Material response reconstruction of ablative TPS using accurate boundary layer modeling

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Topic 6 – Atmospheric En- try Modeling Development Using Orion EFT-1 Flight Data: 1. TPS/Structure Thermal Response

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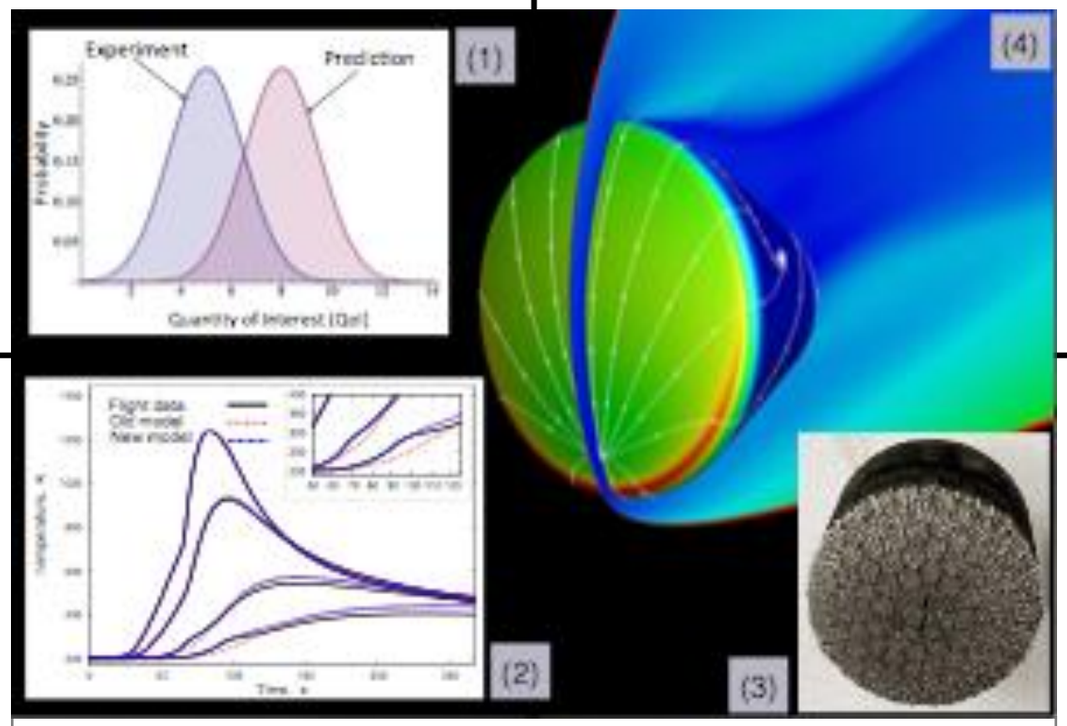
Research Objectives

The need to modernize the approach to physical and material models has been a major discussion point in the ablation and re-entry community. The proposed work directly addresses this need by:

- Devising a validated and calibrated model for the material response of AVCOAT heat shields
- Using a new material response paradigm where the whole domain (flow field, surface and porous maerial) is modeled using one single set of governing equations
- Upon completion, this 3 year project will elevate the TRL for accurate coupling from **TRL 1** to **TRL 3**



The proposed research will use uncertainty quantification (1) to generate a calibrated and validated model for AVCOAT (2) using the arc-jet data (3) and the EFT-1 flight data (4). A new integrated simulation model that solves both the flow field and the ablator will be tested with this new model, also using the EFT1 experimental data.

Approach

- Adapt the current AVCOAT model for modern material response tools
- Using open literature, design in parallel a non-ITAR restricted version of AVCOAT
- Use uncertainty quantification to calibrate the model using arc-jet data and the EFT-1 flight data
- Complete the development of a numerical method that solves both the aerothermal flow field and the material response at the same time
- Compare and validate the new method using beyond-SoA material response problems as well as hypersonic thermo-chemical non-equilibrium simulation
- Use these new tools to simulate arc-jet experiments and the Orion MPCV EFT-1 data

Potential Impact

The proposed project is expected to increase confidence in numerical simulation, which in turn will facilitate the design of new materials, and reduce safety margins on future TPS designs. The short term impact will be:

- A new, calibrated and validated model for AVCOAT that goes beyond the current SoA and could be readily used for the analysis and prediction of future Orion MPCV missions
- A new material model, similar to AVCOAT, based on open literature that will allow future development of physical model without worrying about ITAR restrictions
- A new approach for thermal protection material in aerothermal environments that will remove all current boundary layer assumptions and integrate all recent physical models