



Examples of Composites and Plastics in Automotive Vehicles

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Ford Motor Company

- 244,000 Employees
- 200 Markets
- 100 Plants
 - 23 Countries
 - 6 Continents
- 5 Unique Brands
- 6.5 million vehicles in 2007

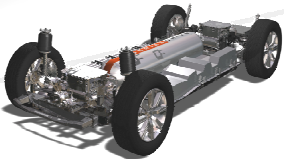




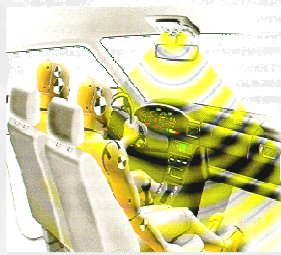
Research & Advanced Engineering



HySERIES DRIVE



Sustainability



Safety & Health



Design & Features



Enabling Expertise and Technologies

**CO₂, Emissions, FE,
Climate Change &
Energy Consumption,
Materials Processing**

**Accident Prevention
& Occupant /
Partner Protection,
Simulation Methods**

**Vehicle Design,
Features, Emotion,
NVH, Materials &
Manufacturing**



Fuel Economy and Weight

Fuel Economy determined by:

- vehicle weight
- driving performance
- towing capability
- vehicle design

**Powertrain
Design**



Focus EPA city/hwy 25/35
curb: 2650 lb, 5 pass, 13.8 cu ft
MSRP \$16,700



Escape Hybrid EPA city/hwy 34/30
curb: 3650 lb, 5 pass, 66/27 cu ft
MSRP \$27,400



Weight Distribution by System (based on Curb Weight)

System	Body-on-Frame (PU)		Unibody (Sedan)	
Body Structure	19%		25%	
Closures	5%		6%	
Interior, Systems & Trim	12%		12%	
Seats		4%		6%
Glazing	2%		2%	
Chassis	30%		25%	
Frame		8%		4%
Susp, Wheels & Tires		12%		13%
Powertrain	27%		26%	
Engine		12%		11%
Transmission		6%		7%
Driveline		7%		6%
Exhaust		2%		2%
Fuel and Battery	5%		4%	



Structural Composite Implementation Issues

- Component Manufacturing (Feasibility and Variability)
- Joining and Vehicle Assembly (Feasibility and Variability)
- Material Performance
- Design Methods and Analytical Capabilities
- Crash Modeling, Energy Absorption and Structural Integrity
- Recycling
- Repair, Insurance
- Durability
- EMC/RFI Compatibility
- Fire and Flammability
- Noise, Vibration and Harshness Performance
- Ageing and environmental effects



Composite & Plastic Processing

Current methods deliver either...

- High structural performance, Low volume, High cost (Liquid Composite Molding, Hand Lay-up, Tape Winding) examples: Aston Martin Vanquish
- High volume, Low cost, Limited structural performance (SMC, Compression Molding) example: Ford GT, closures
- High volume, Low cost, Limited performance (injection molded plastic, Natural Fiber Polypropylene) example: interior trim

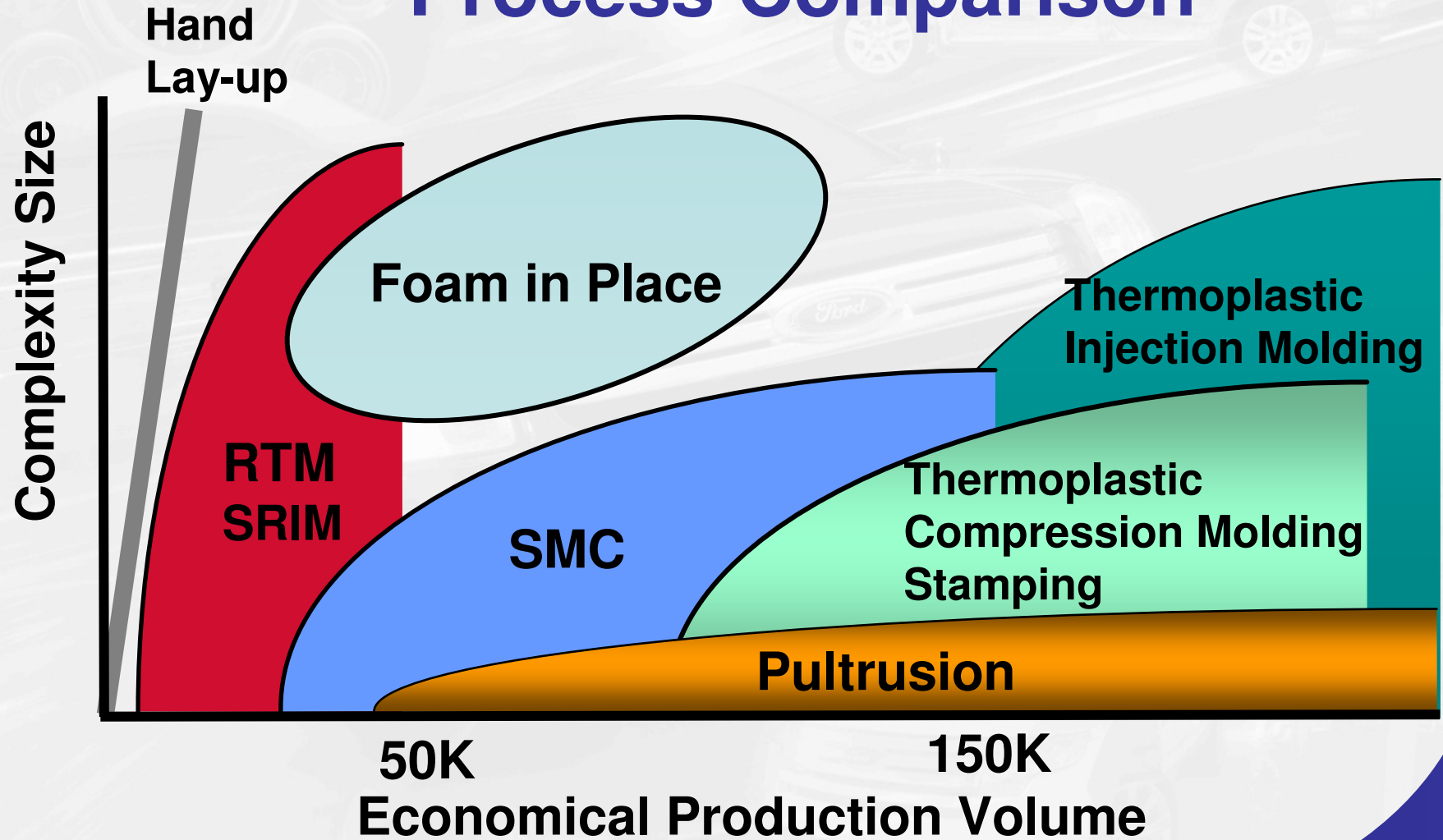
Need: Process and Materials for Automotive Applications

- High volume, Low cost , High structural performance

Explore improving both Sheet Forming and LCM using Carbon and Carbon/Glass reinforcements



Process Comparison





Aston Martin V12 Vanquish



- **Carbon Fiber and Glass Composite structure**
- **Adhesively bonded structure**
- **Approximately 1000 units per year**
- **Approximate price \$220,000**

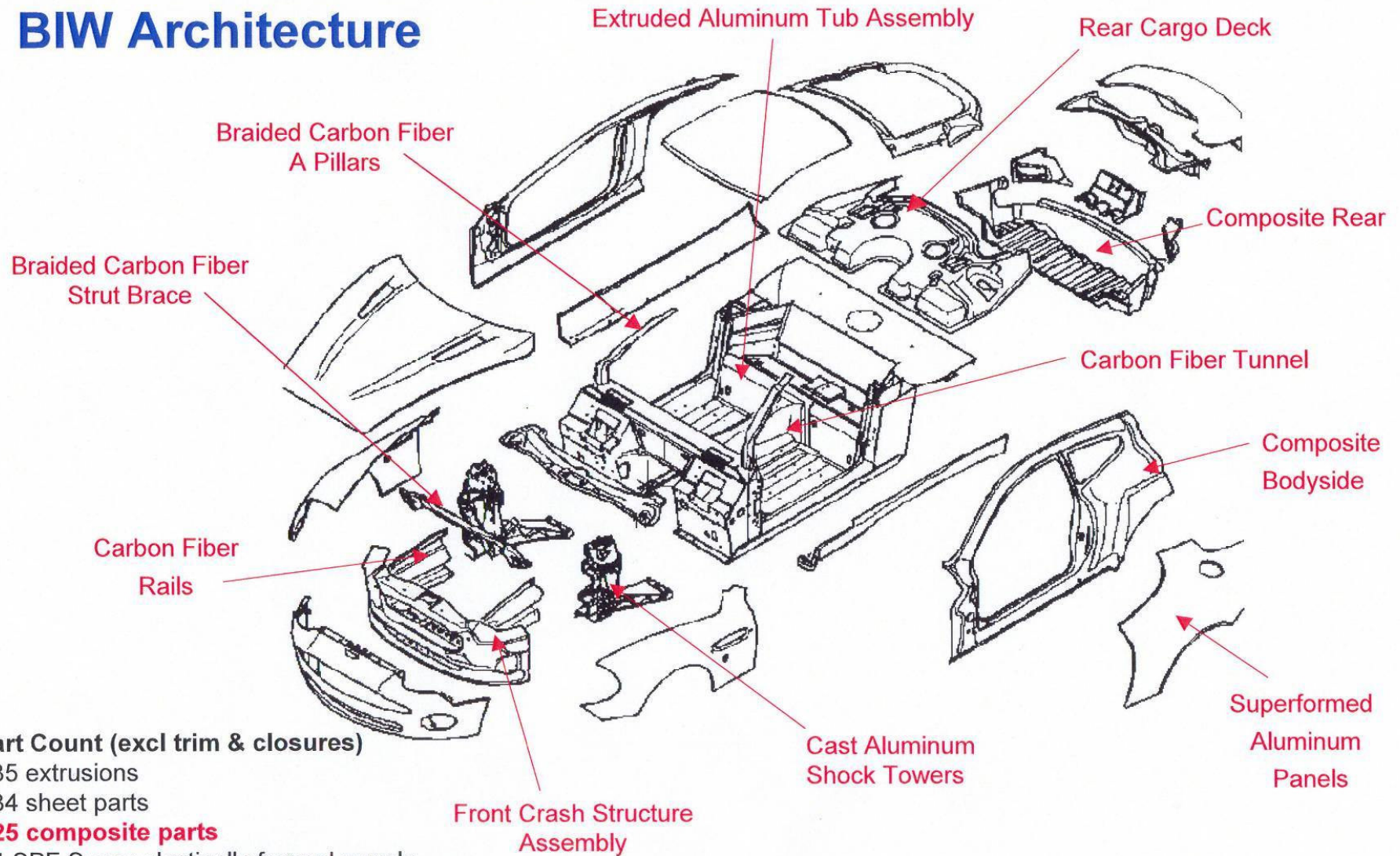


 Composite components



V12 Vanquish Exploded View

BIW Architecture



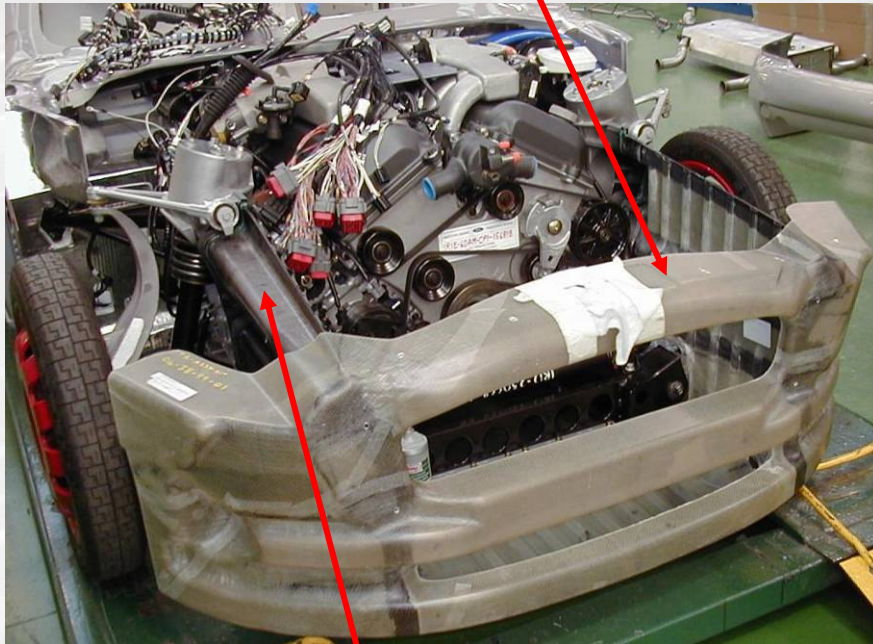
Part Count (excl trim & closures)

- 35 extrusions
- 34 sheet parts
- **25 composite parts**
- 4 SPF Super-plastically formed panels
- 1 pressed panel
- 6 castings



Vanquish Front End Assembly

Composite Crash Structure
(Front End Assembly)

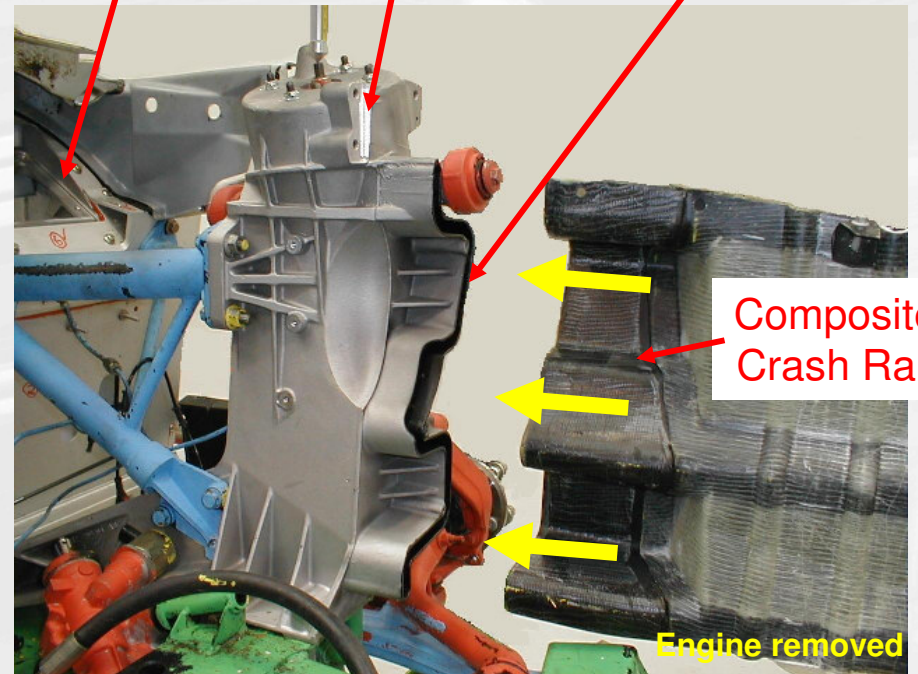


Composite Crash Rail

Cast Aluminum
Shock Tower

Aluminum Tub

Adhesive Groove
(315mm long x 53mm deep)



Composite
Crash Rail

Engine removed

Front end assembly bonded on **after** engine installation



Ford GT

- Full vehicle crash development eliminated through extensive use of CAE methods
- Breakthrough applications of lightweight materials & manufacturing processes
 - **Carbon Fiber**
 - Lightweight Aluminum
 - Superplastic Forming
 - Friction Stir-welding
 - **Structural Adhesives**
- Aluminum space frame
 - Extrusions
 - Castings
 - Stampings

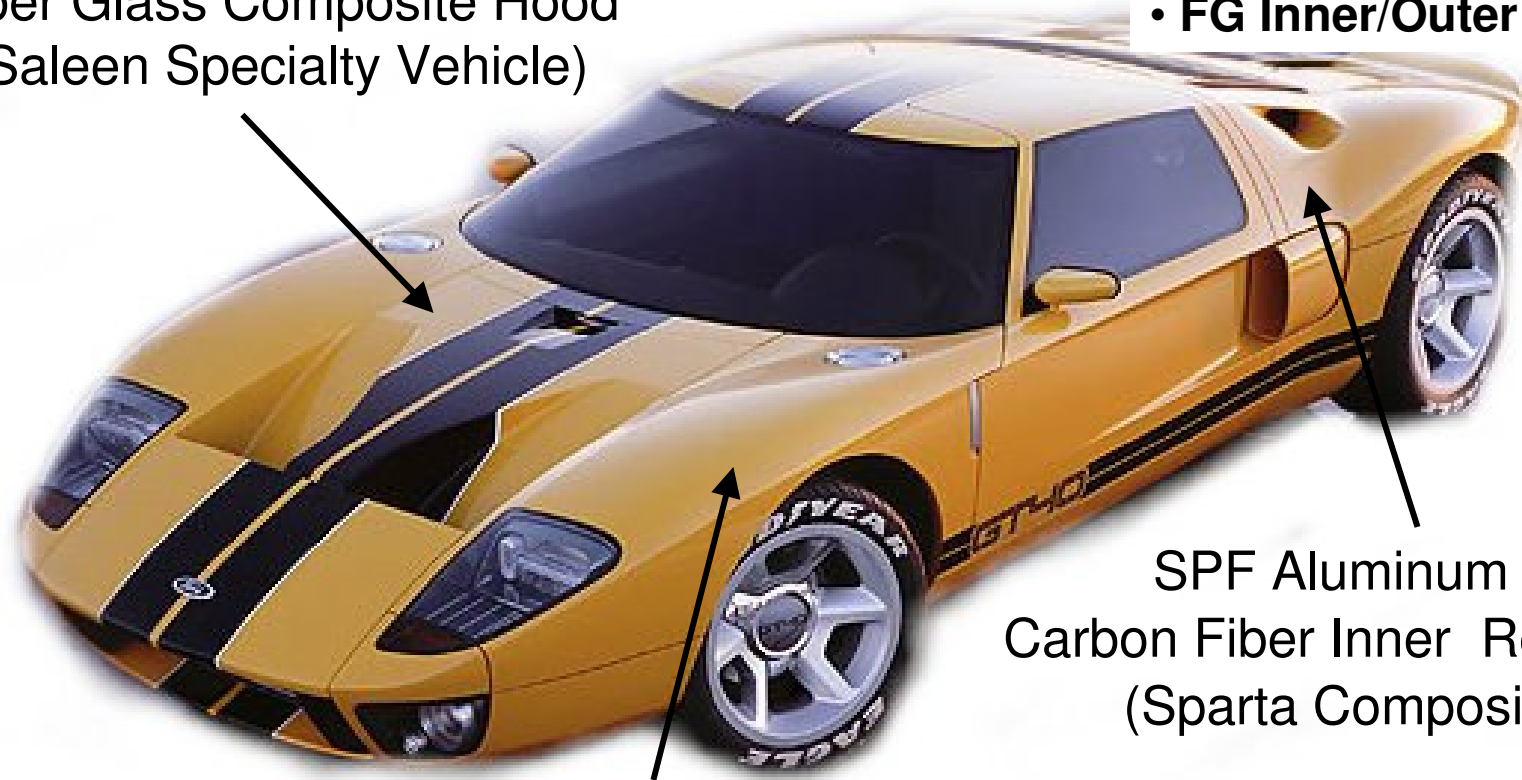




Multi Material Body

- Class A SPF Panels – 7
- Class B SPF Panels - 2
- CF Inner – 1
- FG Inner/Outer - 2

Fiber Glass Composite Hood
(Saleen Specialty Vehicle)



SPF Aluminum Outer /
Carbon Fiber Inner Rear Deck
(Sparta Composites)

Super Plastic Formed Aluminum Outers
(Superform USA)



One Piece Carbon Fiber Rear Decklid Inner





High Volume Plastic Components

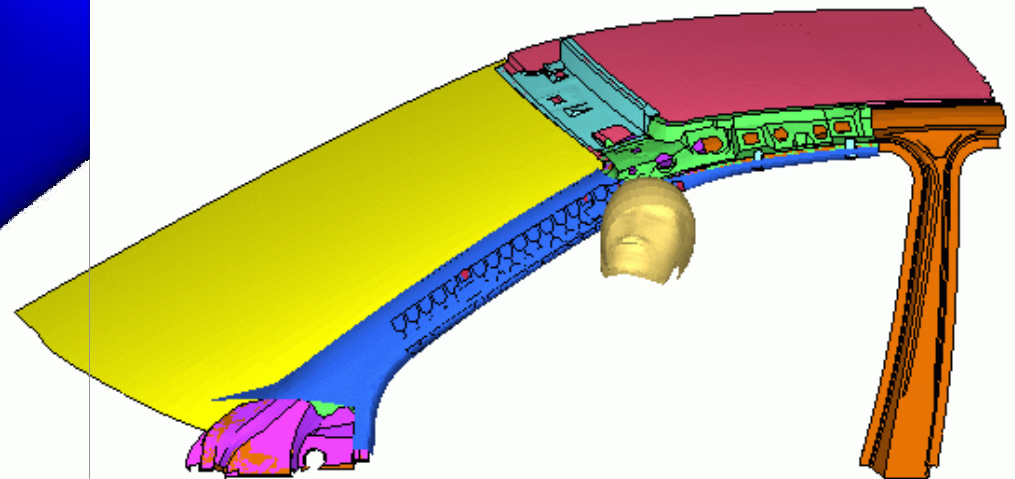
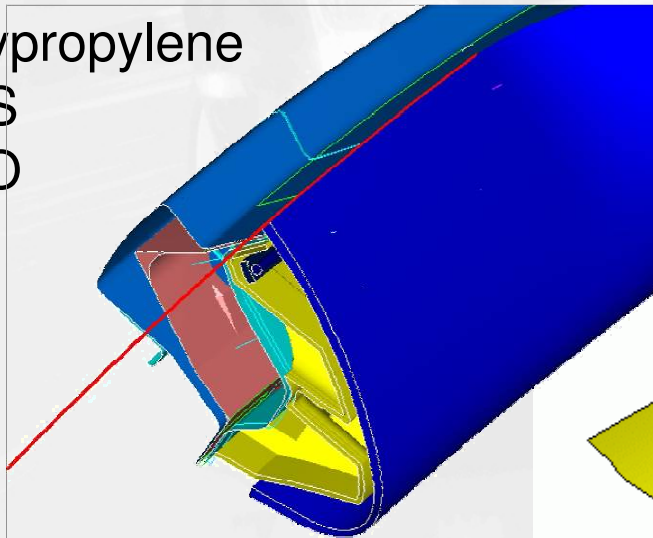
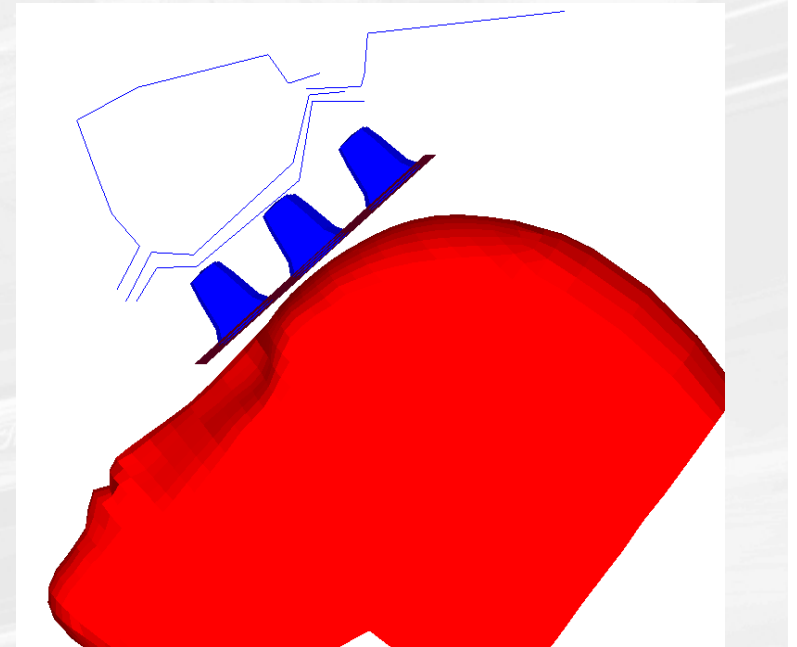
- Injection molded plastic trim for A, B, and C-Pillars, Roof Rails and Headers (interior head impact zones).
- Example: Ford Focus 2007 US volume: 175,000 units.





Interior Plastic Trim Examples

- Interior head impact protection provided by injection molded plastic trim parts.
- Injection molded with internal ribs, cups, etc.
- High volume, low cost.
- Typical materials:
 - polypropylene
 - ABS
 - TPO





Challenges to High Volume, High Performance Structural Composites

Analytical Tools

- Energy absorption prediction,
- Fracture and final shape predictions,
- Robust joining predictions

Component Production

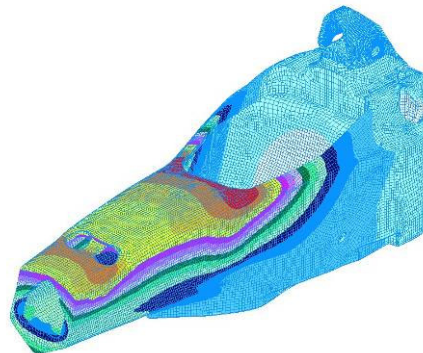
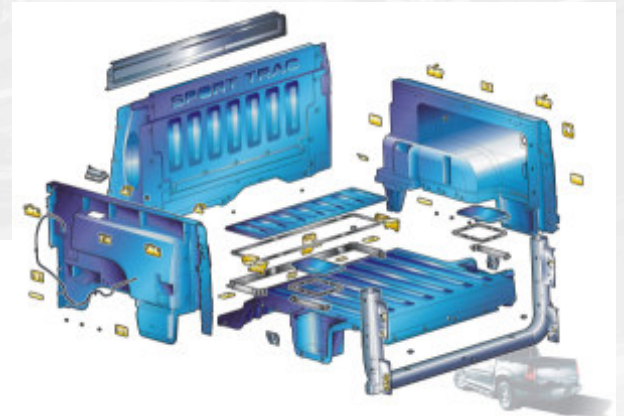
- Cycle times,
- Process robustness

Vehicle Assembly

- Cycle times,
- Coating/Paint processes
- Adhesive joint NDE

Material Systems

- Carbon Fiber Costs
- Recycling





Summary

- High performance structural composites are in limited production for energy absorption, typically low volume high cost vehicles.
- Injection molded plastics in high volume, affordable vehicles for interior trim, meet head impact requirements.
- ***Ford uses plastics and composites where they make good engineering and business sense for value to our customers!***

Future Efforts:

- Need more research and development on fast cycle time, low cost, high performance material systems for structural components.
- Need improved analytical tools for composites in component and full vehicle crash simulations including material characterizations, fracture predictions and environmental effects.



Acknowledgements

We are like dwarfs on the shoulders of giants, so that we can see more than they, and things at a great distance, not by virtue of any sight on our part, or any physical distinction, but because we are carried high and raised up by their giant size.

Bernard of Chartres, 12th Century

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