3D PRINTING: Turn Hype into Industrial Manufacturing Solutions

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Introduction: Consumer 3D Printing - Enterprise 3D Printing
Additive Manufacturing: “The Manufacturing Technology that will Change the World”
EOS – World leader in e-Manufacturing Solutions
EOS Portfolio: Integrated e-Manufacturing Solutions
Industrial e-Manufacturing Solutions for Many Industries: Aerospace, Medical, Tooling
“Enterprise 3D Printing” – 2014
we are on the “Slope of Enlightenment”

“The Manufacturing Technology
that will change the World”
The Economist, 2011

Source: Gartner (July 2013)

Computerworld, 2013
“Enterprise 3D Printing” – 2014
we are on the “Slope of Enlightenment”

Source: Gartner
Current 3D Printing categories

- **Consumer 3D Printing**: from 500 EUR to ~3,000 EUR
  ⇒ Fablab movement, Makerbot, Cubo and dozens more in Kickstarter. Only for polymers.

- **“Prosumer” (Professional Consumer) 3D Printing**: from 3,000 EUR to ~25,000 EUR
  ⇒ Low-end 3D printers. Only for polymers.

- **Professional 3D Printing**: from ~25,000 EUR to ~150,000 EUR
  ⇒ Medium and high-end 3D printers. Only for polymers.

- **Industrial (Enterprise) 3D Printing**: from ~150,000 EUR
  ⇒ Focus on producing fully functional parts, with mechanical properties as per conventionally produced parts.
  ⇒ Polymers and **Metals**.

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**EOS is the only company focused on**

**Industrial 3D Printing with Polymers and Metal**
EOS Additive Manufacturing: Functional Principle

From a 3D CAD model...

- Application of powder
- Exposure by Laser

- Lowering of platform
- Re-application of powder
- Exposure by laser

... to complete parts
AM opportunities

- Lightweight structures
- New and complex designs
- Integrated and complex functions
- Customized products
- Functional integration
- Complex geometries
- Customization
- Patient specific restorations
AM opportunities

Source: Morris Technologies

Source: Evo Magazine and EADS IW Filton

Source: EOS

Source: WITHIN
Agenda

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Supply Chain Shift – Direct to Part

From

To
Production hall with CNC Technology

Source: http://www.freund-drehtechnik.de
UK - production with EOS AM Technology

Source: Materials Solutions
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EOS: Technology and Market Leader for Design-Driven, Integrated e-Manufacturing Solutions

- **Family-owned**, founded in 1989,
- Headquartered in Krailling near Munich, Germany
- **Integrated solution provider for Additive Manufacturing**
- **Solution portfolio**: Additive Manufacturing (AM) systems, materials (plastics and metals), software and services
- **Complete end-to-end solutions**: from part design and data generation to part building and post-processing
- **EOS enables competitive advantages for a variety of industries**, such as medical, aerospace, tooling, industry, lifestyle products and automotive
- EOS is committed to: **Innovation – Quality – Sustainability**
EOS: Global Presence

**EOS worldwide installed base**

~1,800 Systems

- 45% Metal systems
- 55% Polymer systems
- >315 customers with more than 1 system

**EOS global footprint**

- Customers in 53 countries
- EOS Sales & Service offices in 11 countries, distribution partners in 22 countries
- More than 750 employees worldwide (75% Germany, 25% International)
- Strong patent portfolio: „More than 650 active patents in more than 100 patent families“
- R&D Spendings of approx. 14% of Sales

> 50% of Metal 3D printers sold in 2014 are EOS

Source: EOS. Installed base (includes purchased and rented systems) and staff figures as per 08/2015.
Customers from Numerous Industries Rely on EOS Technology

### OEMs

- smith&nephew
- SCANIA
- Unilever
- PORSCHE
- FhG
- Johnson & Johnson
- Saab
- BMW
- Volkswagen
- Audi
- OPEL
- Volvo Trucks
- STOKKE
- Jaguar
- Komatsu
- SIEMENS
- TOYOTA
- BOEING
- GE Aviation
- MTU Aero Engines
- NASA

### Service Providers

- shapeways*
- ACTech
- FIT
- PDS
- Plastic Design & Service
- Hofmann Modellbau
- FKM Sinterotechnik

Sample customers.
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EOS Systems for the Additive Manufacturing of Polymer Parts

**FORMIGA P 110:** Compact system for RP applications and small series

- **Usable build size**
  - Width 200 mm
  - Depth 250 mm
  - Height 330 mm
  - Max. volume: 16.5l per build

- **Main properties**
  - Highest detail resolution and final part accuracy
  - Production flexibility
  - Small machine footprint (1350x1040x2200 mm) for fit into every production environment

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**EOS P 396:** Productive mid-volume polymer laser sintering system

- **Usable build size**
  - Width 340 mm
  - Depth 340 mm
  - Height 600 mm
  - Max. volume: 69.4l per build

- **Main properties**
  - The “workhorse” in the mid-volume segment
  - High mechanical homogeneity across full build volume thanks to EOSAME feature

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**EOSINT P 760:** Largest build volume for polymer parts

- **Usable build size**
  - Width 700 mm
  - Depth 380 mm
  - Height 580 mm
  - Max. vol.: 154.3l per build

- **Main properties**
  - High-volume production
  - Large part sizes
  - Double-laser system
  - Extensive portfolio of periphery for maximum system productivity (e.g. CoolDown Station)

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**EOSINT P 800:** For high-performance polymer parts

- **Usable build size**
  - Width 700 mm
  - Depth 380 mm
  - Height 560 mm
  - Max. volume = 149l per build

- **Main properties**
  - First and only ultra-high-temperature material system (EOS PEEK HP3, melting point of 372°C)
  - Option to reduce build size enabling cost-effective production of fewer parts
## EOS Polymer Materials

<table>
<thead>
<tr>
<th>Composition</th>
<th>Trade name</th>
<th>Colour of parts</th>
<th>Main feature</th>
<th>Typical applications</th>
</tr>
</thead>
</table>
| Polyamide 12 | PA 2200 | white | • Multipurpose material  
• Balanced property profile | • Functional parts |
| PrimePart® PLUS (PA 2221) | natural | • Economic multipurpose material  
• Balanced property profile  
• Certificates available (Biocompatibility, Food contact) | • Functional parts |
| PA 2202 black | anthracite black | • Balanced property profile  
• Pigmented throughout | • Functional parts in anthracite black colour |
| Polyamide 12, glass bead filled | PA 3200 GF | whitish | • High stiffness  
• Wear resistance  
• Improved temperature performance | • Stiff housings  
• Parts with requirements on wear and abrasion  
• Parts used under elevated thermal conditions |
| Polyamide 12, aluminium filled | Alumide® | metallic grey | • Easy post-processing, good machinability  
• High temperature performance  
• Thermal conductivity (limited)  
• High stiffness | • Applications with metal-like look  
• Parts which need machining  
• Parts with thermal loads |
| Polyamide 12, carbon fibre reinforced | CarbonMide® | anthracite black | • Extreme strength and stiffness  
• Thermal and electrical conductivity (limited)  
• Best strength/weight-ratio | • Light and stiff functional parts  
• Metal replacement |
| Polyamide 11 | PA 1101 | natural | • Very high ductility / elongation at break  
• 100% from renewable sources (castor/ricinus oil)  
• Acceptable tensile strength | • Functional parts which need impact resistance  
• Parts with functional elements (film hinges) |

**For special applications**

<table>
<thead>
<tr>
<th>Composition</th>
<th>Trade name</th>
<th>Colour of parts</th>
<th>Main feature</th>
<th>Typical applications</th>
</tr>
</thead>
</table>
| Polyamide 12 | PA 2201 | natural | • Multipurpose material  
• Material certificates available (Food contact) | • Medical, food |
| PA 2105 | light beige | • Highest dimensional accuracy  
• High surface quality and detail resolution | • Dental |
| Polyamide 12, flame retardant | PA 2210 FR | white | • Economic flame-retardant material  
• Halogen-free | • Aerospace  
• Electric & Electronic |
| PrimePart® FR (PA 2241 FR) | white | • Economic flame-retardant material  
• Material certificates available (flammability) | • Aerospace |
| TPE-A Polyetheramide- Block-Copolymer | PrimePart® ST (PEBA 2301) | white | • Rubber-like flexibility (Shore D = 35)  
• No infiltration necessary | • Damping devices, bumpers / cushions, gaskets / gasket seals, shoe sole elements |
| Polystyrene | PrimeCast® 101 | grey | • High dimensional accuracy  
• Low residual ash-content | • Patterns for investment casting  
• Master patterns for vacuum casting |
| Polaryletherketone | EOS PEEK HP3 | beige-brown | • High performance material  
• Excellent temperature performance, strength, stiffness and chemical resistance  
• Excellent wear resistance. Inherently flame retardant  
• Biocompatibility and sterilizability | • Metal replacement  
• Aerospace  
• Automotive and motorsports. Electric & Electronic  
• Medical  
• Industrial |
### EOS Systems for the Additive Manufacturing of Metal Parts

<table>
<thead>
<tr>
<th>System</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EOS M 100</strong></td>
<td>Small-Sized System for Additive Manufacturing of Metal Parts</td>
</tr>
<tr>
<td><strong>EOSINT M 270 Dental</strong></td>
<td>High-Performance DMLS for Dental Copings &amp; Bridges</td>
</tr>
<tr>
<td><strong>EOS M 290</strong></td>
<td>For High-Quality Metal Parts – with Enhanced Quality Management</td>
</tr>
<tr>
<td><strong>EOS M 400</strong></td>
<td>For Industrial Production of High-Quality Large Metal Parts</td>
</tr>
</tbody>
</table>

#### Usable build size
- **EOS M 100**: Diameter 80-100 mm
- **EOSINT M 270 Dental**: Width 250 mm, Depth 250 mm, Height 215 mm
- **EOS M 290**: Width 250mm, Depth 250 mm, Height 325 mm
- **EOS M 400**: Width 400 mm, Depth 400 mm, Height 400 mm

#### Laser
- **EOS M 100**: Yb-fibre laser
- **EOSINT M 270 Dental**: Yb-fibre laser
- **EOS M 290**: Yb-fibre laser
- **EOS M 400**: Yb-fibre laser
- **EOS M 100**: 100 W or 200 W
- **EOSINT M 270 Dental**: 200 W
- **EOS M 290**: 400 W
- **EOS M 400**: 1,000 W

#### Technical data
- **EOS M 100**: Precision optics: F-theta-lens, high-speed scanner
- **EOSINT M 270 Dental**: Precision optics: F-theta-lens, high-speed scanner
- **EOS M 290**: Recirculating Filter System, Monitoring of machine and process parameters
- **EOS M 400**: Precision optics: F-theta-lens
- **EOS M 100**: Scan speed: up to 7.0 m/s
- **EOSINT M 270 Dental**: Scan speed: up to 7.0 m/s
- **EOS M 290**: Scan speed: up to 7.0 m/s
- **EOS M 400**: Scan speed: up to 7.0 m/s

*Pictures not to scale*
## EOS Metal Materials

<table>
<thead>
<tr>
<th>Material Group</th>
<th>Brand name</th>
<th>Material type</th>
<th>Typical applications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maraging Steel</strong></td>
<td>EOS MaragingSteel MS1</td>
<td>18 Mar 300 / 1.2709</td>
<td>Injection moulding series tooling; engineering parts</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>EOS StainlessSteel GP1</td>
<td>Stainless steel 17-4 / 1.4542</td>
<td>Functional prototypes and series parts; engineering and medical</td>
</tr>
<tr>
<td></td>
<td>EOS StainlessSteel PH1</td>
<td>Hardenable stainless</td>
<td>Functional prototypes and series parts; engineering and medical</td>
</tr>
<tr>
<td></td>
<td>EOS StainlessSteel 316L</td>
<td>Stainless steel 1.4404</td>
<td>Functional prototypes and series parts; lifestyle, aerospace, medical</td>
</tr>
<tr>
<td><strong>Nickel Alloy</strong></td>
<td>EOS NickelAlloy IN718</td>
<td>Inconel™ 718, UNS N07718, AMS 5662, W.Nr 2.4668 etc.</td>
<td>Functional prototypes and series parts; high temperature turbine parts etc.</td>
</tr>
<tr>
<td></td>
<td>EOS NickelAlloy IN625</td>
<td>Inconel™ 625, UNS N06625, AMS 5666F, W.Nr 2.4856 etc.</td>
<td>Functional prototypes and series parts; high temperature turbine parts etc.</td>
</tr>
<tr>
<td></td>
<td>EOS NickelAlloy HX</td>
<td>UNS N06002</td>
<td>Severe thermal conditions and high risk of oxidation, e.g. combustion chambers,</td>
</tr>
<tr>
<td><strong>Cobalt Chrome</strong></td>
<td>EOS CobaltChrome MP1</td>
<td>CoCrMo superalloy, UNS R31538, ASTM F75 etc.</td>
<td>Functional prototypes and series parts; engineering, medical, dental</td>
</tr>
<tr>
<td></td>
<td>EOS CobaltChrome SP2</td>
<td>CoCrMo superalloy</td>
<td>Dental restorations (series production)</td>
</tr>
<tr>
<td><strong>Titanium</strong></td>
<td>EOS Titanium Ti64</td>
<td>Ti6Al4V light alloy</td>
<td>Functional prototypes and series parts; aerospace, motor sport etc.</td>
</tr>
<tr>
<td></td>
<td>EOS Titanium Ti64ELI</td>
<td>Ti6Al4V ELI (grade 23)</td>
<td>Medical Implants</td>
</tr>
<tr>
<td><strong>Aluminium</strong></td>
<td>EOS Aluminium AlSi10Mg</td>
<td>AlSi10Mg light alloy</td>
<td>Functional prototypes and series parts; engineering, automotive etc.</td>
</tr>
</tbody>
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**Industrial e-Manufacturing Solutions for Industry: Aerospace, Medical, Tooling**
Business Positioned in Line with Market Demand: EOS Offers Solutions for Many Industries

EOS Distribution Channels: Regional, Industry-Specific, Distributors, Sales Partners

EOS Portfolio

- Products
  - Design*
    - Application specific (e.g. lightweight)
- Solutions
  - Build
    - Systems
    - Material
    - Software
    - Process
    - Service
- Services
  - Finish*
    - Surface engineering

*With EOS technology partners
Challenges to overcome

EOS: Strategy basis and resulting challenges

Balanced triangle

- Process
- System
- Material

Part quality

Process robustness

Industrialization

Hurdles to overcome

Part Quality
- Mechanical properties
- Dimensional accuracy
- Surface quality
- Density

Process Robustness
- Build platform
- Several jobs
- Several machines
- Several suppliers

Industrialization
- Automation
- Quality assurance
- Easy-to-Service
- Productivity
EOS QUALITY MANAGEMENT SERVICES: From Delivery to Validation

FAT system EOS
- Manufacturing inspections
- Safety & calibration
- etc.

IQ system customer
- Installation inspection
- Safety & calibration
- etc.

FAT material EOS
- Material analytic inspections
- Material properties
- etc.

System

Part

PQ finished part customer
- Function
- Dimensions
- Quality
- etc.

Material

Process

OQ customer process
- Process instruction
- Operator training & qualification
- Maintenance of equipment
- etc.

FAT: Factory Acceptance Test
IQ: Installation Qualification
OQ: Operation Qualification
PQ: Performance Qualification

GE Fuel Nozzle
Three main EOS programs support our customers to step into “Serial Production”

**Increased Output - Reduced Cost-per-part**
- Increase of system productivity
- Automation => Industrial powder & job handling periphery

**Repeatable Part Quality**
- Robust process with predictable part quality
- Complete Monitoring / Quality Assessment
- Customer centered Process Development

**Industrialization & Integration into existing manufacturing environment**
- Ease of use (e.g. CAD interface / job preparation)
- Seamless data flow and MES-integration
- Uptime, OEE & Serviceability
- Automation & intelligent interface to post processing

**High productivity platforms**

**Excellent Processing**

**Connected Manufacturing**
Prosthesis model

- Material: Polyamide 12
- Completely functional
- Manufacturing time: approx. 12h

Source: eos, J. Breuninger, IPA
MUCHAS GRACIAS POR SU ATENCIÓN!!!

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