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Space debris testing methodology in Plasma Wind tunnel for D4D tools validation

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The increasing amount of space debris in Earth's orbit is becoming a major concern for both current spacecraft operations and future space activities. Non-operational satellites and debris fragments can collide with active spacecraft and generate even more debris. To reduce these risks, it is important to better understand how space debris behaves and demises during atmospheric reentry.

Design for Demise (D4D) tools have been developed to provide initial guidelines and design parameters to enhance spacecraft demisability. However, these computational models require rigorous validation and refinement to ensure their reliability under real-world reentry conditions. To achieve this, carefully designed experimental test cases are essential to replicate the complex thermal and aerodynamic environments encountered during reentry and to evaluate the performance of spacecraft designs.

An important part of this work is the use of high-enthalpy and plasma test facilities, which can reproduce the extreme conditions experienced during atmospheric reentry. Choosing the right test facility is essential for properly evaluating material and structural breakup, and for improving methods for the controlled reentry and disposal of space debris.

This presentation will discuss the relevance and consistency of the proposed framework and methodology for space debris testing in the context of D4D tool validation. It will highlight the key requirements for defining test conditions and measurement parameters needed to build a reliable database for solid material demise characterization. Particular attention is given to the challenges and methodologies of full-scale equipment testing in ground-based facilities, focusing on their relevance and accuracy when extrapolating results to flight scenarios. By addressing these aspects, this work seeks to enhance the fidelity and applicability of Plasma Wind Tunnel testing to better support the development of sustainable space debris mitigation strategies.