

## Marshall Space Flight Center

# **Damage Tolerance**

Marshall's Materials and Processes (M&P) Laboratory has a rich history of providing damage tolerance expertise in NASA's flagship programs. Damage tolerance experts in the M&P Laboratory assisted the Space Shuttle Program through damage assessments in all primary structures: the orbiter, solid rocket boosters, space shuttle main engines, and the external tank. The lab's damage tolerance personnel play key roles in developing fracture control policies and assessments for NASA's next generation of launch vehicles, commercial launch vehicles, and human landing systems.

Damage tolerance assessments are used to evaluate the ability of a structure to perform reliably throughout its service life in the presence of defects, cracks, or other forms of damage. Assessing damage requires the combination of materials engineering, nondestructive evaluation, testing, and fracture mechanics analysis, which are core capabilities of the Marshall M&P Laboratory Damage Tolerance Team. The Damage Tolerance Team has extensive experience performing advanced analysis, planning tests, and coordinating the lab's resources to solve these problems. With this background, the team can provide valuable input into the evaluation and selection of materials, nondestructive inspection methodologies, and risk mitigation approaches.

Fracture control, the practice of evaluating parts and implementing a range of analyses, inspections, tests, and verifications to ensure mission success, is also a core competence of the Damage Tolerance Team. The team has provided expertise in the development of the NASA Fracture Control Standard, NASA-STD-5019, and has provided



fracture control governance to many projects through the MSFC Fracture Control Board (FCB). Experts on the team have also provided key assistance to external partners through membership of numerous external FCBs.



Friction stir weld pull plug test.



Fractured valve poppet evaluation.

Layered structure fracture model.

### Capabilities

- Expertise in fracture control and damage tolerance guidance; decades of experience providing consultation on fracture control implementation for programs at Marshall and throughout NASA, emphasizing innovative approaches for the implementation of fracture control on advanced materials and structures
- Chair and core technical support of the Marshall FCB
- Development and refinement of NASA and industry guidelines and standards for fracture control and material specifications and qualification
- Materials characterization planning, data evaluation, and generation of design curves for metallic fracture and composites damage tolerance data
- Material test matrix and cut plan development, project engineering for analysis and test campaigns, and post-test analysis and interpretation
- Development of customized experimental techniques to assess fracture toughness and fatigue crack growth, as well as damage tolerance of structures or components under unique loads and environments
- Component test objectives and guidance for damage tolerance for proof tests
- Development of material test data analysis software to streamline process and ensure validity
- Fracture mechanics analysis for metallic hardware and residual strength for composite hardware
- Advanced analysis of fracture and fatigue in metallic structures using finite element and boundary element techniques
- Specialized fracture analysis of short-life, highstress components commonly found in launch vehicle applications



Composite compression after impact specimen.

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- Development of advanced analysis software and techniques to streamline the analysis process
- Support of complex engineering evaluations spearheaded by the NASA Engineering Safety Center (NESC)
- Fracture control and damage tolerance support of additive manufacturing part certification strategies



Finite element analysis design of experiments study.



Compact tension test of nonmetallic material.

#### **Key Benefits**

- Credible and reliable experience in the full range of technical disciplines required for comprehensive damage tolerance assessments
- Synergy of required expertise and tools to provide practical solutions to complex problems regarding structural defects or damage

#### **Doing Business With MSFC**

