NASA SBIR 2019 Phase I Solicitation

A1.08 Aeronautics Ground Test and Measurement Technologies

Lead Center: LaRC

Participating Center(s): ARC, GRC

Technology Area: TA15 Aeronautics

NASA's aeroscience ground test facilities include wind tunnels, air-breathing engine test facilities, and simulation and loads laboratories. They play an integral role in the design, development, evaluation, and analysis of advanced aerospace technologies and vehicles. These facilities provide critical data and fundamental insight required to understand complex phenomena and support the advancement of computational tools for modeling and simulation. The primary objective of this subtopic is to develop innovative tools and technologies that can be applied in NASAâ€™s aeroscience ground test facilities to revolutionize testing and measurement capabilities and improve utilization and efficiency. Of primary interest are technologies which can be applied to NASAâ€™s portfolio of large-scale ground test facilities. For this solicitation, NASA seeks proposals for innovative research and development in the following areas:

Flow Diagnostics for High-Speed FlowsÂ

Spatially- and temporally-resolved molecular-based diagnostics are sought for high-speed wind-tunnel flows (supersonic, hypersonic), both with and without combustion:Â

- Improved measurement capabilities are needed for velocity, temperature, density and species concentrations in harsh wind tunnel environments, including (but not limited to) short-duration facilities and luminous flows. Measurement systems should be reliable and robust and able to be implemented in multiple wind tunnel facilities and facility types including blow-down tunnels, shock tubes, shock tunnels and arc-jets. Some of the target facilities have naturally occurring species such as NO, O, and N atoms. Some facilities have thermal nonequilibrium. Combustion applications use both hydrogen and hydrocarbon fuels. Planar or volumetric measurements are preferred but highly-accurate pointwise measurements will also be considered. Ability to measure multiple parameters simultaneously (for example: (i) NO and O concentrations or (ii) temperature and fuel or combustion intermediate concentration) are desirable. The ability to time resolve unsteady flows so that spectra of the measured phenomena can be obtained is also desirable. Measurement systems should be validated against accepted standards (thermocouples, calibration flames, etc.) to determine measurement accuracy and precision. Proposals should project accuracies and precisions of the proposed measurement system(s) based on prior work.
- Improved measurement capabilities are also needed to obtain high-bandwidth heat flux measurements to complement global techniques like phosphor thermography and provide time-resolved data to investigate boundary layer transition, instability waves, and shock-boundary layer interactions. The application of current approaches is often limited by the sensitivity of the sensor to radiated heat, humidity, and low-tolerance to damage from abrasion. NASA seeks innovative techniques to measure heat flux that that are

robust and can easily applied to or integrated into model surfaces without creating steps or significantly changing the surface profile or mold line of the test article.Â

Current capabilities for measuring velocity, temperature, density, and species concentrations in harsh wind tunnel environments are effective but limited to sample rates of 10 hertz or less. The run times for the facilities where these techniques are used is extremely short (milliseconds to several seconds); therefore, the amount of data that can be acquired in a given amount of time or number of runs is limited. Technology is needed to enable parameters like velocity, temperature, density, and species concentration to be sampled simultaneously and at higher rates to obtain an appropriate amount of data to improve statistical error and provide detailed information about the time-varying nature of these flow fields. Similarly, there are existing technologies for heat flux measurements, but they are often limited by the sensitivity of the sensor to radiated heat, humidity, and low-tolerance to damage from abrasion. Improvements to the existing technology are needed to reduce the sensitivity of existing heat-flux sensors to these factors or entirely new technology and approaches need to be developed to enable heat flux measurements to be made routinely and consistently. The technologies described above are all critical for evaluating and analyzing high-speed vehicle concepts and technologies.Â

Global Shear Stress Measurements

Shear stress is an important parameter for characterizing the interaction between a fluid and a surface over which it is moving. Quantitative measurements of shear stress provide information about features like flow separation as well as boundary conditions for modeling and simulation tools. Currently, shear stress is measured at discrete locations using different sensors and probes; however, determining the proper measurement locations a priori is a significant challenge, especially for advanced configurations and in regions where the flow is highly unsteady.Â

To address these known difficulties, NASA seeks innovative techniques to obtain time-averaged, quantitative measurements of the global shear stress field on test articles in ground test facilities. Techniques are needed for each speed regime (subsonic, transonic, supersonic, and hypersonic) with a spatial resolution of 1 mm or less and applicable on complex geometries and vertical surfaces.Â

Currently, shear stress is measured at discrete locations using different sensors and probes; however, determining the proper measurement locations a priori is a significant challenge, especially for advanced configurations and in regions where the flow is highly unsteady. As such, technology is needed to provide a global picture of the shear-stress field that can be used to validate computational tools and methods and aid in determining where to place discrete shear stress measurement devices and/or make off-body flow field measurements.Â Â

The expected Technology Readiness Level (TRL) range at completion of the project is 1 to 4.Â

This subtopic is cross-cutting and as such, has the potential to improve the measurement capabilities of numerous projects within NASAâ€™s Aeronautics Research Mission Directorate (ARMD) that utilize ground-based test facilities for their R&D activities, including:Â

- Advanced Air Transport Technology (AATT) Project
- Aeronautics Test and Evaluation Project
- Commercial Supersonic Transport (CST) Project
- Hypersonics Technology Project
- Revolutionary Vertical Lift Technology (RVLT) Project
- Transformative Tools and Technologies (TTT) ProjectÂ

While the main deliverable for this topic will be prototype systems based on the measurement techniques and approaches developed by the company, these systems will inherently include hardware and software that can be used by NASA. In cases where a prototype system cannot be produced, the research itself will provide a wealth of information that will hopefully advance the state-of-the-art and can be used by others.

References:Â

https://www.nasa.gov/aeroresearch/programs/aavp/aetc/ground-facilities