



New Developments for Mass Production of Epoxy Automotive Composites

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Hexion Inc.
GALM Detroit 2016





Hexion is a specialty chemicals company with a leading position in the development and production of systems, products and services for the global energy, transportation and construction markets.

At a glance ...

Columbus, Ohio USA
US\$5.2 billion
5000 Employees
60 Global Production &
Technology Sites

Technology Platforms

Epoxy
Phenolics
Versatics™
Formaldehyde

Automotive Applications

Lightweight Composites
Exterior
Structural
Suspension
Under-the-hood
Braking
Coatings

Global Leadership Positions Across
 Our Range of Industries and Technologies



Leading Market Positions



Base Epoxy

Epoxy Resins
Global



Specialty Epoxy

Forest Product Resins
Global



Interior Parts

Phenolic Specialty Resins
Global



Versatic™ Acids & Derivatives
Global



Oilfield Proppant Resins
Global

Blue Chip Customers



■ Products for Automotive
■ Composite Applications



■ **BAKELITE® Engineering Thermosets / Molding Compounds**

- Water pump housings
- Vacuum pump housings
- Oil pump shaft, piston
- Variety of powertrain components




3rd Generation Volkswagen-Audi Water Pump
for 1.8/2.0 L EA 888 Engines

■ **EPIKOTE® Resins and EPIKURE® Curing Agents**

- Exterior panels
- Body structure
- Suspension components
- Driveshafts
- LPG, CNG and H₂ tanks



Audi R8/R10 CFRP "Sideblade"
Produced Using HP-RTM Process

- Auto Industry Imperative: Lightweighting to  HEXION™
- Meet Emission & Fuel Economy Regulations



- Composite Materials Face Perception of
- Low Manufacturing Volumes and High Cost



- Composite Technology Developments Have  **HEXION™**
- Enabled Mass Production of Automotive Parts



- Composite Technology Innovations
- Offer Cost-Efficient Lightweighting



Composites:

Offer highest weight reduction opportunities in automotive applications

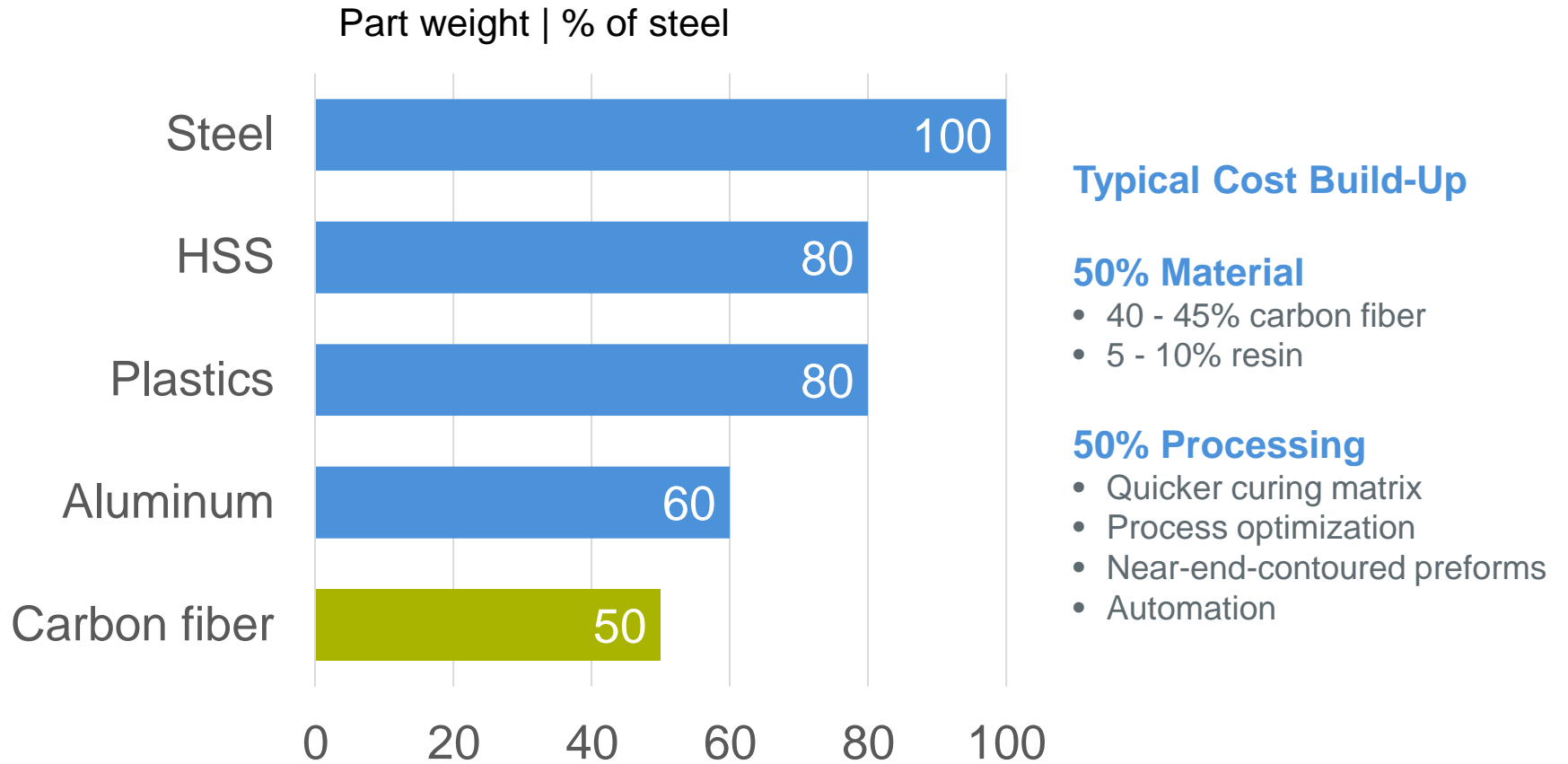
Innovative Processing Technologies:

Enable mass production of automotive parts

Carbon Fibre Reinforced Plastics (CFRP)



Have the Highest Weight Reduction Potential

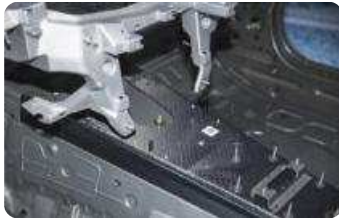


Sources: McKinsey Lightweight, heavy impact 2012, Roland-Berger, 2012

- BMW 7-Series “Carbon Core”
- Illustrates Body-in-White Mixed Material Use



BMW 7-Series SOP: 2015
Various CFRP Parts using Hexion resins
e.g. roof arc and tunnel reinforcement



Benefits

- 40 kg weight reduction vs. steel in the Carbon Core body structure
- Fast curing cycle enabled by Hexion latest resin technology
- Multi material usage: engineered for performance

Source: BMW Group

- Composite Technology Innovations
- Offer Cost-Efficient Lightweighting



Composites:

Offer highest weight reduction opportunities in automotive applications

Innovative processing technologies:

Enable mass production of automotive parts

- Epoxy CFRP with Resin Transfer Molding (RTM) Technology for Structural Applications



Audi R8 Coupe and Lamborghini Huracan (MSS Platform) CFRP Transmission Tunnel

ACE Advanced Composite Engineering GmbH
EPIKOTE™ Resin TRAC 06150/
EPIKURE™ Curing Agent TRAC 06150



Benefits

- 30% lighter than aluminium
- Short cycle time production

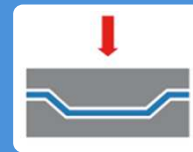
RTM Technology Enables Fast Production
of Highly Complex Structural Parts



Lay-up binder stabilized fabric

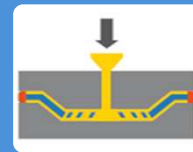


Heating and some pressure



- Fast handling
- Textile stability
- Controlled permeability

Mold closing and resin injection



- Thermal latency
- Low viscosity
- Rapid fiber wetting

Curing



- Fast conversion
- Isothermal
- Low exotherm

Opening and de-molding



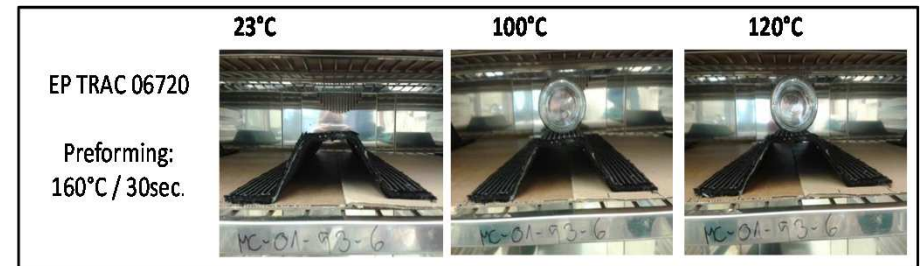
- Easy de-molding
- Part quality
- Reproducibility

Epoxy Binders Address Preforming Challenges in Fast RTM



Benefits

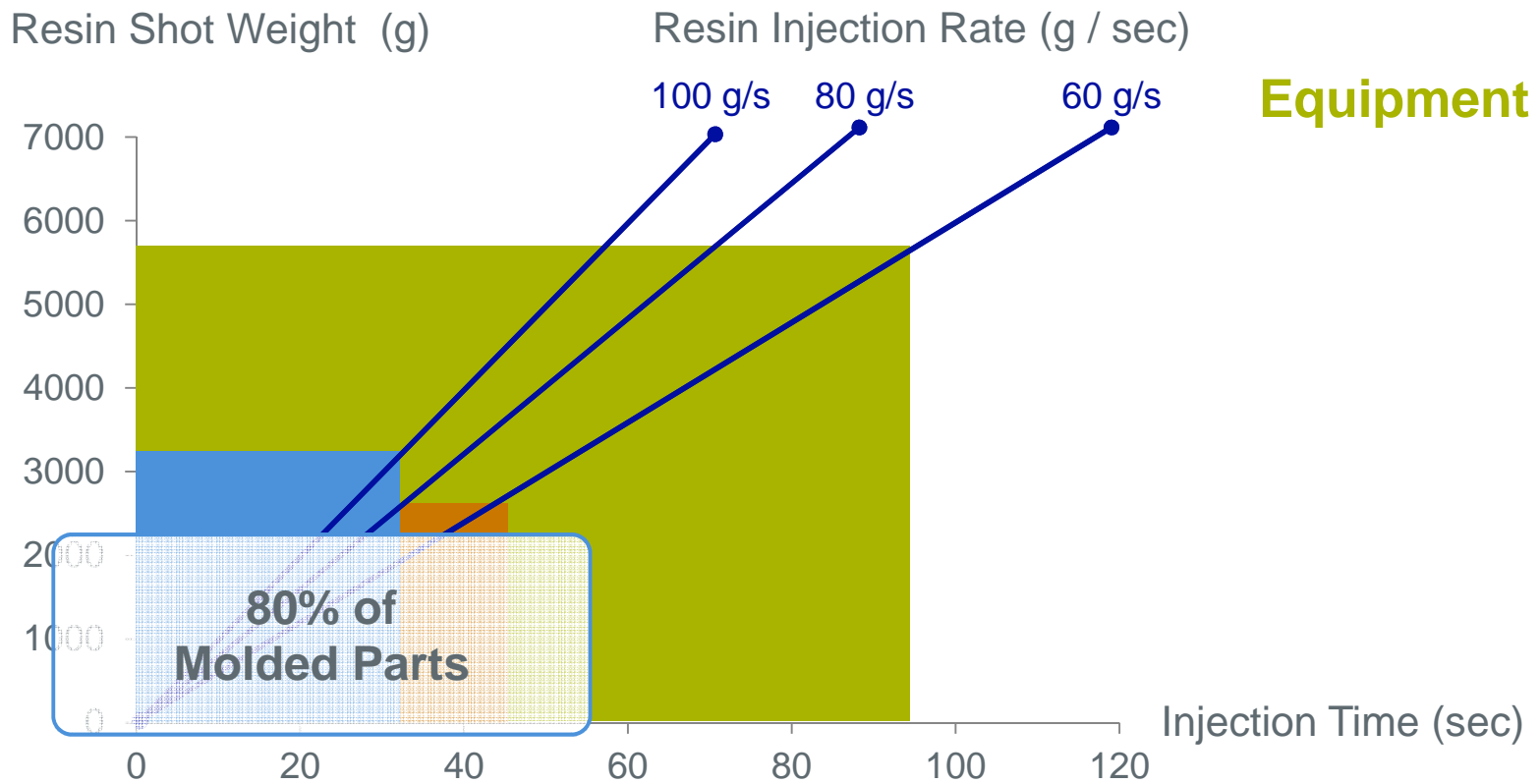
- Faster handling / positioning of preform
- Controlled permeability and lay-up definition
- Textile stability at mold temperature during injection



Part Size and Equipment Determine
 the Material Processing Window



Part



Equipment

EP TRAC 06170
 EK TRAC 06170
 33 sec

EP TRAC 06150
 EK TRAC 06165
 45 sec

EP TRAC 06150
 EK TRAC 06150
 95 sec

Material

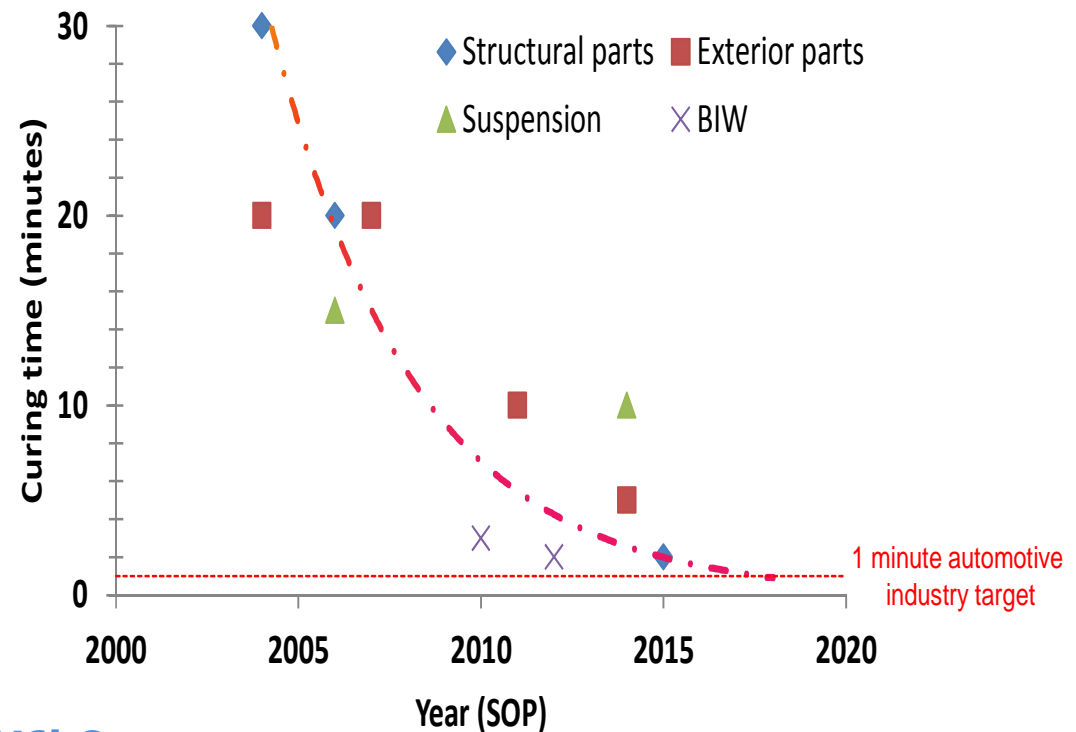
High Pressure RTM / LCM Process

In-Production Examples




- In-Production Examples**

- BMW M Series
- BMW i-Series
- BMW 7 Series
- Porsche 911 GT3 CUP
- Porsche Boxter
- Audi R8
- Lamborghini Aventador
- Volkswagen XL1



- <https://youtu.be/qZrOxQ1V6bQ>

Resin cure time is no longer a limiting factor for support of series production.

■ Epoxy CFRP with RTM & LCM Technology  **HEXION™**
■ for Structural Applications

**BMW 7-Series
CFRP Roof Arc**
EP TRAC 06000/
EK TRAC 06130



Benefits

- Designed to the shape of the car body
- Fast curing cycle with HP-RTM
- Outstanding weight / performance ratio

**BMW 7-Series
CFRP Tunnel Reinforcement**
EP TRAC 06000/
EK TRAC 06130



Benefits

- Local reinforcement enhances torsional stiffness
- Fast curing cycle with LCM

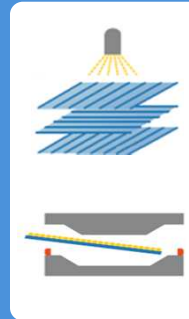
■ LCM: Preforming is Simplified and Direct
■ Liquid Resin Application Shortens Cycle Time



Lay-up dry fabrics



Liquid resin application



Transfer wet lay-up into mold

- Tailorable latency

Curing



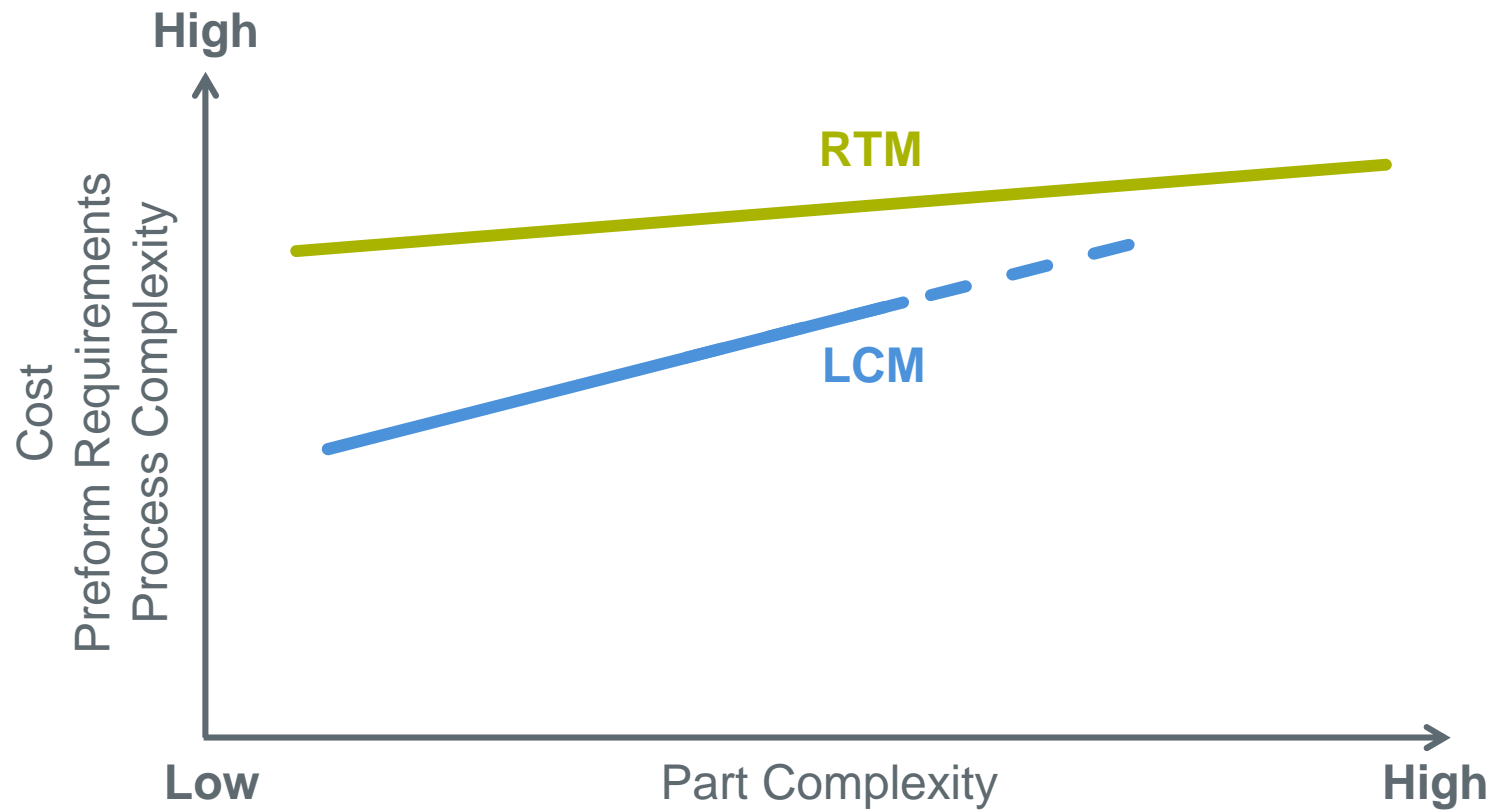
- Controlled viscosity build
- Fast conversion
- Low exotherm

Opening and de-molding



- Easy de-molding

- Liquid Compression Molding (LCM) is
- Increasing Attractive for Complex Parts



- Part-to-Part Cycle Time of <math><1</math> Minute
- Demonstrated w/ Liquid Compression Molding



■ Epoxy CFRP with Prepreg Technology
■ (PCM) for Semi-Structural Applications



Forward Light Holders
CMP GmbH - UBC GmbH
EP TRAC 06425/
EK TRAC 06465



Performance Benefits

- Lightweight versus steel
- Short cycle time (90 sec or 3–5 min)
- High mechanical performance
- High Tg

Mini Front Wings
CMP GmbH - UBC GmbH
EP TRAC 06425/
EK TRAC 06465

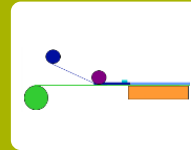


Processing Benefits

- Long shelf life at room temperature
- Easy and versatile molding
- In house prepreg as viable approach to further reduce cost

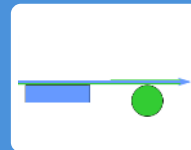
High Mechanical Performance is Achieved 
with Prepreg Technology

Impregnation



- Low viscosity
- No VOC
- No preforming

Fiber or Prepreg Placement



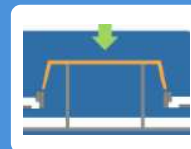
- Easy fiber positioning
- Stable band width
- Good fiber wetting

Cutting & Molding



- Low scrap rate
- Hybrid reinforcement
- Functionalization

Pressing



- Short in-mold cycle times
- Controlled flow
- Net shape

Part de-molding



- Low shrinkage
- Mechanical performance
- Reproducibility

EPIKOTE™ Resin Systems Have
Benefits in SMC



Epoxy Benefits versus Vinyl Ester and Unsaturated Polyester Resins

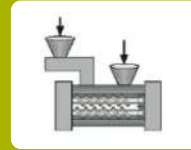
- VOC and styrene free
- Inherently low shrinkage
- Better mechanical strength properties
- Good adhesion to glass and carbon fibre
- Compatible with other epoxy material technologies
- Higher Tg
- Higher fatigue / durability performance

Improved Cost Efficiency of SMC



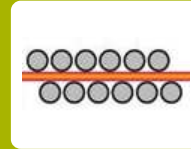
Technology: Net Shape Molding without Preforming

Component Mixing



- Low Viscosity
- No VOC (styrene free)

SMC Compounding



- Good fibre wetting
- Potential use recycled fibre
- Fast maturation

SMC Cutting & Molding



- Lower scrap rate
- Hybrid reinforcement
- Functionalization

Pressing



- Short in mold cycle times
- Controlled flow
- Net shape

Part de-molding



- Low shrinkage
- High strength/modulus
- Reproducibility

■ Optimum CFRP Performance and Cost



■ ... depend upon all 3 factors:

Design

- Equipment Suppliers
- Reinforcement & Preforming
- Part Design and Modeling
- Process Design and Simulation
- Tool Construction

Materials

Epoxy Resins:

- Liquid Resins
- Hot Melts
- Perform Binders
- Mold Release Agents
- Prototyping Systems

Phenolic ETS Compounds



Process

- | | | | |
|---------|-------------------|-------------------------|---------|
| HP-RTM | Injection Molding | LCM Compression Molding | Prepreg |
| Towpreg | Performing | SMC | FiWi |

Optimum CFRP Performance and Cost



... depend upon all 3 factors:



Key Messages



Epoxy Glass and Carbon Fibre Reinforced Composites:
Highest weight saving potentials

New generation resin systems:
Faster cure cycles, easier demolding and more process versatility

Comprehensive component design and development:
Will continue to decrease the cost of weight saving

Automotive Application Centers
 Come visit us!



Composite Application Technologies

Preforming
 RTM (HP-/LP-RTM)
 Prepreg
 CM / SMC / LCM
 Prototyping
 Tooling



HP-3K Dosing
Cannon ESTRIM System



2500 ton press



RTM Tooling



TRAC

Duisburg, Germany



FRAUNHOFER
PROJECT CENTER

London, ON



South Hampton, UK

 Additional Questions?

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Thank You !

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