NASA SBIR 2011 Phase I Solicitation

A2.06 Aerothermodynamics

Lead Center: ARC

Participating Center(s): AFRC, GRC, LaRC

Development of hypersonic flight vehicles for airbreathing access to space and for planetary entry poses several design challenges. One of the primary obstacles is the large uncertainty in predictive capability of the aerothermal environment to which these vehicles are subjected. For airbreathing access to space vehicles, predictions of boundary layer transition to turbulence and shock boundary layer interactions in a turbulent flow regime are sources of large aerothermal uncertainty and require conservative assumptions. For planetary entry vehicles with either rigid or flexible thermal protection systems (TPS), sources of large aerothermal uncertainty in high enthalpy conditions also include the catalytic or ablative properties of the TPS. The fluid dynamic and thermochemical interactions of a rough ablating surface with the aerothermal environment leads to many poorly understood coupled phenomena such as early boundary layer transition, turbulent heating augmentation, catalytic heating, radiation absorption, etc. At high entry speeds and large vehicle sizes, shock layer radiation becomes a large component of the aeroheating, with an increasing fraction of the radiation produced in the poorly understood vacuum ultraviolet part of the spectrum. The low confidence in the predictive capability is apparent in high enthalpy flows that are often difficult to adequately reproduce in a ground test facility.

The model uncertainties require designers to resort to large margins, resulting in reduced mission capabilities and increased costs. Future science and human exploration missions to Mars and other planets will require dramatic improvements in our current capability to land large payloads safely on these worlds. Research in aerothermodynamics focuses on solving some of the most difficult challenges in hypersonic flight. These include the development of predictive models via experimental validation for shock layer radiation phenomena, non-equilibrium thermodynamic and transport properties, catalycity, transition and turbulence, and ablation phenomena, as well as the development of new experimental datasets, especially in high enthalpy flow that can be used to validate theoretical and computational models.

Proposals suggesting innovative approaches to any of these problems are encouraged; specific areas of interest include:

- Advancement of NASA boundary layer transition tools, especially including high enthalpy effects.

- Development of shock turbulent boundary layer interaction models and validation with an experimental program.

- Development of radiation models supported by experimental validation in a laboratory (using shock tube, plasma torch, etc.) simulating extreme entry environments at Earth, Mars, Titan, and the Giant Planets.

- Development of high enthalpy RANS level turbulence models in a rough, ablating environment using experimentation or use of high fidelity computational techniques such as DNS or LES.

- Development of instrumentation for use in high-enthalpy flows to measure pressure, shear, radiation intensity, and off body flow quantities with enhanced capability such as high frequency measurements and/or high temperature tolerance.

- Development of tools and techniques that enable remote thermal imaging of entry vehicles with high temperature and spatial resolution, and lower uncertainty than the state-of-the art.

- Development of numerical techniques and computational tools that advance the start-of-the-art in computations of unsteady, turbulent separated flows with reasonable computational efficiency.