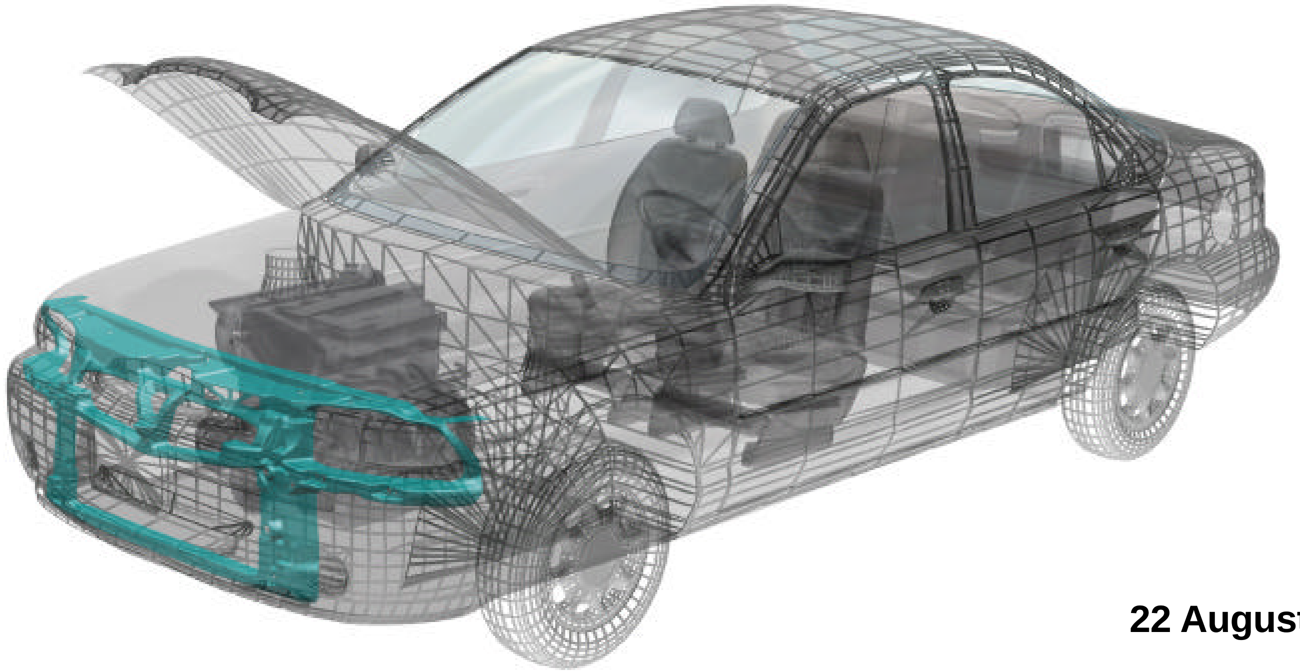
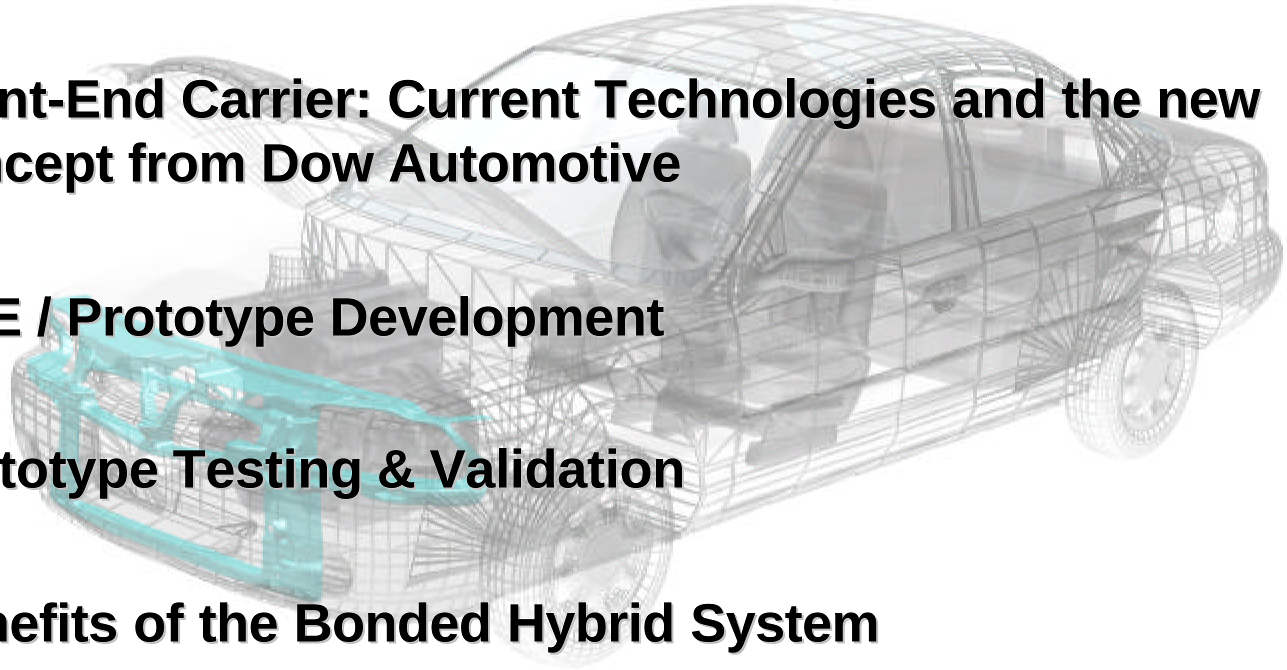
Fiber Filled Materials and New Flexible Design Methodology for Hybrid Front-End Carriers



22 August 2002

Padraig Naughton, Jan Roettger, Bill Bowser
Samar Teli, Eric Kurtycz, Ashish Kotnis

Dow Automotive



- Dow Automotive Introduction
- Front-End Carrier: Current Technologies and the new concept from Dow Automotive
- CAE / Prototype Development
- Prototype Testing & Validation
- Benefits of the Bonded Hybrid System

Overview

Dow Automotive

Original
Dow Automotive
Engineered Thermoplastics
$400MM Annually, 185 Employees
Shared Assets

Essex Chemical
Polymer Glass Bonding
$300MM Annually, 400 Employees
Captive Assets

Sound Alliance
JV with Cascade. NVH Products
100MM Annually
100 Employees

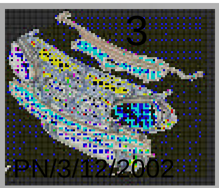
Donnex
JV with Donnelly
Glass Bonding Technology

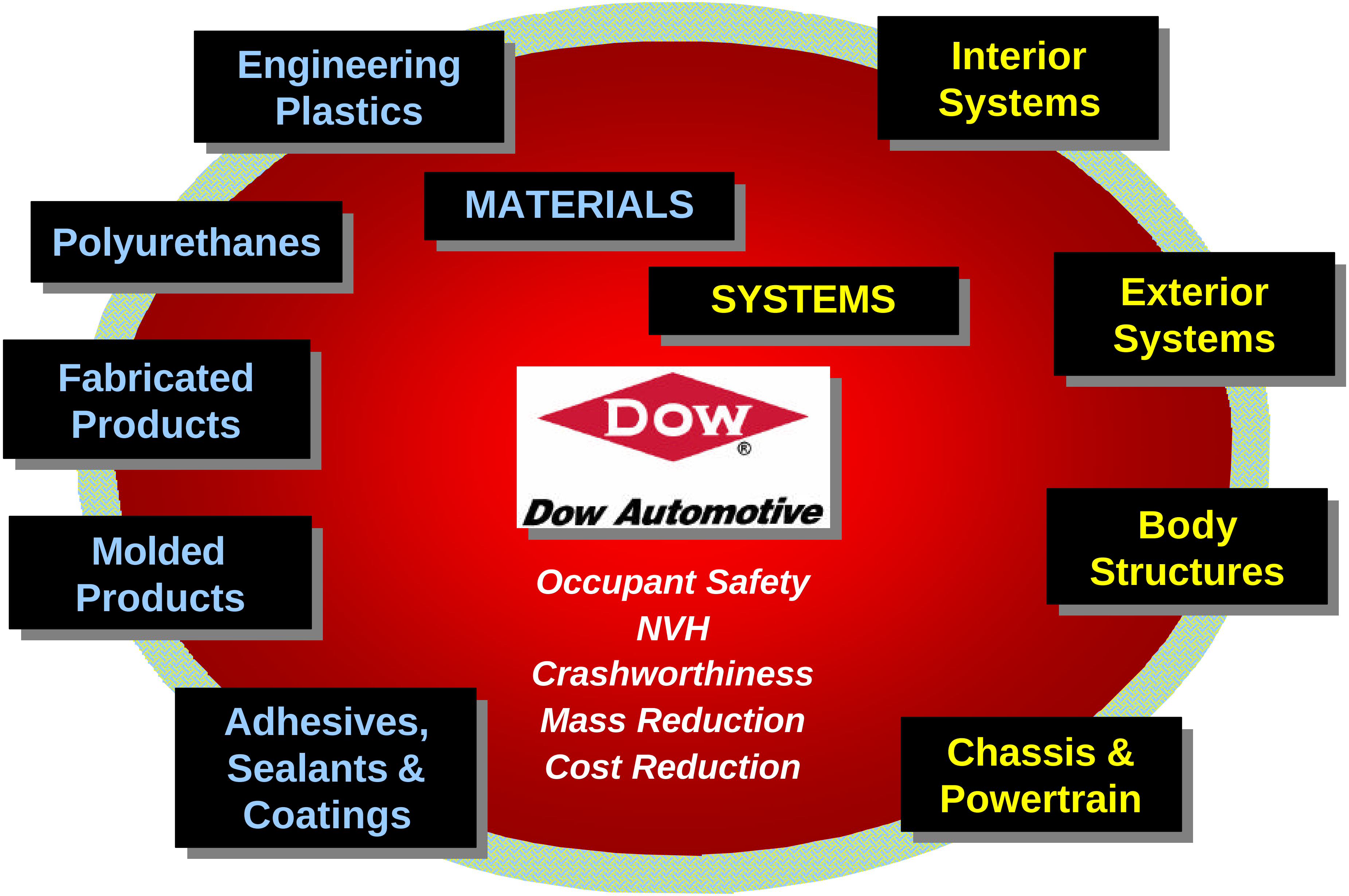
New
Dow Automotive
1st Customer Facing Business Unit of Dow Chemical
$1.6B Annually, 1800 Employees
Captive and Shared Assets

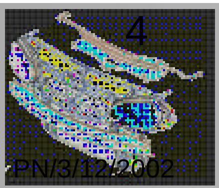
Dow Chemical
PU Seat and NVH Foam
$300MM Annually, 50 Employees
Shared Assets

Dow Chemical
Oxygenated Solvents / Auto Fluids
$30MM Annually, 20 Employees
Shared Assets

Dow Chemical
Fabricated Products / INTEGRAL* Films
$20MM Annually, 10 Employees
Shared Assets





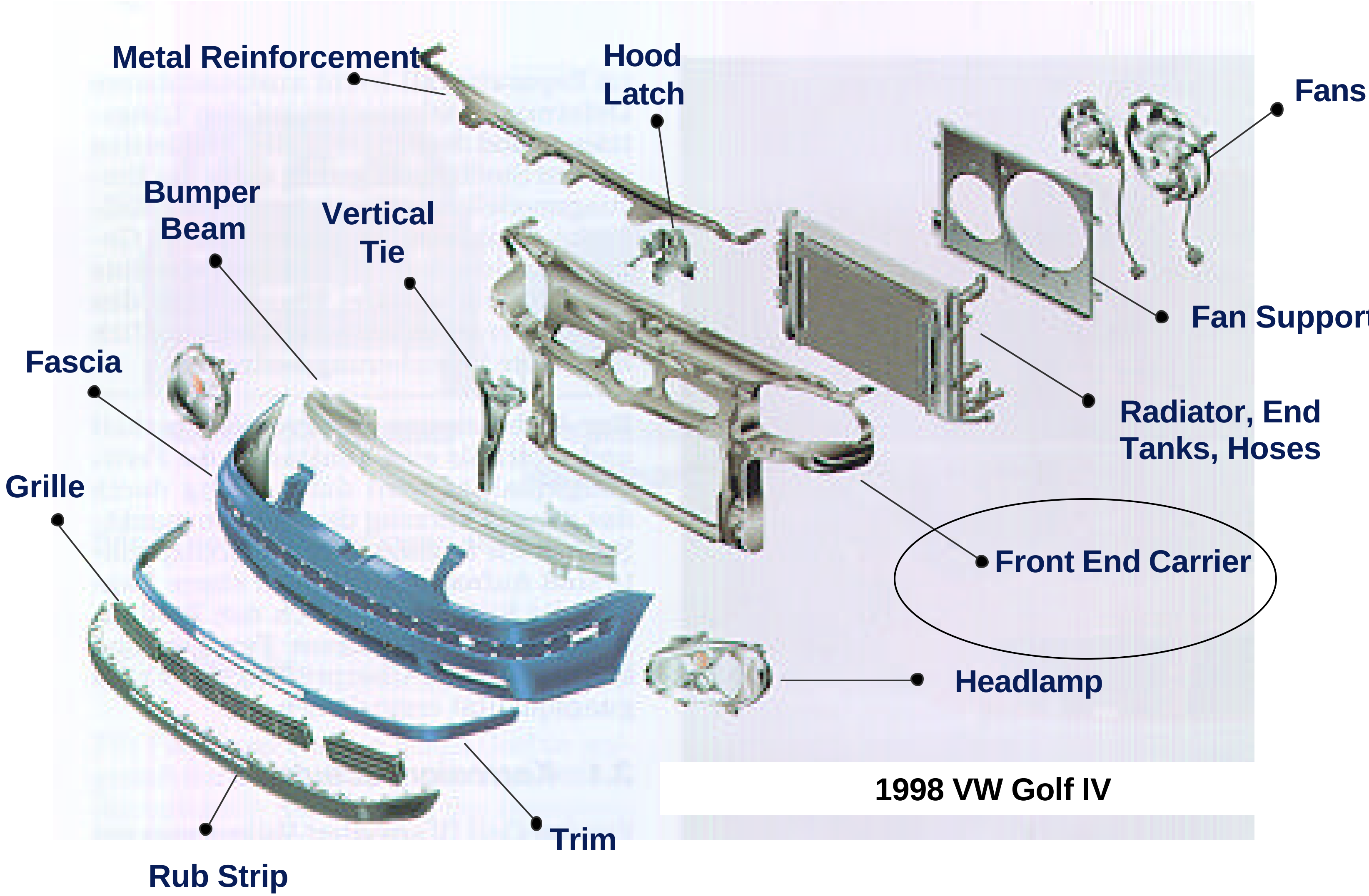


Dow Automotive Business Model

Dow Automotive

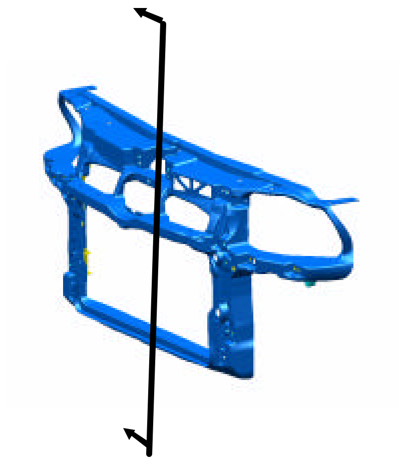
Front End Carrier
Current Technology / Dow Solution

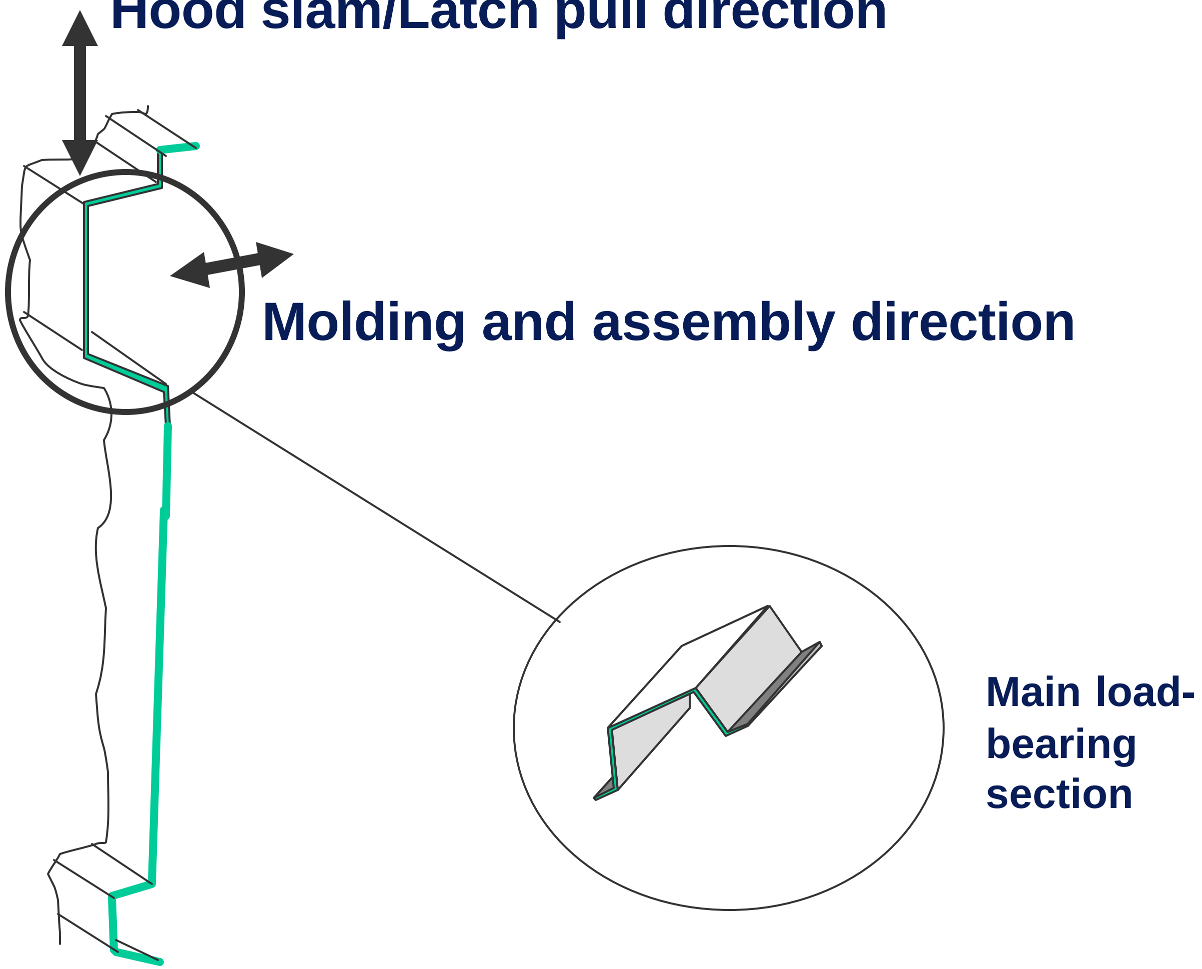
What is a Front End Module ?



1998 VW Golf IV

Dow Automotive





Main Requirements (FEC)

- Hood slam
- Latch pull
- Stiffness
- Vibration/fatigue
- Behavior in crash

Metal Reinforcement is required for better impact performance

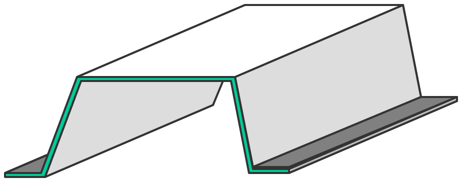
Forces acting on front end carrier

Current Production

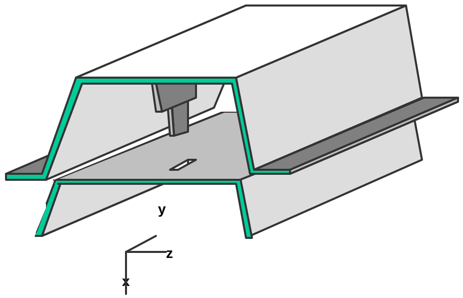
VW Golf (GMT / Steel)

Current Production

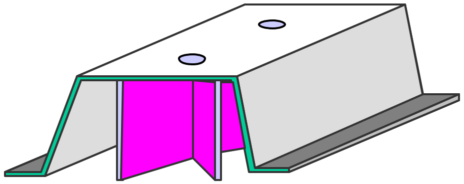
Audi A4(Nylon / Steel)



Basic open box



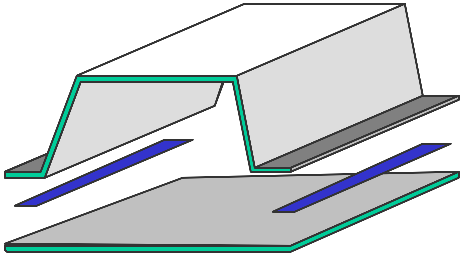
Heat stake metal to plastic



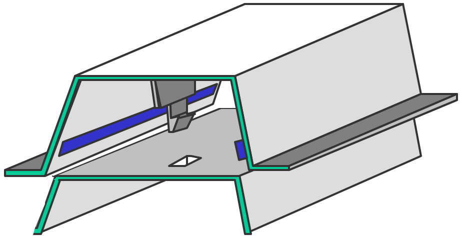
Overmolded open box

Dow Concept

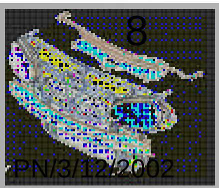
(LGPP / Steel)



Dow Concept : Bonding with closed box

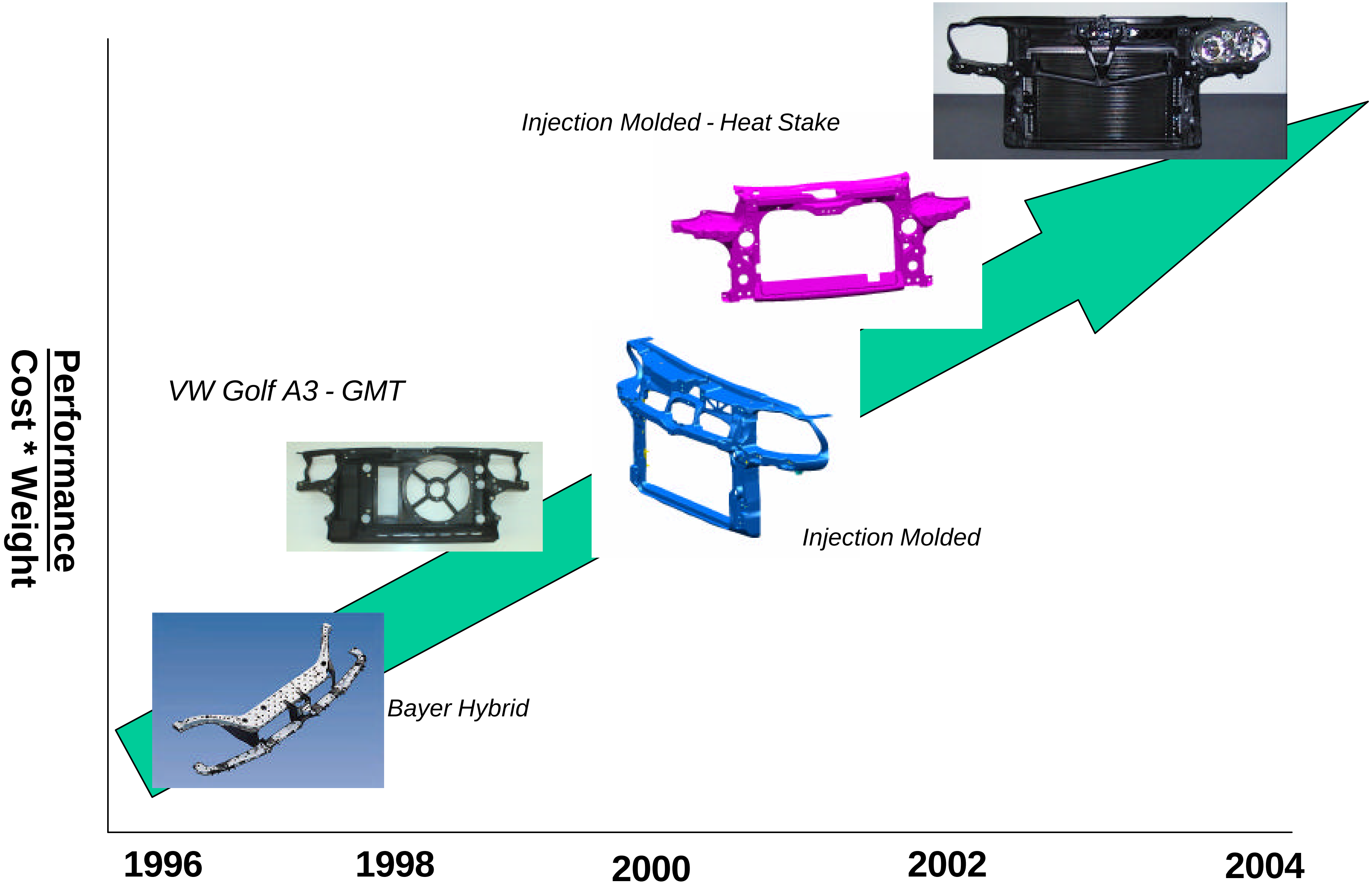


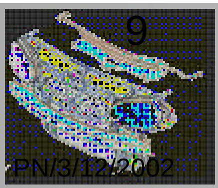
Further Development through clever design and engineering



Metal to Plastic - Technological Approaches

Dow Automotive



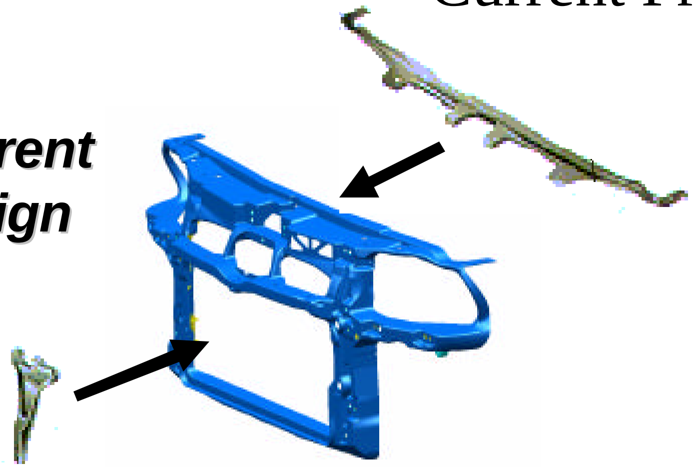


Dow Automotive

Dow Automotive Benchmark

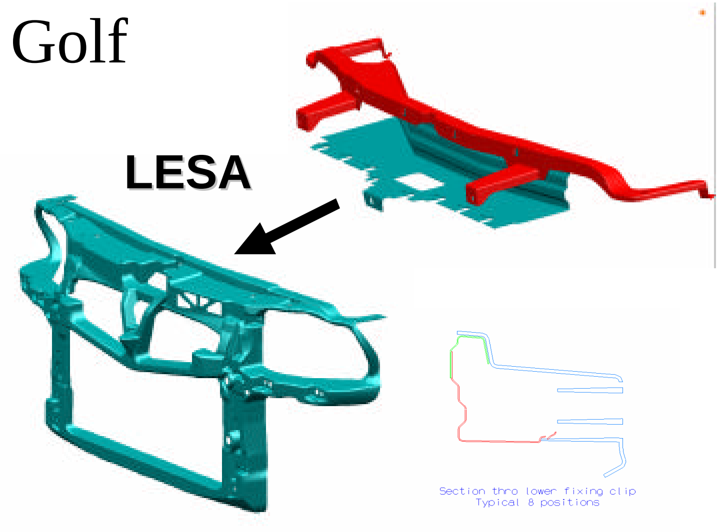
Current Production VW Golf

Current design



Dow design

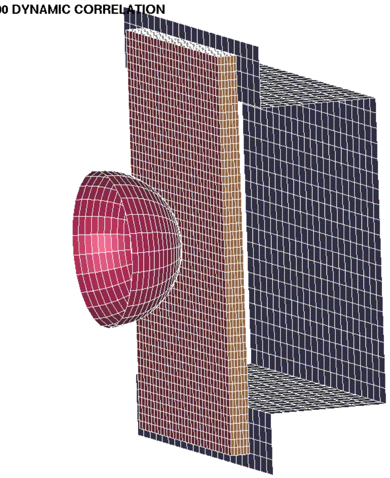
LESA

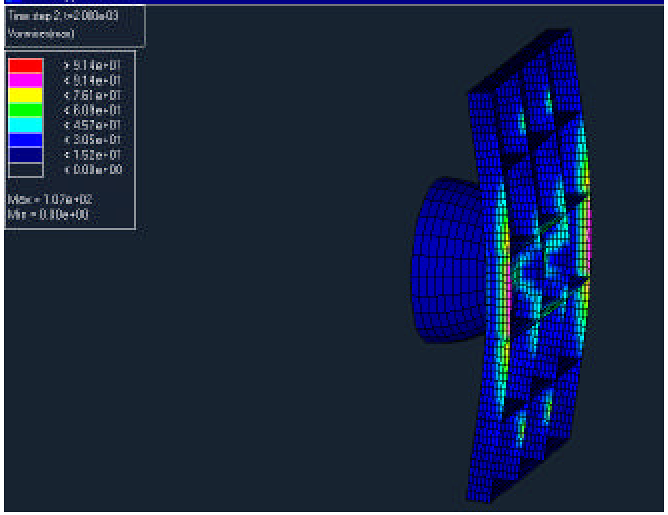


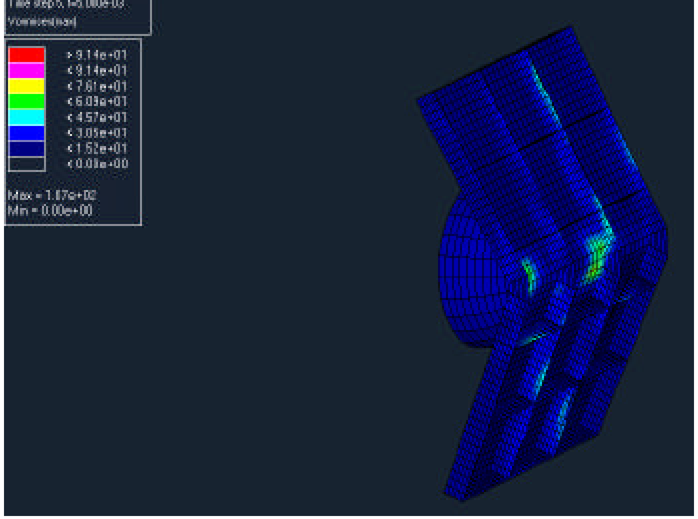
- **GMT Compression molding**
- **Metal to plastic attachment via rivets and heat stacks**
- **Open section in upper box area**
- **Additional vertical tie for latch stiffness**

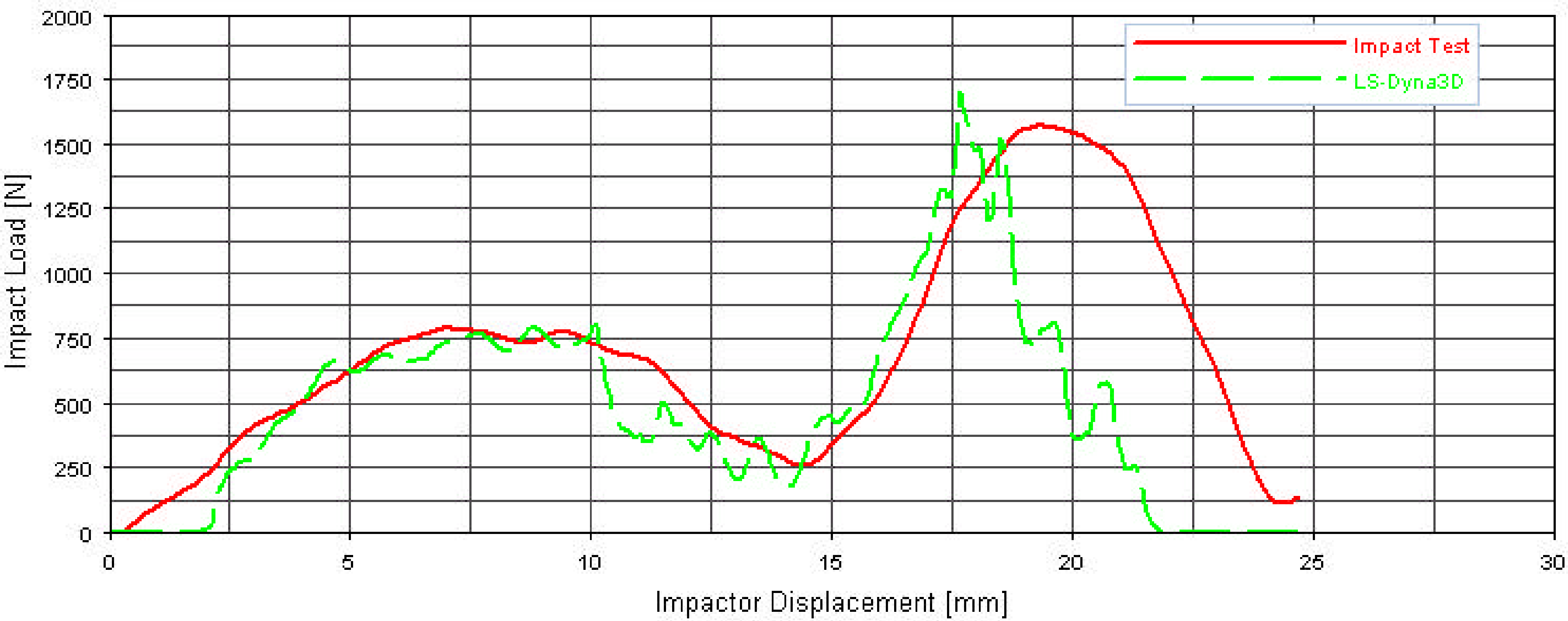
- **PP LGF injection molding**
- **Metal to plastic bonding via LESA technology**
- **Closed section in upper box area gives higher stiffness**
- **Removal of vertical tie with optimized plastic design**
- **Air duct integration**

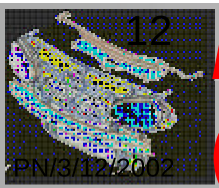
CAE to Develop the Concept and Aid in Tooling



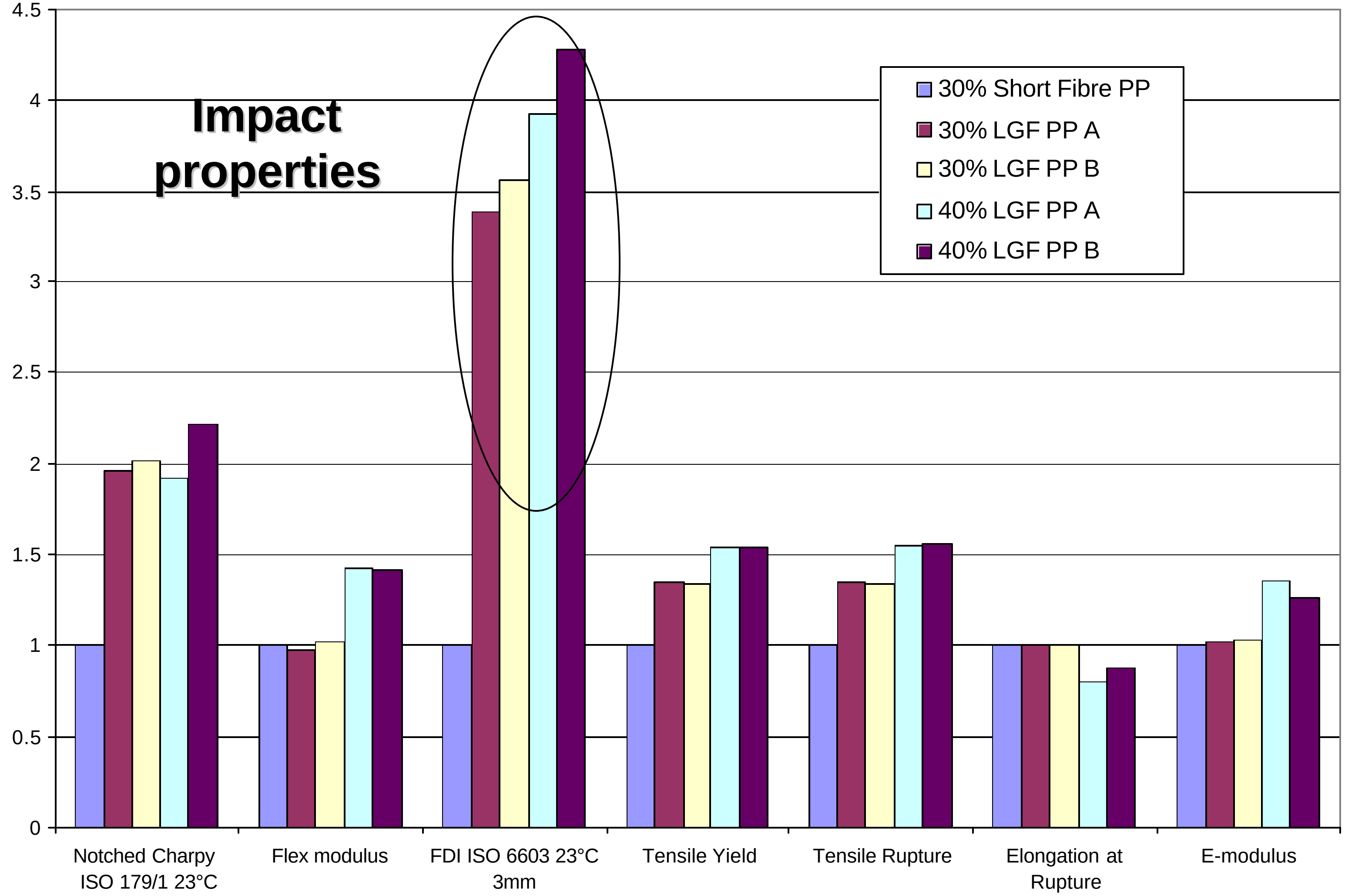


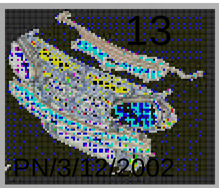






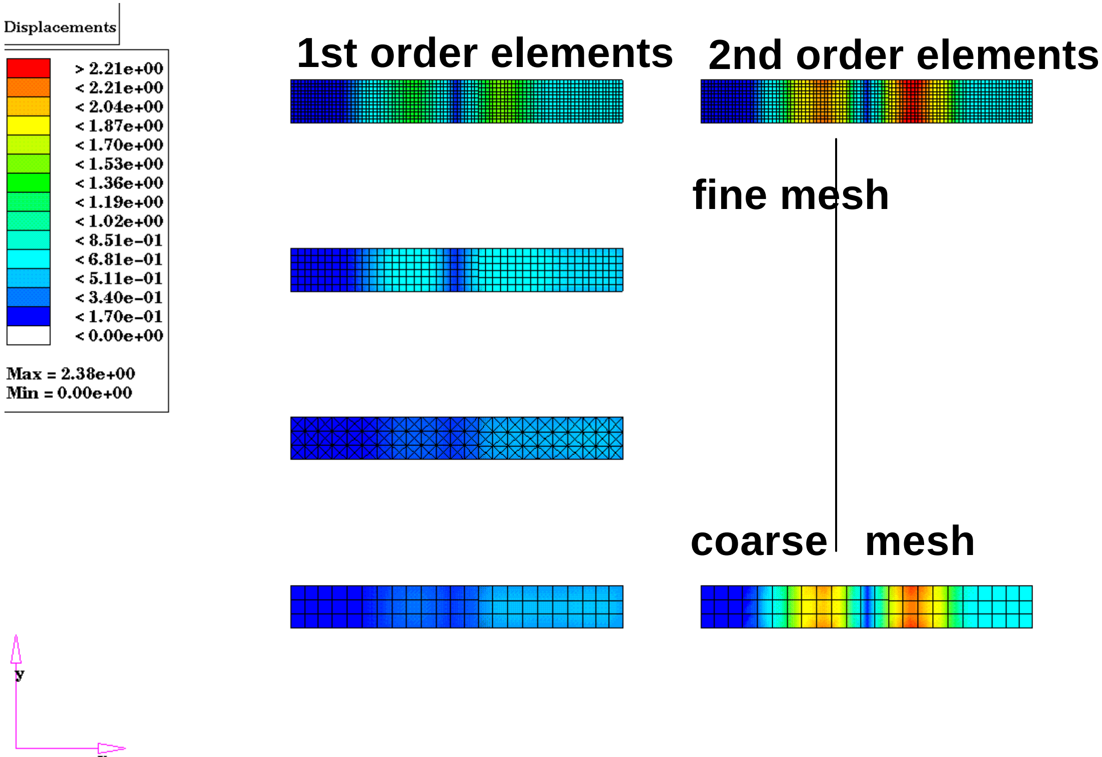
Materials Science & Characterization (LGF PP)





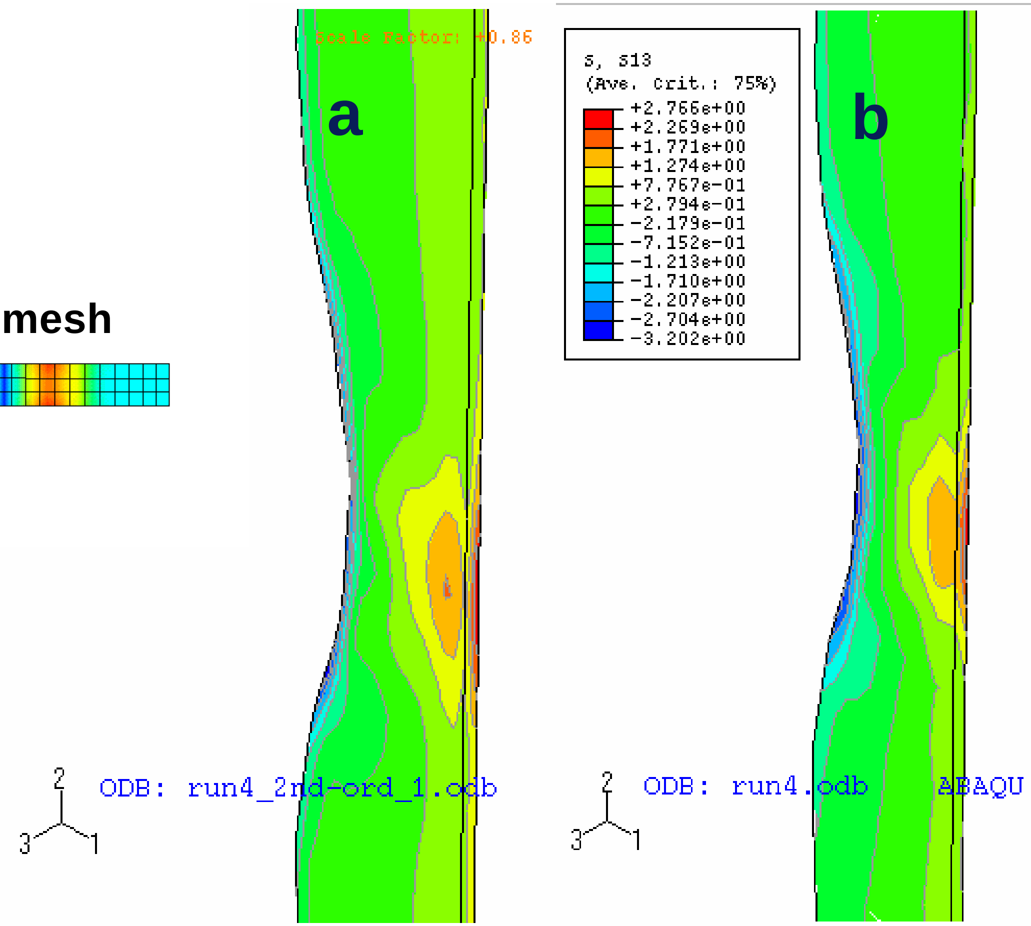
Why LGF PP ?

Dow Automotive



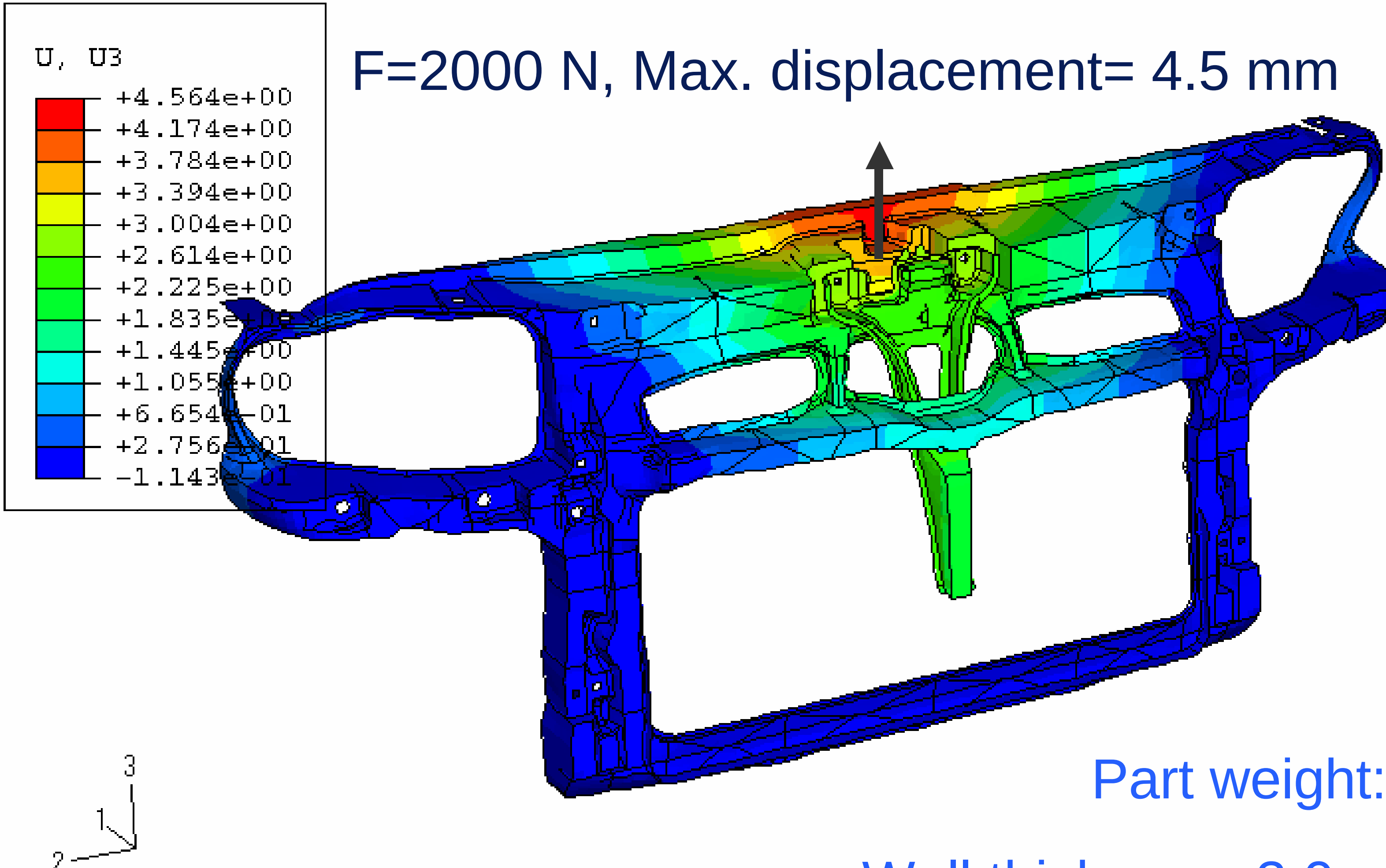
a Adhesive is modeled with solid elements

b Adhesive bonding is modeled using rigid links



Displacement under latch pull load

F=2000 N, Max. displacement= 4.5 mm



Part weight: 5.0 kg,

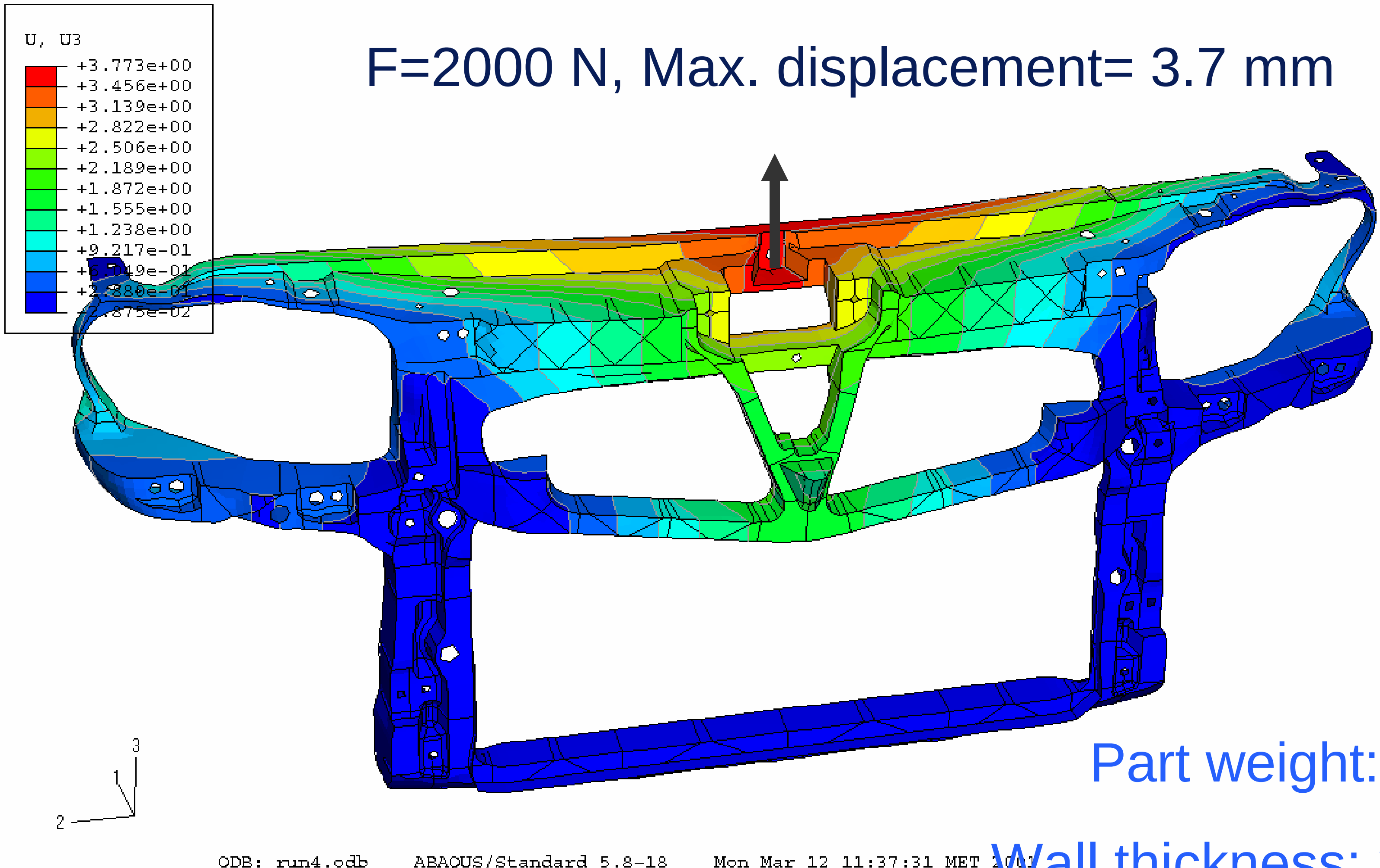
Wall thickness: 3.0 - 3.5 mm

Original FEC - GMT and Metal

Dow Automotive

Displacement under latch pull load

F=2000 N, Max. displacement= 3.7 mm

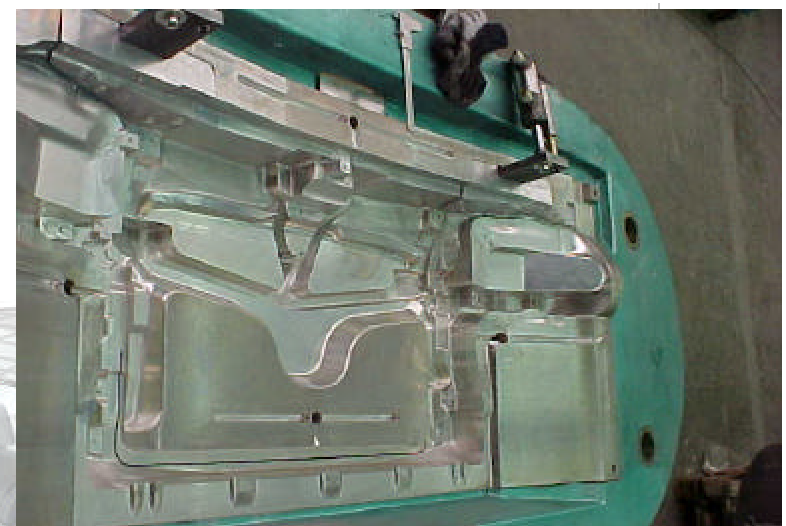


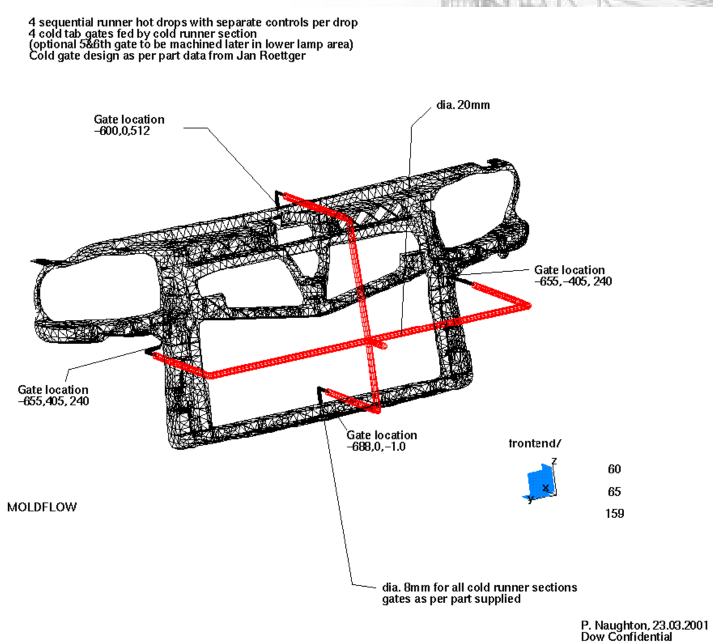
Part weight: 4.0 kg,

Wall thickness: 2.5 mm

Dow Concept - LGF PP and Metal

- Main Requirements
  - Stiffness
  - Latch pull
  - Hood slam
  - Vibration
  - Tooling





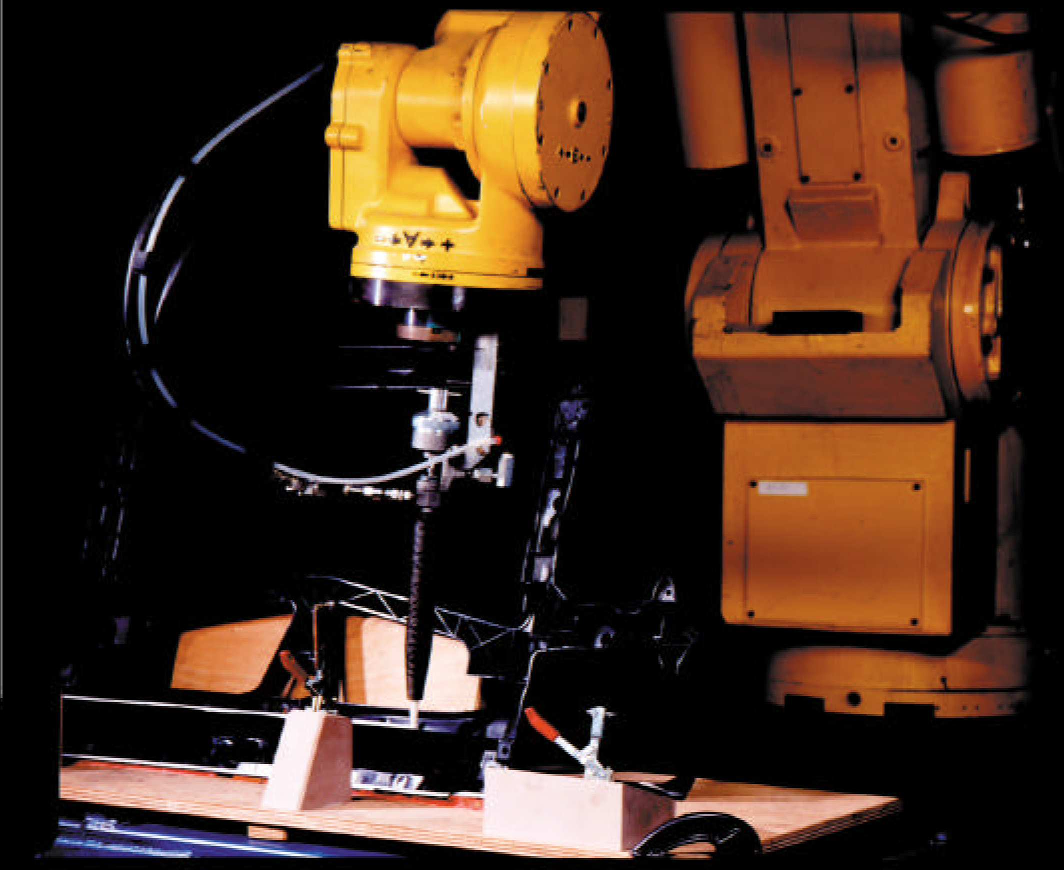
Prototype Development

Dow Automotive

Low Energy Substrate Adhesive

LESA

Assembly of the Dow Hybrid System



No Surface Pre-Treatment

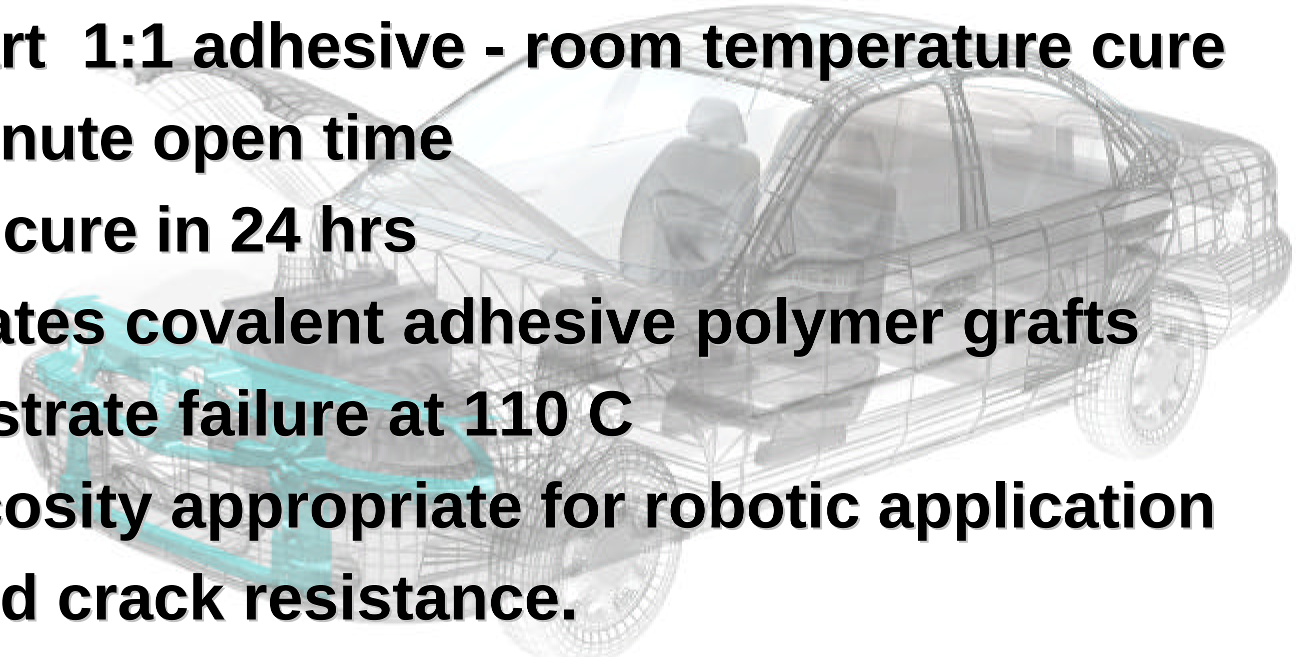
Automated Application

Apply directly to PP

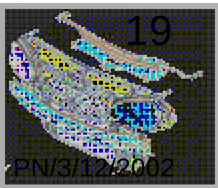
Adhesive Bonding

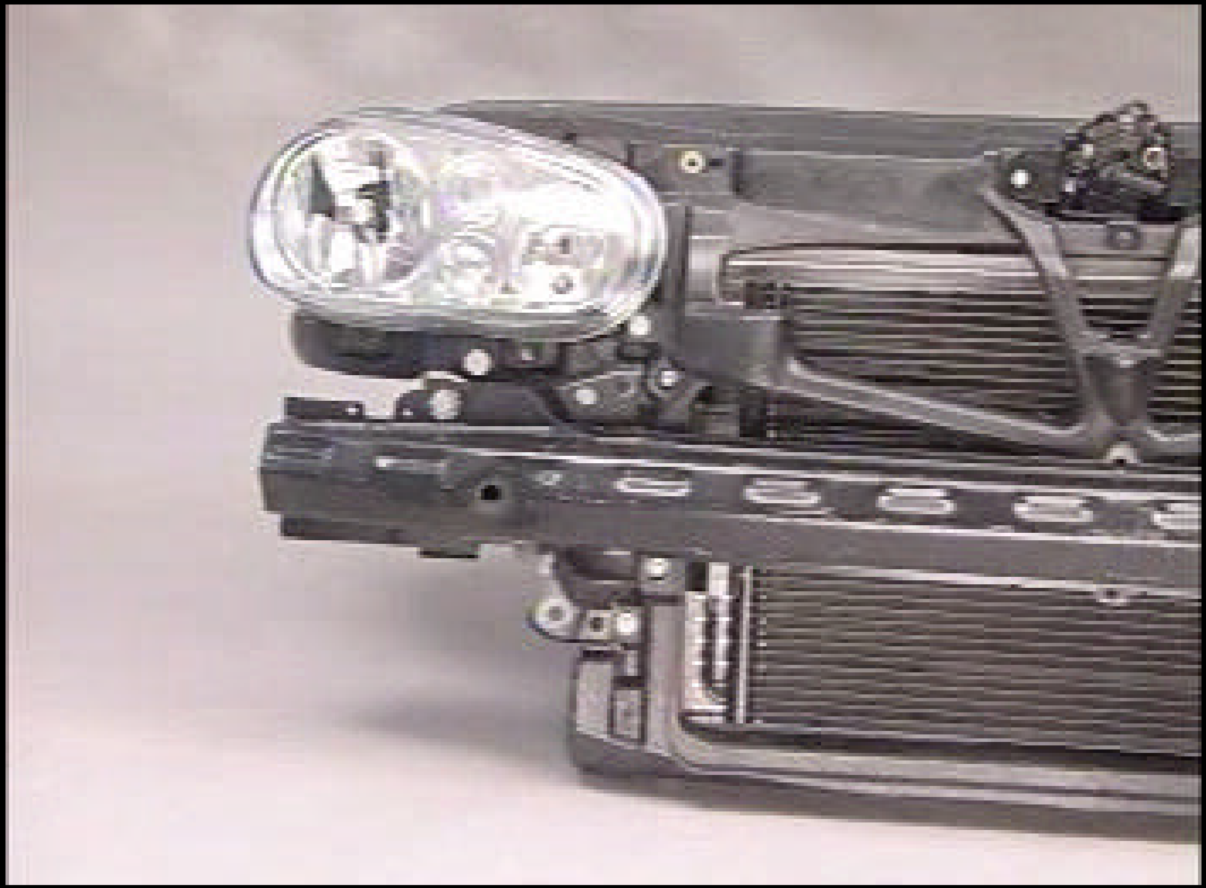
LESA

Truly differentiated technology that enables the structural bonding of PE, PP, PS, SPS, PET, PTFE with no surface pre-treatment!



- **2 part 1:1 adhesive - room temperature cure**
- **7 minute open time**
- **Full cure in 24 hrs**
- **Creates covalent adhesive polymer grafts**
- **substrate failure at 110 C**
- **Viscosity appropriate for robotic application**
- **Good crack resistance.**
- **New formulations developed**



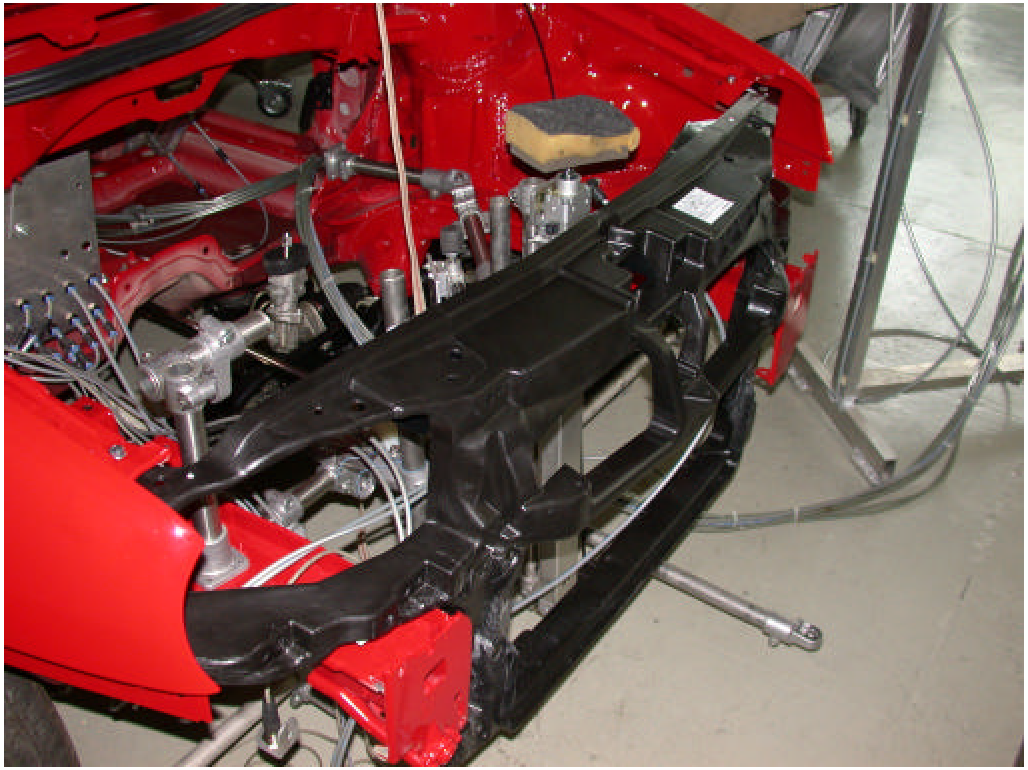


The Assembled Front End Module

Prototype Testing and Validation

Dow Automotive

Testing as per OEM specifications



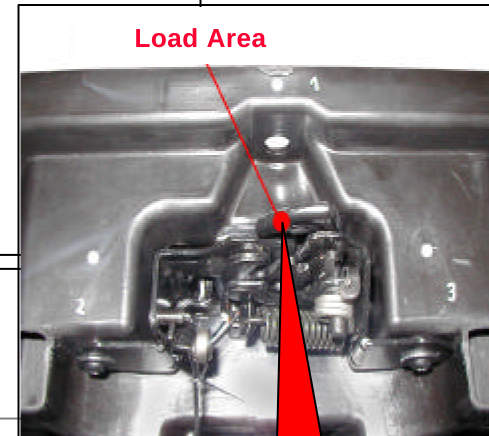
- Hood Contour Run
- Hood Latch Pull Test
- Temperature Test
- Vibration Test
- Climate Test
- Material Test
- Insert Test

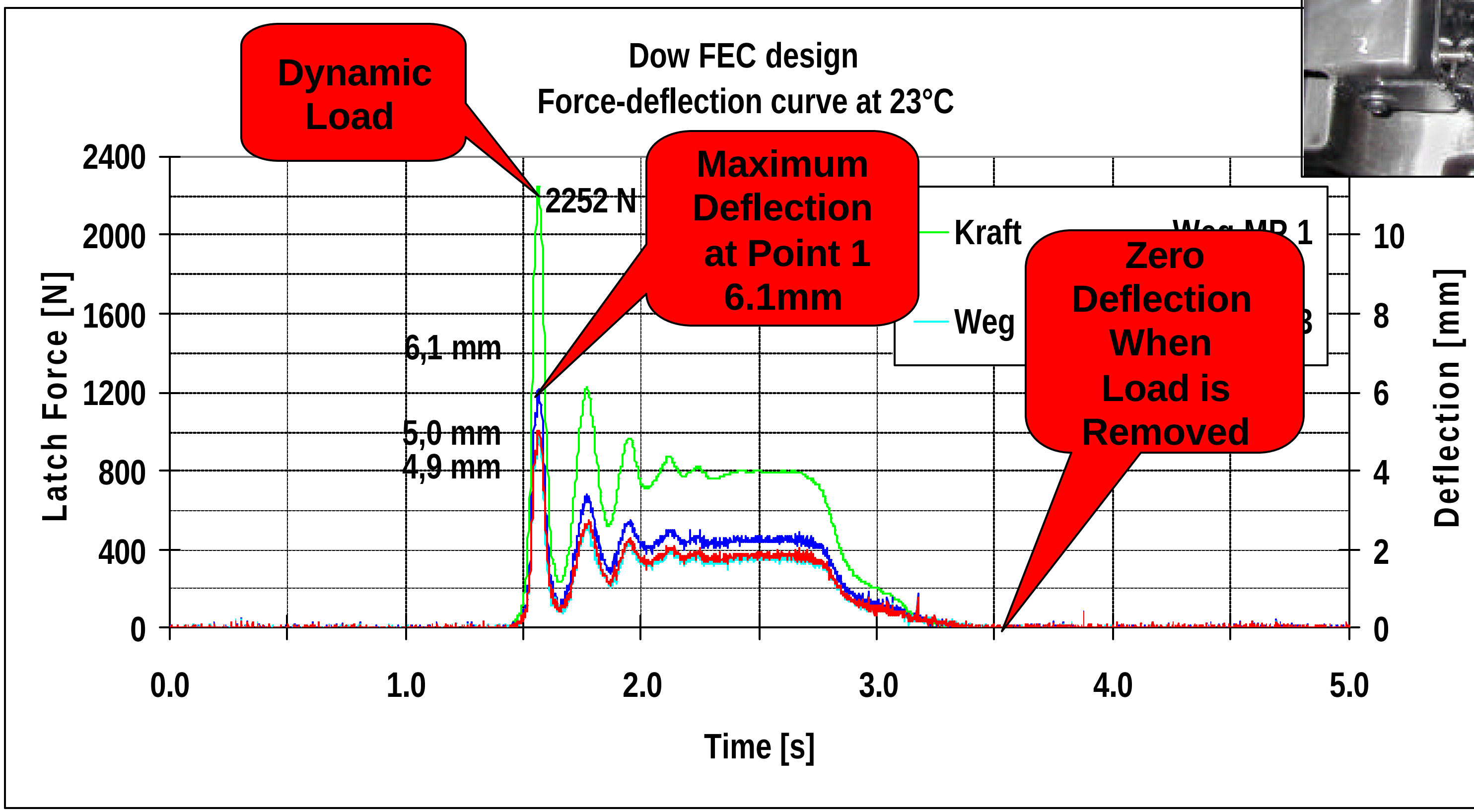
- All test completed and passed without major issues

Prototype Testing and Validation

- **Latch Deflections Under Dynamic Loading (mm)**

	Current	Dow
Temperature 23°C	10.5	6.1
Temperature -40°C	8.7	4.2
Temperature 85°C	10.2	7.3





Latch Pull Test Results

Validation Test Results

Hood Slam:

- Open and close cycles at different temperatures and misuse tests
- No effect to bond-line, cracks or loss of insert torque

Temperature Exposure:

- Four temperatures for specified time
- No effect to bond-line and spit-lines, cracks or loss of insert torque

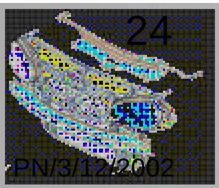
- **Vibration Tests:**
- Test with heaviest front end module assembly at specified temperature
- No cracks, no effect to bond-lines

Latch Pull:

- Dynamic load applied at latch pull area in positive Z (upward) direction
- Elastic deformation
- No cracks or damage
- No effect to bond-lines

Climate Tests:

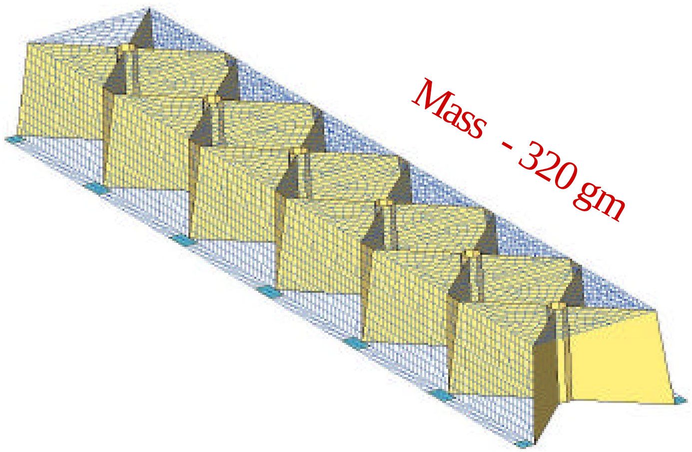
- Climate cycles at different temperatures for specified time periods
- No effect to bond-lines and spit-lines, cracks or loss of insert torque



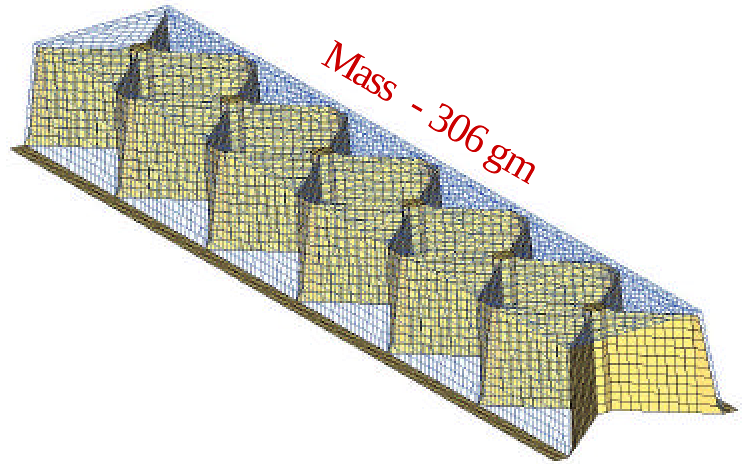
Dow Automotive

Benefits of the Bonded Hybrid System

Bending and Torsion Studies on Several Hybrid FEC Concepts

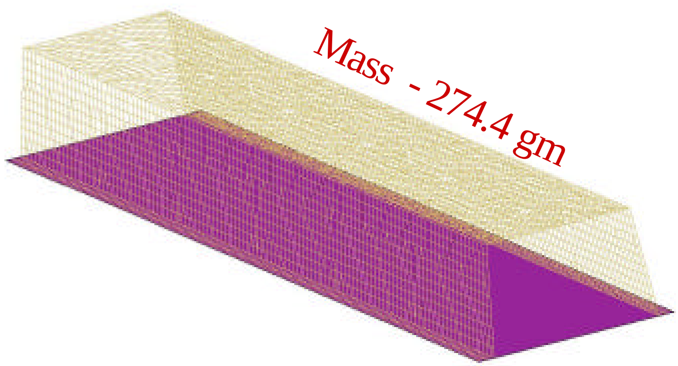


1. Riveted open (GF PA)

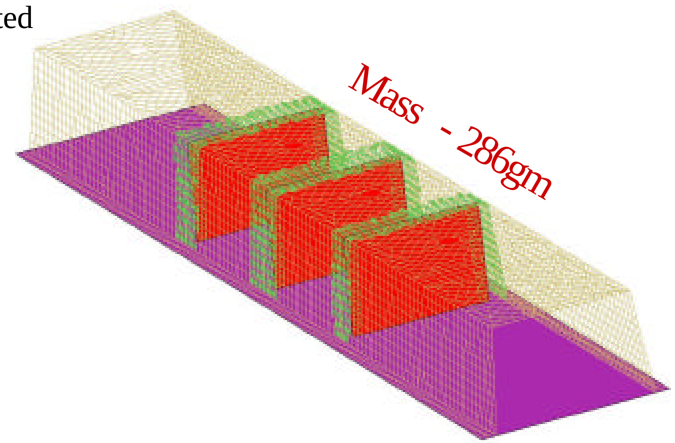


2. Bonded open (LGF PP)

Uniformly distributed dynamic loading of 0-5000 N on top center of simply supported beam



3. Bonded closed without ribs (LGF PP)



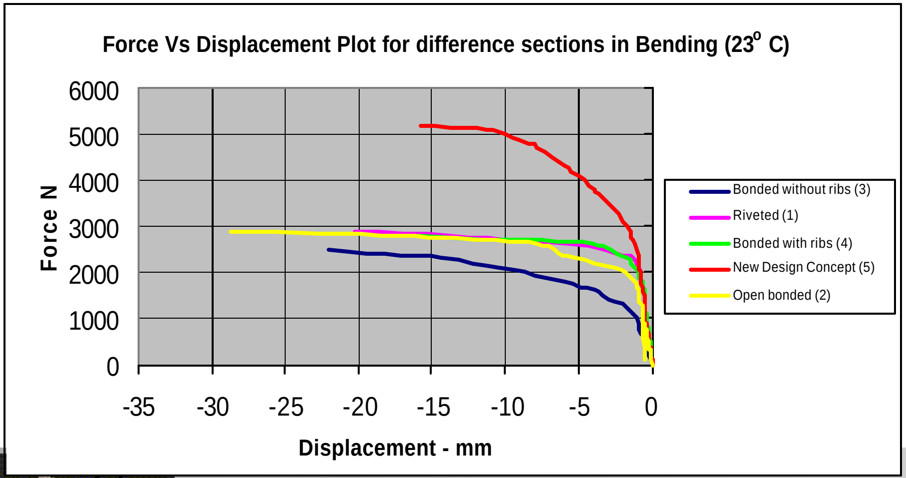
4. Bonded closed with ribs (LGF PP)

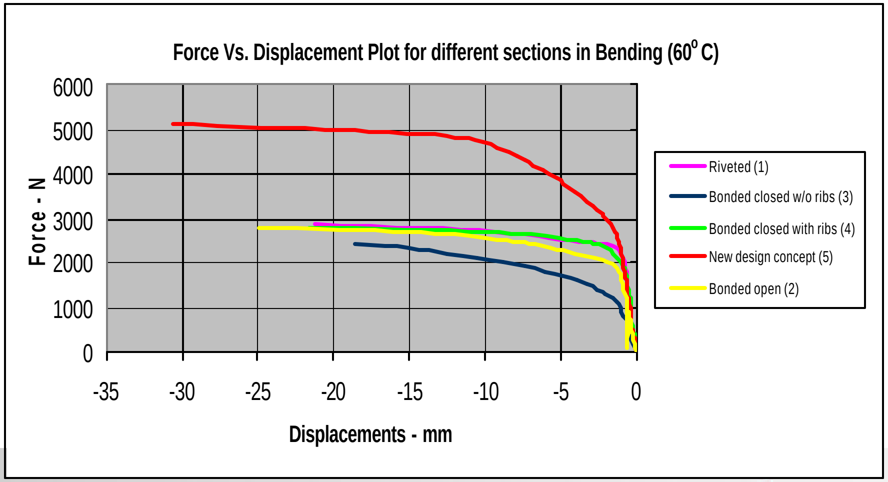
5. Further Bonded Design Concepts (LGF PP) Mass - 305 gm

Comparing Bending Stiffness Performance

Force at Yielding of Metal and Plastic at 23° and 60° C

Section type	Force @ Yield 23° C (Steel) N	Force @Yield 23° C (Plastic) N	Force @ Yield 60° C (steel) N	Force @ Yield 60° C (Plastic) N
Over-Molded (1)	1700	2700	1700	2700
Bonded open (2)	1600	2600	1600	2400
Bonded closed w/o ribs (3)	800	2400	700	2400
Bonded closed with ribs (4)	1700	2700	1600	2700
New Design Concept (5)	1900	4300	1800	3800





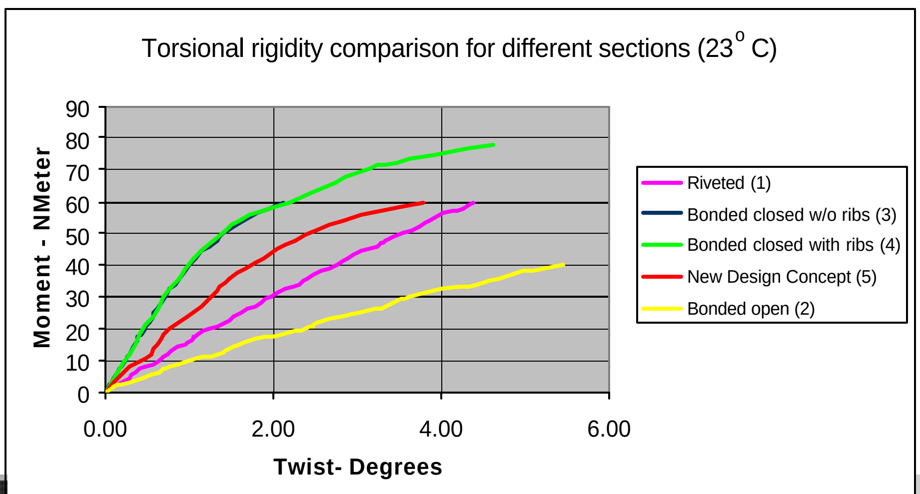
CAE for Further Development

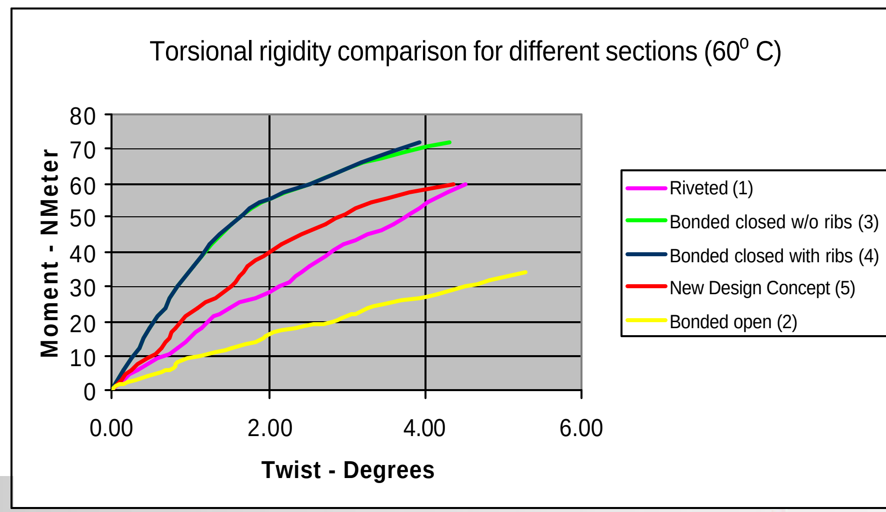
Dow Automotive

Comparing Torsional Rigidity Performance

Reaction Moment at 1, 2 and 3 degree twists at 23^o and 60^o C

Section type	Torsional rigidity @ 1,2,3 deg twist	Torsional rigidity @ 1,2,3 deg twist
	N-m (@ 23^o C	N-m (@ 60^o C
Over-Molded (1)	~ 15, 30, 44	~ 15, 28, 43
Bonded open (2)	~ 10, 18, 25	~ 10, 16, 22
Bonded closed w/o ribs (3)	~ 40, 59, 70	~ 35, 56, 65
Bonded closed with ribs (4)	~ 40, 58, 70	~ 35, 56, 65
New Design Concept (5)	~ 25, 45, 55	~ 22, 40, 52

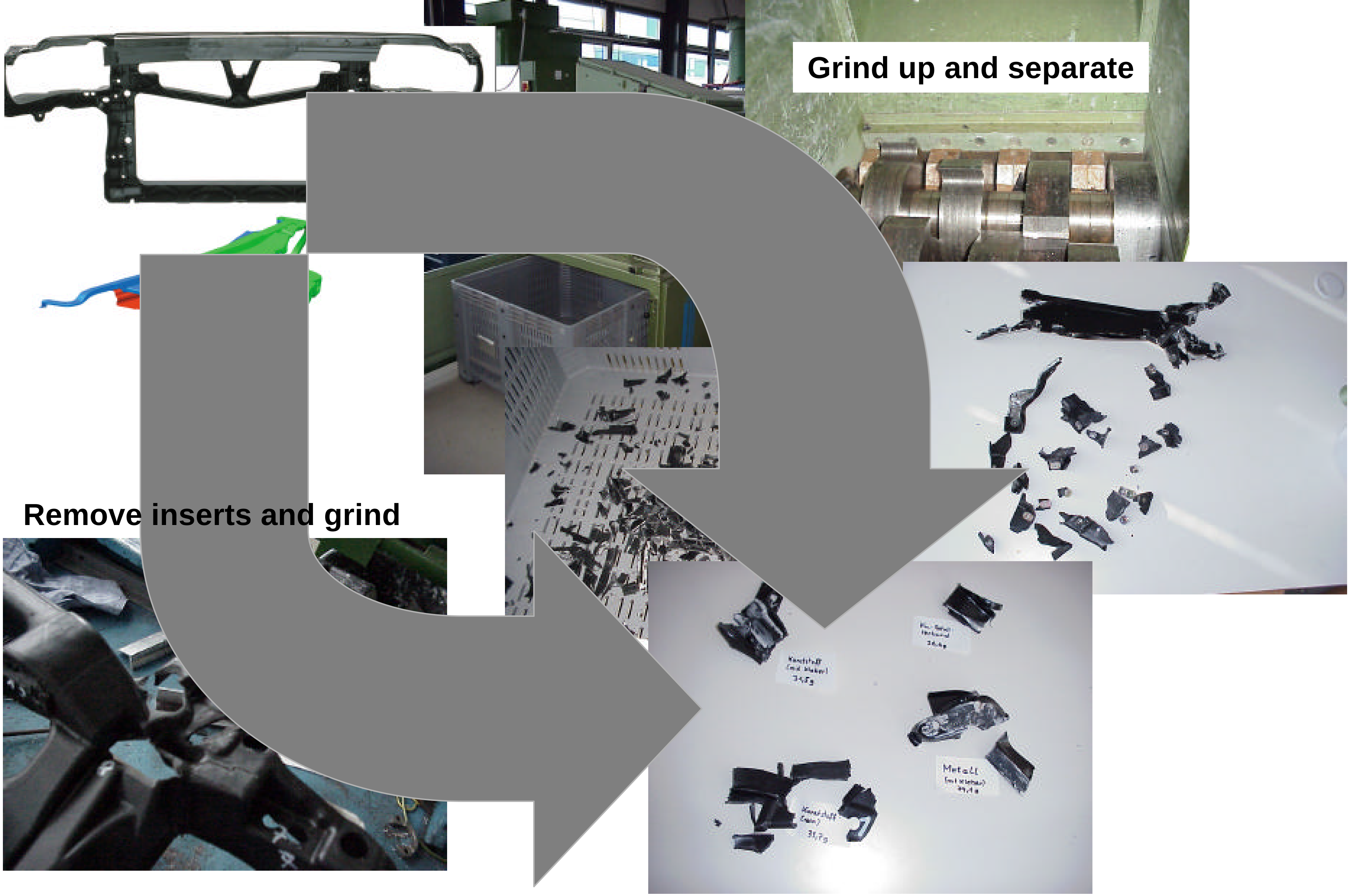




Mass Comparison

	GMT	Dow Concept
Reinforcement	1,40 kg	1,70 kg
Plastic structure	3,50 kg	2,30 kg
Air duct	0,12 kg	0,00 kg
Adhesive bonding	0,00 kg	0,05 kg
Inserts	----	----
Total system	5,00 kg	4,05 kg

~1 Kg mass reduction = 20 %



Recycling

	Long -Glass Fibre PP	Recyclate from LGF PP	Short -Glass Fibre PP	
Tensile Strength	120	68	85	MPa
Tensile Modulus	6700	5628	5500	MPa
Elongation	2.6	1.9	3.5	%
Flexural Strength	170	127	85	MPa
Flexural Modulus	6800	5377	5500	MPa
Charpy Impact	55	41	40	kJ/m^2

Recylate Properties

Dow Automotive

- Mass reduction
- Performance improvement
- Consistent high quality
- Flexibility of design
- Availability of process capabilities
- Materials tuned to optimise system
- CAE capabilities developed

Summary:Benefits and Advantages of the Dow Front-End System

Thank you !

Questions ?