Coupled Aerothermodynamics, Ablation, and Material Response

- Discussion was framed in regards to a potential Basic Research Initiative (BRI) in this area

Results:

- We reached a consensus on what the problem is…
- Despite the “basic research” aspect, it is important to define a real application, i.e. a finite parameter space (we spent some time on narrowing this down)
- A consensus on the type of problem that requires basic research:
  - AF vehicle that involves ablation and material response (not super-orbital reentry, but high enough Mach number / heat flux to require ablative TPS)
  - Nonequilbrium flight regime (not ballistic trajectory with equilibrium chemistry at material surface)
  - Shape change due to ablation must be important (lifting aerodynamic vehicle, not blunt body)
  - Potential for strong interaction/coupling between aerothermal/fluid dynamic – energy transport to surface – material response – ablation – aerthermal/fluid dynamic – etc… etc…
- Although other flight conditions may be reasonably well understood, the above problem is not and requires basic research (i.e. lack of confidence in current models current experimental data sets)

- General: The global strike hypersonic capability in Eglin Munitions presentation on Tues. a.m.
- Broader:
  - Understanding existing fluid-material response coupling (diamond patterns on TPS even without ablation and nonequilbrium)
  - Aerodynamic ablating high-lift vehicle
  - Ablation by-design, slightly wider-range than driven simply by heat-flux levels

Coupled Aerothermodynamics, Ablation, and Material Response

Ideas on what is necessary to tackle such a problem:

No single experimental facility can combine:

- High enthalpy
- Hypersonic flow and high-shear
- Quiet tunnels for transition and turbulence
- High surface temperature ablation processes

Therefore, modeling is necessary to bridge various facilities to flight (also required for understanding)

- Models are very tightly coupled
  - Shock layer physics
  - Boundary layer physics (with ablation products)
  - Gas surface interaction (energy transfer to/from surface)
  - Material response

Need well characterized conditions, break the problem up (can't simulate entire Arc Jet flow…)

Ideas:

- Low enthalpy flow over an artificial ablator (study ablation-fluid dynamics coupling) (BL perturbations due to ablation – resin-pockets) (high shear)
- Maybe high enthalpy (CUBRC equivalent)?
- Inductively coupled plasma (ICP) subsonic plasma-jet experiments (Vermont, VKI) to access radiative equilbrium long-time material response and ablation measurements (no shear, no turbulent coupling, subsonic BL) (but may tell you actual ablation behavior at high T instead of artificial ablator above)
- Material response (to heat flux) experiments (microstructure, perturbations, etc.)