Automotive Composites Consortium Focal Project 4: Automotive Components from Structural Composites

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Member – ACC Board of Directors

Principal Investigators:

Libby Berger – General Motors (Underbody)

John Jaranson – Ford (Seat)

February 27, 2008

Approach

- Guide, focus, and showcase the technology research of the four ACC working groups (Materials, Processing, Joining, and Energy Management).
- 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, as well as methods for structural joining and assembly to dissimilar materials.

- This project will encompass two components and the materials and processes necessary to meet our objectives.
  - Structural Underbody
  - Second Row Seat
- Each with unique goals relative to:
  - Volume per annum
  - Physical size
  - Materials
  - Technology Development

Structural Composite Underbody

- While composite floorpans are currently in use in mainstream automotive production, none currently are designed to be structural in terms of carrying cras   loads. This project will demonstrate:
  - 2 ½ minute cycle time (100k vehicles, 2 shift production)
  - Structural joining and assembly
  - Oriented fibers in high volume applications

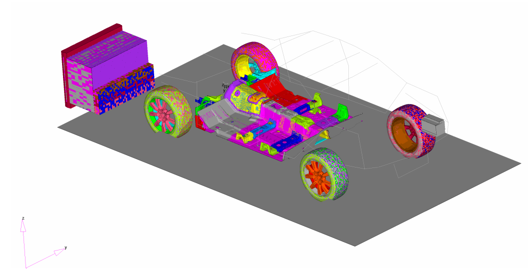
Project Approach

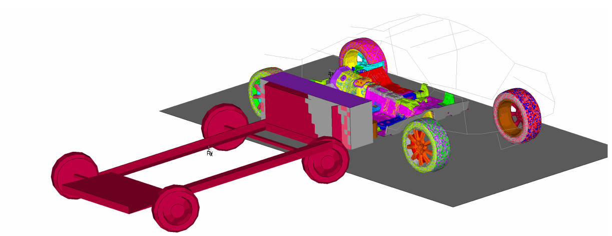
- *Phase 1* is the selection of a design concept and a material and process system (MPS) – completed Nov. 1, 2007
  - Preliminary design and analysis
  - Determination of properties for 3 MPS's
  - Technical Cost Model
- *Phase 2* will be full design, incorporating other components of the Multi-Material Vehicle, as available, based on the donor vehicle. 1Q09
- *Phase 3* will be fabrication of the underbody and assembly into the donor vehicle. 4Q10

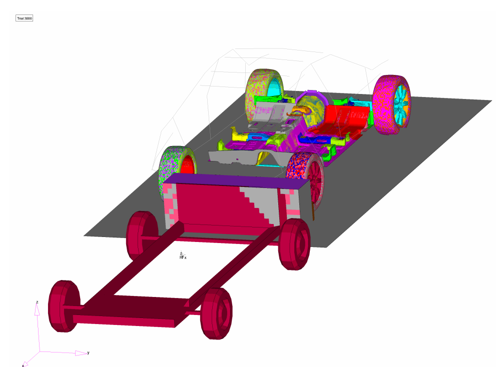
CAE Performance Assessment

Phase 1 Load Cases:

- Body-in-White (BIW) static torsional and bending stiffness
- BIW first bending and torsional modal response
- EuroNCAP/IIHS 40 mph Frontal Offset Deformable Barrier (ODB)
- FMVSS214 33.5 mph Side Impact
- FMVSS301 50 mph Rear Offset Impact





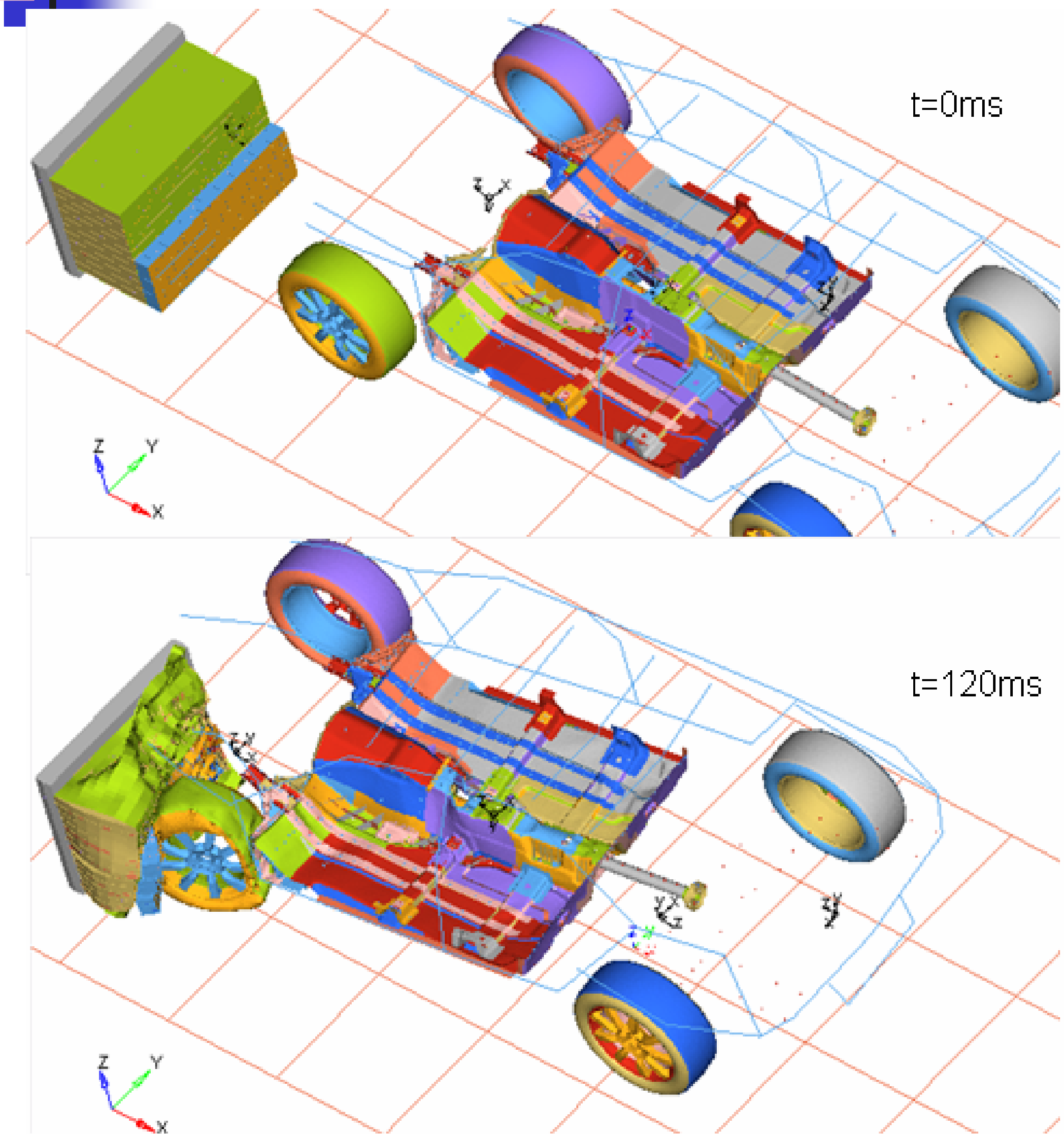


Crash requirements were found to overshadow the vehicle level stiffness requirements

40 mph Frontal ODB: Composite Proposals

- Based on the results of >135 ODB simulations, the most effective methods for achieving acceptable performance and mass reduction were:
  - Optimizing the local material thickness and orientation
  - Adding a high-elongation core material to the laminate with a thickness of up to 2.5mm in strategic regions of the floor
  - Allowing the driveshaft to telescope an additional 70mm
  - Reducing the thickness of the steel underbody rail components
  - Reducing the ribbing height and deleted the ribbing in some locations

Front ODB – Predicted Deformed Shape for Proposed Composite Underbody



Only localized damage predicted – acceptable failure

Mass Comparison: Steel vs. Composite

- Mass summary for fiberglass fabric based design with a 2.5mm thick high strain-to-failure high-elongation core
- Mass reduction depends on material assumptions
- Stiffness increase from composite floorpan allows decrease in rails, as well as further anticipated mass compounding

Trial	Description	Total (Floor & Rails)			Floor Only			Rails Only		
		Mass	Reduction		Mass	Reduction		Mass	Reduction	
		kg	kg	%	kg	kg	%	kg	kg	%
1098	Baseline steel	68.5	0	0%	44.9	0	0%	23.6	0.0	0%
1103	Fiberglass fabric, 2.5mm core, reduced rail thickness, telescoping driveshaft	53.9	-14.6	-21%	33.6	-11.3	-25%	20.3	-3.3	-14%

Significant additive mass reduction

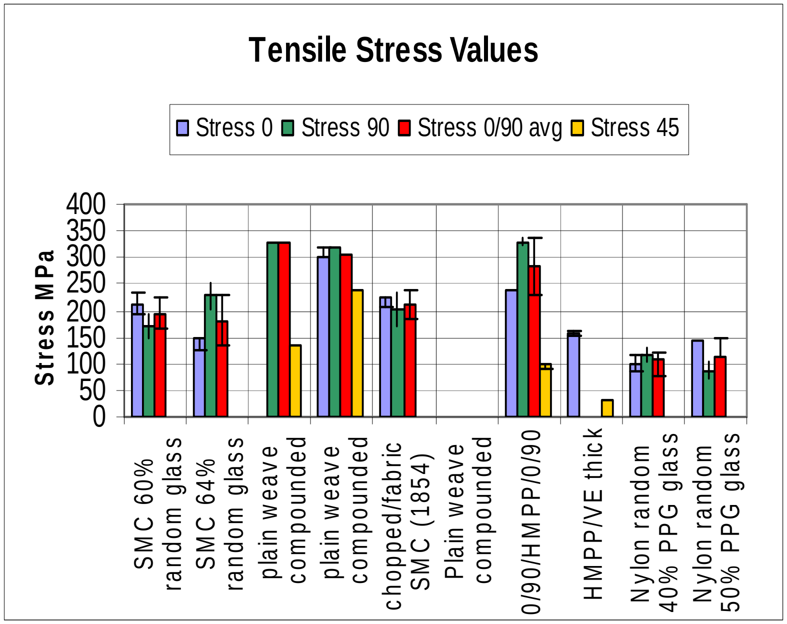
Primary mass reduction

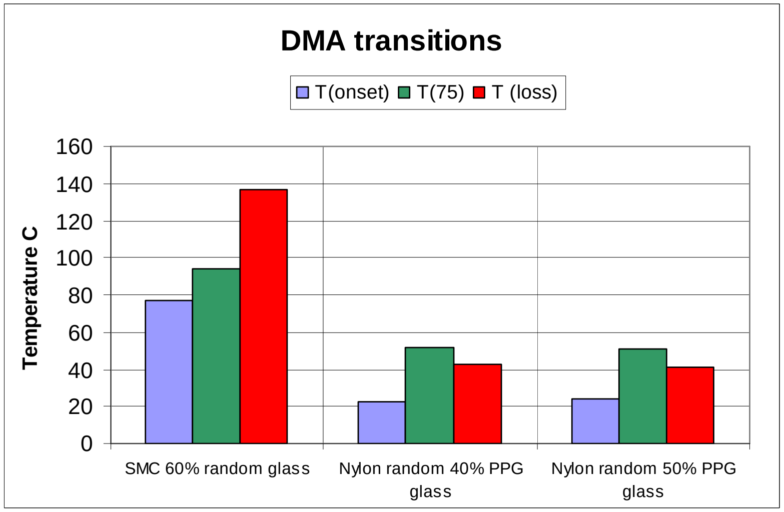
Secondary mass reduction

Material and Process Trials

- SMC
  - Random material to 61 wt% glass
  - Compounded glass fabric material
  - Compounded material with high-elongation core
- DLFT
  - Random polyamide to 50 wt%
  - Glass fabric molded with random
- LFI
  - Random material to 60 wt%
  - Fabric reinforcement still under development

- Best mechanical properties are for SMC with fabric
- Thermal properties of SMC are significantly higher than for polyamide DLFT





MPS Selection

- Cost model does not show major differences between the 3 processes
  - Assumes lower cost nylon will work
- SMC is the only process that has so far demonstrated ability to mix random with high content fabric
- Fabric/core saves the mos mas
- Carbon fabric saves about 3 kg more mass than glass, but at a cost of about $250 more at current carbon pricing.
- Select SMC glass fabric, with cor   if it can meet th temperature requirements, as our mainstream MPS
- Continue to develop the LFI and TP processes and evaluate the benefits they would have to a structural composite underbody

Assembly and Joining

- Weld-bonding
  - A combination of welding and bonding
  - Welds have two functions
    - Peel stoppers
    - Fixturing for cure
  - Joints perform better than either welding or bonding alone
  - Study underway to compare static and dynamic weld-bonded joint behavior
    - With ORNL TMAC facility
- Mixed material joint durability project (proposed with ORNL)
  - CLTE mismatch
  - Environmental exposure
  - Creep
  - Fatigue

Accomplishments

- Crash requirements found to overshadow the vehicle level stiffness requirements
- Preliminary design shows mass savings of up to 14.6kg in floorpan and rails
- Innovative materials and processes demonstrated in SMC and DLFT
  - Use of compounded fabric in SMC
  - Use of fabric in DLFT
  - Addition of high-elongation core
- SMC with glass fabric and high elongation core selected as Material and Process System

Composite Seat Team

- Chrysler
  - Jerry Olszewski
  - Jeremy Panasiewicz
  - Becky Joitke
- Ford
  - John Jaranson
  - Dan Houston
- General Motors
  - Pete Foss
  - Chuck Mentzer
- Supplier Partners
  - Altair Engineering
  - Chelexa Design
  - EPFL
  - MSX International

Project Assumptions/Scope

- **Vehicle Level**
  - 2nd Row Outboard Seat only
  - Minivan/Crossover/SUV Comparator Vehicles
    - Land Rover LR 3
    - Chrysler Town & Country (Stow N Go)
    - Chevrolet GMT800
  - Up to 340k upa Volume
- **Structures Level**
  - Back Frame and Cushion Frame only
  - Carry-over Headrest Design
  - Mechanisms and legs not included (except as related to attachments and joints)
  - Seat Integrated Restraint to be included.
- **Materials Level**
  - Thermoplastics and Thermosets included
  - Glass reinforcement with local carbon as required
  - Metal reinforcements included.

Stretch Research/Approach

- **Design**
  - Parts Integration of Structural and Appearance parts.
    - Seat back structure
    - Load Floor Structure
    - Load Floor Appearance
  - Hard Point Design
    - Belt Attachment
    - Pivot Points
    - Head Restraint Attachments
- **Structure/Materials/Process**
  - Orientated Fibers in High Volume
  - Carbon and Glass hybrids
  - Thermoset and Thermoplastic Materials.
- **Design Approach**
  - Design and CAE Analysis to determine optimal design of the seat structure
    - Include material considerations in optimization
  - Cost Modeling to determine appropriateness of design and material selection
- **Verification and Prove-out**
  - Development manufacturing processes for materials and part design
  - Build and test prototypes
  - Verify cycle time and cost assumptions.

Current Design

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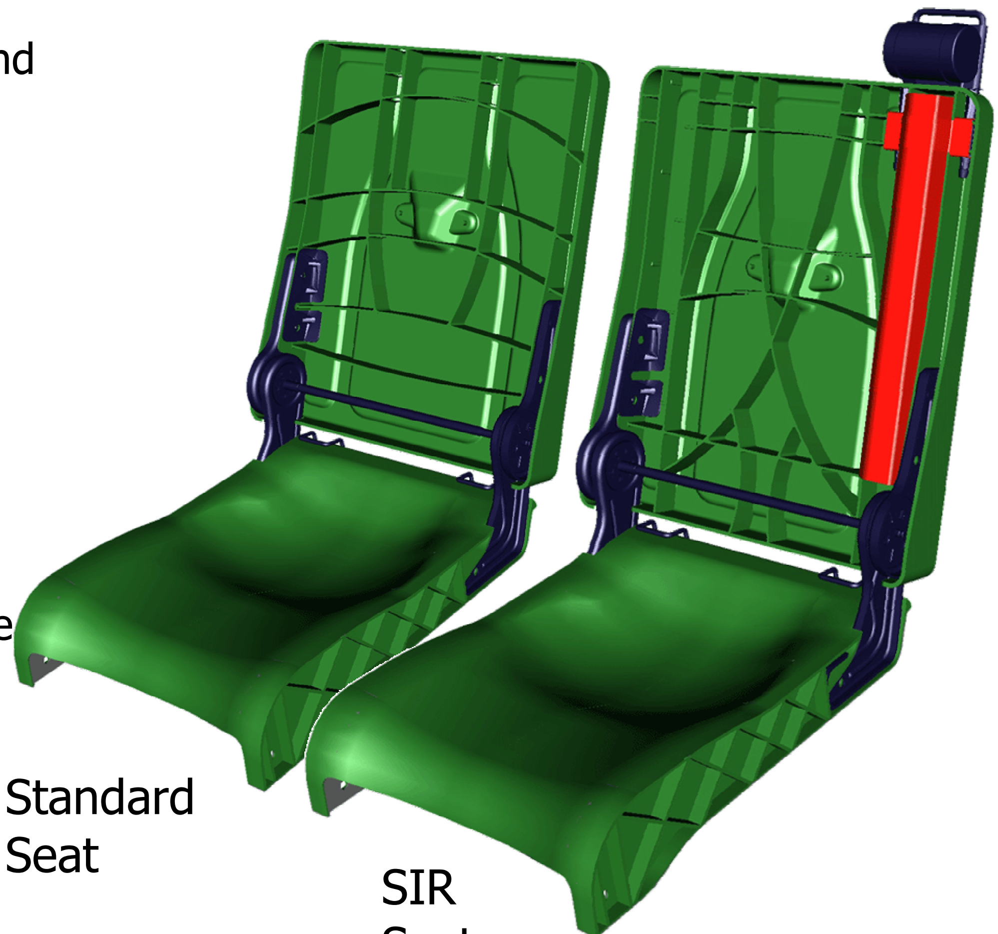
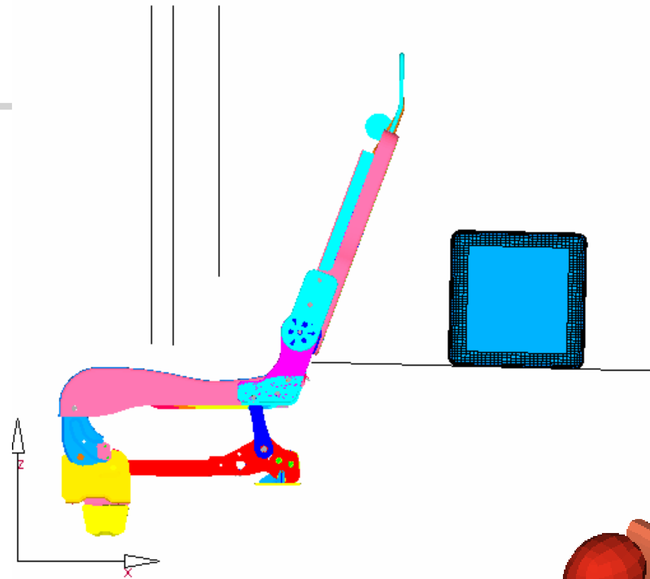
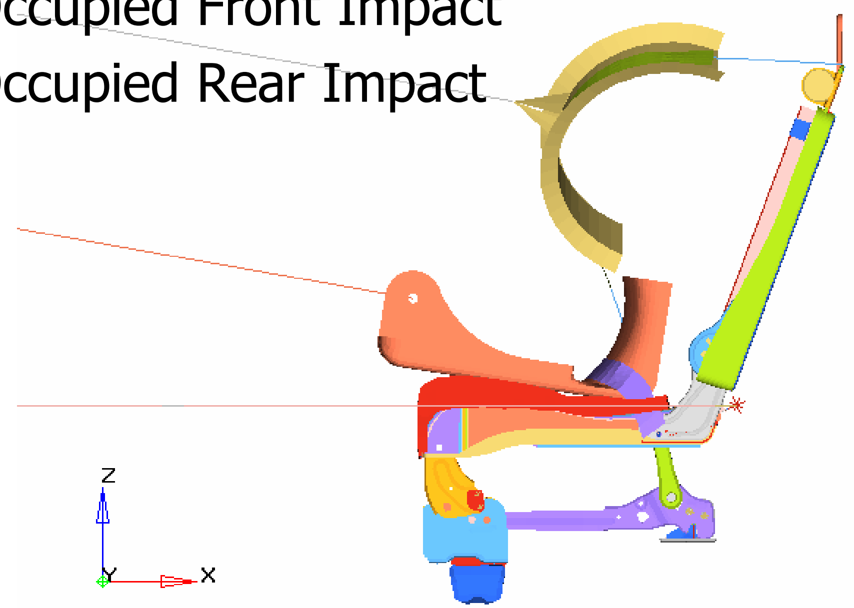
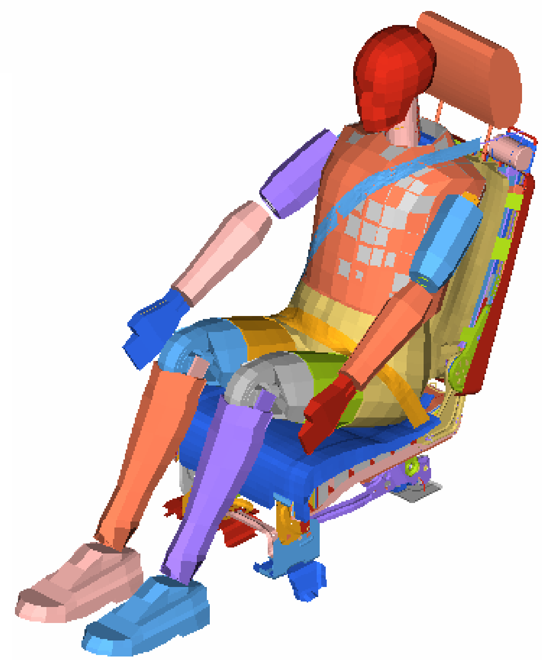


Current Design

- **CAE Analysis**
  - Current designs meet worst case load requirements
    - FMVSS 207/210 Belt Load
    - ECE0017 Carg   Retention
    - 25g Occupied Front Impact
    - 20g Occupied Rear Impact







Weight Status

Focal Project 4 Composite Seat	Weights (kg)						
	Complete Seat	Riser	Headrest	Soft Trim	Hardware	Cushion Str	Back Str
Comparators							
DCX Stow N Go (non-SIR)	33.02	15.34	0.89	3.59	6.79	4.62	1.79
Ford LR3 (non-SIR)	23.65	8.79	0.63	2.78	3.36	4.28	3.81
GM GMT900 (non-SIR)	22.41	9.29	0.69	3.37	2.29	3.47	3.30
Average (no DCX)	23.03	9.04	0.66	3.08	2.83	3.88	3.56
Targets - 30% Weight Save	**20.46**	**8.80**	**0.63**	**3.00**	**2.83**	2.71	2.49
Current Design Status							
Composite Std Seat	20.52	8.80	0.63	2.78	2.63	2.70	2.98
%Weight Save	11%	3%	5%	10%	7%	30%	16%
Weight Save (kg)	2.5	0.2	0.0	0.3	0.2	1.2	0.6
Composite SIR Seat	22.30	8.80	0.63	2.78	3.59	2.89	3.10

Specifc Gravity Assumptions	Steel	7.8
	Carbon/Nylon	1.3

Cost Modeling

- EPFL is creating TPP4 versions of the seatback for comparison.
  - Glass filled Polypropylene
  - Non-appearance
  - Seatback only
    - Both Standard and SIR
- Preliminary cost modeling is complete.
  - ACC Carbon fiber seat looks to be cost prohibitive.
  - Additional work needs to be completed to get complete cost picture.