NASA SBIR/STTR Technologies

T9.01-9966 - A Multi-disciplinary Tool for Space Launch Systems Propulsion Analysis

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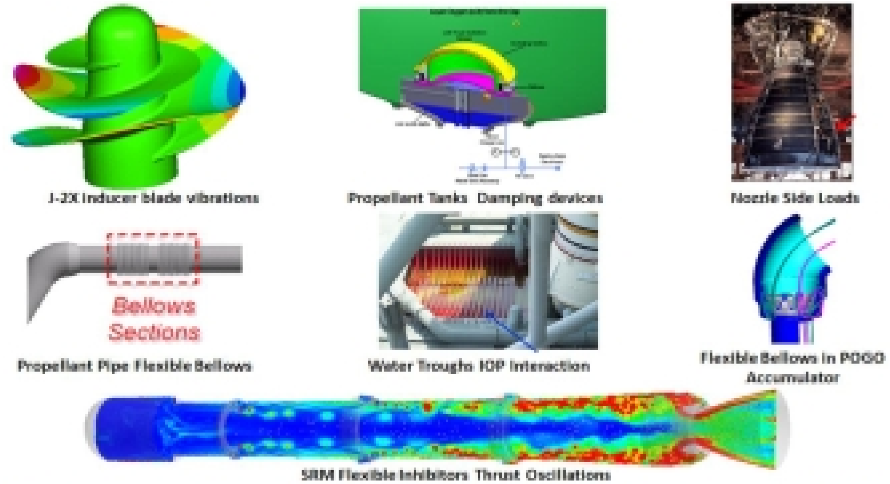
Identification and Significance of Innovation

Space Launch System architecture involves nonlinear interaction between flow and multiple structures that dominate the performance characteristics of the launch vehicle and could lead to catastrophic failures if not properly understood. Some of the fluid-structure phenomena include: SRM thrust oscillations; self-vibration of fluid feed lines; next-generation POGO accumulators; liquid propellant tank breathing; water trough interactions with IOP waves. This STTR effort will develop and deliver a multi-disciplinary computational tool to provide critical prediction capability for modeling these and other coupled fluid-structure interaction (FSI) phenomena in SLS. This one-of-a-kind enabling technology offers the following advanced features: (1) fully-coupled fluid-structure interaction with nonlinear large deformation finite element structural solution; (2) support for all flow regimes with unified capability; and (3) tight integration with highly-scalable NASA Loci production framework.

Estimated TRL at beginning and end of contract: (Begin: 2 End: 6)



Space Launch System Multi-Disciplinary Fluid-Structure Propulsion Applications

Technical Objectives and Work Plan

The overall goal of this project is to develop a comprehensive, fully-coupled, high-fidelity, user friendly simulation tool for fluid-structure interaction (FSI) analysis of SLS propulsion applications. The developed tool will supplement NASA's workhorse production CFD solvers, Loci/CHEM and Loci/STREAM, with highly accurate and efficient integrated FSI capabilities to support multidisciplinary simulation in all flow regimes, from incompressible to hypersonic. In addition, thermal coupling and conjugate heat transfer will be included to form a comprehensive fluid- structure-thermal analysis environment for SLS. The tool will be rigorously validated against published and experimental data.
The specific objectives of the Phase II study are summarized as follows:
- Refine and optimize FSI capabilities developed during Phase I;
- Fully integrate FSI capabilities into Loci framework to better utilize inherent benefits and scalability of Loci infrastructure;
- Port integrated FSI capabilities to Loci/STREAM code;
- Implement thermal coupling to facilitate fluid-structure-thermal coupling in Loci/CHEM;
- Deliver, test, and optimize the software on NASA HPC systems, perform verification & validation studies, assist MSFC personnel w/application, demonstrations, and offer user training.

Continuous software delivery will be carried out during the Phase II as software enhancements and bug-fixes are realized, in addition to six formal

NASA Applications

Potential applications for NASA include: (a) Self-generated dynamics of fluid feed lines with deformable bellows; (b) Water trough interaction with ignition overpressure; (c) Liquid damping devices (LOX damper); (d) Liquid propellant tank breathing; (e) Fluid-structure interaction in nuclear thermal rockets; (f) Fluid-thermal-structural coupling of rocket nozzles; (g) Fluid-induced vibration of J-2X turbine and inducer blades; (h) Next generation POGO accumulator design, and many others.

Non-NASA Applications

The proposed tool will be beneficial for aerospace vehicle dynamic loads analyses, such as buffet, flutter, buzz, fatigue and control reversal; and noise, vibrations, and rotorcraft buffet suppression and blade-vortex interaction, and commercial aircraft. General applications include, aircraft vortex dynamics, heat exchanger vibration, strumming of cables and pipelines, galloping towers and masts.

Firm Contacts

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