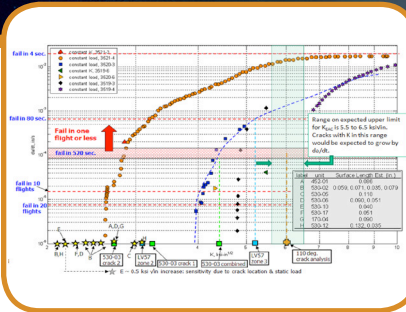
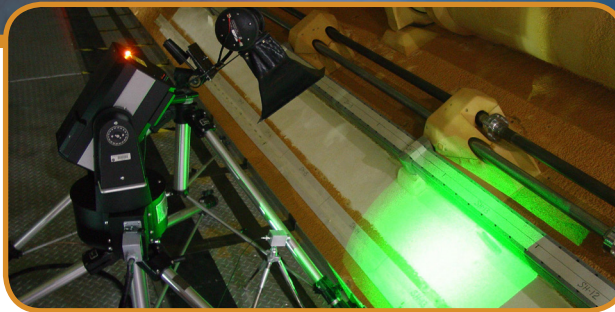


Marshall Space Flight Center Damage Tolerance

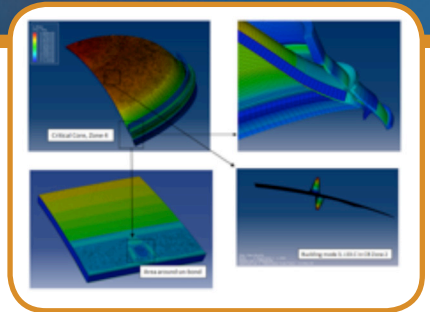
Engineering Solutions for Space Science and Exploration



Sustained Load Fracture Assessment



Shearography of External Tank spray-on-foam-insulation



Finite Element Assessment
for Residual Strength

Damage Tolerance Assessments

—the evaluation of a structure to perform reliably throughout its service life in the presence of a defect, crack or other forms of damage - is a core capability of Marshall Space Flight Center's (MSFC) Materials and Processes Laboratory. Assessing damage requires the combination of materials engineering, fracture mechanics or damage mechanics testing and analysis, and non-destructive evaluation (NDE) found within the Laboratory.

Due to its ability to examine a part without damaging it, NDE is a highly valuable time and cost saver for verifying the nature and extent of existing damage induced during manufacture or while in service. The Laboratory's NDE capability includes the five standard NDE methods, numerous special NDE methods, and the development of techniques and tooling to provide unique inspection solutions for specific projects. Standard and special NDE methods include ultrasonic, magnetic-particle, liquid penetrant, radiographic, eddy-current, thermographic, x-ray computed tomographic, shearographic, acoustic emission, microwave, and terahertz testing. The Laboratory has the ability to inspect both metallic and non-metallic structures and materials, either in the field where the hardware is in service or being produced, or within dedicated laboratories for subscale development components. The Lab's NDE capability has served key roles in many of NASA's missions. For the Space Shuttle's External Tank (ET), the Lab's NDE personnel developed on-pad radiographic techniques for cracked aluminum stringers. The ET spray-on foam insulation, Space Shuttle Main Engines (SSME) flow liners, and SSME cold wall leak

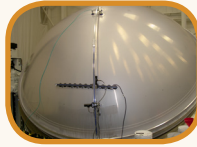
detection were inspected using techniques developed by the Laboratory. Ultrasonic testing techniques were developed to inspect friction stir and friction stir plug welds, the primary joining techniques for the Space Launch System (SLS) Stages.

The Laboratory has expertise in evaluating the ability of a structure to perform when there is a defect – the structure's damage tolerance. Damage tolerance brings together many of the Lab's core capabilities including: NDE, materials testing, materials engineering, and fracture mechanics assessments. Combining these skills, the Laboratory can determine if a structure with a reliably detectable NDE flaw size can survive the intended service life or inspection interval. Damage tolerance can be used to determine if a specific NDE method/technique is adequate, or if an inspection interval is of an appropriate length. The Laboratory can also provide expertise in the development of fracture control policy for programs and projects. Damage tolerance expertise was used throughout the Space Shuttle Program for assessing damage in all primary structures: the Orbiter, Solid Rocket Boosters, Space Shuttle Main Engines and the External Tank. The Lab's damage tolerance personnel continue in key roles in developing fracture control policies and assessments for NASA's next generation of launch vehicles.

Capabilities

Non-Destructive Evaluation (NDE)

- Certified NDE Inspectors
 - In accordance with NAS410 requirements
- Available Techniques
 - Ultrasonic (Conventional and Phased Array)
 - Magnetic-particle
 - Liquid penetrant
 - Radiography
 - Eddy-current
 - Thermography
 - X-ray Computed Tomography
 - Shearographic testing
 - Acoustic Emission Testing
 - Microwave Testing
 - Terahertz Testing
 - Bond Testing
- Ability to work problems from technique development to demonstration to implementation and finally integration with production tooling and process flow.
- Supports the Agency-wide NASA NDE Working Group (NNWG).
- Supports the development and qualification of test articles to provide clear and rational NDE and proof logic.
- Develops large-scale automated NDE techniques and associated tooling.
- Develops verification, validation and certification programs for advanced NDE methods by proper inspector training and validated probability of detection studies.
- The design and validation of capability studies for new NDE applications.
- Active membership and participation in the NASA Engineering Safety Center (NESC) NDE Technical Discipline Team (TDT)
- The design and fabrication of realistic NDE reliability and calibration standards.

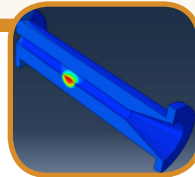


Damage Tolerance Assessment

- Materials characterization planning, data evaluation, and generation of design curves for metallic fracture and composites damage tolerance data.
- Analytical predictions in fracture mechanics for metallic hardware and residual strength for composite hardware.
- Component test objectives for damage tolerance guidance for proof test.
- Fracture control and damage tolerance guidance for mitigation of failure due to defects or damage.
- Customized experimental techniques developed to assess toughness and fatigue crack growth in metallic materials, as well as damage tolerance of structures or components under unique loads and environments
- Development of methodologies for experimentally assessing damage tolerance of solid composite laminates and honeycomb cored composite structures
- Advanced analysis of fracture and fatigue in metallic structures using finite element and boundary element techniques
- Structural assessment in accordance with all common codes and criteria (e.g. NASGRO®, API, or R6 failure assessment diagrams, constraint-corrected JIc, etc.)
- Specialized fracture analysis for short-life, high-stress components commonly found in launch vehicle applications
- Development of advanced analysis software and techniques applicable to launch vehicle structures and materials
- Consultation on fracture control implementation for new and advanced programs at MSFC and throughout NASA
- Chairmanship and technical support for the MSFC Fracture Control Board
- Development and refinement of NASA and industry guidelines and standards
- Emphasis on innovative approaches to the implementation of fracture control for advanced materials and structures
- Support NASA Engineering Safety Center (NESC) initiatives.

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
- > Demonstrated experience developing new damage tolerance assessment techniques and approaches



For more information, please visit www.nasa.gov/centers/marshall/about/business.html

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