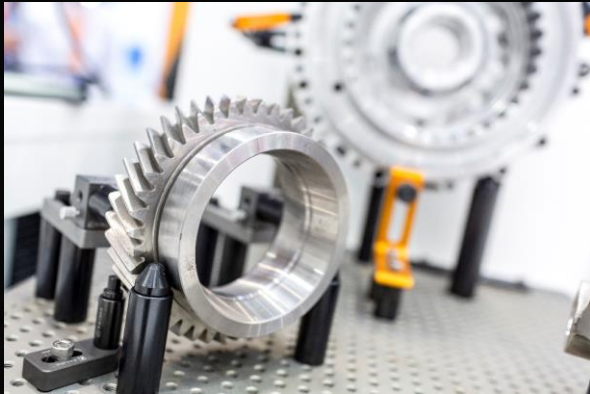


Renishaw and Additive Manufacturing

About Renishaw

World leading metrology company

A FTSE 250 company with headquarters in the United Kingdom



Our ethos

“Renishaw fundamentally believes that success comes from patented and innovative products and processes, high quality manufacturing, and the ability to provide local customer support in all its markets around the globe.”

Sir David McMurtry
Executive Chairman



Vision

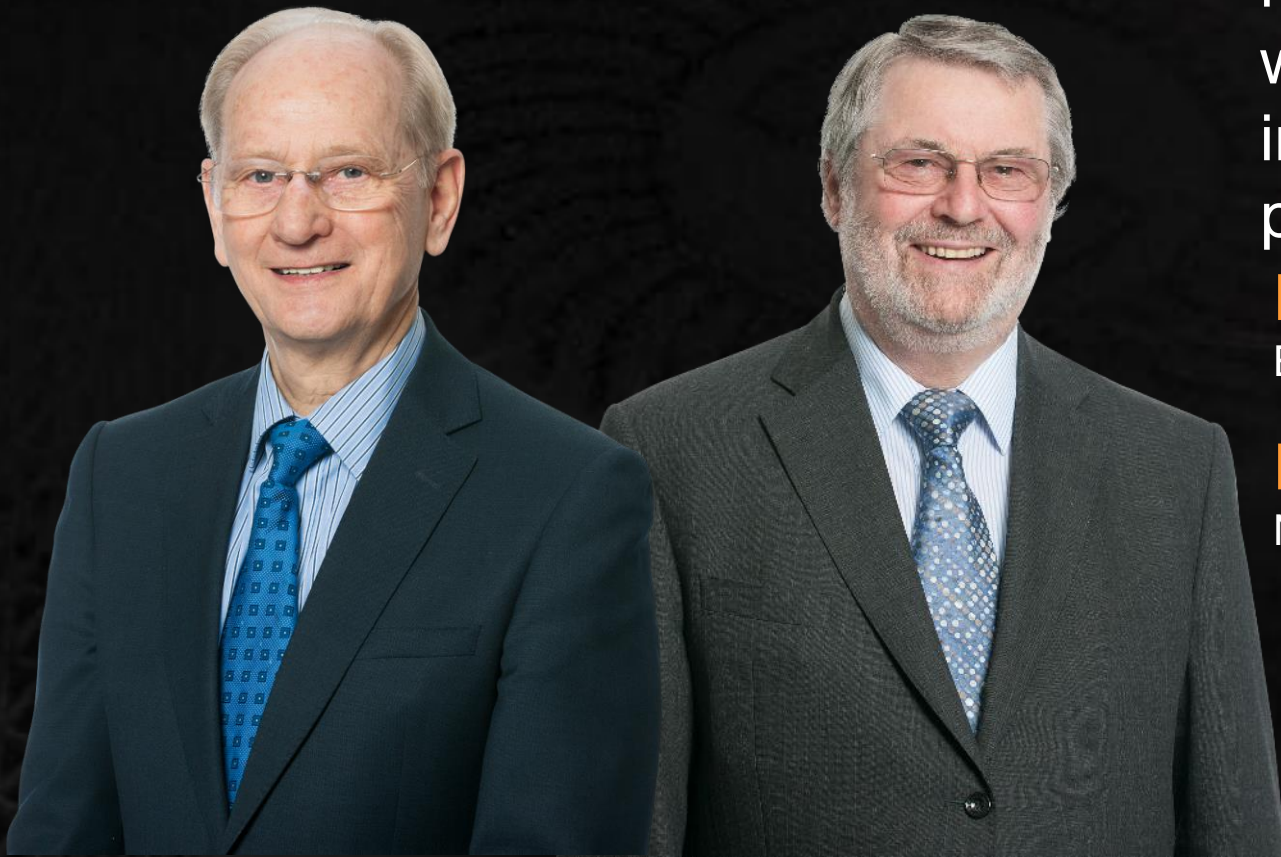
“Over the years, we have tried to build a company that is different to most others. Different in how we apply technology to real world problems; in how we invest for the long term; in how we manufacture rather than outsource; in how we treat our customers as partners”

Left: Sir David McMurtry

Executive Chairman

Right: John Deer

Non-executive Deputy Chairman



Our investment in long term growth

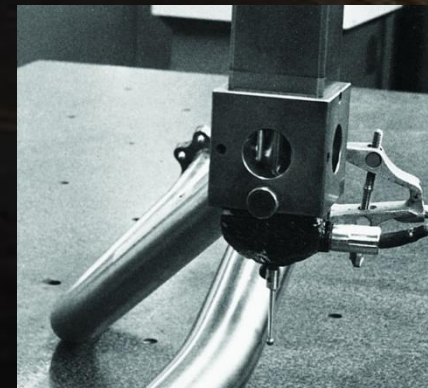
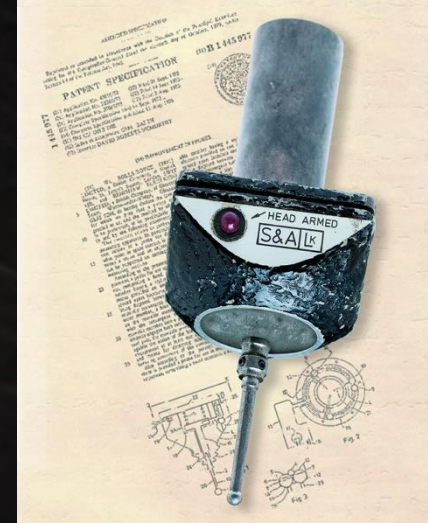
“The Group continues its strategy to invest for the long term, expanding our global marketing and distribution infrastructure, along with increasing manufacturing capacity and R&D activities.”

William Lee
Chief Executive



Our origins

- 1972** David McMurtry invented the touch-trigger probe to solve a measurement problem for Concorde's Olympus engines
- 1973** Renishaw Electrical Ltd registered; probe patent licenced from Rolls-Royce
- 1976** First commercial premises in Wotton-under-Edge, Gloucestershire, UK
- 1977** First dedicated probe for machine tools
- 1984** Full listing for Renishaw plc shares on the London Stock Exchange



Our strategy



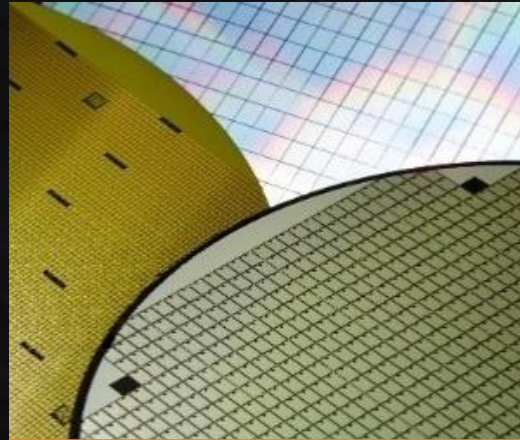
Our customers



Aerospace



Automotive



Electronics



Energy



Heavy industry



Medical and healthcare



Precision manufacturing



Scientific, research and analysis

Highlights in 2021*



£565.6m
sales

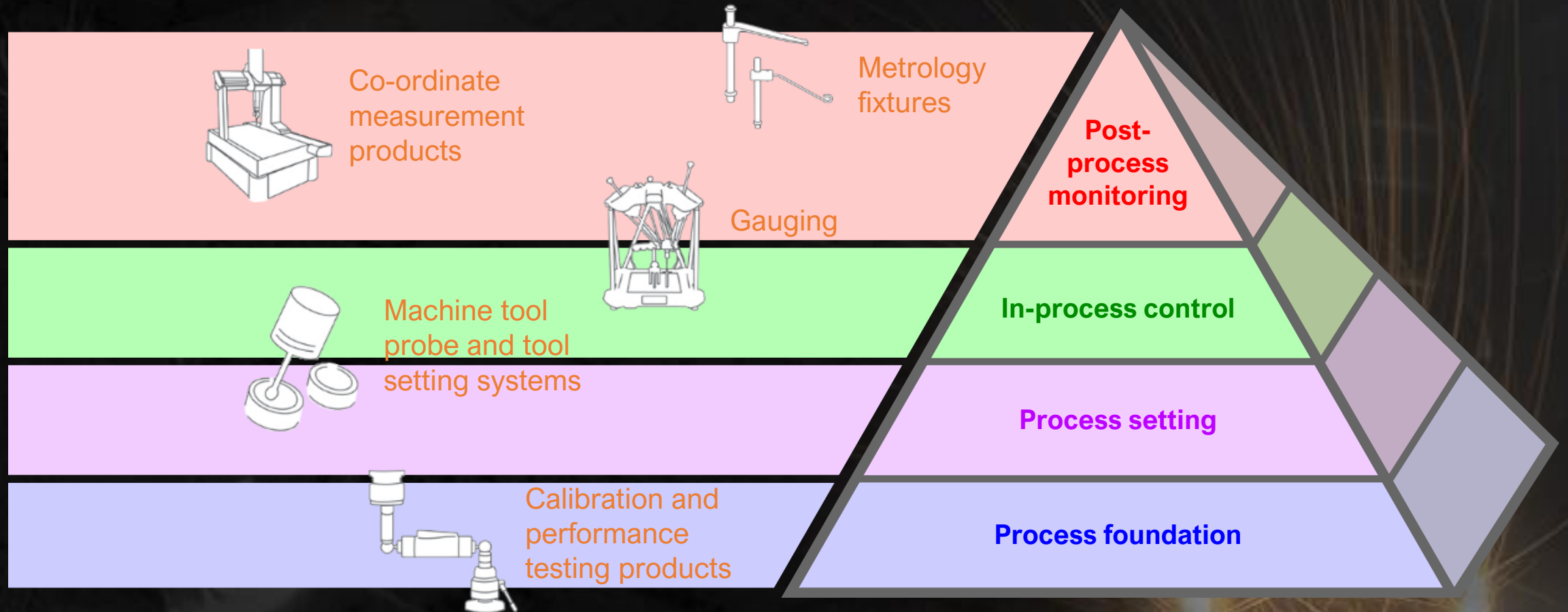
37
countries with
local subsidiary
contacts

4,664
employees

13%
of revenue spent
on engineering
including R&D

*All figures for year ending June 2021

Our expertise – Manufacturing process control

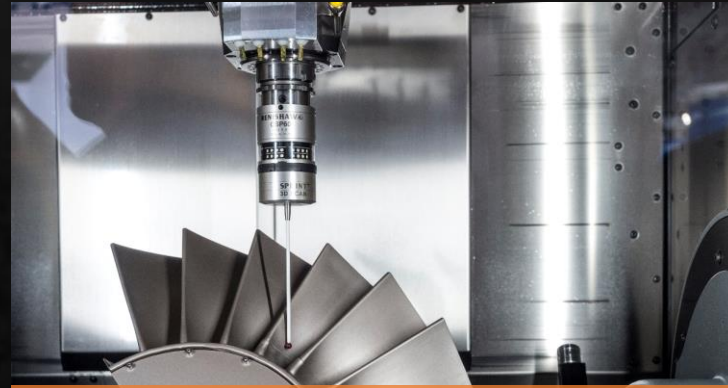


Our expertise

Industrial metrology



CMM probes, software and retrofits



Machine tool probes and software



Automated gauging systems



Machine calibration and optimisation



Styli for probes



Metrology fixtures

Our expertise

Position encoders



Magnetic



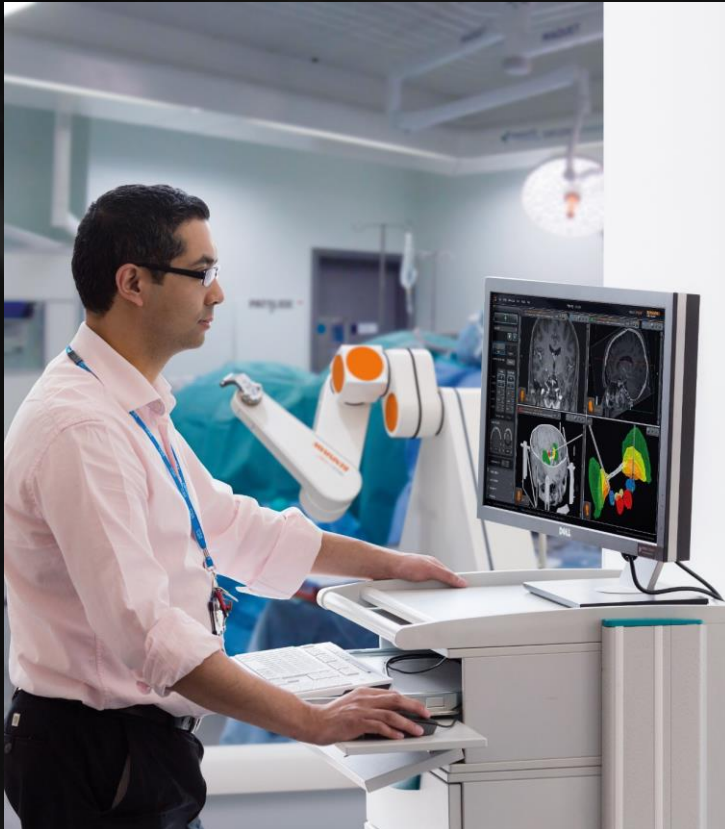
Optical



Laser

Our expertise

Healthcare



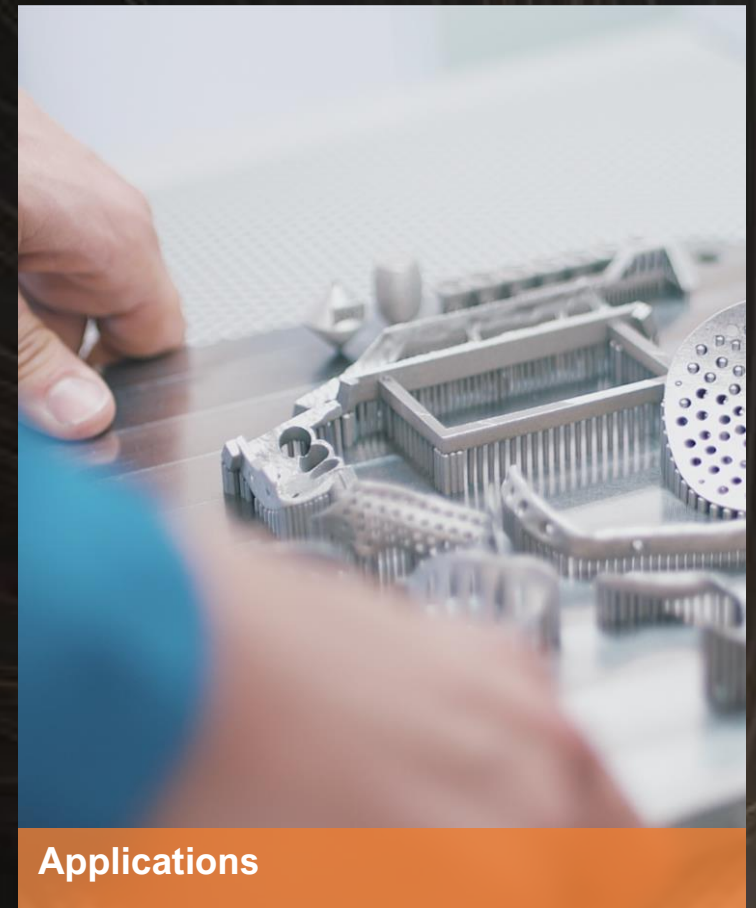
Neurological products and therapies



Raman spectroscopy

Our expertise

Additive manufacturing



Global Overview – Key AM Centres

Headquarters

Renishaw Innovation Centre (RIC)

153,000 ft² (14,200 m²)



Cardiff

Manufacturing plant

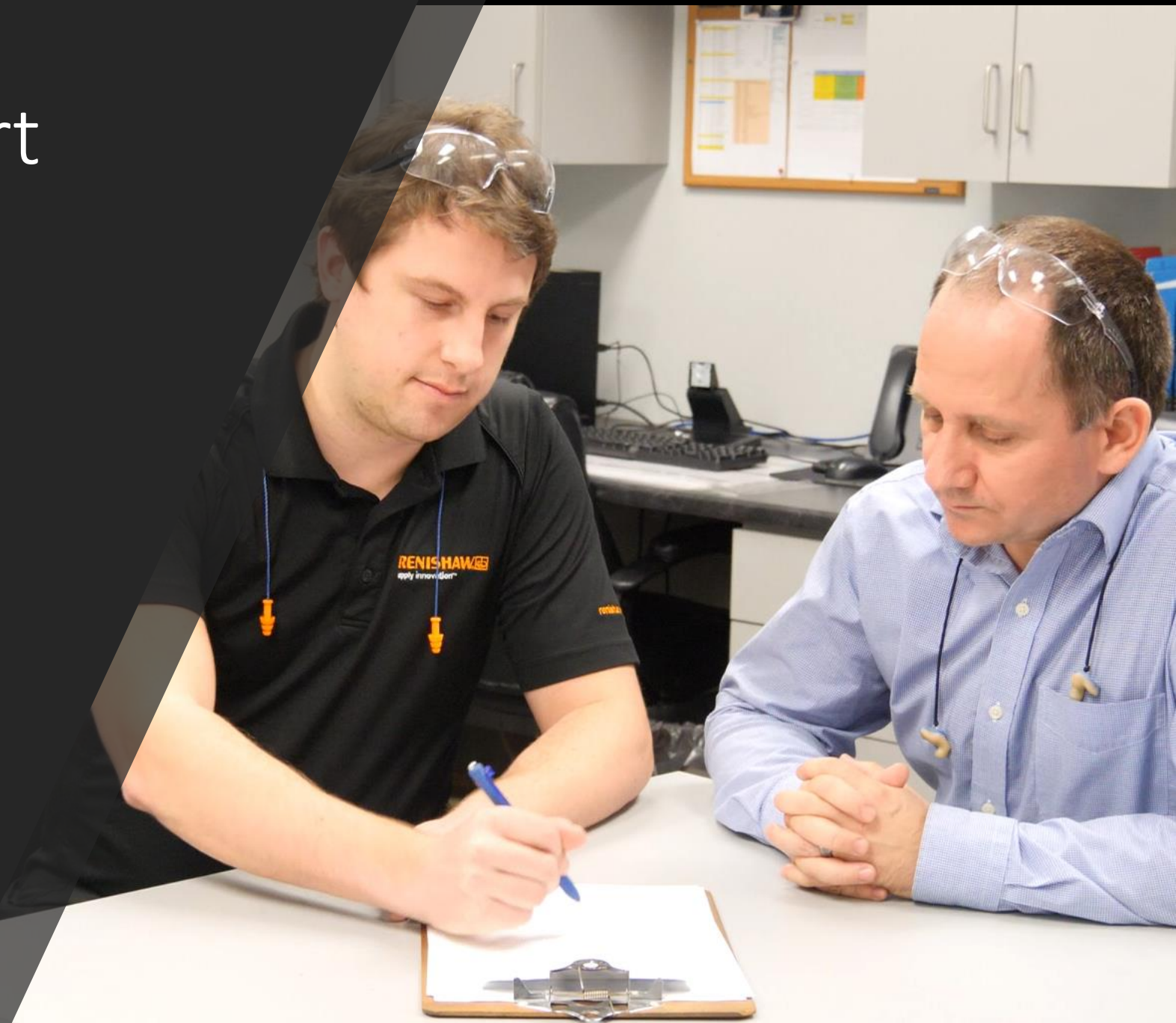
461,000 ft² (42,800 m²)



Customer support

Renishaw offers exceptional customer support

Support from multiples engineers based in the UK, Chicago and Barcelona with expertise in a vast array of industry sectors

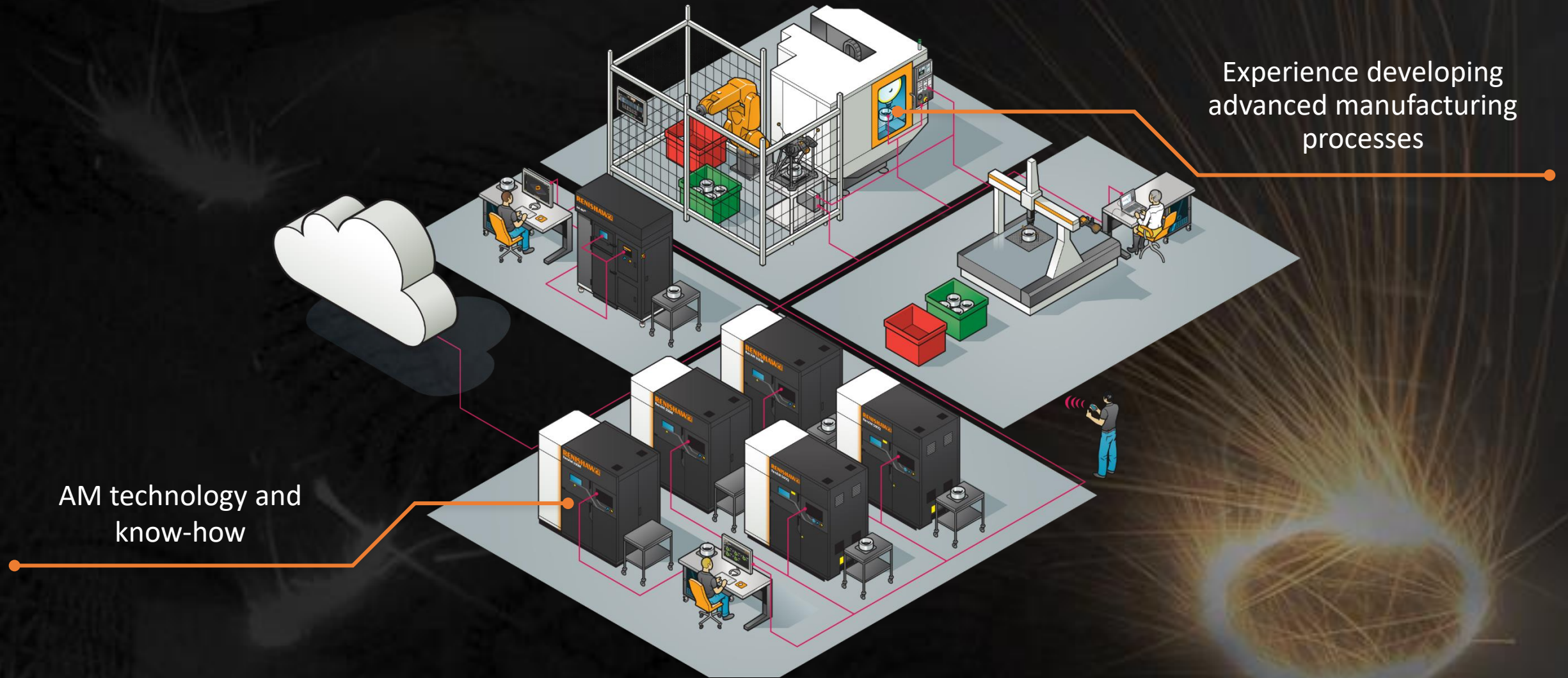


Renishaw can help you achieve

- Light weighting
- Part consolidation
- Improved functional performance
- Shorter development cycles
- Reduced design constraints / greater design freedom



Options for an end to end process



Faster and more cost effective without compromising on quality



Aerospace



Automotive

Case study **RENISHAW**
Ready Innovation™

Exchanging metal 3D printing solutions with HIETA



Customer: HIETA Technologies Ltd Industry: Automotive	Challenge: To produce their ultra-precision manufacturing and tooling, HIETA Technologies Ltd needed a solution that could produce parts with high precision and accuracy, and that could be used in a range of environments.	Solution: The solution was to use metal 3D printing technology to produce parts that could be used in a range of environments.
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Technology from Renishaw is helping HIETA to create more accurate manufacturing and tooling, and to produce parts that can be used in a range of environments.

Through our partnership with Renishaw, we have produced components that are highly accurate and reliable by using the highest precision that is available in the market. With the Renishaw technology, we can design and manufacture more complex and high-precision parts, and we can do this in a much shorter time. This is a very difficult to do with conventional methods.

HIETA Technologies Ltd

Renishaw is a world leader in precision manufacturing and tooling, and we are proud to be a part of the Renishaw family. Our technology is used in a wide range of industries, from automotive to aerospace, and we are committed to providing our customers with the highest quality products and services.

Background:
HIETA Technologies Ltd is a leading manufacturer of precision metal parts for the automotive and aerospace industries. The company has a long history of producing high-precision parts, and it is now looking to expand its capabilities to meet the growing demand for ultra-precision manufacturing.

Extremely good accuracy of complex softwares
Through the ultra-precision of the production system, Renishaw can produce parts that are highly accurate and reliable. This is a very difficult to do with conventional methods, and it is now possible to do so with Renishaw's technology.

Case study **RENISHAW**
Ready Innovation™

Renishaw produces a prototype nose tip for the BLOODHOUND Supersonic Car SSC



Customer: BLOODHOUND Industry: Automotive	Challenge: To be the first level surface to exceed 1000 miles per hour, the car needed a nose tip that could withstand the extreme conditions of supersonic flight.	Solution: The solution was to use metal 3D printing technology to produce a nose tip that could withstand the extreme conditions of supersonic flight.
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Background:
The BLOODHOUND Supersonic Car SSC is a land speed record car that is designed to reach speeds of over 1000 miles per hour. The car is currently in development, and it is expected to be the first level surface to exceed 1000 miles per hour.

Industry leader
The nose tip is a critical component of the car, and it is made from a material that is highly resistant to heat and wear. The nose tip is made from a material that is highly resistant to heat and wear, and it is made from a material that is highly resistant to heat and wear.

Manufacturing solution
The nose tip is made from a material that is highly resistant to heat and wear, and it is made from a material that is highly resistant to heat and wear. The nose tip is made from a material that is highly resistant to heat and wear, and it is made from a material that is highly resistant to heat and wear.

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Case study **RENISHAW**
Ready Innovation™

Metal 3D printing pushes the boundaries in Moto2™ through defiant innovation



Customer: Moto2 Industry: Automotive	Challenge: To produce a nose tip that could withstand the extreme conditions of supersonic flight.	Solution: The solution was to use metal 3D printing technology to produce a nose tip that could withstand the extreme conditions of supersonic flight.
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Background:
Moto2 is a high-performance motorcycle that is designed to reach speeds of over 1000 miles per hour. The motorcycle is currently in development, and it is expected to be the first level surface to exceed 1000 miles per hour.

Manufacturing solution
The nose tip is made from a material that is highly resistant to heat and wear, and it is made from a material that is highly resistant to heat and wear. The nose tip is made from a material that is highly resistant to heat and wear, and it is made from a material that is highly resistant to heat and wear.

Extremely good accuracy of complex softwares
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Medical

Case study **RENISHAW**
Apply Innovation™

Additive manufacturing for serial production of orthopaedic implants



Customer Eikon Precision Medical Medical device manufacturer	Challenge Manufacture complex, porous lattice implants in high volumes, and reduce the amount of waste during production	Solution Renishaw provided an AM solution for serial production of implants, reducing material waste and improving production efficiency
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Eikon Precision Medical has chosen Renishaw as their additive manufacturing (AM) and finishing partner, offering Renishaw technology throughout the production and validation of their 3D printed orthopaedic medical devices. The company has found that using Renishaw's AM technology allows them to manufacture complex lattice-like, high-precision implants at a commercially viable cost. It is a highly regulated environment, Renishaw's ISO 9001:2015 additive manufacturing solution allows Eikon to maintain traceability throughout their manufacturing process.

Background
Eikon Precision Medical sits at the heart of industry-leading medical device company, founded in 1985. Eikon has been producing over 1.2 million 3D printed devices in the orthopaedic market for over 30 years. Although these devices are relatively small in size, they are highly complex in design. It is essential that Eikon meets regulatory requirements and standards to ensure safety and effectiveness of its devices, both during and following production.

This led to a number of concerns and obstacles in the products that are made. Eikon has a vision of increasing a series of standards for additive manufacturing to meet regulatory, clinical, financial, operational and environmental challenges at Eikon.

Eikon operates an Integrated Management System (IMS), which encompasses ISO 9001, ISO 13485 and ISO 14001 accreditation. In order to demonstrate compliance with the standards, Eikon must maintain comprehensive and traceable data at each stage of the manufacturing process.



Case study **RENISHAW**
Apply Innovation™

Digital evolution of cranial surgery



Customer Neurologica Neurological Medical device manufacturer	Challenge Manufacture complex, porous lattice implants in high volumes, and reduce the amount of waste during production	Solution Renishaw provided an AM solution for serial production of implants, reducing material waste and improving production efficiency
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Neurologica Neurological (Neuro) is a leading provider of 3D printed medical devices in Europe, USA and Canada. The company has found that using Renishaw's AM technology allows them to manufacture complex lattice-like, high-precision implants at a commercially viable cost. It is a highly regulated environment, Renishaw's ISO 9001:2015 additive manufacturing solution allows Neuro to maintain traceability throughout their manufacturing process.

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Challenge
Manufacture complex, porous lattice implants in high volumes, and reduce the amount of waste during production

Solution
Renishaw provided an AM solution for serial production of implants, reducing material waste and improving production efficiency

Case presentation
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Case study **RENISHAW**
Apply Innovation™

Egan adopts digital workflow for Removable Partial Dentures (RPD)



Customer Egan Dental Laboratory Medical device manufacturer	Challenge Manufacture complex, porous lattice implants in high volumes, and reduce the amount of waste during production	Solution Renishaw provided an AM solution for serial production of implants, reducing material waste and improving production efficiency
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Egan Dental Laboratory is a leading provider of 3D printed medical devices in Europe, USA and Canada. The company has found that using Renishaw's AM technology allows them to manufacture complex lattice-like, high-precision implants at a commercially viable cost. It is a highly regulated environment, Renishaw's ISO 9001:2015 additive manufacturing solution allows Egan to maintain traceability throughout their manufacturing process.

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Challenge
Manufacture complex, porous lattice implants in high volumes, and reduce the amount of waste during production

Solution
Renishaw provided an AM solution for serial production of implants, reducing material waste and improving production efficiency

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Systems



Key features of RenAM 500 series

- Intelligent gas flow system
- High precision dynamic optical control
- Controlled powder management
- Connected and intelligent sensing technologies
 - Increasing productivity
 - Reducing cost per part
 - Without compromising on quality



Intelligent gas flow

Vacuum build chamber preparation

- Patented vacuum build preparation system to rapidly reduce the oxygen level

Gas flow control

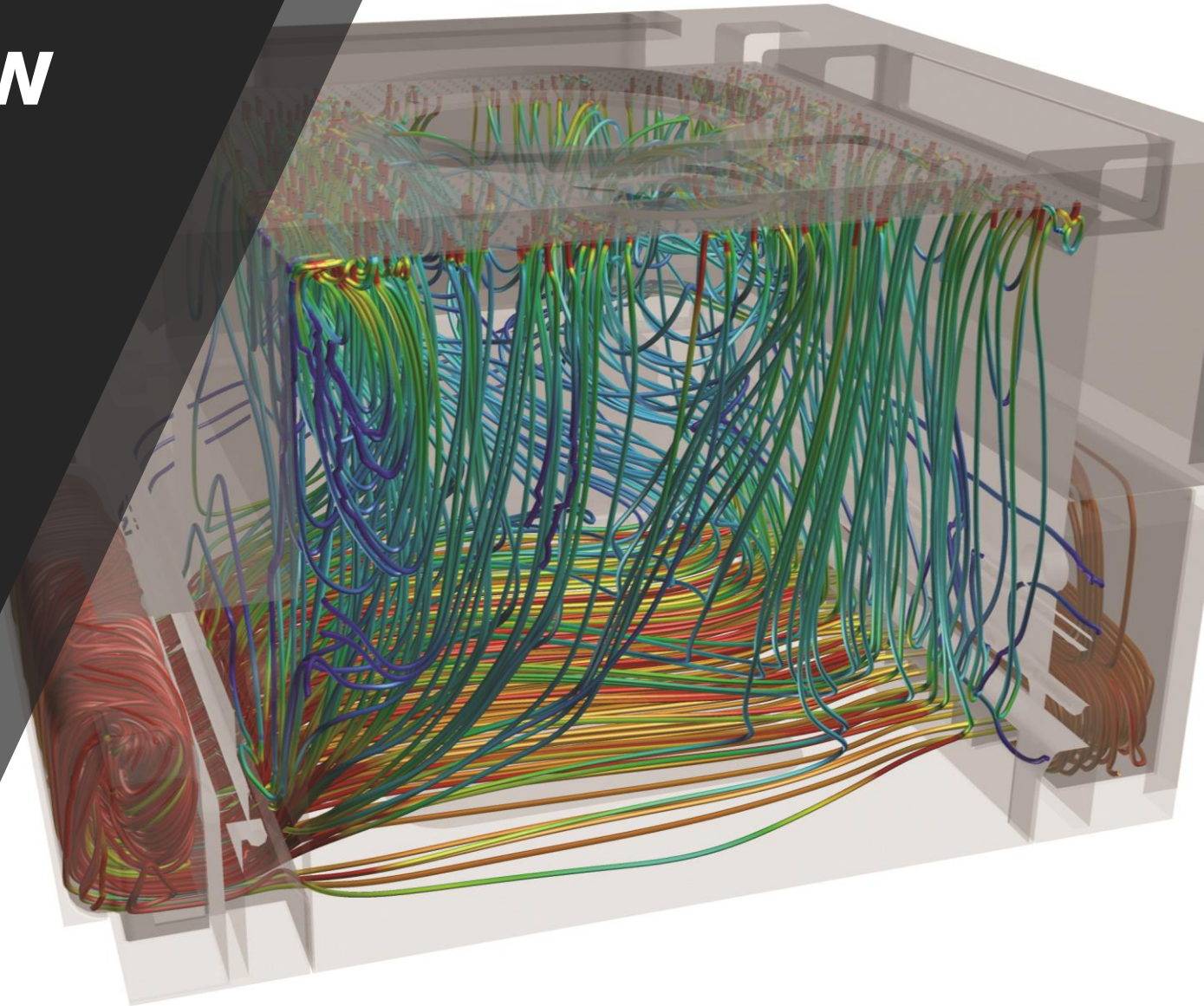
- Intelligent gas flow efficiently removes process emissions in a stream of inter argon gas leaving a clean build chamber

Intercooler

- The intercooler reduces and stabilizes the temperature of the argon gas stream by cooling the recirculating gas

Dual SafeChange™ filters

- Dual patented SafeChange™ filter system to capture the very smallest process emissions in an inert argon gas atmosphere



High precision optical control

High performance laser guiding technology

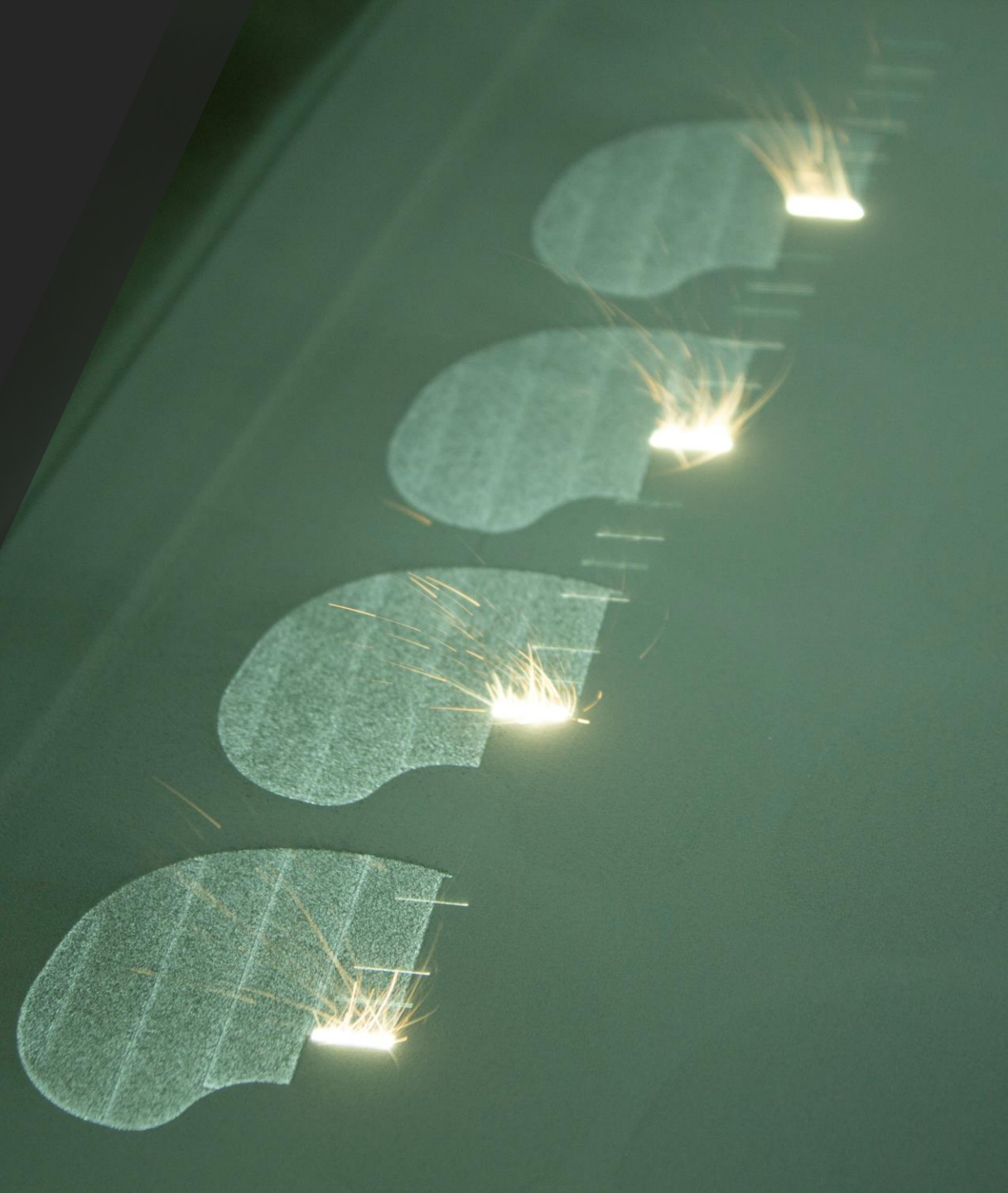
- To deliver accuracy at the powder bed takes expert optical and control engineering, something Renishaw has spent years perfecting

High precision z-axis

- The z-axis is equipped with a Renishaw RESOLUTE™ optical encoder with a 1 nm resolution for high-accuracy positional sensing

Kinematic re-coater with flexible blade

- A kinematic re-coater mounting for rapid and precise re-coater changes reduces operator error and improves turn-around time



Controlled powder management

Cyclone pre-filter separator

- To allow high volumes of gas at a high velocity to be used, a pre-filter cyclone separator captures larger process emissions from the gas stream before they reach the SafeChange™ filters

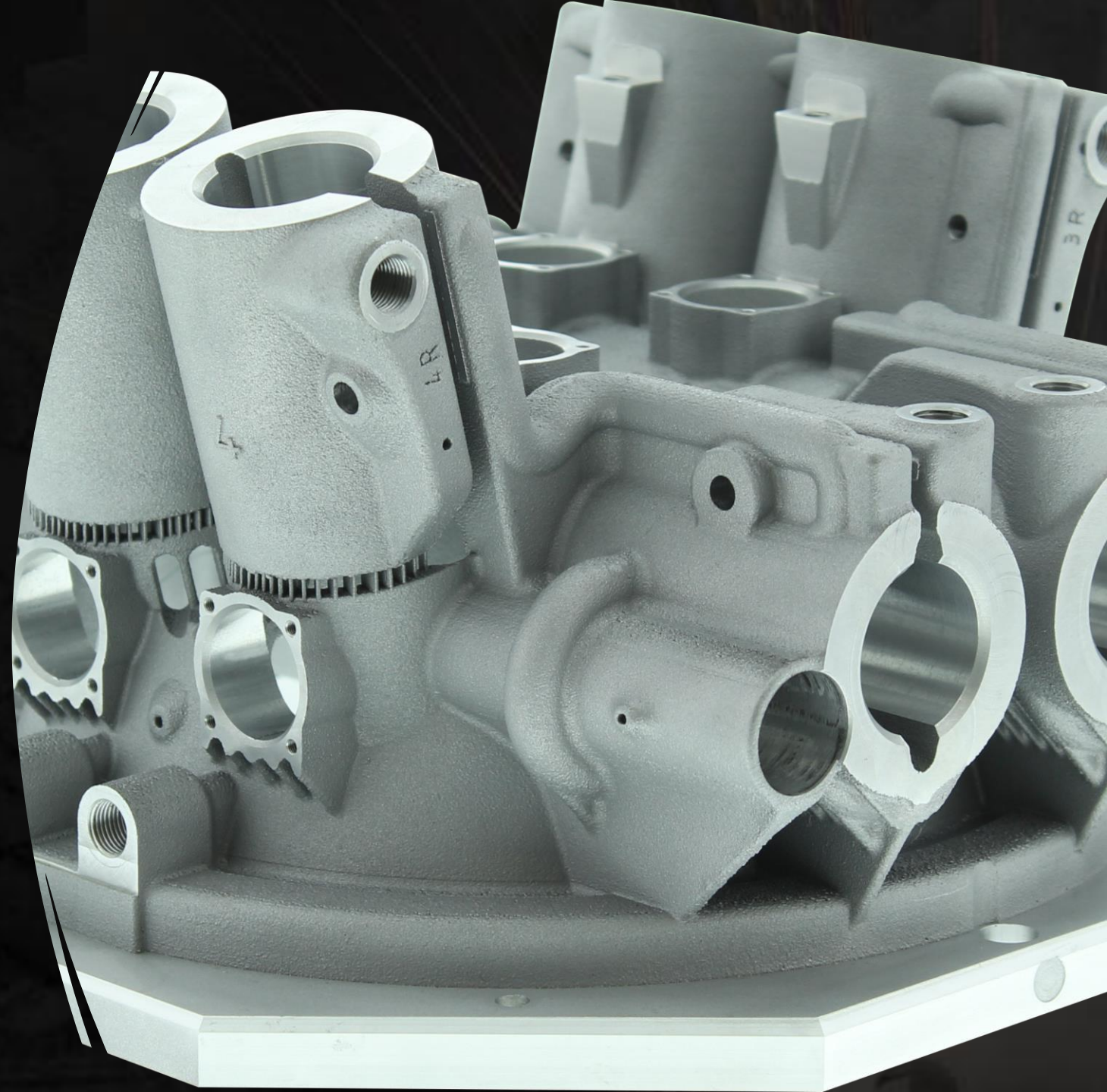
Built-in sieve and powder recirculation system

- The built-in sieve and powder recirculation system ensures all powder handling is automated and under a safe gas argon atmosphere.



RenAM 500Q – Additively manufactured galvo mounting

- Full field of view for all lasers with unmatched precision
- RenAM 500Q uses 8 digital galvanometer mirrors closely mounted in a single additively manufactured module.
 - Additively manufactured from AlSi10Mg
 - AM delivers significant performance benefits over traditional manufacturing methods.
- Lasers mounted close to the centre of the working area, combined with optimised fluid cooling, significantly reduce the thermal and mechanical errors associated with separate optical module designs.
- Designed to provide each laser with full field of view for optimum production efficiency.

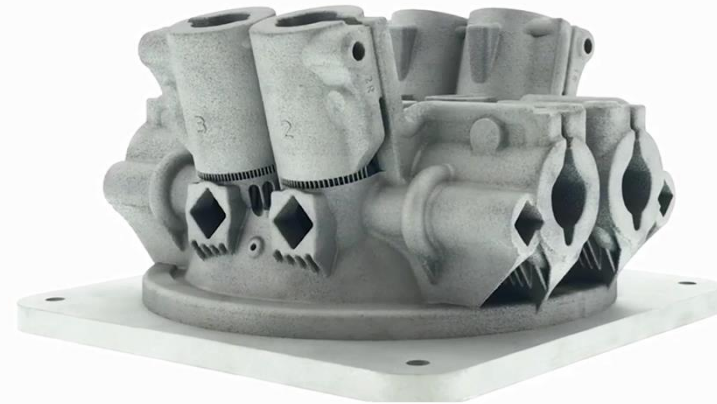


Standard vs high productivity

2 lasers



4 lasers



Build progress after 19 hours

The different systems within the 500 series

RenAM 500Q & 500S

High volume production of a broad range of components, supplied with an integrated recirculating powder system



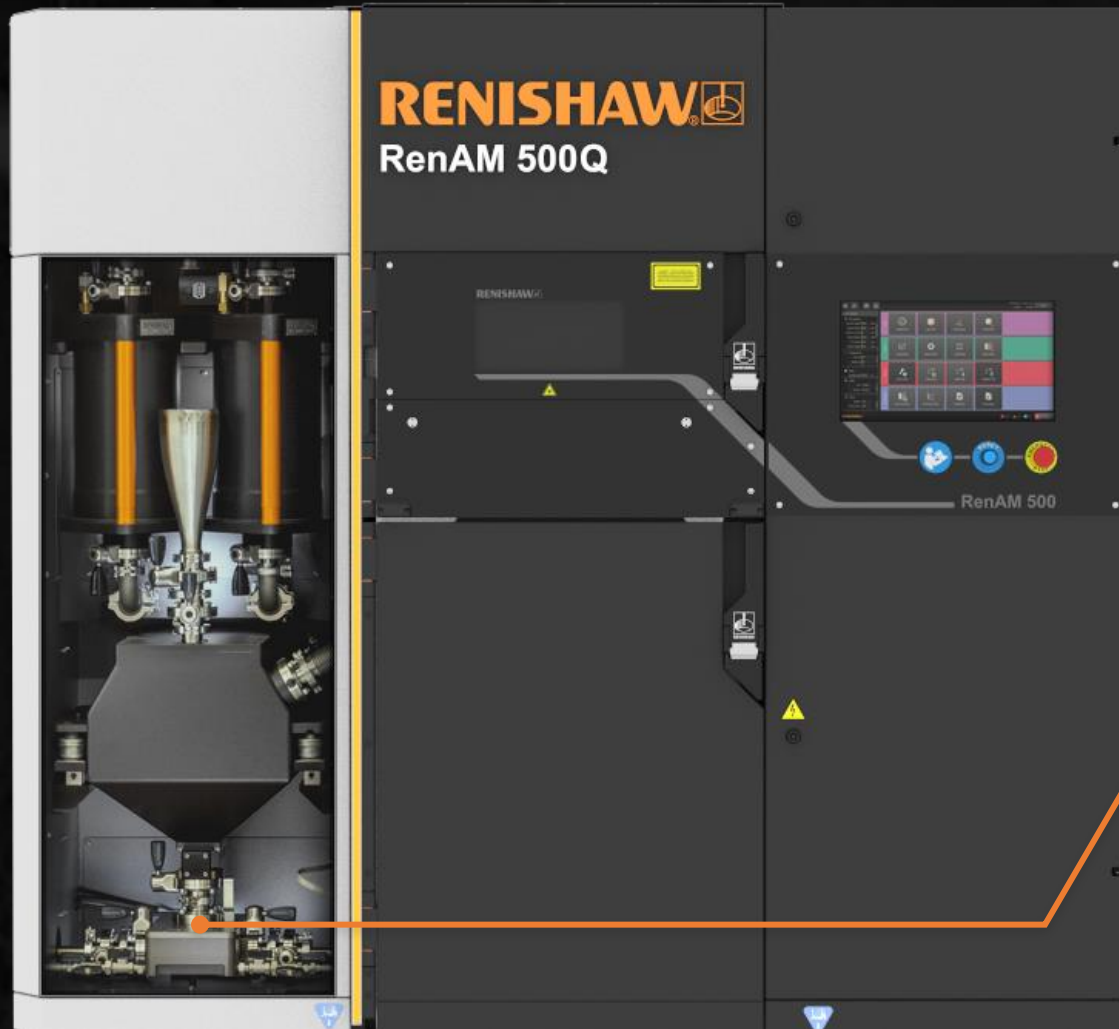
RenAM 500Q Flex & 500S Flex

High volume production of a broad range of components, supplied with a batch control powder system.

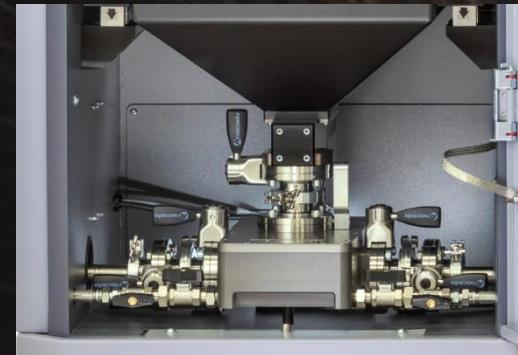


Platform X/Y size: 250 mm
Q: Quad Laser version
S: Single Laser version

RenAM 500Q & 500S – Delivering productivity through product innovation



Automatic powder recirculation system with integrated sieving and vacuum & inert gas control



- On-board sieving

RenAM 500Q Flex & 500S Flex – stand alone or integration into a factory powder supply system



Powder hopper or gravity fed centralised delivery system

Systems keep core features such as vacuum assisted inert gas supply and fully open parameter.

Powder collection containers or connection to a centralised powder collection system

Software offerings

For more details see
software presentation

QuantAM

- Two separate “products” – QuantAM App and QuantAM Post Processor
- QuantAM App – User interface for build preparation
- QuantAM Post Processor – Software interface for producing build files within 3rd party software applications

InfiniAM Central

- System sensor and build information software.

InfiniAM Spectral

- Live analysis and post build investigations

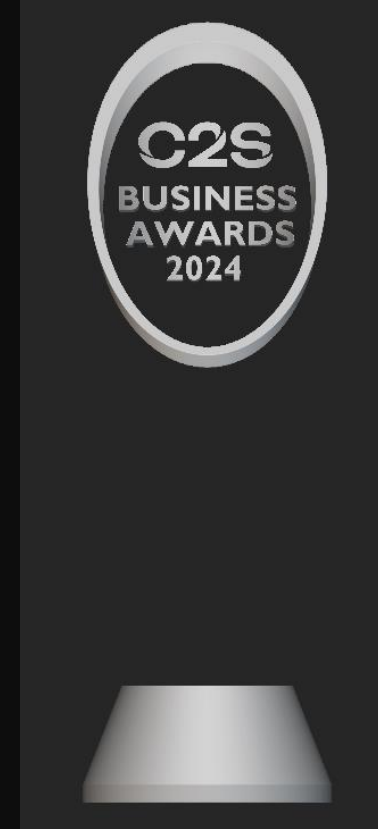
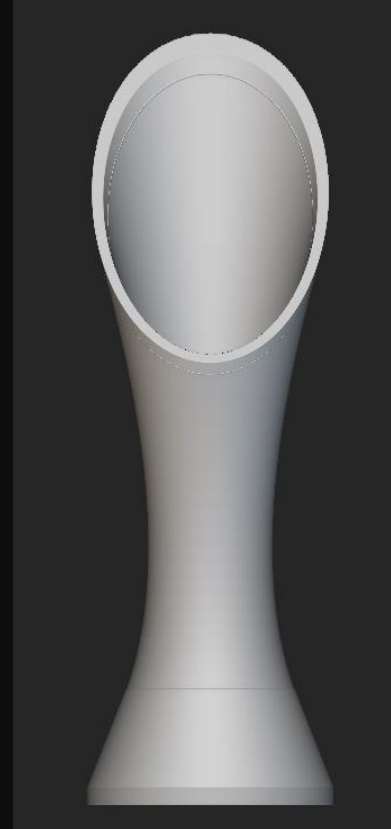
Machine Software Suite

- All software on AM Machine – RenAMP, Camera App, Windows etc.

C2S Award Design & Build Process

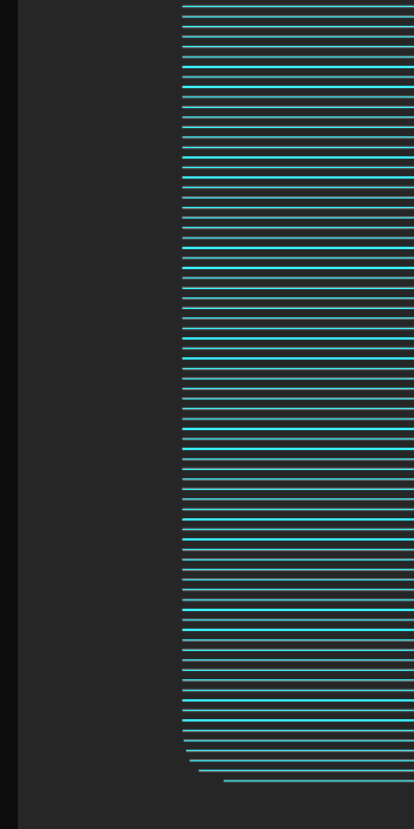
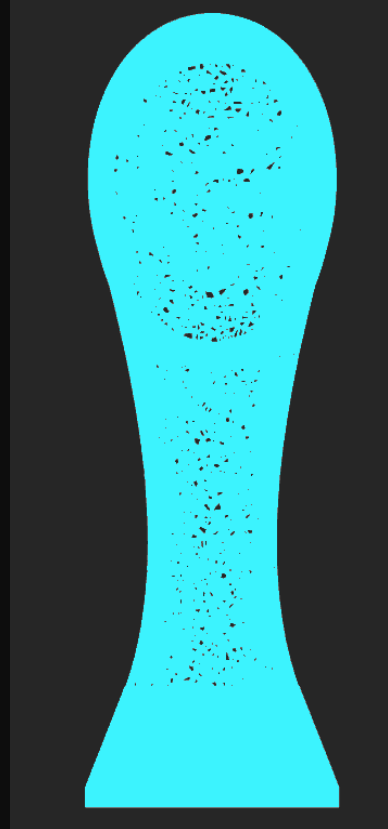
The Initial award concept was designed in Siemens NX cad software this was then imported into nTop Topology optimization software to generate the lattice for lightweighting of the award.

The Logo was used as a field to create a variable thickened lattice to allow for no support regions in these areas



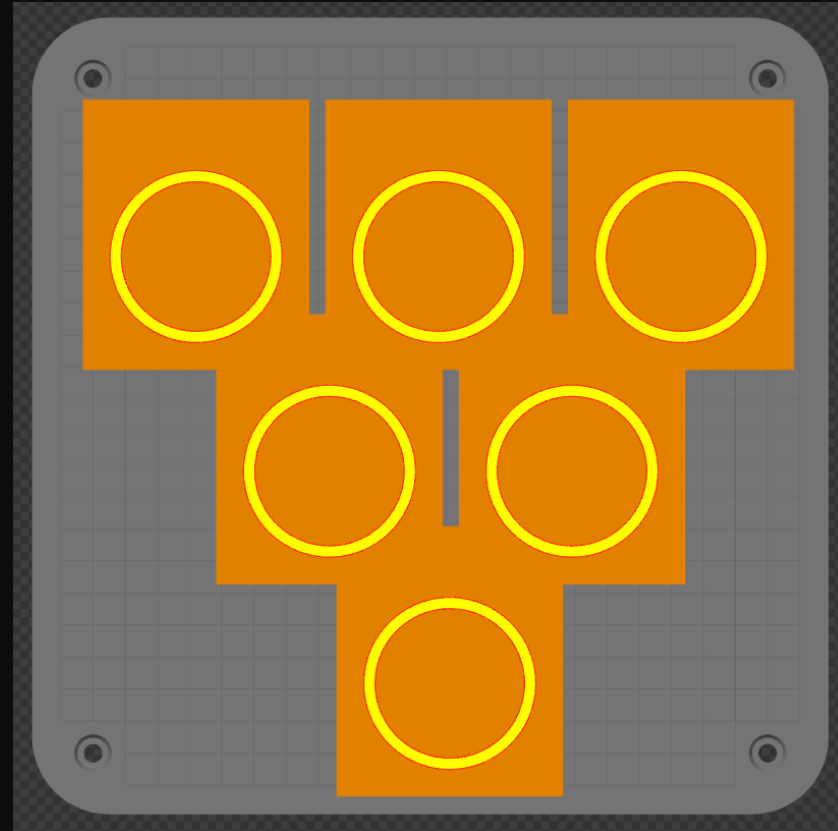
C2S Award Design & Build Process

The final design part was sliced into 60 micron layers in Ntop prior to exporting CLI file into QuantAM the software used for generating the AM machine build file.



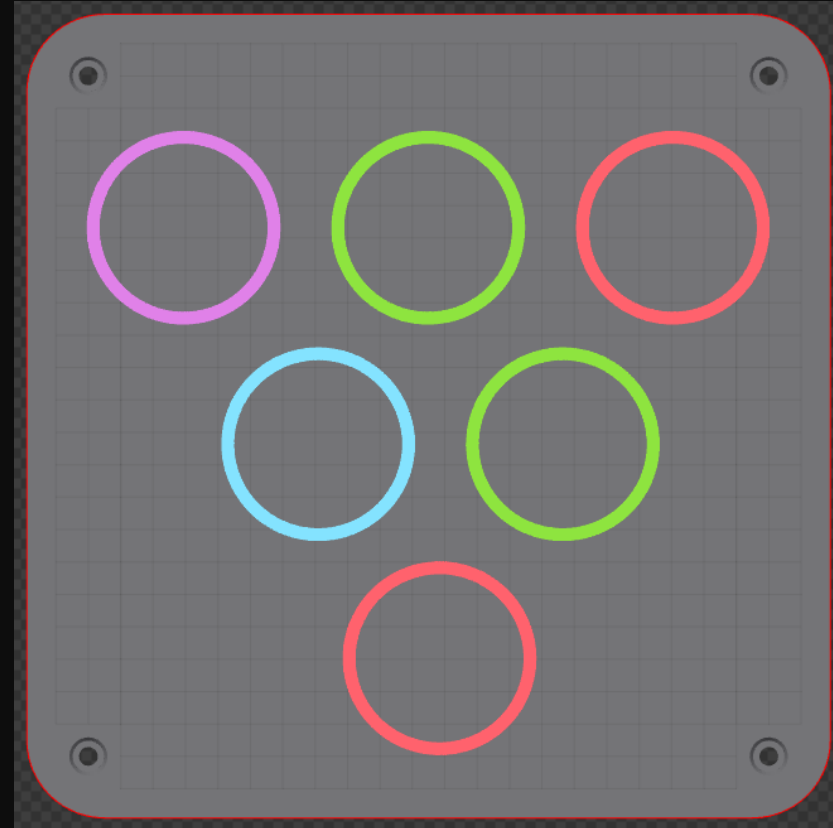
C2S Award Design & Build Process

The individual x1 CLI file was imported into QuantAM and then duplicated to allow for x6 awards per build at this stage the material selection was made Inconel 625 and a parameter selected to optimise part quality and finish.



C2S Award Design & Build Process

The next process was to assign lasers to each award to utilise the multi laser system and minimise build time and to export the .mtt file ready to run on the RenAM 500Q.



C2S Award Design & Build Process

The build is run and takes approx 12 hrs to complete x6 Awards. This build was repeated x3 times to complete all x18 Awards



C2S Award Design & Build Process

The final build is de-powdered and removed from the build chamber.



C2S Award Design & Build Process

Once all powder is removed the Awards are set up on a wire EDM machine to cut the parts off from the build plate. Each individual part is then ready for post processing.

The final steps for post processing are.

- File and smooth out top ring and Text using rotary finishing tools.
 - Fine Ceramic bead blast whole Award.
 - CNC Etch Award winner text.
 - Final polish of Main Logo.
-