Dynamic Impact Testing and Model Development in Support of NASA's Advanced Composites Program

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Outline

- **Provide an Executive Overview of this Session**
- **Brief Overview of the Advanced Composites Project**
- **Summary of the High Energy Dynamic Impact Program Element**
  - Advanced Composites Consortium Effort
  - Impact Testing programs at NASA Glenn
  - MAT213 Development at NASA Glenn
  - Future Work

The Advanced Composites Project

Objective

To reduce the time to develop and certify composite materials and structures, helping American industry retain their global competitive advantage in aircraft manufacturing.

Accurate Strength & Life Prediction

Develop validated strength and life prediction tools with known accuracy for complex composite structures and standardized procedures for their reliable use.

Rapid Inspection & Characterization

Develop and demonstrate NDE systems and enabling technologies to fully inspect and rapidly disposition findings in complex composite structures.

Efficient Manufacturing Process Development

Develop and demonstrate new manufacturing technologies to enable structural optimization while resolving predicted manufacturing issues.

The Advanced Composites Project

The FAA along with industrial and academic participants have joined NASA to form the Advanced Composites Consortium (ACC)

Universities participate through NASA Research Announcements (NRA)

The Advanced Composites Project

The ACP work will be performed over approximately five years and will be conducted in two phases

High Energy Dynamic Impact Program Element

Objective

- Evaluate & develop impact analysis tools to predict performance of safety-critical engine/airframe structures dominated by high-energy impact events.
- Benchmark methods and tools for reducing development to certification timeline.

← Five Year Project Duration →

Phase 1 :
- Establish state of the art
- Identify deficiencies and technologies to be advanced
- Fundamental and small scale testing
- Validate methods against tests

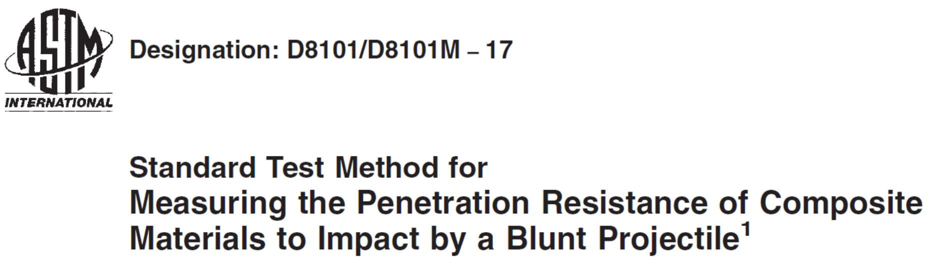
Phase 2 :
- Continue more focused technology maturation on selected methods
- Sub-component and component testing
- Continue validation with higher level tests
- Establish best practices and guidance

Predominant focus on LS DYNA with smaller effort on Peridynamics

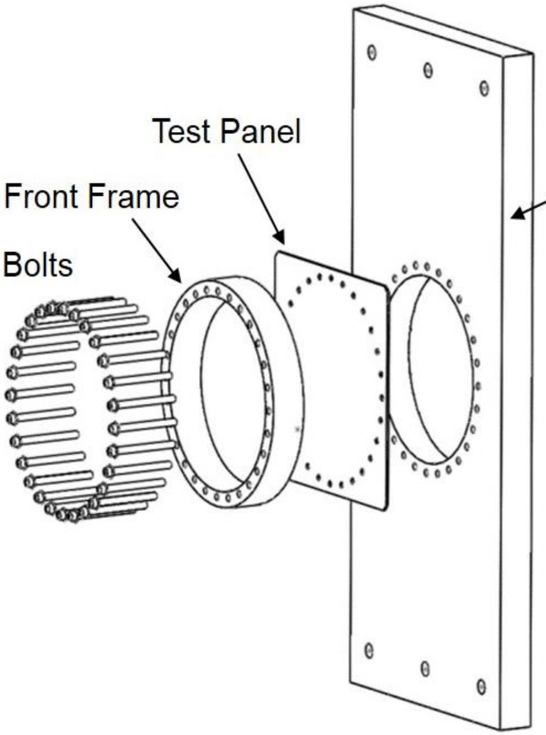
Existing LS DYNA models utilized in this study are MAT162 and 261 along with a new model under development at NASA Glenn called MAT213

Impact Testing at NASA Glenn (12” x 12” Panels)

ASTM Standard Test Method Published For Composite Impact Testing (ASTM D8101/D8101M)

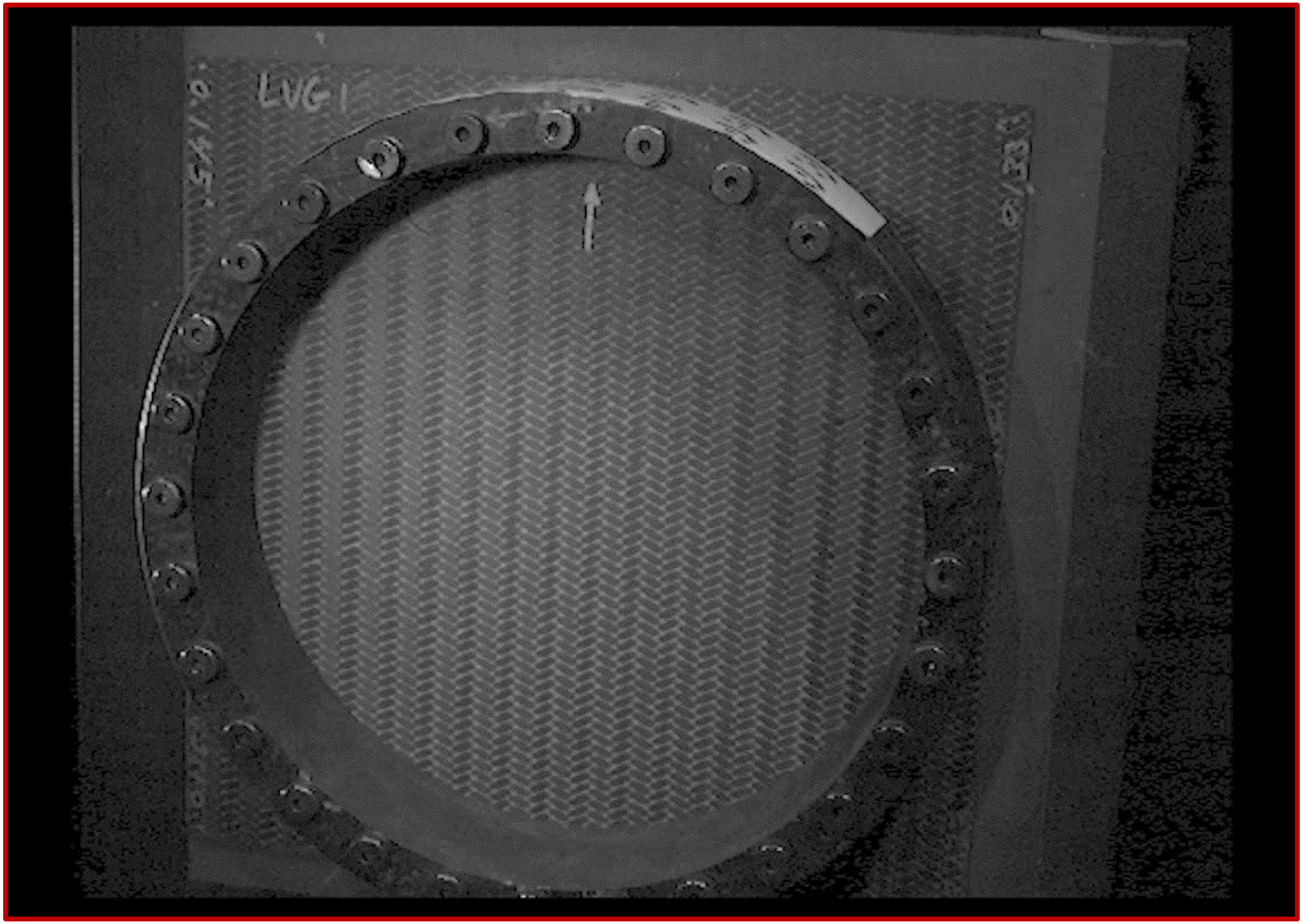

Designation: D8101/D8101M – 17

Standard Test Method for
Measuring the Penetration Resistance of Composite Materials to Impact by a Blunt Projectile[1]

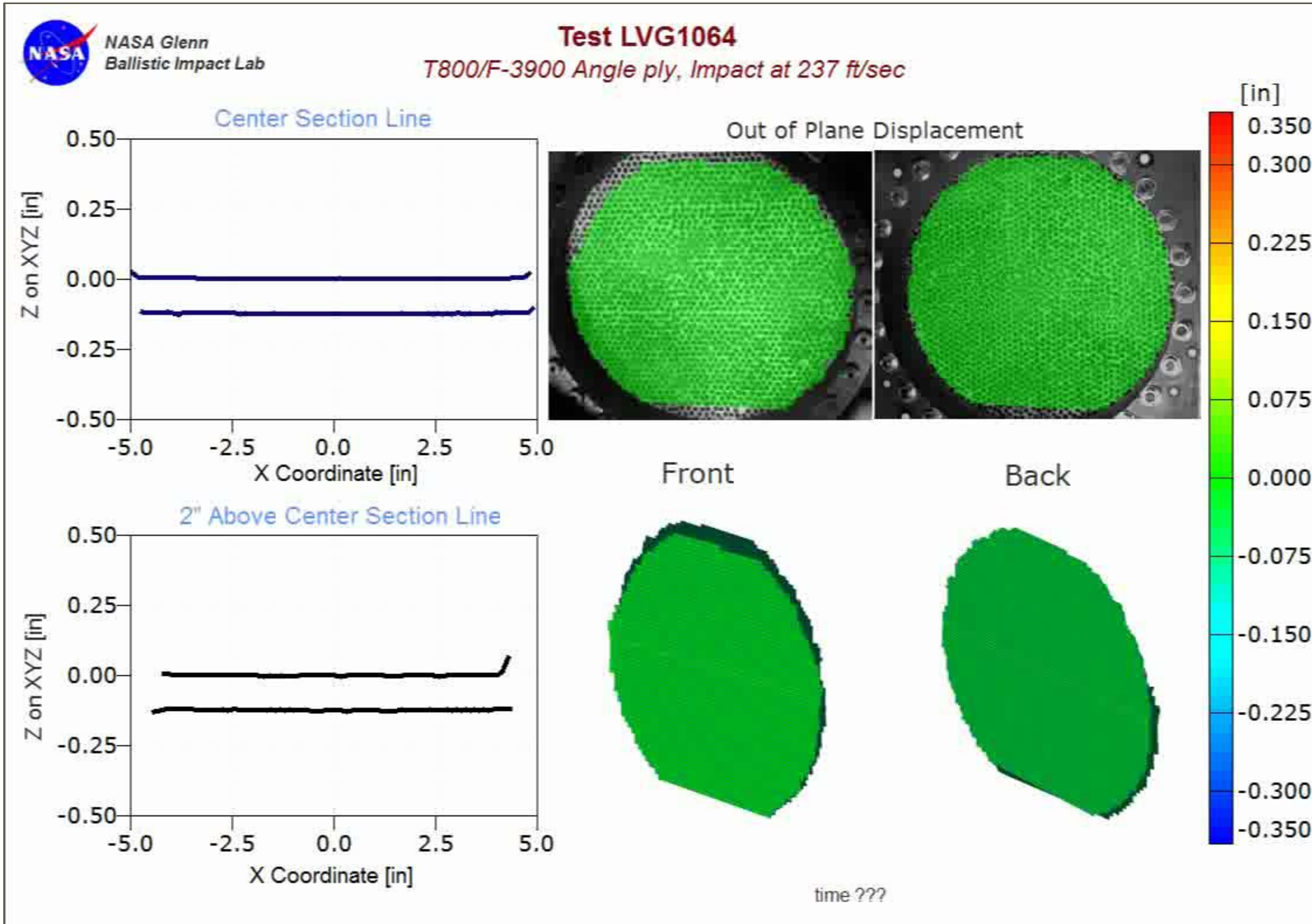


The test method is designed to quantify the effects of variables such as constituents, architecture, environment, extended hygro-thermal environmental exposure, and processing variations on the impact resistance of composite materials.

Impact Testing at NASA Glenn (12” x 12” Panels)



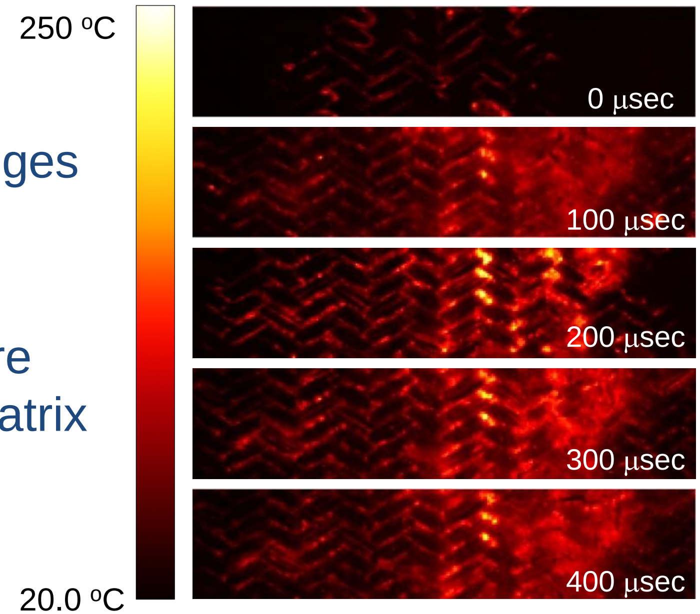
Impact Testing at NASA Glenn (12” x 12” Panels)

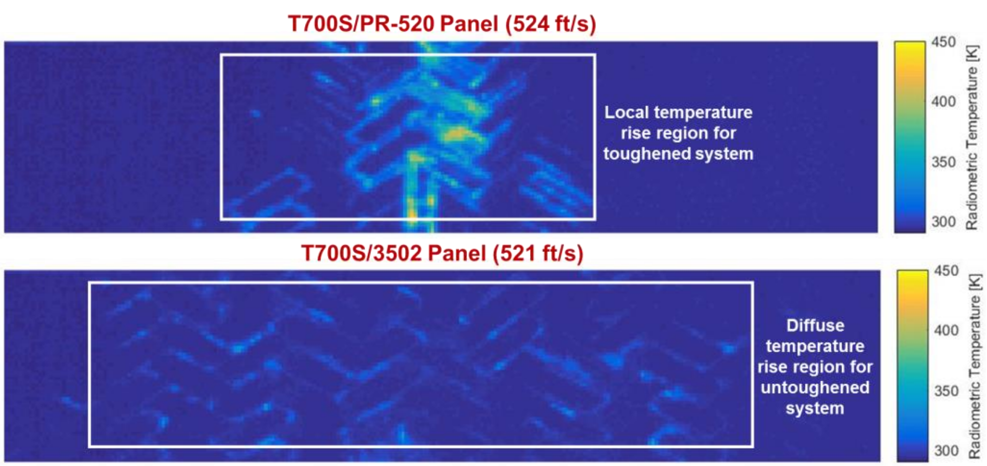


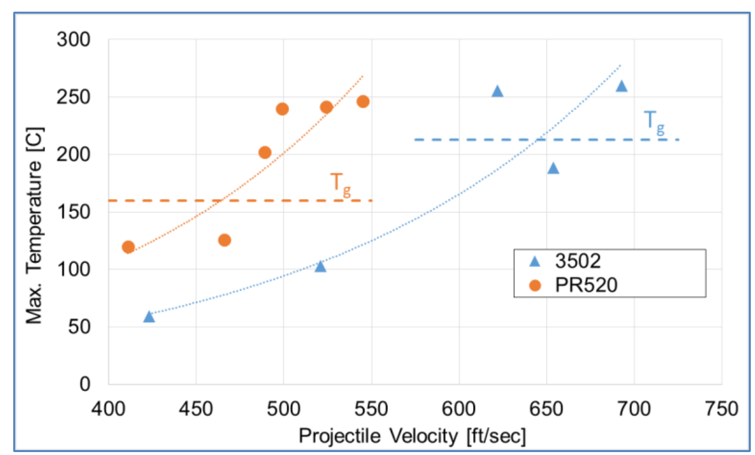
High Speed Infra-Red Images Capture Impact Induced Temperature Rise in Composites

Computational modeling of impact tests on composites has suggested that temperature changes during the impact effect material performance.

High speed IR measurements capture temperature rises exceeding glass transition temperature of matrix materials during impact event.

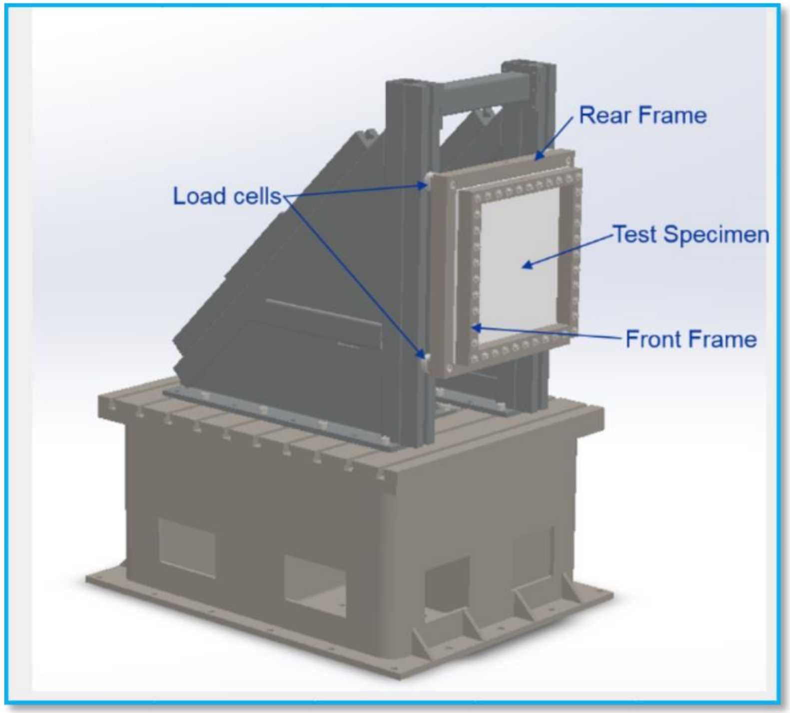






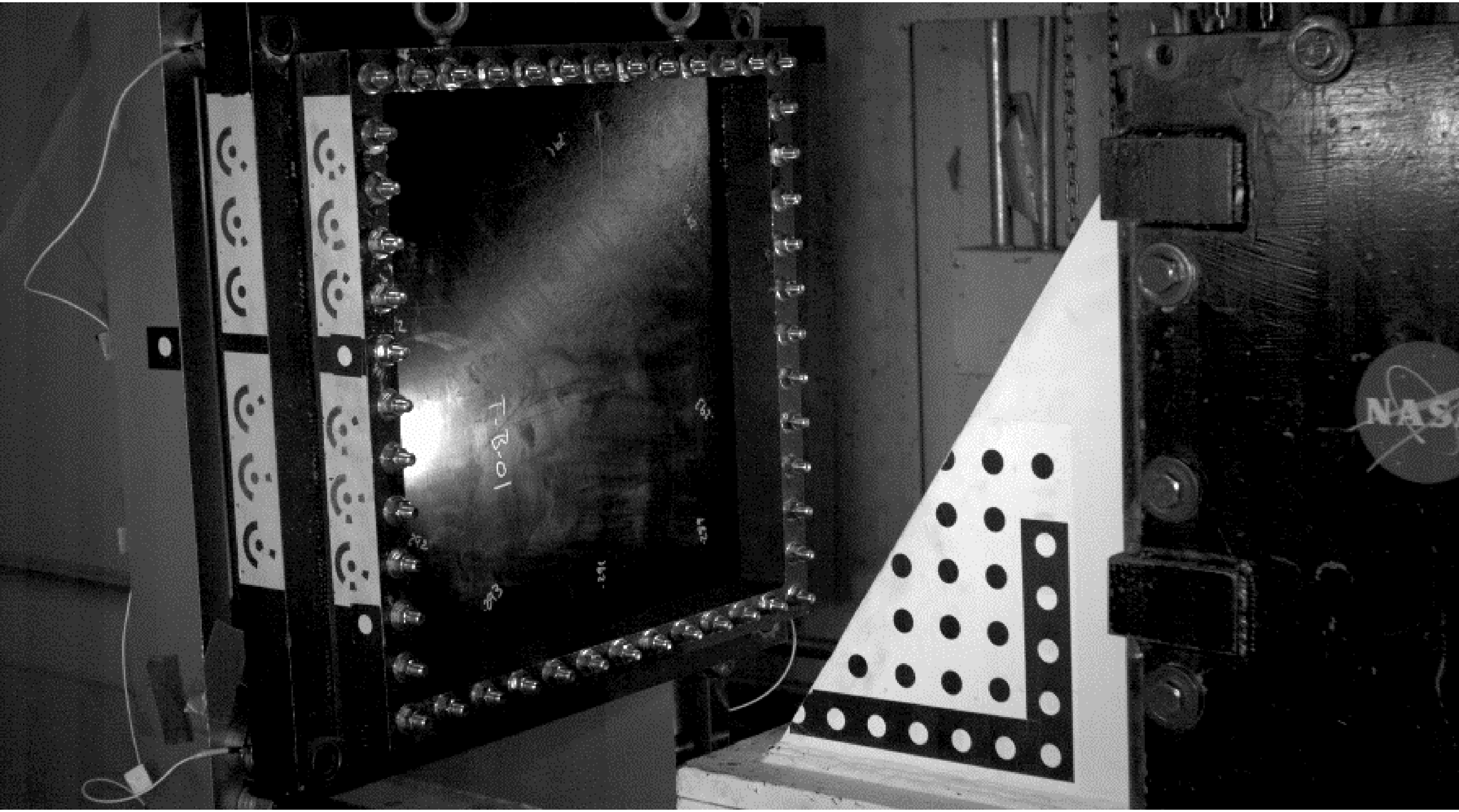
High temperatures during impact will have consequences on new advanced composite impact models

Impact Testing at NASA Glenn (25” x 25” Panels)



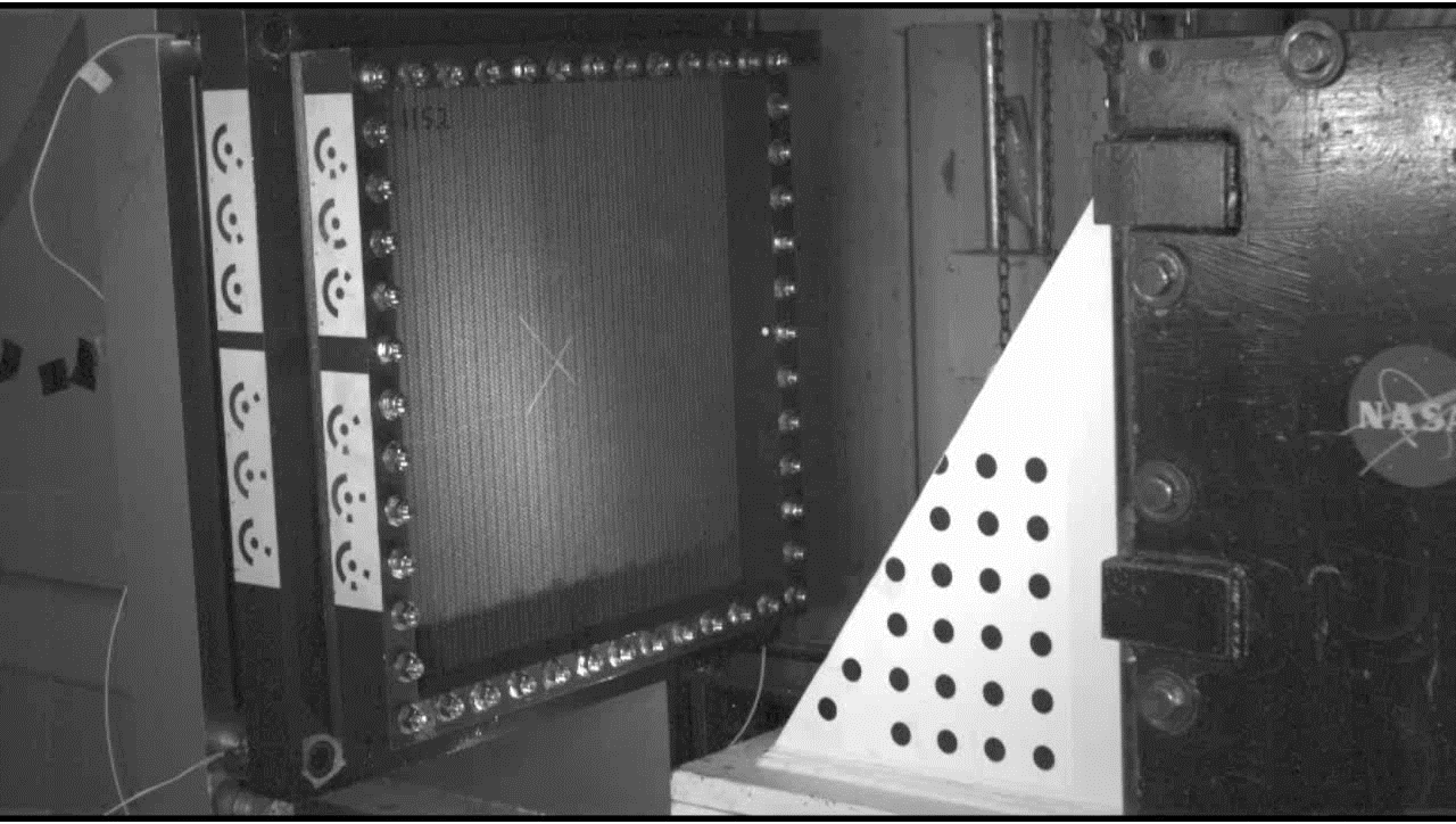
Multiple material systems and projectiles are tested to expand an experimental database for which to validate impact predictive models

Impact Testing at NASA Glenn (25” x 25” Panels)



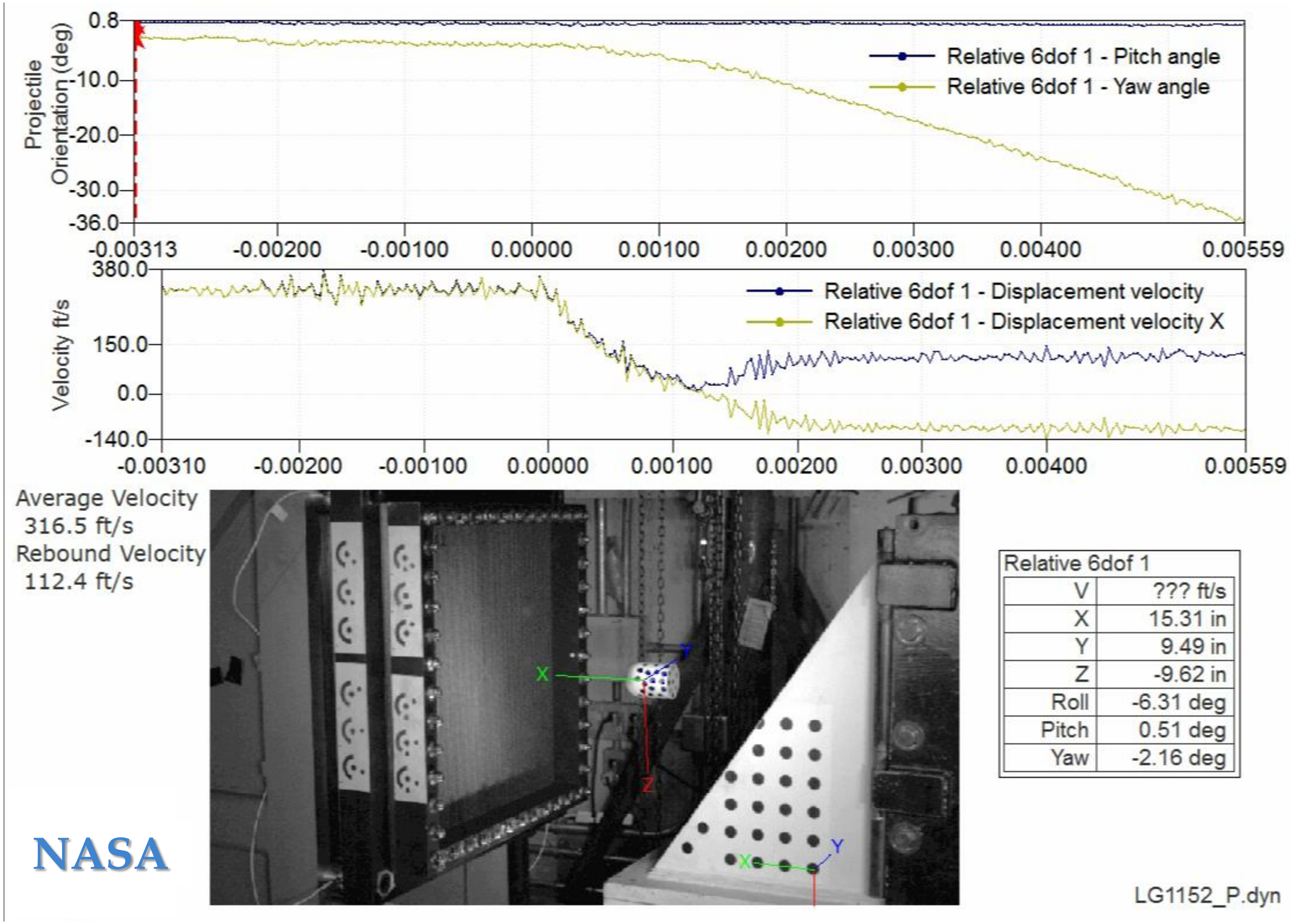
Impact Test on 40ply Tape Layup at 586 ft/sec

Impact Testing at NASA Glenn (25” x 25” Panels)



Impact Test 3-D Triaxial Braided Panel at 317 ft/sec

Impact Testing at NASA Glenn (25” x 25” Panels)



Impact Test 3-D Triaxial Braided Panel at 317 ft/sec

Impact Testing at NASA Glenn (25” x 25” Panels)

Impact Test on 3-D Braided Panel at 408 ft/sec

MAT213 Model Development

- Accurate material models for predicting composite material response under impact are in significant need in the aerospace community

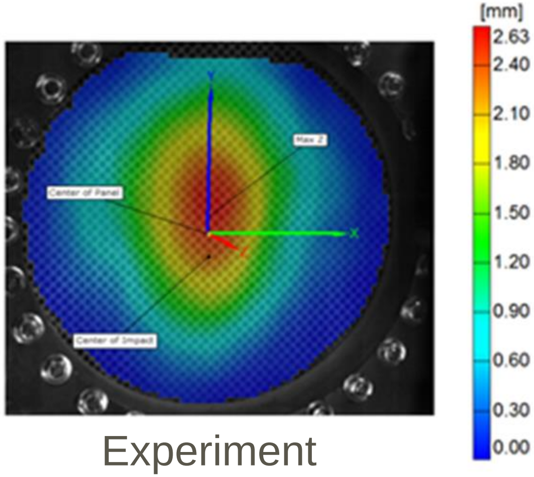
- Key deficiencies were identified in the existing suite of material models available today in LS DYNA and the MAT213 development effort was initiated to address them.

- MAT213 will incorporate both plasticity, damage, and failure as well as the ability to input tabulated material property data to define the evolution of these parameters with higher levels of fidelity.

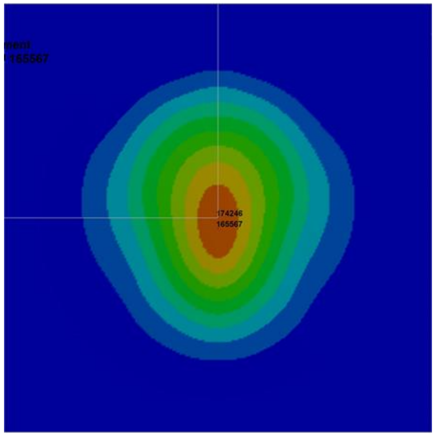
- This model is currently undergoing a rigorous verification study in preparation for it’s initial general commercial release as a public domain material model in LS DYNA in April of 2018.

MAT213 Model Development

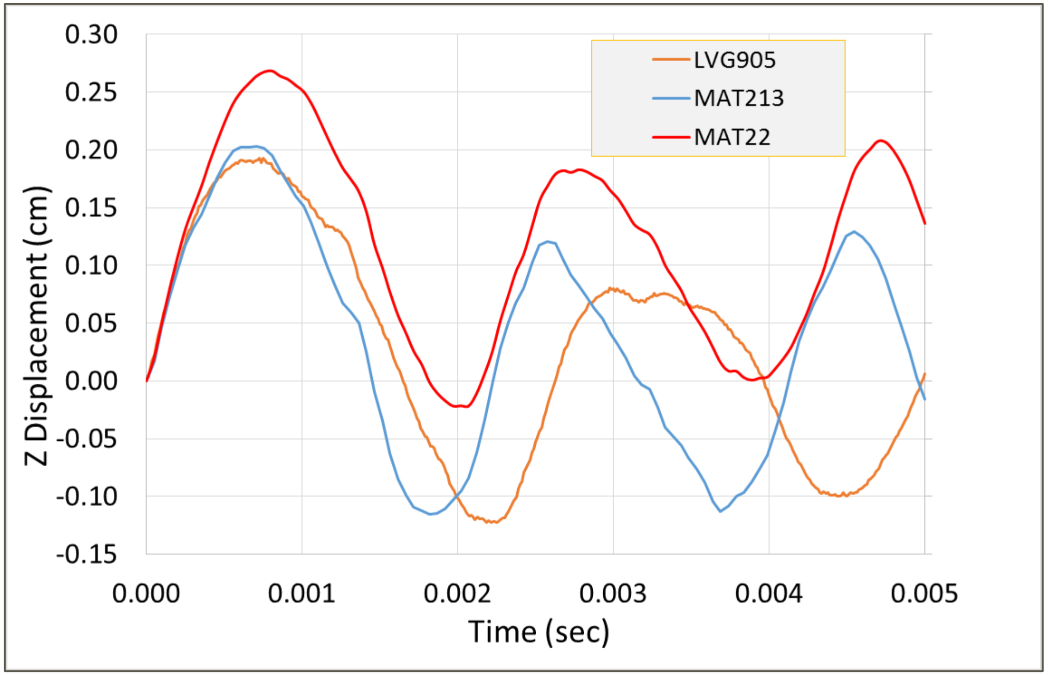
In validation studies, back side deformation patterns predicted by simulations compared favorably with experimental results obtained with high speed photogrammetry.



Experiment



Simulation



Simulation vs Experiment

Summary

- **Phase 2 of this ACP effort will continue with emphasis on sub-component impact testing in 2018**
- **Validation studies against this test data will be performed to further mature the technology and develop best practices**
- **A rigorous verification and validation of MAT213 shall continue with multiple material architectures and constituents.**