



Additive Manufacturing and its Potential in the Automotive Industry

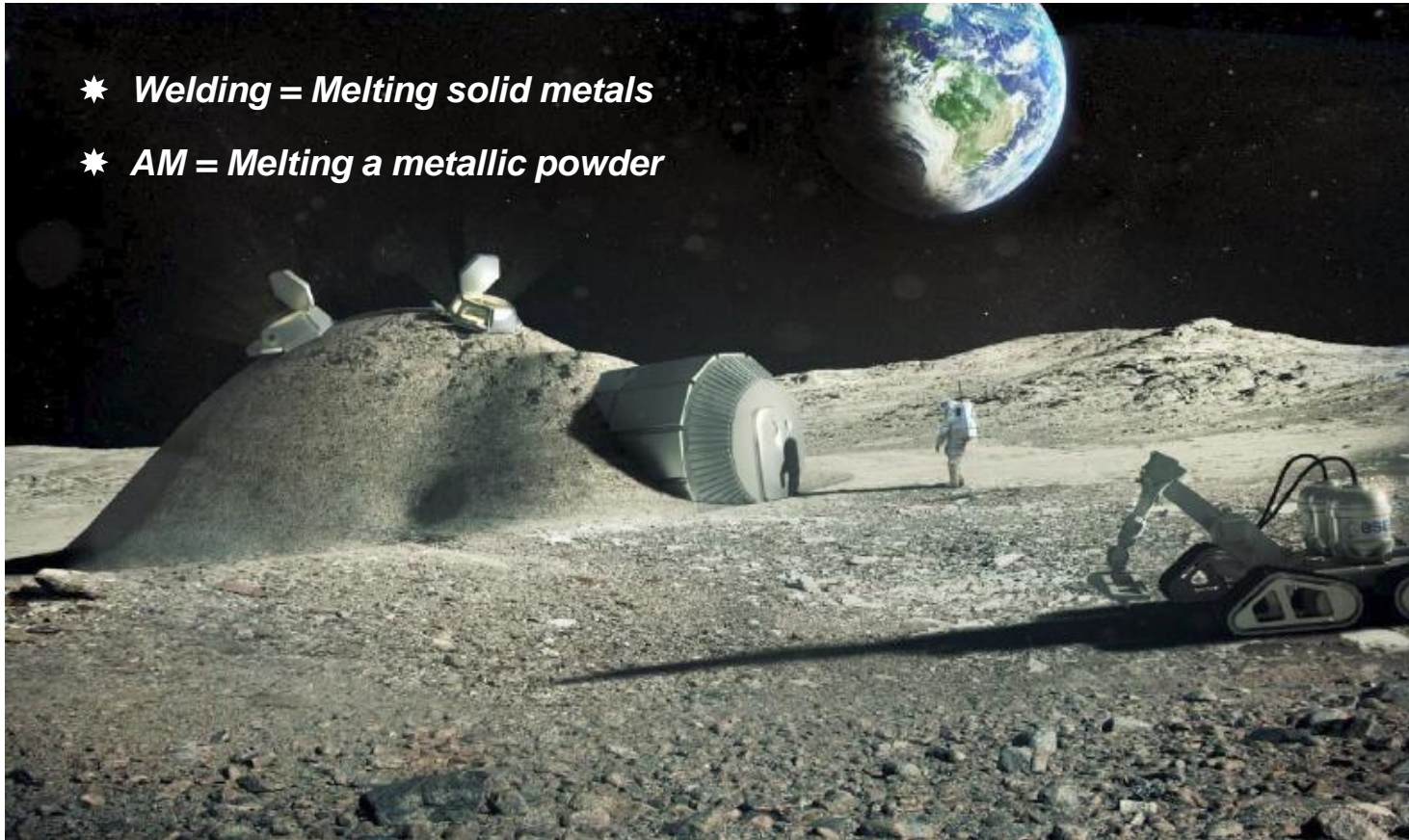
*Johnny K Larsson
Autokropolis Engineering
Research & Development*



3D-printing on the Moon

Housing Made out of Existing Regolit

- ★ *Welding = Melting solid metals*
- ★ *AM = Melting a metallic powder*

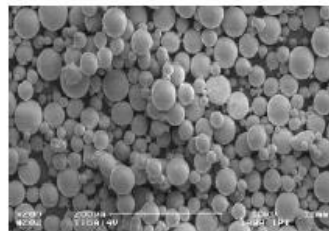
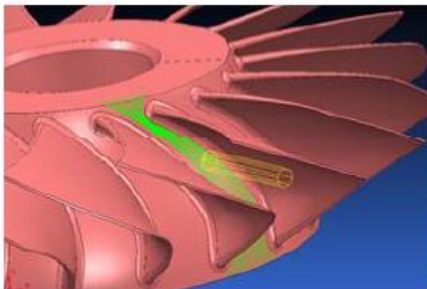


Additive Manufacturing instead of Subtractive Manufacturing

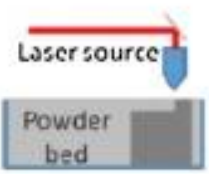
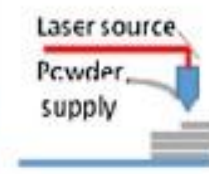



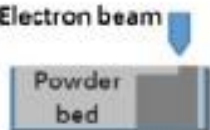
From material removal (Stone Age through today)...



...to additive manufacture (tomorrow)

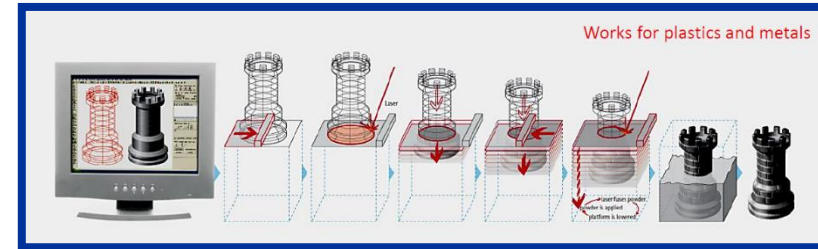


Additive Manufacturing Methods

Additive Manufacturing (AM) Processes																
Process	Laser Based AM Processes				Extrusion Thermal	Material Jetting	Material Adhesion	Electron Beam								
	Laser Melting		Laser Polymerization													
Process Schematic																
Name Material	SLS	Green	DMD	Green	SLA	Blue	FDM	Red	3DP	Green	Blue	LOM	Red	EBM	Green	
	SLM	Green	LENS	Green	SGC	Blue	Robocasting	Red	IJP	Blue	Blue	SFP	Red			
	DMLS	Green	SLC	Green	LTP	Blue			MJM	Blue	Blue					
			LPD	Green	BIS	Blue			BPM	Blue	Blue					
					HIS	Blue			Thermojet	Blue	Blue					
Bulk Material Type		Powder	Green	Liquid	Blue	Solid	Red									



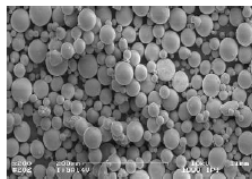
The Process of Selective Laser Melting



**All functions
in one part !**



3D-CAD model
subdivided into layers

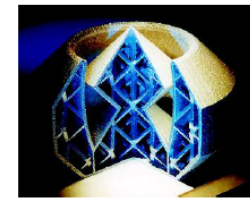
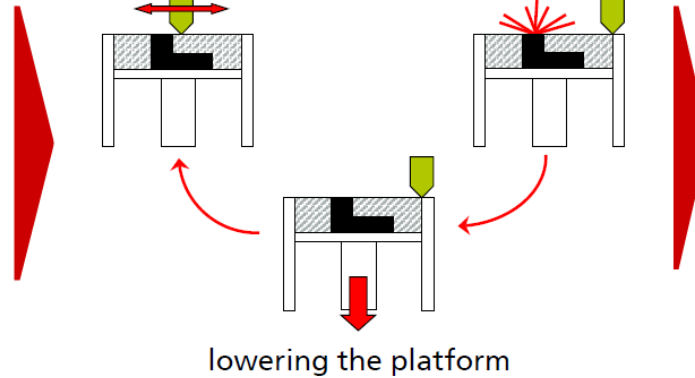


metal powder



application of
powder layer

melting of
the powder



metal part made
of serial material



The Main Components for Laser Metal Deposition



Laser source



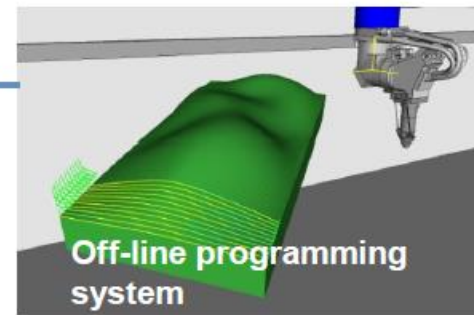
Powder feeder



Laser optic and nozzle



Motion systems



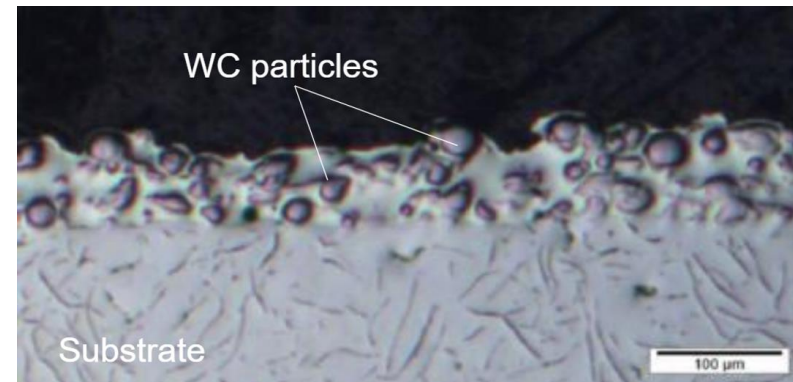
Off-line programming system



High Speed LMD [EHLA] for Brake Discs



Metal composite coated brake disc with improved corrosion- and wear resistance



Transverse section of composite material

Conventional LMD:

- ✱ Application on cast iron (lamellar graphite) with risk of crack formation due to intermetallic phases (C in Fe-matrix)

EHLA:

- ✱ Strong reduction in thermal stress will reduce the formation of brittle phases



Examples of Tool Repair



Stamping tool



Hardfacing of trim die



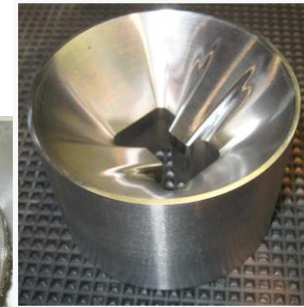
Hardfacing of forge die



Aluminium casting dies



Aluminium extrusion die



Plastic injection mould

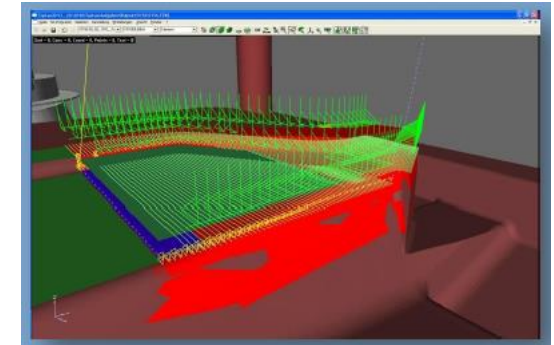


Repair and Re-conditioning of Stamping Tools

Erlas GmbH



Laser processing with the combitool ERLAS HardClad™



Offline Programming

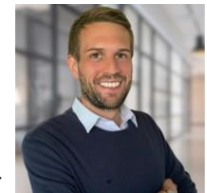


Selected Tool Segments for Hot Forming

Audi Metal 3D Printing Centre, Ingolstadt



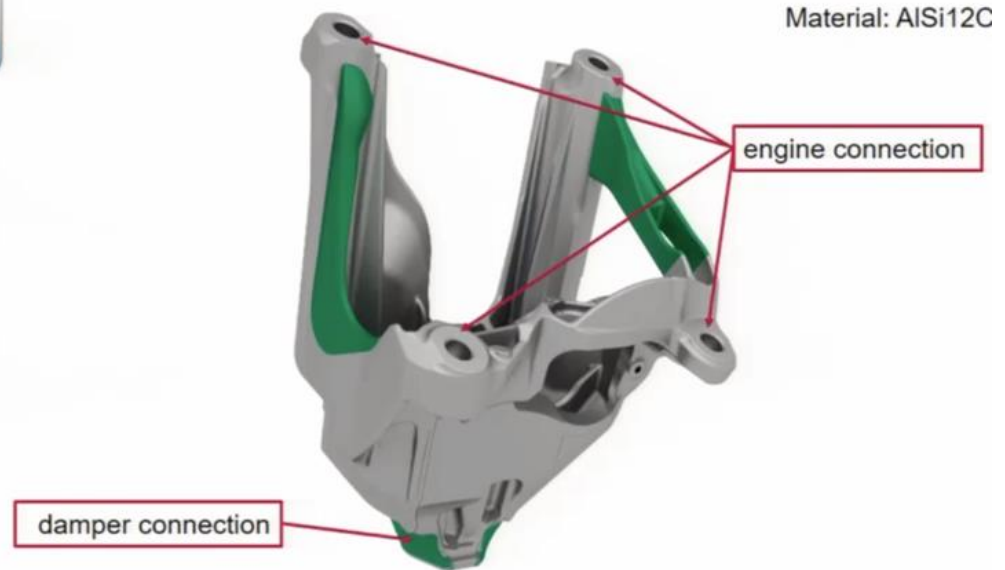
- * Each tool consists of 12 segments
- * Length 400 mm, Weight 120 kgs
- * ~20 days manufacturing time on an EOS M400 system



* Matthias Herker, Technical Project Leader



Hybrid Manufacturing Modified Engine Mount [LMD + Die Casting]

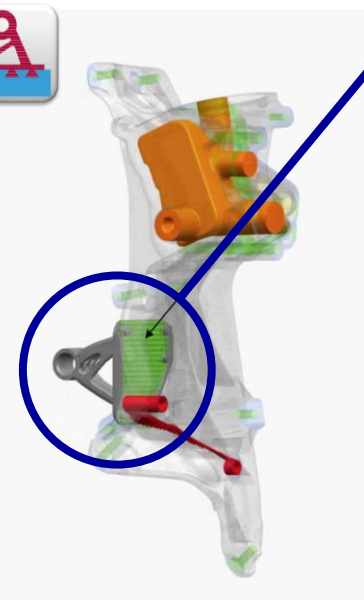
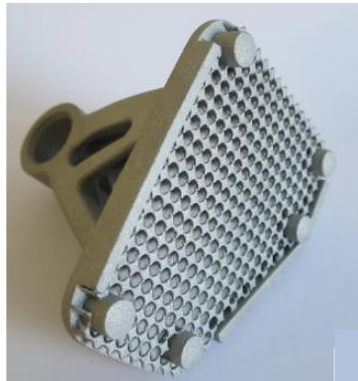


Courtesy of EDAG AG

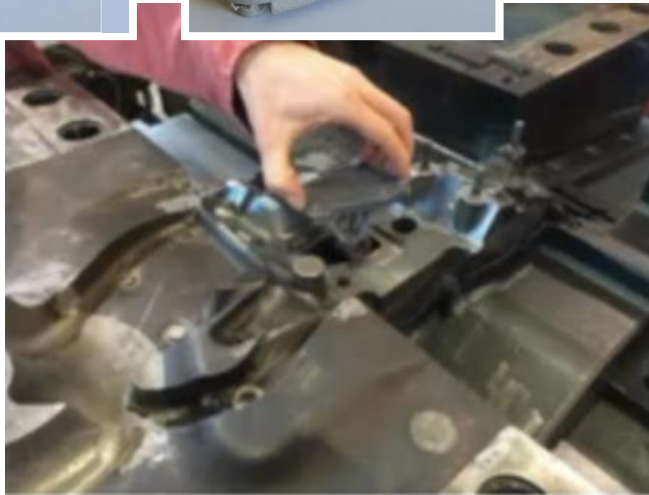
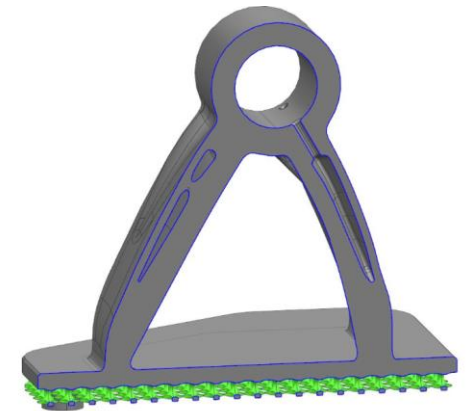


Hybrid Manufacturing

Steering Pump Bracket [SLM + Die Casting]



- * Variants on demand
- * Lightweight design
- * Material: AlSi10Mg



Courtesy of EDAG AG





Prototyping and Simplified Jigs

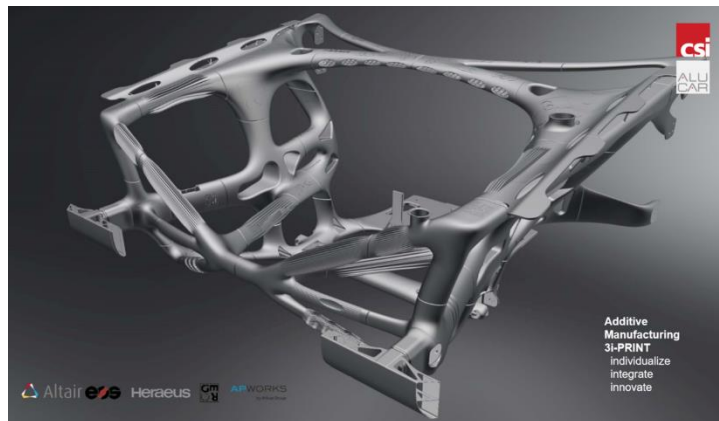
Ford Motor Company



Ford Mustang Aluminium Front Structure



Guiding Jig for the Final Assembly Shop



Prototyping and Simplified Jigs

Ford Motor Company & BigRep



Cost-effective Welding Jigs



Cost-Effective Rapid Prototyping



Long Lasting Assembly Jigs



Additively Manufactured Spare Parts for Vintage Cars

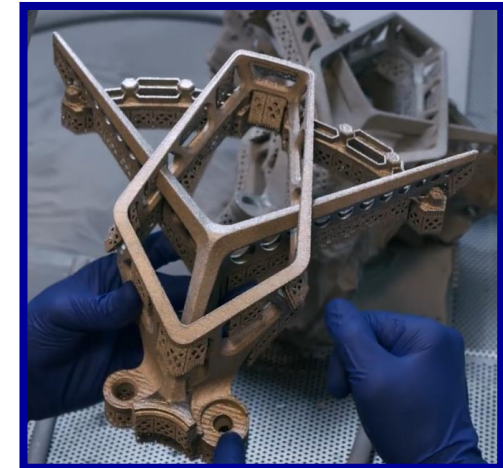


Ford GT Titanium Wheel

HRE3+ High Performance Wheels & GE Additive



- ★ Manufactured in the EBM process
- ★ Trapezoid section design increases strength
- ★ Consists of 5 individual sections
- ★ Subtractive CNC machining would have meant 80% material waste



Mechanism Brackets for Foldable Roof

BMW i8 Roadster



World's first automotive volume produced SLM-part



- ★ PA6 GF30 substituted by AlSi10Mg
- ★ 10 times stiffness increase
- ★ Unit weight 11 g; 44% weight reduction
- ★ 30% cost reduction
- ★ Possible to manufacture > 200 parts on the same building platform
- ★ 82 hours production time for 628 parts by using four 700 W lasers simultaneously



New Eight-piston Monoblock Break Caliper Bugatti



- ★ Bugatti
Bionic Production AG
Fraunhofer IAPT
- ★ Designed by Bugatti & printed at Fraunhofer IAPT
- ★ Manufactured on a SLM500HL machine with four
400 W lasers
2,213 layers in roughly 45 hours printing time
- ★ Largest 3D-printed functional titanium part
410×210×136 mm
- ★ Material Ti-6Al-4V
- ★ Net weight 2.9 kg (40% weight savings)



3D-printed Thin-wall Titanium Components for Weight Saving

Bugatti Bolide

Product data

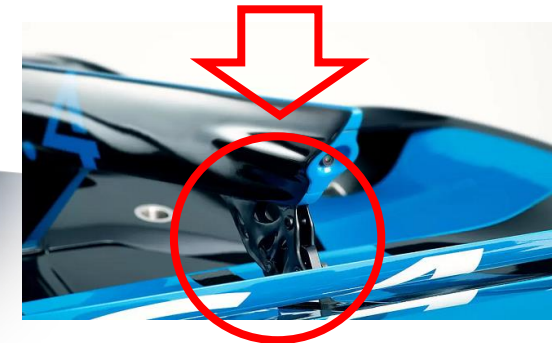
- * Weight 1,240 kg
- * Weight-to-power ratio 0,67 kg/bhp
- * Top speed >500 km/h



Air vents

Mounting brackets;

- * Front wing [Down force 800 kgs]
Weight: 600 grams each
- * Rear wing [Down force 1,800 kgs]
Weight: 325 grams each



Spring damper pushrod elements, with variable wall thickness

- * Weight: 100 grams each

Steering column, mounting bracket

Steering column, support collar

Radial turbo fan compressor, with reinforcement fins (t=0.48 mm)

- * Weight: 100 grams each

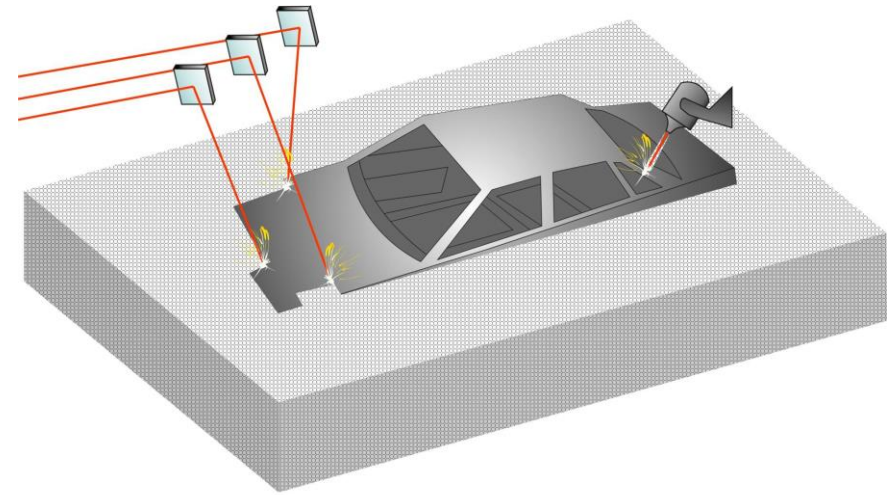
Tailpipe trim covers,

3D-printed hybrid in titanium/ceramics

- * Length: 280 mm
- * Wall thickness: 0.5 mm
- * Weight 750 grams each



Our Visionor a Reality already Today?

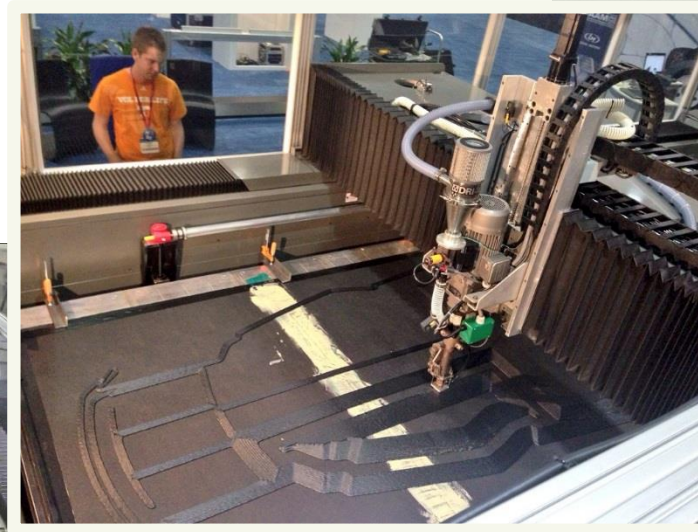


“EDAG Light Cocoon” Concept Lightweight Sports Car Utilizing a “Bionic Design”



Your Car Built for You – While You Wait

Local Motors, Phoenix, AZ



Additive Manufacturing in the Automotive industry

State-of-the-Art

Prototyping



3D-Printing is used for more than 20 years in automotive prototyping

- Early stage of development
- Designs/concepts
- Showcars

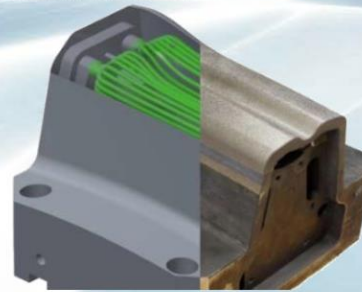


Tooling



3D-Printing is used in several areas in industrial environments

- Tools (casting, hot stamping)
- Jigs/Fixtures
- Mounting aids
- Installation



Manufacturing



3D-Printing is actually only used for special cars and low volumes

- Bionic design
- Customization
- Lightweight structures



Thank You for Your Attention !!

