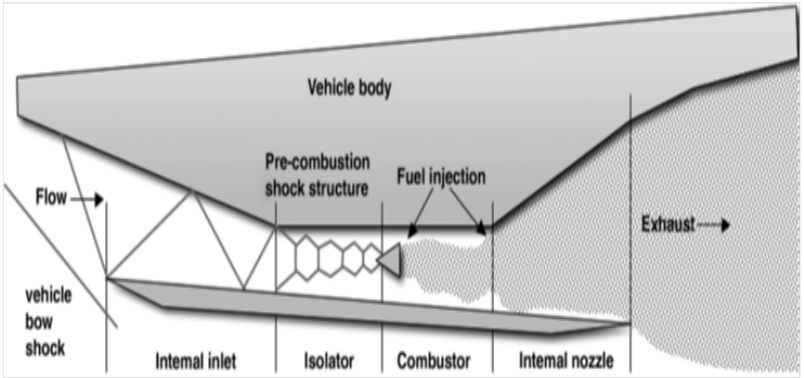
NASA SBIR/STTR Technologies

A2.02-9783 - Eulerian Transported PDF Framework for Scramjet Flowpath Analysis

PI: Ranjan Metha
CFD Research Corporation - Huntsville, AL

Identification and Significance of Innovation

Scramjet engines promise to become a next-generation revolutionary technology for aerospace applications. Some of the significant challenges in rapid development of scramjets include complex flow, combustion, flow-combustion interactions. The role of computational fluid dynamics is crucial in development of scramjet engines. The overall innovation includes development of a comprehensive Eulerian transported PDF methods framework for simulating high-speed turbulent reacting flows and developing innovative techniques for achieving up to two orders of magnitude reduction in computing times for the scramjet flow simulations. In Phase I feasibility of the proposed Eulerian transported PDF approaches will be demonstrated and analyzed. In Phase II, we will perform additional developments to deliver a comprehensive, turbulent combustion modeling framework coupled with RANS and LES flow solvers.



Complex flow-structures in a typical scramjet flow path [M. Berglund et al., AIAA J 48(3),2010].

Estimated TRL at beginning and end of contract: (Begin: 2 End: 4)

Technical Objectives and Work Plan

In Phase I the feasibility of the proposed Eulerian TPDF approach for accurately and efficiently modeling turbulence-chemistry interactions will be demonstrated. Specific objectives of Phase I include the following:

1. Develop a basic Eulerian Transported PDF framework for modeling supersonic turbulent combustion.
2. Identify and implement specific extensions to the transported PDF approach for accurately modeling turbulent, high-speed, compressible reacting flows.
3. Analyze and quantify the differences between the Stochastic Eulerian Field PDF and Deterministic Multi-environment Field PDF versions of the Eulerian PDF methods in the context of high-speed reacting flow equations.
4. Demonstrate the efficiacy of the transported PDF methods in modeling supersonic turbulent reacting flows in canonical (jet-flames) configurations and in a typical scramjet type applications.

NASA Applications

The tools developed in this SBIR project will be directly useful to NASA's Hypersonics Program. The methods developed under this project will have wide ranging applications at NASA in addition to high-speed combustion devices such as ramjets and scramjets, including design of propulsion devices such as solid rocket motors, liquid rocket engines and gas turbine combustors.

Non-NASA Applications

The software tool developed in this project will significantly improve the accuracy and reduce turn-around times for design and analysis cycles for scramjet applications to the Department of Defense programs. It will also be useful for simulating low-speed combustion devices such as gas turbine combustors and augmenters.

Firm Contacts

Ranjan Metha
CFD Research Corporation
215 Wynn Drive, 5th Floor
Huntsville, 358051926
PHONE: (256) 726-4800
FAX: (256) 726-4806

NON-PROPRIETARY DATA