ACC 040 Development of Manufacturing Methods for Fiber Preforms

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Member – ACC Board of Directors

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Ford Motor Company

27 February 2008

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ACC 040 Manufacturing Methods for Fiber Preforms

Purpose

- Develop and demonstrate fiber preforming processes to decrease cost, increase manufacturing rates and improve reproducibility of large preforms for composite molding.
- Extend processing technology to include thermoplastic matrix composites (TP-P4).
- Develop low cost process technology for high volume processing of lightweight structural thermoplastic composites.
  - Develop P-4 chopper gun technology to produce tailored hybrid blanks from a combination of glass, carbon and natural fiber reinforcements for subsequent hot flow compression molding.
- Explore opportunities to integrate structural components into one molded structure.
- Demonstrate encapsulation process combined with part consolidation.
- Determine the feasibility of using polymer encapsulation to mitigate Mg corrosion concerns.

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Team Members

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ACC 040 Manufacturing Methods for Fiber Preforms
‘Thermoplastic P-4 Process Development”

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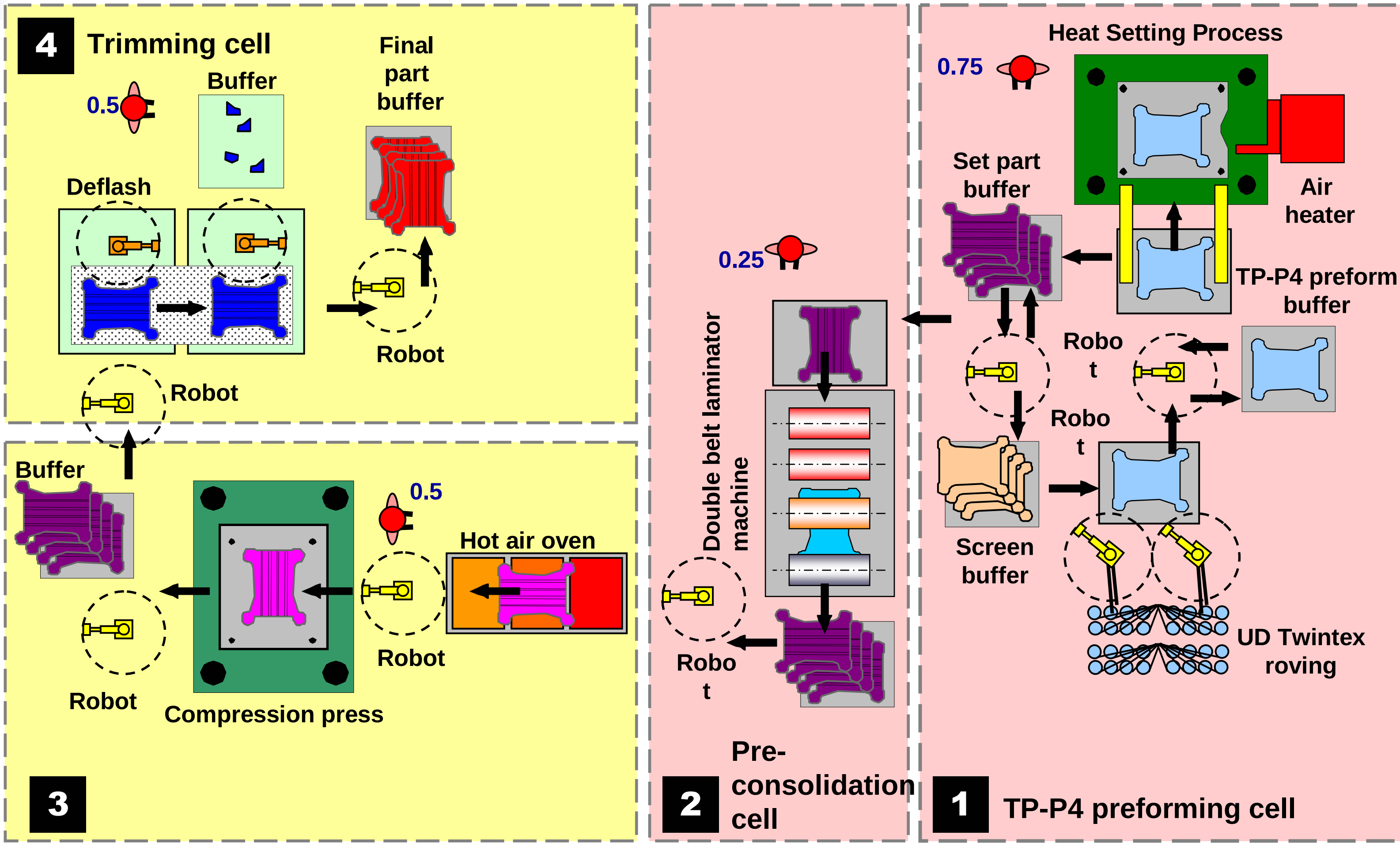

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Proposed TP-P4 Compression Molding Cell

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Approach

- Based upon 2006 analysis, cost appears favorable, but cost benefits of TP-P4 process technology need further verification.
- Fiber chopping process studies (Norris ORNL)
  - Verify throughput capability for 45s cycle times.
  - Demonstrate process robustness for continuous, uninterrupted operation.
- Establish consolidation and pre-heating methods
  - Investigate batch vs. continuous consolidation methods.
  - Explore the possibility of eliminating pre-consolidation step.
- Demonstrate hot flow compression molding of TP-P4 materials

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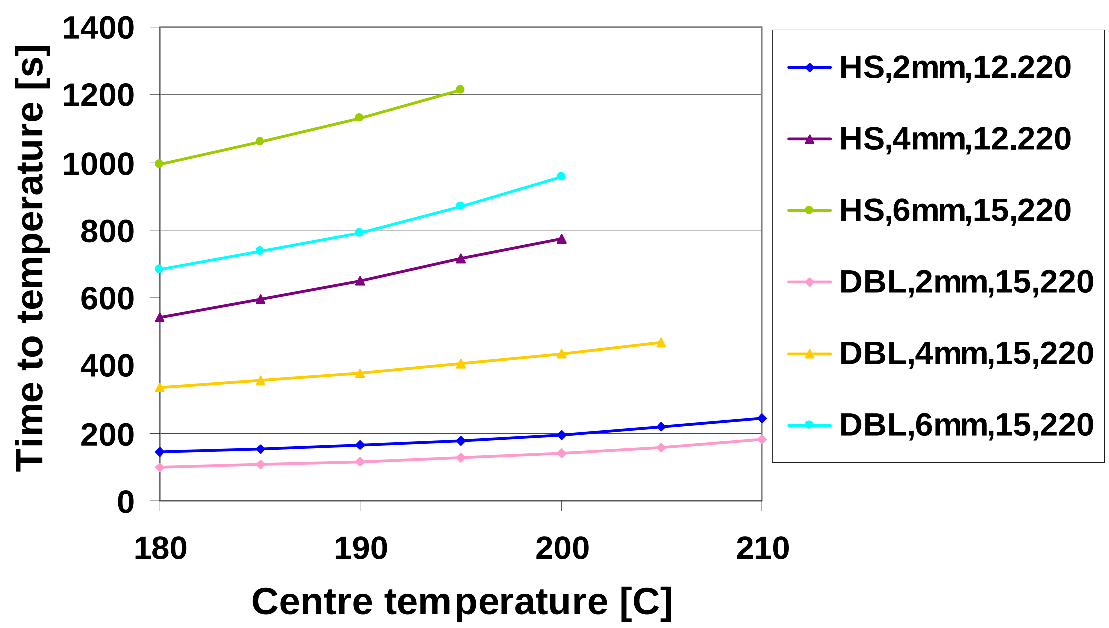
Consolidation and pre-heating methods

- Time required to heat a DBL 6mm to 190°C in centre ~7x a 2mm thick sample
- Laminated (DBL) blanks heat up at least 50% faster than HS
- 2mm DBL panels heat up 7x faster than DBL 6mm
- Fan speed: statistically insignificant for both HS and DBL materials
- Surface of the samples 'browner' when using warmer oven or higher fan speed

Other observations…

- **TP-P4 materials degraded before GMT and GMTex materials under the same conditions**
- **Using a forced hot air convection oven, 220°C was reached without degrading 2mm TP-P4 blanks**



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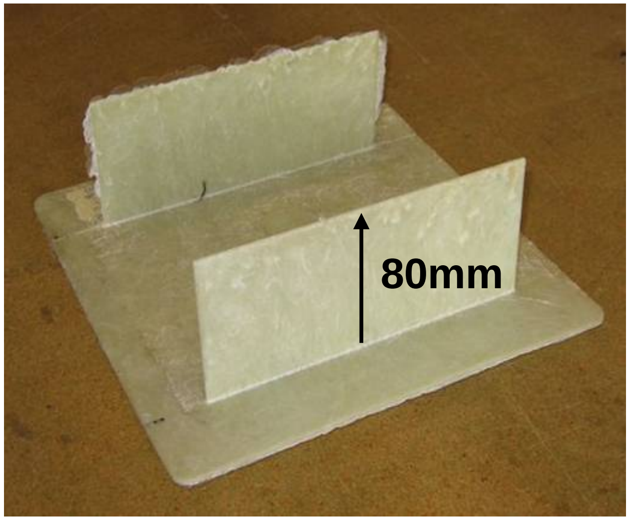
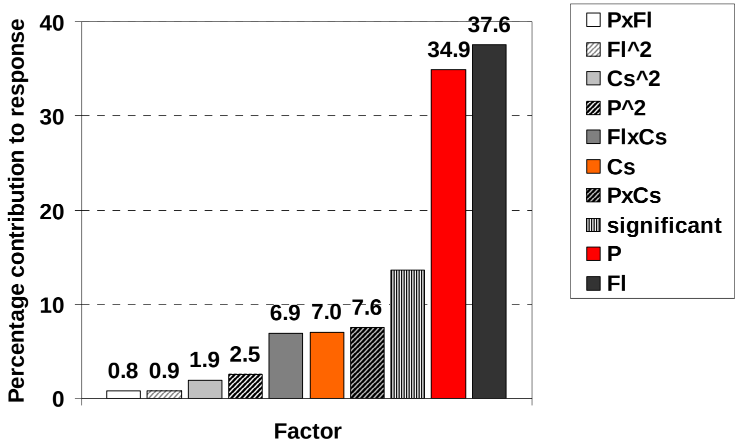
Rib Flow Studies

Parameter	Low	Med	High
Fibre length [mm]	25	50	75
Pressure [bar]	150	200	250
Compression speed [mm/s]	20	70	120



- **Three 2mm panels (216 x 216mm) heated to 220°C in a forced hot air oven**
- **Pressed to a final main panel thickness of 3mm**
- **Time at pressure = 30s**
- **Tool temperature = 60°C**



Observations

- **Complete filling of the mould was achieved with 25 and 50mm panels**
- **Also for 75mm by increasing the pressure to 300bar**
  - **a little outside the DOE bounds**
- **Little warpage was observed and the base plate was smooth and flat**

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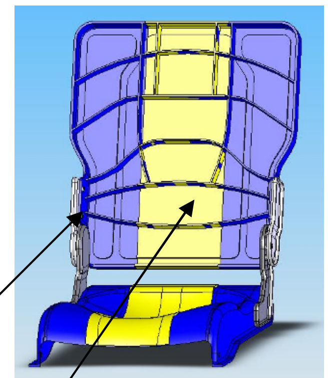
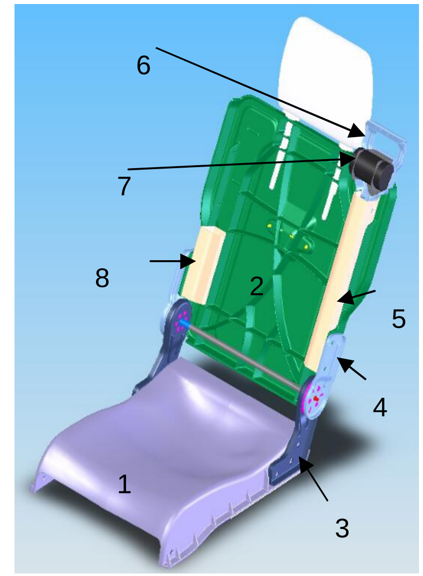
Design, cost, ROI modeling - initiated

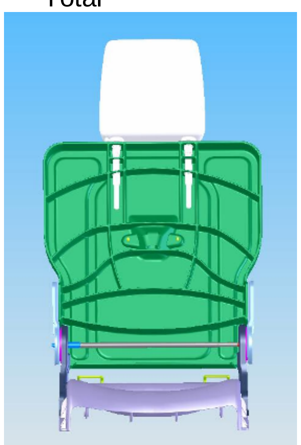
	Part	Material	Quant	Thickness	Dens	Mass
			-	mm	kg/dm3	g
1	Seat pan	PA/carbon	1	5	1.5	2900
2	Seat back	PA/carbon	1	5	1.5	2810
3	Recliner bracket, lower	Steel 550X	2	3	7.8	540
4	Recliner bracket, upper	Steel 550X	2	3	7.8	390
5	Reinforcement tube1	Steel 550X	1	1.5	7.8	880
6	Web guide	Steel ?	1	x	x	x
7	Retractor	Assy	1	x	x	x
8	Reinforcement tube2	Steel 550X	1	1.5	7.8	350
	Total					8800



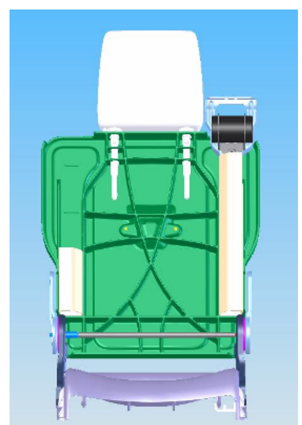
Blue: UD carbon structure

Yellow: PA/carbon …





STD – Standard Seat



Volumes: 20,000 – 340,000 units per year
Life time: 5 years

SIR – Seat Integrated Restraint

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Accomplishments

- TP-P4 process
  - Chopping system improved (6kg/min) but requires further work to match cost model assumptions (7.5 to 12.2 kg/min for 1 robot)
  - Parts successfully molded at pilot scale without DBL preconsolidation, but limit of 3mm (final blank thickness) to avoid degradation
- Deep rib fill is possible with TP-P4; as fiber lengths increase higher pressures are needed
  - TP-P4 can be co-compression molded with GMT
  - Significantly improved mechanical properties vs. GMT

- Rear seat case study
  - Work in progress
    - Final design, FEA, and cost results in progress
    - Next decision gateway will occur following seat cost analysis

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ACC 040 Manufacturing Methods for Fiber Preforms ‘Integrated Polymer/Magnesium Front End Module”

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- Develop and demonstrate fiber preforming processes to decrease cost, increase manufacturing rates and improve reproducibility of large preforms for composite molding.
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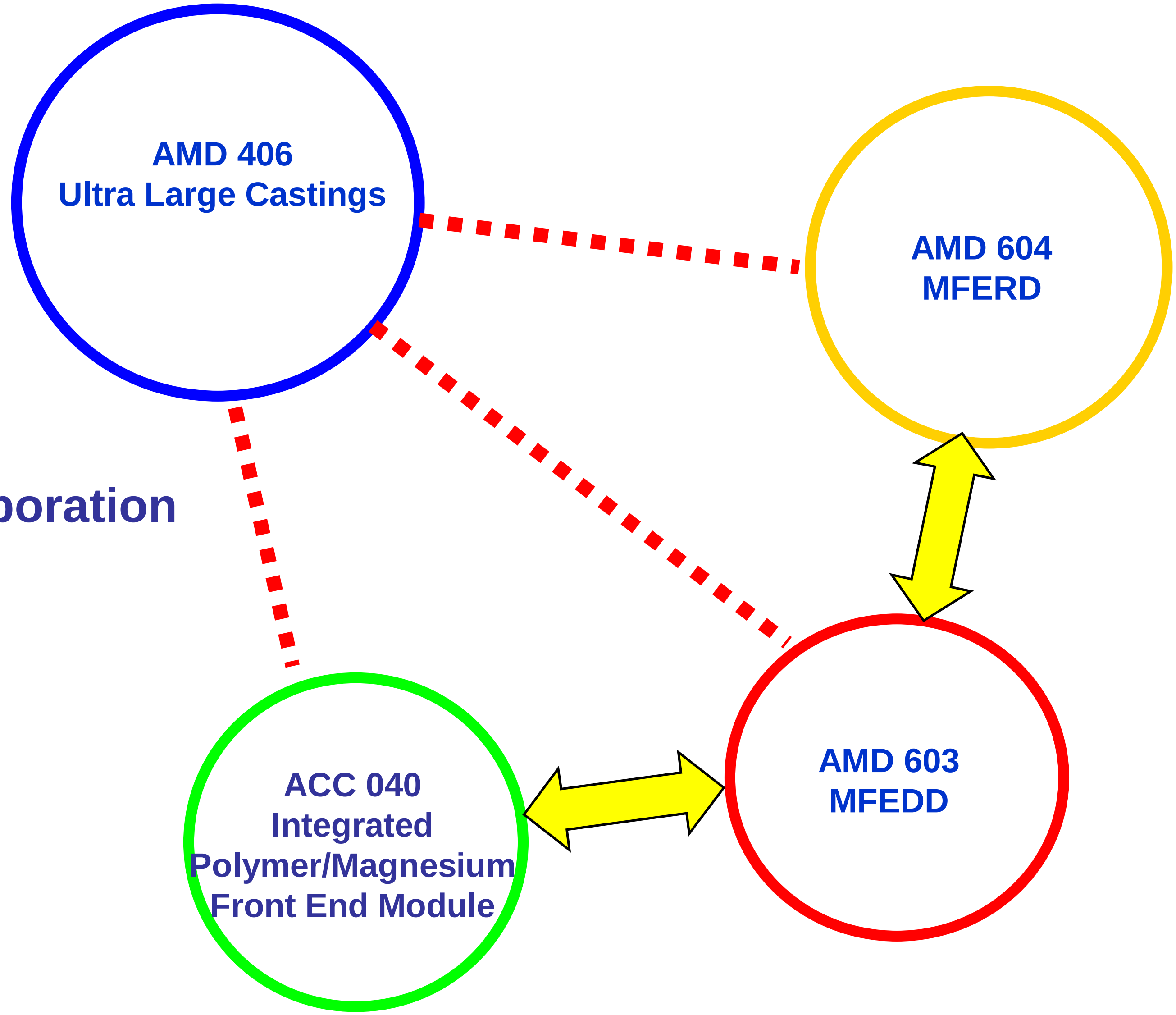
ACC/AMD Collaboration



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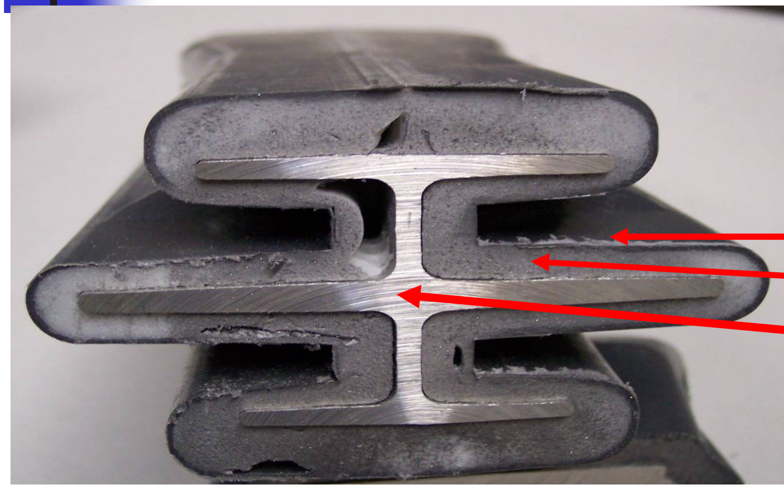


Plastic Encapsulation

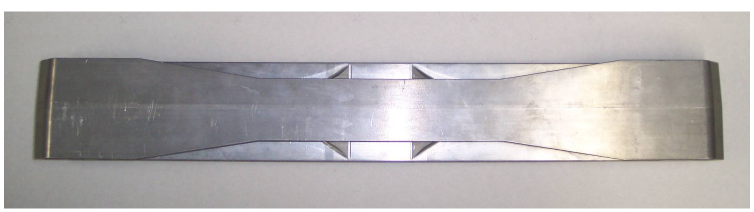
Skin

Rigid Foam

Mag Structural Insert

Uncoated Mg crossmember

Before corrosion testing



After corrosion testing

Encapsulated Mg crossmember

Before corrosion testing

After corrosion testing

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Approach

- **Explore manufacturing processes and materials that are capable of encapsulating magnesium structures.**
  - Powder Impression Molding (PIM) Process
    - Global Tech/VP Tech (Auburn Hills, MI)
  - SAAM Process (a Low Pressure SMC molding process)
    - Magna Advanced Technologies (Aurora, Ontario)
  - Injection Molding
    - Husky Injection Molding Systems (Bolton, Ontario)
- **Document encapsulation work done to date.**
- **Concept Design tailored for the PIM Process and compatible with SAAM.**
- **Preliminary Cost Model.**

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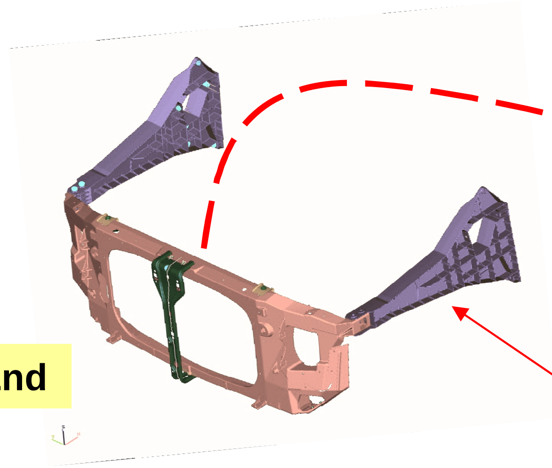
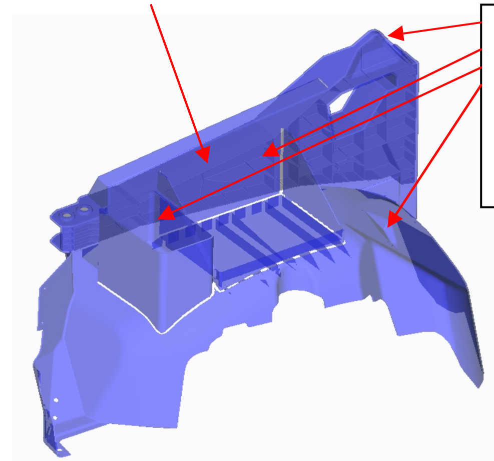


ULC Mag Front End

Ford F-150
Donor Vehicle

Mg Shotgun



Hood Hinge Pivot,
Battery Tray,
Washer Reservoir,
and
Splash Shield are
Integrated.

Encapsulated Mag
Front End
Module

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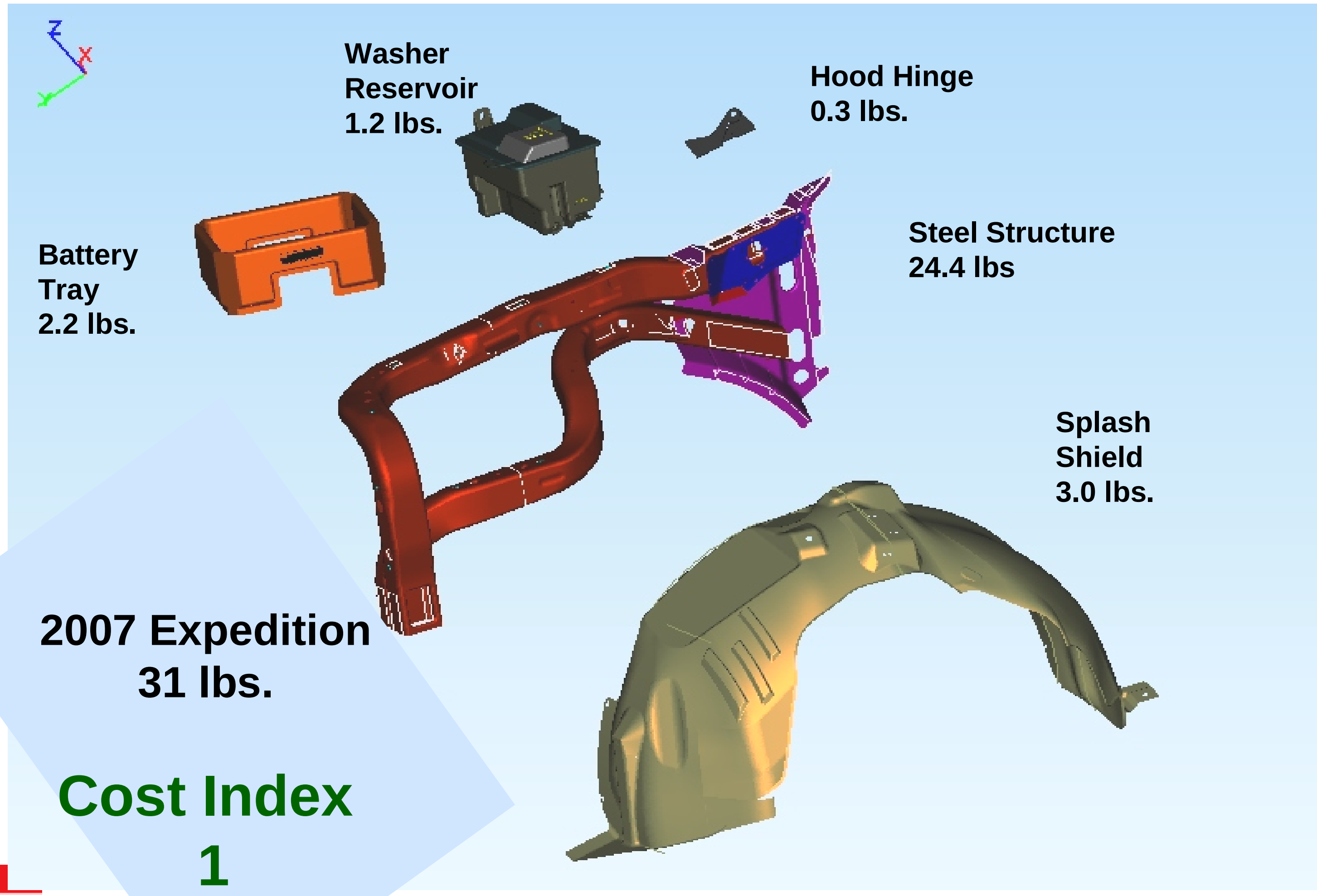

2007 Expedition
31 lbs.

Cost Index
1

Cost and Weight

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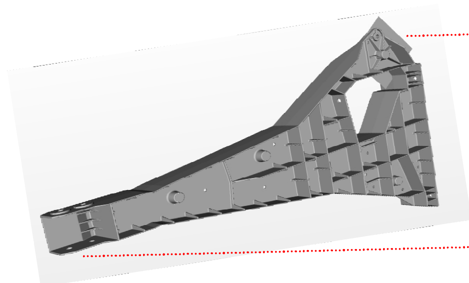
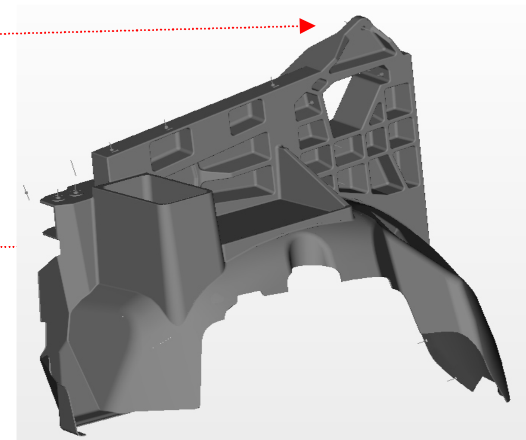
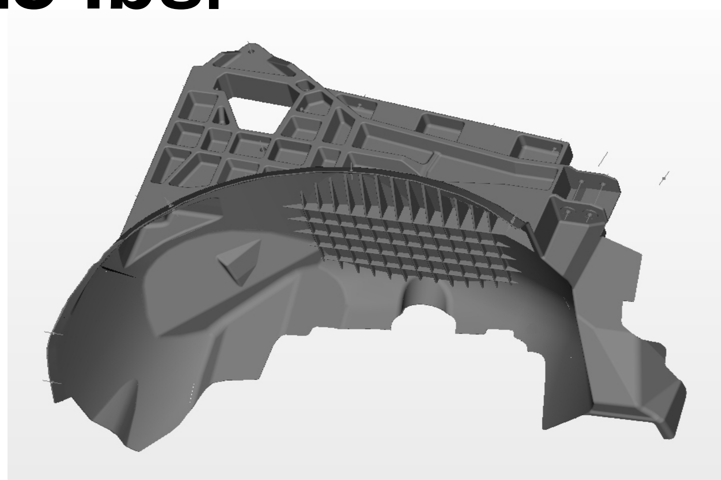
6 lbs.
Mag





9 lbs.
Plastic

~15 lbs.



50% Weight Savings

Cost Index

.71

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Accomplishments

- Collaborating with VPTech in Auburn Hills (PIM process).
  - Purchase order submitted for first task
    - Completed concept design tailored for the PIM process (adaptable to LPMC process) utilizing F150 shotgun
    - Detailed preliminary cost model completed
    - Report on encapsulation work completed to date
    - Material performance characterization initiated
    - Initiated FEA analysis of battery tray area

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