e-Manufacturing applications:
Any shape, anytime, anywhere
EOS was founded in 1989 - worldwide market leader since 2002 for laser-sintering systems

**EOS History**

1989

Founding EOS GmbH - Electro Optical Systems
Pilot customer BMW.

2002

Worldwide market leader for laser-sintering systems, the key technology for e-Manufacturing™.

2007


**Philosophy**

Application oriented solutions for numerous industries
Technology leader for high-end Rapid Prototyping, Rapid Tooling and Rapid Manufacturing Systems.
Joint solutions with customers.

Source: EOS
EOS grows its revenue at +16% p.a. since 2000 - e-Manufacturing major growth driver

**EOS revenue and employees [2000 - 2006]**

<table>
<thead>
<tr>
<th>Year</th>
<th>Revenues [Mio. €]</th>
<th>Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>21.9</td>
<td>107</td>
</tr>
<tr>
<td>2001</td>
<td>26.4</td>
<td>125</td>
</tr>
<tr>
<td>2002</td>
<td>37.4</td>
<td>140</td>
</tr>
<tr>
<td>2003</td>
<td>38.4</td>
<td>157</td>
</tr>
<tr>
<td>2004</td>
<td>44.4</td>
<td>172</td>
</tr>
<tr>
<td>2005</td>
<td>48.4</td>
<td>187</td>
</tr>
<tr>
<td>2006</td>
<td>52.3</td>
<td>207</td>
</tr>
</tbody>
</table>

Source: EOS
EOS is the worldwide market leader, present in all key regions of the world

EOS world-wide 2007 – approx. 720 systems installed

NA: 50
Europe: 510
Asia: 130
ROW: 30

Source: EOS
EOS has subsidiaries or distribution partners in all major markets of the world

**EOS worldwide 2007**

- Worldwide recognized technology leader for high-end systems for e-Manufacturing™
- Customers in > 30 countries
- EOS sales/service/application offices in 10 countries (Germany, UK, France, Italy, USA, India, Singapore, Korea, Taiwan, Finland)
- Distributors in 10 countries
  - 6 distributors in Asia/Pacific
  - 5 distributors in Europe and ROW

Source: EOS
Customers from various industries all over the world rely on EOS technologies

Sample EOS customers (incomplete)
As of EuroMold `06 EOS rejuvenated its plastics laser-sintering product line

EOS plastics laser-sintering product line

EOSINT P 730

EOSINT P 390

FORMIGA P 100

Pictures not scaled

Source: CDR
The EOSINT M 270 for the direct laser-sintering of metal positions very well in the market
The EOSINT S 750 is used for laser-sintering croning moulding material
EOS innovation-, technology-, and growth-leadership are widely recognized

EOS accolades 2005/2006

FROST & SULLIVAN
Technology Leadership of the year award 2005

Source: EOS
EOS has patented many of its own inventions
- more than 50 patent families, mostly patented in various countries

EOS has also acquired or licensed patent rights from many third parties including ...
- 3D Systems, DTM Corp.
- University of Texas
- Trumpf
- Fraunhofer Society
- DaimlerChrysler
- Electrolux
- Particular
- Dr. Florian Wendt, etc.

EOS owns many patents and licensed patent rights in many regions including USA and Europe

---

**Examples of EOS patent rights**

Source: EOS
e-Manufacturing: The business case
Laser-sintering is automatic, generative, and application oriented - key to e-Manufacturing

Laser-sintering process: Key-technology for e-Manufacturing
e-Manufacturing means the fast, flexible and cost efficient production directly from electronic data

**e-Manufacturing process**

From 3D Data ... ... to laser-sintering ... ... to the final product

Source: EOS
With laser-sintering plastic parts can be built in volumes from one-offs to several hundred thousand

Plastic parts manufactured via DirectPart

Source: EOS, Lübbering, Trevisio Tecnologia
Plastic parts can also be generated with tools built on EOSINT M

Plastic parts manufactured via DirectTool

— DirectTool®
  • Injection moulding tools
  • Injection moulding tool inserts
  • Blow moulding etc.

Source: EOS, Arberg, Kashiyama Kanagata, Transcat

Mobile phone tooling
Above: Twin colour key ring
Below: Fan wheel
With laser-sintering metal parts can be built in volumes from one-offs to several hundred thousand.

**Metal parts manufactured via DirectPart**

- Gear Wheels
- Chess set
- Dental Crowns (left: veneered)

Source: EOS, Sirona
Metal parts can also be casted with patterns built on EOSINT P

---

**Metal Parts via DirectPattern**

- DirectPattern®
  - Lost patterns for plaster casting
  - Lost patterns for investment casting

---

Source: EOS, Poggipolini
Metal parts can also be cast with moulds and cores built on EOSINT S

**Metal parts via DirectCast**

- DirectCast® sand moulds and cores for metal castings
  - Engine blocks
  - Pumps
  - Hydraulic devices
  - Housings
  - Special castings

Source: EOS, ACTech
This way e-Manufacturing offers solutions meeting current market trends

Solutions to market trends with e-Manufacturing

**Market trends**
- Mass Customization
- One-off production
- Shortening life-cycles
- Cost pressure in development and manufacturing
- Customer proximity

**Solutions**
- Rapid Product Development
- Freedom of design
- Flexible manufacturing
- New business models

Source: EOS
The EOS Vision promotes laser-sintering value add as „Any shape, anytime, anywhere“

Laser-sintering value add

- **Any shape**: Manufacture even the „impossible“
- **Anytime**: In every phase of the product life cycle
- **Anywhere**: In every industry

Source: EOS
e-Manufacturing adds value in every phase of the product life cycle - in any industry

<table>
<thead>
<tr>
<th><strong>Content</strong></th>
<th><strong>Mean</strong></th>
<th><strong>Result</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Get the “impossible”</td>
<td>In every phase of the product life cycle</td>
<td>Make Mass Customization real</td>
</tr>
<tr>
<td>No mould draught angles</td>
<td>Speed up product development</td>
<td>Fast customer response</td>
</tr>
<tr>
<td>Undercuts are possible</td>
<td>Flexible series manufacturing</td>
<td>New business models</td>
</tr>
<tr>
<td>Functional integration possible</td>
<td>Flexible spare part manufacturing</td>
<td></td>
</tr>
</tbody>
</table>

Source: EOS
Laser-sintering eventually means the liberation of design from manufacturing restraints

Paradigm shift in design and manufacturing

Manufacturing-driven design → Design-driven manufacturing
This allows for the creation of convincingly attractive products - both to customers and to manufacturers.

The business case: Convincingly attractive products

Customers’ point of view
Increased willingness to pay

Manufacturers’ point of view
Reducing manufacturing costs

Creating convincingly attractive products

Source: EOS, McKinsey & Comp.
With laser-sintering you can improve customers’ willingness to pay while reducing manufacturing costs

**Details on business case**

- Attractive product design
- Customization in terms of functionality, fit and design
- Customization to regions
- Customer as innovator

**Willingness to pay**

- No sunk-costs in tooling
- Reduced risk
- Small batch sizes production feasible
- Production synchronous to customer demand
- Reduced design to cost (complexity is not an issue)

Source: EOS, McKinsey & Comp.
Creating convincingly attractive products, laser-sintering can add value along the entire life-cycle

### Anytime: Laser-Sintering in the product life cycle

<table>
<thead>
<tr>
<th>Product development</th>
<th>Series manufacturing</th>
<th>Spare parts supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed up product development</td>
<td>Flexible manufacturing</td>
<td>Reduce stock keeping costs of work in progress and finished parts</td>
</tr>
<tr>
<td>Prototypes as communication models</td>
<td>Independence of batch size</td>
<td>Manufacture on demand</td>
</tr>
<tr>
<td>Shortening of “time to market”</td>
<td>Demand anticipation not required</td>
<td>Get data directly from customer</td>
</tr>
<tr>
<td>Reduce development risks</td>
<td>Flexibility to change</td>
<td></td>
</tr>
<tr>
<td>Reduced risk of “flop”</td>
<td>Customer integration into design and innovation</td>
<td></td>
</tr>
</tbody>
</table>
Sample applications
With laser-sintering complexity is not a cost driver anymore - profitable business models possible

**Any shape (I)**

---
**Content**
- Freedom of design
- Integration of functions
- Minimal limitations of manufacturing
- Think the impossible. You can get it.

---
**Means**
- Make Mass Customization real
- Add complexity

---
**Result**
- Market success in low volume niche markets
- Convincingly attractive product selling @ 400 €

project partner: **FOC**

Source: Freedom of Creation, EOS
Arts and fashion industry are potential markets for laser-sintering

Any shape (II)

Content
- Art is not subject to manufacturing limitations

Means
- Industrial manufacturing of art
- Complexity without extra costs

Result
- Artists can embrace industrial manufacturing
- Artists and designer can make visionary ideas reality

Bonsai as silver cast via DirectPattern, Rings made by laser-sintering via DirectPart

Source: Connet, Ron Arad, EOS
EOS customers create convincingly attractive products winning market success and awards

Any shape (III)

Content
• Art is not subject to manufacturing limitations

Means
• Industrial manufacturing of art
• Complexity without extra costs

Result
• 32 cm diameter “Scon” with 16 cm in height
• Convincingly attractive product selling @ 600 €

Source: Freedom of creation, EOS

Freedom of creation 1597: Winner of the interior innovation award, Köln, 2006

project partner: FOC
Laser-sintering stems from product development - value add for speeding up design process

Anytime: Product development

Content
- Prototypes

Means
- Communication model for customers and employees

Result
- Reduction of development costs
- Minimize development risk
- Speed up design process

Laser-sintered car dashboard module 1:2 (4 pieces)

Source: EOS, Shonan
The future of laser-sintering is series manufacturing - value add not only to small series

Anytime: Series manufacturing

Content
- Customized products
- Series manufacturing (down to one-offs)
- Increase number of varieties offered

Means
- Reducing economies-of-scale dependency
- Minimize risks by eliminating tooling
- Integrate customer into product development

Result
- Serve low volume niche markets
- Increase customers’ willingness to pay
- Customization (e.g. for regions)
- Create convincingly attractive products

Source: Hettich, EOS
With conventional tools the product caused significant costs in finishing

**Product prior to using laser-sintering**

— Conventional tooling manufacturing:
  - Variety of tools needed
  - 32 different parts to be manufactured and assembled
  - Intensive post processing (chamfering)

— Problems:
  - Burrs at berths and stainless-steel tubes
  - Intensive finishing required
  - Therefore product very cost intensive

— Costs
  - Tools mean extensive investments
  - Dependency on economies of scale is significant
  - Assembling is cost intensive

Source: Hettich, EOS

Hettich washing rotor with inner structures, manufactured with conventional tooling (12 berth)
Laser-sintering has no fixed costs - elimination of costs in tooling

Cost comparison laser-sintering vs. tool based manufacturing

Source: EOS
If functions are integrated with laser-sintering, the gap widens in favor of laser-sintering.

Cost comparison laser-sintering vs. tool based manufacturing

Increased tooling complexity required to make up for the integration of functions.
A continuous data flow from CAD to the finished product is the key driver for e-Manufacturing

Anytime: CAD to Part Series manufacturing - Scheme

From wax imprint ... ... to CAD manipulation ... ... to laser-sintering ... ... to the finished product

Source: EOS
Laser-sintering implants is beneficial to patients and reduces health care costs

Anytime: Series manufacturing - Medical

---

Content
- Customized implants and prosthesis

Means
- Exact fit to the patient’s anatomy
- Mechanical follow up processes (e. g. coating)

Result
- Reduce time spent in hospital
- Minimize follow-up problems
- Reduce health care costs
- Improve quality of life for patients

Source: EOS, Stryker
In aerospace laser-sintering can add value where complexity and individuality coincide

**Anytime: Series manufacturing - Aerospace**

---

**Content**
- Design and manufacture complex geometries
- Meet individual customer needs
- Fit special purpose equipment

---

**Means**
- Flexibility of laser-sintering to create individual parts
- Fast, industrial manufacturing

---

**Result**
- Improve aircraft reliability
- Boost customer satisfaction
- Target new markets

Source: EOS
This little float is manufactured by laser-sintering in a series of 8000

**Latching water level indicator**

- **Requirement:**
  - Series of 8000 floats to be manufactured
  - Multi-component design and subsequent assembly (e.g. integrating magnet)
  - Sealing of the float at the end

- **Solution:**
  - Laser-sintering in lot-sizes of 1000
  - Subsequent dying in flashy orange

- **Result:**
  - Convincingly attractive product that saves life in the London underground
  - Selling @ 70 £ net. (ca. 100 €)

Projektpartner: 3T RPD

Source: EOS, 3T RPD
The float consists of 4 parts and subsequently is assembled, sealed and dyed

**Latchling water level indicator**

Float assembly with reset levers

Laser-sintered components to be assembled

Projektpartner: 3T RPD

Source: EOS, 3T RPD
Finishing is made easier by intelligently manufacturing small parts on a laser-sintered bridge

**Latchng water level indicator**

Single components held together by a laser-sintered bridge, easing finish

Projektpartner: 3T RPD

Source: EOS, 3T RPD

EOS 2007 · Company Presentation · CST
Laser-sintering opens a market for spare parts that can not economically be addressed otherwise

**Anytime: Spare parts**

- **Content**
  - Manufacturing of spare parts on demand
  - Customer has no other choice: Spare parts are not offered by OEM

- **Means**
  - Integrate customer into design process of spare part
  - Integrate product improvements into spare part design

- **Result**
  - Improve customer satisfaction
  - Reduce costs of spare part supply
  - Gather input for further innovations

Source: JuniorTacke, EOS
By laser-sintering production aids, cost and time savings can be realized in mass manufacturing

---

**Anywhere: Manufacturing aids**

- Requirement:
  - Provide “assembly combs“ as manufacturing aid for automotive interior-filters

- Solution:
  - DirectPart® with PA 2200®
    - built on EOSINT P

- Result:
  - very short delivery times
  - low costs compared to conventional methods of manufacturing “combs”
  - freedom of design at dimensional accuracy
  - low weight at unparalleled roughness

---

project partner: MAHLE

Source: EOS, MAHLE
Laser-sintering is the best alternative for the production of the assembly comb - not only costwise

**Cost overview [€]**

![Cost overview chart](chart.png)

**Source:** EOS, MAHLE

**Project partner:** MAHLE
Mahle is committed to laser-sintering manufacturing aids

Ulrich Boch, Manager prototype and production equipment, Mahle Filtersysteme

— “Laser-sintered parts in PA 2200 can be used in series production as production aids”

— “Advantages are: high freedom of design, short procurement times and low production costs”

— “Certain parts in Mahle proprietary special purpose machines are also potential targets being addressed by laser-sintered parts thus making cost intensive manual work obsolete”

— “There is a large cost advantage if small parts can be built more or less at no extra costs in a job together with our parts that need to be built anyway”

Source: EOS, MAHLE
Jaguar uses EOSINT P Laser-Sintering technology for manufacturing production aids

**Anywhere: Window opener mechanism**

- **Requirement:**
  - Cost-effective manufacturing of production aids for the assembly of a window opener mechanism

- **Solution:**
  - Laser-sintering on EOSINT P

- **Result:**
  - 3,000 production aids are produced via Laser-Sintering at Jaguar
  - Savings of cost and time during the assembly process

---

Project partner: JAGUAR

Source: JAGUAR CARS, EOS
Jaguar expects Laser-sintering as key for the next generation of volume production technologies

**Details and in general**

- Part used for positioning of the window opener mechanism during the assembly process
- At Jaguar XK Coupé and XK Convertible assembly lines
- Whereabouts of the production aid during the entire assembly process on the car
- Replacement of production of injection moulding tools
- Cost savings
- No limitation in design
- Elimination of tooling- and warehousing-costs
- EOSINT as key for the next generation of volume production technologies

Source: JAGUAR CARS, EOS
e-Manufacturing @ EOS
EOS itself is an e-Manufacturing company - 2 600 parts per year manufactured by laser-sintering.

**Laser-Sintering @ EOS**

- Reducing time to market: approx. 2 600 parts p. a.
- Minimizing logistics
- Speeding up Innovation Tests/Mock-ups
- IPCM-Fixture: Integrated functions of high volume part
- M 270 handle: Living design-driven manufacturing
- Manufacturing spare parts on demand
- Offering customized products

Source: TOM, AZ
EOS manufactures the EOSINT M 270 door handle with laser-sintering

**Requirement:**
- small series production of functional parts in design quality

**Solution:**
- e-Manufacturing with EOSINT
- EOSINT M for small parts
- Alumide® for large parts

**Result:**
- high functionality
- economical production
- cost-efficient production with high flexibility
- Convincingly attractive product to EOS and customers
The handle consists of 3 Alumide parts that are combined with DMLS parts

**EOSINT M 270 Door Handle - Details**

- **Door handle:**
  - 3-piece handle frame in Alumide®
  - Button and locking device in EOS StainlessSteel 17-4
  - Pin with internal features in DirectMetal 20

- **Alumide® parts:**
  - built on EOSINT P 380
  - build time for 20 sets approx. 52 hours
  - Autofinish and varnishing

- **DMLS parts:**
  - built on EOSINT M 270
  - post processed

Source: EOS
Working principle EOSINT M 270 handle (I)
Working principle EOSINT M 270 handle (II)
Often laser-sintered parts are better in function and less expensive to produce

**EOS example**

— Laser-sintering:
  - Material PA 2200, Batch size 5
  - Laser-sintering total costs: 70,00 € per part
    (@ 54 € per kg powder, incl. Jobpreperation and -finish, @ 50 €/h machine costs)

— Conventional (milling):
  - Material PA 6.6
  - Milling only possible if part is divided into 2
  - Batch size 5
  - Conventional total costs: 64,62 € per part direct costs
    + one time programming: 325,- €
    + one time tooling: 150,- €

Source: EOS

EOS example

EOS micro switch berth
Even if tooling was sufficient for high volumes, milling breaks even only at 89 parts.

**Cost comparison laser-sintering vs. milling**

Break-even: 89 parts

448 € saved on conventional manufacturing

*) Assumption: Tooling is sufficient for 89 parts

Source: EOS
Any shape · Anytime · Anywhere

www.eos.info