**Additive Manufacturing is a Company Core Technology for Siemens**

Electrification, automation, digitalization - Siemens’ Divisional setup

<table>
<thead>
<tr>
<th>Digital Factory</th>
<th>Energy Management</th>
<th>Wind Power</th>
<th>Power and Gas, Power Generation Services</th>
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Additive Manufacturing is a Company Core Technology

>10 years experience
Power Generation, Aerospace, Automotive

>55 industrial AM machines in operation

End-to-end software, automation and digitalization solutions
Digital Factory integrates unique competencies in Product Lifecycle Management and automation under one roof.

Our integrated product portfolio paves the way for the Digital Enterprise.
Additive Manufacturing changes everything

**STATUS QUO**

- **Product transformation**
  - Shift from conventional design to innovative DFAM

  **Reimagine products**
  - Reduce weight, material
  - Scan-to-product
  - Expand performance
  - Accelerate innovation cycles

  **Rethink business**
  - Individualization, personalization
  - Zero inventory – on demand printing
  - Design anywhere. Print anywhere.
  - Accelerate innovation

  **Reinvent manufacturing**
  - Eliminate molding/castings/tooling
  - Eliminate/simplify assembly process
  - Reduce supply chains
  - Affordable low volume production

  **Manufacturing transformation**
  - Shift from prototyping / experimentation to mainstream industrial production
Today's barriers to industrialize Additive Manufacturing

Disconnected process chain – multiple file conversions – uncontrolled machine performance
Our holistic approach
Specific for product manufacturers and machine builders

Product manufacturer perspective

Product design
Production planning
Production engineering
Production execution
Services

Machine concept
Machine engineering
Machine commissioning
Machine operation
Machine services

Machine builder perspective
Tailored to various industrial AM technologies

Fixed Plane

Powder Bed Fusion

Multi Jet Fusion

Multi-Axis

Directed Energy Deposition

Material Extrusion
Example
Directed Energy Deposition

Directed Energy Deposition

Multi Jet Fusion

Material Extrusion

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Example: Directed Energy Deposition

**PLM Software**

NX Hybrid Version developed with DMG Mori for AM, welding and milling in one machine

**Automation**

DMG Mori Lasertec 65 controlled and automated with Sinumerik 840D SL

**Technology and Application**

DED Customer Experience Center in Erlangen
Tailored to various industrial AM technologies

- **Fixed Plane**
  - Powder Bed Fusion
  - e.s.
  - TRUMPF

- **Multi-Axis**
  - Directed Energy Deposition
  - DMG MORI

- **Multi Jet Fusion**
  - Productivity Simulation
  - HP Multi Jet Fusion

- **Material Extrusion**
  - stratasys
Overcoming the limitations of classical FDM printing by robotic Composite 3D Printing

**Today**

Traditional Material Extrusion
- Fiber orientation limited to in-plane
- ~15 hrs build & post processing time
- Support material required

**The Future of Material Extrusion**

Robotic Composite 3D Platform
Titelmasterformat durch Klicken bearbeiten
A vital part of the airplane: the radome

Avionics protection

Antenna protection

Prone to impacts
The most holistic Digital Twin

Design, simulate and verify products digitally, including mechanics and multi-physics, electronics and management of software
Design of the product in CAD software
Impact simulation at the product
The most holistic Digital Twin

Plan, simulate, predict and optimize production digitally with G-code generation and virtual commissioning.
Validation of the manufacturing process
The most holistic Digital Twin

Run production efficiently and securely with Totally Integrated Automation.
Robot-enabled, multi-axis additive manufacturing
Toolless construction
The most holistic Digital Twin

Digital Twin Product
- Virtual product
  - Specification
  - Verification

Digital Twin Production
- Virtual production
  - Specification
  - Commissioning
  - Validation

Digital Twin Performance
- Real production
  - Automation

Collaboration platform: Teamcenter
Runtime optimization of production and product through data analysis
Feed back insights to optimize the Digital Twin of product and production

Digital Twin Product

Digital Twin Production

Digital Twin Performance

Insights from performance with MindSphere

Virtual product

Verification

Virtual production

Validation

Specification

Real production

Commissioning

Automation

Real product

Ideal delivery

Continuous improvement

Collaboration platform: Teamcenter
Tailored to various industrial AM technologies

- **Fixed Plane**
  - Powder Bed Fusion

- **Multi-Axis**
  - Directed Energy Deposition

- **Multi Jet Fusion**
  - Productivity Simulation

- **Material Extrusion**
  - HP Multi Jet Fusion

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How do you keep a Bugatti Chiron on the ground while pushing the speed envelope to new extremes?
Innovate a new way to make a highly optimized vehicle even more aero-dynamic and lighter weight.
Industrialize Additive Manufacturing:
Design and produce useful parts at scale

Digital Twin Product

Digital Twin Production

Digital Twin Performance

Insights from performance

Virtual product

Virtual production

Real production

Automation

Continuous improvement

Real product

10x faster innovation process

Reduced aerodynamic drag

50% weight reduction
Build process simulation as key enabler for First-Time-Right Printing

Virtual detection and elimination of distortion, overheating and other defects with build process simulation leading from “try and see” to First-Time-Right.
Automation of Additive Manufacturing
New AM production system launched with EOS at IMTS

EOS M 300-4 – Digital Additive Manufacturing
for the Industrial Production of High-Quality Metal Parts

Using automation systems and communication interfaces which are industrial standard is a basic requirement to embed an AM production system in an automated process chain.
Automation of Additive Manufacturing
AM Post processing – Value add by Siemens DF solutions

A higher degree of automation on data management and processing an machining enables Additive Manufacturing to become more and more competitive

Automated powder removal
CNC controlled removal of support structures

Siemens Software  Siemens Automation  NX CAD  NX CAM  SINUMERIK

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Industrializing Additive Manufacturing requires CONSULTING
Five action areas to speed up usage of Additive Manufacturing for your business

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**Five action areas to speed up usage of Additive Manufacturing for your business**

- **Digitize**
  - Driving efficiency through **digitalization**!
  - Protect your know-how through state of the art **data security**!

- **Define and pilot**
  - **Identify** and design products!
  - Start a **pilot** as reference case!

- **Monetize**
  - Understand your ecosystem!
  - Innovate your **business model**!

- **Scale**
  - Ramp-up and **industrialize**!
  - Set-up leading edge **production**!

- **Understand and ideate**
  - **Learn** about potentials and threats of Additive Manufacturing for your business!
  - Create an Additive Manufacturing **vision** for your company!
Industrializing Additive Manufacturing requires EXPERIENCE
Additive Manufacturing Experience Center
Industrialize Additive Manufacturing means „Design and produce useful parts at scale“
Five action areas to speed up usage of Additive Manufacturing for your business – at the right place, the right level, the right pace

- Understand and ideate
- Define and pilot
- Monetize
- Scale
- Digitize

Digitize
Driving efficiency through digitalization!

Protect your know-how through state of the art data security!

Understand and ideate
Learn about potentials and threats of Additive Manufacturing for your business!

Create an Additive Manufacturing vision for your company!

Scale
Ramp-up and industrialize!

Set-up leading edge production!

Monetize
Understand your ecosystem!

Innovate your business model!

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Identify and design products!

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**Digitize**

- Driving efficiency through **digitalization**!
- Protect your know-how through state of the art **data security**!
Questions?

Tim Bell
Additive Manufacturing Business Manager
US Center of Competence
Digital Factory

Tel.: 630-217-3502

E-Mail: tim.bell@siemens.com

https://www.linkedin.com/in/tim-bell