

CARRIER STRUCTURE

FROM 180 KG CHIPS TO 20 KG ADDITIVE MANUFACTURING

KOEN MENTINK, MANAGING DIRECTOR HITTECH BIHCA

NICHOLAS MAYER, VICE PRESIDENT COMMERCIAL NORSK TITANIUM

CONTENT

COMPANIES

- Hittech Group
- Norsk Titanium

NXT Carrier Structure

- From Machining to Printing and machining

Norsk Titanium proces

- Process
- Aerospace
- Carrier Structure

Future Outlook

Lessons Learned

Hittech Group at a glance

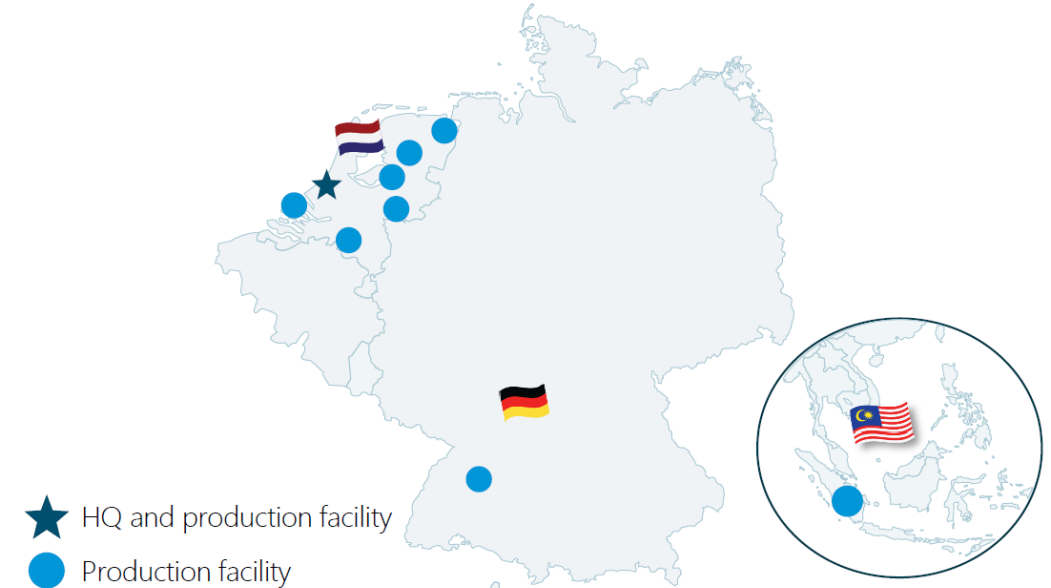
A well-focused system supplier with presence in Europe and Southeast Asia

Key figures

Supplier of highly complex and mission-critical components and assemblies



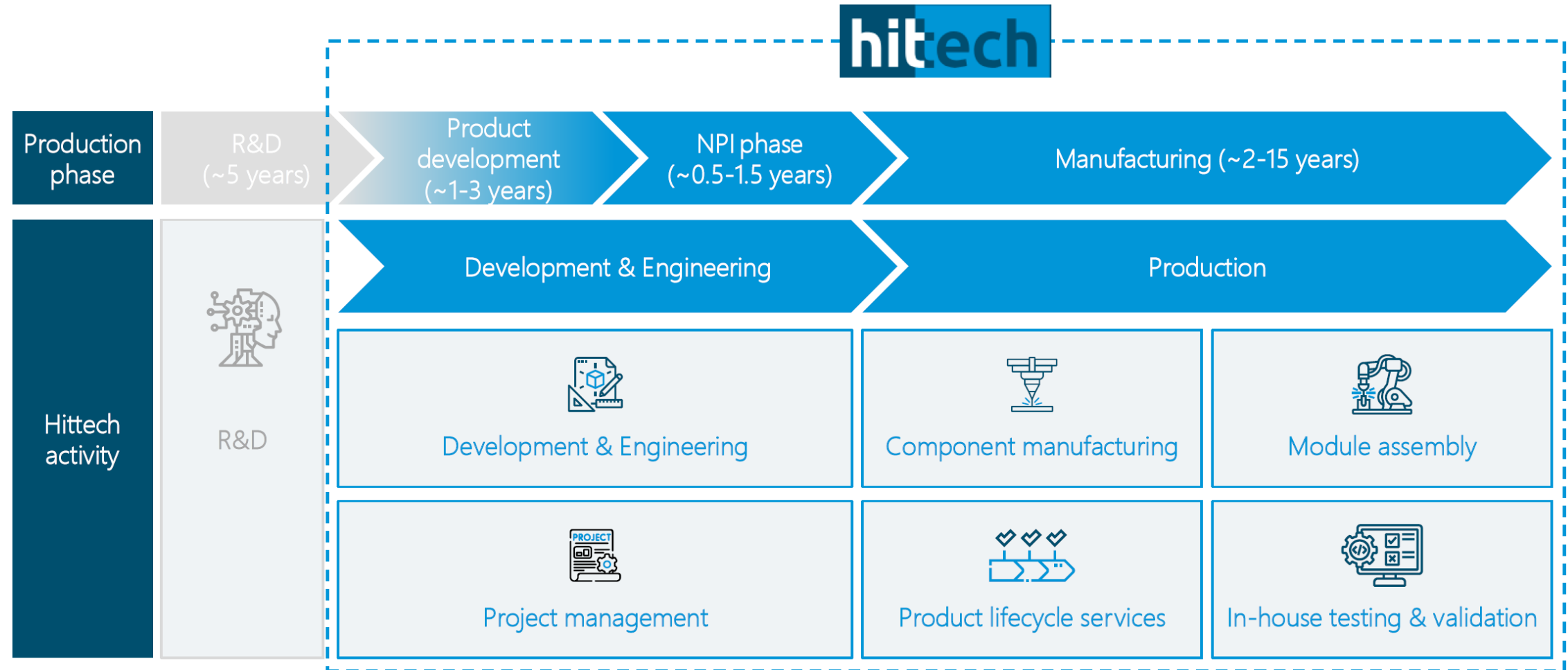
Geographical footprint



High-tech end markets

<p>Semicon</p>	<p>ASML</p>	<p>evatec process systems</p>	<p>Analytical Equipment</p>	<p>FARO</p>	<p>Thermo SCIENTIFIC</p>	
<p>MedTech</p>	<p>ZEISS</p>	<p>CARL ZEISS MEDITEC</p>	<p>mSI</p>	<p>Robotics & Automation</p>	<p>Fuji Seal</p>	<p>H2L ROBOTICS</p>

Hittech a development, engineering and supply partner



Norsk Titanium

Norsk Titanium founded

- Norsk Titanium founded by Dr. Alf Bjørseth and Petter Gjørvad to develop and commercialize aerospace-grade titanium components
- Initial investment by Scatec Innovation

Second prototype machine operational



Third prototype machine operational

- Patent "Method and Device for Manufacturing Titanium Objects"



Serial production deliveries of the world's first 3D-printed, FAA-approved structural aircraft parts to Boeing

- Delivers MERKE IV® RPD® machines to Plattsburgh, New York
- Strategic Investments from Rose Park and Fortress

EURONEXT GROWTH

IPO on Euronext Growth

Initial Airbus Qualification



Northrop Grumman Approved Supplier List



2007

2008

2009

2010

2012

2015

2017

2019

2020

2021

2022

2023

First prototype machine operational



Cooperation agreement with Airbus

- NORSOK Oil & Gas certification
- Investment by Aljomaih Group



Full-rate production RPD™ machines operational

- \$125m agreement with State of New York
- Boeing Approved Supplier



Expanded Boeing qualification for critical parts



Qualification with Airbus Begins



NYS completed construction of Plattsburgh Production Center

- 1st Leonardo delivery
- 1st consumer electronics development effort
- 1st defense development test part printed

Hittech/ASML order for 80kg carrier tray



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Machining of complex Titanium Products

Carrier structure 90% titanium burrs and 10% part

Titanium machining: Expensive

- Poor thermal conductivity
- Hardness

Resulting in

- Lower Cutting Speeds
- Shorter tool life

Complex production NXT carrier structure:

- High Cost and Risk
- Long Lead time: 8 weeks machining



Additive Manufacturing and NXT Carrier Structure

Hittech contacted Norsk Titanium to reduce cost

2014 Feasibility proven

Risk too High

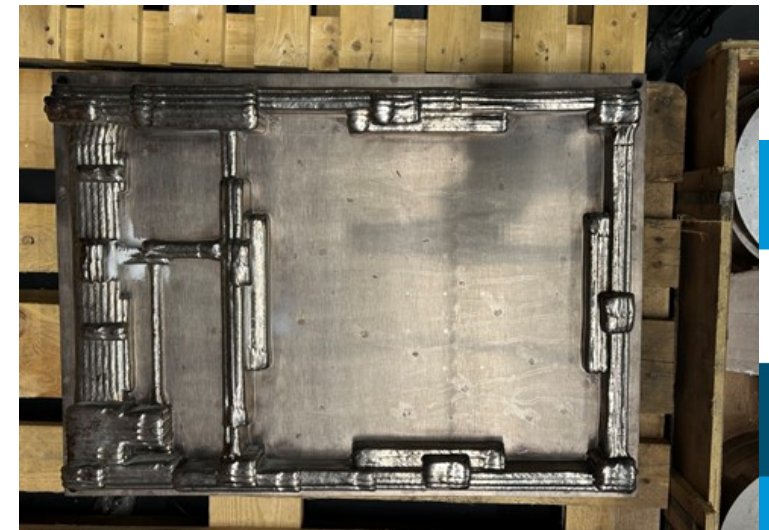
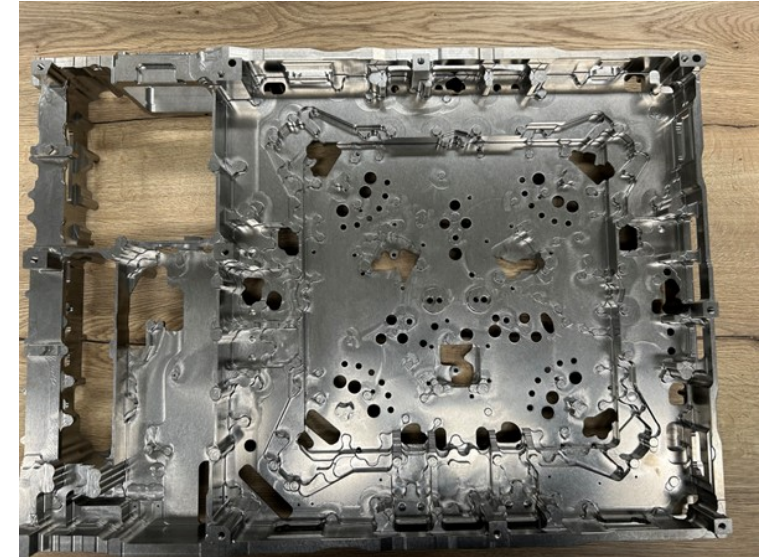
2022 massive Ramp up

Resulting in severe throughput issues

RPD accepted

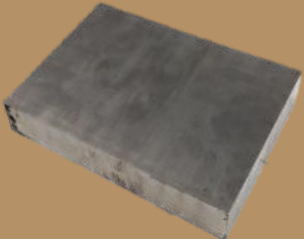

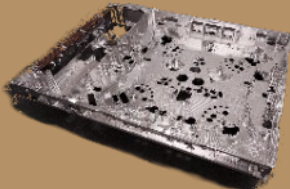
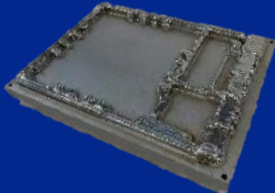
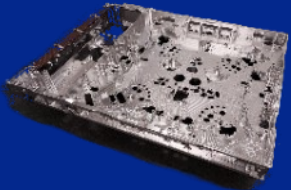
Pre model Production in place

Pre-model 120 kg <> Original 230 kg.

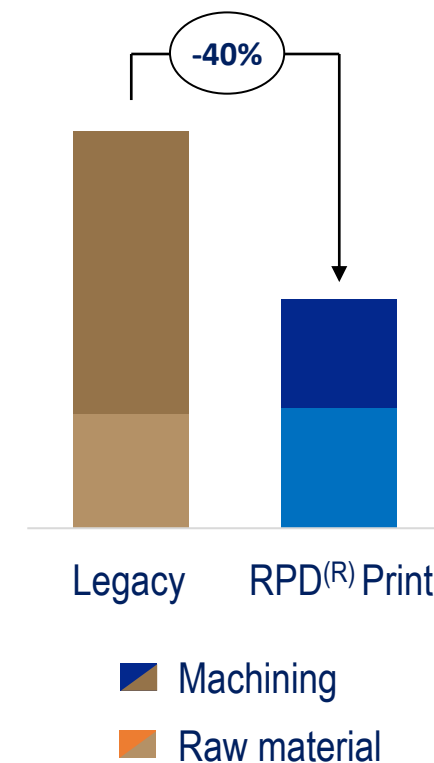


RPD[®] for ASML's NXT Carrier Structure

Less CNC Machinery Required

Legacy Block	220 kg Forged Block 	<i>15,000 kg additional machining required per year</i> 	< 10kg Finished 
Norsk Titanium	~90 kg RPD [®] Print 	<i>Saves 2 CNC machines, or \$2 million capital investment</i>	< 10kg Finished 

Less Cost



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Norsk Titanium Process

Material

- Ti -6-4 Wire & Substrate – Plasma – Argon Process

Characteristics

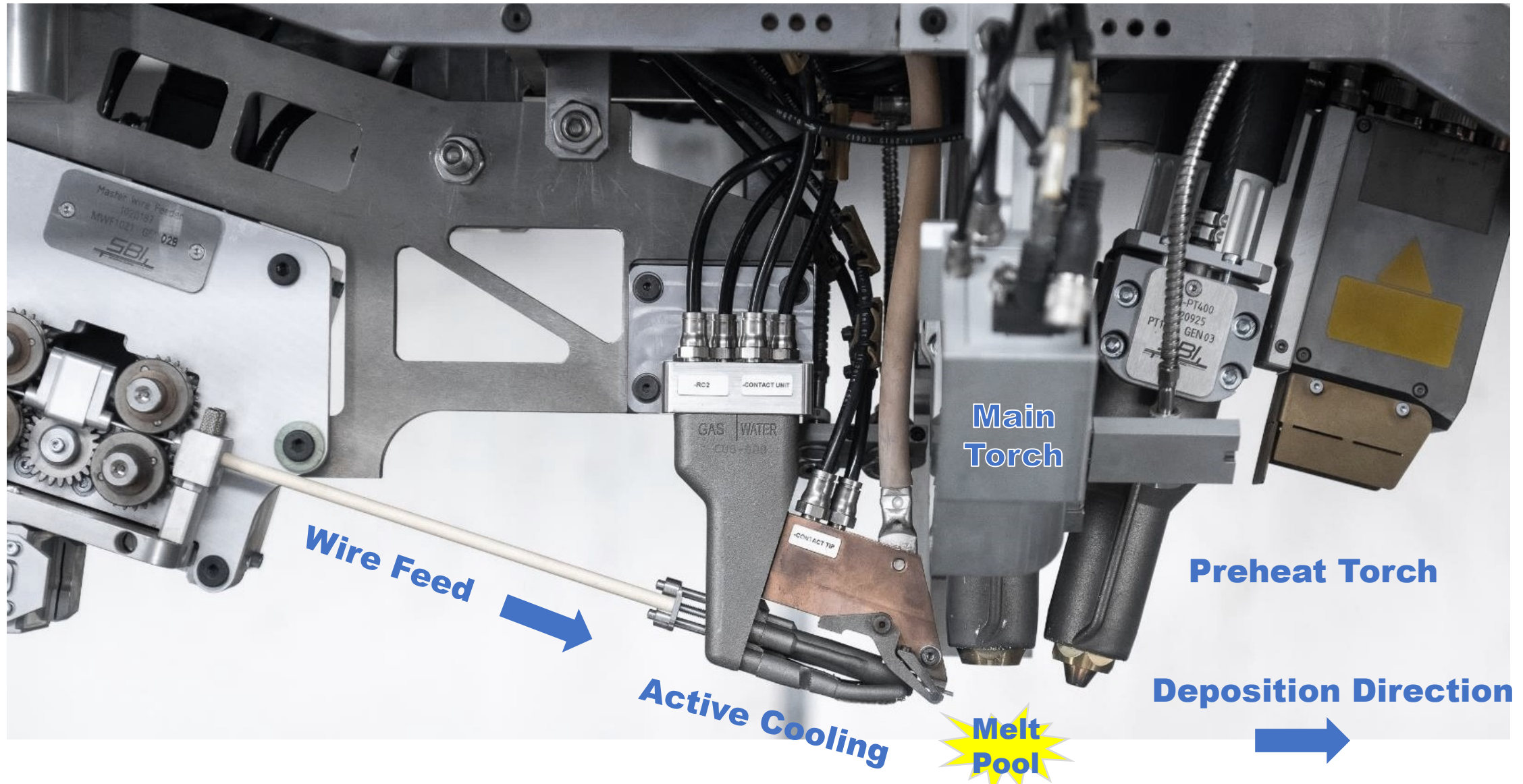
- Very Fast (5-10 kg/Hr)
- Large Structural Components
 - G4B (90 cm X 60 cm x 30 cm)
 - G4L (190 cm x 40 cm x 60 cm)
- High density product - No HIP Required
- Vertical Build
- Positive Pressure Inert Environment

SAE Qualifications

- Material Specification SAE AMS 7004
- Process Specification SAE AMS 7005

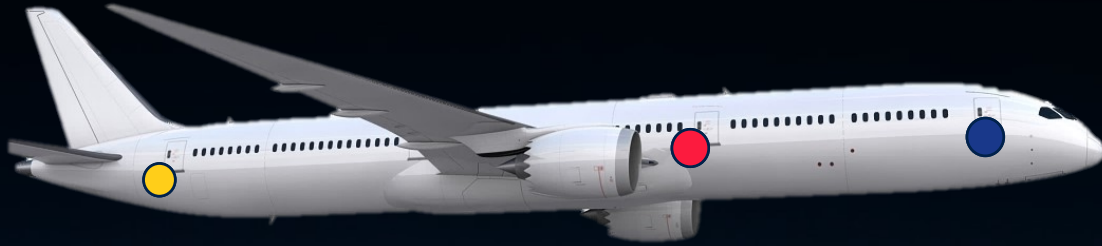


Norsk Titanium Tool and Process



Norsk Titanium process for Commercial Aerospace

7 RPD[®] printed parts on every Boeing 787 Dreamliner:



Norsk Titanium sells parts to Boeing through tier-1 suppliers

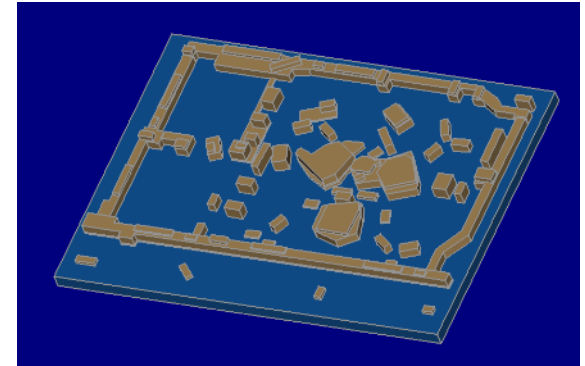
We are a direct replacement for forged titanium parts on Airbus programs



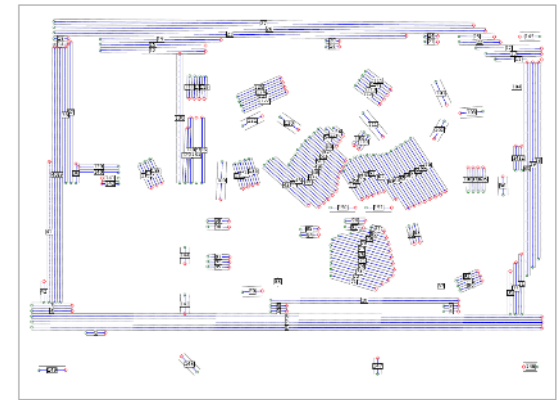
NXT Carrier Structure RPD design

- Designed with Norsk proprietary RPD builder™ software
 - Print Time: 32 hours (assume 50% torch on time)
 - Over 2,700 total deposition strings
 - Net deposition rate: 1.1 kg/hr
- Initial prints ~110 kg
- Cost out initiatives underway

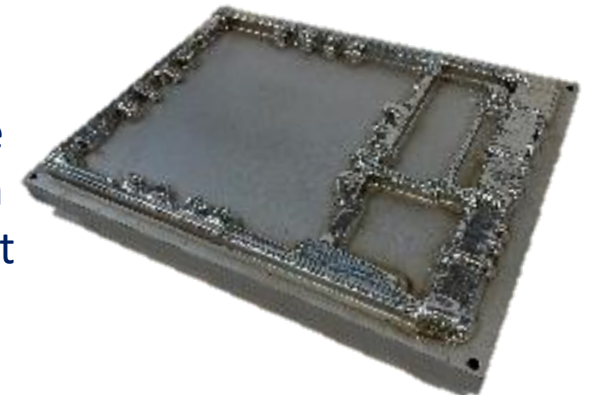
RPD® Form Design



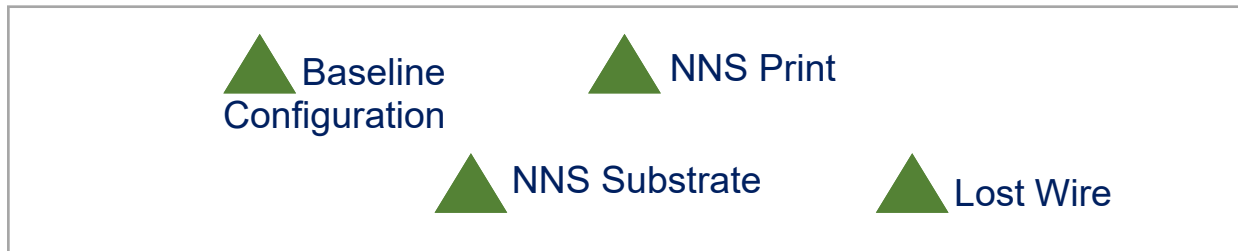
RPD Builder™ Deposition Strategy



Baseline Configuration Print



2023 2024 2025



SAE Specified Process Applied to NXT Carrier Design

AMS 7004 - Titanium Alloy Preforms from

High Deposition Rate Additive Manufacturing On Substrate Ti-6Al-4v Stress Relieved

AMS 7005 - Plasma Arc Directed Energy Deposition Additive Manufacturing Process

Specification Minimus

	Tensile Strength X and Y Directions	Tensile Strength Z Direction	Yield Strength X and Y Directions	Yield Strength Z Direction	Elongation (%) X and Y Direction	Elongation (%) Z Direction
Inch/Pounds	130 Ksi	123 ksi	117 ksi	112 ksi	5	5
SI	896 MPa	848 MPa	807 MPa	772 MPa	5	5

RPD[®] Sustainability benefits

Third Party Model used to calculate energy savings

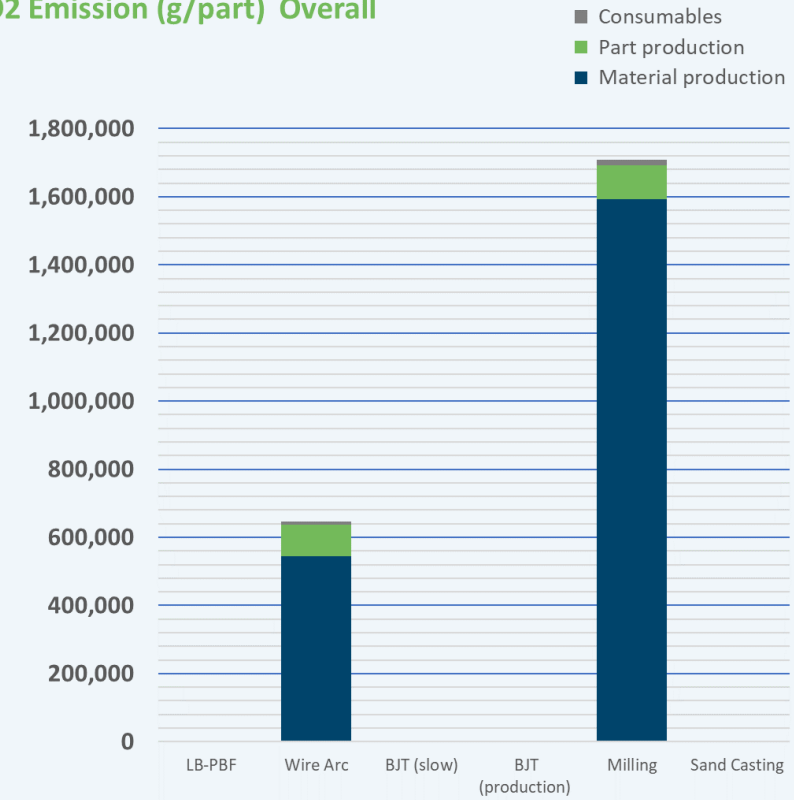
Accounts for:

- Raw material production
- Additive process
- Machining savings

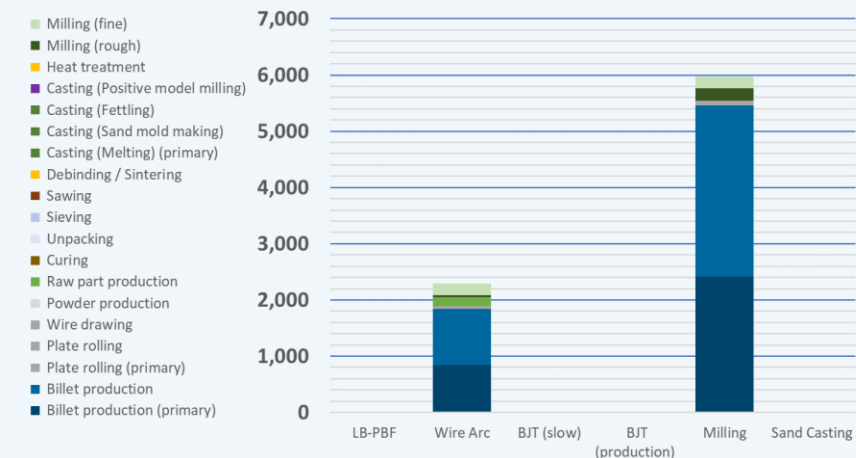
Each RPD[®] NXT Carrier structure saves

1M g CO2, ~60% Reduction from legacy plate

CO2 Emission (g/part) Overall



Energy Consumption (kWh/part) - without consumables



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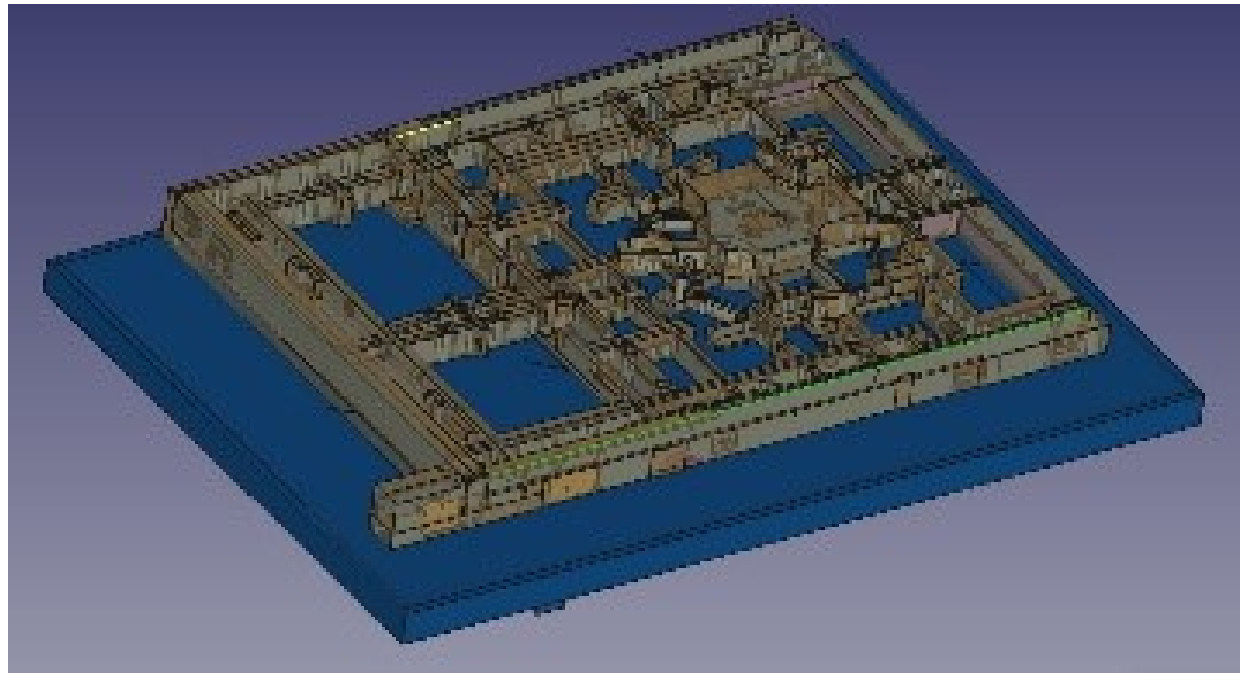
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Future Outlook

Lessons Learned

Future outlook Carrier structure production

A next even bigger Carrier structure is designed and will be produced by RPD and machining



Tips and tricks

When do you apply RPD? It is all about material reduction.

- Parts with large 'pockets' to save material removal
- Typically parts 100+ mm thick

Base plate will warp

- Can be pre-corrected,
- Currently solved by thicker baseplate

Only measure what you already did measure on current product

Convincing the Customer of new technology

Start of a new technology: Other and new possibilities will follow!!

QUESTIONS?



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