NASA SBIR/STTR Technologies

Computational Tool for Coupled Simulation of Nonequilibrium Hypersonic Flows with Ablation

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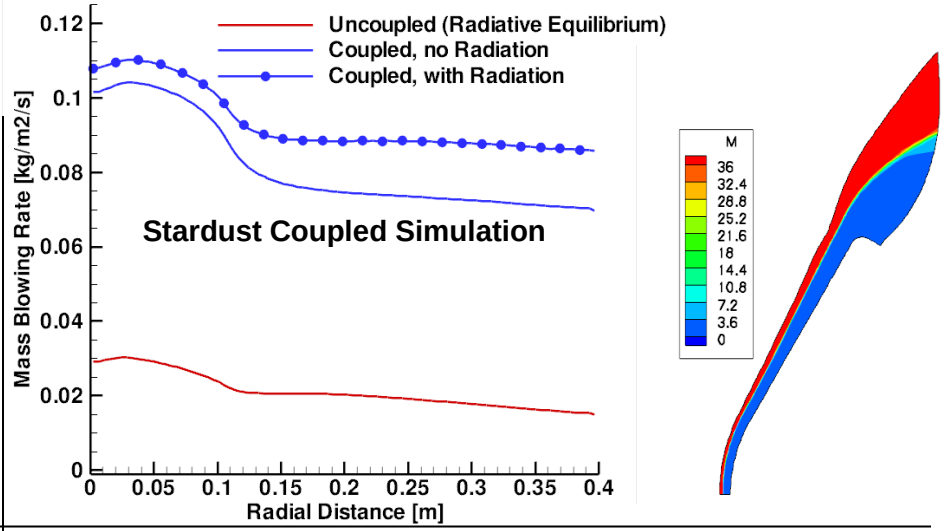
Identification and Significance of Innovation

This project provides a predictive computational tool for the aerothermal environment around ablation-cooled hypersonic atmospheric entry vehicles. A powerful framework to allow fully coupled simulations of hypersonic flows has been developed and will accurately account for 1) gas-phase chemical nonequilibrium 2) nonequilibrium radiation from dissociated species behind the shock 3) a detailed nonequilibrium surface chemistry, and 4) material response with coupled ablation and pyrolysis. Such a fully coupled analysis capability is unique and will significantly improve the state-of-the-art for modeling ablation and design of thermal protective systems in general.

Expected TRL Range at the end of Contract (1-9): 4-6



Technical Objectives and Work Plan

The specific technical objectives included development of 1) nonequilibrium surface chemistry models and their coupling to the flow solver, 2) nonequilibrium chemistry models for pyrolysis gases and development of new finite rate chemistry models, 3) a radiative transfer equation (RTE) solver module which will accurately account for participating media, surface-to-surface radiation in the presence of participating media, 4) a radiative property modeling framework to account for nonequilibrium processes present in a hypersonic shock layer and 5) a framework to couple these models together into a single integral analysis software.

NASA Applications

Direct applications in NASA technology programs including: In-Space Propulsion Technology, Fundamental Aeronautics Hypersonics Project, Orion Multi Purpose Crew Vehicle, and future aerodynamic decelerators programs such as HIAD, ADEPT and others.

Non-NASA Applications

Technology applications beyond NASA include the Theater and National Missile Defense vehicles performing exo-atmospheric missile intercepts, and missile warhead re-entry applications. The computational tool will also be relevant to the joint DOD/NASA effort called the National Aerospace Initiative (NAI) that involves, among other things, the development of air-breathing hypersonic vehicles. OEMs will also find the tool useful in exploring and designing newer and more robust ablative TPS materials and heat shield systems.

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