NASA SBIR 2011 Phase I Solicitation

O2.05 Advanced Propulsion Testing Technologies

Lead Center: SSC

The aim of this subtopic is to develop new technologies to reduce cost and schedule, improve reliability and quality, and increase safety of Rocket Propulsion Testing. To this end, proposals for technology development will be accepted for any of the following four subject areas:

- Critical Vacuum Sensing.
- Helium Recovery.
- Robust Components.
- Advanced Propulsion Test Data Management.

Critical Vacuum Sensing Technology

Develop new innovative methods for remotely and automatically locating and quantifying vacuum leaks in large vacuum chambers subject to harsh environmental conditions. A new test stand, A3, is being built at SSC to test rocket engines at altitude conditions. Information on A3 Test Stand can be found at the following URLs:

- http://sscfreedom.ssc.nasa.gov/etd/ETDTestFacilitiesA3.asp.
- http://www.tulane.edu/~sse/FORUM_2010/pdfs/e1.pdf.
- http://www.nasa.gov/centers/stennis/pdf/436170main_A-3%20Test%20Stand%20FS-2010-03-00093.pdf.

To simulate altitude during rocket engine testing, A3 test stand produces a vacuum of 0.15psia inside a large, 40 ft diameter, rocket engine test chamber using 27 chemical steam generators and a 2-stage diffuser/ejector system. If vacuum leaks occur, the desired simulated altitude may not be achievable thus any leaks must be located and repaired. However, personnel access to the vacuum test chamber during operation is restricted due to the hazardous nature of its operation. This makes locating vacuum leaks difficult, if not impossible. Therefore, automated remote detection and location of areas of air in-leakage is required. Due to the unique nature of this test facility, innovation in these technologies is necessary. Performance metrics include accuracy and sensitivity in detecting leaks in the harsh operational environment with high levels of noise and vibration while not producing false leak indications, as well as robust design for the harsh environment.

Helium Recovery Technology

Helium is a rare and nonrenewable resource with many properties critical to the commercial, military, and fundamental scientific research sectors. NASA consumes approximately 1 million pounds of helium each year, primarily for purging of cryogenic propellant systems in which the helium is discharged to atmosphere and lost. The goal of this subtopic thrust area is to develop innovative helium recovery technologies that economically dissociate helium from large volumes of mixtures of helium, air, and hydrogen purge discharge, and pressurize the reclaimed helium for storage and reuse. The total cost of recovering and reusing helium, from both capital and energy expenditure, should be less than procuring the same amount of helium from traditional sources. Also, particular emphasis is placed on portability (i.e., not a fixed installation) and speed of separation (near-real-time) that accommodates a single system servicing numerous distinct sources of helium, air, and hydrogen mixtures developed over the range of rocket propulsion testing and ground and flight operations and the temporal transient nature of production of these mixtures.

Robust Component Technologies

Rocket propulsion test hardware as well as ground and flight launch operations hardware regularly experience large and rapid changes in pressures, temperatures, vibration, and fluid flow rates while demanding high precision control and reliability. Typical ranges in these parameters are pressures from vacuum all the way up to 10,000 psi, working fluids at ambient temperature all the way down to -420F, vibration environments in the 100's of G RMS acceleration. These parameters can span their entire range in milliseconds. State of the art propulsion system testing hardware has evolved over time as better materials and experience in hardware interactions with these environments have progressed. Innovation in component performance diagnostics technology is required to continue the current progression in hardware operational reliability, cost, and weight optimization. Accordingly, the goal of this subtopic thrust area is to develop innovative in situ hardware performance measurement and diagnostics technology along with the accompanying data acquisition and management systems required for utilization the new technologies.

Advanced Propulsion Test Data Management Capability

Substantial advances in data capture and storage technologies have exponentially increased real and near-real time data availability in rocket propulsion testing. Effective utilization of this increase in data availability requires evolution of data management technologies, methods, and concepts that will enable greater and more effective real-time access, manipulation, and application in the control and quality of propulsion systems testing. Recent initiatives in development of hardware-in-the-loop technologies, merging measured and simulation data in real time feedback with propulsion test hardware have demonstrated the feasibility and utility of this technology. The goal of this subtopic thrust area is to develop innovative ways to take advantage of increased propulsion test data availability utilizing high performance hardware such as GPU based computer systems along with innovation in algorithms and software to implement new data management technologies, methods, and concepts.

In these subject areas, research should be conducted to demonstrate technical feasibility during Phase I and show a path toward hardware and/or software development as appropriate, which occurs during Phase II and culminates in a proof-of-concept system.

Phase I Deliverables: A final report describing optimal design for the technology concept including feasibility, trade studies, detailed results of Phase I analysis, modeling, prototyping, and testing as applicable. The report should also contain a detailed path towards Phase II hardware and/or software proof-of-concept system. The technology concept at the end of Phase I should be at a TRL of 3-4.

Phase II Deliverables: A working proof-of-concept system successfully demonstrated in a relevant environment and delivered to NASA for testing and verification. The technology at the end of Phase II should be at a TRL of 6-7.