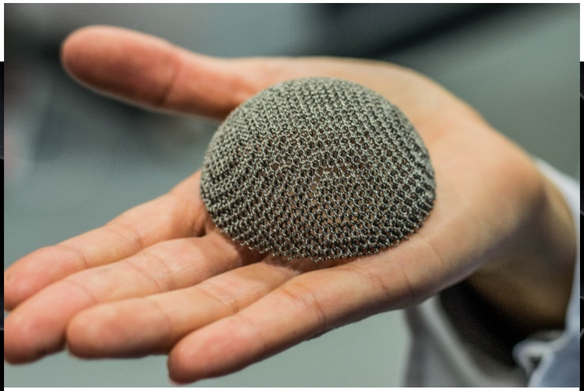
Manufacturing Market Challenges



CHALLENGE

COMPLEX GEOMETRIES & FUNCTIONAL INTEGRATION

Today's components have to perform increasingly complex functions requiring close integration of new materials, mechanical and electronic capabilities

Barrier: Designing integrated systems requires new manufacturing technologies beyond today's conventional possibilities

CHALLENGE

LOW QTY + HIGHLY DIFFERENTIATED MFG

Today's manufacturing needs rely on variable short term production planning with high customization requirements

Barrier: Mass manufacturing methods have shortfalls in efficiency in order to deliver on these new manufacturing requirements

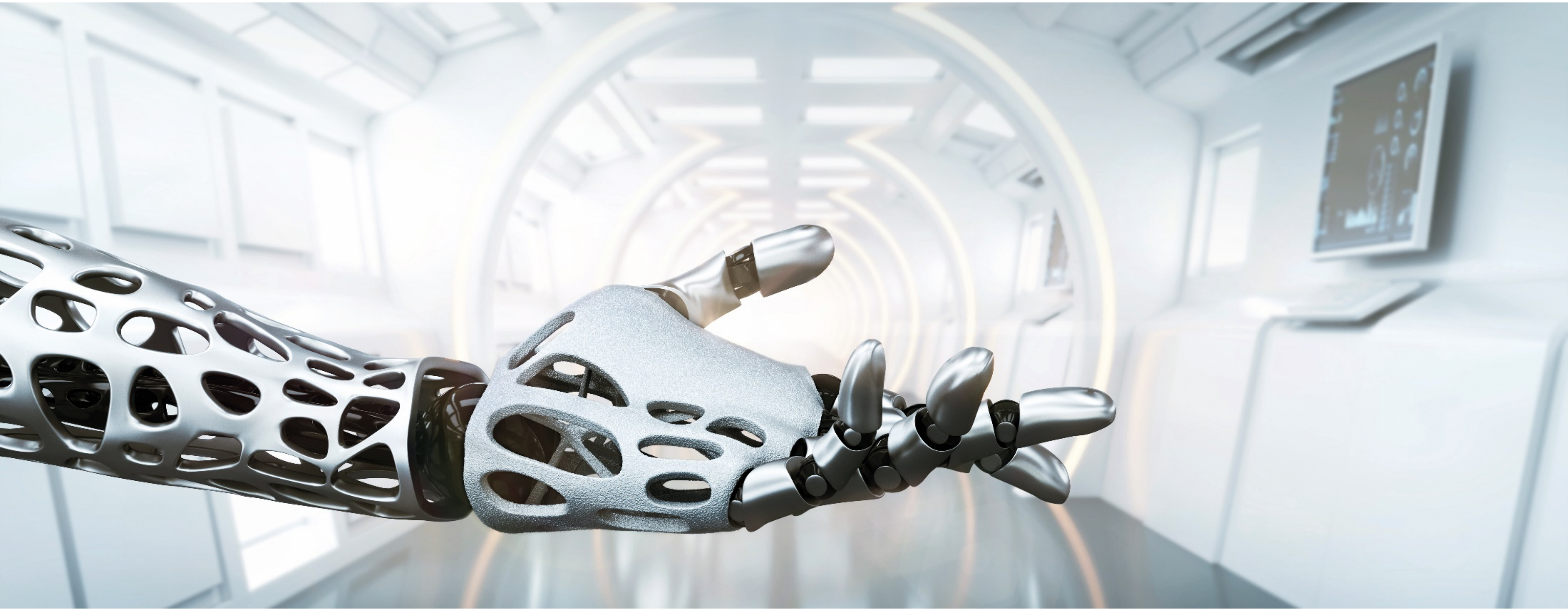
CHALLENGE

LEAN PRODUCTION

Optimization of weight and performance in a cost competitive framework. Weight optimized designs with balanced stress distributions increase energy efficiency and performance

Barrier: Ensuring maximum performance with minimal material is mostly limited by design tool capabilities and manufacturing process constraints

Additive manufacturing technologies – an integral part of the Industry 4.0



Enhanced geometric freedom	Fully optimized performance	Shorter innovation cycles	Customization made easy	Shorter supply chain	Driving new business models

AM Technology is rapidly maturing

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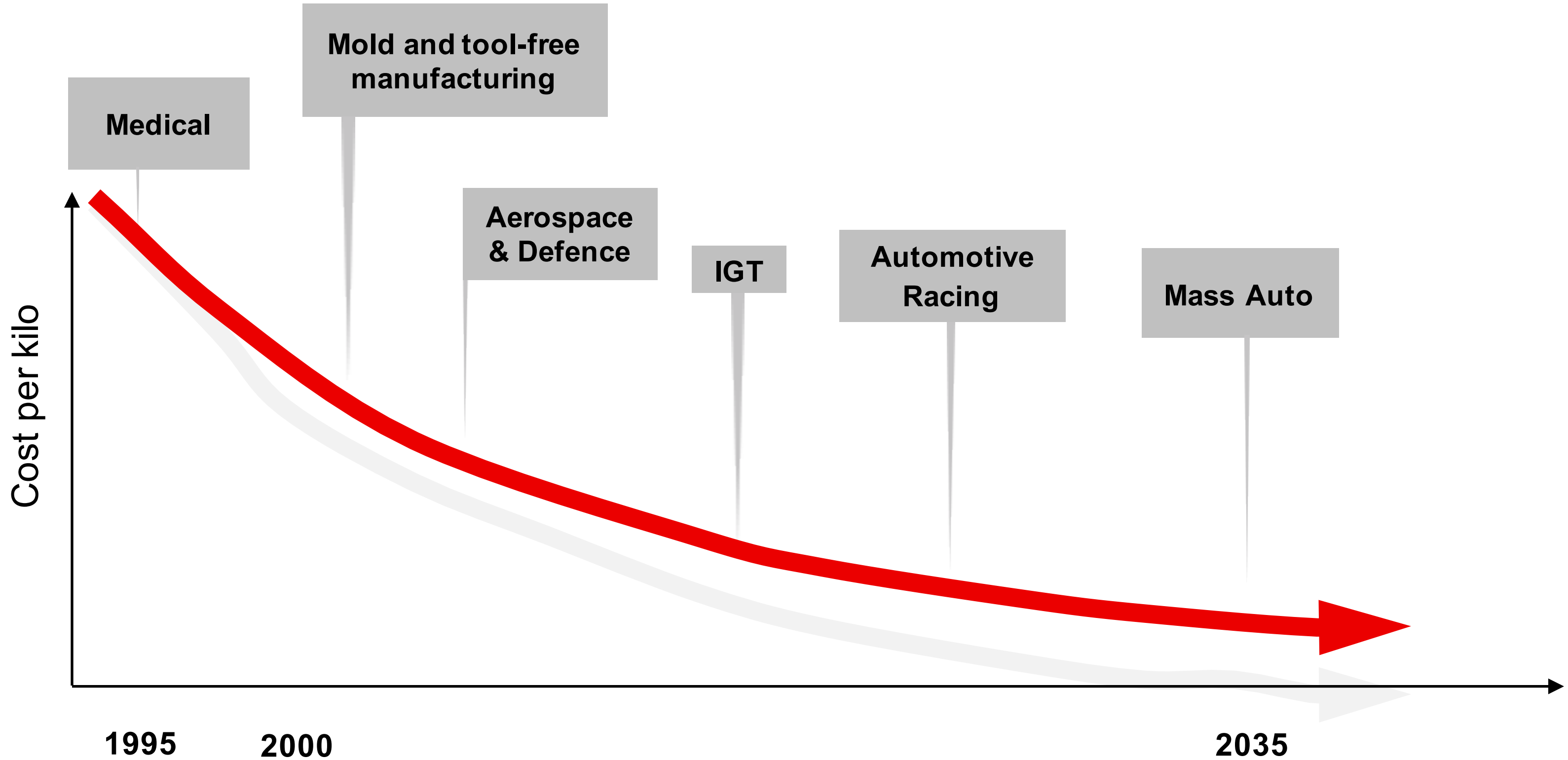
When does AM become a mainstream manufacturing technology?



Cost Reduction Drivers

Mid-term drivers:

- Machine cost down 30%
- Increased build factor of 10
- Part cost down 90%

Long-term drivers:

- Powder cost down 30%
- Machine cost down 30%
- Increased build factor of 30
- Process automation
- Part cost down 98%

AM is helping to drive weight and efficiency optimization and reduce cost

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Advantages of AM

Faster time to market — AM provides a fast track from concept to production, where complex objects can be manufactured in a single process step.

Optimized design and high complexity — AM allows highly complex designs in new geometries and materials to be developed.

Shorter innovation cycles – Innovations are designed, developed and tested more rapidly, eliminating the need for expensive and time-consuming part tooling and prototype fabrication.

Performance enhancement — AM manufactured parts can be designed with new properties, features or materials to improve performance.

Elimination of production steps — AM lowers cost of manufacturing by reducing outlay on high-value materials and shortens lead time.

Perfect for mass customization — AM's flexibility and customization at low unit costs make AM optimal for small production batches and mass customization of components and parts.

Less waste — AM allows for the efficient use of materials where material needs and costs can be reduced by up to 90%. No more scrap needs to be disposed of, and it requires fewer tools, molds and fixtures, saving resources.

Shorter supply chain — AM makes it possible for production to be done near the final destination, which leads to savings through reduced sub-suppliers, transportation and warehousing.

New business models — Parts or entire products can be built on demand that has enormous implications on how manufacturers design, build, and sell their goods.

Tasks to be solved

AM have a great potential, in order to accelerate the introduction of additive production processes, it is necessary to reduce the impact of the following factors:

Size restriction: the size of the parts produced depends on the size of the camera of the machine

Print speed: long time printing process

Software: most existing CAD programs are designed for traditional production methods - it is necessary to create a new complex software

Materials: expand the range of materials for AM and optimize their properties

Standardization: the development of international standards and their unification, enabling AM to move forward

Skills: too few experienced specialists and trainings on additive production techniques

Automation: the lack of automation of the AM

The solution of the set tasks for Additive Manufacturing is the main condition of Industry 4.0

Oerlikon Group Global Industrial Leader

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Oerlikon Group (FY 2016)	Surface Solutions Segment			Industries

Sales: CHF 2,331m

> 13 700 employees

4% sales invested in R&D

Surface Solutions Segment

oerlikon balzers	oerlikon metco	oerlikon additive manufacturing
Thin film surface solutions and precision coated components	Thick film surface solutions including materials and hardware.	AM metal powders and components

Industries

Aerospace

Automotive

Medical

General Industry

Power Generation

AM Market Needs & Solutions

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MARKET NEEDS

OERLIKON SOLUTION

Experienced component manufacturer

Dedicated Oerlikon AM Team

- Provider of metal powders, thermal spray equipment and manufacturing of medical parts
- Manufacturer of AM components

Quality Management System

Quality Management System

- Accreditation
- Repeatability through machine stabilization program
- Traceable from powder to part

R&D Excellence

Development of Materials and Process Data Sets and Components

- Experienced R&D team
- Materials expertise
- Powder development and production
- AM process development labs

Efficiency, Affordability

FULL SPECTRUM

AM VALUE CHAIN INTEGRATION

Aerospace Case Study Antenna Bracket For Sentinel Satellites

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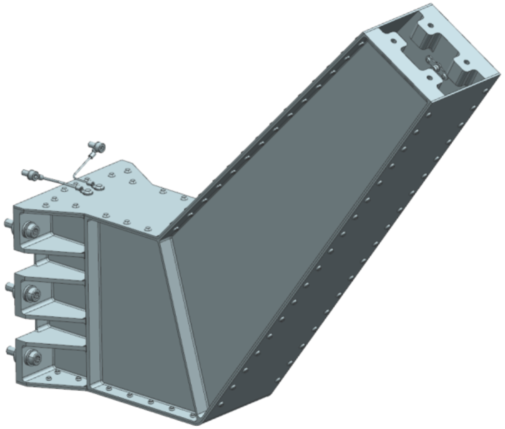
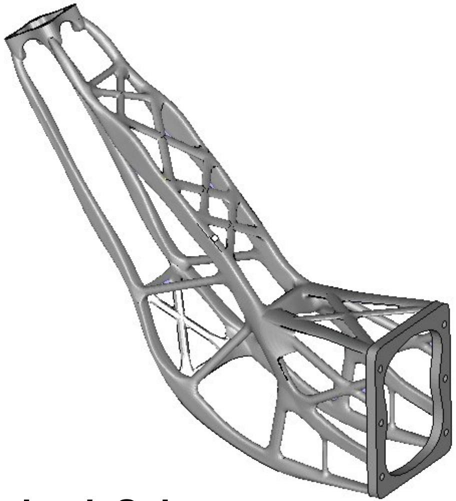


Original Scheme

- Weight: 1.626kg
- Frequency: 88.7Hz
- Manufacture: Sheet metal fabrication
- Material: Aluminum

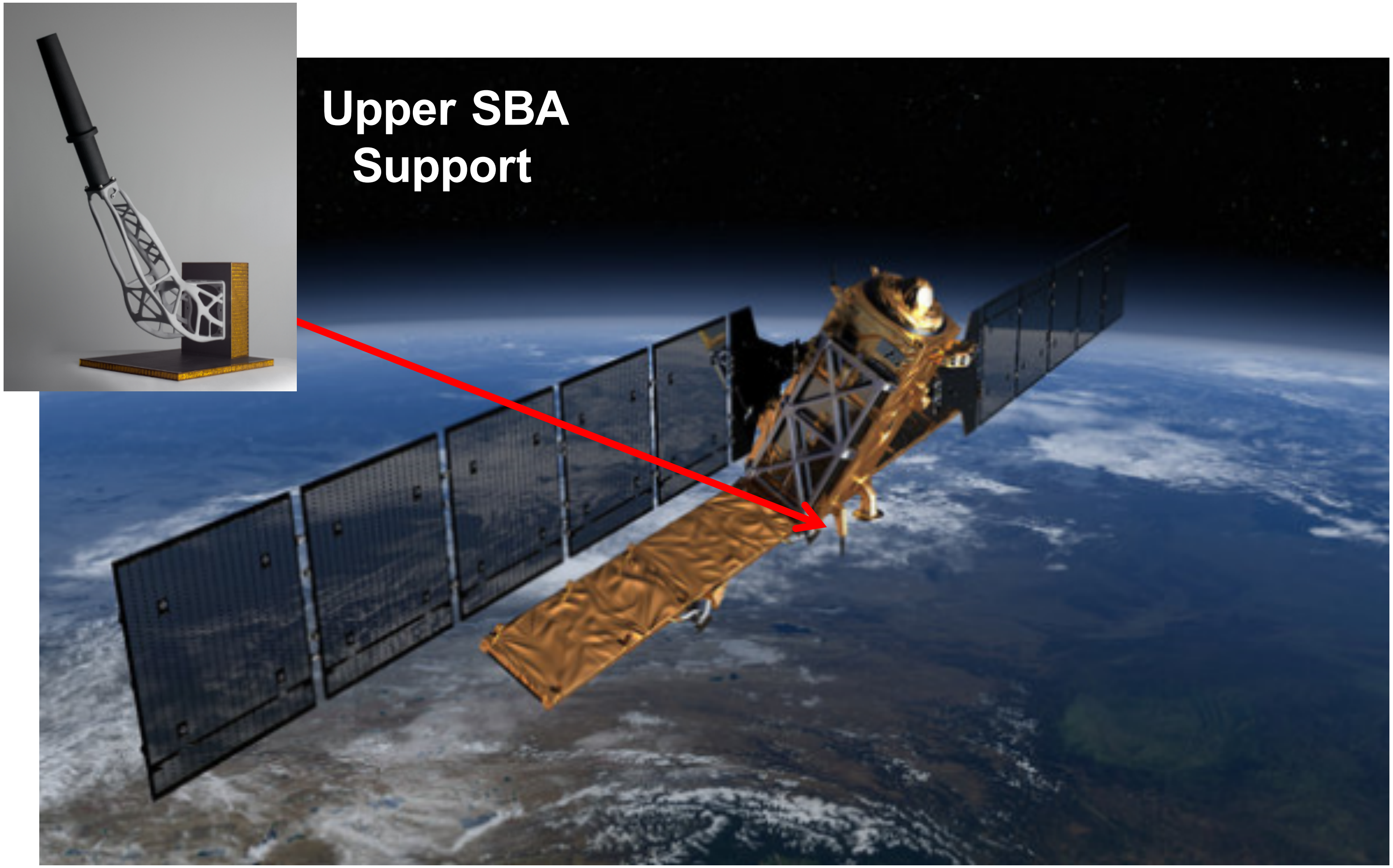


Optimized Scheme

- Weight: 0.96kg
- Frequency: 88.7Hz
- Manufacture: AM
- Material: AlSi10Mg (Aluminum)

- RUAG & Oerlikon partnered in Engineering, Materials and Production to develop application through Test & Qualification for space flight
- Final iteration provided ~40% weight saving whilst maintaining frequency (88.7Hz)
- No fabrication tooling required
- Lead time greatly reduced

Aerospace Case Study Antenna Bracket For Sentinel Satellites



Aerospace Case Study Turbo Pump: Turbine Rotor for Low Earth Orbit launchers (LENA Space)

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Original Scheme

- Current Manufacture multi-part fabrication, separate blades
- Performance constrained due to assembly and multiple different thermal expansion
- Material: Aluminum, Steel, Inconel

Optimized AM Scheme

- AM permits single part consolidation
- Design un-constrained for performance and reduced packaging (smaller design envelope)
- Material: IN718 and high performing coatings

- **Q2/18 enters test program to run the rotor at 11,000rpm**
- **Partners include ESA and Lockheed Martin**
- **Oerlikon AM Engineering, Material Science and Coatings reduced the original design from 150+ parts down to 1**
- **Concept to 1st article 6 weeks**

Aerospace Case Study 3D AM RF Antenna

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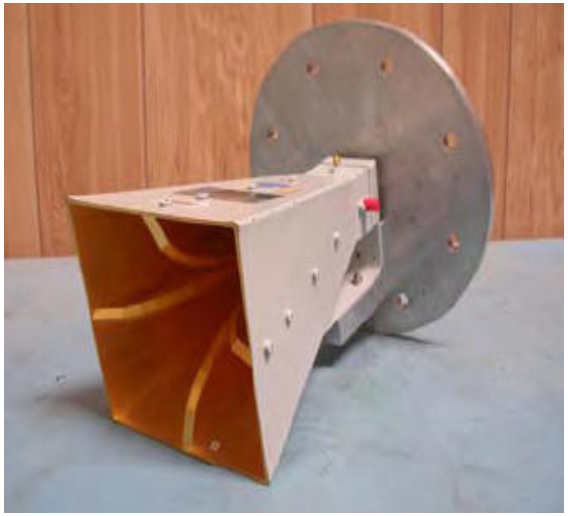
Typical antenna horn



'Generic' AM antenna horn

Original Scheme

- Manufacture permits 2D Radio Frequency (RF) elements
- Design constrained for manufacture
- Manufacture: Multiple fabrication and lead time
- Material: Aluminum

Optimized AM Scheme

- AM permits 3D RF elements
- Design un-constrained for performance
- Manufacture: AM
- Material: AlSi10Mg (Aluminum)

- **AM enabled design provides superior performance with multi-planar emission capability**
- **Integral circuit board cooling**
- **Highly customized performance for mechanical and thermal requirements**
- **<1/3 cost of conventional component and 10X improvement in lead time**

Aero&IGT Case Study **Gas Turbine Blades**

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Challenge

- Provide a printed turbine blade with protective Thermal Barrier Coating
- Apply Non-conventional machining & Heat treatments
- Reduce time to testable component

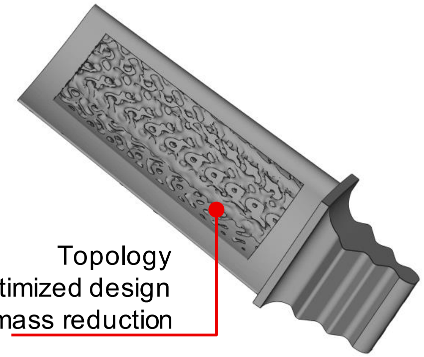
Solution

- Oerlikon part design, additive manufacturing NCM of fir tree and heat treatments
- Oerlikon coatings for reduced erosion, corrosion and high temp exposure
- Synova Laser MicroJet® (LMJ) drilling of cooling holes & diffusors through non-conductive coating

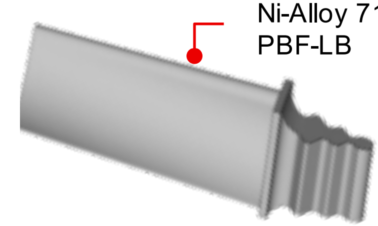
Impact

- In-house production of all materials
- Simplified supply using one stop shop
- Cost & time production
- Shorter time to testable component

eurostars SYNOVA



Topology optimized design for mass reduction



Ni-Alloy 718
PBF-LB

Fir tree finishing

Blade root after buffing to remove ceramic overspray

Surface coating
- Metco Diffusion Bond Coating
- Metco YSZ Top Coating

LMJ drilling of cooling holes & diffusors

Metallurgical expertise | AM application expertise | Supplier integration | Effective timetable | Cost optimization

Aero&IGT Case Study Seal Segment For Gas Turbine

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Challenge

- Provide a seal segment with 3D structured seal and Thermal Barrier Coating
- Simplify the supply chain
- Reduce time to testable component

Solution

- Oerlikon completed part design, build, post processing using in-house materials
- Quick and effective turnaround of prototype component for testing

Impact

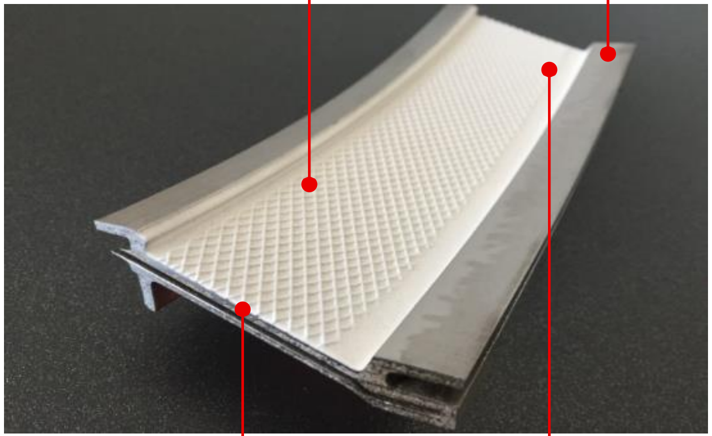
- In-house production of all materials
- Supply chain simplification
- Cost reduction
- Shorter time to testable component

Thermal barrier coating applied using **plasma spray**

Material: Metco 204NS

HVOF intermediate bond coating to increase coating strength

Material: Metco 4199



Base of segment seal made by **PBF** process, embedding seal slots normally requiring additional EDM

Material: Ni-Alloy 718

3D diamond grid applied to enable heat transfer using **laser cladding** process

Material: Metco 4199

Metallurgical expertise | AM application expertise | Supplier integration | Effective timetable | Cost optimization

AM in Aerospace – Industry Examples

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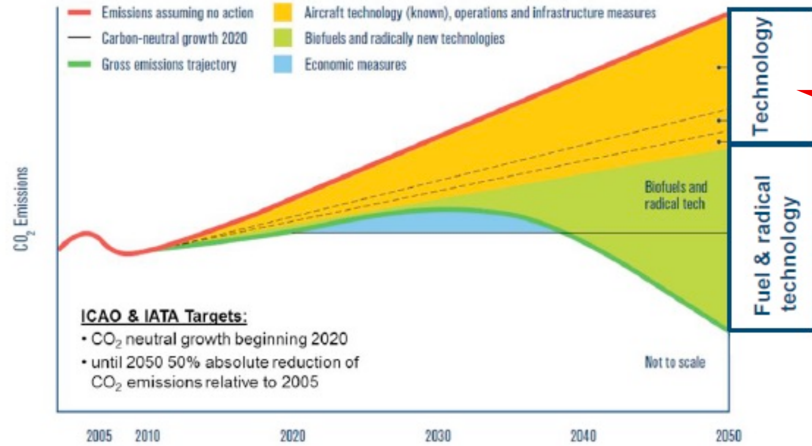
- Aerospace AM market is estimated to be **ca. EUR 1B,** according to Roland Berger consultancy, but includes materials, AM machines and services.
- Components have focused on lightweight parts with complex geometries – e.g. small Ti aerostructure components, turbine components.

Adoption drivers:

- Increasing efficiency requirements – improved materials and manufacturing processes e.g. Flightpath 2050 carbon emission targets.
- Increasing design confidence – data sets for alloys being developed to enable engineers to design parts for AM.
- Increasing regulatory acceptance – Airworthiness authorities have approved for production and service components such as GE's fuel nozzle.

Flightpath 2050: carbon emission targets



AM can play a role here

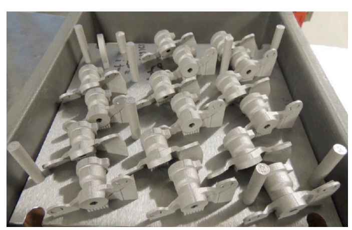
Space

Space X – Main Oxidizer Valve

- Higher strength, ductility and fracture toughness.
- Printed in Inconel – Ni-based superalloy
- Printed in less than 2 days vs months for casting
- Qualified to fly interchangeably with cast parts on Falcon 9.

Aero engines

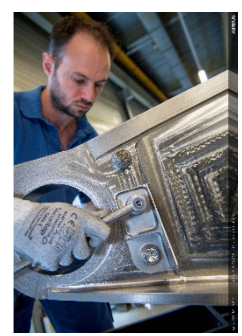
MTU Aero Engines – Borescope Eyepiece



- Printed in Inconel 718 – Ni-based superalloy
- Qualified for aero engines and in-service today.
- Substitution of a casting
- MTU predict that by 2030 a typical narrow body engine will contain 15% of AM parts
- Weight reduction of 100kg per engine possible.

Airframe

Airbus – A350 bracket



- Titanium bracket printed engine pylon
- Fitted onto an in-series production A350 XWB in 2017
- Builds on experience gained with first SLM and EBM parts for EADS satellites

Source: Roland Berger, Space X, MTU Aero Engines, Airbus


we are disruptors

Thank you.