

Applying Innovation to aerospace manufacturing

# Industrial Metrology

## Process control & Part verification

- CNC machine calibration and performance assessment
- Consistent process output - accommodate variation
- Compensate for changes or drift during machining
- Verification of parts to meet design intent



# Renishaw as a manufacturer

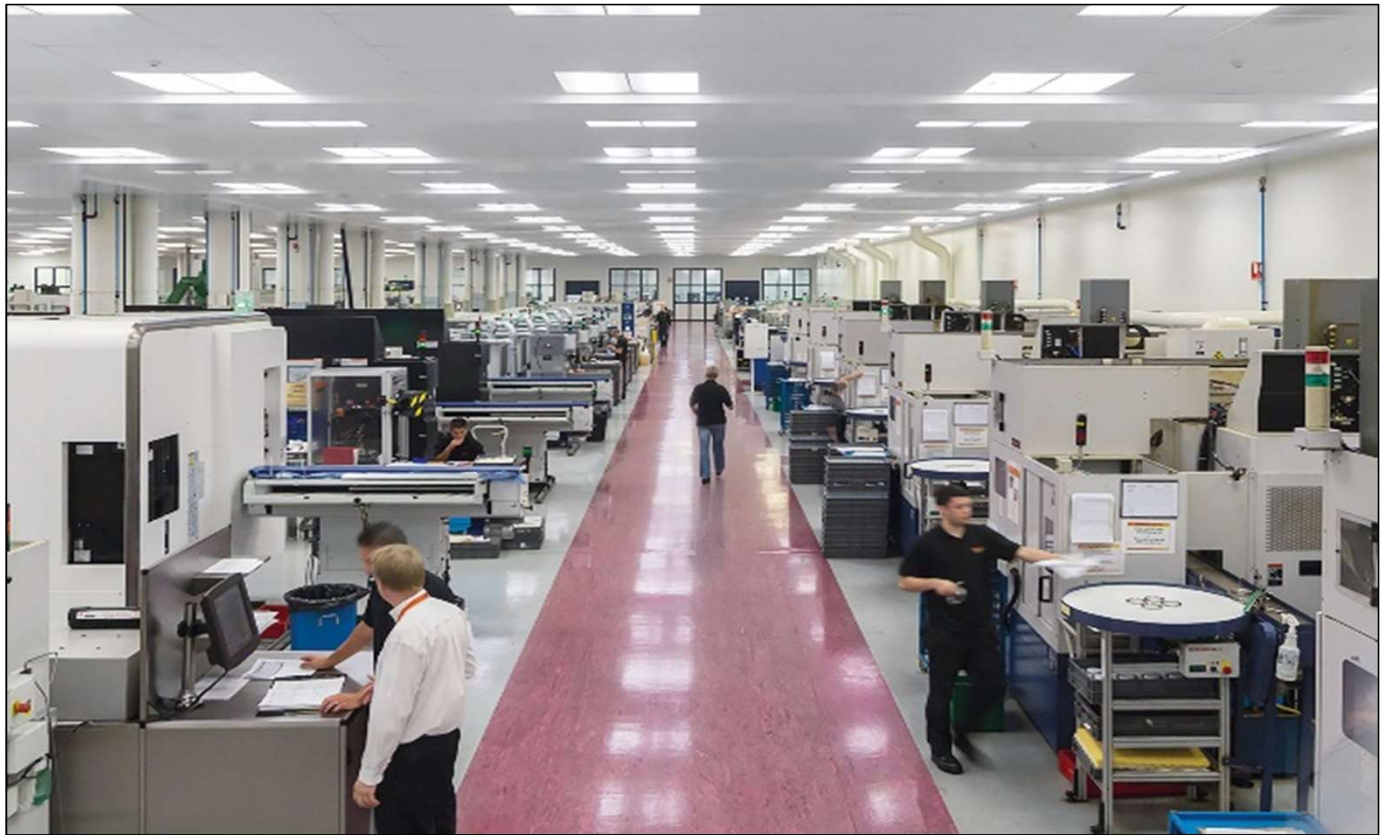
- High variety, low volume.
- Reduced CNC machining operations
- Automation
- Minimise costs
- Continually introduce new product parts



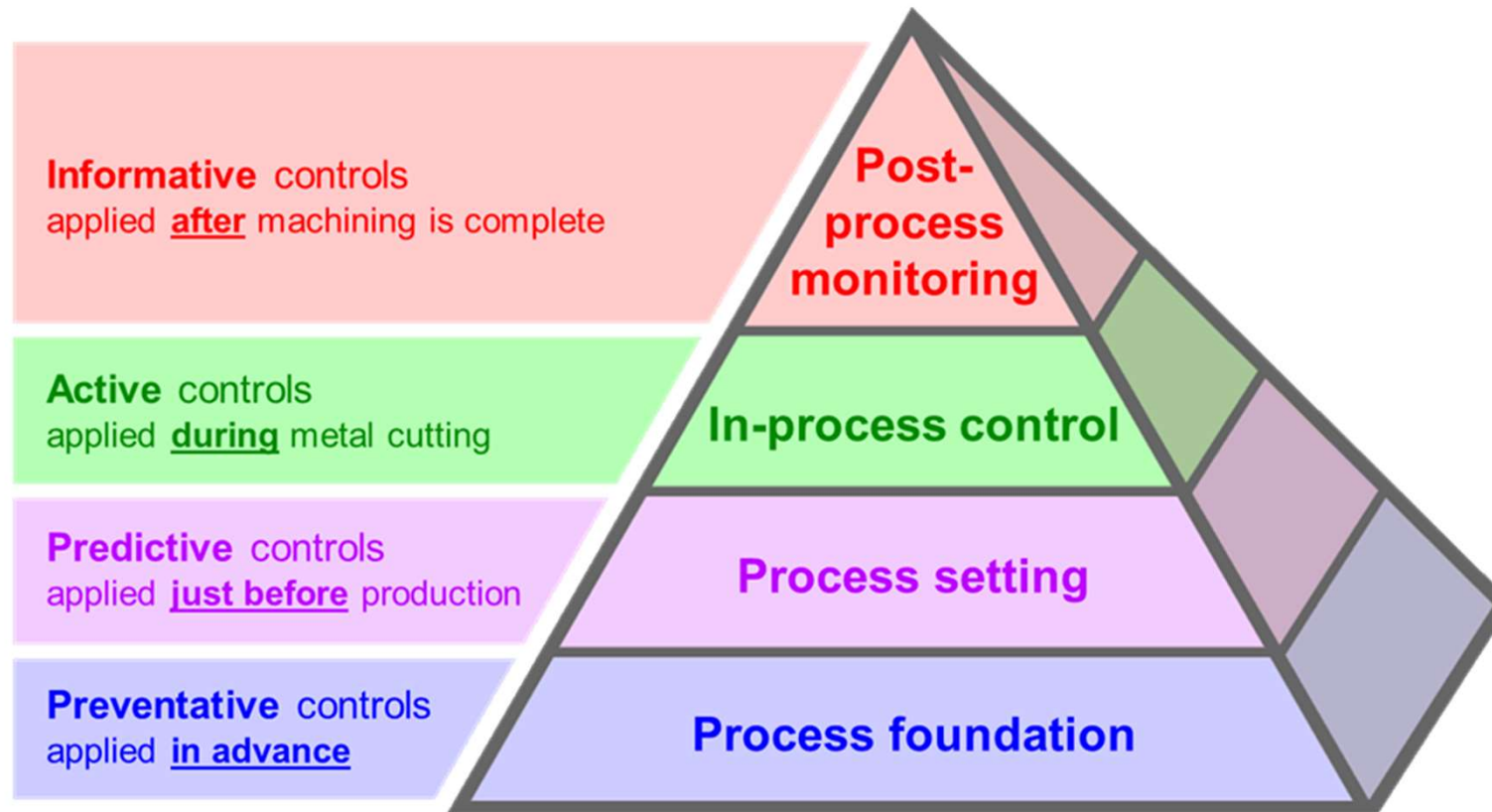


# Renishaw technology enables...






- Highly productive precision machining
- Reduced skill requirements
- Reduced quality costs
- Enabler for factory automation



# The Productive Process Pyramid



# Applications relevant to many industries

Process Input / source of variability					
Machine dynamic performance – accuracy of interpolated features	✓				
Cosmetic surface finish on circular interpolation	✓				
Machine set up – critical alignments and positions			✓		
Tool length and diameter offset measurement		✓			
Confirmation of expected tool assembly		✓			
Work piece set up – position and alignment			✓		
Compensation for input material variation			✓		
Machine and part thermal growth compensation			✓	✓	
Tool breakage detection		✓			
Process control of tool offsets			✓	✓	
Point of manufacture QA				✓	
Final certification and pass off prior to assembly					✓

# Traditional CNC manufacturing environment

High labour cost

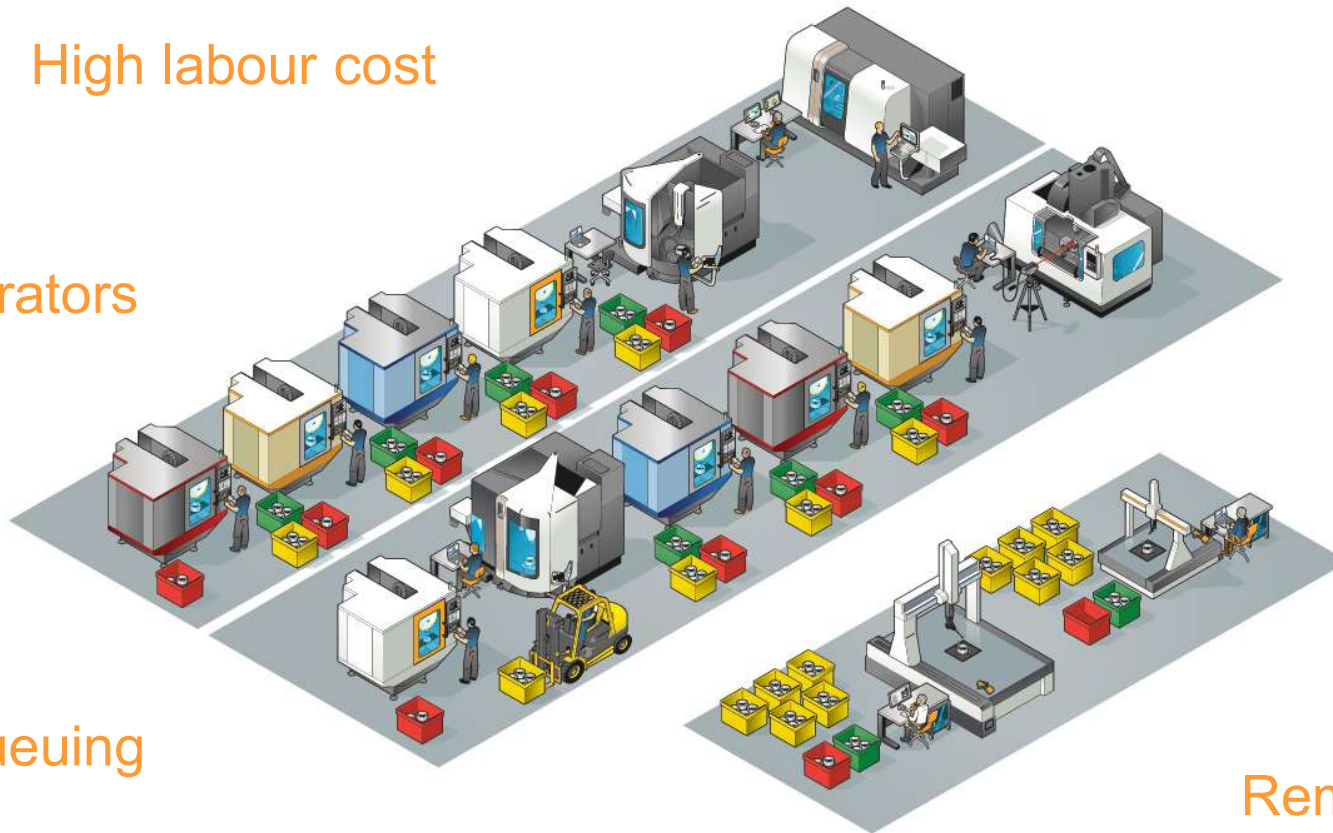
Low productivity

Skilled operators

High quality costs

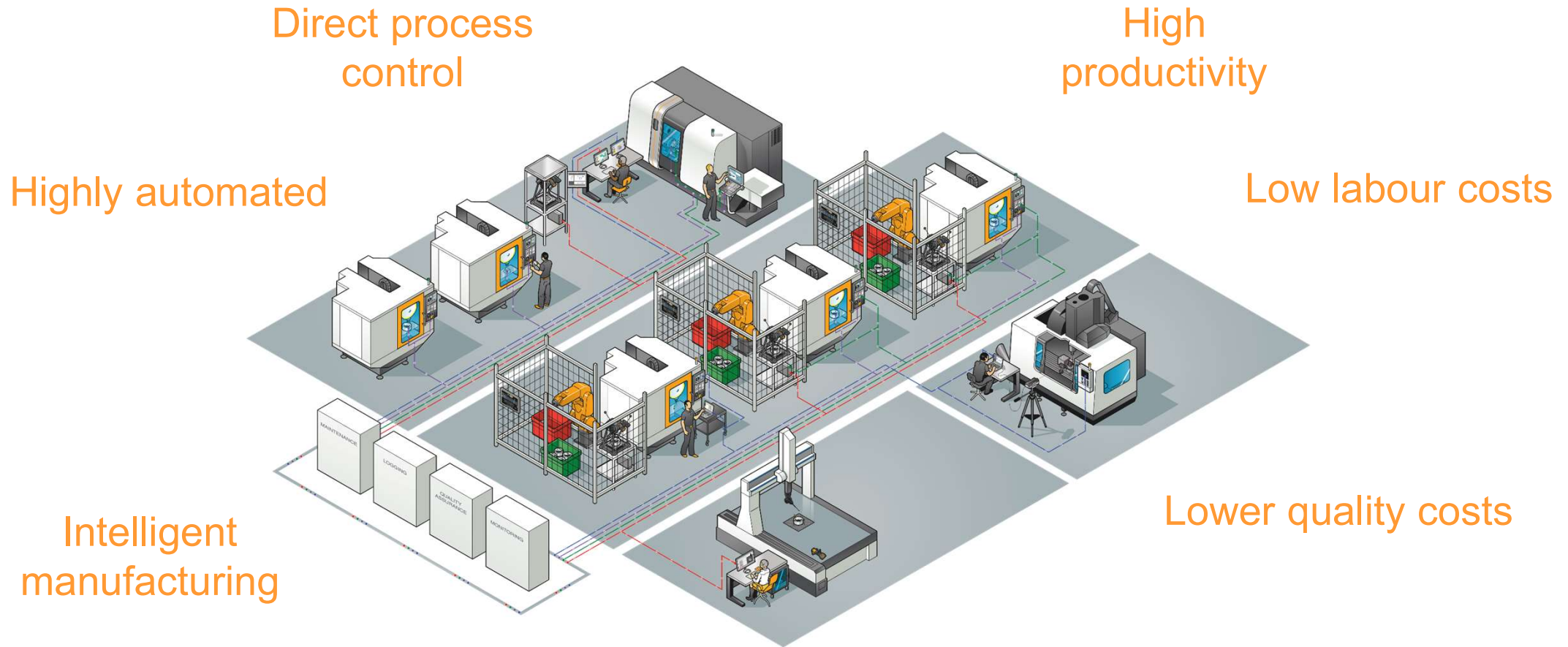
Queuing

Remote QC area





# Smart factory – our view





# Aerospace manufacturing challenges

- Increased throughput
- Cost pressures – global supply chain, labour / skills
- Quicker product development time
- Closer tolerances, better manufacturing capability
- Increased Flexible Automation
- New materials, near net processes
- Increased digitalisation of manufacturing



# Large volume machine performance

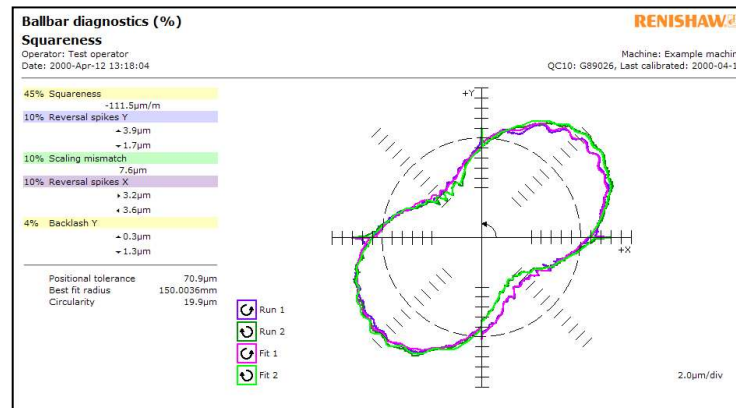
## Flow International Corporation

- HS20 Laser Encoder / RCU10
- 40m Waterjet / Routing gantry machine
- 130 hour machining cycle
- RMP60 Spindle probing system
- High value parts



# Establishing CNC machine performance

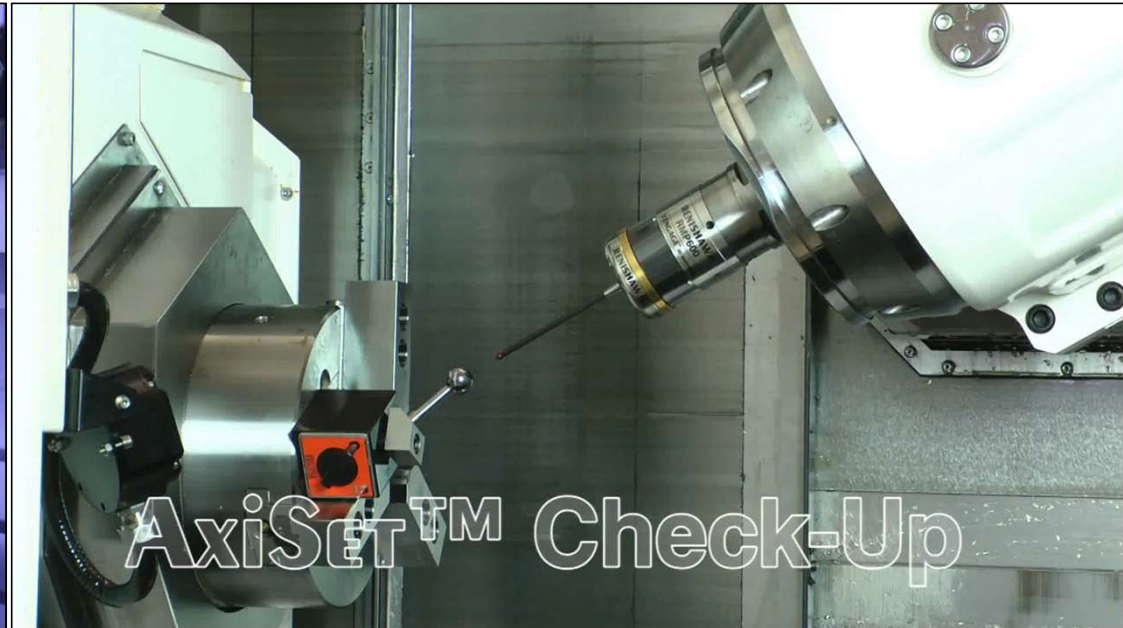
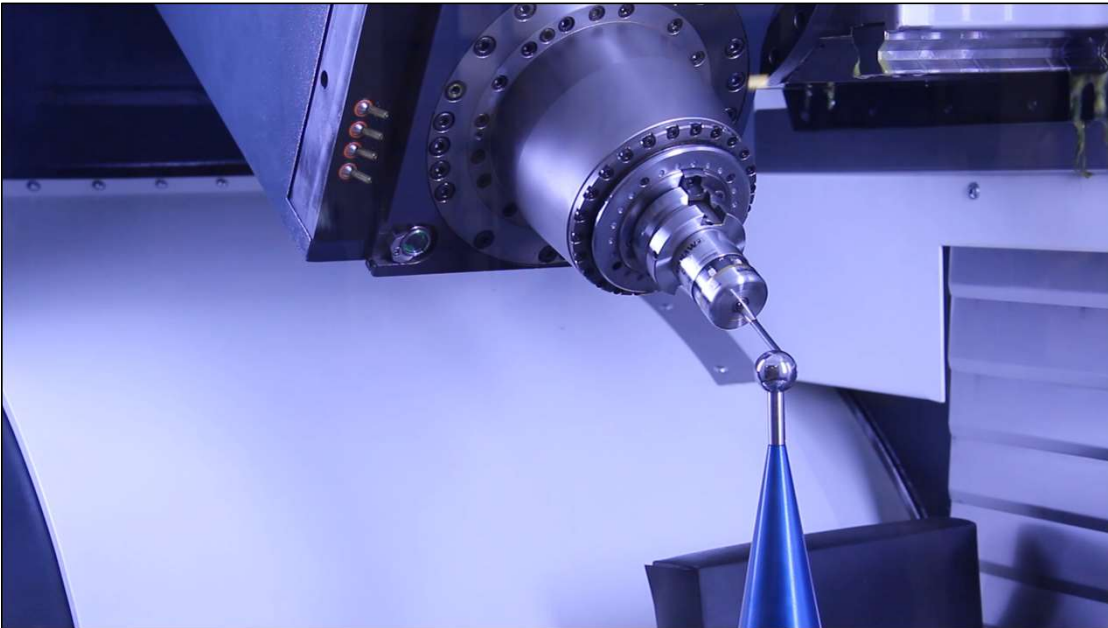
## Machine calibration





# Establishing CNC machine performance

## 5-axis machine kinematics





# Establishing CNC machine performance

## Health check



# CNC machining process set up

## On-machine tool setting

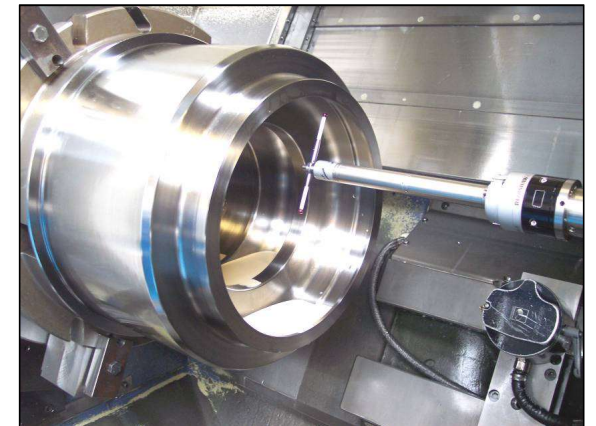
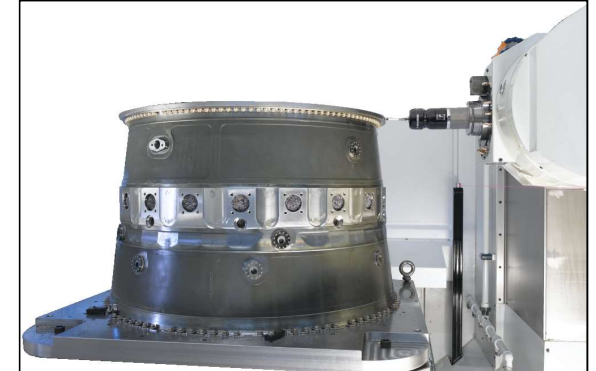
- Automatic setting of offsets
- Confirmation of correct tool
- Tool wear / breakage detection



# CNC machining process set up

## Part Setting

- Part location – work offsets
- Part alignment
- Error checking



# CNC machining process set up

## NC-PerfectPart



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Northumberland, NE66 2DE,  
United Kingdom  
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info@metsoftpro.com  
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**Case Study**  
**How MSP Helped BAE Systems Save £21 Million**  
**Using NC-PerfectPart**



INSPIRED WORK  
chairman's awards

**Customer:**  
BAE Systems PLC

**Challenge:**  
Increasing production rate and part quality while reducing setup times and costs

**Result:**  
Part setup was reduced from days to minutes leading to savings of £21m over the life of the F-35 program

**Industry:**  
Defence

BAE Systems PLC is the UK's largest defence and aerospace manufacturer, employing 90,000 people at 200 locations globally. A major contract is the rear fuselage assemblies for the F-35 Lightning II Joint Strike Fighter to US defence giant Lockheed Martin.

**Challenge**  
The Sarnesbury Engineering team are challenged with increasing the F-35 production rate to one plane set per day.

One milestone was streamlining production of Nozzle Bay Doors (NBD) for the F-35 STOVL (Short Take Off Vertical Landing) variant. A critical step was future development to allow the door to be machined to tight tolerances despite its complex and varying shape.

Other strategic project aims were reducing long setup times, lower production costs and increasing part quality.

**Working together**  
BAE Systems had already worked with MSP successfully on a number of key defence projects, including Eurofighter Typhoon, and previous F-35 projects, making MSP natural partners for this new challenge.

**Success**  
Using NC-PerfectPart, the BAE Systems engineering team developed an innovative setup technique, known as sticky fixturing. A simple way to hold a component in its free-state while it is machined.

Conventional components being processed similarly to the new were held in place on vacuum routing fixtures, however, vacuum would have distorted this configuration of component.

Working together BAE Systems and MSP developed adaptive machining on a sticky fixture utilising MSP's automated parts set up. This collaboration ensured the team realised the challenge for the NBD.

Part setup was reduced from days to minutes leading to savings of £21m over the life of the F-35 program.

"Collaboration between MSP and BAE Systems has allowed the team to develop a unique method of holding and adaptively machining on a sticky fixture. The team's innovative approach and expertise in their respective fields has led to considerable safety, quality & cost improvements."

Bob Greenhalgh  
Combat Air Detail Manufacture Fabrications  
Manufacturing Engineering Manager  
BAE Systems PLC

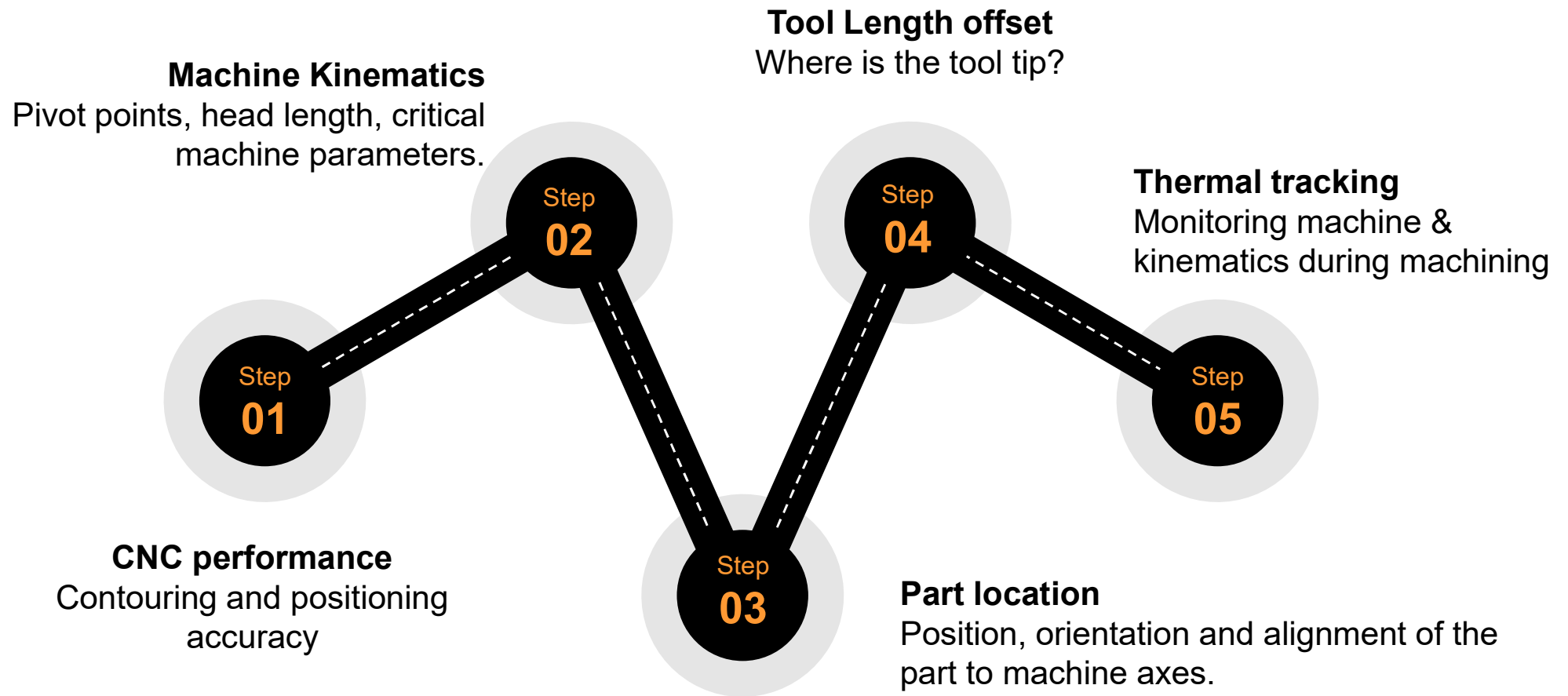
**Award**  
The innovation and engineering excellence involved was recognised with a BAE Systems Chairman's Gold Award. This was the 3rd award the collaborating teams have won for their contributions to innovation and cost reduction.

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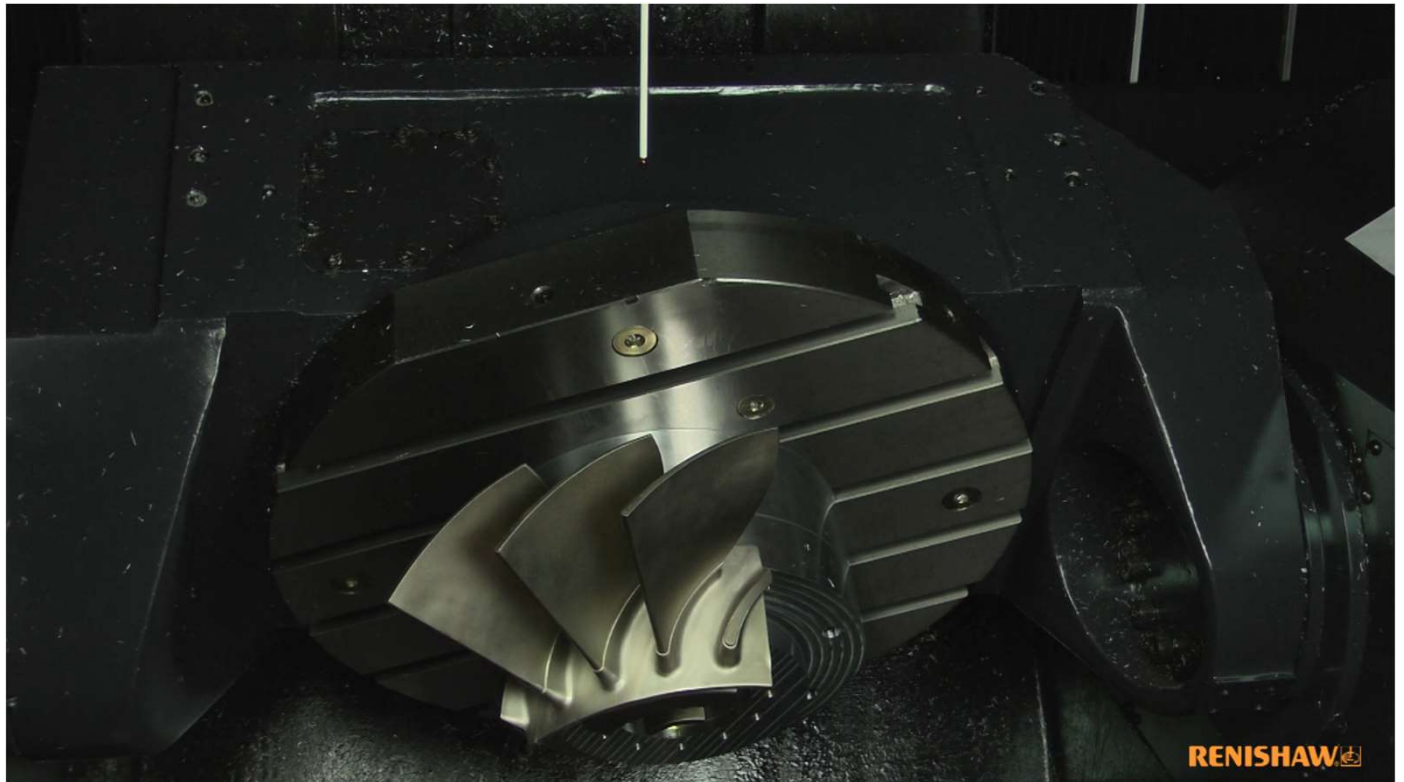
# Precision 5-axis machining



# Automated process control

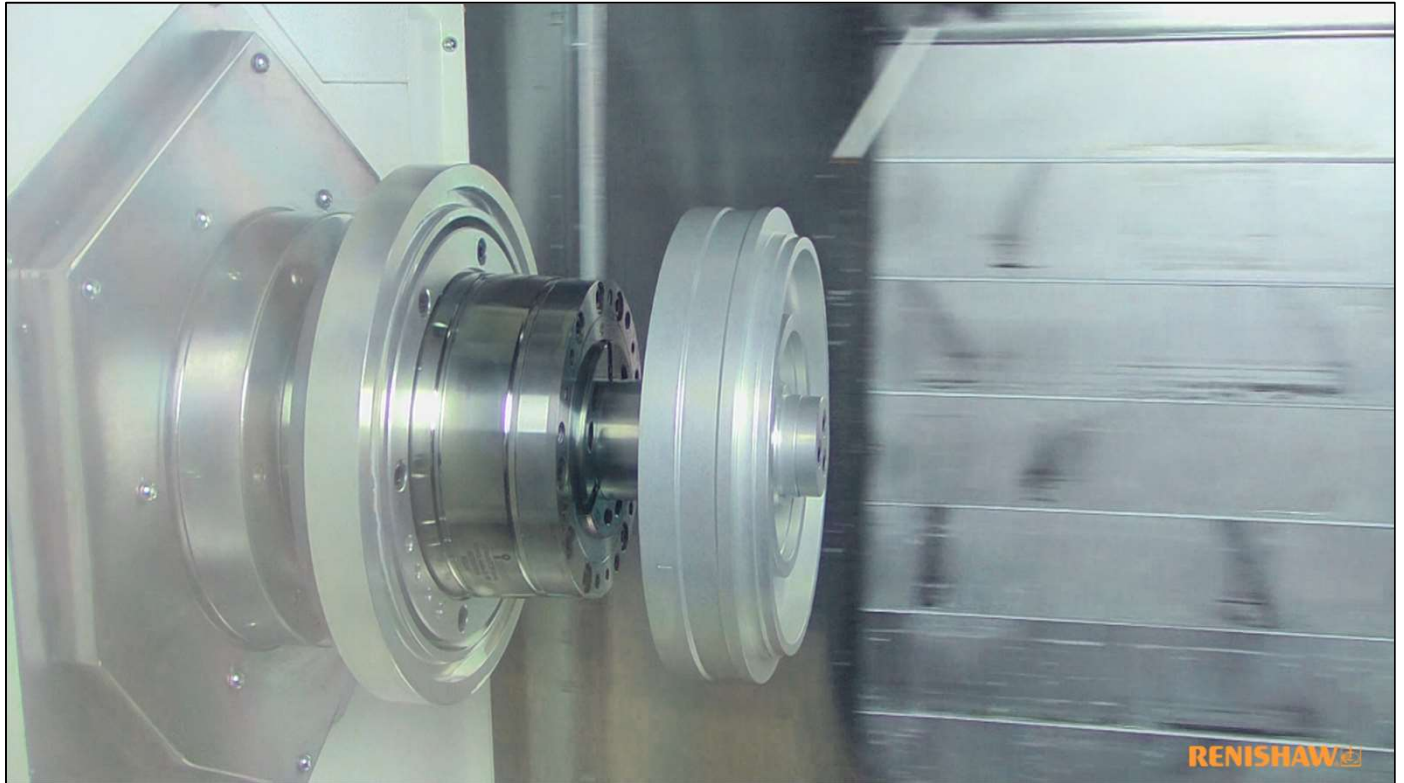
## Adaptive machining...

- Removal of friction welded excess material.
- Removal of welded bead on blade tip.
- Zero fettling or manual polishing.



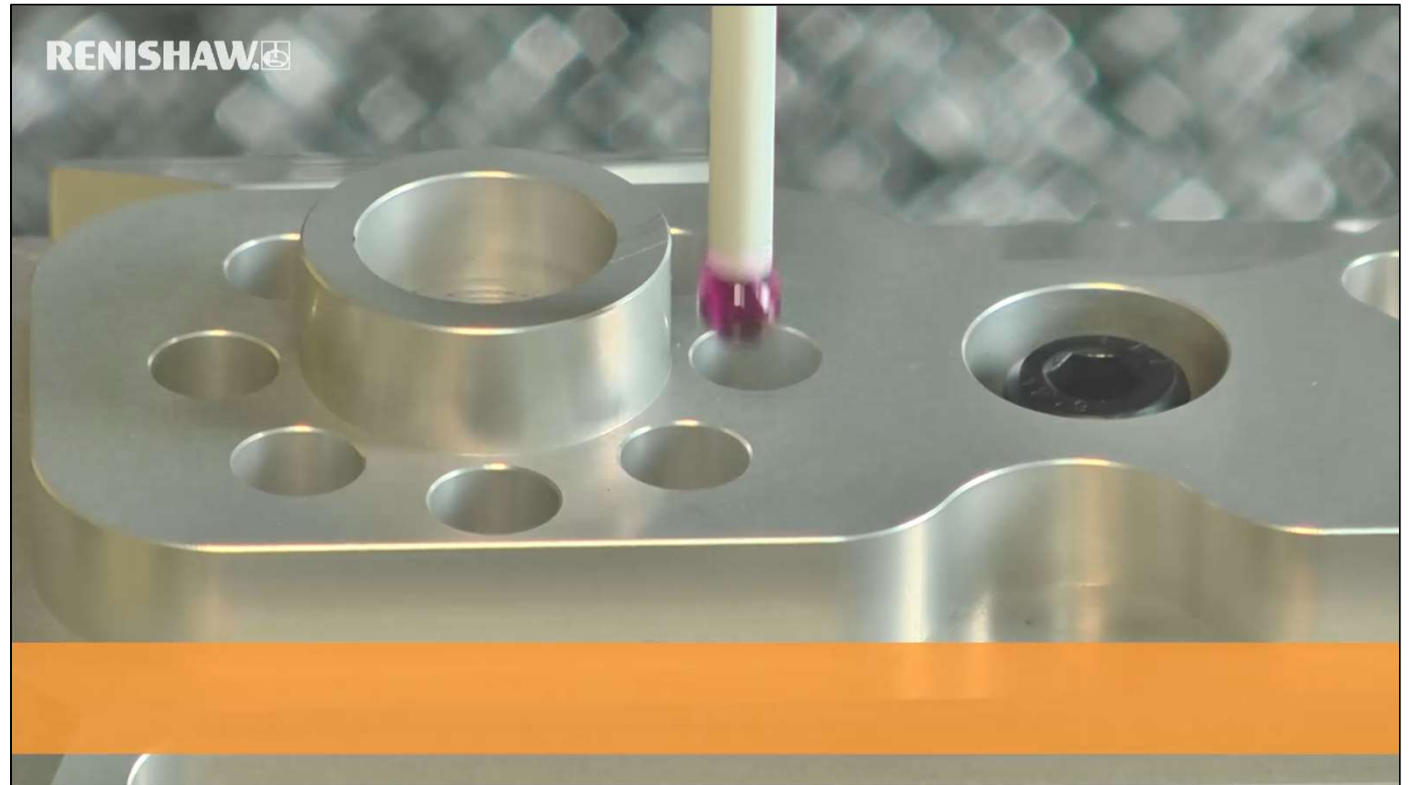
# Automated process control

## Automated strategies



# Automated process control

## In-process checks





# Automated process control

## In-batch measurement – Equator



# Process and part validation

## Process validation



# Process and part validation

## Part validation



# Process and part validation

## Multi sensor technology





# Additive manufacturing in aerospace

## Aerospace performance drivers

- ✓ Light-weighting
- ✓ Part consolidation
- ✓ Complex forms
- ✓ Automated manufacture
- ✓ Efficient use of materials

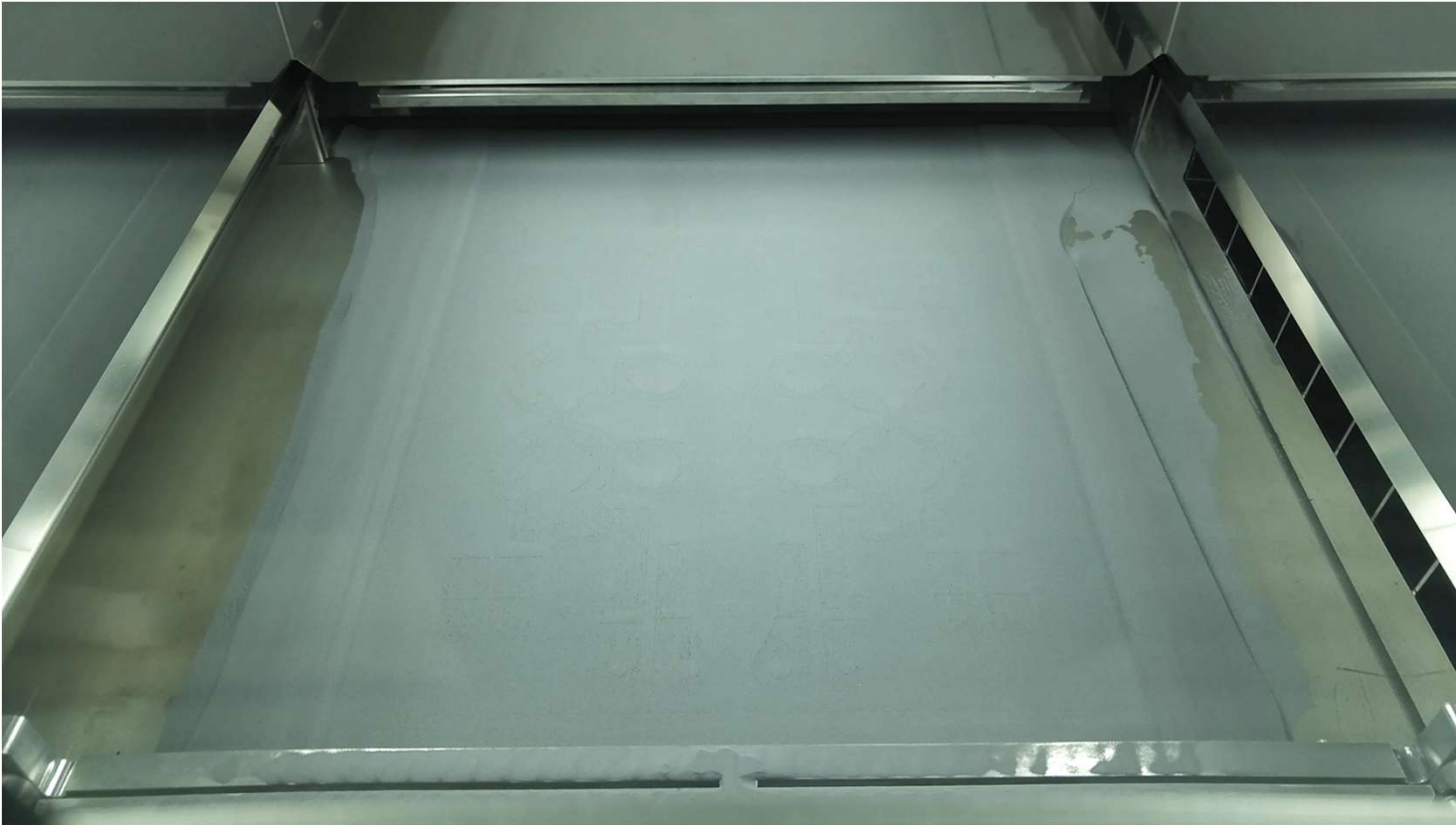
Microwave guide  
for telecoms  
satellite



Titanium  
rocket  
nozzle



# Productive laser powder bed fusion



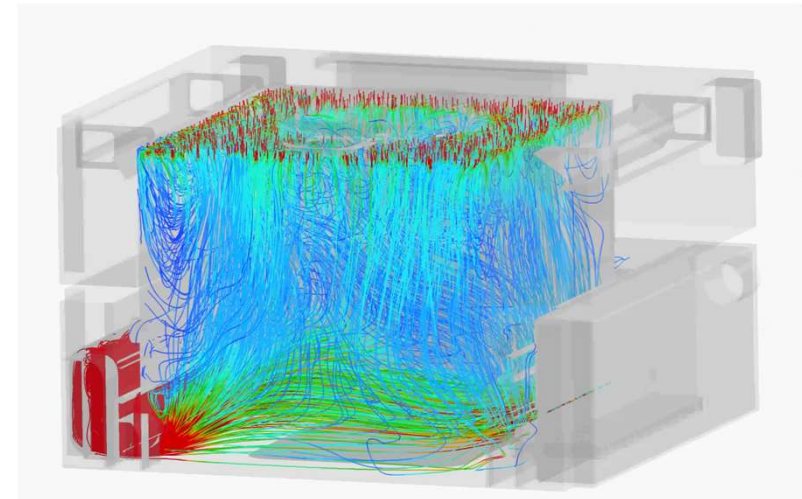
# Higher productivity = lower part cost



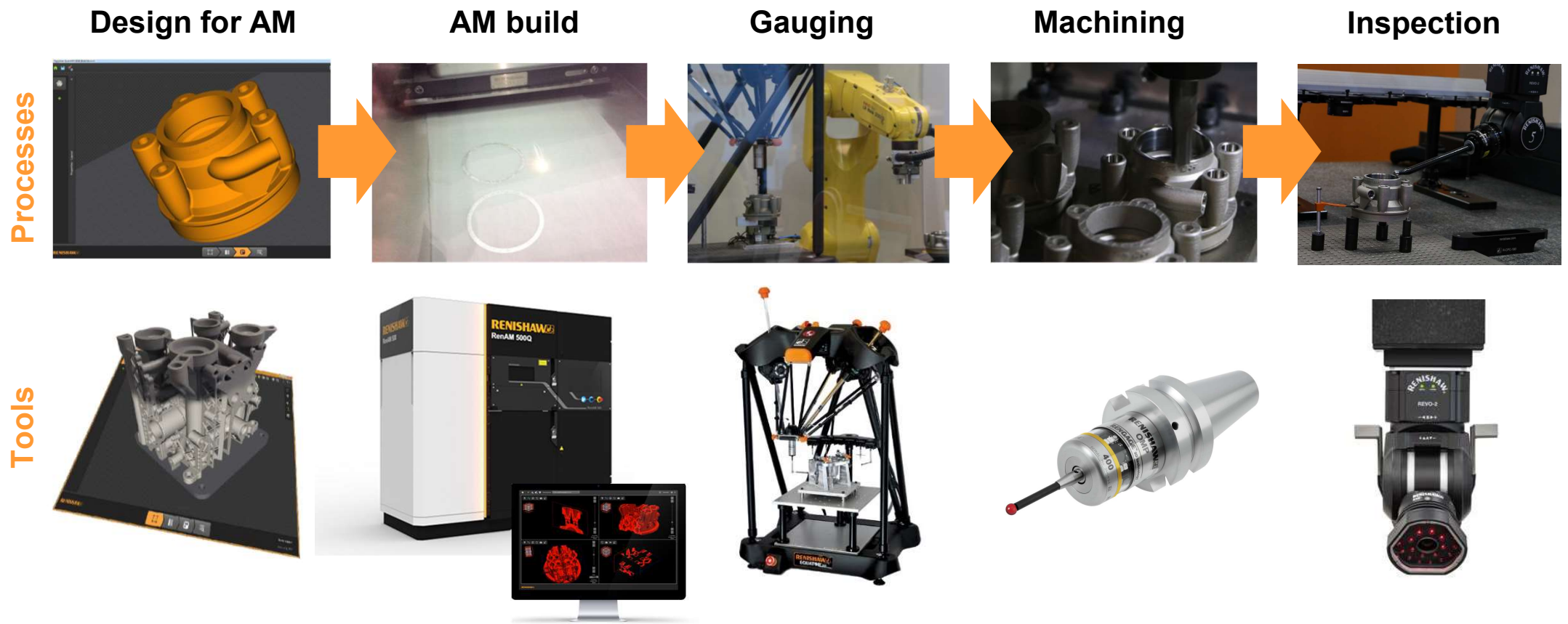
## Faster laser powder bed fusion

- Multi-lasers enable faster builds for lower part costs
- Intelligent gas flow ensures consistent quality for high fatigue performance
- Efficient powder re-cycling for minimal waste

Gas flow CFD  
simulation



# Solutions for the entire AM process chain





*aerospace*  
**Your partner** for innovative manufacturing

