RQ16-25

1. **Research Title:** *In-situ characterization of supersonic combustor and isolator behavior and dynamics using line-of-sight diode-laser-based measurements*
2. **Individual Sponsor:**

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3. **Academic Area/Field and Education Level:** Engineering Physics, Applied Physics, Mechanical Engineering, Aerospace Engineering, Physical Chemistry (MS and/or Ph.D. level)
4. **Objectives:** The proposed thesis topic aims to develop in-situ supersonic combustion diagnostics using diode laser sensors for ground test applications where the in-stream determination of species concentration, temperature, pressure, density and velocity are desired. Particularly attractive are the measurement schemes that yield information with both spatial and temporal resolution.
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/RQH) three direct-connect supersonic combustion facilities for the experimental research. In the experiments, tunable diode laser absorption spectroscopy (TDLAS) and its close relatives (e. g. wavelength modulation spectroscopy) 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. Additionally, optical measurements of density fluctuations within the boundary layer of the isolator will be made and correlated with shock train dynamics. Measurements will be made at several locations within the flow path from the facility nozzle to the combustor exhaust plane. Currently, the following two areas of research are of great interest: 1) Approaches to tomography using simultaneous TDLAS along multiple lines of sight. 2) Direct comparison of TDLAS measurements with computational fluid dynamics results for the flow path. Comparisons of measurements and low-order (e.g. one dimensional) are also of interest. As needed for technique development, measurements can be made in a laboratory-scale burner available to this program at WPAFB.

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. **Eligible Research Institutions:**

[X] **DAGSI** (Wright State University, AFIT, Ohio State University, University of Dayton, Miami University, Ohio University, University of Cincinnati) NOTE: Topics submitted to DAGSI must be approved for public release. Distribution A – Public Release (88ABW-2013-3050)

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