Physics-informed Modeling of Multi-nozzle Plume Physics with Quantifiable Uncertainties from Supersonic Retropropulsion Tests

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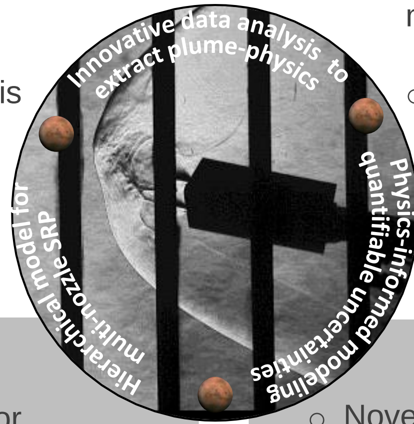
Collaborations with NASA on:

- Analysis of wind-tunnel test data
- Model application and uncertainty analysis
- Identification of data gaps

Research Objectives

- Develop and apply innovative data-analysis methods to advance fundamental understanding of multi-nozzle plume physics, quantify uncertainties, and analyze sensitivities for enabling supersonic retropropulsion (SRP) technology
- Develop hierarchical model framework to describe plume physics, plume-aerodynamics interaction, and sensitivity of aerodynamic forces and moments for relevance operating conditions and nozzle configurations
- Integrate uncertainty quantification to consider sparse and incomplete experimental data



Approach

- Develop hierarchical model framework for describing plume physics and sensitivity of aero-dynamic forces and moments
- Employ data-analytics, regression and feature selection to identify similitude parameters that collapse plume physics
- Construct consistent physics-informed reduced-order model that describes plume-interaction and coalescence using generalized perturbation theory
- Construct coupling function with embedded uncertainty models to describe multi-nozzle physical processes, model uncertainties and identify gaps in experimental data

Potential Impact

- Novel data-analytic methods enable extraction of fundamental understanding of multi-nozzle plume physics, necessary for design, analysis, and control of human-scale Mars lander powered descent
- Reliable and affordable physics-based engineering models with quantifiable uncertainties enable prediction of multi-nozzle plume retropropulsion-aerodynamic interference and data analysis
- Hierarchical model framework supports aerodynamic databases, analysis of sensitivities and uncertainties from unsteady behavior, and informs experimental analysis and implications on scaling