

# Impact Of NASA'S Entry Systems Modeling Project On Planetary Mission Design



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**Rationale:** Every mission that enters an atmosphere relies on specialized expertise and tools for entry system design.  
*We are the only cross-cutting Agency project serving this critical and NASA-unique function.*

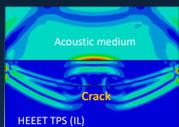
## What is the Entry Systems Modeling Project?

Develop high-priority model improvements and validation testing, driven by mission requirements, that can be delivered in 3-5 years to reduce mission risk and improve performance for Entry, Descent and Landing.

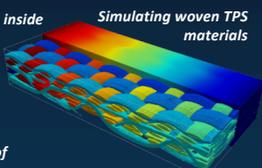
## Focused research in four elements:

### Predictive Materials Modeling

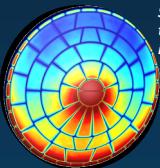
- Micro- to engineering-scale analysis tools
- Full 3-D material response and TPS sizing
- TPS reliability: How flaws and features turn into failures



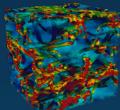
Identifying flaws inside TPS materials



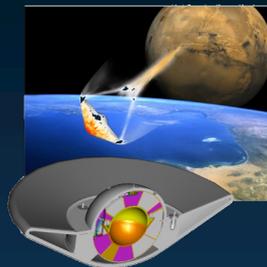
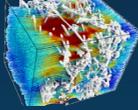
Simulating woven TPS materials



Simulated recession of tiled MSL heat shield including gap fillers



Microscale modeling of material properties and performance



## Infusion into current missions:

### Earth Entry Vehicle

Advanced models are needed to meet EEV's stringent reliability requirements:

- High fidelity woven TPS response modeling and understanding failure mechanisms
- Roughness heating augmentation
- Free-flight CFD to inform capsule dynamics
- High speed radiation models & benchmark data

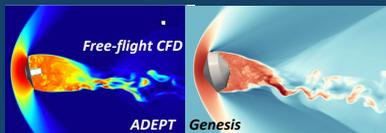
### Sample Retrieval Lander

SRL design benefits from several ESM advancements:

- High fidelity TPS response modeling of tiled PICA
- Roughness & atmospheric dust heating
- Deep dive into MEDLI2 data – inform future design
- Development of PICA-NuSil response model
- Validation of CO<sub>2</sub> radiation against COMARS
- New techniques enabling precision landing

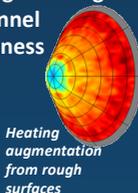
### Computational and Experimental Aerosciences

- Simulate parachute inflation & dynamics
- Investigating vehicle dynamics using Free-Flight CFD and Magnetic Suspension Wind Tunnel
- Evaluating the impact of TPS roughness

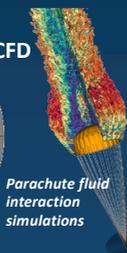


Free-flight CFD

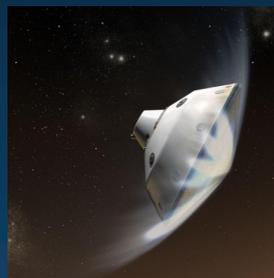
ADEPT Genesis



Heating augmentation from rough surfaces



Parachute fluid interaction simulations



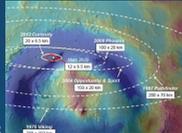
### Dragonfly

ESM helps Dragonfly retire risk through analysis and providing state-of-the-art tools:

- Benchmark radiative heating data & codes
- Capsule dynamic stability assessment
- 3-D material response of complicated geometry

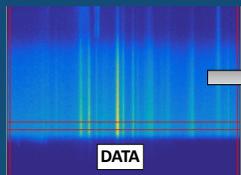
### Guidance, Navigation, and Control

- Improving tools and developing advanced guidance and control algorithms



### Shock Layer Kinetics and Radiation

- Shock layer radiation databases and models for all solar system destinations
- Reduced TPS margins and mission risk

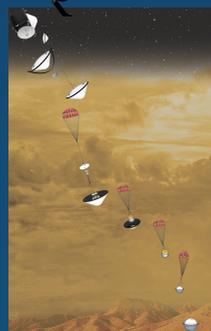


DATA



SIMULATION

Electric Arc Shock Tube



### Venus

Venus creates several challenges for EDL due to extreme entry conditions:

- Radiative heating data and simulation tools
- Roughness heating augmentation
- Advanced guidance / control aerocapture algorithms
- Woven TPS response & thermal structural models

*ESM is interested in collaborating with recently announced SMD Discovery missions*