SMART Wind Consortium Subgroup Virtual Meeting:

Composite Materials and Process Opportunities
Opportunities to Improve Manufacturing

Metal to Plastic Conversion…
Injection Molding of Component Parts

- One method for evaluating the pros and cons of conversion is to assess the primary performance demands like:
  - System operating temperature range
  - Maximum load, stress and deflection conditions
  - Creep and fatigue constraints
  - Wear limitations (tribology) and the types of materials to which the parts will mate
  - Impact or shock-load requirements
  - Chemical contact or use inside the system
  - UV or other weatherability requirements
  - Part consolidation potential
Material Pros and Cons

- **Material choice will impact manufacturing and assembly costs**
  - Molded or machined cost per unit
  - Lighter weight plastics, offer more advantages when manufacturing and assemblies are considered
  - Mold life for plastic parts is typically ten times that expected from a die cast mold for aluminum
  - Usually metal castings are near-net shape and require numerous additional steps for final precision. Plastic components are usually molded to final dimensional and finish requirements
  - Many metal parts also need either a coating (paint, oil, etc.) or anodizing for corrosion protection. Plastic materials are often inherently corrosion resistant
  - Metal parts generally can't be switched to a less-expensive metal without going through a redesign. In contrast, less-costly plastics can often use the same molds as their more-expensive predecessors
Metal to Plastic Conversion is used to **Improve Products, Reduce Costs** and Streamline Manufacturing

- **Improve Products**
  - Designs consolidate parts and create additional performance features
  - Ability for more complex shapes and geometries
  - Opportunity to combine materials for enhanced features using multi-shot molding, over-molding or insert molding
  - Increased strength and durability
  - Enhanced decoration or labeling with in-mold decorating and labeling
  - Improved aesthetics
  - Ability to maintain close tolerances
  - Plastic materials and construction absorb impact and reduce noise
  - Lighter weight components for improved product performance
Reduce Costs

• Reduced secondary operations, such as painting, machining or assembly
• Improved production consistency
• Reduced part / product weight – reduced shipping and operating costs
• Product improvements resulting in increased customer satisfaction and decreased warranty issues
• Streamlined manufacturing cost savings
• Reduced scrap and waste
• Part consolidation
Streamline Manufacturing

- Reduced labor and time, eliminating secondary operations and assembly
- Plastic injection molding is a faster and more consistent manufacturing process than metal fabrication
- Tools for testing materials and performance in the design phase predict performance
2015 Capabilities Overview
- **Injection Molding**
  - >30 electric presses; 55 – 400 tons
  - All production volumes
  - Clean room molding

- **Value-added Operations**
  - Assembly
  - Decorating
  - Kitting & Logistics

- 5-days/3-shifts per week
300 + Types of Polymer in Inventory

- **Engineering Resins** with superior performance characteristics
  - ABS, Nylon, Polycarbonate
  - Bioreins: bioorigin, reclaimed, biodegradable
  - Chemical-resistant: Isoplast™
  - Filled: carbon, glass, metal, mineral
  - High-density: EcoMass™
  - High-heat: PEEK, Radel™, Stanyl™, Ultem™
  - Thermally-conductive: electric and dielectric

- **Metals**
  - Xyloy™: injection-moldable Zinc-Aluminum Alloy
Full In-house Capabilities

- Design
- Production
  - Two Shifts
  - Large Toolmaker Team
  - Broad Subcontractor Base
- Maintenance and repair

Dedicated Sampling Team

- Material Trials
- Fill-time and gate-freeze studies
- De-bugging and initial part run-offs
## Rapid Prototyping: Part Parameters

<table>
<thead>
<tr>
<th>Process</th>
<th>Materials</th>
<th>Tolerance (mm)</th>
<th>Size (cm)</th>
<th>Surface Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLS (DTM)</td>
<td>Polyamide, TPE</td>
<td>+/- 0.25</td>
<td>30 x 35 x 42</td>
<td>Fair</td>
</tr>
<tr>
<td>DMLS (EOS)</td>
<td>Stainless Steel, Titanium, Maraging Steel, Nickel-Bronze (DM20)</td>
<td>+/- 0.1</td>
<td>20 x 25 x 25</td>
<td>Good</td>
</tr>
<tr>
<td>CNC</td>
<td>Plastics: PEEK, Ultem, Stanyl, ABS, Nylon, Metals: Steel, Aluminum, Brass, Copper, Titanium, Inconel, Magnesium</td>
<td>+/- 0.075</td>
<td>Open</td>
<td>Very Good</td>
</tr>
<tr>
<td>QMS</td>
<td>Engineering Resins (except high temp)</td>
<td>+/- 0.075</td>
<td>7.5 x 30 x 30</td>
<td>Excellent</td>
</tr>
</tbody>
</table>
**Rapid Prototyping: Lead Time & Costs**

<table>
<thead>
<tr>
<th>Process</th>
<th>Lead Time¹</th>
<th>Tool Cost</th>
<th>Part Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLS (DTM)</td>
<td>1 – 2 Days</td>
<td>$0</td>
<td>Low $100s to $1,000</td>
</tr>
<tr>
<td>DMLS (EOS)</td>
<td>1 – 2 Days</td>
<td>$0</td>
<td>Low $100s to $1,000</td>
</tr>
<tr>
<td>CNC</td>
<td>2 – 7 Days</td>
<td>$500 - $750² (optional)</td>
<td>$10 – Low $100s</td>
</tr>
<tr>
<td>QMS</td>
<td>2 – 5 Weeks</td>
<td>$1,500 - $20,000</td>
<td>&lt;$1 - $5</td>
</tr>
</tbody>
</table>

**NOTES**

¹Lead Time – assumes model file is complete and final.
²CNC Tool Cost – for fixturing (not needed for every job).
Additive Manufacturing ~~~ Tool-Less Manufacturing

- Production Quality Parts in Over 40 Different materials
  - Filled materials
  - Engineering Polymers
  - Carbon Fiber
  - Fiberglass
  - Kevlar®
  - Metals

- Additive Manufacturing
  - Stereolithography (SLA)
  - Selective Laser Sintering (SLS)
  - Direct Metal Laser Sintering (DMLS)
  - Fused Deposition Modeling
HARBEC Development Support

- **Part Design Optimization**
  - Performance
  - Appearance
  - Manufacturability
  - Topology

- **Tool Design**
  - Tool Life vs. Tool Cost
  - Tool Cost vs. Part Cost

- **Material Specification**
  - Cost vs. Performance
  - Supply Risk Mitigation
  - Bioreins = Sustainability
### Sustainable Manufacturing

**In 2013 HARBEC achieved Carbon Neutrality and by the end of 2015 we will achieve Water Neutrality.**

Our **investments in operational excellence result in tangible cycle time reductions, speed to market, and quality benefits to our customers.**

<table>
<thead>
<tr>
<th>Management Systems &amp; Governance</th>
<th>Tools, Policies, Technologies</th>
<th>Energy Generation, Innovation, Leadership</th>
</tr>
</thead>
<tbody>
<tr>
<td>• ISO 9001</td>
<td>• Facility level energy management system</td>
<td>• Wind</td>
</tr>
<tr>
<td>• ISO 14001</td>
<td>• Sustainable building design</td>
<td>• Geothermal</td>
</tr>
<tr>
<td>• ISO 50001/SEP Platinum</td>
<td>• Green transportation fleet</td>
<td>• CHP/Co-Gen</td>
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<tr>
<td>• Environmental Policy</td>
<td>• Energy efficient equipment</td>
<td>• Energy Efficiency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 60% of total energy needed at HARBEC comes from TWO On-site wind turbines</td>
</tr>
</tbody>
</table>

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Contact

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