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SEMA PRODUCT DEVELOPMENT CONFERENCE

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Additive Manufacturing 101
How the Future of Product Development and Manufacturing is Changing
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Senior Applications Engineer
Stratasys Inc.
**Additive Manufacturing is known by many names:**

- 3D Printing
- Rapid Prototyping
- Rapid Tooling
- Rapid Technologies
- Rapid Manufacturing
- Advanced Manufacturing
- Additive Fabrication
- Additive Layer Manufacturing
- Direct Digital Manufacturing
- Direct Manufacturing
Terminology

- **Additive Manufacturing**
  - Term covering all technologies
  - Term covering all applications
  - Replacement for “RP” and “Additive Fabrication”

- **Definition:**
  - Collection of technologies, directly driven by CAD data, to produce 3-dimensional physical models and parts through an additive process.
Typical Build Process

1- Pre-Process

2- Produce Part

3- Post Process
FDM-Specific Materials

Engineering-grade thermoplastics

- ABS-M30
- ABS-M30i (medical grade)
- ABS-ESD7
- Polycarbonate
- Polycarbonate/ABS blend
- PC-ISO Class 6: pharmaceutical
- ULTEM* 9085
- Polyphenylsulfone – PPSF

*Ultem 9085 is a trademark of SABIC Innovative Plastics IP BV.
Solution Classification

Additive Manufacturing

On-Demand Services (Service Bureaus)
- Lowest barrier to parts
  - Distributed globally
  - 3 – 10 day turn around avg.
  - Almost all technologies

3D Printers
- Most affordable solutions
  - $10 - $50K USD
  - Simple and easy to use
  - Optimized for form, fit some function

3D Production Systems
- Highest performance systems
  - $50-$500K & up USD
  - Optimized for performance
  - Broad application solution
Primary Applications for Additive Manufacturing Technology

Additive Manufacturing

- Concept Models
- Functional Prototypes
- Manufacturing Tools
- End-Use Parts

Established / Traditional (Design)

Direct Digital Manufacturing (Manufacturing)
Technology Assessment

3D Printers

Conceptual Models

Functional Prototypes

Manufacturing Tools

End-Use Parts

Performance Requirements Increase

3D Production Systems
Typical Design Cycle

Production

Concept Design

Tooling

Design Change

Detail Design

Design Change

Prototype

Engineering

Design Change

Design Change

Design Change
Ducati Cuts Development Time 20 Months

Needed time-to-market reduction
- Engine: 28 months to design and build
- Majority of prototypes were outsourced

Fortus for in-house prototypes
- 2 alternative prototype engines built
- Nearly all from polycarbonate

More holistic view of engine design
- Found 83 design errors/changes
- Saved estimated $285,000 changes

Time-to-market reduced 71%
- Engine designed and built in 8 months
- Prototyping costs also substantially reduced

<table>
<thead>
<tr>
<th>Process</th>
<th>Development Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outsourcing to Service Bureau</td>
<td>28 months</td>
</tr>
<tr>
<td>Fortus system in-house</td>
<td>8 months</td>
</tr>
<tr>
<td>Savings</td>
<td>20 months (71%)</td>
</tr>
</tbody>
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Toro Prototypes Withstand 100 psi

Prototypes need to withstand high pressures
- Other rapid prototypes don’t hold up
- Machining is costly; requires long lead times

Fortus makes functional prototypes
- Produced in a few hours
- PC meets mechanical requirements

Design perfected for a fraction of the cost
- Engineers able to quickly test design ideas
- Mold right the first time

Dramatic savings over 2 years
- Development time reduced by 283 weeks
- Tooling and bureau costs cut $500,000

<table>
<thead>
<tr>
<th>Conventional Machining</th>
<th>Fortus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time savings</td>
<td>283 weeks</td>
</tr>
<tr>
<td>Cost savings</td>
<td>$500,000+</td>
</tr>
</tbody>
</table>
BMW Reduces Time and Cost to Build Fixtures

Conventional fixture making
- Cost and time requirements were high
- Lack of design freedom reduced productivity

FDM used to produce fixtures
- Have over 400 assembly fixtures
- Several built on Fortus system

FDM enhances ergonomics
- Organic shapes maximize performance
- Sparse fill cut weight 72%

Time and cost savings
- Typical cost reduced from $420 to $176
- Typical lead time reduced from 18 to 1.5 days

<table>
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<tr>
<th>Method</th>
<th>Cost</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNC Machining Aluminum</td>
<td>$420</td>
<td>18.0 days</td>
</tr>
<tr>
<td>Fortus system ABS-M30</td>
<td>$176</td>
<td>1.5 days</td>
</tr>
<tr>
<td>Savings</td>
<td>$244 (58%)</td>
<td>16.5 days (92%)</td>
</tr>
</tbody>
</table>
Manufacturing Tools - BMW

- Emblem Placement
- Headlight Alignment
- Cubing Device
- Gage Checker
Manufacturing Tools

Examples:

- Jigs
- Fixtures
- Check gauges
- Drill / rivet guides
- Go / no-go gauges
- Alignment tools & guides
- Tooling masters & patterns
Custom machines require many bezel sizes
- Difficult to forecast which bezels are needed
- Cost of tooling would be very high

ScriptPro invested in Fortus system
- Builds bezels as needed to customer orders
- Meets precise tolerance requirements

Elimination of tooling saves money
- Injection molding would cost $31,650/year
- FDM DDM costs $6,750/year

New or modified bezels don’t require re-tooling
- Add new bezels at very low cost
- Continually improve the product

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<th>Cost</th>
<th>Time</th>
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<tbody>
<tr>
<td>Injection molding</td>
<td>$31,650</td>
<td>60 days</td>
</tr>
<tr>
<td>FDM direct digital mfg.</td>
<td>$6,750</td>
<td>1 day</td>
</tr>
<tr>
<td>Savings</td>
<td>$24,900(79%)</td>
<td>59 days (98%)</td>
</tr>
</tbody>
</table>
End-Use Parts

- **Direct benefits**
  - Lower cost
  - Shorter lead time

- **Indirect benefits**
  - Design freedom
  - Change freedom
  - Mass customization
  - Supports lean initiatives
  - True JIT (just-in-time) manufacturing
  - Reduced warehouse space/inventory cost
Summary

• Additive Manufacturing Technologies
  ▪ Proven
  ▪ Integrated in many markets
  ▪ Poised as a disruptive technology
  ▪ Never been a more appropriate time evaluate benefits
Questions?