Mr Daniel Ageda – COO JEC Group

OVERVIEW OF COMPOSITES IN THE AUTOMOTIVE INDUSTRY

Bangkok – 4th of July 2017
JEC Group Mission Statement

- International organization 100% solely dedicated to the development of the composites industry worldwide
- Generalist (all segments / entire value chain) and International
- Our role is to inform, educate, network, share…
- We have strong Innovation and Business Platform (to ensure cross fertilization)
- Cross fertilization between show organization and media activities (JEC Mag)
- Strongly investing to develop the Composites industry worldwide (launching new platforms, promoting innovation, go-between…)
- The largest network of composites specialists

Six major fields of expertise:
- Information channels, Business Intelligence, Information channels,
- Innovation Programs, Education & conferences, Platforms & trade-shows
JEC Offices in North America, Europe and Asia

- Contribute to expanding composites markets
- Services provider globally and locally
- Offices and staff in the US, European Union and Asia
JEC GROUP SERVES THE COMPOSITES INDUSTRY ALL YEAR ROUND, WORLDWIDE

Networking Events

Media
Next JEC International Composites Events

- **THE FUTURE OF Composites in Construction**
  - Chicago, IL, USA
  - June 20-21-22, 2017

- **JECasia**
  - Seoul, Republic of Korea
  - November 1-2-3, 2017

- **JEC forums**
  - Knoxville, TN, USA
  - November 15-16, 2017

- **JEC WORLD 2018**
  - Paris, France
  - March 6-7-8, 2018

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Composites worldwide... in few words...
Global composites industry

- **Continued growth trend** is supported by **two major drivers:**
  - **The economic growth in emerging countries:** increasing penetration in most application industries...
  - **Innovation trends:** in aeronautics, automotive and wind energy applications, thermoplastic resins, automated processing (in particular injection)

- **The emergence of Asia** as the main market for composite materials in volume – Asia could represents 50% of global market with China representing 50% by its own...

- **The leading role of North America and Europe on high-end composites** (Aeronautics, Automotive and wind energy) and manufacturing processes (injection)

- **The technological catch-up expected on the long term in emerging Asia** driven by continued and strong industry growth with positive impacts on investments, experience and scale effects
Size of the composites Market in 2016 per region in value

Asia represents 43% of the global market in value (Euros)

Market share (value)

- India Asia Pacific: 34.80 Bn€
- North America: 23.70 Bn€
- Europe: 16.50 Bn€
- Latin America Africa: 4 Bn€
- Total: 79 Bn€

Market size (value)

- India Asia Pacific: 35.26 Bn$ (US Dollars)
- North America: 24.60 Bn$
- Europe: 17.22 Bn$
- Latin America Africa: 4.92 Bn$
- Total: 82 Bn$
The global composite industry should continue to grow, with China representing 60% of the global growth in volume - 2010 - 2021.
Transportation, Construction and E&E are the three industries that have largest weight in the global composites market, 2016 - In volume (kt)

Sources: Lucintel, interviews, Estin & Co analysis and estimates
Breakdown of the demand for carbon fibre from 2013 to 2020, by main user sector (Source: JEC Survey)
Composites are only at the beginning of their history...
Automotive worldwide... in few words...
• Between 1980 to 2014, global vehicle production has increased by 125%.

• The main events of these last 10 years were the high growth of China and the automotive crisis in Europe (-20% of vehicles produced between 2007 and 2009) and the US (-47% of vehicles produced between 2007 and 2009).
Since 2010, automotive production has increased continuously and surpassed pre-crisis level, except for Europe, which didn’t recover completely.
The Worldwide market has also increased, naturally driving global production upwards. Between 1980 and 2014, **Asia-Oceania was the only region which had significantly increased**. Other regions (Americas, Europe and the rest of the World), experienced variations but keeping the same volume of sales.

During the last decade, **the combination** of the economic crisis and its impact on historic automotive markets, **political and economic instability** in markets showing potential, **the tremendous growth of China**, but also the **development of alternative ways of mobility gives a complex view of the Worldwide automotive industry**.
• What will the automotive market be like in the “realistic” term (2020-2025)? Which regions will increase, remain stable or decrease?
• Will China exports vehicle all around the World?
• Can a new economic crisis impact the automotive industry?
What is impacting composites materials development?

• Environmental concerns:
  • Emissions
  • Waste management – end of life

• Economic trends
Environmental concerns: Emissions

- The opportunities opened for composite materials are driven by reduction of both emissions, CO2 and pollutants:

  - CO2 emissions can be reduced by **decreasing the weight of vehicles and the CX**. Use of composite materials can contribute significantly to lower vehicles weight and CX.

  - The pollutant emissions are generally reduced by an action on the power chain: engines (downsizing, combustion improvement, ...) and post-treatment (SRC, D-Nox trap, Particulates filter).

  Direct contribution of composite materials is usually low in this area. However composite materials may be indirectly involved.

For instance, **decrease of diesel market** share in Europe, consequence of more stringent standards and lobbies attack, **leads to an increase of CO2 emissions** in Europe for a same number of vehicles sold. It become therefore necessary to develop actions to decrease the CO2 emissions further than with the previous diesel/gasoline mix situation.
Ecological concerns lead to needs of weight decrease

- The CO2 emissions are strongly correlated to the mass of the vehicle

- From OEMs feedback, around 10 g/km of CO2 can be gained by a weight decrease of 100kg. This value may change with the application of new tests WLTC/WLTP.

- It is important to work on heavier functions, such as structural functions.
- But decreasing weight of small parts can also be very interesting.
- And it may provide a strategic advantage to the suppliers which develop them.
Environmental concerns: Emissions

• The CO2 situation is quite different from a region of the world to another one. There is no common approach.

• Regulation may consist in **mandatory or voluntary standards.**
• Standards are expressed in terms of CO2 targets (g/km or g/mi) or in terms of consumption (l/100 km or mpg), both being intimately linked.
• Test cycles and processes are different, with two main eras:
  - WLTC (C=cycle) and WLTP (P=Process)
    - European Union: currently NEDC and then : WLTC and WLTP+ RDE (Real Driving Emission).
    - China and India: currently NEDC and then : WLTC (C for cycle) and WLTP (P for process)
    - Japan: currently JECO8 and then WLTC/WLTP.
  - Combination of US tests.
    - NAFTA and South Kore
• Target CO2 in 2020/2021 (source:VDA) :
  **Targets by region get closer and closer but Europe has the most ambitious fleet targets:**
  Europe: 95g/km , Japan: 105 g/km, China:117 g/km, USA:124 g/km.
Three key datelines for light-weighting of vehicles

Source: Faurecia 2015 presentation
**CO₂- Emission Standards - Market-Specific**

<table>
<thead>
<tr>
<th>Market</th>
<th>2025 CO₂ Consumption (g CO₂/mile)</th>
<th>2020 CO₂ Consumption (g CO₂/mile)</th>
<th>2020 Fuel Efficiency (mpg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>163 g CO₂/mile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Europe</td>
<td>153 g CO₂/mile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td></td>
<td>47 mpg</td>
<td></td>
</tr>
</tbody>
</table>

**CO₂- consumption laws are market-specific and very inhomogeneous!**

In all markets CO₂ is a key issue.
Emission Reduction Targets in the Global Automotive Industry

Source: ICCT

97 g/km of CO₂ = 54.5 mpg
Economic trend

• More people in the world have access to ownership of a vehicle.

• A scissor effect:
  - more and more demand for low cost vehicles,
  - and, at the same time, more and more demand for more Premium vehicles (including SUV),
  - the medium range becoming squeezed between both but still very strong.

• An economy more and more digital which opens new possibilities:
  - Electronic support to driving, towards safer and more autonomous vehicles;
  - Extension of connectivity.
By the year 2030, emerging Asia will account for 60% of the total middle class.

### Middle class growth 2010 - 2030

<table>
<thead>
<tr>
<th>Region</th>
<th>2010 (in M)</th>
<th>2020 (in M)</th>
<th>2030 (in M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emerging Europe</td>
<td>181</td>
<td>264</td>
<td>268</td>
</tr>
<tr>
<td>Mature Asia</td>
<td>222</td>
<td>1472</td>
<td>2960</td>
</tr>
<tr>
<td>Emerging Asia</td>
<td>338</td>
<td>333</td>
<td>333</td>
</tr>
<tr>
<td>North America</td>
<td>450</td>
<td>439</td>
<td>439</td>
</tr>
<tr>
<td>Latin America</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mature Europe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1845</td>
<td>3249</td>
<td>4884</td>
</tr>
</tbody>
</table>

### Percentage from emerging Asia (%)
- 2010: 13%
- 2020: 45%
- 2030: 60%

### Total middle class (1) (in M)
- 2010: 1845
- 2020: 3249
- 2030: 4884

### CAGR 2010-2030
- Emerging Asia: 13.0%
- Mature Asia: -0.2%
- North America: -0.2%
- Other areas: 4.7%
- Total: 5.0%

### Chinese and India middle class (in M of people)

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(1) OECD definition: The middle class is defined as those with daily purchasing power between $10 and $100 per person; (2) Middle East and Africa; (3) China, India, Indonesia, Pakistan, Bangladesh, Philippines, Vietnam, Myanmar, Malaysia, Cambodia, Laos, Brunei, Central Asia and other Asian countries (Iran, Afghanistan, Uzbekistan, Nepal, North Korea, Sri Lanka, Kazakhstan, Tajikistan, Azerbaijan, Kirghizistan, Turkmenistan, Georgia, Mongolia, Armenia, East Timor, Bhutan, Maldives); (4) Japan, Singapore, Australia, New Zealand, South Korea, Taiwan, Thailand.

Source: OECD, Estin & Co analysis and estimates.
New opportunities

• The new environment opens big opportunities for composite materials:

  • Ecological concerns lead to needs of weight decrease of cars and therefore the use of more light materials.

  • New energy vehicles pave way for new types of parts.

  • New functions (electrification, electronic support of driving, connectivity ..) are developed.

  • New shape/design are developed in order to respond to the taste of different markets.

  • Globalisation means manufacture of small-medium series of vehicles, which is favourable for the use of composites materials.

  • = weight reduction to compensate integration of new function necessary
Weight causes about ¼ of fuel consumption
New energy vehicles pave way for new type of parts
Composites in Automotive… in few words…
Many parts have been developed and manufactured in the past in mass production, especially GFRP (Glass Fibers Reinforced Plastics), with some highs and some lows:

- SMC bumpers, which have finally been replaced by a combination of steel and thermoplastics.
- Fenders which have reached a peak and then decreased.
- Rear floors and spare wheel trays.
- Tailgates.
- Front modules.
- ............

The need of even more weight saving pushed OEMs towards CFRP... even though composites are still far from metals (steel and aluminium) in mass production use.
Future Automotive Materials will be Dominated by increasing demand in Lightweight Materials


<table>
<thead>
<tr>
<th>Year</th>
<th>Lightweight Materials</th>
<th>Conventional Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>312 Blbs</td>
<td>76%</td>
</tr>
<tr>
<td>2015</td>
<td>356 Blbs</td>
<td>70%</td>
</tr>
<tr>
<td>2025</td>
<td>469 Blbs</td>
<td>53%</td>
</tr>
</tbody>
</table>

CAGR (2015-2025)
- HSS (>550 Mpa) ~9%
- Aluminum ~5.3%
- Plastics ~9%
- CFRP ~16%
- Other Composites ~5%
- Magnesium ~8%

Source: Lucintel
Mega-trends Automotive Segment

- Consolidation of the Value Chain continues, M&A, partnerships between CF manuf. and OEMs

- Many consortia established with key players of the supply chain to achieve breakthrough developments

- Reduce CO2 emissions, and avoid paying penalties... weight saving...

- Lower cost - price performance ratio - Low cost carbon fibers... (right fiber for the right use, i.e. development of new precursors)...

- Hybrid Structures: The right material for the right function at the right place... and of course at the right cost... (define assembly strategies/solutions, management of CLTE between different materials, ...)

- Affordable, scalable, predictable and reproducible composite manufacturing capabilities (faster processes with cycle time below 1 mn, fast TS curing resin, penetration of TP, ”in mould” reactive resins, tooling for forming netshape, one shot A-Class surface...)
Mega-trends Automotive Segment

• Assessing concepts, materials and body architectures that have the potential to assert themselves in the future...

• Introducing friendly processing - aimed at one shot and net shape – in a mass production constraint – defining how should production concepts look like in the next 20 years in order to meet the OEM demands

• Using simulation as a key leverage of to increase added value of composites, to reduce validation cost (predicting the behavior of composite materials without actually manufacturing the part is an important endeavor) and time to market... Design/Process/Raw materials...from virtual design to virtual testing, and then on to virtual manufacturing.

• Defining maintenance and repair strategies

• Recycling challenge – end of life

• Secured supply chain – international – consistent materials performance and availability
**Main Composites Trends**

- **High growth rate of thermoplastics** (Cycle time around 1 minute vs. 2 minutes or more, Impact resistance, Process control (no chemical reaction), Recyclability, VOC emissions and odor).

- Development of **injection / in mould processes** (High Speed/HP RTM, TP RTM, …)

- UD Tape Technology to boost Mechanicals in thermoplastic Composites

- Combination of continuous fiber reinforced thermoplastics (for structure) and overmolded chopped fiber thermoplastics (for function integration)

- 3D Braided structures

- Biocomposites

- **Hybrid Structures**: Joining composites to metals… the right material for the right function at the right place…

- Faster processes: Polymer Curing Technology (microwave…), Induction heating technology

- Coatings/surface finishing for A-class

- **Low cost carbon fibers**… (different precursors, right fiber for the right performance)
Usage of composites by car part

The usage of composites part varies according to the price level of the car

- **Interior parts**
  - Instrumental Panel: >70%
  - Interior trimming: >70%

- **Functional parts**
  - Oil tank: <20%
  - Water tank: <20%

- **Exterior body parts**
  - Hardtop: 25%
  - Sunroof: >75%
  - Door panels: 25%
  - Bonnet: 50-75%
  - Front/Rear bumper: 50-75%
  - Deck lid/tailgates: 75%

- **Semi-structure parts**
  - Front frame: >75%
  - Bumper frame: >50-75%
  - Seat frame: 50-75%
  - Floor: 50-75%

- **Chassis**
  - Chassis: Not before 2020

**ORDERS OF MAGNITUDE**

- **Widely used**
  - Composites penetration % -
- **Emerging usage**
  - 25-50%
- **No current usage**
  - >75%
- **Usage expected 2015-2020**
  - 50-75%
- **Not before 2020**
  - <25%

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Weight reduction potential by type of car part

The chassis presents the most potential for weight reduction but cost-efficient materials/processes do not yet exist.
## Challenges in Using Lightweight Materials

<table>
<thead>
<tr>
<th>Category</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased Costs</td>
<td>Excessive use of lightweight materials will lead to increase in cost of vehicles</td>
</tr>
<tr>
<td>Safety Concerns</td>
<td>Replacement of traditional metals with lightweight materials need to pass through various evaluation tests and technical challenges</td>
</tr>
<tr>
<td></td>
<td>Crashworthiness of lightweight materials is still under test</td>
</tr>
<tr>
<td>Temperature Resistance</td>
<td>Introduction of dissimilar materials may lead to difference in temperature resistance impacting the overall temperature susceptibility of the part</td>
</tr>
<tr>
<td>Joining Difficulty</td>
<td>Attaching two similar substrates is easier when compared to dissimilar materials as they have different physical and chemical properties. With decrease in material weight adhesion to lighter surfaces becomes difficult</td>
</tr>
<tr>
<td>Noisier Parts</td>
<td>Lighter parts tend to produce higher vibration and noise as compared to traditional steel body panels</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>Changing to different substrates, from metals to plastics or composites, changes the appearance of the part thus creates perception of poor quality</td>
</tr>
<tr>
<td>Repair Ability</td>
<td>Parts made using multi-material systems increases the complexity of repairing parts of the vehicle</td>
</tr>
</tbody>
</table>

**Increased Costs**

**Safety Concerns**

**Temperature Resistance**

**Joining Difficulty**

**Noisier Parts**

**Aesthetics**

**Repair Ability**

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### Structural Application

<table>
<thead>
<tr>
<th>Relative Part Weight</th>
<th>Steel</th>
<th>AHSS</th>
<th>Aluminum</th>
<th>CFRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>100%</td>
<td>120%-140%</td>
<td>150%-230%</td>
<td>700%-900%</td>
</tr>
<tr>
<td>75%-90%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50%-60%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Non Structural Application (Fender)

<table>
<thead>
<tr>
<th>Relative Part Weight</th>
<th>Steel</th>
<th>AHSS</th>
<th>Plastics</th>
<th>Aluminum</th>
<th>CFRP (RTM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>100%</td>
<td>110%-130%</td>
<td>100%-110%</td>
<td>120%-140%</td>
<td>500%-700%</td>
</tr>
<tr>
<td>75%-90%</td>
<td></td>
<td>75%-80%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50%-60%</td>
<td></td>
<td></td>
<td>50%-60%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25%</td>
<td></td>
<td></td>
<td></td>
<td>30%-50%</td>
<td>30%-50%</td>
</tr>
</tbody>
</table>

### Drivers

- **CAFÉ Requirement**
- **CO₂ Emission**

Source: Lucintel
## Key Lightweight Technologies Used to Manufacture Automotive Parts

### Key Processes
- **HSS/AHSS**
  - Stamping
- **Aluminum**
  - Stamping
  - Casting
  - Extrusion
- **Glass Composites**
  - Compression Molding
  - Injection Molding
  - RTM

### Key Applications (Process)
- **HSS/AHSS**
  - Usibor (A-pillar, Bumper Beam, B-Pillar, C-Pillar, Door Beam)
  - Fuel Tank Guard
  - Body in White
  - Door Panels
  - Axle Carrier
  - Engine Cradle
  - Dash Panel
  - Crash Box
  - Side Rail
  - Seat Frame
- **Aluminum**
  - Heat Shield, Bumpers, Hoods, and Closure Panels: (Stamping Process)
  - Powertrain (Engine Block, Transmission): (Casting Process)
  - Chassis & Suspension, Heat Exchangers: (Extrusion Process)
- **Glass Composites**
  - Intake Manifold: (Injection Molding)
  - Hood (Compression Molding)
  - Door Module: (Compression Molding)
  - Radiator End Tank: (Injection Molding)
  - Oil Pan: (Injection Molding)

*Source: Lucintel*
### Key Lightweight Technologies Used to Manufacture Automotive Parts

<table>
<thead>
<tr>
<th>Carbon Composites</th>
<th>Natural Composites</th>
<th>Magnesium</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Prepreg Layup</td>
<td>• Compression Molding</td>
<td>• Casting</td>
</tr>
<tr>
<td>• Resin Infusion (HP-RTM)</td>
<td>• Injection moulding</td>
<td>• Extrusion</td>
</tr>
<tr>
<td>• Monocoque: (Prepreg &amp; RTM Process)</td>
<td>• Door Panel</td>
<td>• Door Inner, Roof Frame, Lift Gate Inner, Pillar: (Casting Process)</td>
</tr>
<tr>
<td>• Hood: (Prepreg Layup)</td>
<td>• Seat Back</td>
<td>• Support Beam, Connectors, Side Rails: (Extrusion Process)</td>
</tr>
<tr>
<td>• Door Panel: (Prepreg Layup)</td>
<td>• Load Floor</td>
<td></td>
</tr>
<tr>
<td>• Roof: (Prepreg Layup)</td>
<td>• Interior Panels</td>
<td></td>
</tr>
<tr>
<td>• Body Panels: (Prepreg Layup &amp; RTM Process)</td>
<td>• Under Body Shields</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Lucintel
# Lightweight Materials Options in Various Applications

<table>
<thead>
<tr>
<th>Body-in-White</th>
<th>Closures &amp; Fenders</th>
<th>Powertrain</th>
<th>Suspension &amp; Chassis</th>
<th>Interior &amp; Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>(22%-25%)</td>
<td>(7%-8%)</td>
<td>(24%-28%)</td>
<td>(22%-27%)</td>
<td>(18%-23%)</td>
</tr>
</tbody>
</table>

## Key Materials
- **Steel**
- **HSS/AHSS**
- **Aluminum**
- **CFRP**

## Key Applications
- **Passenger Compartment Frame**
- **A,B, & C Pillars**
- **Roof Structure**
- **Floor Structure**
- **Front & Rear Door**
- **Hood/ Bonnet**
- **Fenders**
- **Tailgate/ Liftgate**
- **Engine**
- **Exhaust System**
- **Fuel Tank**
- **Transmission**
- **Chassis**
- **Wheels**
- **Steering Brakes**
- **Seats**
- **Instrument Panel**
- **Insulation**
- **Airbags**
- **Windows**
- **Glazing**
- **Trim**

## Source: Lucintel
Cost/Performance Trade-off

Carbon-fiber-reinforced plastics (CFRP)

- Carbon fiber
- Thermo-set

Glass-fiber-reinforced plastics (GFRP)

- Glass fiber
- Thermo-set

Application examples

- Source: Lamborghini
- Source: ENGEL Austria
- Source: Laminaa

<table>
<thead>
<tr>
<th>Stiffness</th>
<th>CFRP</th>
<th>GFRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Weight</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Cost</td>
<td>↑</td>
<td>↓</td>
</tr>
</tbody>
</table>

- "Best mechanical properties but highest cost"
- "High impact resistance and short cycle time"
- "Reduced mech. properties but cost advantage"
- "Short cycle times and attractive cost profile"

Cost/ Performance will dictate the material choice
<table>
<thead>
<tr>
<th>Reinforcement type</th>
<th>Molding process</th>
<th>Europe</th>
<th>N.America</th>
<th>Asia</th>
<th>Typical applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass fiber</td>
<td>Reactive thermoplastic, curved pultrusion – then overmolded</td>
<td>✓</td>
<td>?</td>
<td>?</td>
<td>Bumper beam</td>
</tr>
<tr>
<td></td>
<td>HP RTM (PU based) or patented process by Sogefi</td>
<td>✓</td>
<td>?</td>
<td>?</td>
<td>Coil and leaf springs</td>
</tr>
<tr>
<td>Carbon fiber</td>
<td>HP RTM, sometimes with gap</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Monocoques, structural parts</td>
</tr>
<tr>
<td></td>
<td>Liquid Compression molding</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Structural parts</td>
</tr>
<tr>
<td></td>
<td>Carbon Fiber SMC</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Monocoques, structural parts</td>
</tr>
<tr>
<td></td>
<td>Molding high speed curing multilayer prepreg systems without autoclave</td>
<td>✓</td>
<td>✓</td>
<td>?</td>
<td>Structural parts</td>
</tr>
<tr>
<td></td>
<td>Filament winding of CNG and Hydrogen pressure vessels</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Tanks for alternative fuels</td>
</tr>
<tr>
<td>Natural fiber</td>
<td>Flaxpreg development</td>
<td>✓</td>
<td>?</td>
<td>?</td>
<td>Trunk load floor, seat backs</td>
</tr>
</tbody>
</table>
## Key Challenges for Lightweight Materials in the Automotive Industry

<table>
<thead>
<tr>
<th>AHSS/HSS</th>
<th>Aluminum</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-cost as compared to traditional steel</td>
<td>High-cost</td>
</tr>
<tr>
<td>Complexity in stamping due to high strength</td>
<td>Limited compatibility with existing manufacturing infrastructure</td>
</tr>
<tr>
<td>Spring back behavior of AHSS</td>
<td>Aluminum is difficult to process compared to steel</td>
</tr>
<tr>
<td>HSS possesses challenges for joining</td>
<td>Joining and welding is difficult</td>
</tr>
<tr>
<td>Low corrosion resistance</td>
<td>Higher lifecycle emission than steel</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Magnesium</th>
<th>Plastics &amp; Composites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formability of magnesium is difficult</td>
<td>Recycling of waste materials after use</td>
</tr>
<tr>
<td>High-cost compared to other materials</td>
<td>High-cost compared to other lightweight materials</td>
</tr>
<tr>
<td>Processing magnesium to sheet requires high cost</td>
<td>Lack of mass production technology</td>
</tr>
<tr>
<td>Low corrosion and creep resistance</td>
<td>Joining plastics and composites to metallic surfaces can be difficult</td>
</tr>
<tr>
<td>Recycling of magnesium alloys</td>
<td>High repair cost</td>
</tr>
<tr>
<td>Low temperature resistance</td>
<td></td>
</tr>
</tbody>
</table>
## Mass Production
requires further innovation and cost reduction

<table>
<thead>
<tr>
<th></th>
<th>Carbon fibre</th>
<th>Glass fibre</th>
<th>Matrix</th>
<th>Production Method</th>
</tr>
</thead>
</table>
| Current Fields of Development | ➢ Modified conversion methods with reduced energy consumption  
➢ Innovative precursor technology | ➢ Energetic optimization  
➢ Improved glass properties (tensile strength, stiffness) | ➢ Quicker curing matrix systems  
➢ Tailored properties  
➢ Thermoplastics | ➢ Process optimization  
➢ Automation  
➢ Near-end contoured preforms by means of textile technology  
➢ Organo sheets |
| Cost reduction potential until 2020 | 15-25%                                                                         | 5-10%                                                                       | 8-10%                                                                    | 30-40%                                                                            |
| Comments       | Alternative precursors of sufficient quality are not to be expected before 2020 | Glass fibres as a commodity do not yield any significant further cost benefits | Shorter cycle times yield additional savings in component manufacturing | High potential on virtually all levels of the process chain |
BMW case study

2013

BMW i3

CF Life Module (BIW / Life Module)
Aluminium Drive Module

2014

BMW i8

Life Module
Drive Module

2016

BMW 7-series

BIW combining steel / aluminum / CFRP
16 CFRP parts

Towards an architecture including composites ‘just-where-needed’ instead of a complete BIW in composite

Oct 2016: BMW announces they will limit the use of CF, turning instead to lightweight steel to keep profit.

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Automotive Example

- 30% weight reduction leads to significant CO2 reductions
- 3000 liter lower fuel consumption during a 250,000 km life cycle

CO2 – Emission reduction
- During production (synthesis / carbonization): 20 tons
- During whole life cycle: 50 tons
Major Factors Driving the Usage of Carbon Composites by BMW in its Electric Vehicles

Factors Driving the Use of Carbon Composites by BMW

A. Weight Saving
B. Emission Reduction
C. Part Consolidation
D. Strength and Safety gains
E. Efficiency Improvement

Strategies Adopted by BMW to Ensure Effective Usage of CF Materials

Challenges to adopt Carbon Fiber

- High Cost of carbon fiber restricts its usage in high volume vehicles
- Continuous availability
- High cycle time

Solutions

- BMW & SGL jointly invested to establish carbon fiber manufacturing plant at Moses Lake
- The facility supplies CF and preforms for BMW i vehicles & 7 series
- This strategy helps BMW to have control over CF prices
In the Last Three Years, Carbon Fiber Composites in Automotive Industry was Driven by BMW i3 and i8 Model

Global BMW i3 and i8 Sales: 2014-2016

Key Insights

- High cost of carbon fiber impact the profitability of BMW i3 and i8 models, but its make the vehicle light weight
- In last three years, carbon fiber composites in automotive industry was driven by BMW i3 and i8 models
- BMW recently is facing cost pressure from other electric vehicle suppliers, which is likely to impact the carbon fiber demand
- BMW is working on ways to reduce the cost of carbon components

Source: Lucintel
Manufacture of small medium-series of vehicles is favourable for the use of composite materials

- Mid-size market premium vehicles have opened the way to CFRP

BMW 7 series (source: BMW)

- The necessity to manufacture a given model in different countries (local integration) pushes carmakers to substitute steel or aluminium by composite materials, when quantities to produce in a country are low.
BMW 2015 7-series

- In addition to the i3/i8 developments, BMW made extensive use of CF in the new, 2015, 7 series
- The diagram shows the 8 main uses of CF including the use of plain CF, woven CF and CF prepreg molded and glued to steel (see next slides on Hexcel)
- The 8 parts include:
  - B and C pillars
  - Center and rear roof rails
  - Windshield frame
  - Rocker panel
  - Center console
  - Side roof frame
  - Rear shelf
Hexcel developed new prepreg stacking technology for the BMW 7 Series B-Pillar

- This is the first hybrid composite B pillar
- Metal outer B-Pillar of the new 7 series is reinforced with a cured CFRP patch on the inner side of the B-pillar
- Hexcel manufactures a complex 2D UD prepreg stack including an adhesive layer for BMW
- Hexcel’s fast cure prepreg (HexPly®M77) is used to allow high volume production at BMW
- Cures in 1.5 minutes at 160ºC combined with adhesive
- Hexcel’s is running a fully automated production line meeting the highest automotive quality standards
- Production of up to 1,000 preforms a day

The first hybrid composite B-pillar from the first high rate prepreg stack production line

Photos and text courtesy of HEXCEL
BMW 7 Series B-Pillar Prepreg Stack Production at Hexcel

Fully automated Prepreg stack production (Hexcel Austria)
- UD carbon prepreg is stacked in different orientations consolidated and cut to shape
- Additional layers, such as adhesive, can be added

C-prepreg
mechanical performance

Adhesive
bonding to metal; corrosion protection

Key benefits of Hexcel’s pioneering stack technology
- **Handling:** Low tack allows poly-free prepreg handling by robots
- **Flexibility:** Full ply-book flexibility (number/nature/orientation)
- **Quality:** Fully automated and integrated controls
- **Process reproducibility:** Dimensions and weight of stack to ensure stable process at customer
- **Throughput:** Up to 3kg/min to prevent preforming as the cycle time bottle neck
- A game changer for large volume and cost efficiency
3 Major Future Disruptions in the Composites Industry

<table>
<thead>
<tr>
<th>Major Disruptions</th>
<th>Enablers</th>
<th>Impacted Industries</th>
</tr>
</thead>
</table>
| Cost Reduction in Carbon fiber  | Alternative precursors, such as lignin, olefin, textile PAN, etc. Someone will launch low cost carbon fiber ($3 - $6 per lb) in future | • Automotive  
  • Industrial  
  • Construction |
| Improvement in Productivity     | Low cure resins and faster and dependable technologies. Part manufacturing process with cycle time of 1 to 2 minutes for mass production | • Automotive  
  • Industrial  
  • Aerospace |
| Mass Customization              | 3D printing for different composites applications especially in automotive and healthcare | • Aerospace  
  • Automotive  
  • Healthcare |

“Mobile phones disrupted landlines, Apple iPod disrupted music industry. Similarly, composites will disrupt traditional materials in various industries. Shift to composites will potentially help the environment, OEMs, and end users”
Disruption 1: Development of Low Cost Carbon Fiber Using Alternative Precursors and Manufacturing Process

Current carbon fiber price is very high. Auto Industry is looking for price in the range of $5-$6/lbs

Major Areas of Carbon Fiber Cost Reduction

Alternative Precursors
- Textile grade PAN
- Lignin based
- Polyolefin based

Cost Reduction Potential 20%-30%

Manufacturing Process
- Advanced Oxidative Stabilization
- MAP Carbonization
- Advanced Surface Treatment & Sizing
- Tow Splitting

Cost Reduction Potential 40%-60%

Source: Lucintel
Disruption 2: Major Players are Developing Shorter Cure Time Epoxy Resins to Reduce the Production Cycle Time

![Graph showing curing time for various products and resin types over time from 2010 to 2015.]

<table>
<thead>
<tr>
<th>Product</th>
<th>Resin</th>
<th>Year</th>
<th>Curing Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HexPly® M77</td>
<td>2010</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>CYCOM 823 RTM</td>
<td>2012</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>XMTR50</td>
<td>2014</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>XMTR750</td>
<td>2015</td>
<td>60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product</th>
<th>Resin</th>
<th>Year</th>
<th>Curing Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VORAFORCE 5300 ultra-fast epoxy resin</td>
<td>2010</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>VORAFORCE 5300</td>
<td>2012</td>
<td>5</td>
</tr>
<tr>
<td>1</td>
<td>Araldite MY 0610</td>
<td>2014</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>Araldite LY 3585</td>
<td>2015</td>
<td>60</td>
</tr>
</tbody>
</table>

Source: Lucintel

**Aerospace and Defense**
- Spars
- Fan Blades
- Interior parts
- Drone Rotor Support Arm
- Hollow composite parts
- Propellers, etc.

**Automotive**
- Car Body
- Air Intake
- Airfoil
- Roof parts, etc.

**Healthcare**
- Orthopedic implants
- Prosthetics
- Hearing aids, etc.

**Impact on Industries**
- Improved customization
- Parts on demand / fast tooling
- Little to no scrap
- Short lead time

**Major Barriers**
- Cost, skill requirements, and access to specialized machinery

**Source:** Lucintel
Exemples of Innovative Applications...
Structural epoxy parts with autoclave quality in less than 1 minute

Combining the new fast-cure Araldite® epoxy chemistry with a novel compression molding process enables the simplified manufacture of structural composite parts with cycle times as low as one minute without any further post-curing. For high-volume applications such as automotive, this makes cost-efficient manufacture of high-performance structural parts using thermoset technology a reality.

The new rapid-cure Araldite® epoxy system is not only faster but also displays a higher Tg enabling robust processing up to 150°C. These factors combine to give a cure time of only 30 seconds at 140°C, meaning that a press cycle time of only 1 minute is possible without any further post-curing of the part.

The novel compression molding process can remove the need for a complex fiber preform and enables a fiber volume content in excess of 60% to be easily achieved. The process offers high design freedom, including complex deep-draw parts, and generates very little wastage compared to classical compression molding.

The novel process also ensures a very low void content, with a composite quality comparable to RTM or autoclave-prepreg processes. A press equipped with an industrial demonstrator mold repeatedly produced high-quality parts in only one minute per part, even when heavy-tow industrial carbon fabrics were used.

Regarding the market, the primary focus is on transportation, especially in automotive, but consumer goods are also an area that will benefit from this innovation. In conclusion, the high fiber volume coupled with low void content offers outstanding mechanical performance. It is ideal for high-volume production of CFRP parts to enable the adoption of lightweight composites as a metal replacement.
The main aim for this project was to manufacture a complex hollow composite structure using a high-volume production process. The geometric complexity integrated in the developed part can only be reached with this unique technology. Therefore, an additively-manufactured, water-soluble and reusable core, with sand as filler, is used. A fully automatatable braiding technology is used as a preforming method, ensuring that the complex shape of the part can be achieved. The high-pressure resin transfer molding process using a polyurethane resin system was chosen to manufacture the parts. A bicycle handlebar with several functional integrations was chosen as a technology demonstrator. The integrated features can be upscaled to be built in high-volume production processes. The CAVUS technology allows for the fabrication of complex, hollow composite parts. Despite the complex geometry, no adhesives are necessary to create integral structures. These integral structures raise the level of mechanical properties thanks to the continuous fiber path. The automated braiding process enables a load direction suitable for lightweight manufacturing and nearly 100% fiber-placement on the part. The newly developed core material, which can be formed by additive manufacturing or by core-shooting, can be dissolved in water without any toxic solvents. The crucial benefit of the processes is clear: they are fast, reliable and approved. Flexibility, automatatability, competitive costs, eco-friendliness and sustainability, efficient material usage and high-volume potential are just a few advantages of this technology.
Tailored non-crimp fiber technology for cost-saving, high-efficiency manufacturing of tailgate components

Due to their complexity, the current technologies for manufacturing composite parts are not economically viable. To face the large-scale production of composite parts, KCTECH, the Ssangyong Motor Company, and ITA use the tailored non-crimp fabric technology (TNCF). This technology allows a high productivity with local reinforcements, locally adjusted drapeability and a high amount of fiber layers to reduce the number of processing steps in the subsequent preforming process.

To obtain local reinforcements, a feeding unit is integrated into the TNCF machine. The feeding unit can be equipped with several textile structures, which are cut before application on the basic textile. Textiles with different heights can be knitted by an elastic sequential pressing bar. For a locally adjusted drapeability, the stitching pattern parameters can be varied in-line in the production direction. Due to the locally adjusted drapeability, the textile preform can easily be transformed into the targeted geometry by a stamping process. The positive effect of the stitching pattern on drapeability was demonstrated producing a component that is geometrically similar to the complex side surface of a tailgate. The evaluation showed that the use of TNCF with a pillar knitting structure leads to better results in the preforming process than the tricot knitting structure. Complex surfaces can thus be produced without any textile defects, thus ensuring the fiber orientation. Compared to current metal sheet production (7 parts, weight 15kg), the TNCF-technology made it possible to reduce the number of components by 70% and the weight by about 35%.

The conventional non-crimp fiber (NCF) technology is suitable for the highly productive manufacturing of textile semi-finished structures on rolls, which can be further processed into a complex textile preform. Further processing means pre-cutting, stacking and joining the textiles to the said complex textile preform.
Centre console carrier produced from polyamide with a secondary carbon fiber reinforcement using injection molding technology

During the production of endless carbon fiber-reinforced plastics (thermosets), a certain amount of residual carbon fibers is generated. To maximize the utilization of carbon fibers, special thermoplastic granulates with secondary carbon fibers as reinforcements have been developed (in co-operation with selected companies). The thermoplastic resins used are PA, PP, PPA, PBT/PET, etc. Apart from the improved mechanical properties, especially tensile modulus and tensile strength, there is a significant weight saving for every single part compared to glass fiber reinforcements.

Additionally, the new material can also be used in several applications such as intake silencers, engine covers, clutch pedals, bearing blocks, etc. Several secondary carbon fiber-reinforced thermoplastics have already been successfully developed and an application has already been launched in series production. The center console carrier is used in the current Mini Clubman.

RECYCLING

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The process consists in preparing thermoplastic woven organo-sheet blanks cut into the final shape to minimize waste and avoid machining after thermoforming followed by overmolding. Then, the blanks are heated to an optimized temperature and stacked accordingly. The next step involves transferring and laying the blanks quickly in the mold using a specific gripper. Afterwards, the mold is closed and the molten organo-sheet is overmolded with PPGF40 (polypropylene + 40% glass fiber) using an ingenious injection process validated through simulation. The final part is a net-shape part.

Developed 100% by Faurecia, this program was entirely conducted in-house from early engineering to final part validation, involving all the teams: design, CAE materials, manufacturing engineering and laboratories. The program was launched in April 2014 and is now almost finished. Most of the validation steps were performed for both the products and processes. With this project, Faurecia mainly targets the automotive industry. The first parts concerned are liftgates and tailgates, but front end carriers, seats and any visible or non-visible structural parts will also benefit from this innovation. Weight is saved by combining in one part functions that are usually spread out into three parts, but also due to the improved interface between the reinforcement and the over-molding material.
The lightweight decklid concept was developed as part of a study to compare the weight of decklids made from steel or aluminum versus a multi-material approach – in this case, a composite and carbon fiber RTM. Reducing the cycle time associated with the use of carbon fiber was also a key requirement. The material combination used in the Lincoln MKS decklid concept, which combines Continental Structural Plastics’ (CSP) TCA Ultra Lite and carbon fiber RTM, results in a decklid that is 13% lighter than its aluminum counterpart, and cost competitive. This concept also incorporates nylon (polyamide or PA) multi-directional glass fiber tape decklid brackets that are 50% lighter than steel counterparts.

The value of using composite materials is presented in terms of weight saved, which ultimately results in improved fuel economy and reduced vehicle emissions. The carbon fiber RTM structural inner component represents a number of breakthroughs in the use of recycled carbon fiber materials for cost-effective serial production applications.

This decklid is the result of CSP’s ongoing effort to work with OEM and supplier partners to achieve even greater weight savings with cost-competitive materials. This comes on the heels of CSP’s successful launch of TCA Ultra Lite, currently used for 21 body panel assemblies on the Chevrolet C7 Corvette.
Modular, self-supporting, full composite bus body

The project consists in the development and production of modular, self load-bearing full-composite bus bodies for public transportation. These buses have the advantage of being able to be driven by diesel, trolley, CNG, hybrid or full electric engines.

The glass fiber-reinforced sandwich composite used for the body is a thin, self load-bearing structure that also bears the entire load in the bus. Due to the modular architecture of the body, the composite parts can be produced cost effectively in higher series. What’s more, owing to the modular system, different lengths of bus bodies can be built from the same parts.

The first bus concepts were finished back in 2014 and the production of the first 50-part series is currently in process. In October 2015, 25 complete bus bodies were built and waiting for final assembly. Five completed buses (2 electric, 1 hybrid, 1 CNG and 1 trolley) are currently running in Budapest, Hungary. Further developments are in progress to improve the production output.

The benefits of this project are numerous: lightweight body, low emissions and fuel consumption, corrosion-resistant body and low maintenance costs. Thanks to the modular body structure, cost-effective and fast manufacturing with RTM technology, the concept is extremely competitive with traditional metal body buses.
Combination of C-SMC and patented application to Automotive A-class components

For the first time, chopped composites are going to be widely used for aesthetic purposes in the automotive industry. Lamborghini owns the patent to achieve A-grade surfaces out of C-SMC materials.

The Lamborghini Huracán carbon package no longer uses traditional 2x2 twill prepreg, but results from a combination of C-SMC and a patented manufacturing process, achieving an A-grade result. Lamborghini’s aim is to change the customer’s mindset, as far as carbon package is concerned.

The Forged Composite material application was launched in 2010 with the Sesto Elemento project, but it was then limited to structural applications. Today, Lamborghini’s engineers have worked to achieve the A-class surface requirement for automotive standard out of the Forged Composite material process. The main challenges encountered were the reduction of the edge vortex (not acceptable according to Lamborghini’s quality standards), the surface quality after molding, the component paintability and the integration of the fixing systems in a one-step molding process. In 2014, all the automotive tests were conducted successfully and the material was ready to be used and processed for a new Lamborghini project: the Huracán carbon package.

The biggest achievement of this innovation is the fact that carbon fiber usage is extended to large production volumes, thanks to the use of the press molding process. Despite the traditionally low production volumes of Lamborghini cars, this technology is capable of producing over 500 parts per day. Additionally, the C-SMC process is less expensive than traditional prepregs. Finally, a relevant and particularly interesting point considering the environmental impact is that it recycled fibers can be used in the raw material preparation.
During the past few years, Audi AG researched and developed a technology that allows a more cost-effective and high-performance manufacturing of thermoset fiber composites. The aim of this technology development was to combine a high-volume production process with the advantages of integral sandwich construction for large and complex fiber-reinforced plastic structural components.

This technology could be implemented for the first time in the Modular Sports-Car System (MSS) new Audi chassis platform in cooperation with the series supplier Benteler SGL Composite Technology GmbH. The MSS is the newest chassis platform for the upcoming Audi R8 and the Lamborghini Huracán. In the future, the rear shelf and the B-pillar inner reinforcement for the new-generation R8 Spyder will be manufactured as an integral reinforced sandwich component.

This innovative approach for component manufacturing, internally known as the Audi ultra-RTM technology, includes the following key components: material development of fiber and fast-cure resins (1-2min cure time), sandwich technology with functional integration and low-density foam cores, automated preforming and preform assembly and, finally, process development for large structural CFRP components.

The key advantage is the possibility of combining all of these technological components. The main challenge is the infiltration of complex parts with low-density foam cores, inserts and matrix systems with a small processing window. The key to success is to control the process with in-tool sensors during the resin injection step.
Structural module in thermoplastic composites for trucks

This project focuses on the front structural parts of a truck cabin. Large-sized organosheets (2x1.2m) made of thermoplastic composite materials based on high-flow polyamide 6 and a woven glass fabric were developed for their extreme laminate strength and stiffness. Together with OEMs, Solvay designed all the thermoplastic composite firewall structural parts. For the simulation, Solvay supplied numerical laws and used an advanced material database for the Evolite composite, the PA6/short glass fiber material and the adhesive, as well as an advanced simulation for composites and assembly to predict strength, stiffness and the fracture initiation area. To validate all these numerical laws, Solvay produced thermoplastic composite prototypes and tested them in dynamic conditions to correlate the simulation with the reality. Finally, the manufacturing step used an innovative process developed by HBW Gubesch. This one-shot process combines a stamping process (for organosheets) and a single pressing process (for structural ribs) to ensure a short manufacturing cycle.

In order to address these challenges, an industry consortium joined forces to design, manufacture and validate a composite firewall (front structural parts of the truck cab) offering a 25% weight reduction, that divided by two the number of parts compared to current metal designs without compromising performance.
Company: Forward Engineering GmbH (Germany)

Partners: KraussMaffei (Germany), Alpex Technologies GmbH (Austria), Dieffenbacher (Germany), Saertex (Germany), Henkel (Germany), Handtmann (Germany), TUM/LCC (Germany)

T-RTM

The aim of this project is to develop the near net shape T-RTM (thermoplastic resin transfer moulding) process for high volume production. This innovative process combines the advantages of thermoplastic resin and the design freedom offered by HP-RTM technology for complex parts.

To demonstrate the process potential, a roof frame for the Roding Roadster was re-designed, having in mind that the roof frame is a structural element for the car. The roof structure is made of a complex multi-preform part with hybrid textiles and integrated metal inserts, impregnated by a low viscosity polyamide 6 (PA6) by HP-RTM. This low viscosity allows better impregnation of the fibres, a higher fibre-volume-fraction, and thus improved mechanical properties and an overall reduced wall thickness, which reduces material cost.

To further reduce cost, the expensive carbon fibre was partly replaced by glass fibre, thanks to in-ply hybridisation within a non-crimp fabric (NCF). As such, a low amount of carbon fibres is enough to add stiffness to the glass fibre layers. All these optimisations lead to a 30% material cost savings for the roof frame compared to a pure CFRP lay-up without near net-shape technology.

To ensure a cost as low as possible, Forward Engineering also focused on the integration of metal inserts in order to ensure optimised load transfer and to minimise roof assembly cost in mass production. Two types of inserts are used in the demonstrator: Al-casted inserts treated for ideal matrix adhesion applied directly on the dry preforms, and steel-threaded inserts applied by rivet nuts. During the RTM process, an additional form locking due to overmoulding with pure resin occurs, and the resin also prevents galvanic corrosion.

The production cell provided by KraussMaffei melts the material for a few shots only. This makes it possible to prevent a material aging of the two caprolactam components (caprolactam base material and activator or catalyst) by minimizing the thermal load on the melt.
2. AUTOMOTIVE, EXTERIOR

Company: LG Hausys (South Korea)
Co-Winner: Hyundai Motor Company (South Korea)

LIGHTWEIGHT ONE-PIECE ROOF RACK

With increasing pressure on automobile manufacturers to reduce the carbon footprint of their vehicles, weight reduction is becoming a prerequisite. The goal of this project is to reduce the weight and cost of a part that is traditionally made of aluminium and largely unnoticed in the composite industry.

This innovation aims to reduce the weight and cost of a roof rack through the use of continuous-fibre thermoplastic (CFT) composite. To achieve this goal, LG Hausys developed a manufacturing process where the CFT, made of polypropylene and glass fibres, is first pre-formed to the desired shape and then overmoulded to form the ribs that will add rigidity to the rack. In the final step, the formed roof rack is painted using a new surface treatment technology.

The advantage of this project is that the technology was developed for high design freedom, enabling better adaptation of the rack on the roof, which will help reduce the part cost for mass production across a broad range of vehicles. This innovation reduced the part's weight from 3.8 kg to 2.76 kg, which represents a 28% reduction, while maintaining the required performance. This CFT roof rack is also beneficial from an assembly point of view as the number of parts is reduced to 1 from 5 in existing aluminium roof racks.

Overall, compared to an aluminium roof rack, the cost is reduced by 5.2€/part.
Hyundai led consortium has developed a front bumper crash beam produced by curved reactive thermoplastic pultrusion

- The front bumper consists of a new types of composite insert overmolded with plastic resin for function integration
- The composite insert is manufactured by a Curved Reactive Thermoplastic Pultrusion Process
- The reinforcement consists of glass fiber rovings, glass fabrics and optional use of carbon fiber
- Major innovations were:
  - In-mold reactive polymersisation during pultrusion
  - Curving the thermoplastic profile during pultrusion
  - A mix of continuous UD glass fibers, carbon fiber and glass textiles
  - Development of adhesion between insert and overmolding
- Resulting max weight reduction was 43%

Consortium Members:

[Images of Hyundai Motor Group, OP, ECOD, and Arkema logos]
Structural module for Renault truck by consortium developed in organosheet reinforced with glass fabric

- Organosheet of high flow PA6 and glass fibre fabric developed for their extreme laminate strength and stiffness
- The part has a rib structure and the PA6 is impact modified with 30% short glass fiber
- The “one shot” manufacturing process was developed by HBW Gubesch combining stamping of the organosheet and single pressing for the structural ribs to ensure short cycle time
- Consortium members were Bollhof, HBW Gubesch, SIKA and Solvay

Photo and information at JEC World, 2016
Conclusion
• Automotive is expected to be the largest growth potential with a growth at a CAGR (2015-2025) of 7% (if CFRP cost can be reduced thanks to lower CF price, optimized material usage, innovative faster manufacturing process, ...)

• Automation/Mass production, automation, optimal design for better price-performance ratio, hybrid solutions, will support the growth of this very dynamic market; robotics (3D fiber spraying, ATP UD tape, AFP...)

• CFRP, is definitely the most important field driving growth, followed by GFRP and mixed materials.
• We have been claiming for years that the future of Composites is bright and we still believe this is the case.

• However, for some business segments such as automotive, the Composites Industry is at the Crossroads of its future.
• Our industry’s capacity to answer the many challenges that we are currently facing and that are still to overcome, will decide if this steady and slow penetration will accelerate and boost composite applications, or if the composites industry will remain, for some segments, a niche market.

• Competition is not waiting...
• Designing lightweight components to match the CAFE standards is not the issue.

• Every conference or media reports the challenges of large scale, lean, fast and automated mass production, cost of raw materials, multi-material car architectures, repair strategies, recycling and so on.
• Whether we talk about new car architectures, new processes or new materials, there’s always a voice to claim that composites can meet the challenge of placing the right material, for the right function at the right cost in a mass production constraint.

• But when will it happen? If we maintain the trend of collaborative/consortium approach we believe soon !...
Thank you very much