

Development of a Composite Material Aerodynamic Demise Model for the Object Reentry Survival Analysis Tool (ORSAT)

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ABSTRACT

The reentry demise of fiber-reinforced polymer (FRP) composites is an increasing concern for modern spacecraft at end of life. Unlike traditional materials such as metals, shredding of the material by aerodynamic forces appears to be a major component of the reentry demise mechanism. This paper will describe a new mechanical, strength-based, material demise model for the Object Reentry Survival Analysis Tool (ORSAT) Version 7.1. The model is based on laboratory *in-situ* and residual strength tests of several FRP materials performed during the NASA Orbital Debris Program Office's Phase II Composite Material Demise test campaign.

To test the residual strength of partially charred FRP materials, the authors tested 107 rectangular shaped samples of different thicknesses that were previously exposed to high-enthalpy flow at the University of Texas at Austin's Inductively Coupled Plasma Torch facility. Tests were performed under normal atmospheric conditions at NASA Johnson Space Center's Experimental Impact Laboratory using a Chatillon TCD1000 tensile test machine configured with a three-point bending jig. Mean fracture load, residual strength, delamination, and flexural modulus were measured for each test. An engineering model of aeromechanical demise for each material was developed by correlating the measured residual strength of the samples with the duration and magnitude of the applied heat flux and the mass loss and char progression. This model has been implemented in ORSAT 7.1 for the built-in, charring carbon fiber/epoxy and charring glass fiber/epoxy material models.

The new model was verified by calculating the demise of hundreds of FRP composite fragments of various shapes and sizes and checking the calculations for consistency, with specific focus on material characterization in one-dimension. Further tests are planned in hypersonic flow facilities to validate the assumptions used in the model.