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 determination of species concentration, temperature, 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 (usually 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/PR) two direct-connect supersonic combustion facilities for the experimental research. In the experiments, tunable diode laser absorption spectroscopy (TDLAS) will be evaluated against the combined approaches of coherent anti-Stokes Raman spectroscopy (CARS), filtered Rayleigh scattering (FRS) and particle image velocimetry (PIV) to make temperature, density, and velocity measurements at the exit plane of ducted supersonic flows. These techniques will be used on selected test cases in laboratory scale flames to provide model validation data and in AFRL supersonic direct-connect combustion facilities. Wall measurements of temperature and pressure will be implemented on a more regular basis, along with the laser-based methods, to reveal global features (such as lean blow-out characteristics, mixing properties, flame structure, and combustion efficiency). Numerical simulations of the engine configurations will be performed using 3-D Navier Stokes CFD solvers, namely, CFD++ and VULCAN. Conventional Reynolds-Averaged Navier Stokes (RANS) simulations will be performed. Direct comparisons between the computational and experimental results will be made to reveal deficiencies associated with measurement and/or modeling techniques. The diode laser absorption measurements are planned for O_2, CO, CO_2, NO, H_2O, fuel (methane, ethylene, JP-7 marker) and will be used to determine absolute densities for these species, the gas temperature, and flow velocity. If the application of these techniques is successful as determined by quantitative comparison to the CARS, FRS, and PIV results, the TDLAS systems will be applied to flight applications.

6. Research Classification/Restrictions: 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. Eligible Research Institutions:

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