Overview

Timeline
• Start – October 2006
• Finish – December 2010
• 55% Complete

Budget
• Total Project Funding
  • DOE: $4,600k
  • Contractor: $720k
• Funding received FY07
  • $920k
• Funding received FY08
  • 943k
• Funding for FY09
  • $943

Barriers and Targets
• A 2 ½ minute cycle time (100k vpa, 2 shift operation)
• Methods of joining and assembly of the composite structure to the vehicle
• Processes for fabricating localized areas of oriented reinforcement within the time window

Partners
• Multimatic
  • Design and engineering
• U Mass Lowell
  • Fabric drape analysis

This presentation does not contain any proprietary, confidential, or otherwise restricted information
Objectives

• 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.
Approach

Design, analyze, fabricate and test a structural composite underbody, capable of carrying crash loads, focusing on:

- A 2 ½ minute cycle time (100k units per year, 2 shift operation)
- Methods of joining and assembly of the underbody to the vehicle
- Processes for fabricating oriented reinforcement within the time window

Design, analyze, fabricate and test a second row composite seat which will combine the functions of a seat and a load floor.
Milestones

• Structural Composite Underbody
  • *Phase 1:* The selection of a design concept and a material and process system, completed 4Q07.
  • *Phase 2:* Full design, 4Q09.
    • Underbody, suitable for full tooling.
    • Fabrication and assembly scenario.
  • *Phase 3:* Fabrication and testing of the composite underbody, 4Q10.

• Composite Seat
  • *Phase 1:* Develop ribbed single surface design. Completed 1Q08.
  • *Phase 2:* Develop bonded two-piece design. 2Q09.
Technical Accomplishments
Structural Composite Underbody

- Selected glass fabric SMC with a high elongation core as material and process system
  - Glass fabric gives high strength needed for crash loads
  - High elongation core allows for structural connectivity post crash (more development needed for core)
  - Enables a 31% mass savings over optimized high strength steel

- Developed design methodologies for acceptable static and dynamic performance
Technical Accomplishments
Structural Composite Underbody

• Selected surrogate tool for initial processing, fabric drape, and correlation of analytical and experimental dynamic testing.
Technical Accomplishments
Structural Composite Underbody

• Initial testing of composite-to-steel weld bond joint, with steel double (Applied for US patent)

• Demonstrated vibro-thermography for NDE of damaged weld bonds.
Future Direction
Structural Composite Underbody

- Development of high elongation core material
- Fabrication of surrogate parts
  - 2 ½ minute cycle time
  - Drape analysis
  - Durability and high strain rate properties
- Weld bonded joint development
  - Processing
  - High strain rate properties
  - Durability
- Development of NDE techniques for durability validation
  - Target use by independent body shop
  - Low cost
  - Easy to use
Summary

Structural Composite Underbody

- A structural composite underbody, capable of carrying crash loads, is being designed and fabricated.
- A weld bonding method for joining the composite to a steel structure has been developed.
- Fabric drape analysis is being used to guide processing and to fine tune the design.
- Non-Destructive Evaluation methods for manufacturing quality and long-term inspection are being developed.
Technical Accomplishments
Composite Seat

• Inner and outer bonded shell designs allow much more geometric section modulus to be designed into the seat.

• Adhesive bonding of the inner and outer shell provides closed sections for managing loads.
Technical Accomplishments
Composite Seat

- Cost modeling of initial design has been completed that shows:
  - Significant cost penalties for carbon based designs
  - Opportunity to get reasonable cost with glass based designs.

<table>
<thead>
<tr>
<th>Cushion</th>
<th>Weight (kg)</th>
<th>Weight (kg)</th>
<th>Cost [1] ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACC Carbon Design</td>
<td>2.70</td>
<td>2.92</td>
<td>$73.76</td>
</tr>
<tr>
<td>% of Steel Comparator</td>
<td>-30%</td>
<td>-18%</td>
<td>738%</td>
</tr>
<tr>
<td>ACC Re-Design Carbon</td>
<td>1.71</td>
<td>2.11</td>
<td>TBD</td>
</tr>
<tr>
<td>% of Steel Comparator</td>
<td>-56%</td>
<td>-41%</td>
<td></td>
</tr>
<tr>
<td>ACC Re-Design Glass</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>% of Steel Comparator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EPFL Carbon Design</td>
<td>na</td>
<td>1.50</td>
<td>$41.51</td>
</tr>
<tr>
<td>% of Steel Comparator</td>
<td>-58%</td>
<td></td>
<td>415%</td>
</tr>
<tr>
<td>EPFL Glass Design</td>
<td>na</td>
<td>2.42</td>
<td>$15.74</td>
</tr>
<tr>
<td>% of Steel Comparator</td>
<td>-32%</td>
<td></td>
<td>157%</td>
</tr>
<tr>
<td>Steel Comparator</td>
<td>3.88</td>
<td>3.56</td>
<td>$10.00</td>
</tr>
</tbody>
</table>

[1] at 260k upa

This presentation does not contain any proprietary, confidential, or otherwise restricted information.
Future Direction
Composite Seat

• Optimize design of carbon-reinforced design

• Develop glass-reinforced composite design based on above design.

• Re-do cost modeling exercise to determine final cost of a composite seat structure.

• Determine appropriateness of tooling, building parts and testing them based on the results of the above steps.
Weight savings greater than 50% can be achieved with a carbon reinforced composite seat structure, *but at significant cost penalty*.

A two-piece bonded design is being developed with glass-reinforcement to reduce the cost.