



**ExOne**

DIGITAL PART MATERIALIZATION

**Engine Expo**

**Novi, MI**

**Terrence Senish**

**October 23-25, 2012**

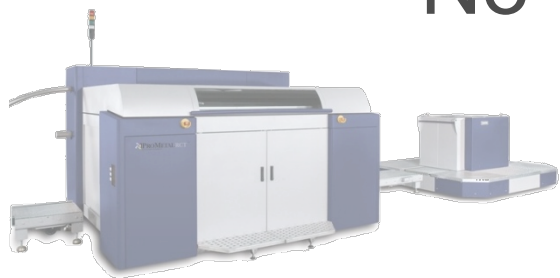
- **Pattern-less Sand Casting Via  
Additive Manufacturing**

# Digital Core Production

## Molds & Cores printed directly from CAD

### for SANDCASTING using 3D-Printing

- Lightweight Castings
- Complex Castings
- No Traditional Constraints





## ■ Company Overview

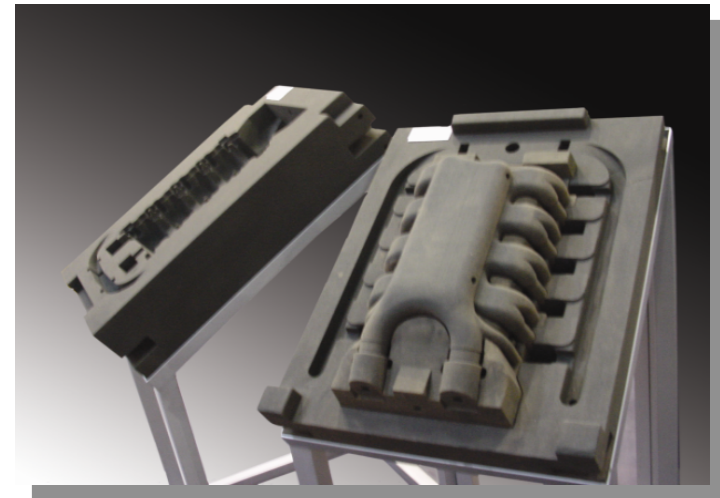
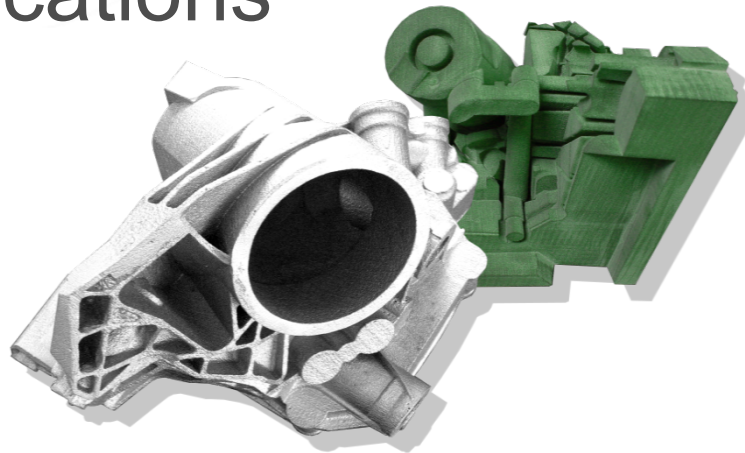
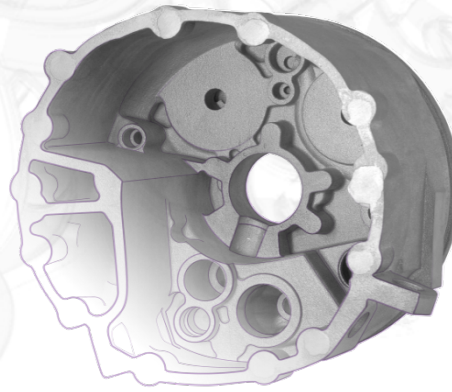
### Plants worldwide



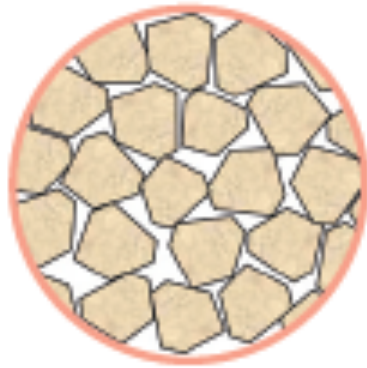
■ 120 employees, Troy, Pennsylvania, Houston, Augsburg & Tokyo



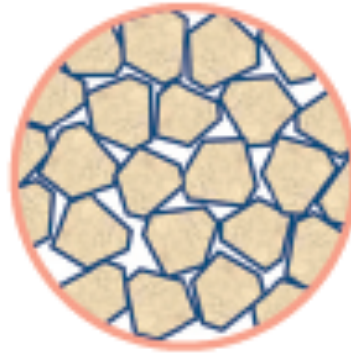
- Company
- **Technology**
- Products
- Applications



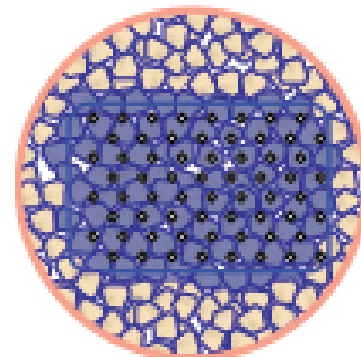
## ■ 3D Printing process



- Uncombined
- loose sand



- Sand coated with **Activator**
- ready for printing



- **Binder** is being spread on the Sand - curing by contact with Activator

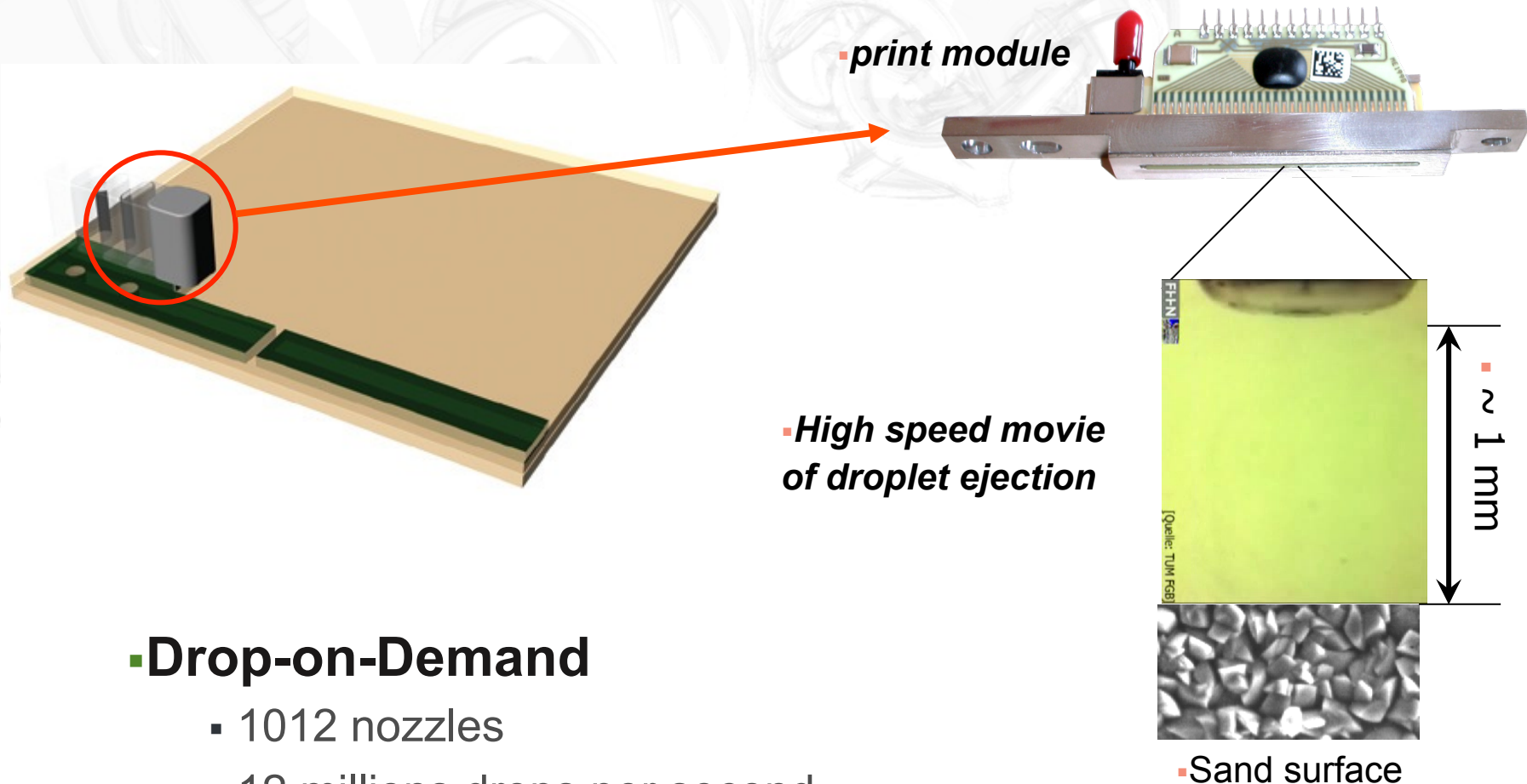
- A new process to manufacture sand molds and cores
- No limitations “spend more time designing, short time prototyping”
- No upfront tooling costs
- Fast, quick, rapid...
- Well known foundry-grade materials





# Technology

## 3D-Printing of Molds and cores



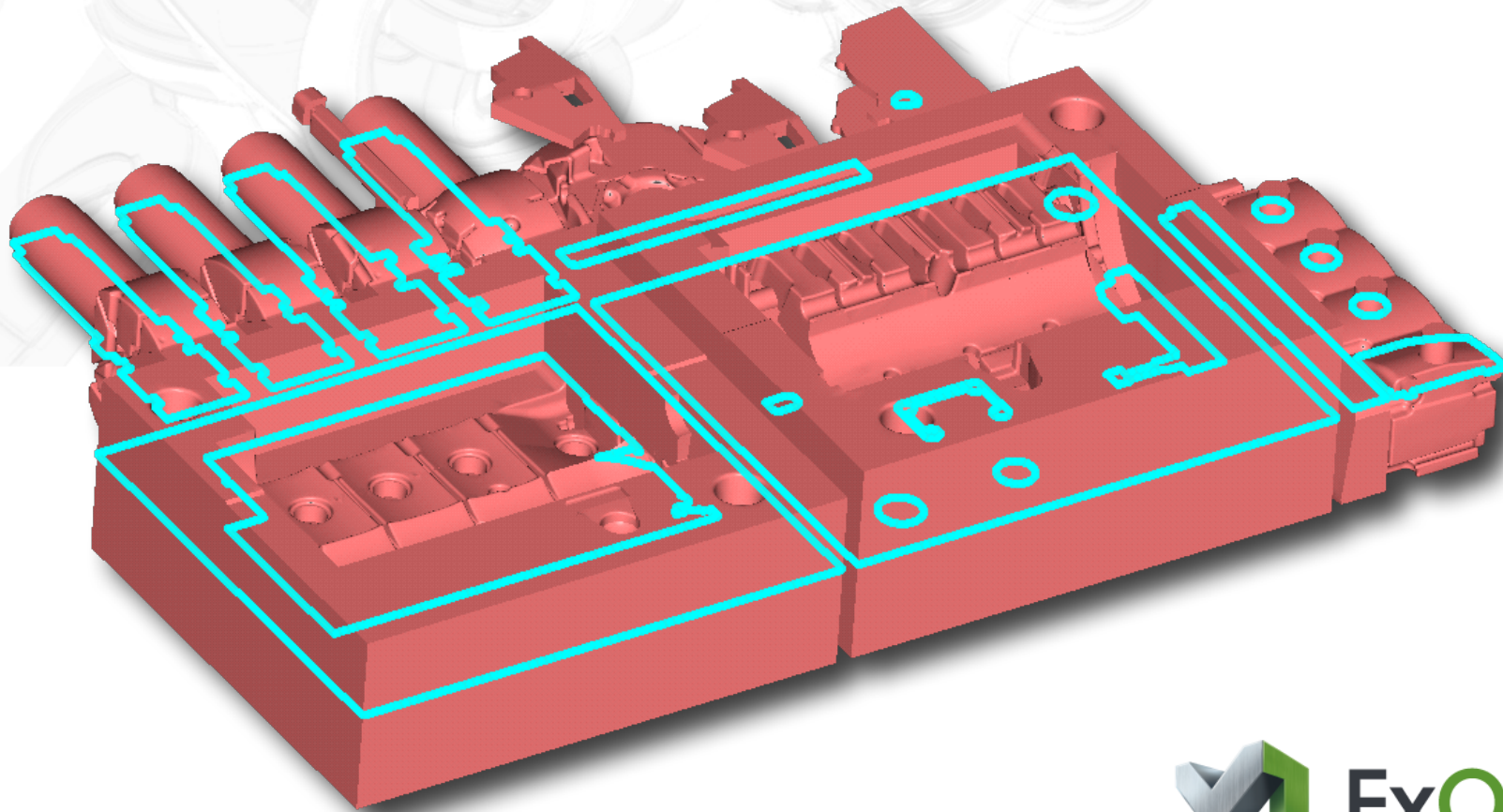
### ▪ Drop-on-Demand

- 1012 nozzles
- 12 millions drops per second
- 200 PicoLiter per drop



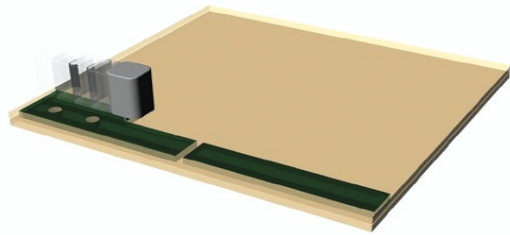
## Technology

Software to convert molds and cores to single slices



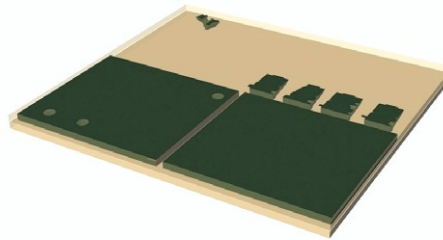


## Technology Layer by Layer



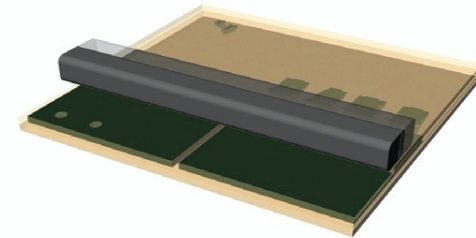
### 1. Printing

- Binder to activated sand



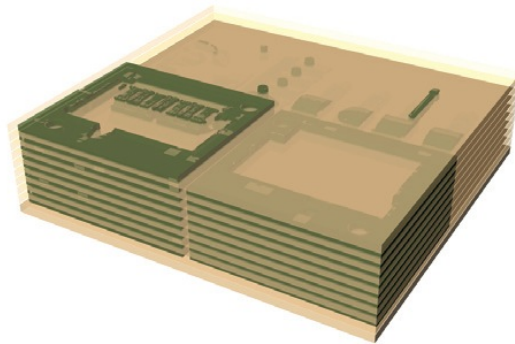
### 2. Finishing of Layer

- Lower platform by one layer



### 3. Spread New Sand layer

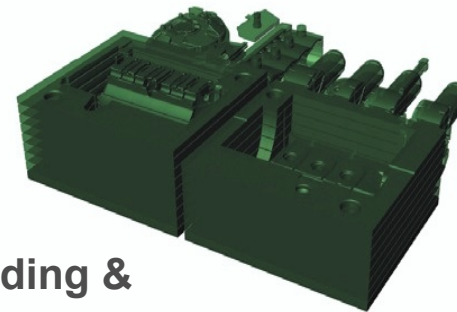
- of pre-mixed sand



### 4. Repeat step 1. through 3. until last layer

### 5. Unloading & Finishing

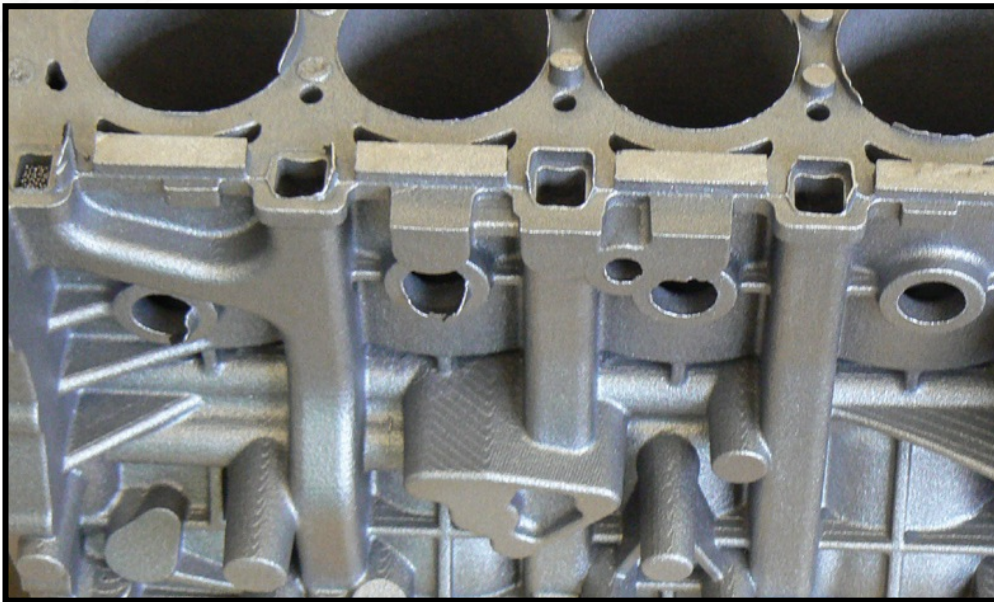
- Unbound sand is removed.



## ■ Technology

# Digital Molds and Core ready for Casting

- Molds and Cores are immediately available for casting
- No post-processing required
- Industrial-proven casting materials (Aluminium, Cast-iron, magnesium...)
- Furan-based binder system
- Low resin content (< 1,3%)
- Excellent gas permeability
- Complex geometries, not feasible using traditional methods



## Technology

### Type of sand and process accuracy

Type of sand Released	Strength (240N/cm <sup>2</sup> minimum)
<b>Quarz</b> d50=140µm, d50=190µm, d50=250µm	280 N/cm <sup>2</sup>
<b>Aluminoxid</b> (Al <sub>2</sub> O <sub>3</sub> ): Lower thermal expansion	360 N/cm <sup>2</sup>
<b>Zircon</b> (ZrSiO <sub>4</sub> ) - only with S-Print machine: - Lower thermal expansion - Higher sand density (cores are heavier)	360 N/cm <sup>2</sup>

<b>Direction X, Y</b> printhead resolution	100 µm
<b>Direction Z</b>	300 µm



## Technology

### Type of sand and development

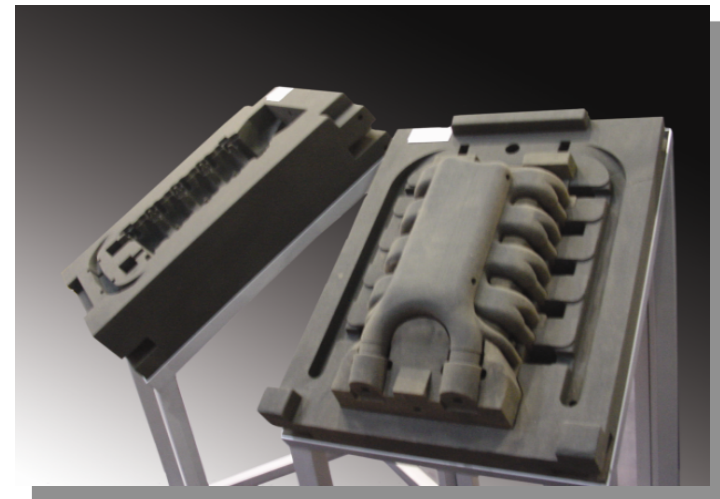
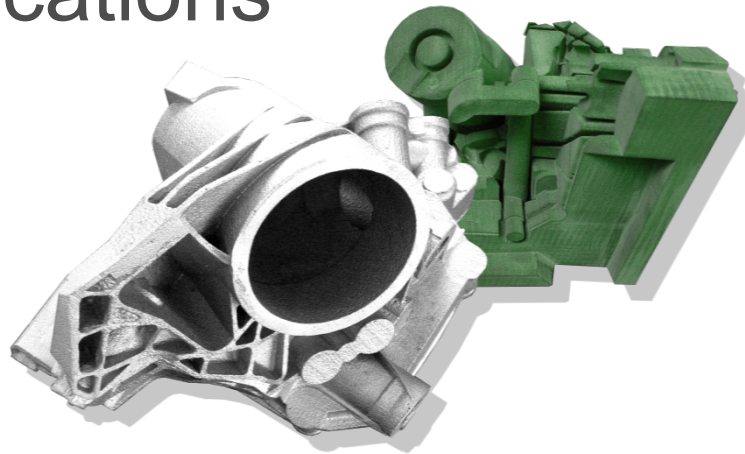
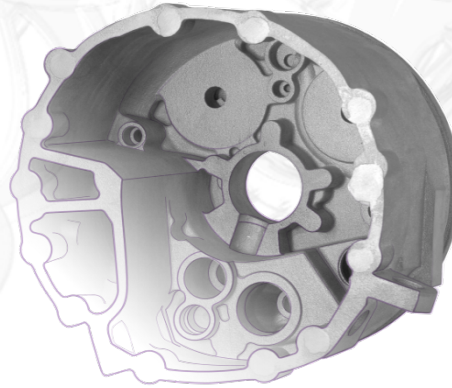
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Type of Binder in development	Resin Base
Improvement of current resin: - for lower gas emission and higher heat strength	Furan
New binder generation: - for highest heat strength and lowest gas emission	Phenol
New binder generation: - Environment friendly	Inorganic





- Company
- Technology
- **Products**
- Applications





## Product S-Print specification

- 800 x 500 x 400 mm
- Max 28 liters/hours
- Medium production
- High flexibility

### Features:

- Sand recycling
- Fluidmatic central fluid supply
- Joblist feature
- Larger printhead
- Multi-sand possibilities:  
silica sand, aluminum oxide, synthetic sand
- No control room temperature needed



- Up to 10 000 cm<sup>3</sup>/h



## Product S-Max specification

- 1800 x 1000 x 700 mm
- Max 108 liters/hours
- Series / flow production



# S-Max

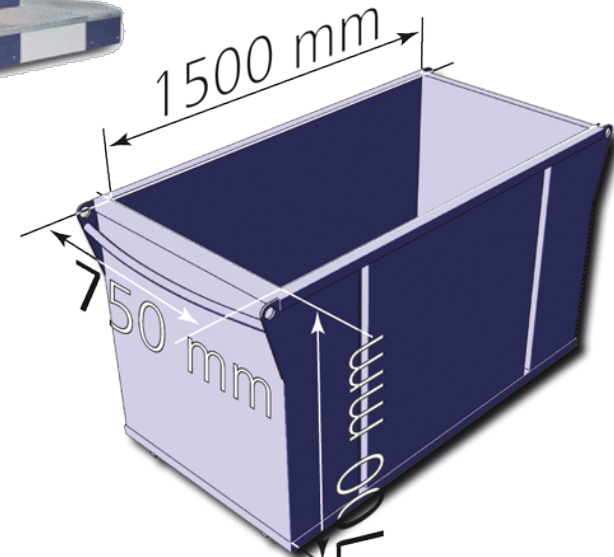
## Features:

- Sand recycling
- Fluidmatic central fluid supply
- Jobmatic automatic job starter
- Joblist feature
- Larger printhead
- Multisand possibilities: silica sand, aluminum oxide, synthetic sand
- No control room temperature needed
- Job can be stopped anytime and restarted within 7 min (urgent printing for 2nd job)



- **Product**  
**S-15 specification**

- **Build space**  
**1500x750x700mm**



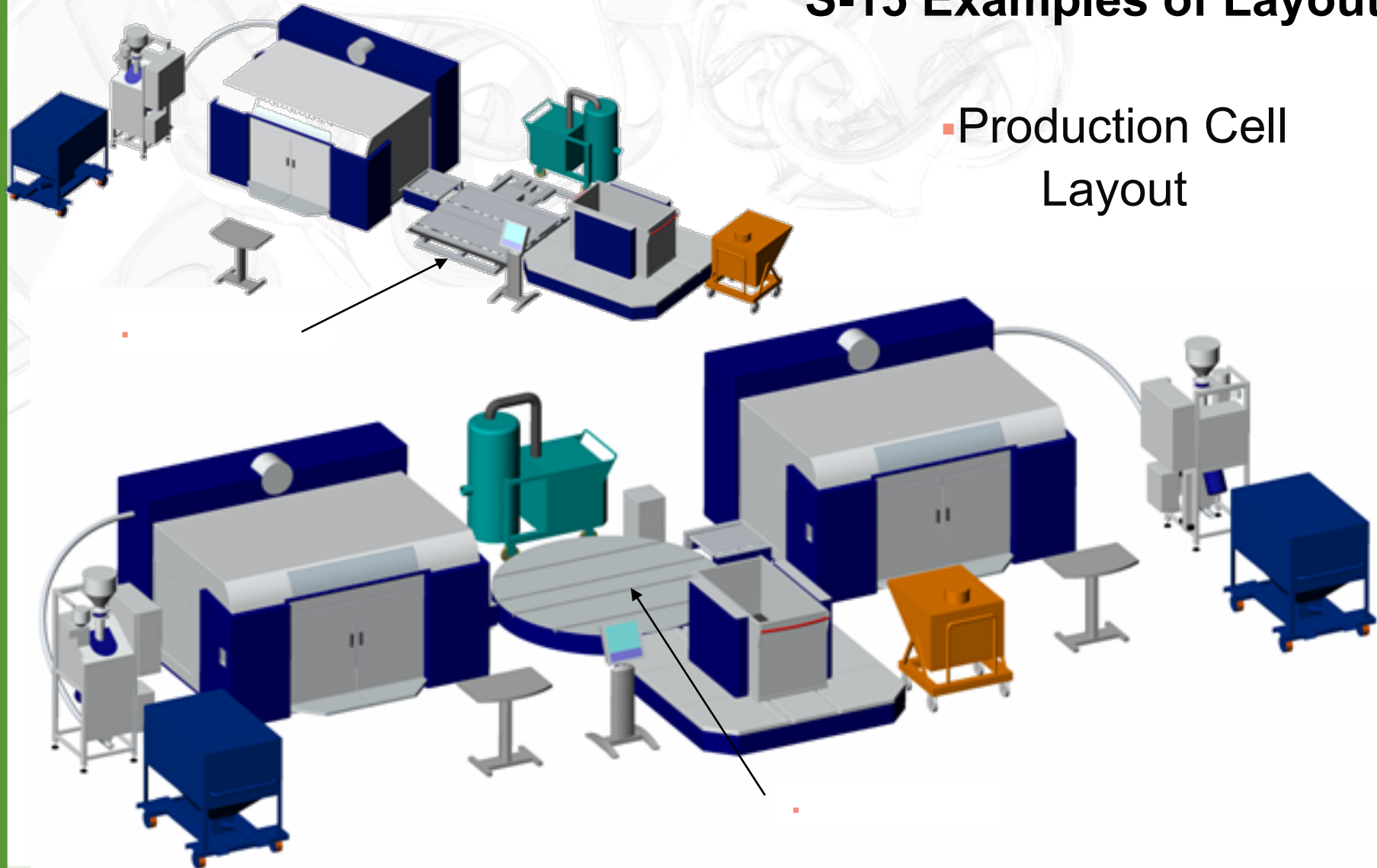
- **Up to 29 000 cm<sup>3</sup>/h**





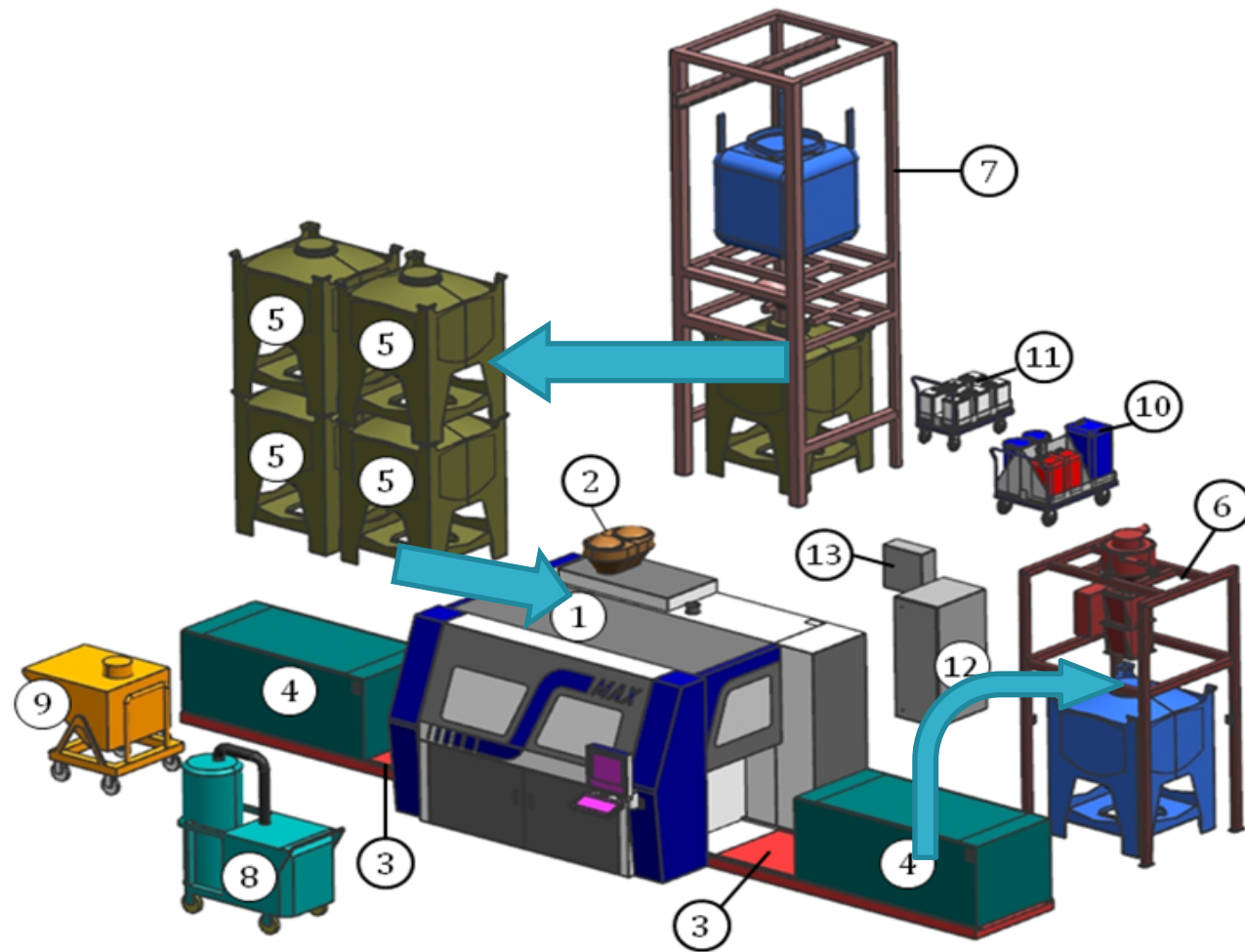
## Product S-15 Examples of Layout

### Production Cell Layout

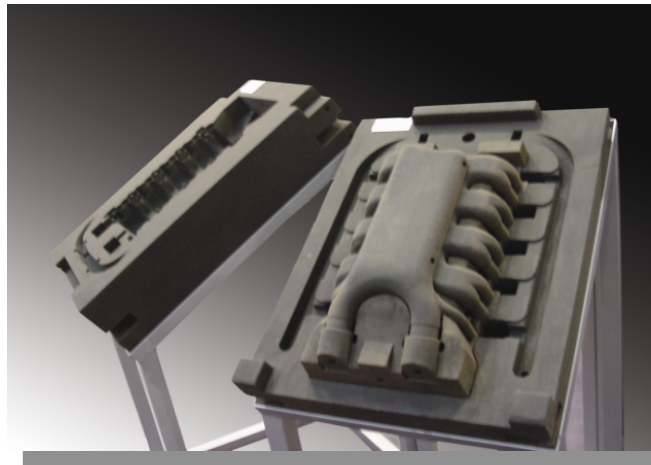
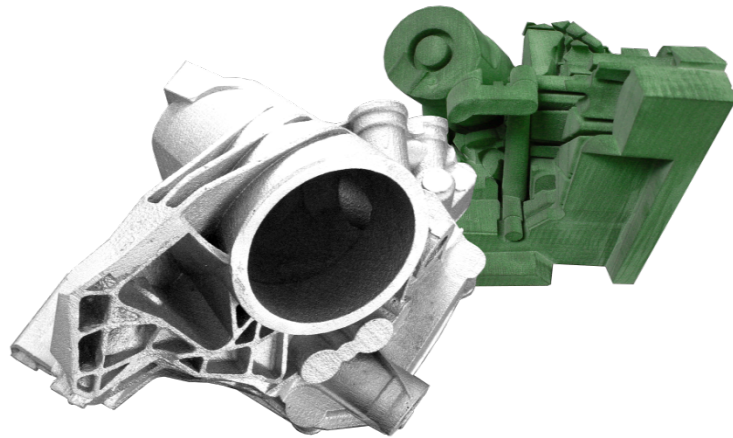




## Product S-Max specification and layout



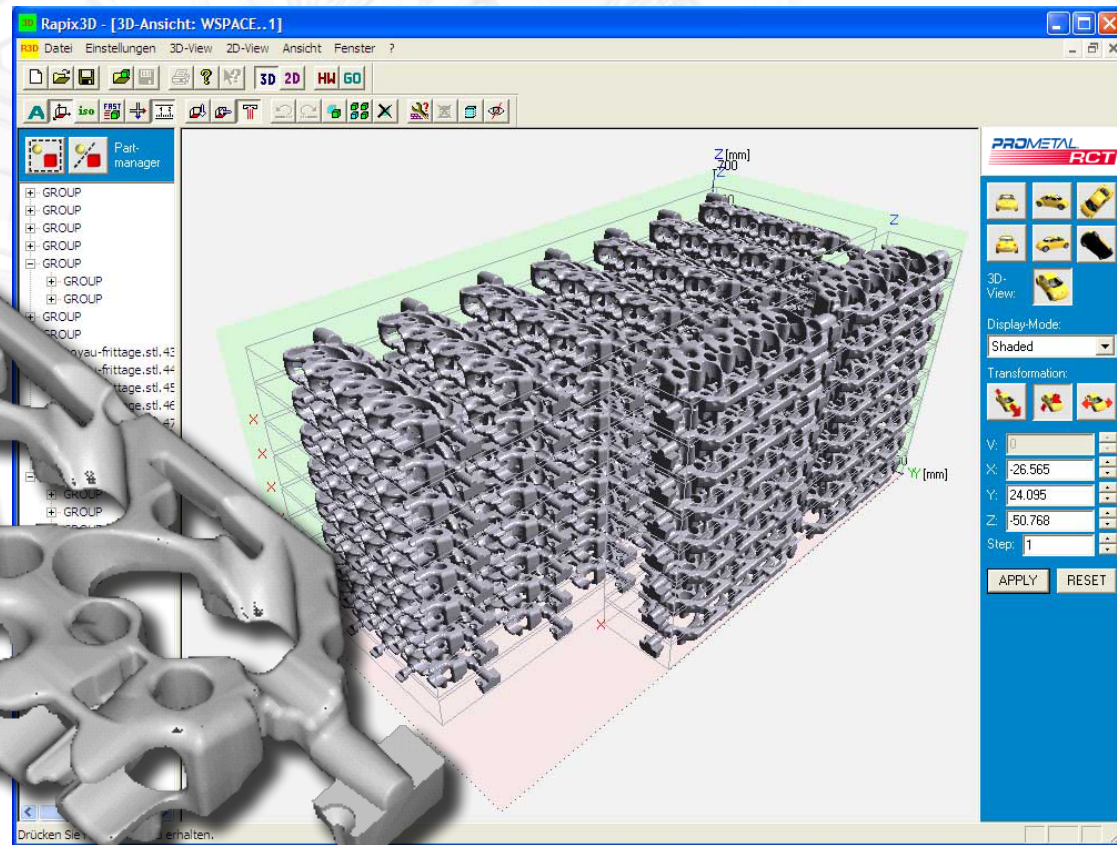
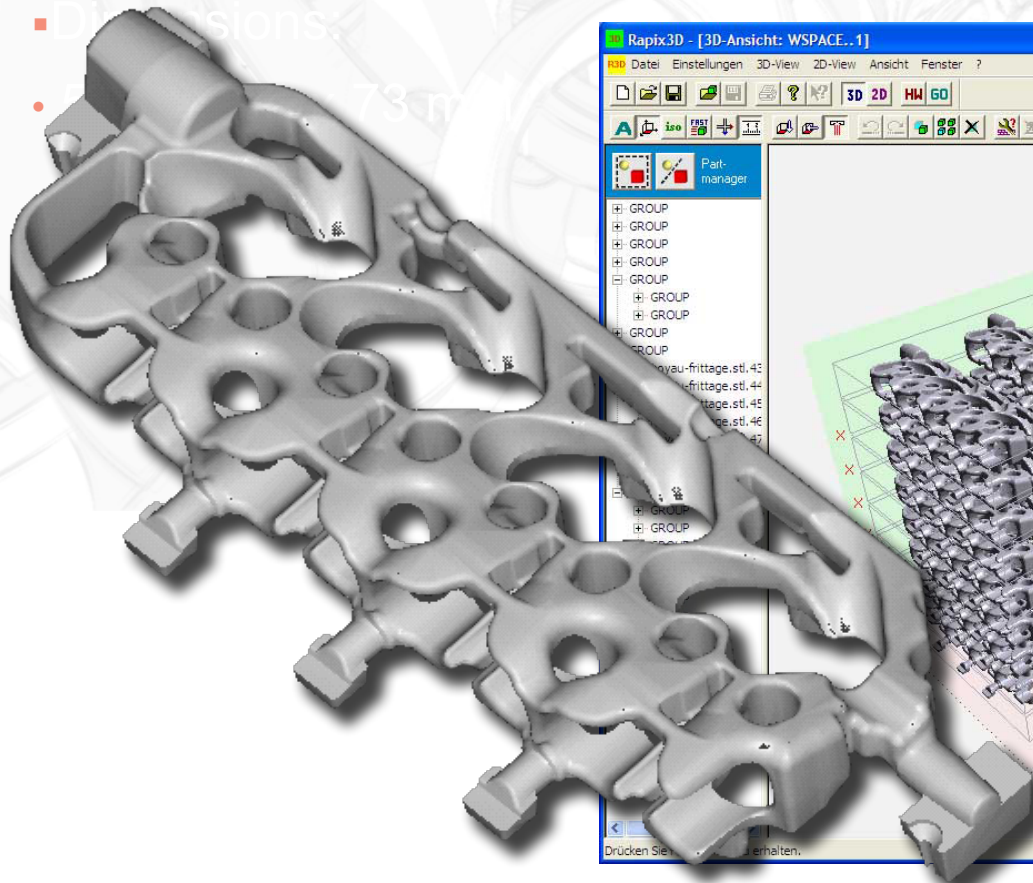
- Company
- Technology
- Products
- **Applications – Digital Core Production**



# Applications – Digital Core Production Water Jacket Core

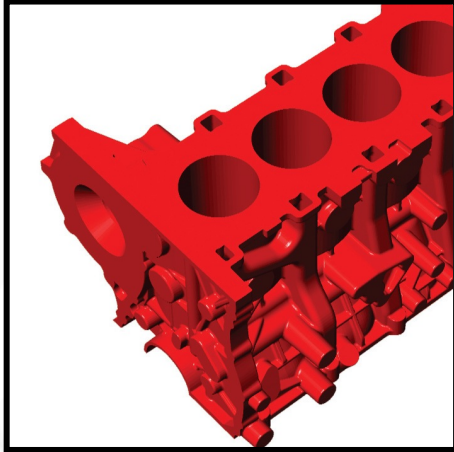
■ Dimensions:

• 73 mm

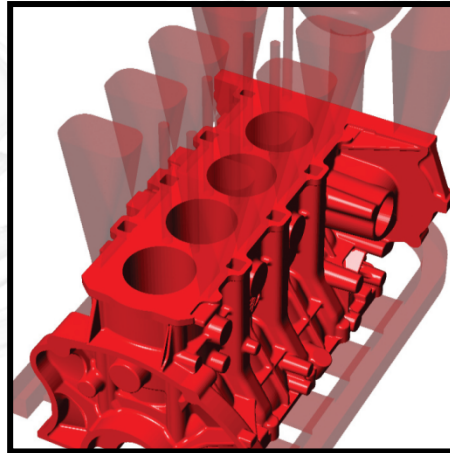




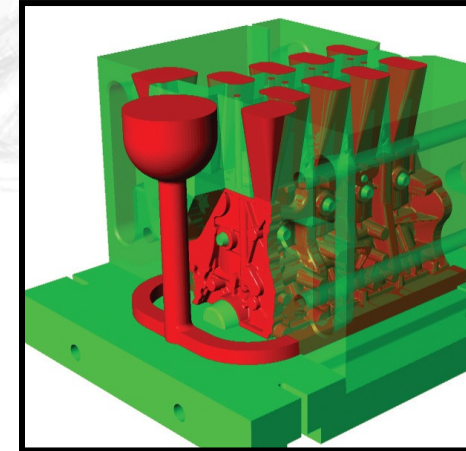
## Applications – Rapid Prototyping Rapid casting process - Example



▪ *3D CAD Model*



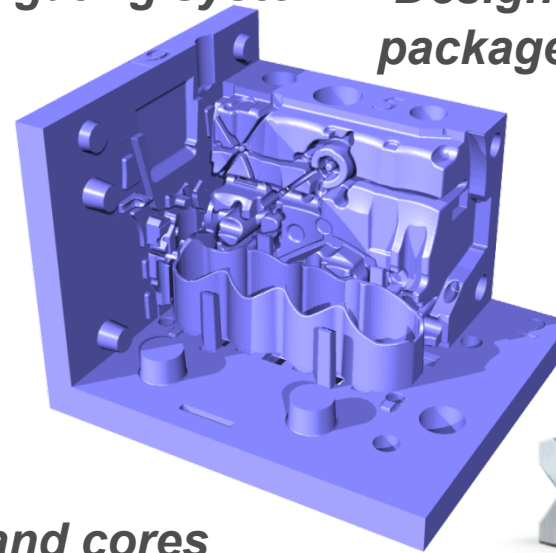
▪ *Definition of gating system*



▪ *Design molds and cores package*



▪ *Printing - finishing sand molds and cores*



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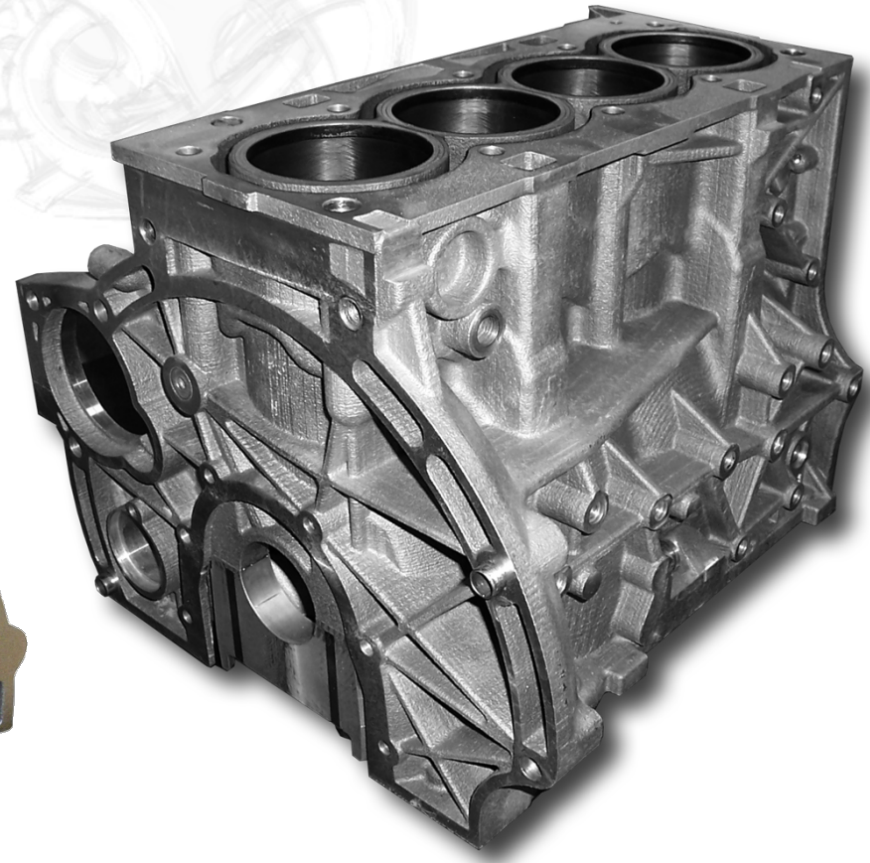
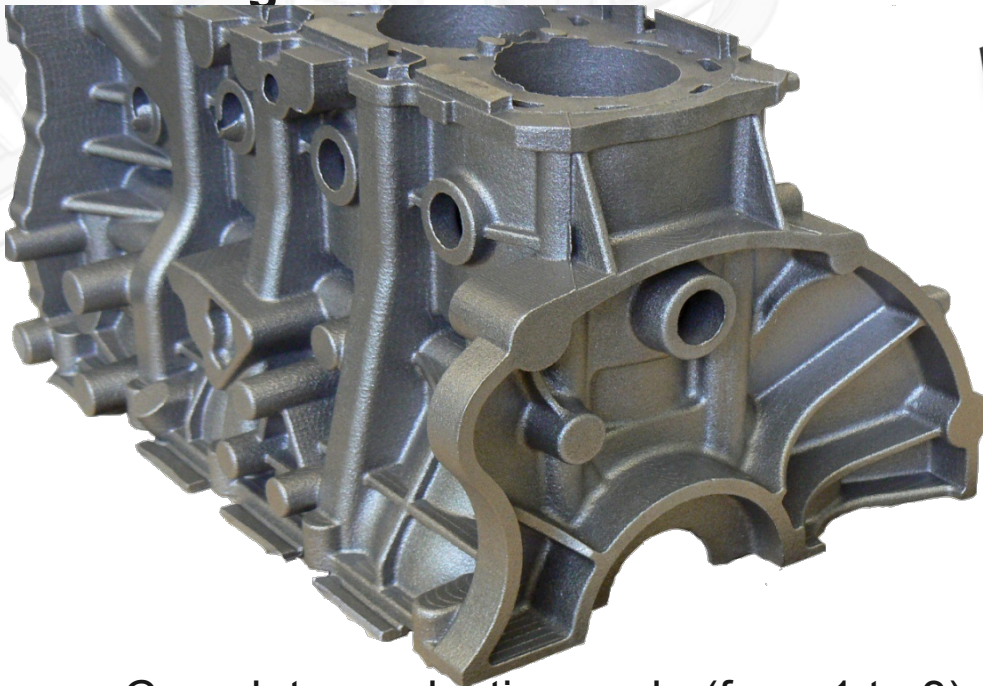


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## ■ Applications – Rapid Prototyping 4cyl. engine block - Aluminium

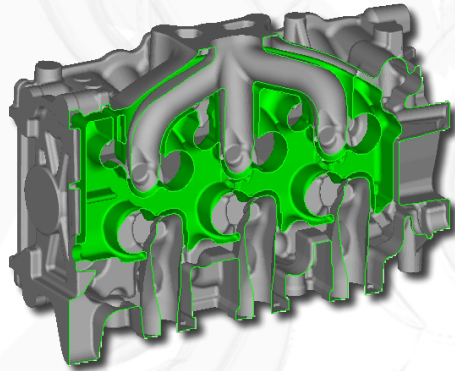
- Cast Aluminum over steel liners,
- 30 Blocks produced in 3 Months,
- All blocks passed endurance testing



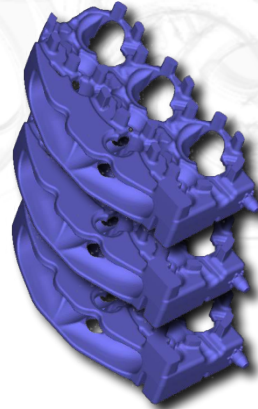
- Complete production cycle (from 1 to 3) = 5 days
- Approximate Manufacturing time for 4 Complete Sets +  
Cores = 1 Day



## Applications – Rapid Prototyping Cylinder head optimization - Aluminium



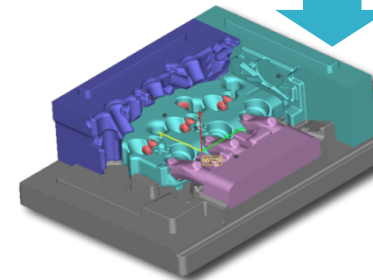
▪ *Water Core Chamber*



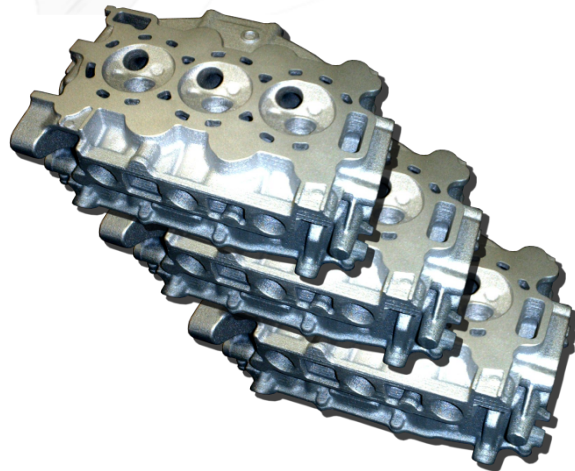
▪ *Multiple Variations*



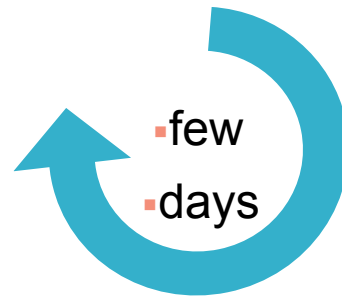
▪ *Water Jacket Core*



▪ *Standard Pattern Plates*



▪ *Functional Prototypes*



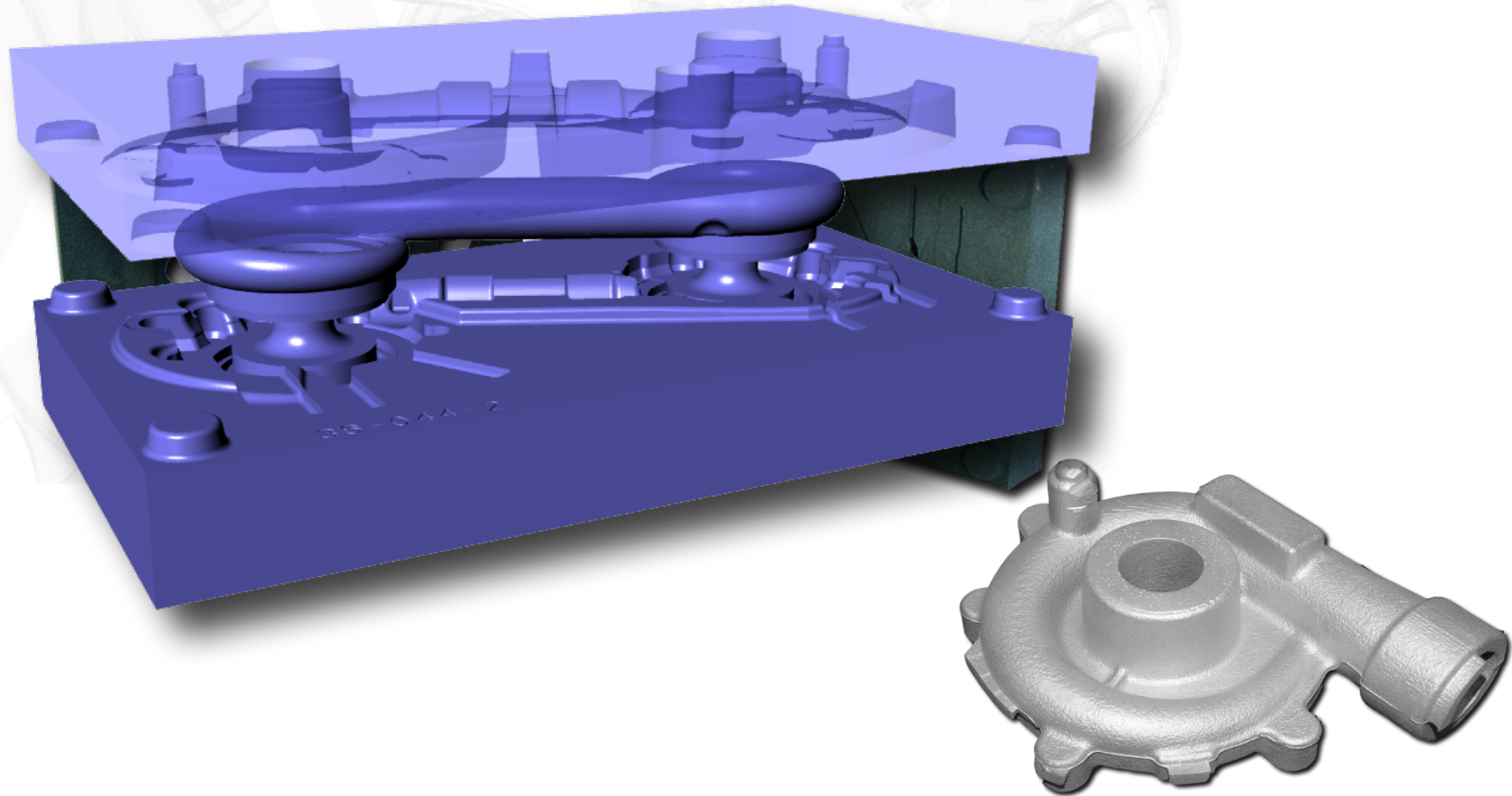
▪ few  
▪ days



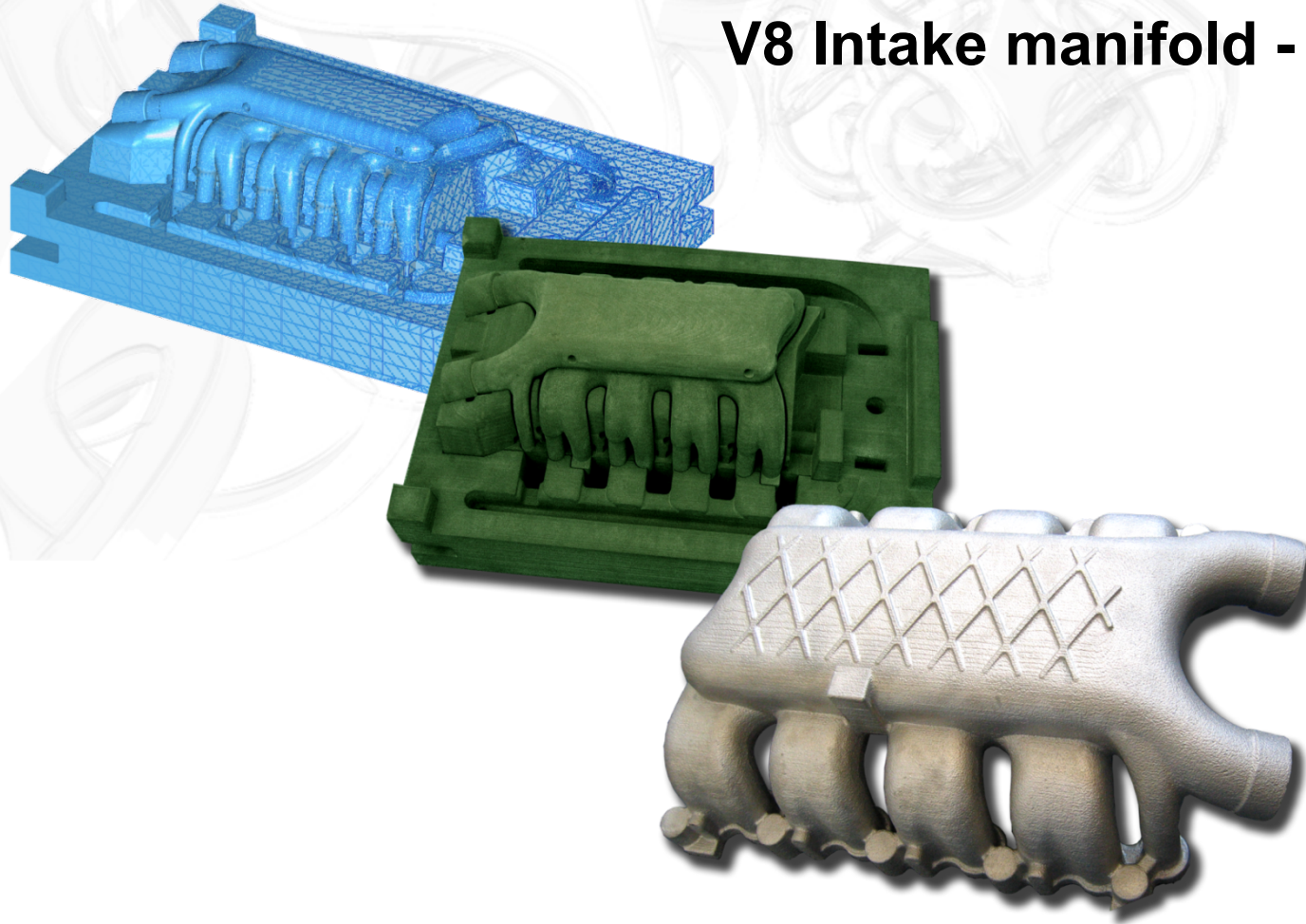
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## ■ Applications – Rapid Prototyping Turbo housing - Steel

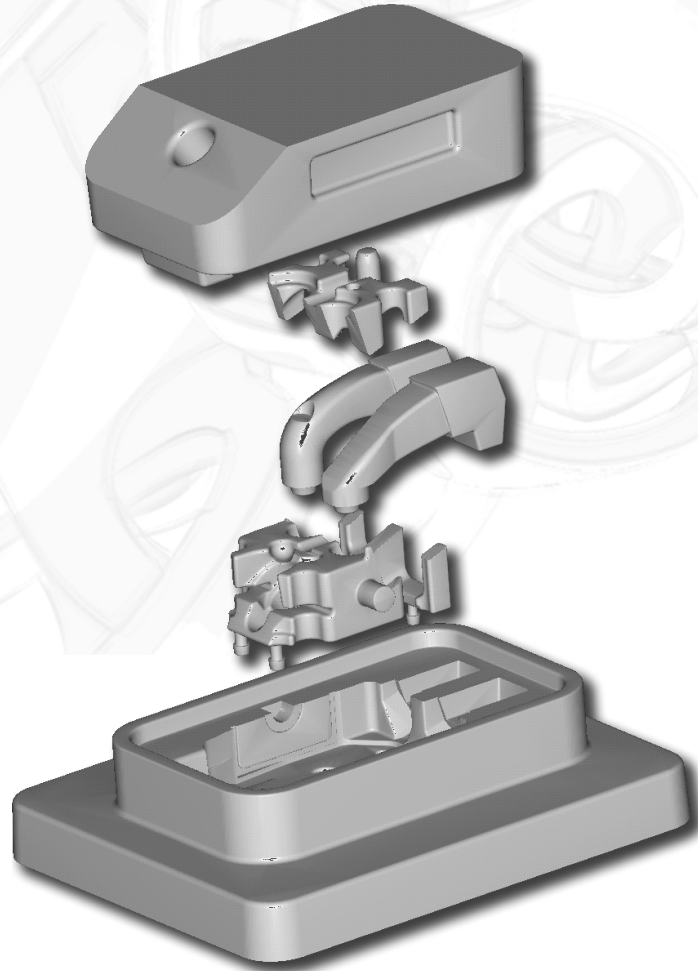


- **Applications – Rapid Prototyping  
V8 Intake manifold - Aluminium**





## ■ Cylinder head



## ■ Mold and Core Package

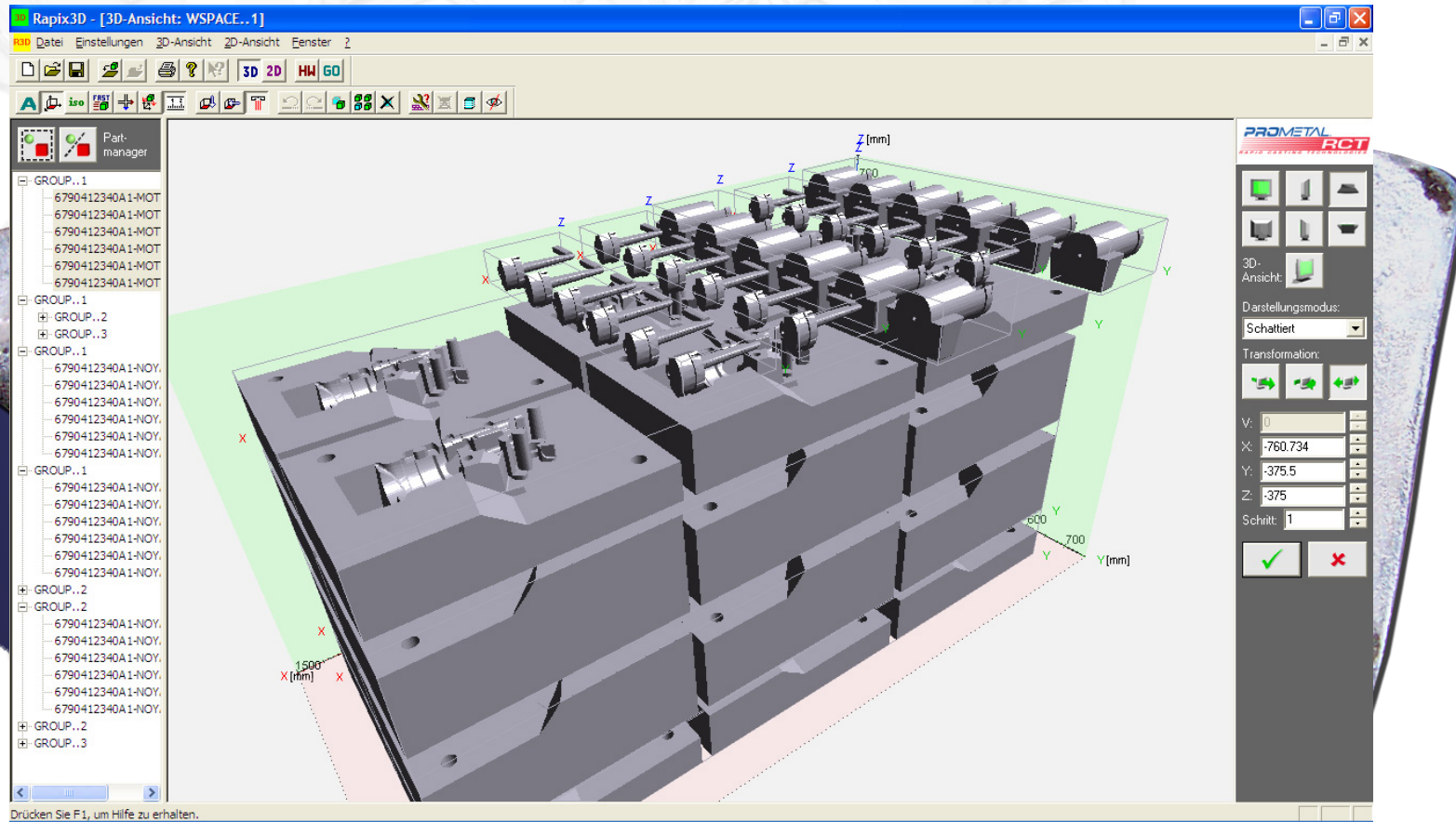


## ■ Single Cylinder heads

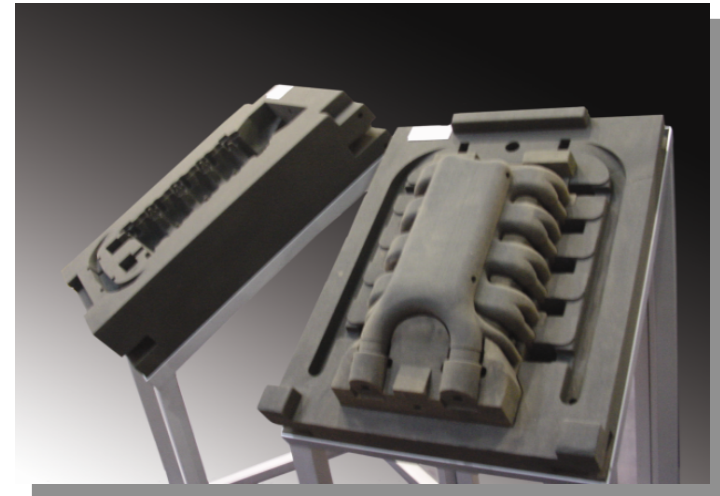
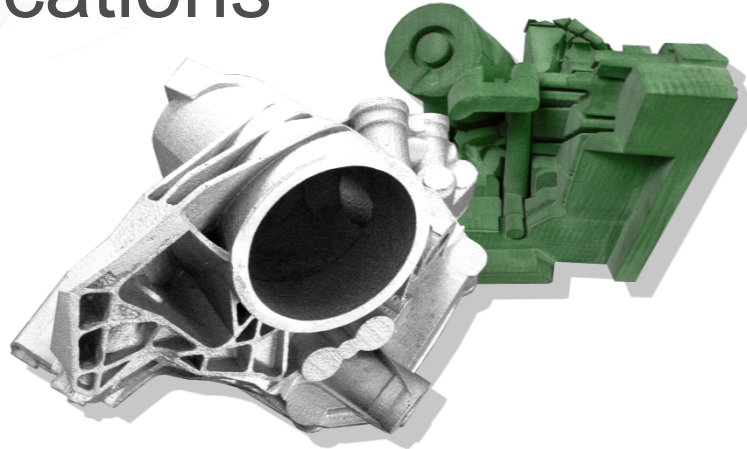
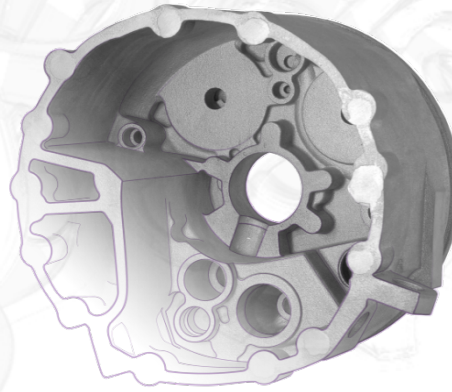


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# ■ oil filter housing

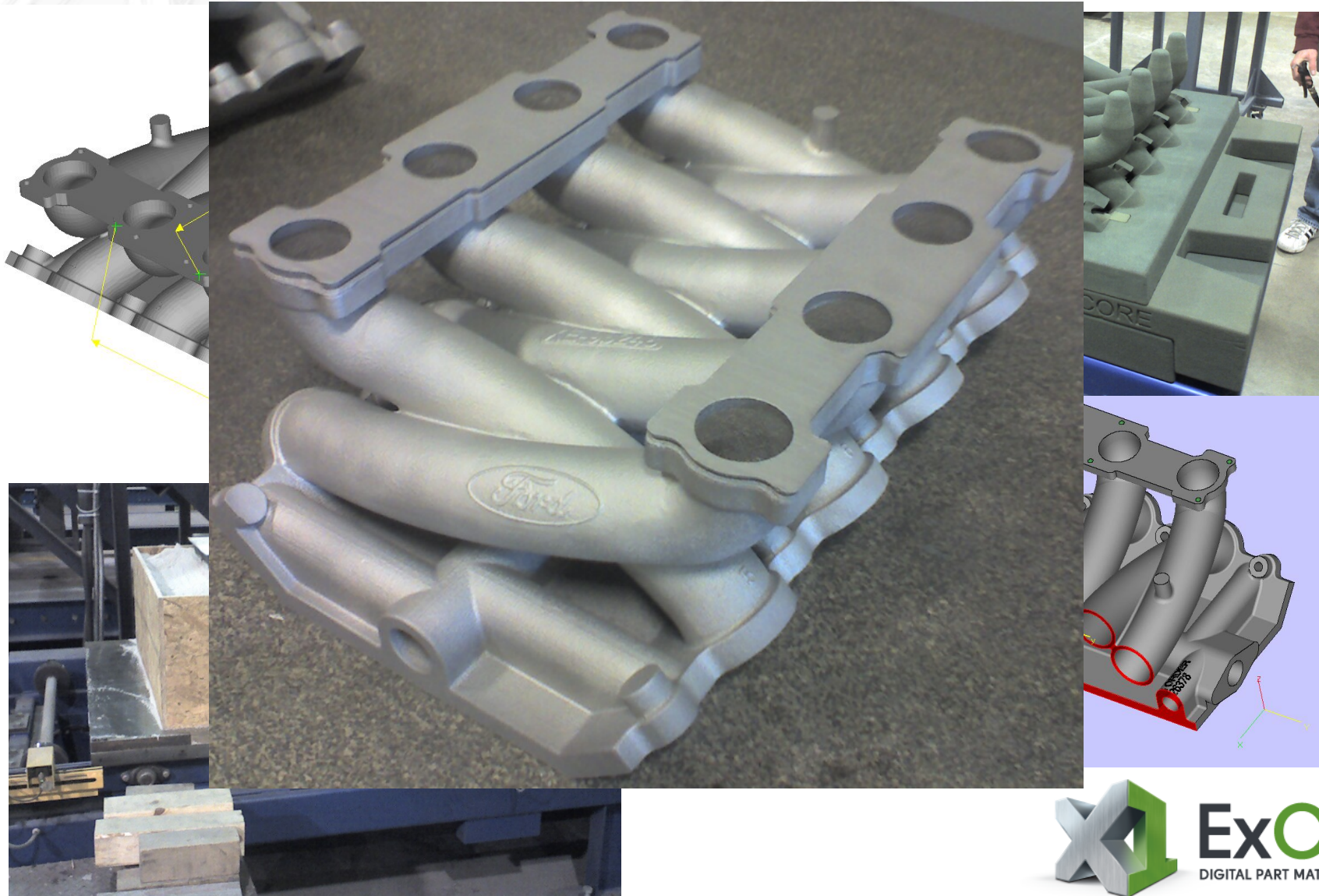


- Company
- Technology
- Products
- Applications





# Low Pressure Casting

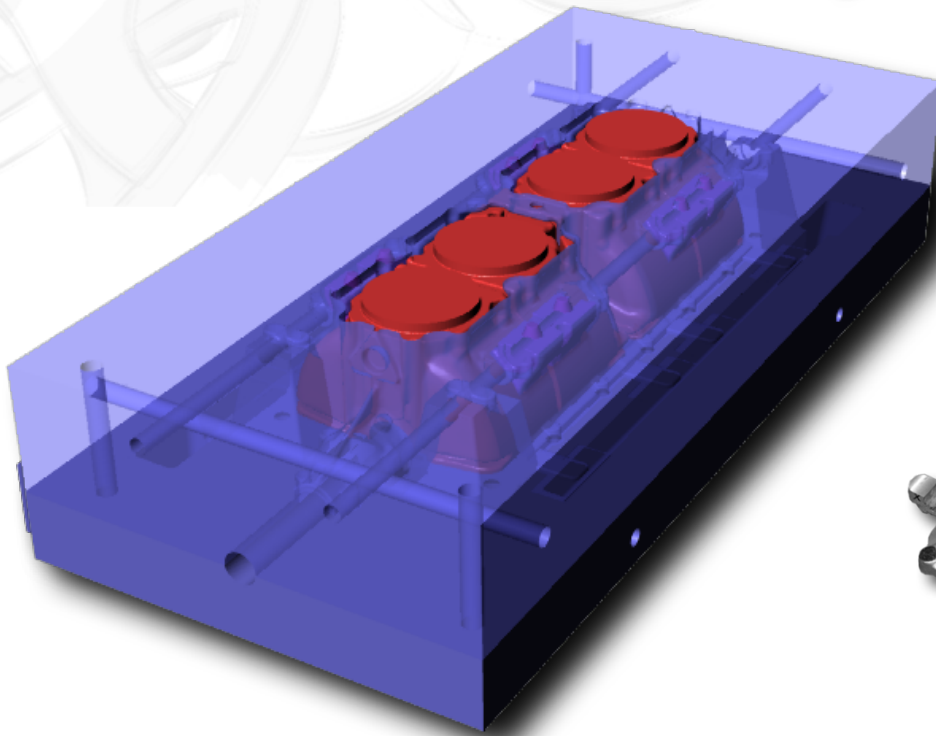
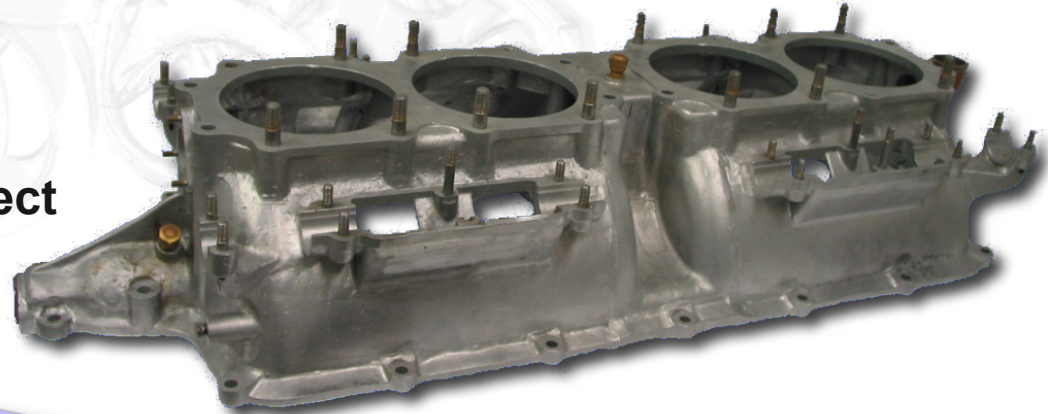


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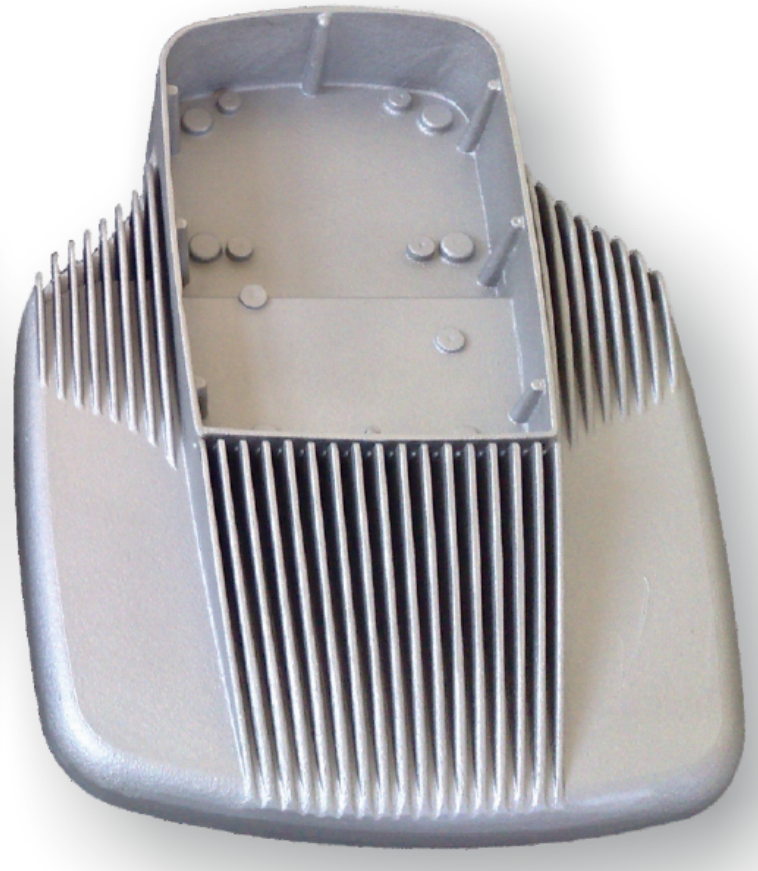
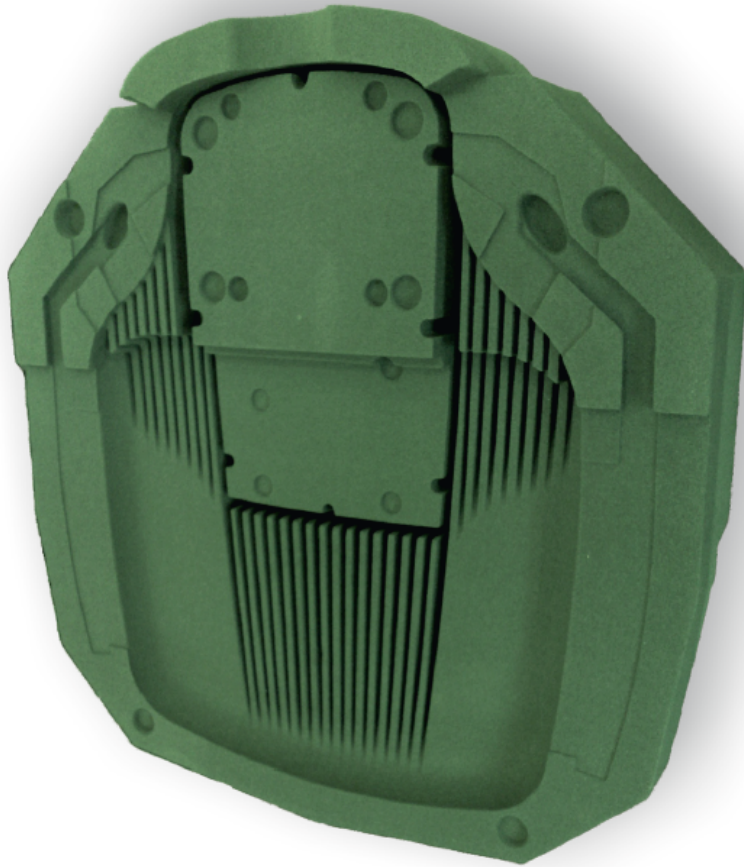


## ■ Applications – Rapid Prototyping Housing for engine – Cast-Iron

- 1904 Engine Block
  - - Approx. 10 l
  - - 6 Weeks restoration project
  - - Aluminum Casting



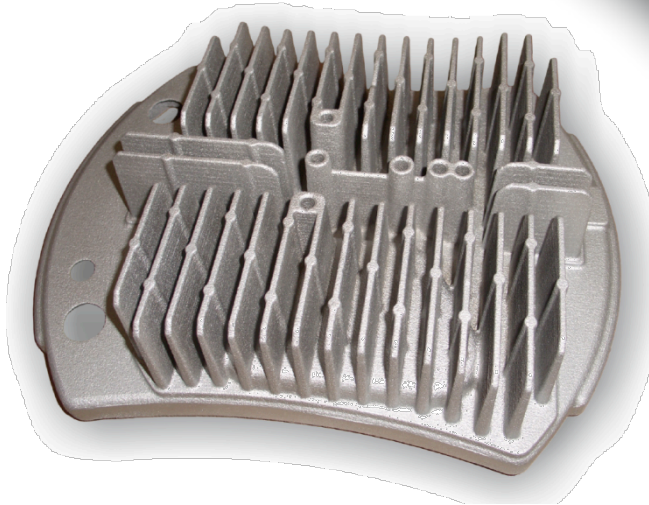
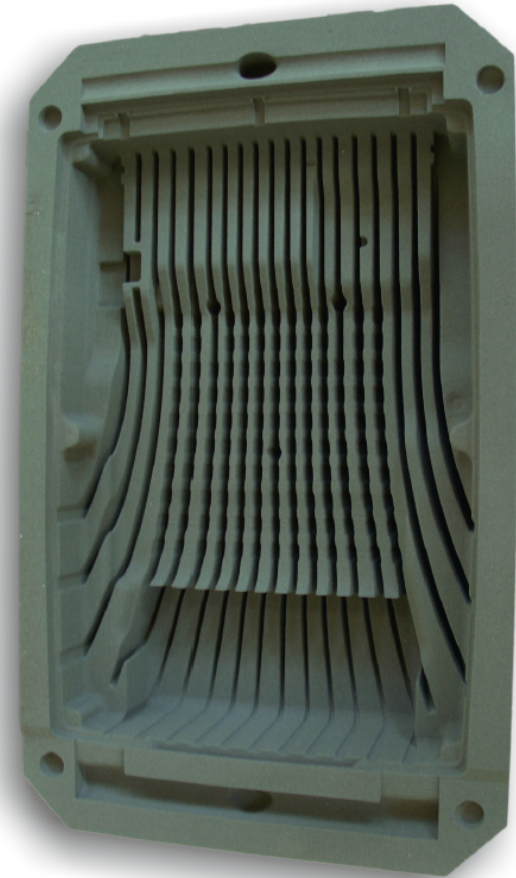
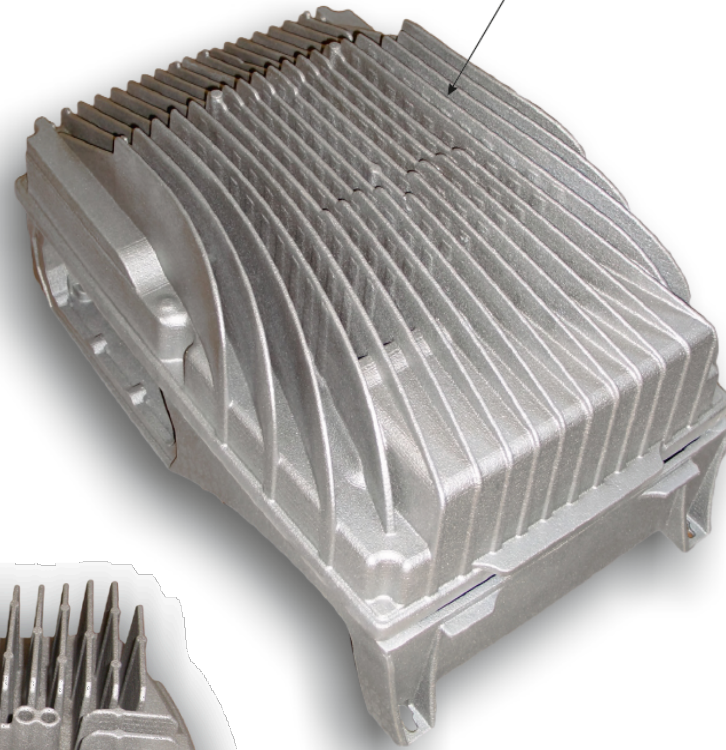
## ■ Applications – Rapid Prototyping Housing - Aluminium



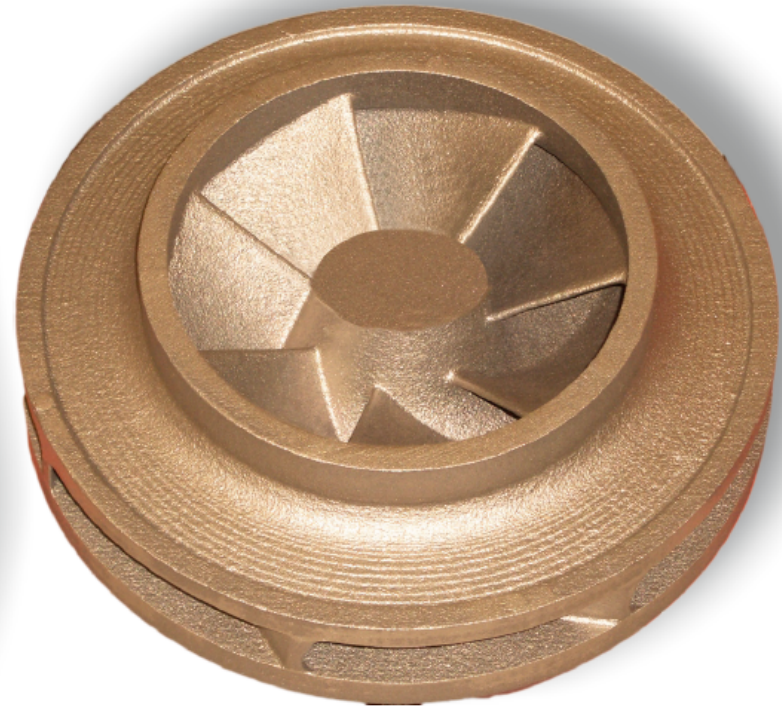


## ■ Applications – Rapid Prototyping Housing - Aluminium

■ Ribs 2.6mm wide

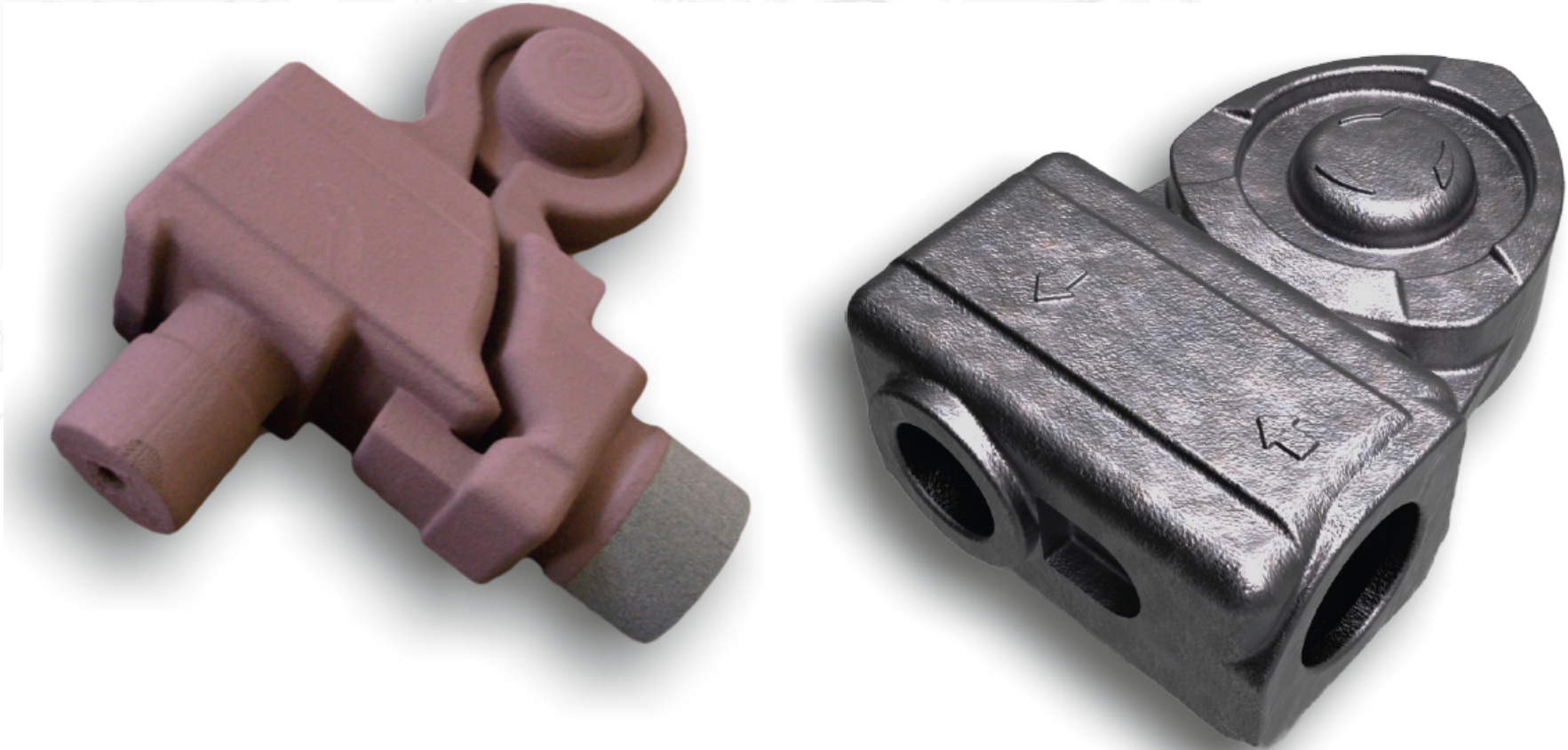


## ■ Applications – Rapid Prototyping Housing for pumps

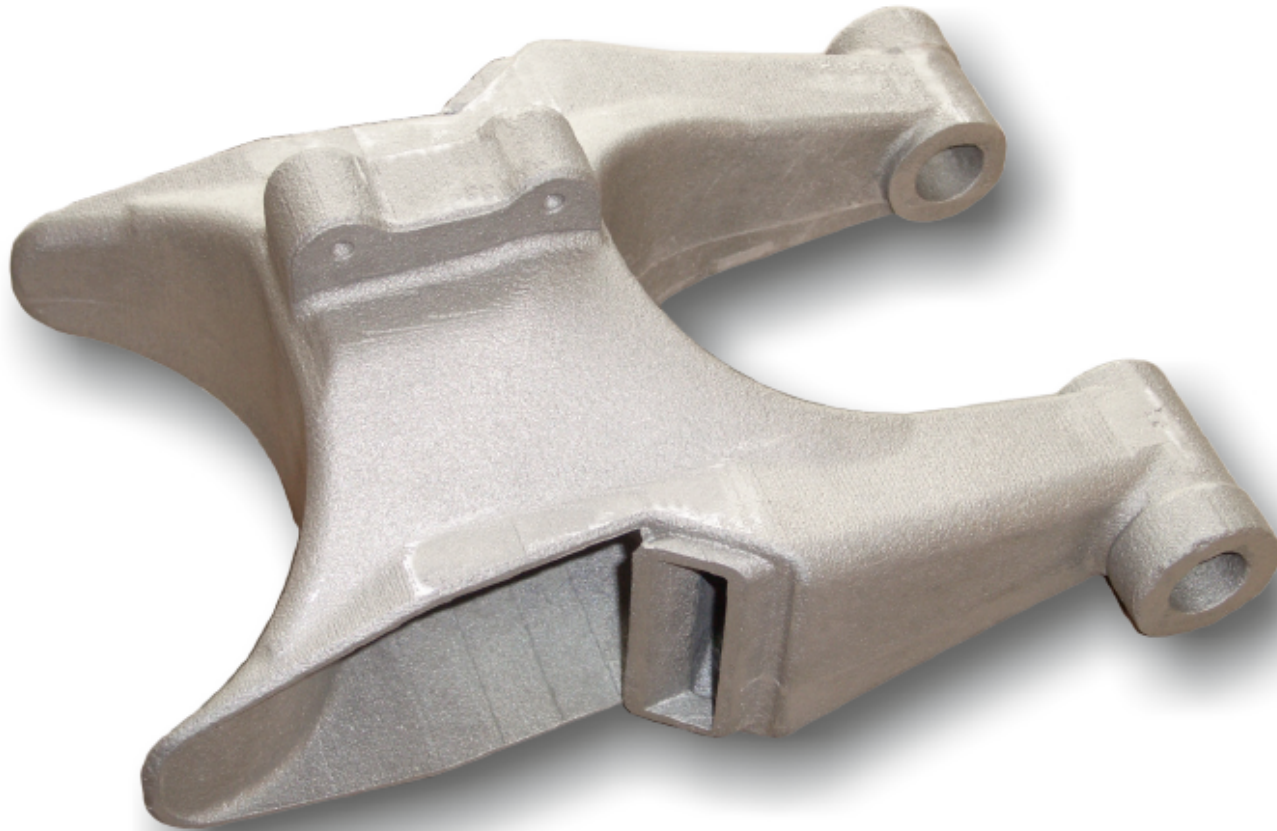




- **Applications – Rapid Prototyping  
Housing for water pump**

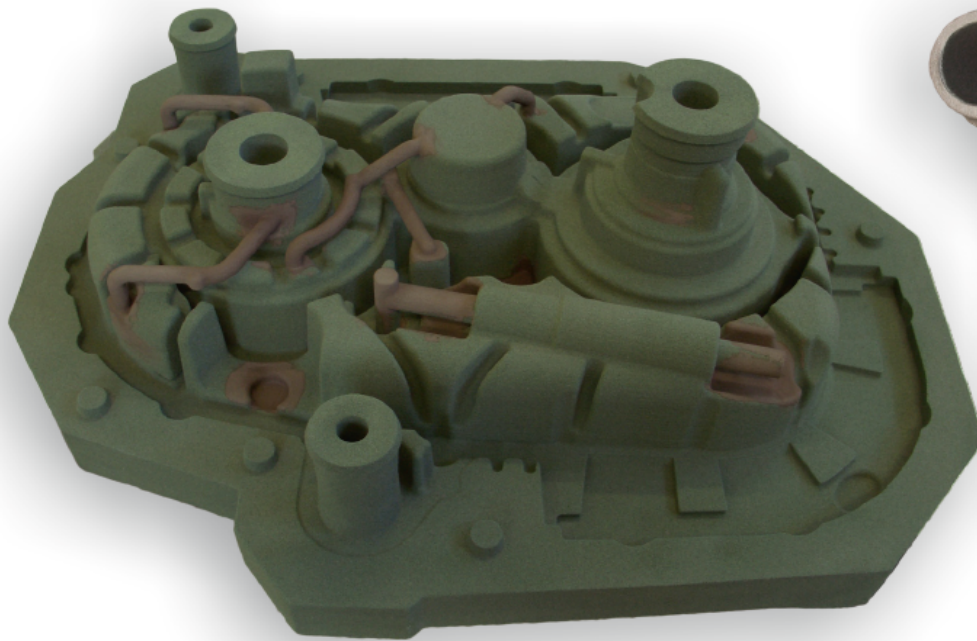


- **Applications – Rapid Prototyping  
Motorcycle swing arm (aluminium)**

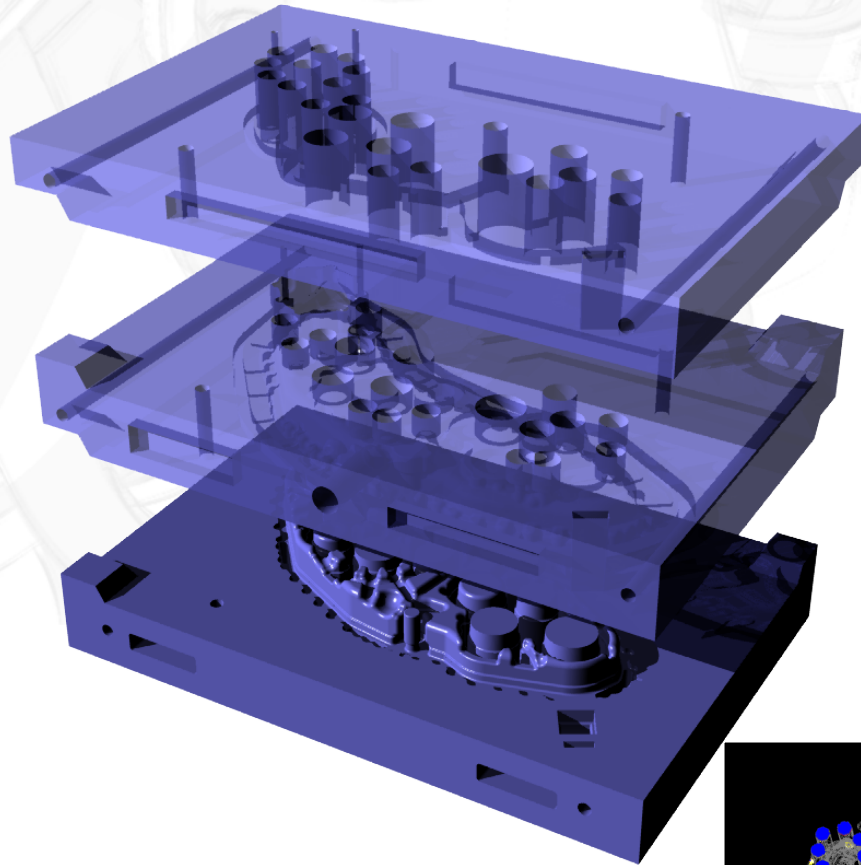




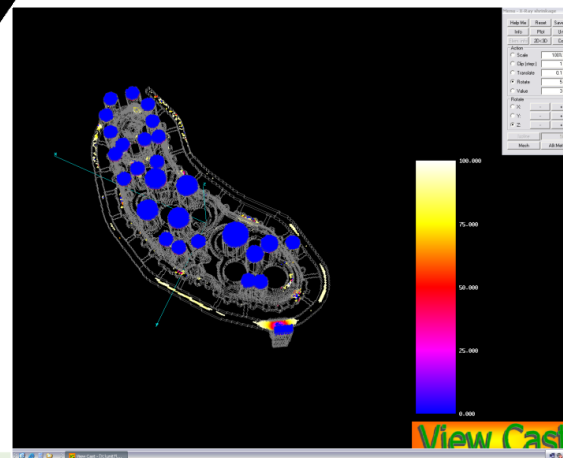
## ■ Applications – Rapid Prototyping Housing aluminium



## ▪ Applications – Rapid Prototyping Gearbox housing - Magnesium



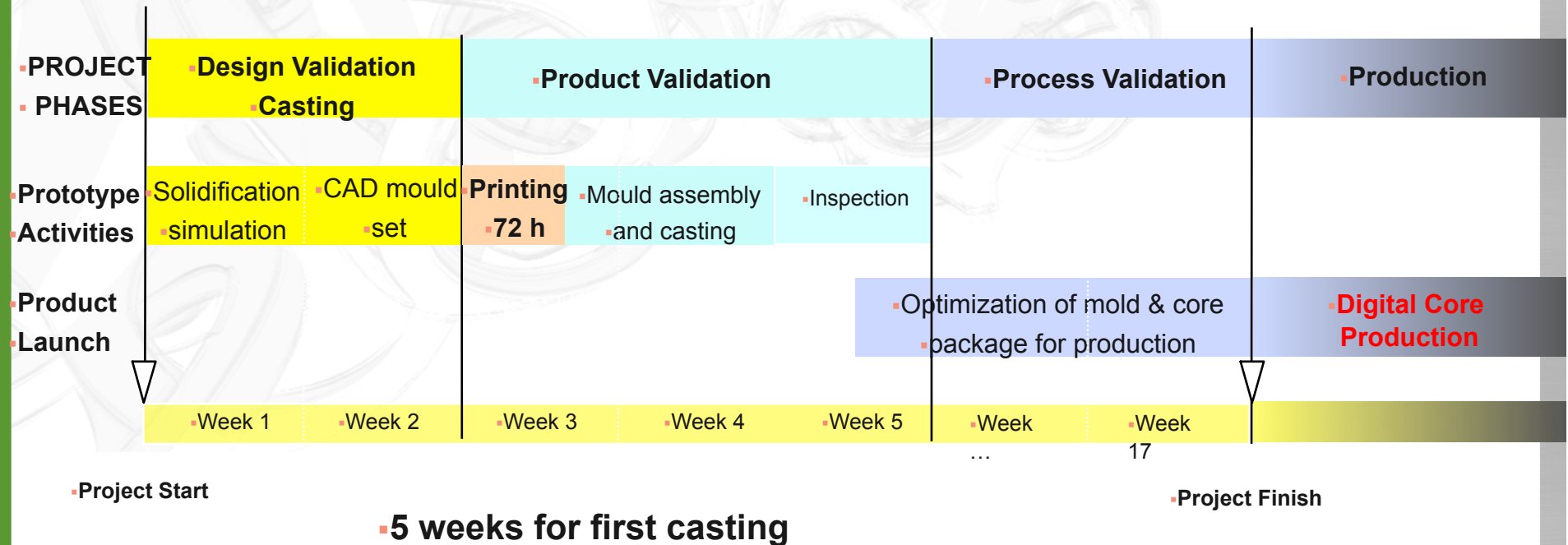
- Part is a gearbox housing
- Dimensions ~ 750 mm
- Material: AZ91 HP





# Applications – Rapid Manufacturing

## Case study of housing - Magnesium



### Project Management

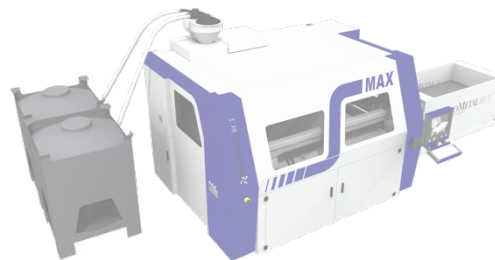
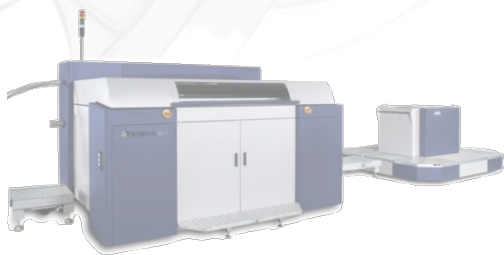
- Short lead time
- Cost saving
- Innovative product design



## ■ Rapid Manufacturing & Rapid Prototyping Some references



# Thank you for your attention



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