Automotive Composites Consortium:

Focal Project 4: Structural Automotive Components from Composite Materials

Libby Berger (General Motors)

John Jaranson (Ford)

Presented by Hamid Kia (General Motors)

May 16, 2012

Project ID #LM049

Focal Project 4: Overview

Timeline

- Start – October 2006
- Finish- April 2012
- 100% complete (based on time)

Budget

- Total project funding
  - DOE share: $2,974K
  - Contractor share: $2,974K
- Funding received in FY11
  - $466K
- Funding for FY12
  - $86K

Barriers

- Barriers addressed
  - The cost-effective mass reduction of the passenger vehicle, with safety, performance, and recyclability;
  - Performance, reliability, and safety comparable to conventional vehicle materials;
  - Development and commercial availability of low cost structural composites, with lifecycle costs equivalent to conventional steel.

Partners

- Interactions/ collaborations
  - Multimatic
  - Continental Structural Plastics (CSP)
  - Century Tool and Gage
  - ORNL
  - U Mass Lowell
  - IBIS and Camanoe
- Project leads
  - Libby Berger
  - John Jaranson

Objectives

AUTOMOTIVE COMPOSITES CONSORTIUM

Focal Project 4: Structural Automotive Components from Composite Materials (ACC007)

The objective of this project is to use composite materials to decrease the mass of high-volume automotive structures, at acceptable cost. The project goals are:

- **Guide, focus, and showcase the technology research of the ACC working groups.**
- **Design and fabricate structural automotive components with reduced mass and cost, and with equivalent or superior performance to existing components.**
- **Develop new composite materials and processes for the manufacture of these high volume components.**

Focal Project 4

Approach

- This project targets ***two automotive structures***, a structural composite underbody and a lightweight composite seat, as well as the materials and processes required to produce them.
- The underbody project will ***design, analyze, fabricate, and test a structural composite underbody*** for a large rear-wheel-drive vehicle. The primary research outcomes of this project are:
  - o A 2 ½ minute cycle time (100k vehicles per year, 2 shift operation)
  - o Methods of joining and assembly of the underbody to the vehicle
  - o Processes for fabricating oriented reinforcement within the time window
- The seat project focuses on a ***second row seat which combines the functions of a seat*** (both with and without an integrated restraint system) ***and a load floor***. The seat must save mass, be cost competitive at volumes from 20k to 300k, and the seat back must fold flat to create a load floor.

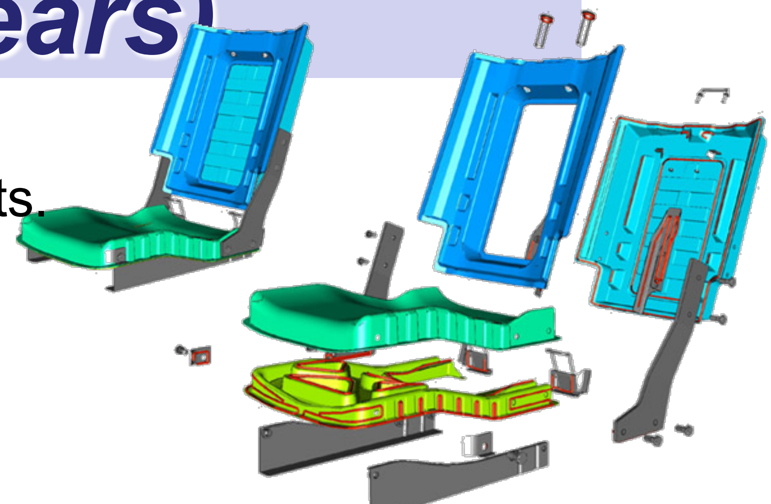
AUTOMOTIVE COMPOSITES CONSORTIUM

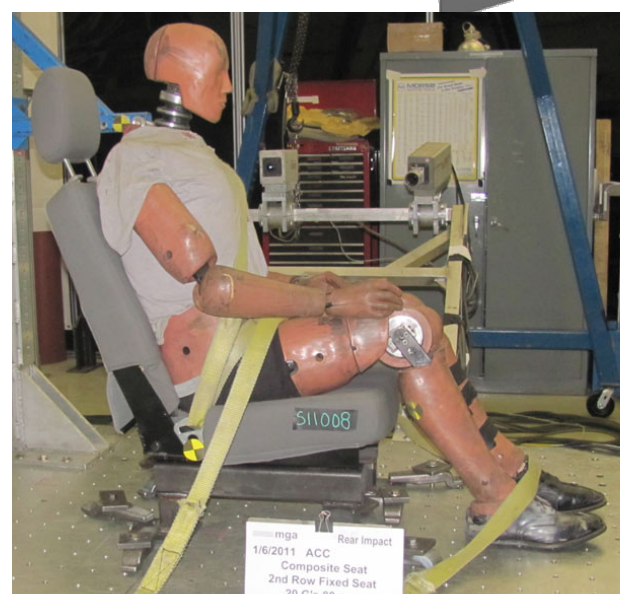
Milestones

Month/ Year	
Nov 2007	Structural Composite Underbody: Selection of a Material and Process System
Mar 2010	Structural Composite Underbody: Full Design of Underbody, Including Manufacturing and Analysis Scenarios
Dec 2010	Structural Composite Underbody: Fabrication of Testable Underbodies
Sept 2011	***Structural Composite Underbody: Assembly Testing and Correlation with Analysis***
Mar 2008	Lightweight Composite Seat: Initial Design and Structural Analysis
Aug 2009	Lightweight Composite Seat: Design for a Cost-effective Seat
Feb 2011	Lightweight Composite Seat: Fabrication and Testing of Seat

Composite Seat Technical Accomplishments (previous years)

- Completed final design of composite seat.
- Completed CAE for all loading requirements.
- Completed molding and assembly of 30 sets of seats.
- Tested 22 seats.





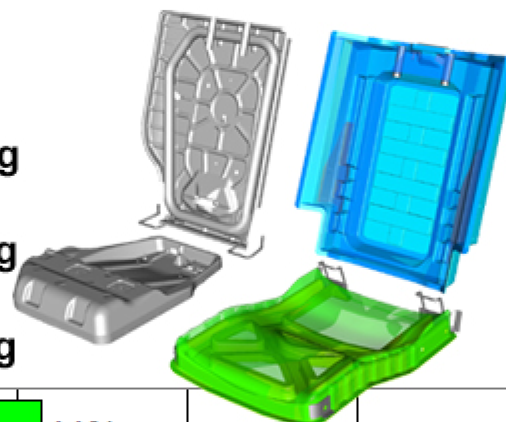
ACC
AUTOMOTIVE COMPOSITES CONSORTIUM

Composite Seat Technical Accomplishments (previous years)

- Achieved a 23% weight reduction for the seat structure compared to a typical steel seat structure.

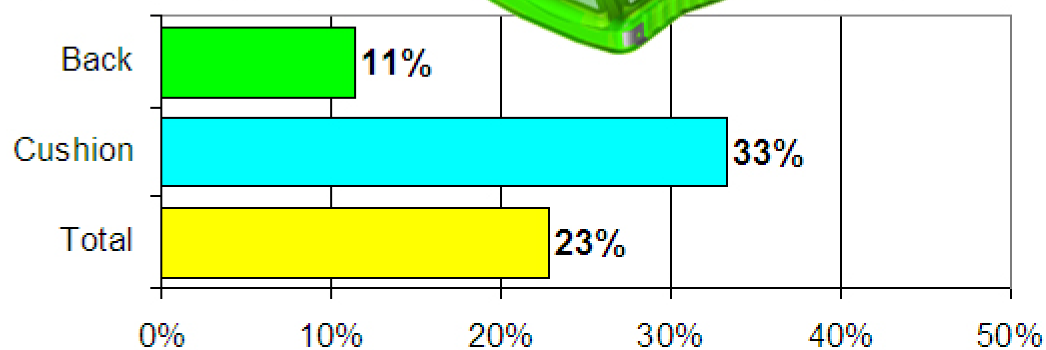
Steel Seat Structure

Back	3.56 kg
Cushion	3.88 kg
Total	7.44 kg



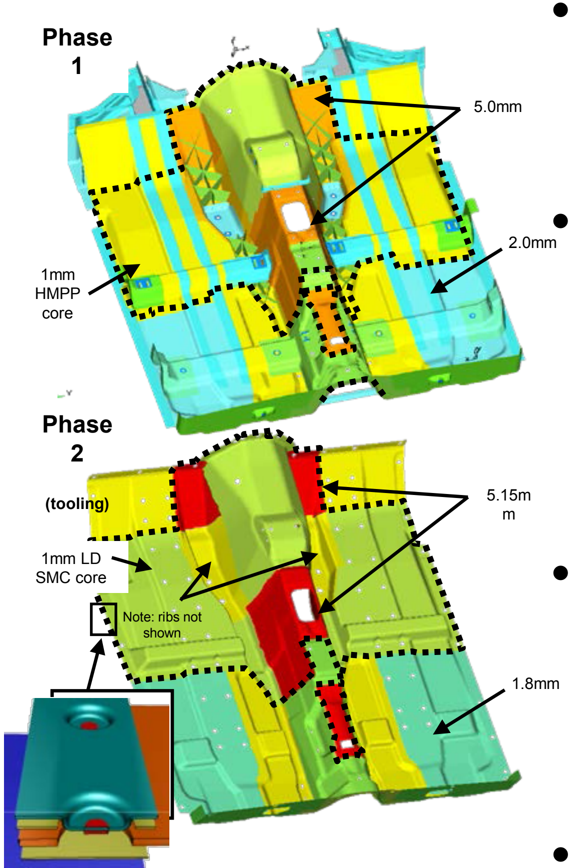
Composite Seat Structure

Back	3.16 kg
Cushion	2.59 kg
Total	5.75 kg



AUTOMOTIVE COMPOSITES CONSORTIUM

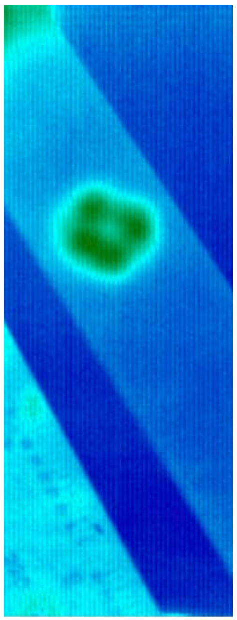
Technical Accomplishments (previous years)



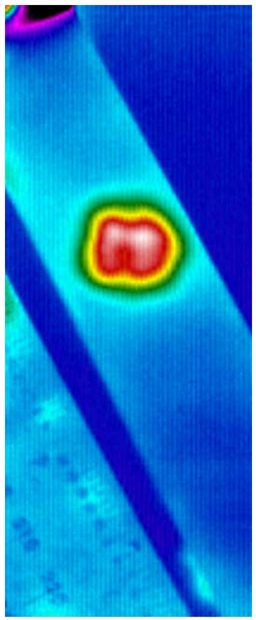
- Full design of underbody, including manufacturing and assembly scenarios
- Design composite underbody with high elongation material (patent granted in 2010), combining 16 steel parts
- Develop glass fabric/vinyl ester SMC with low density SMC core
  - Glass selected over carbon since part is strength limited instead of stiffness limited.
- Design mass savings 11.5 kg + enabling 3.3 kg mass savings from front rails, due to greater stiffness (31% of underbody and rail savings)
- Composite to steel weld bond joint (patents granted in 2010 and 2011)

ACC
AUTOMOTIVE COMPOSITES CONSORTIUM

Technical Accomplishments (previous years)

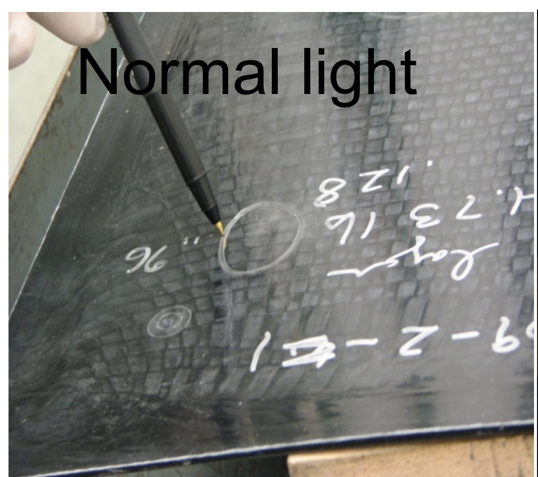


Impact side



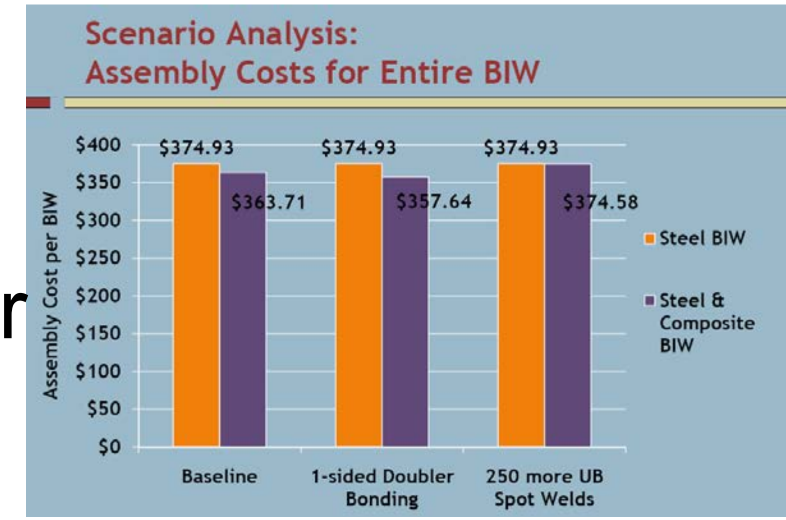
back side

- Non-destructive evaluation of impact damage from steel ball drops shown. Focused on:
  - Vibrothermography
  - UV florescent dye penetrant



Technical Accomplishments (previous years)

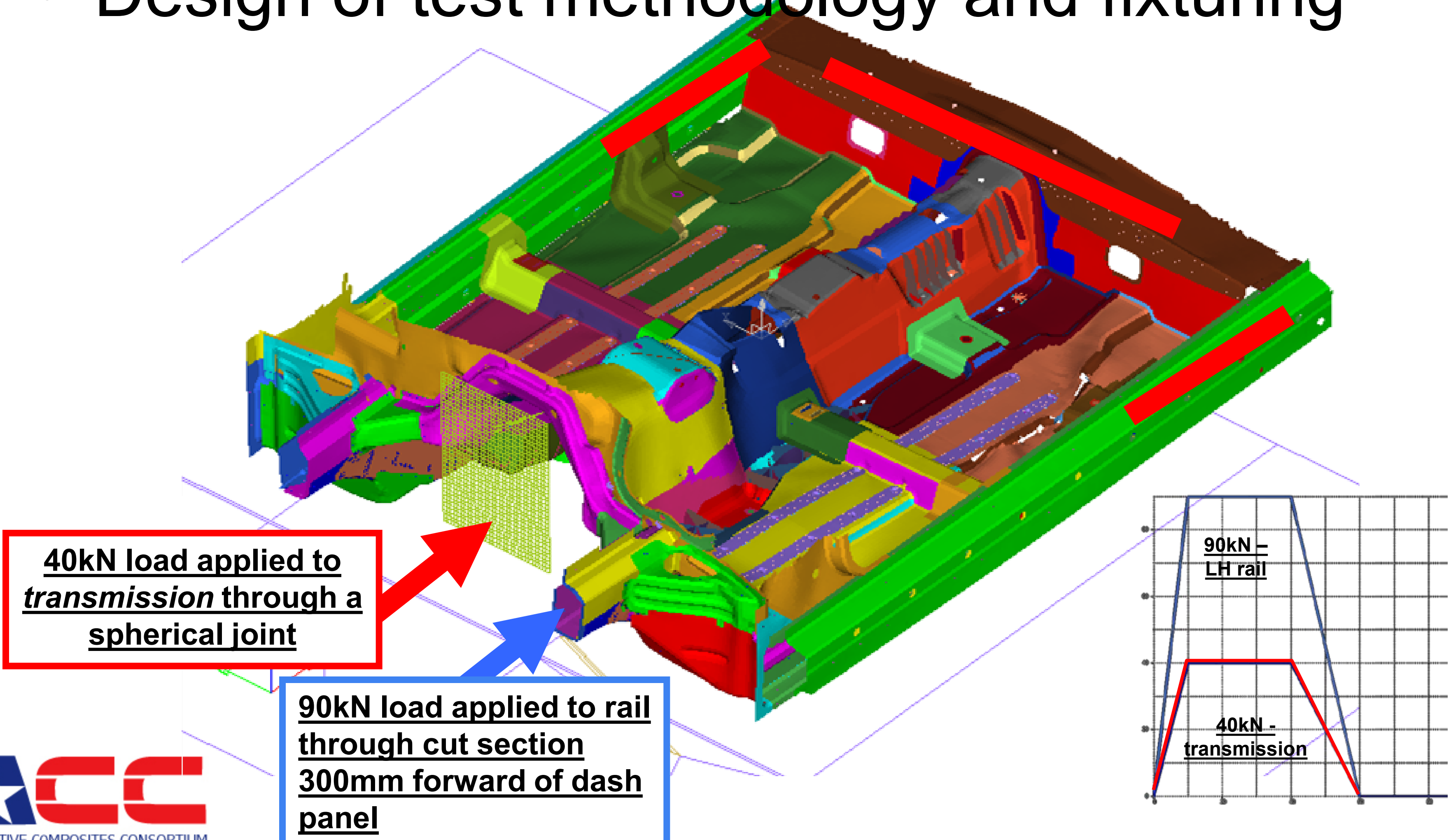
- Technical Cost Model
  - Manufacture and Assemble Underbody for $5/kg saved, based on TCM of steel and composite systems
- Successfully molded and delivered over a dozen Underbodies for assembly and testing



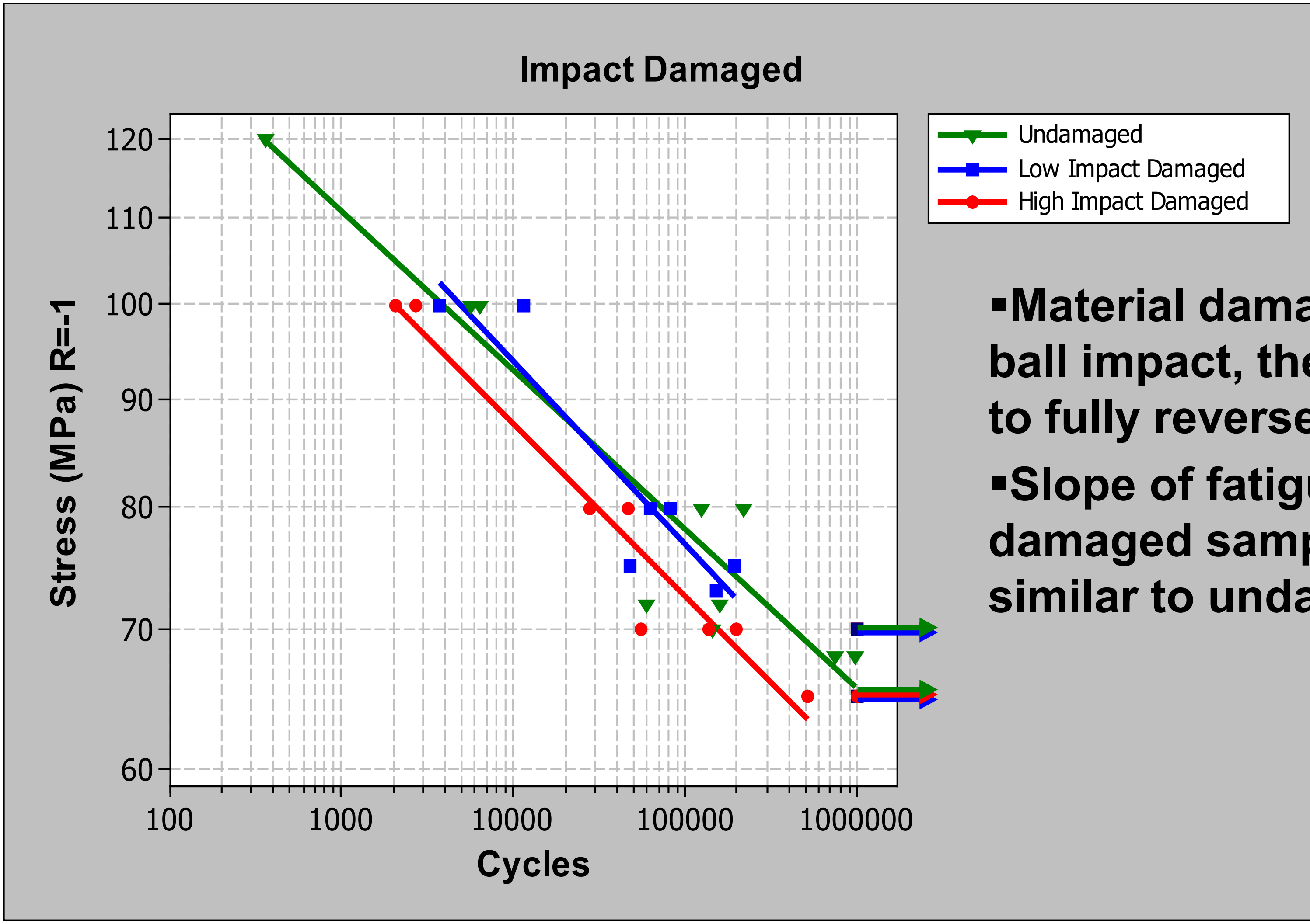
AUTOMOTIVE COMPOSITES CONSORTIUM

Technical Accomplishments (previous years)

- Design of test methodology and fixturing



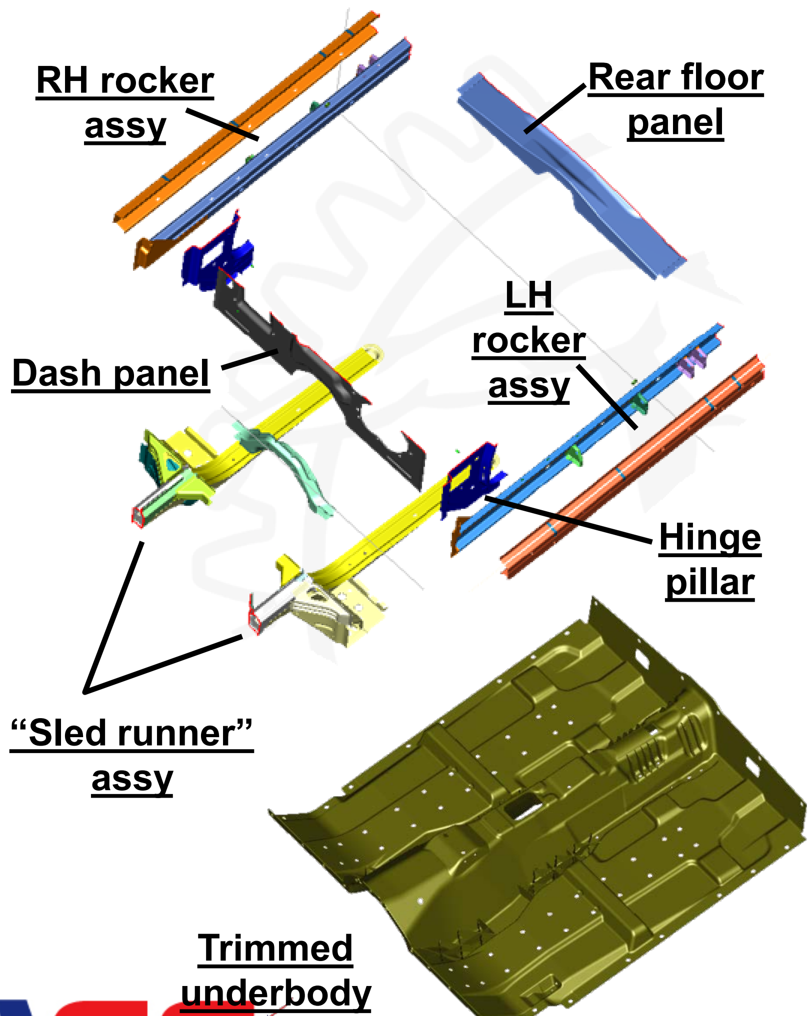
Material Fatigue after Damage



- Material damaged by steel ball impact, then subjected to fully reversed fatigue
- Slope of fatigue curve for damaged samples is very similar to undamaged

AUTOMOTIVE COMPOSITES CONSORTIUM

Assembly Build



- Modified BIW components and trimmed underbody were joined in a custom assembly fixture
- Crash-toughened epoxy adhesive was oven cured after spot welding

Assembly fixture

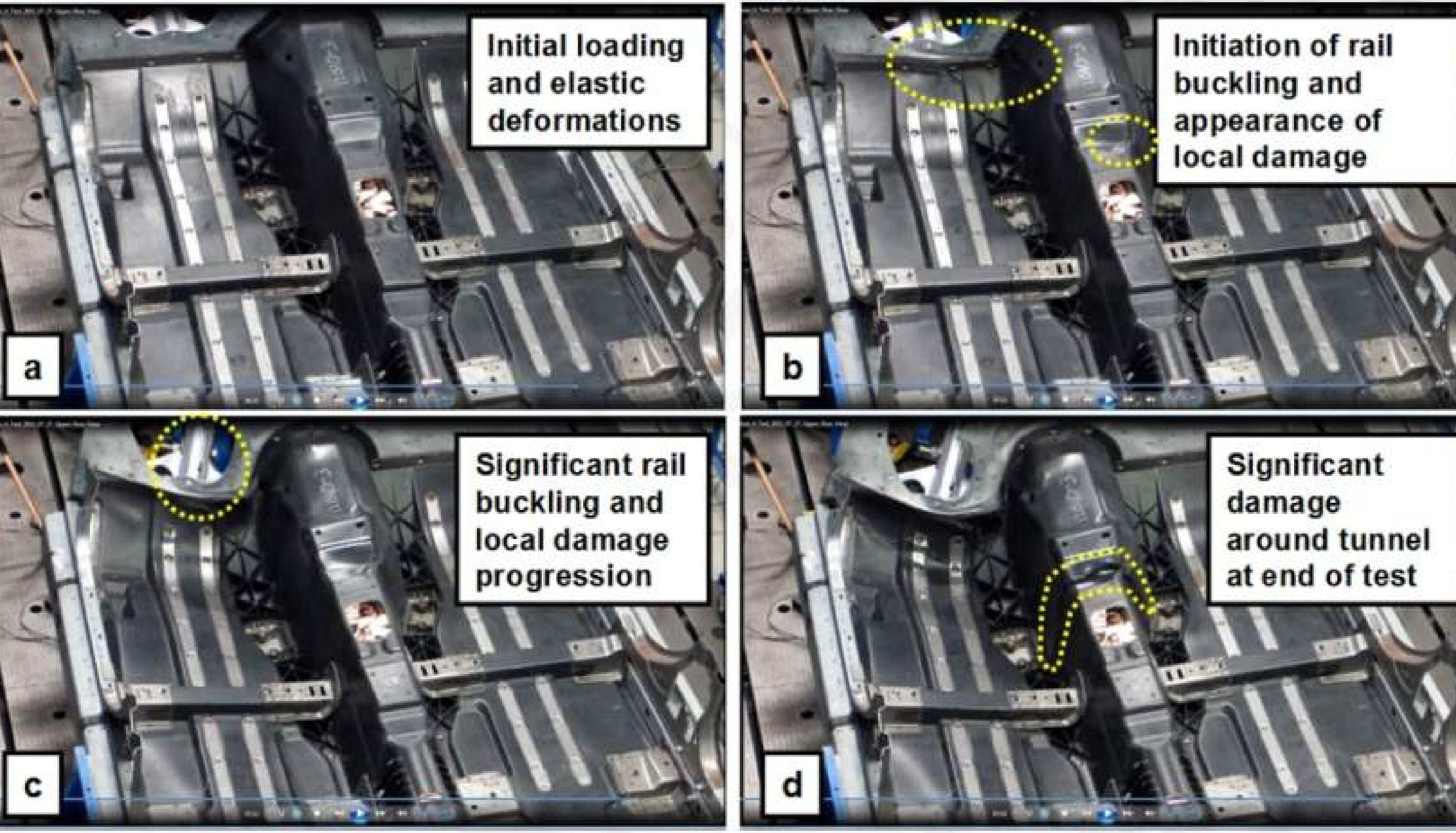
Completed Assembly

- Demonstrate full underbody molding
- Path forward for 2.5 min cycle with 3-piece tool and multiple preforming stations
- Assembly to steel BIW sections using weld bonding

Offset Deformable Barrier Results

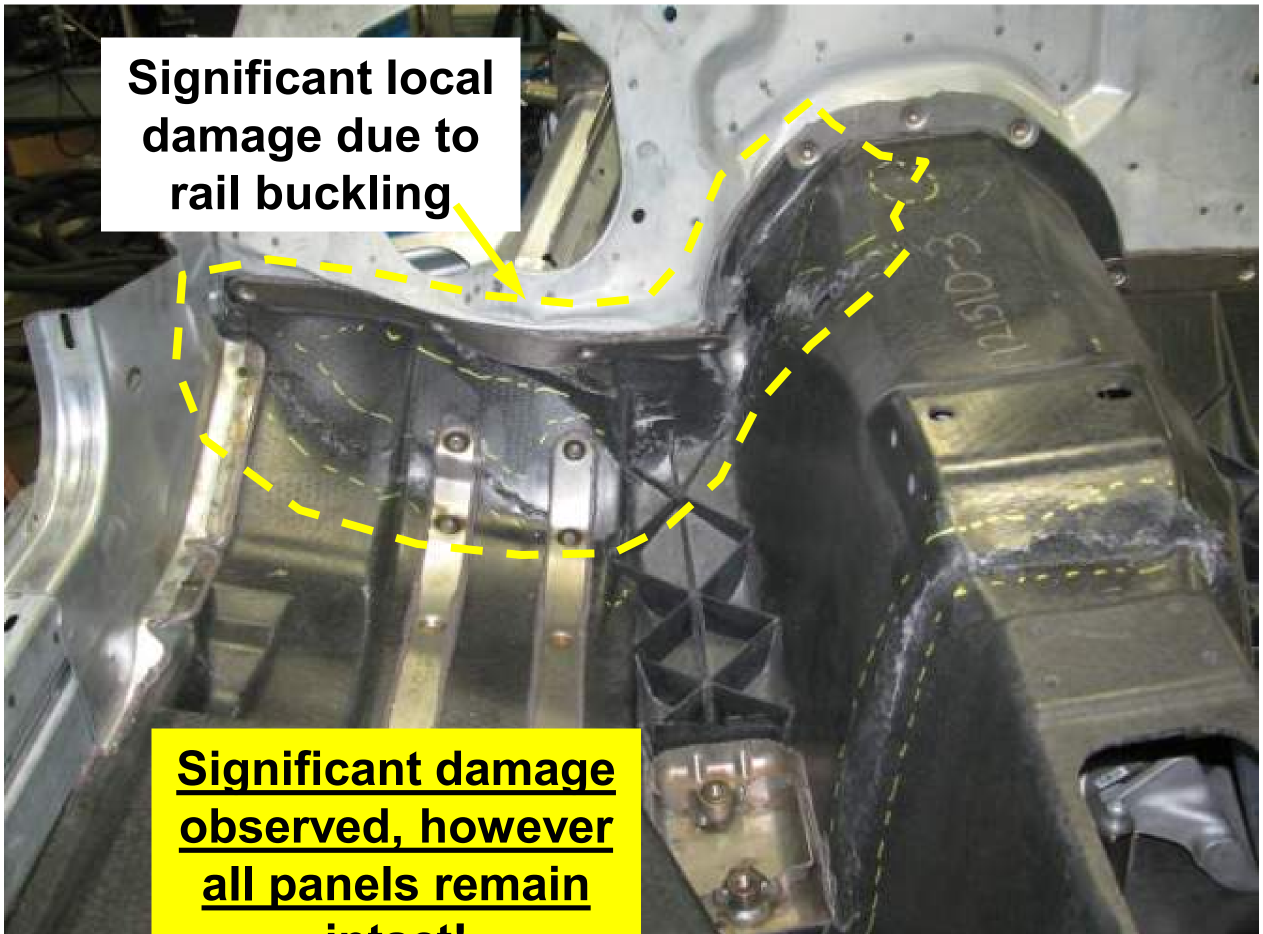
Load steel sled runner rail

Load transmission housing



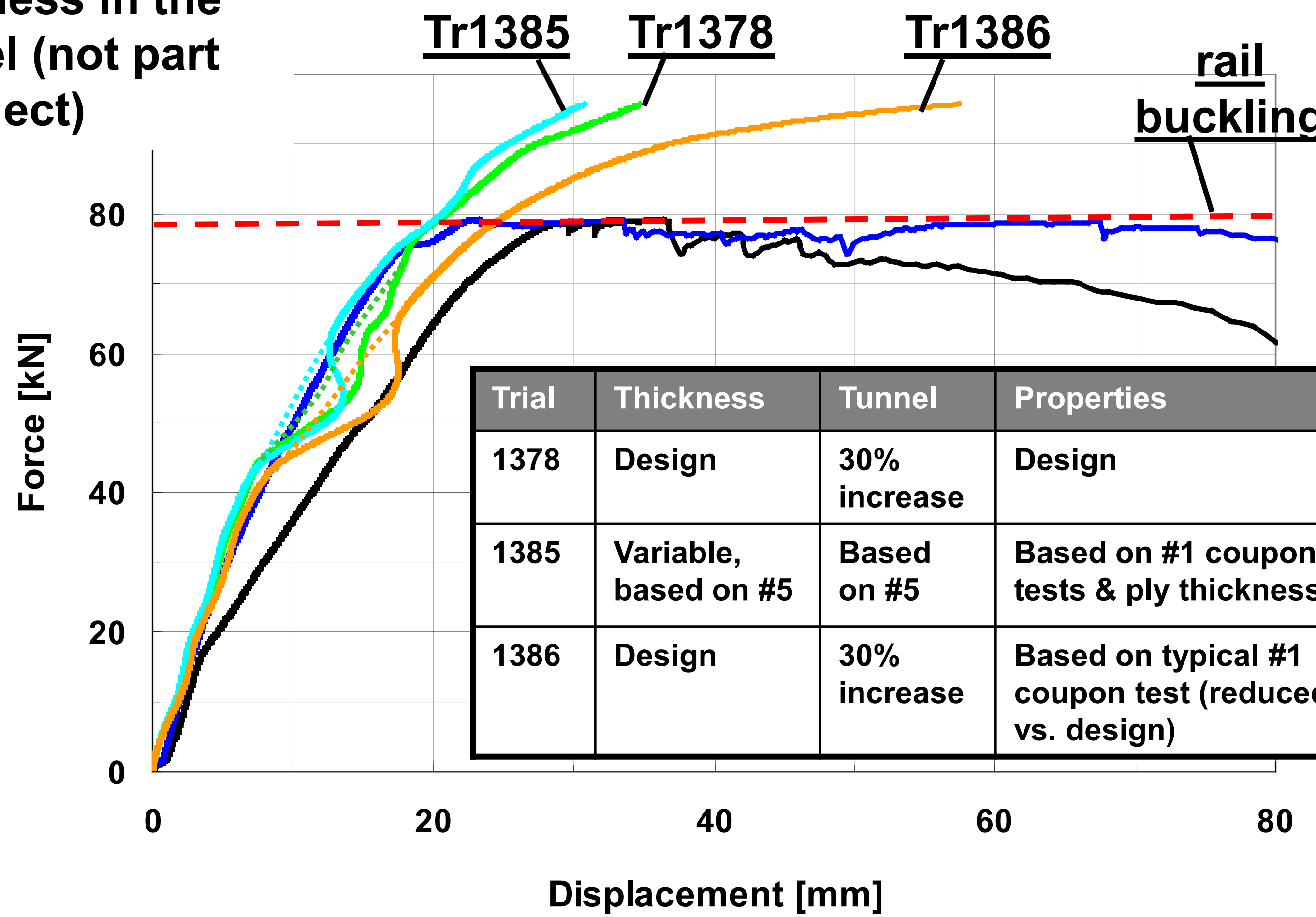
After ODB Test

Damage meets our structure criteria of no large section failure.



ODB/FEA Test Results

- Experimental curves fit very closely up to the premature buckling of the steel rail (dashed red line)
- Rail buckling caused by coarseness in the steel model (not part of this project)



Trial	Thickness	Tunnel	Properties
1378	Design	30% increase	Design
1385	Variable, based on #5	Based on #5	Based on #1 coupon tests & ply thickness
1386	Design	30% increase	Based on typical #1 coupon test (reduced vs. design)

Focal Project 4: Collaborations

- **Partners**
  - Multimatic
  - Continental Structural Plastics (CSP)
  - Century Tool and Gage
  - ORNL
  - U Mass Lowell
  - IBIS & Camanoe
  - Composite Products, Inc
  - Altair Engineering
  - Chelexa Design
  - RCO Engineering
  - MGA Research

- **Technical Transfer**
  - OEM's to determine opportunities for future implementation

Focal Project 4: Future Efforts

The technical work for both projects has been completed. We are writing final reports and publications.

Summary

- Structural Composite Underbody
  - Molding of full underbody part, which replaces 16 steel parts, saving 11.5 kg mass (31%)
  - Development of a high strength glass fabric SMC
  - Weld bonding assembly scenario demonstrated
  - Technical cost model indicates $5/kg mass saved
  - Design methodology demonstrated for crush of surrogate part
  - Molded underbodies were assembled to steel BIW components
  - Assemblies were tested in a simulated ODB test
  - Test results were compared to FEA analysis and found to compare well.

Summary

- Composite seat
  - Final design, CAE, molding and assembly of seats, showing 23% mass savings relative to steel seat
  - Static and dynamic testing of seat assemblies
- Both projects are finishing final reports