AFRL CALL FOR RESEARCH

1. Research Title: *In-situ characterization of combustor performance in supersonic flows using laser-based diagnostics*

2. Individual Sponsor:

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3. Academic Area/Field and Education Level: Engineering Physics, Applied Physics, Mechanical Engineering, Aerospace Engineering (MS and/or Ph.D. level)

4. Objectives: The proposed thesis topic aims to develop in-situ combustion performance diagnostics using diode laser sensors for ground test applications where the in-stream determination of species concentration, temperature, pressure, and velocities in flows associated with scramjet engines are required.

5. Description: The current state-of-the-art in hypersonic air-breathing propulsion system development relies heavily on a combination of ground tests and numerical simulations. Generally, wall measurements (e.g., pressure, temperature, and heat flux) dominate the instrumentation suite available in most ground test facilities. If in-stream information (typically pitot pressure) is available, it is usually sparse and is generally available only at the inflow and outflow planes of the test article. While valuable for various analyses, these types of information provide little or no detailed descriptions of the mean and turbulent velocity fields, the turbulence-chemistry interactions, or the local state properties within the device. The proposed thesis topic is intended to address some of these deficiencies using laser-based instrumentation. The DAGSI masters or PhD student and faculty member will utilize the Propulsion Directorate's (AFRL/RZ) two direct-connect supersonic combustion facilities for the experimental research. In the experiments, tunable diode laser absorption spectroscopy (TDLAS) will be used for the in-stream measurements in hypersonic flow paths. Measurements are planned for O_2, H_2O, fuel (methane, ethylene, JP-7 marker), and CO_2 and will be used to determine absolute densities for these species, the gas temperature and pressure, and flow velocity. Measurements will be made at several locations within the flow path from the nozzle to the exhaust plane. Currently, the following three areas of research are of great interest: 1) Direct comparison of TDLAS (intrinsically path-averaged) measurements with point measurements made using other laser-based techniques. 2) Approaches to tomography using simultaneous TDLAS along multiple lines of sight. 3) Direct comparison of TDLAS measurements with computational fluid dynamics results for the flow path. As needed, measurements can be made in a laboratory-scale burner available to this program at WPAFB. Standard wall measurements of temperature and pressure will be implemented in the hypersonic facilities along with the laser-based methods, to reveal global features (such as lean blow-out characteristics, mixing properties, flame structure, and combustion efficiency).

6. Research Classification/Restrictions: U.S. Citizens only. Most aspects of this research fall under the 6.1 basic research classification. However, some aspects, in particular those dealing with specific engine configurations and performance parameters, are FOUO with ITAR restrictions.

7. Interest in Summer USAFA Cadet: No

8. Eligible Research Institutions:

[X] Universities (DAGSI) [X] AFIT [ ] USAFA