Shifting Into High Gear:
OPEN AND HOLISTIC RESEARCH MODELS AS AN ACCELERATOR FOR INNOVATION IN THE NORTH AMERICAN COMPOSITES INDUSTRY

ACCE 2012, Troy Michigan
Motivation

Open, collaborative models of knowledge creation give organizations and even whole sectors a competitive advantage.

Advantages:

- Increased capacity for innovation, at a faster rate
- Flexibility to respond to market changes
- Continual creation of new products that create sustainable value
  - While this is not new, perhaps by looking at a historical example we can see some similarities to our present situation
Historical Example

British Textile Industry – 19th Century

• One of the key sectors of the Industrial Revolution, source of incredible wealth for the British Empire

  • Movement occurred from cottage (hand made) industry to automated systems

  • Both drove and benefited from quantum leaps in energy production, machinery, transportation, and organizational structure

  • Made it possible for the British national industry to respond and drive a global market and to achieve incredible wealth and massive quality of life changes
Historical Example, Part 2

British Textile Industry – Early 20th Century

- Technology leading industry had evolved to a state where there was little investment in technology and new processes.
- Attention was focused on increasing margins and relying on installed capital base.
- Competition focused on low cost production leading to inevitable commoditization without innovations to lead to sustainable margins.
- Earnings were eventually not substantive enough to invest in a response capable of sustaining the industry.
  
  - Whereas one point of view is that all products and industries go through life cycles – the decline in this and other industries for the same reason led to the ossification and decline of the British Empire.
- Are we there in the North American automotive industry? Could we be there?

Source: The Wealth and Poverty of Nations
Next...

- Let’s take a look at certain trends in our own industry...
- Regulatory
- Materials
- Various Collaborative Partner Choices and Approaches that could accelerate and sustain development
Motivation

Motivation for light-weight design

- Weight increase of typical medium-class vehicle since 1970
- Implementation of CAFE regulation

- Reduction of consumption and emissions through lighter structures
- Improvement of passive and active safety and product attractiveness through functional design
- For commercial vehicles: Increased payload
- Lightweight design requires quality controlled, high-volume manufacturing processes for composites

Source: Fraunhofer
Regulations in Europe force OEMs to significantly reduce CO2 emissions

Average grams CO2 emissions per km of all cars sold per year in Europe

<table>
<thead>
<tr>
<th>Current Fleet average Europe (2010)</th>
<th>140</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target (2020)</td>
<td>95</td>
</tr>
<tr>
<td>Potential target (2025)</td>
<td>75  (-46% from 2010)</td>
</tr>
</tbody>
</table>

Potential Penalties (EUR per car in fleet)

<table>
<thead>
<tr>
<th>Current Fleet average Europe (2010)</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target (2020)</td>
<td>4,035</td>
</tr>
<tr>
<td>Potential target (2025)</td>
<td>12,350</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Current Fleet average US (2010)</th>
<th>27 m/gallon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target (2016)</td>
<td>32 m/gallon</td>
</tr>
<tr>
<td>Potential target (2025)</td>
<td>54 m/gallon</td>
</tr>
</tbody>
</table>

Source: McKinsey Company
Today lightweight materials are costly, but offer significant advantages to respond to regulatory changes

<table>
<thead>
<tr>
<th>Part Weight % of Steel</th>
<th>Part cost (2010) % of steel</th>
<th>Part applications in automotive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>100</td>
<td>Structural parts requiring strength and formability needed; side intrusion needed</td>
</tr>
<tr>
<td>HSS</td>
<td>80</td>
<td>Structural parts, but additional strength comes with increased difficulties in molding; e.g. B-pillar</td>
</tr>
<tr>
<td>Plastics</td>
<td>60</td>
<td>Exterior and interior parts with no requirements for structural strength; e.g. Fascias or covers</td>
</tr>
<tr>
<td>Aluminum</td>
<td>60</td>
<td>Structural or functional parts; e.g. Subframes or covers</td>
</tr>
<tr>
<td>CFRP</td>
<td>50</td>
<td>Structural parts requiring high strength; e.g. Frame, hood, or tailgates</td>
</tr>
</tbody>
</table>

Part costs based on 60K part per year volume

Source: McKinsey Company
Changes in material mix result in a number of challenges and opportunities for players in all relevant industries

<table>
<thead>
<tr>
<th>Main challenges and opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OEMs</strong></td>
</tr>
<tr>
<td>High costs of new materials pose additional threats to margins</td>
</tr>
<tr>
<td>Repairability and maintenance with potential additional cost for the industry</td>
</tr>
<tr>
<td>New designs/car concepts possible.</td>
</tr>
<tr>
<td><strong>Suppliers</strong></td>
</tr>
<tr>
<td>Chances for automotive suppliers with lightweight competencies - aviation suppliers entering automotive area to a significant extent not currently observed</td>
</tr>
<tr>
<td>Demand for normal steel reduced....</td>
</tr>
<tr>
<td><strong>Materials Industry</strong></td>
</tr>
<tr>
<td>...but chances for high strength steel and aluminum players to increase volumes, as well as for new entrants in CFRP</td>
</tr>
<tr>
<td><strong>Machinery Industry</strong></td>
</tr>
<tr>
<td>New production technologies for parts with high need for innovation</td>
</tr>
<tr>
<td>New tools for CFRP</td>
</tr>
<tr>
<td><strong>Other Players</strong></td>
</tr>
<tr>
<td>New business opportunities for after market and recycling in CFRP</td>
</tr>
<tr>
<td>? Insurance companies face more uncertainty in the automotive business due to repairability issues.</td>
</tr>
</tbody>
</table>

Source: McKinsey Company
With CRFP, Several Surmountable Industrialization Hurdles Exist

<table>
<thead>
<tr>
<th>Topic</th>
<th>Aviation</th>
<th>Wind</th>
<th>Auto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliability</td>
<td>Maintenance and Repair</td>
<td>Damages invisible</td>
<td>high maintenance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aging effects often unknown</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Corrosion</td>
<td></td>
</tr>
<tr>
<td>Environment</td>
<td>Sustainability</td>
<td>Only partially recyclable</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>High energy consumption for fibre production, risk for negative CO2 impact</td>
<td></td>
</tr>
<tr>
<td>Physical parameters</td>
<td>Development</td>
<td>Challenges to install Faraday cage, steer by wire, etc.</td>
<td></td>
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<tr>
<td></td>
<td>Simulation</td>
<td>Limited crash simulation available</td>
<td></td>
</tr>
<tr>
<td>Production</td>
<td>Workforce</td>
<td>Little experienced workforce available</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Little experience with production technologies</td>
<td></td>
</tr>
<tr>
<td>Tooling &amp; Assembly</td>
<td></td>
<td>Low tolerance, difficult to reach (787 disaster)</td>
<td></td>
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<tr>
<td></td>
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<td>Low turnover due to slow curing times (e.g. 4 min. with RTM)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expensive to tool/hard to form - high scrap rate (about 30%)</td>
<td></td>
</tr>
</tbody>
</table>

Source: McKinsey Company
How will the automotive industry respond to the lightweighting challenge?

- Evolve new answers from internal resources
- Draw answers from other sectors
- Collaboration with Universities, national labs, private institutes
- Increase collaboration among participants in the value chain
Pros:
Control of IP
Know-how retained internally

Cons:
Potentially slower innovation cycle
Potentially high capital and HR cost
Potential lack of responsiveness to market
Drawing Answers from Other Sectors

• Cross-fertilization of sectors using common factors (i.e. Similar materials) can help us understand how to solve problems as we gain insight and knowledge from different angles
  • Optics Sector – new tools evolve from applications in biology through to physics
• This method is useful, and yet, indirect
• The organization itself must still decide how to use its resources to optimize knowledge creation
Cross industry exchange may increase the pace of industrialization

<table>
<thead>
<tr>
<th>Engineering</th>
<th>Knowledge of composite design, crash simulation, recyclability, material failure mechanisms is transferred from aviation to automotive, leading to fast learning in automotive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Materials</td>
<td>Advances in materials (e.g. resins) pushed by the automotive industry will be transferred back to wind and aviation, leading to potential cost and process improvements</td>
</tr>
<tr>
<td>Pre-forming</td>
<td>New technologies in material placement and pre-forming in the automotive industry will generate new time and cost opportunities in wind and aviation (but, potentially limited due to different requirements)</td>
</tr>
<tr>
<td>Molding</td>
<td>Molding and heating technology from aviation will be partly transferred to wind industry (for parts with similar dimensions e.g. no autoclave)</td>
</tr>
<tr>
<td>Part Forming</td>
<td>Advances in part-forming methods (RTM, VARI) with time and cost advantages will continue to be transferred from automotive to aviation (e.g. wing of Bombardier C series, but not for fuselage)</td>
</tr>
<tr>
<td>Assembly</td>
<td>Assembly technologies (e.g. bonding) are transferred from aviation to automotive, allowing quick learning curves as well as cost and time improvements</td>
</tr>
</tbody>
</table>

Source: McKinsey Company
...resulting in significant changes in the materials industry

- Steel will decrease 8% by 2020, increase 3% by 2030 (all numbers include all three industries) (all numbers reflect compounded annual growth)
- High strength steel will increase 19% by 2020 and 1% between 2020 and 2030
- Aluminum will increase 6% between 2010 and 2030
- CFRP will increase by 17%
## Collaboration with Universities, National Labs, Private Institutes

<table>
<thead>
<tr>
<th>Entity Type</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
</table>
| Universities      |  Access to expertise and know-how at fraction of cost  
|                   |    Rigorous approach  
|                   |    Avenue for new trainees  
|                   |    New insights |  Not often responsive to industrial development time cycles  
|                   |                                                                       |  Some limitations around IP control (public funding) |
| National Labs     |  Access to expertise and know-how at lower cost  
|                   |    Rigorous approach and new insights  
|                   |    Applied focus |  National lab funding is often directed to increasing the competitiveness of a particular jurisdiction; may limit activities of international players; may limit technology development relative to non-domestic market needs  
|                   |                                                                       |  Sometimes bureaucracy inhibits responsiveness |
| Private Labs      |  Access to expertise and know-how at lower cost  
|                   |    Rigorous approach and new insights  
|                   |    Applied focus  
|                   |    Faster responsiveness |  IP control  
|                   |                                                                       |  Cost may be an issue  
|                   |                                                                       |  Other collaborators required for the project’s ultimate success may not wish to come in to the R+D environment |
The Fraunhofer Project Centre at Western is a response to the need to maximize the positive elements of these models in a new approach (to the North American composites industry)

Structural Characteristics

- Not-for-profit, applied, contract research organization, offshoot of Europe’s largest applied research organization
- Partners with Universities
- Technology focus, rather than industry focus
- Performance driven fiscal management, allows (forces) flexible market adaptation
- Aims to offer interdisciplinary system solutions and strategic partnerships; but the institutes act autonomously in terms of strategic planning.
The Fraunhofer Project Centre at Western is a response to the need to maximize the positive elements of these models in a new approach to the North American composites industry

Industrial Demand

- North American OEMs, Tier 1 suppliers, raw material suppliers, machine makers as early as 2000 were engaging Fraunhofer’s Institute of Chemical Technology in trials to develop new technologies and processes. Travel and transport costs would often be more expensive than the trial itself. Demand increased for a North American version of the same institute.

Three Attempts to Establish the FPC

- Ohio: a collaboration based on US federal contributions resulted in some private sector partners pulling out due to IP restrictions

- Windsor: a private sector led attempt failed as the model was too costly for one company to justify in the end; market response was luke warm to the idea of a lab run under partial management of one private sector entity

- Successful attempt in London, Ontario. Joint venture with University. Capital funding from University and City of London. Research Funding in tri-partite agreement between industry and Province. Operational Funding provided through contracts
Fraunhofer Project Center @ Western
Fraunhofer Project Center for Composites Research at Western University

FPC@Western is a joint venture between Western University (UWO), London (Ontario), Canada and Fraunhofer Gesellschaft, Munich, Germany

With its Institute for Chemical Technology (ICT), Pfinztal, Germany

FPC Mission:

- To accelerate the development and adoption of advanced composites technologies and processes by North American industry
- To offer an excellent environment for the transfer of know-how to industry leaders, engineers and technicians
Twin Regions

Joint Expertise for Local Demands

Both entities being situated in the heart of automotive areas will jointly work on composite technologies adapted to the local demands of each region’s industry. The activities of both research entities will utilize and increase the expertise to accelerate composite innovations as lightweight solutions.
Set of Principles

- The FPC is a neutral, not-for-profit, University-linked applied research facility
- The FPC is open to all potential users (no exclusive relationships)
- The FPC focuses on industry-led and industrially relevant needs
- The FPC takes a holistic approach to problem-solving
- The FPC collaborates with academic institutions and leverages industry funding with grants from research agencies (the ICRC takes the lead at UWO for developing and managing research grants and works closely with the FPC)
- The FPC acts with the aim of being self-sustaining
FPC Approach

In an international market of composite materials, regional demands need to be fulfilled.

- Grades of raw materials vary locally
- Requirements are given by the regional market
- Shipping of sample materials is budget and time consuming

- Processes are adapted to regional materials and part design
- Conversion of technology needs to be developed
- Shipping of processes is not possible

- Part design varies in the different markets
- Requirements vary in the different markets
- Shipping of molds is budget and time consuming
Motivation

Interdisciplinary, holistic approach

- Holistic consideration of materials, production processes and methods leads to new construction methods in multi-material design
- A holistic consideration of materials, production processes and methods with regard to costs, time and quality is therefore necessary
Applied research with industry

Bridging the gap in the knowledge chain

- Realization of industrial processes
- Application of developed innovative processes
- Optimization of existing processes and materials

- Process and material development
  - Scientific research on intermediate level
  - Transfer from basic research to industrial scale

- Basic research on fiber matrix phenomena
  - Simulation and Design
  - Investigation of fundamental interests

Collaboration with:
- Industry
- Fraunhofer FPC@Western
- Universities
FPC’s service offerings

Clients can engage FPC personnel for:

- Trials in industrial scale
- Material and formulation development
- Manufacturing process investigation and development
- Part development
- Workshops for know-how transfer into industry
- Training of personnel and students
- Access to a cluster of other research facilities and services
Road Map of FPC operations

May 2011: Closing of Cooperation Contract between FhG and UWO
July 2011: Closing of Contract between UWO and City of London
November 2011: Relocating of FhG Engineers to London (ON)
February 2012: Start of First Joint Project ($8M) with ICRC in ORF projects
July 2012: Installation of Equipment
Start of Operations (Completion of Facility Construction and Equipment Installation)
By December 2014: End of Fraunhofer Start Up Funding
From January 2015: Self Sustaining Operations
The FPC and the ICRC

- The FPC is the press facility and applied research project centre; the ICRC is the academic counterpart of the FPC, focusing on research and training in composite materials related disciplines.
- The FPC works closely with the ICRC to co-develop research grants, accessing funding from publically funded sources to leverage industry funding.
- The FPC also provides a production-scale environment for practical hands-on training for advanced equipment operation, process and part design.
- The ICRC links users of the FPC to large research infrastructure installations at UWO or sister institutions (Surface Science, mechanical testing, etc.).