering Measurement in the Age of Informatics (Cat. No.01CH 37188)
- https://www.nasa.gov/sites/default/files/atoms/files/propulsion_testing.pdf
- <https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20040053475.pdf>
- <https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20090026441.pdf>
- https://www.nasa.gov/centers/wstf/pdf/397001main_Prop_test_data_acq_cntl_sys_DACS_doc.pdf

Â