NASA SBIR/STTR Technologies

Computational Tool for Coupled Simulation of Nonequilibrium Hypersonic Flows with Ablation

CFDRC - Huntsville, AL

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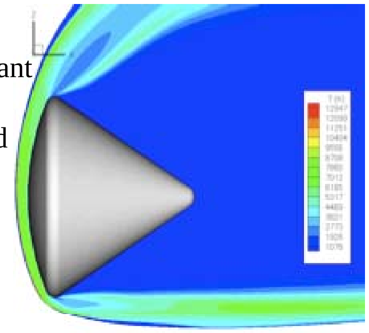
Proposal Number: X9.01 9440

Description

- Future NASA missions will be more demanding and will require better performing ablative TPS than currently available.
- Accurate numerical modeling of the aerothermal environment around an ablation-cooled hypersonic re-entry vehicle will require high-fidelity models for surface themochemistry, pyrolysis chemistry, multi-scale radiation, spallation and charring.
- Radiation transport models must be accurate over a range of length scales (i.e. multi-scale) from optically thin to optically think media.
- All models will have to be incorporated, in a coupled manner, into a computational framework comprising a hypersonic flow solver and a material response solver.
- To the best of our knowledge, no such comprehensive and coupled modeling capability currently exists.

Proposed Solution

- Phase I – (1) Develop a module for the Modified Differential Approximation (MDA) to solve the RTE; (2) Develop a framework for coupling the MDA module to LeMANS-MOPAR; and (3) Demonstrate the coupled framework, thereby establishing feasibility.
- Phase II - The tool will be made comprehensive by implementing important models identified above, including advanced non-equilibrium chemistry and non-gray radiation models.



Innovation

- In the proposed SBIR project, CFDRC and the University of Michigan will develop a unique, coupled ablation-flowphysics modeling tool.
- An innovative framework will be developed for this tool such that all relevant models can be coupled to the LeMANS code for nonequilibrium hypersonic flows and the MOPAR code for ablation material response, both developed by the University of Michigan.
- Innovative models will be developed and implemented for non-equilibrium surface thermochemistry, non-equilibrium pyrolysis chemistry, non-equilibrium multi-scale radiation, spallation and charring.
- The proposed tool will upgrade the modeling fidelity of hypersonic ablations flows to the next level, fulfilling a key NASA requirement.

Applications

- The tool will find direct application in numerous NASA technology development programs under the Project Constellation, the New Millennium Program, and the In-Space Propulsion Technology Program.
- The tool can also be used as a design tool for the development of new generation re-entry vehicles such as the Crew Exploration Vehicle.
- Non-NASA governmental applications include Theater and National Missile Defense vehicles performing exo-atmospheric missile intercepts, and missile warhead re-entry applications.
- Ablative material OEMs will also find the tool useful in exploring and designing newer and more robust ablative TPS materials and heat shield systems.

Subcontractor: University of Michigan (Prof. Iain Boyd)

Estimated TRL: 2 at beginning and 4 at end of contract

NON-PROPRIETARY DATA