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PARAMETRIC THERMAL SOAK MODEL FOR EARTH ENTRY VEHICLES

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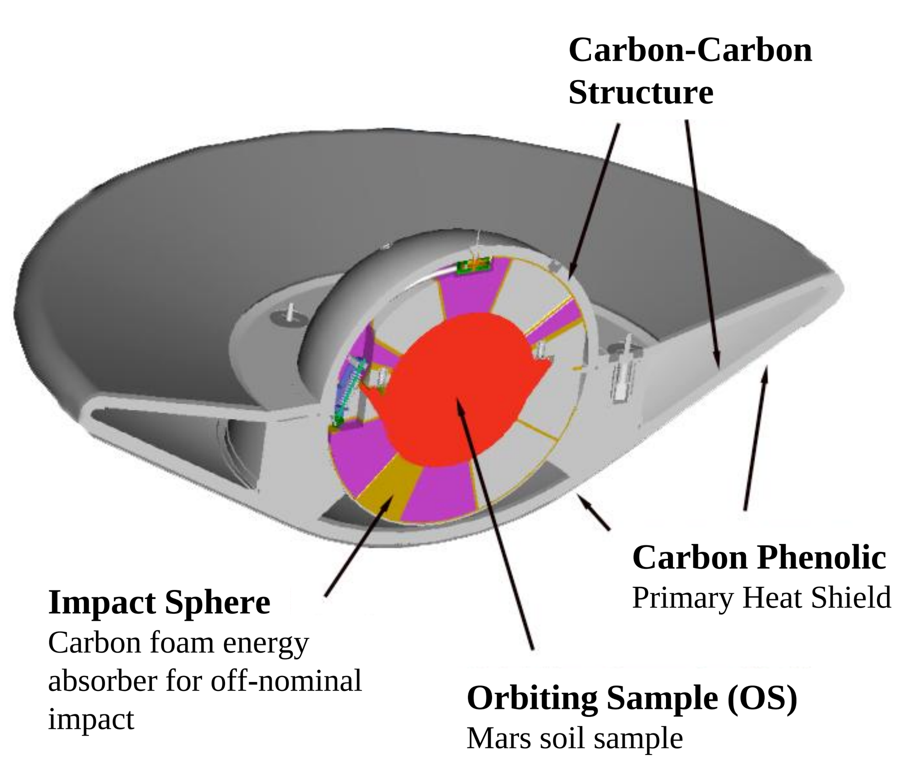
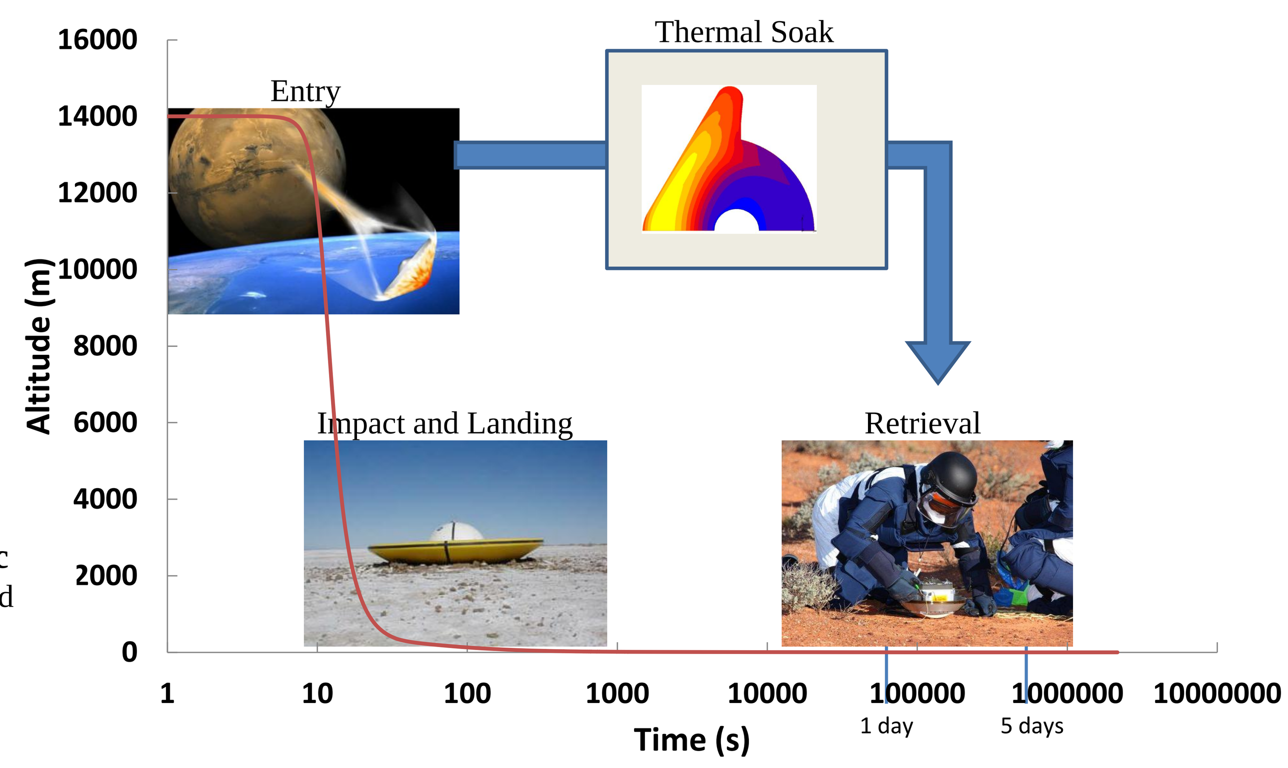
Objective

Predict peak payload temperature and temperature contours of an Earth Entry Vehicle (EEV) **for sample return missions**

Background



Mars Sample Return EEV

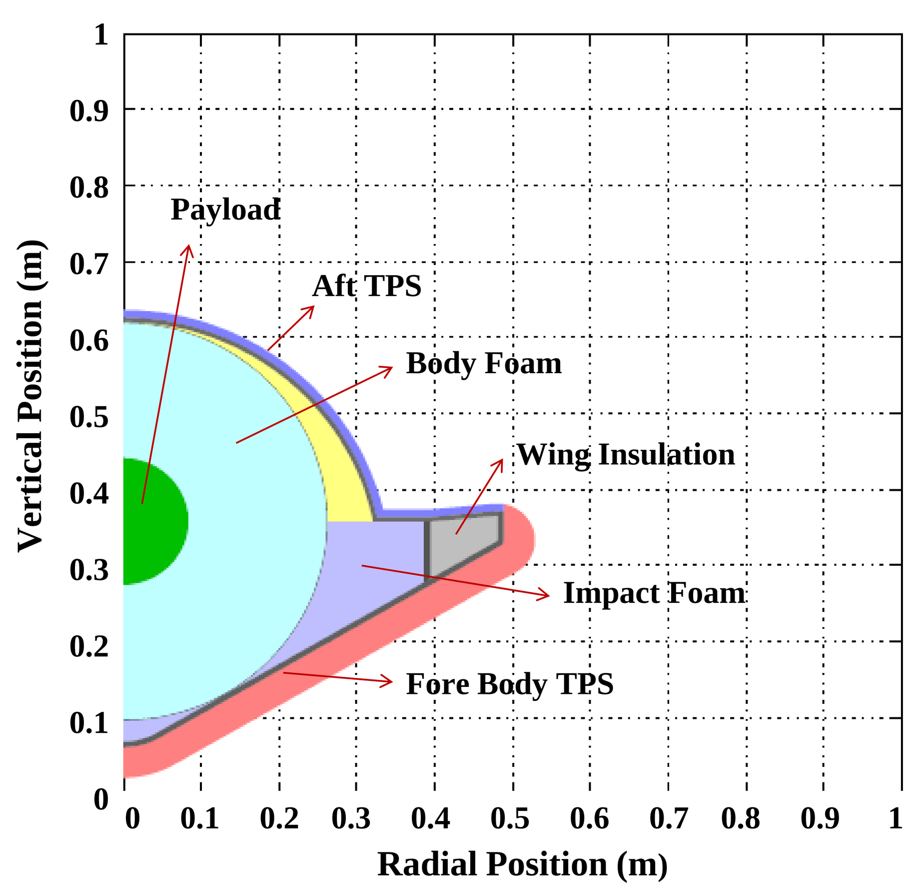


Time span for thermal soak

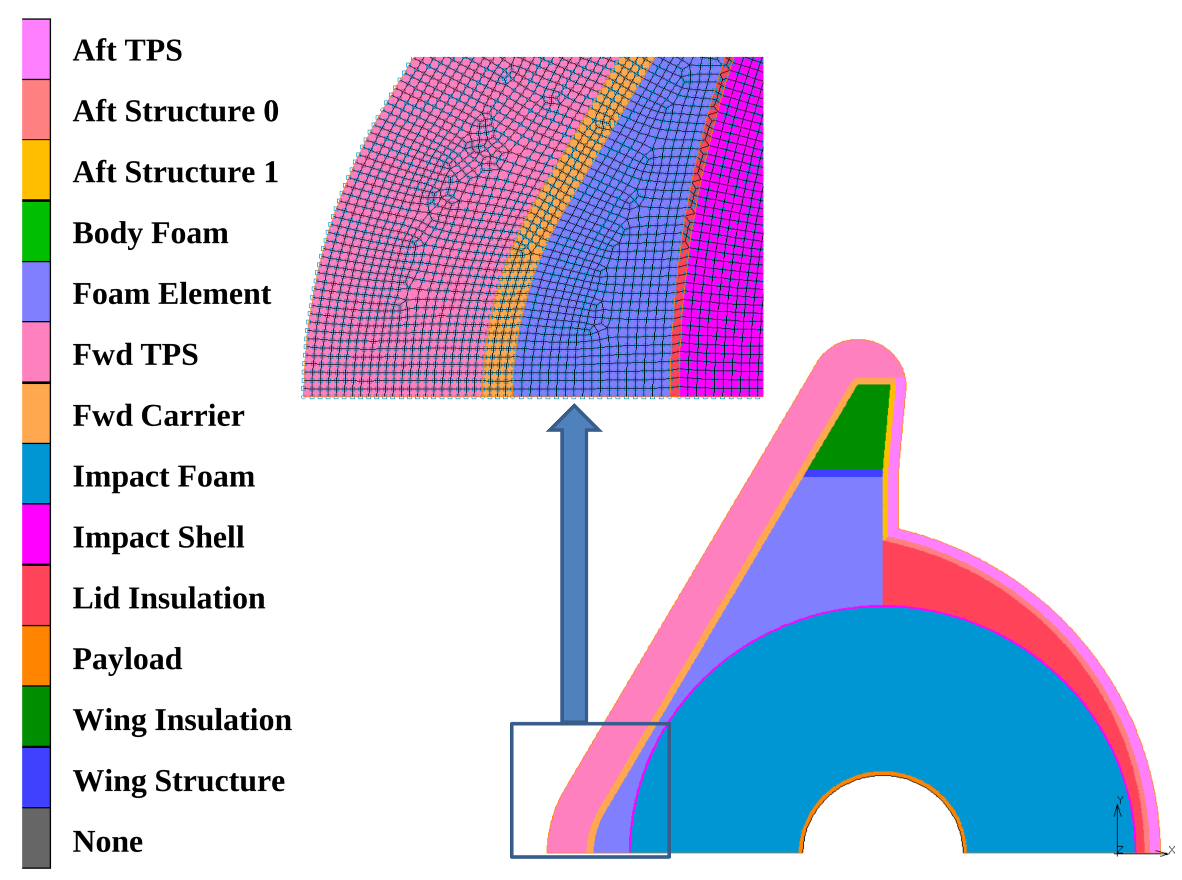
- Samples from outer space are brought to earth by means of earth entry vehicles
- During the re-entry these vehicles are subjected to extremely high heating
- Science mission requirements for biological samples are very stringent
- MSR requires to maintain temperature control below 20^0C
- Payload temperature history and peak temperature knowledge is critical for mission success

Model Development

- Design elements influenced by MSR geometry
- 2-D axi-symmetric model with1.05m diameter, 60 deg sphere cone angle and spherical nose
- Sample container protected by crushable foam and C-C structure.
- Marc. Mentat Finite Element (FE) Software
- Conduction, external and internal re-radiation as heat-transfer mechanisms
- Adaptive time-temperature
- Spatially and temporally varying heatflux from CFD imposed as surface boundary condition
- Carbon Phenolic and PICA as TPS candidates

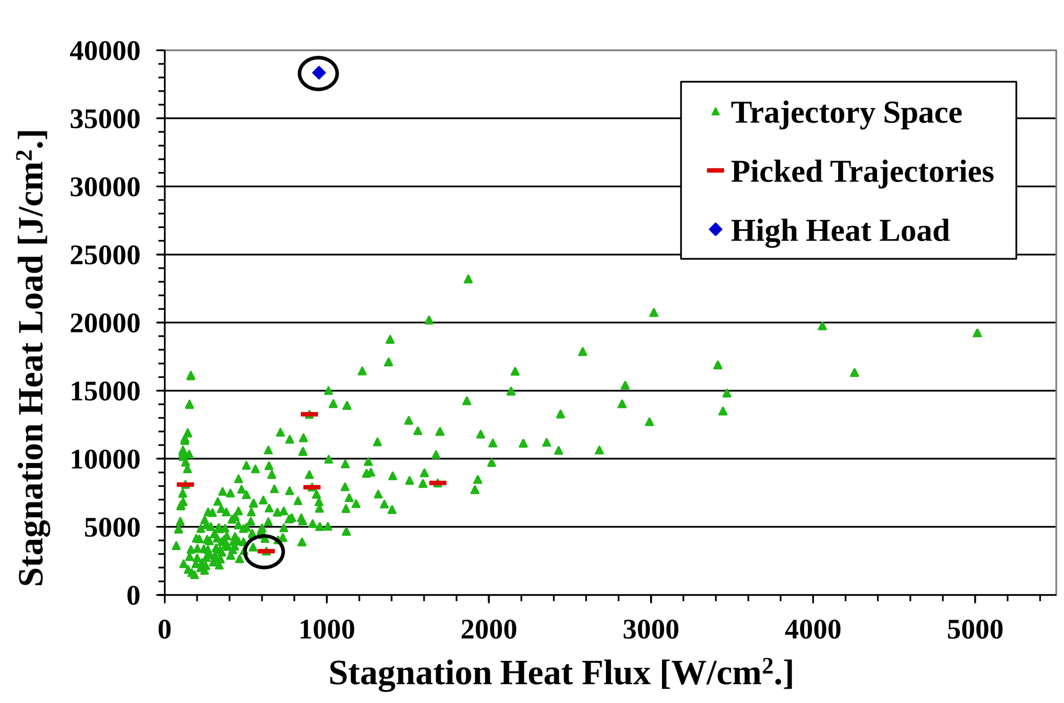


Vehicle Geometry

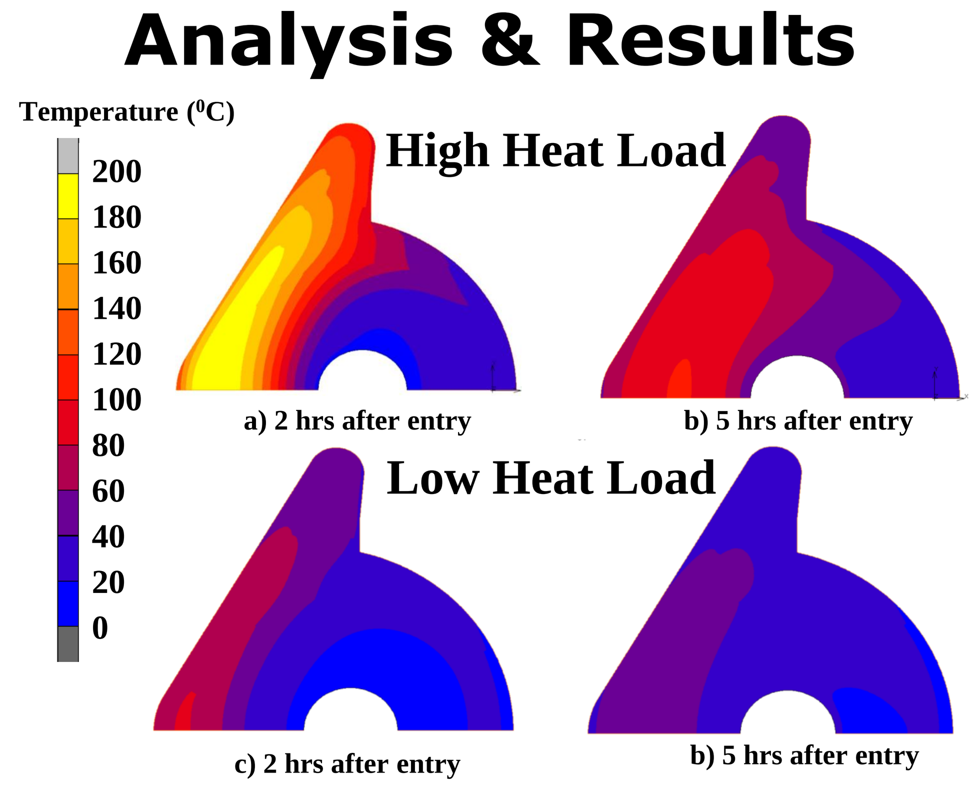


Finite Element Model

Analysis & Results



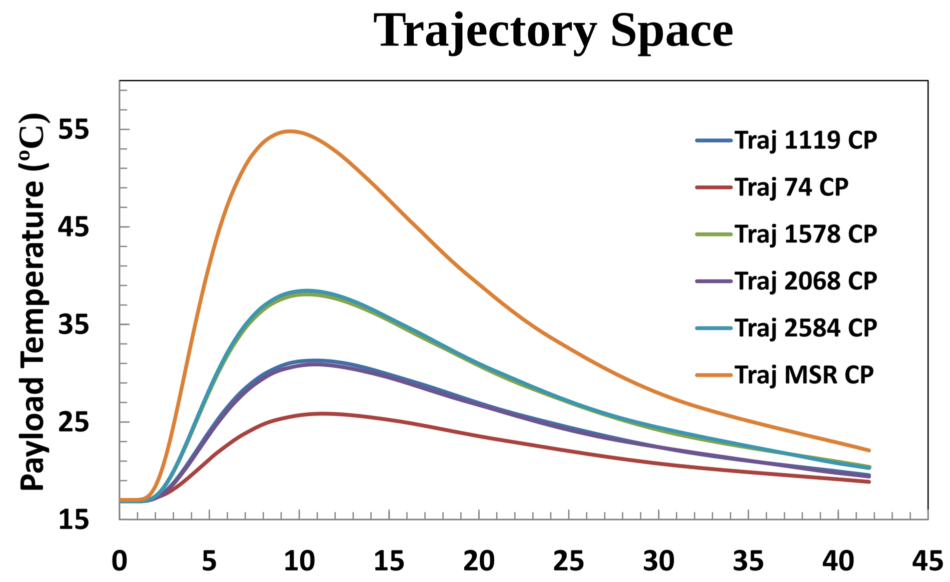
Trajectory Space



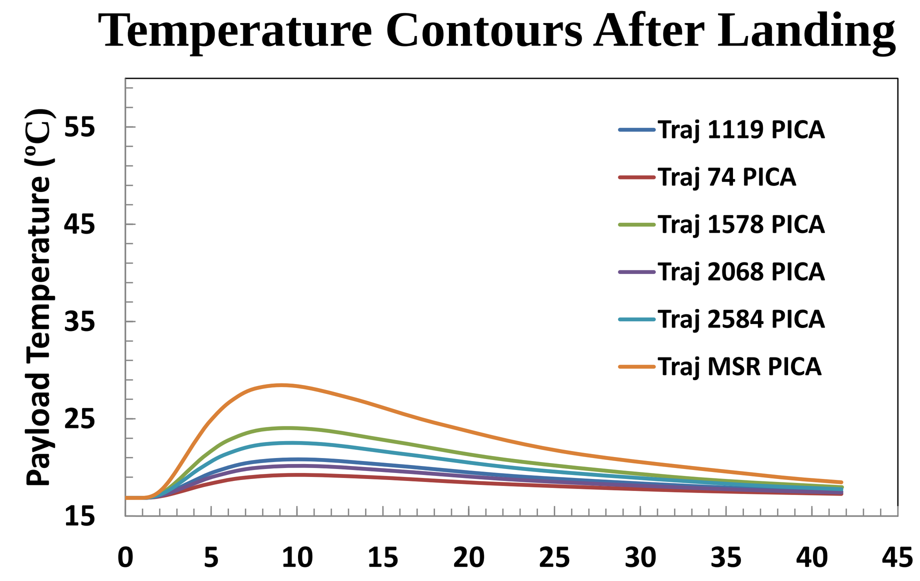
Temperature Contours After Landing

- It takes several hours for the payload container and interior foam to heat up
- Entry heatload and choice of TPS materials significantly affect the payload temperature
- Lower peak payload temperature with PICA compared to CP

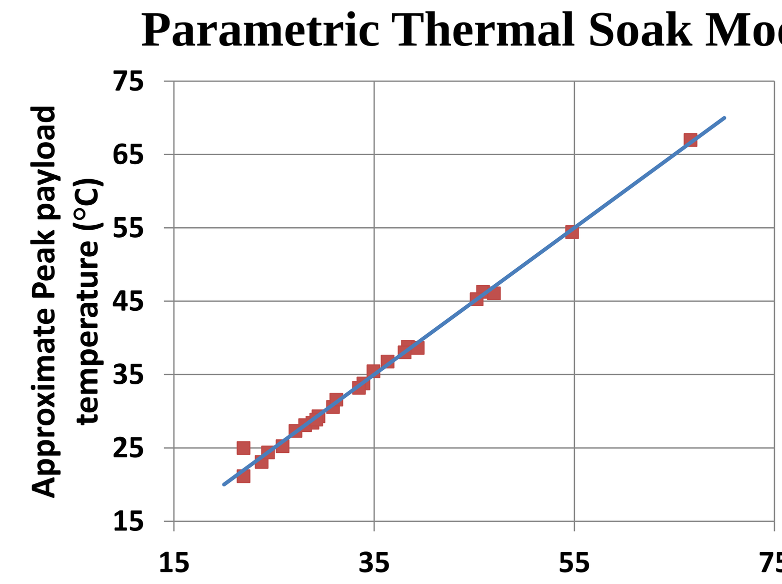
Parametric Thermal Soak Model



Payload Container Temperature: CP TPS



Payload Container Temperature: PICA TPS



Goodness of Fit

$T_{Payload} = a\xi^2 + b\xi + c$,
where $\xi = dq^eQ^fD^g$

Conclusions & Outlook

- **Parametric thermal soak model can be developed for a representative EEV geometry to predict peak payload temperature for a given heatload, heatflux and vehicle diameter**
- **Future work to include different TPS thickness, entry vehicle configurations - integrated with a thermal soak model**