PARAMETRIC THERMAL SOAK MODEL FOR EARTH ENTRY VEHICLES

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

Background
- Samples from outer space are brought to earth by means of earth entry vehicles (EEV).
- 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°C.
- Payload temperature history and peak temperature knowledge is critical for mission success.

Mars Sample Return EEV

Time span for thermal soak

Model Development
- Design elements influenced by MSR geometry.
- 2-D axi-symmetric model with 1.05m 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.
- Supports fully transient, non-linear, thermal analysis.
- 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.

Analysis and Results
- 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.

Conclusions and 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 will include different TPS thickness and entry vehicle configurations, and incorporate them into thermal soak model.