GE Additive & CeC Pittsburgh Short Introduction

October 2017
Who has experience in AM?
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What is Additive Manufacturing (a.k.a. 3D Printing)

Any of various processes for making a three-dimensional object of almost any shape from a 3D model or other electronic data source primarily through additive processes in which successive layers of material are laid down under computer control.

- Wikipedia
AM - Level of Complexity

Level 0 Jigs & Fixtures

Level 1 - Component

Level 2 – Sub Systems

Level 3 - Function

Level 4 – advanced function

Self assembling structures
Embedded functional electronics

46→1 piece

structural Thermal fluid
Level 0: Tools and fixtures

- 3D Model
- Solidification Modeling & Mold Design
- Print Mold
- Pour Castina
- Inspection
- Finished Part

<table>
<thead>
<tr>
<th></th>
<th>Traditional Molds</th>
<th>Printed Molds</th>
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<tbody>
<tr>
<td>Lead Time</td>
<td>6 Months</td>
<td>6 Weeks</td>
</tr>
<tr>
<td>Tooling Investment</td>
<td>$70k</td>
<td>$0</td>
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<tr>
<td>Cost</td>
<td>$500/casting</td>
<td>$6500/casting</td>
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Level 3: Functional Integration... ATP

Combustor test schedule reduced from 12 months to 6 months

5% WEIGHT REDUCTION

20% LOWER MISSION FUEL BURN

855 12 PARTS
GE’s additive journey... so far

**Technology**
- 1st LEAP Fuel Nozzle
- 1st Heat Exchanger
- GE90 engine T25 Sensor Certified
- GE9X Low Pressure Turbine Blade
- Power F-Class Flex Tip
- Oil & Gas Nova LT Swirler
- A-CT7 Engine
- Advanced Turboprop Prelim design

**Infrastructural**
- Formation of GE Aviation’s additive team
- Acquisition of Morris Technologies
- GE Aviation Additive Technology Center (ATC) opens
- GE’s Center for Additive Technology Advancement (CATA) opens
- Acquisition of Arcam AB
- Concept Laser
- Customer Experience Centers (Munich, Pittsburgh, others...)

**From fuel nozzle to bigger parts ... & now systems**
GE Additive Customer Experience Centers

Americas | Europe | Middle East | China | Australasia

Our Customer Experience Centers are designed to help customers understand the additive process; from design to prototyping to production and support them along the way.

**Customer Collaboration**
- Application Engineering
- Rapid Prototyping
- Low Rate Manufacturing

**Customer Training**
- Additive Design
- Additive Machines
- Additive Materials

**Customer Support**
- Field Support
- Spare Parts
- Materials
- Logistics
GE Additive’s Pittsburgh site opened in April, 2016 to serve as an enabler for the GE businesses to accelerate the adoption of additive technology. Transitioning to GE Additive in May 2017, the facility kept its core mission, but expanded that focus to serve a broader customer base as well.

Site Details

- ~50 employees
- 125,000 square ft
- $39M Corporate investment
- 7 modalities of additive manufacturing

Customer Experience Center - Pittsburgh

Pittsburgh, PA

Technology readiness level

1 3 7 10

Research

Invent
- Part & process design tools
- Next generation equipment
- Material development

Business

Develop
- Develop, prototype, scale & mature
- Should-be cost development
- Low rate initial production

Implement
- Large scale output
- Proven technology
- Standard routers & quality plans
We’re focused in three areas...

- Materials
- Machines + PREDIX
- Engineering
Machines

Mlab

Mline

Q10plus

Q20plus

M2

Xline

A2X
GE Additive ... our Mission

$1B annual revenues by 2020

10,000 units sold by 2026

$3-5B+ product cost-out by 2026