



Exceptional service in the national interest

Overview of Ablation Research at Sandia National Laboratories

12th Ablation Workshop

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Sandia's multi-scale, multi-disciplinary approach to ablation

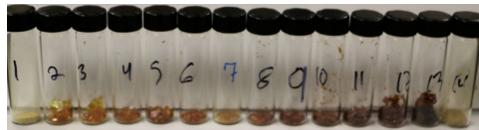
Length Scale

Processing: prepreg, hot press



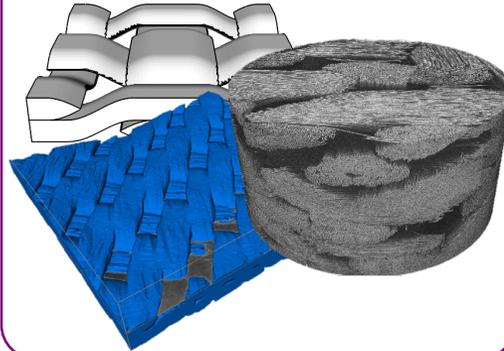
Nanoscale + Microscale

Composition: Property measurement, performance prediction, interface characterization, chemistry (MD)



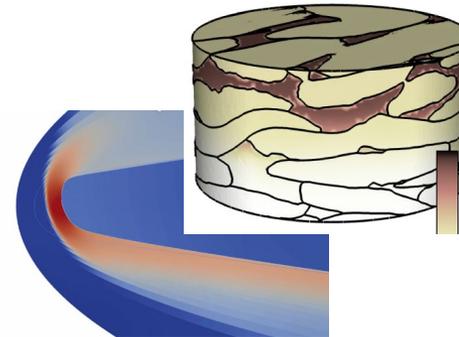
Mesoscale

Structure: Parametric studies, thermal, mechanical, 3D imaging



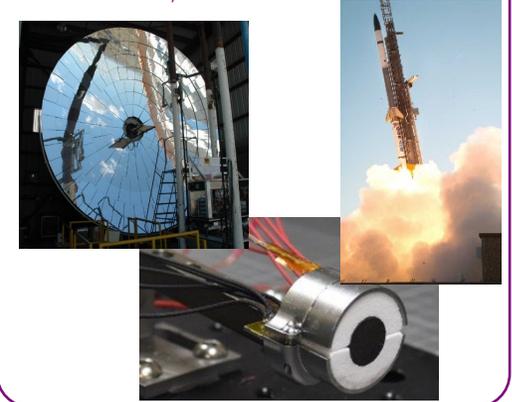
Macroscale

Behavior: mesoscale simulation, measurement, full system ablation



Coupon/vehicle scale

Performance: Thermal, recession, mechanical



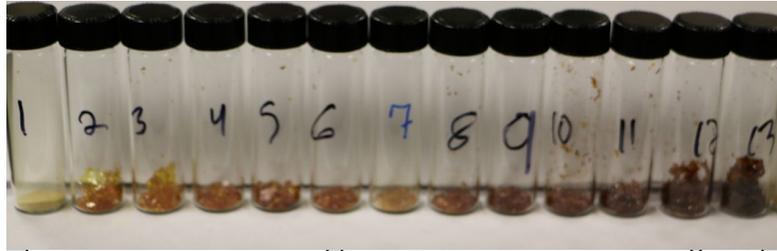
Simulation

Experiment

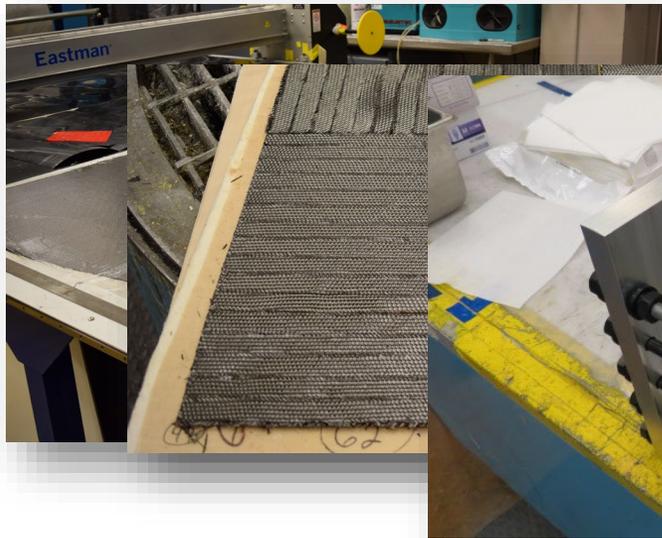
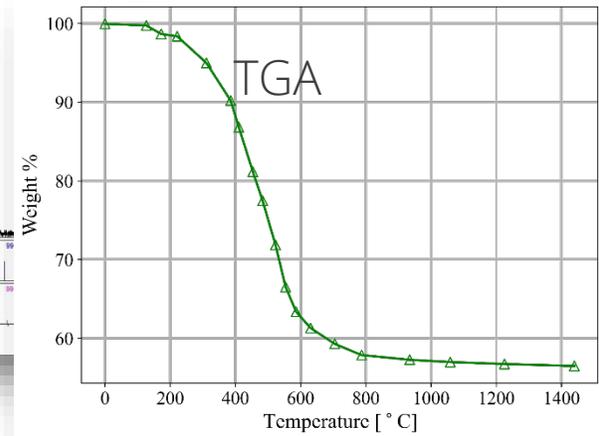
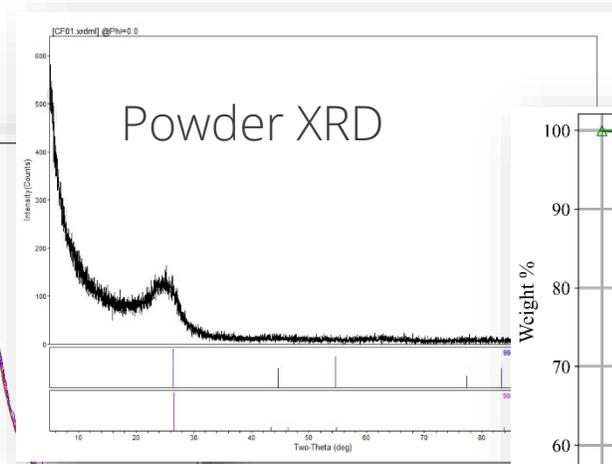
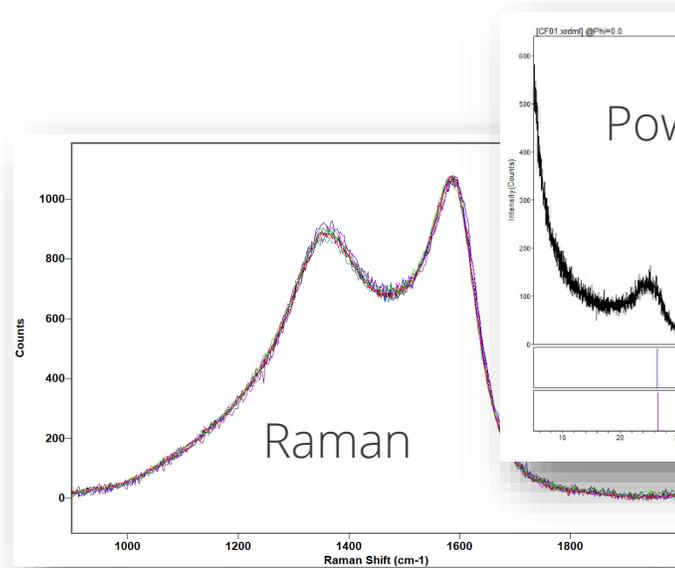
Combined



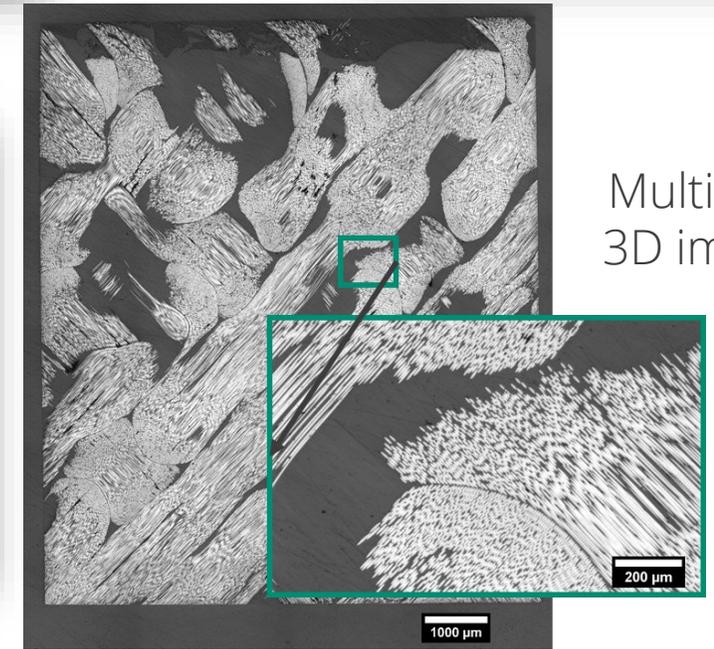
Materials and manufacturing research



10 min 20 min 30 min
Constituent material characterization



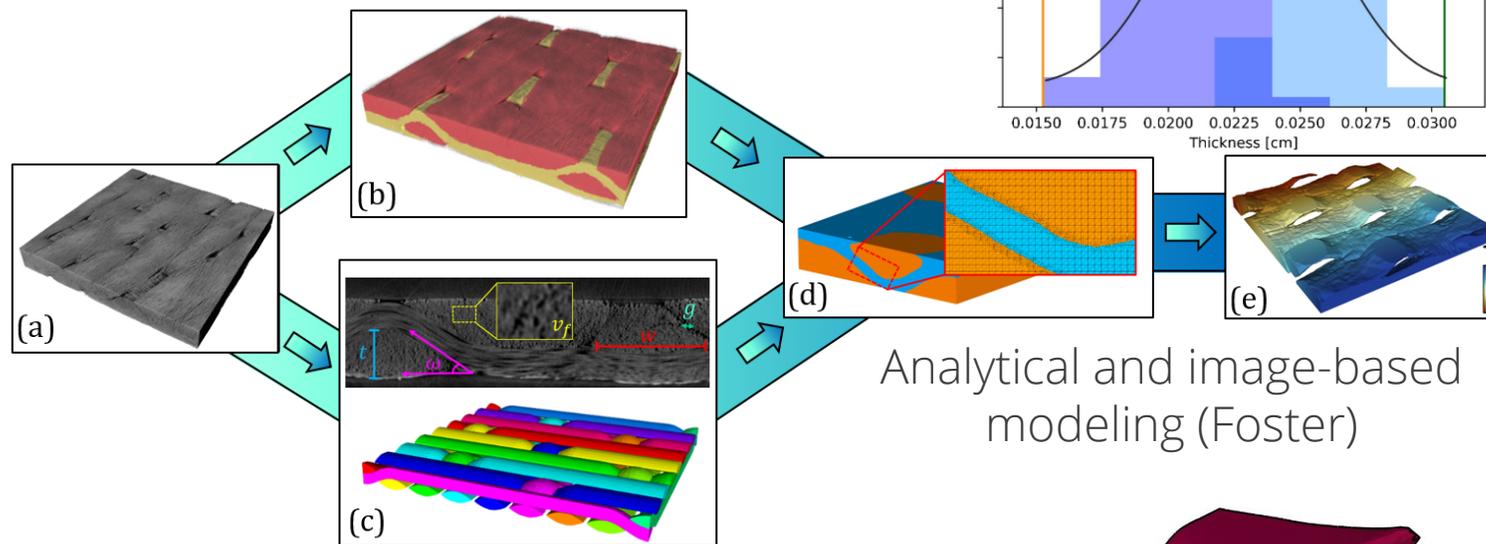
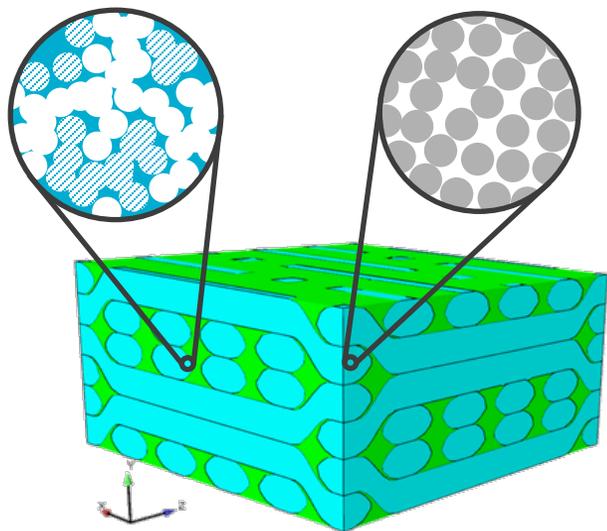
Composite manufacturing



Multi-scale
3D imaging

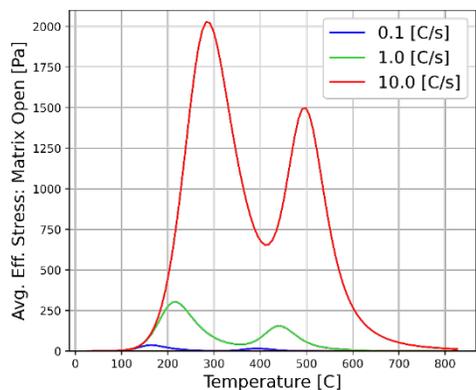


Microscale and mesoscale modeling

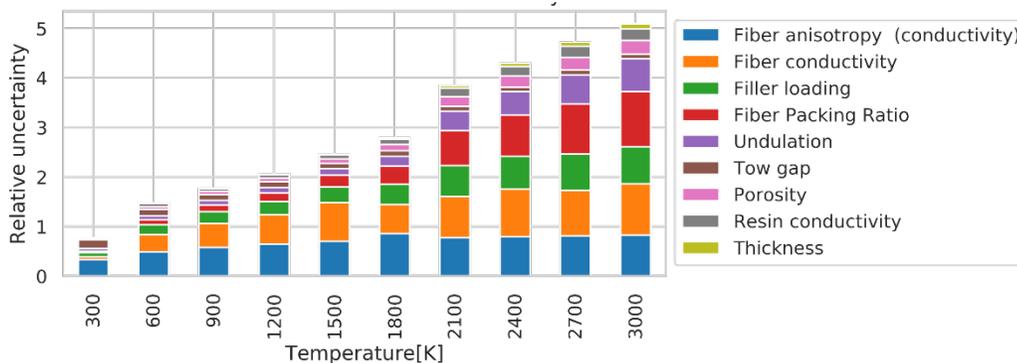


Analytical and image-based modeling (Foster)

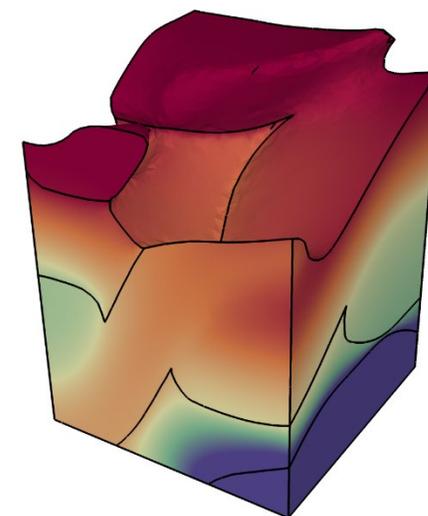
Micro- and meso-scale modeling



Manufacturing of C-C



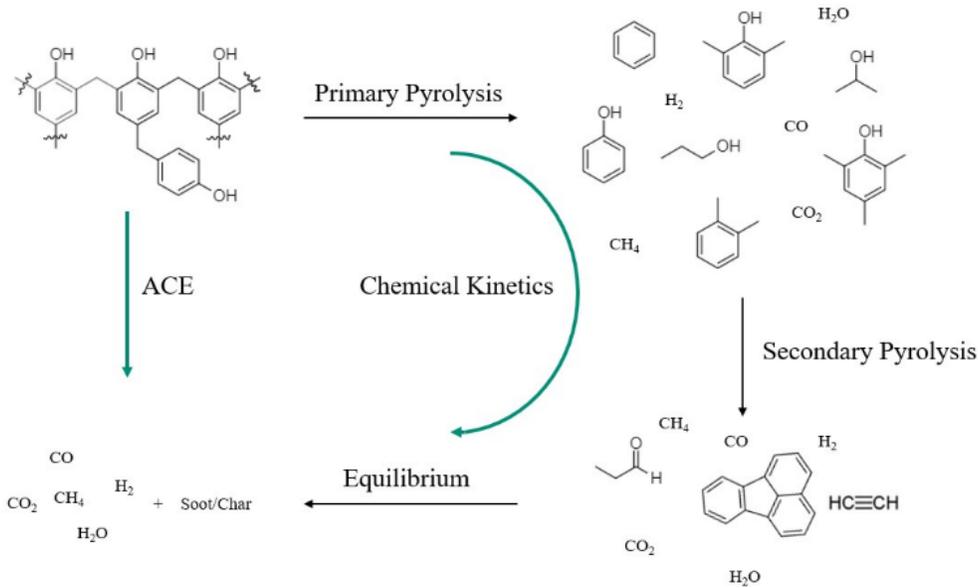
Property prediction, interpolation, and UQ



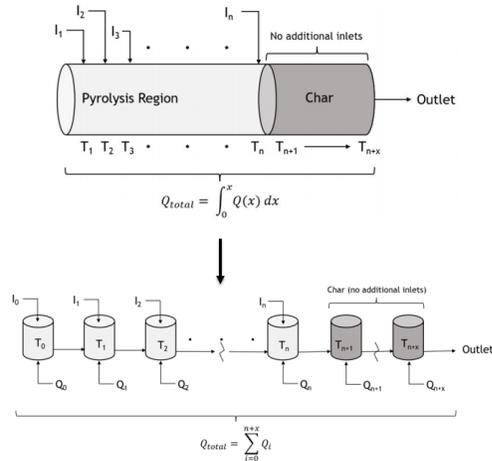
Ablation predictions (Collins)



Advanced chemistry modeling



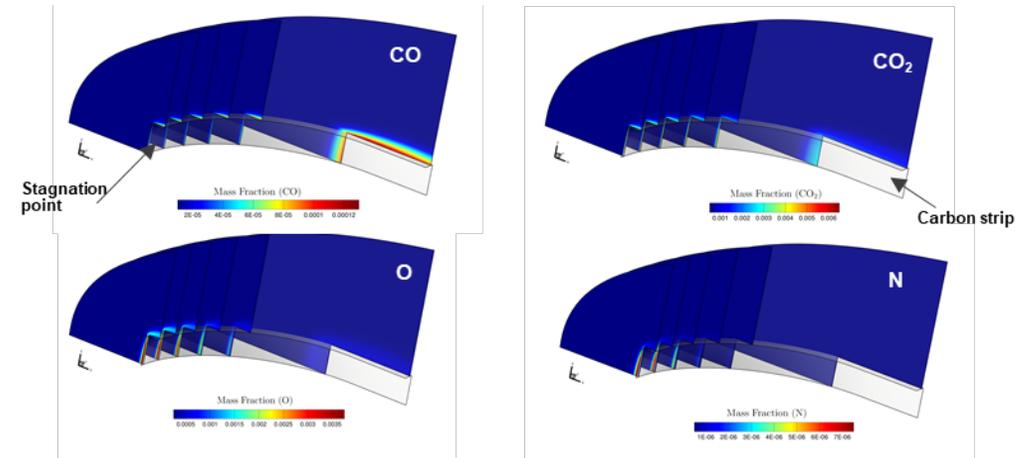
Evaluating equilibrium vs. finite-rate chemistry models for pyrolysis (Gosma) and surface chemistry



Sandia Hypersonic Shock Tunnel nozzle and test chamber (SPARC)

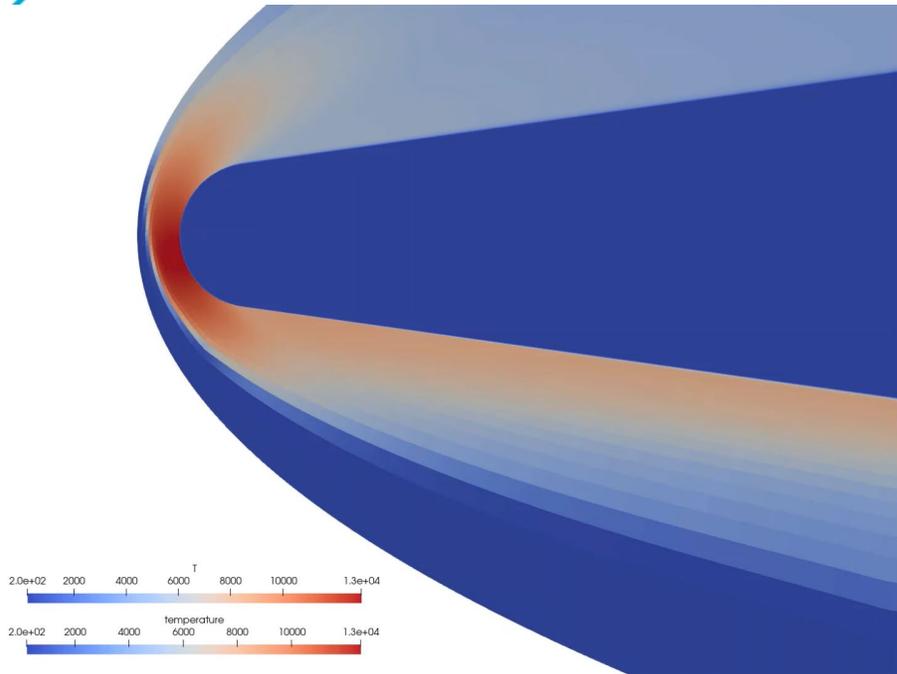


Mass fraction predictions of selected gas-species around carbon test sample (US3D)





Vehicle-scale and aerothermal modeling

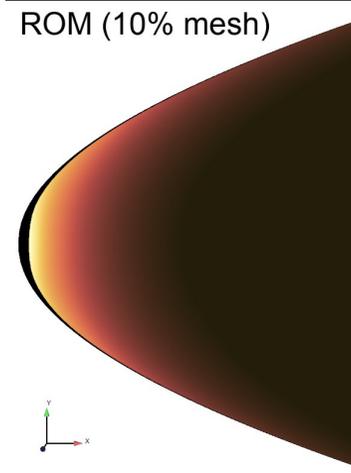
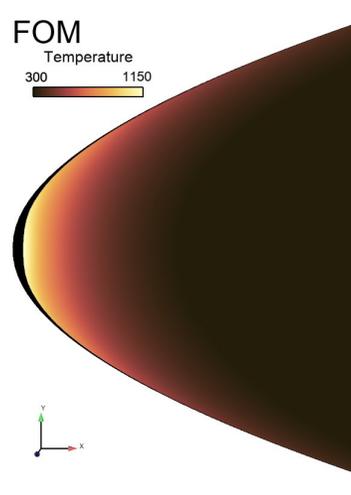


Coupled aerothermal material thermal response with shape change using SPARC/Aria

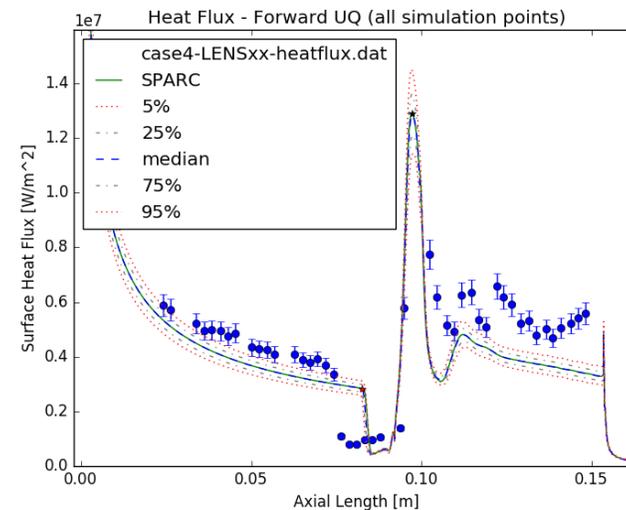
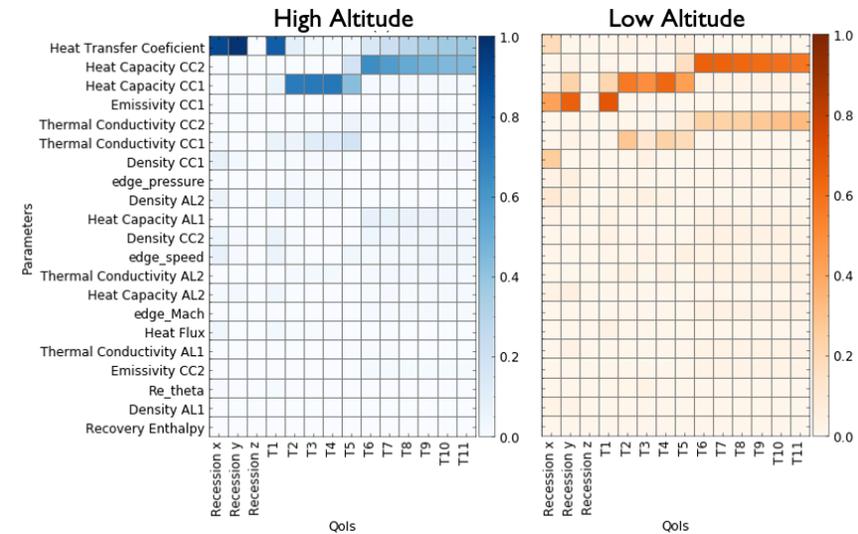
Enthalpy, HTC, Pressure, Wall Composition

MPMD

Temperature, Recession, Surface chemistry



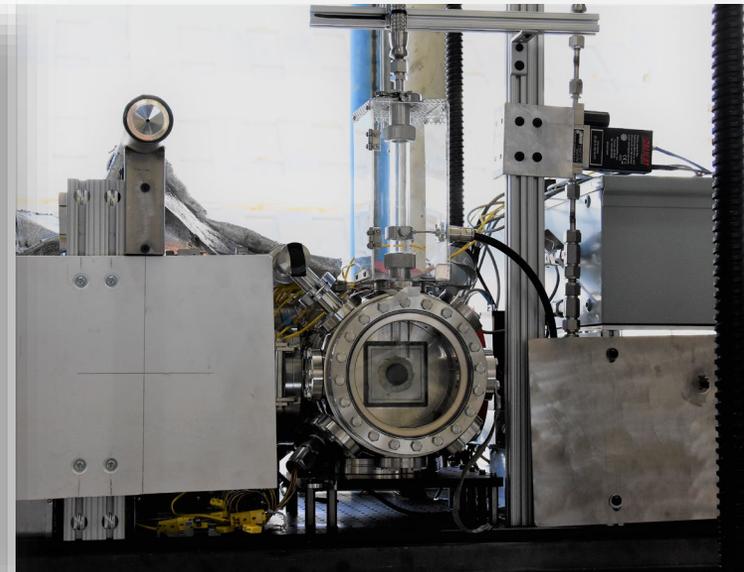
Projection-based reduced order models



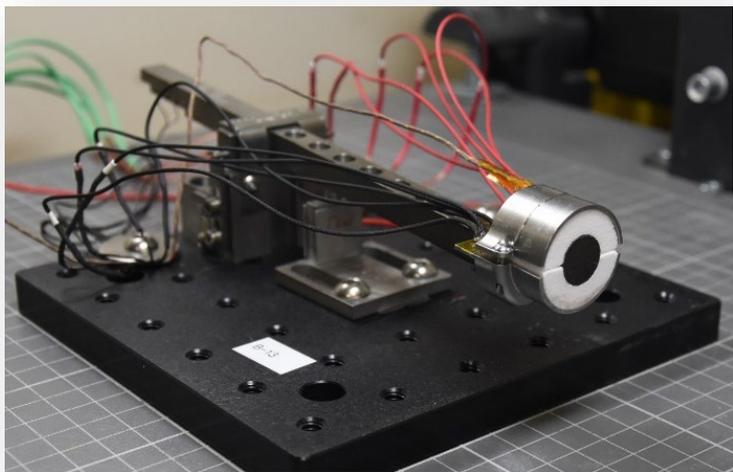
Credibility assessments:
Sensitivity analysis (top, generic hypersonic flight), validation (bottom, CUBRC double-cone)



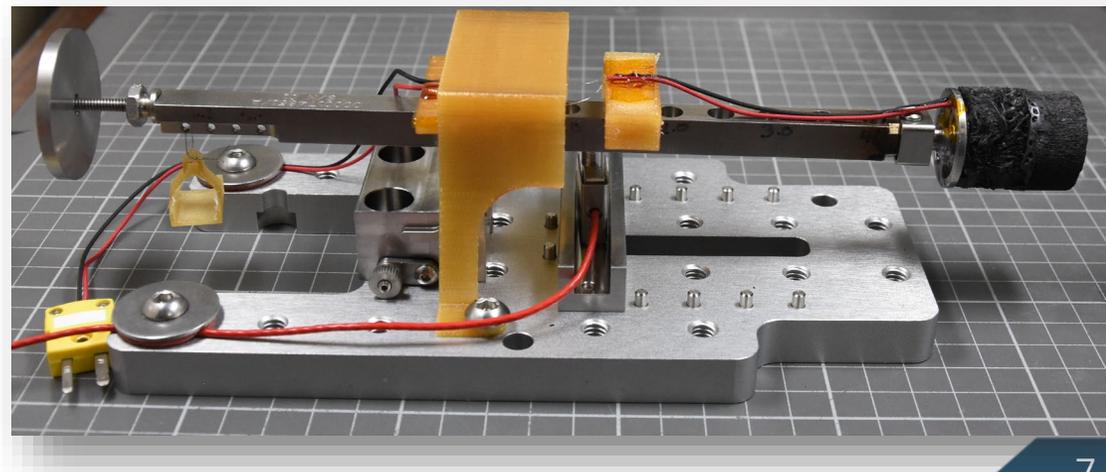
Ground testing



Solar testing (solar furnace, chamber, and plasma facility [Anderson]) – 600 W/cm^2 , 3000 C



Diagnostics and instrumentation
(thermocouples, mass)

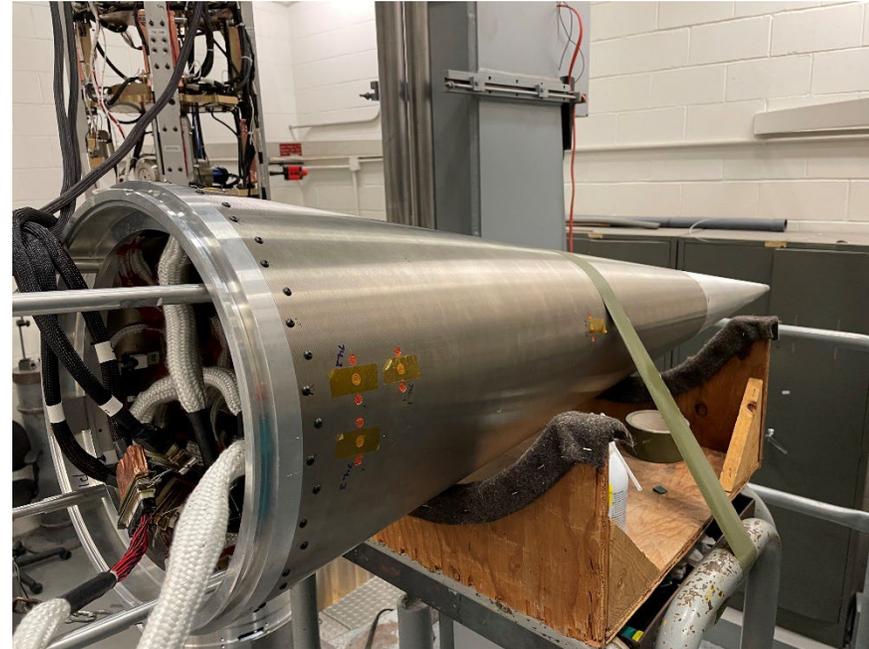




Vehicle-scale manufacturing and testing



Tape winding of TPS materials



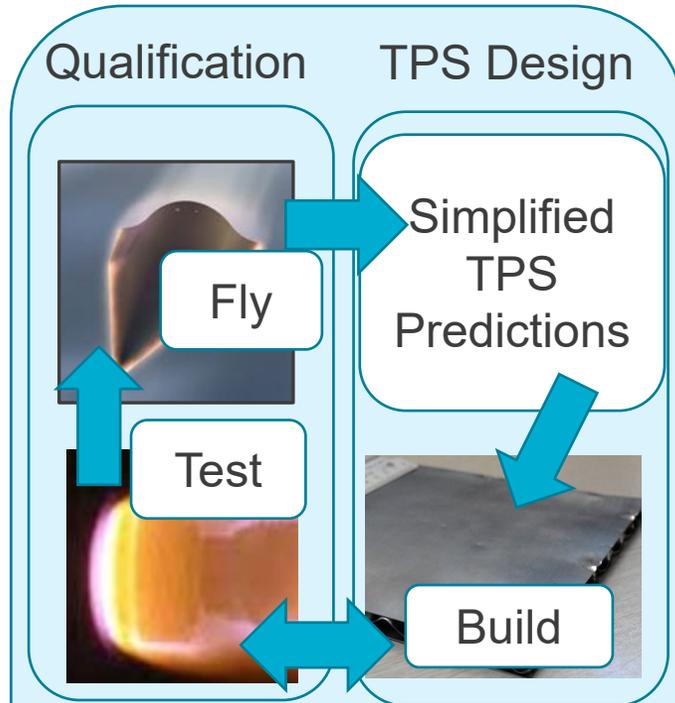
Sounding rocket tests
(manufacturing, payload
instrumentation)





Hypersonic TPS Grand Challenge LDRD

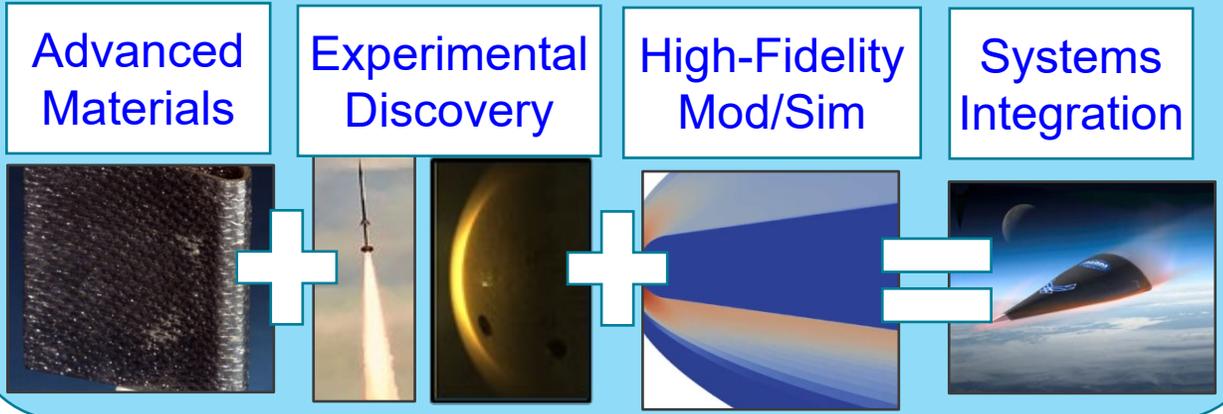
State-of-the-Art



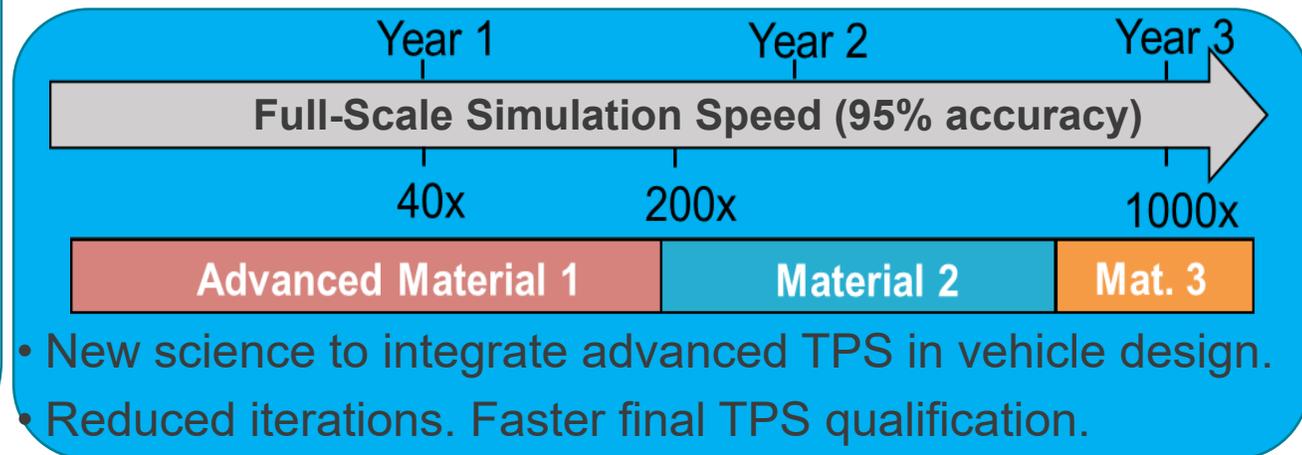
- Limited predictive capabilities lead to a build-test-fly approach that is *iterative*, slow, & risk averse.

TPS Grand Challenge

- Fast-running, science-based TPS predictions informed by experimental discovery and novel materials methods.



GC Outcomes





Closing thoughts

Sandia is pushing forward on TPS and ablation research on all fronts.

- Looking forward to learning from you and discussing collaboration opportunities!

Sandia talks

- Mesoscale modeling (Collins)
- Resin pyrolysis imaging (Foster/UIUC)
- Pyrolysis chemistry (Gosma/UIUC)
- Solar testing (Engerer)
- Ablation product instrumentation (Hargis)

Sandia posters

- Resin pyrolysis (Guiles)
- Solar thermal testing in plasma (Anderson)

We're hiring in hypersonics/ablation/TPS!

<https://careers.sandia.gov>

- 4 post-docs in TPS material modeling, NM (Roberts/Collins, 685922)
- Thermal analysis in CA (Mussoni; early career, 685822; experienced 685821)
- Summer graduate internships (685933, NM; 686417, CA)
- Materials fabrication and characterization post-doc (NM, Hernandez-Sanchez)
- See Sandia SMEs for other opportunities