Developing a Pyrolysis Gas Thermal Blocking Model for Reentry Demise

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In NASA's Object Reentry Survival Analysis Tool (ORSAT), aerodynamic drag and aerothermal heating coefficients are computed for each of the free-molecular, continuum, and transitional flow regimes using analytical and semi-analytical methods. These heating coefficients were derived for typical metallic materials that melt and do not have a strong gas-phase contribution to the flow in the boundary layer. Modern satellites typically feature fiber-reinforced polymer (FRP) components, such as solar array booms, facesheets of sandwich panels, or overwraps for composite-overwrapped pressure vessels (COPV). These FRP materials do not behave the same as metals in the reentry environment, but instead will pyrolyze and develop significant volumes of gas into the boundary layer.

Accurately predicting the reentry demise of FRP components is critical to assessing the reentry casualty risk for modern spacecraft. Research in recent years has shown that this demisability can depend heavily on how the expulsion of gaseous pyrolysis products through the outer surface of the material affects the heat flux at the surface. The Orbital Debris Program Office has been developing a reduced-order model of the effect of pyrolysis gas blowing on the heat flux based on a correlation between a blowing factor and a non-dimensional heat flux to be incorporated in the upcoming version 7.3 of the Object Reentry Survivability Analysis Tool (ORSAT). This presentation discusses the progress of this development project and the challenges remaining for generalizing the model across families of FRP materials.