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Composite Dry Structure Cost Improvement Approach

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Sponsoring Program(s)

Human Exploration and Operations Mission Directorate
Space Launch System Advanced Development

Project Description

This effort demonstrates that by focusing only on properties of relevance, composite interstage and shroud structures can be placed on the Space Launch System vehicle that simultaneously reduces cost, improves reliability, and maximizes performance, thus providing the Advanced Development Group with a new methodology of how to utilize composites to reduce weight for composite structures on launch vehicles. Interstage and shroud structures were chosen since both of these structures are simple in configuration and do not experience extreme environments (such as cryogenic or hot gas temperatures) and should represent a good starting point for flying composites on a 'man-rated' vehicle. They are used as an example only.

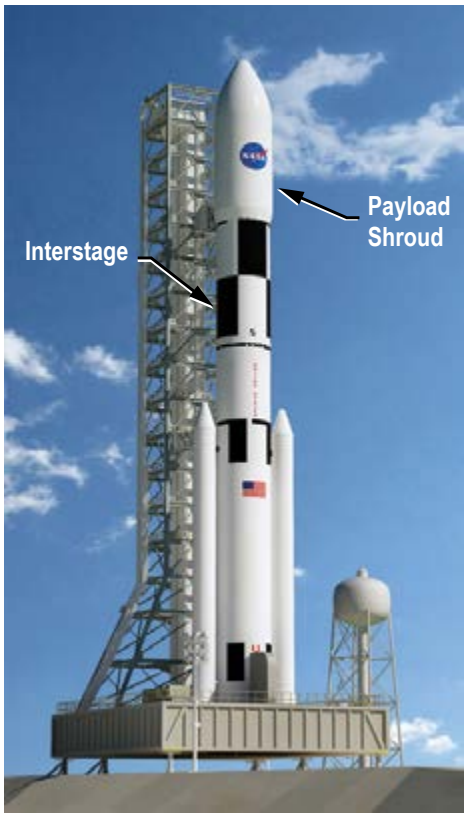
The project involves using polymer matrix composites for launch vehicle structures, and the logic and rationale behind the proposed new methodology.

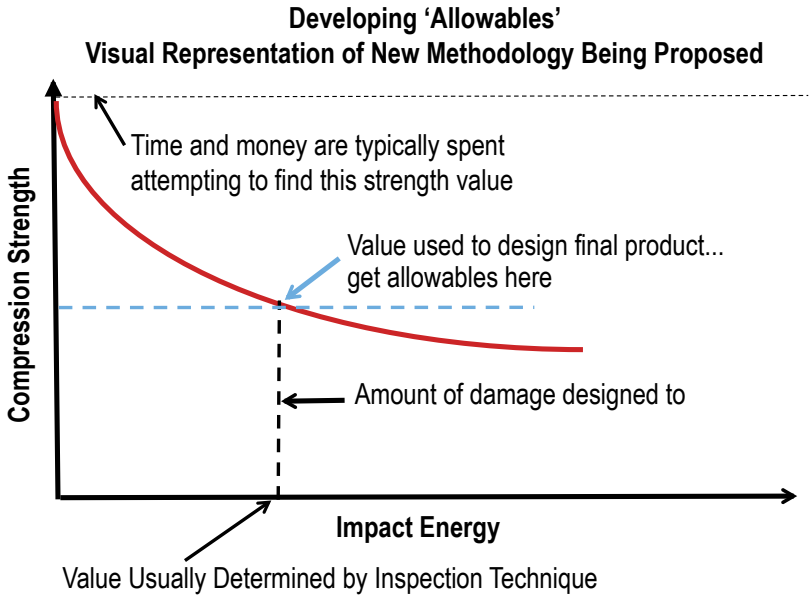
Notable Accomplishments

Notable accomplishments include rationale and remedies for the barriers in using composites: (1) Testing of lamina is not only expensive and difficult but futile since no laminate failure criteria has been shown to be valid for practical use; (2) Undamaged laminate testing is time consuming and costly. This is hard to justify as these strength numbers will probably never be used since damage must be assumed to exist in the laminate; (3) Undamaged laminate testing is more of a 'test of the test method' rather than a material property test; (4) If a structure has a dominant loading case (such as compression for an interstage structure), then characterizing other strength (such as tension) is of no practical use; (5) Costly fatigue testing is usually not necessary; (6) The statistical significance (the obtaining of which is very costly) of the multitude of undamaged test specimens is lost many times over by the time a final design number for a given piece of hardware is agreed upon; and (7) The final product will have an optimum lay-up based on undamaged properties that may not result in an optimum lay-up for damage tolerance considerations. This may contribute to design values that are either too high (poor reliability) or too low (compromised performance) being used.

References

Crumbly, C.M.; Bickley, F.P.; and Hueter, U.: "Space Launch System Spacecraft/Payloads Integration and Evolution Office Advanced Development FY 2014 Annual Report," NASA/TM—2015–218201, NASA Marshall Space Flight Center, Huntsville, AL, January 2015.


Payload
Shroud
Interstage


Developing 'Allowables'
Visual Representation of New Methodology Being Proposed
Time and money are typically spent
attempting to find this strength value
Value used to design final product...
get allowables here
Amount of damage designed to
Compression Strength
Impact Energy
Value Usually Determined by Inspection Technique