RQ 16-27

1. **Research Title:** *Computational Model Evaluation in Turbulent Combustion*
2. **Individual Sponsor:**

Ez A. Hassan, PhD
AFRL/RQHP Bldg 18, Room A131
1950 Fifth Street
WPAFB, OH 45433-7251
Ezeldin.Hassan@WPAFB.AF.MIL
Ph: 937-255-7302

3. **Academic Area/Field and Education Level:** Computer Science, Mechanical Engineering, Aerospace Engineering (MS and/or Ph.D. level)
4. **Objectives:** The objective of this proposed 3-year DAGSI project is to develop a computational framework where combustion and/or turbulence subgrid models are evaluated for high speed combustion applications. Evaluation should be based on reconstruction of DNS data and should not require an implementation within a larger CFD code.
5. **Description:** Building a computational tool suitable for numerical simulation of Scramjet combustors is a daunting task involving many modeling approaches. The error associated with grid discretization, numerical advection-diffusion algorithm, shock-capturing, complex geometry representation, boundary conditions, combustion/turbulence models, and other assumptions made are all combined. When developing a combustion and/or turbulence subgrid model, it takes many years and vast computational resources before this model is implemented into a larger CFD code and validated by comparison to experiments. Within the validation process, it is impossible to separate all the other errors in the CFD code and experimental measurements from those associated with the proposed combustion/turbulence model. A recent AIAA paper by Cocks and coworkers in 2013 compared 4 different LES codes with the same turbulence subgrid and combustion model. Results produced by all four codes were vastly different due to the numerical implementations.

   The DAGSI student will work to build a computational framework that uses high-quality DNS database to serve as a model evaluator for combustion and/or turbulence models. The DNS database will be filtered in space and time to obtain a solution in the filtered domain along with the subgrid stresses. The framework would allow the predictions of the tested model to replace portions of the solution in different temporal and spatial locations. Those predictions can be evaluated by comparing to the DNS predictions. The framework should be built initially with a sample DNS database input and a sample tested model (either turbulence or combustion) but should be able to handle additional DNS database and models as they become available. The framework is expected to evaluate the models in complete isolation from numerical code implementations and thus provide an understanding of the model's capabilities and limitations. An early evaluation of a sample combustion and/or turbulence model will serve as a strong basis for publishable work and a PhD or Master's thesis.

6. **Research Classification/Restrictions:** U.S. Citizens only.
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)

[x] **AFIT** (only)