

Large Machine Tool Challenges

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LUMINAR Large Volume Metrology Workshop – NPL 18/5/2016

Content

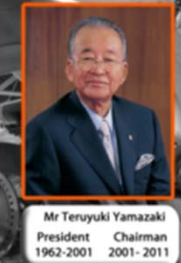
It's all about you 

- Mazak overview
- Multi-tasking & large machines
- Current trends in machine compensation
 - Thermal
 - Volumetric
- Current trends in multi-tasking
 - Gear form machining
 - Hybrid additive/laser cladding
- Manufacturing challenges
 - Aerospace
 - Mazak UK

Yamazaki Mazak Corporation

It's all about you

- **Family owned business**
 - Founded in 1919
- **Turnover:**
 - More than \$ 2.6 billion US
- **No of Employees:> 7,000**
 - >1,000 in Europe (600+ in UK)
- **10 Production Plants:**
 - 5 Japan, USA, Singapore, Europe (UK), 2 China
 - European facility established in 1987 – 29,000m²
 - Manufacturing for the European Market
- **78 Technology Centres in 22 Countries**
 - 14 in Europe
- **Over 250 different models produced**
 - 55 manufactured in the European facility.
- **Installed base in excess of 195,000 Machines**
 - More than 50,000 in Europe – 50% manufactured in Europe
- **Serving industries that touch our daily lives.**



Supporting Customers Through Technology Centres



The need for Multi -Tasking Machining

It's all about you



CNC Lathe



CNC Lathe with Milling or
CNC Lathe + Vertical machining centre



Multi-tasking Machine

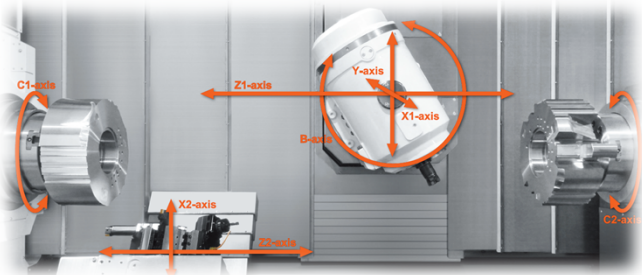
Main components of a Multi-Tasking machine It's all about you

Combination turning centre and machining centre – horizontal work spindle

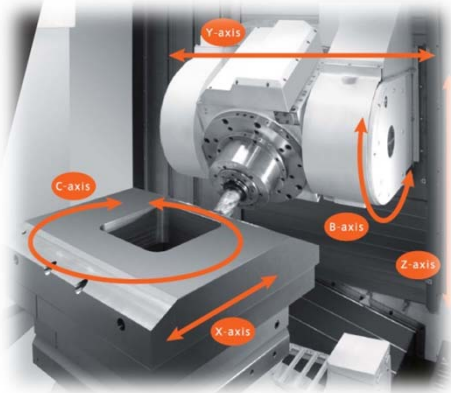


Horizontal or Vertical spindle configurations

It's all about you



Horizontal spindle



Vertical spindle



0.4 – 8m between centres capacity



0.67 – 3.5mØ capacity

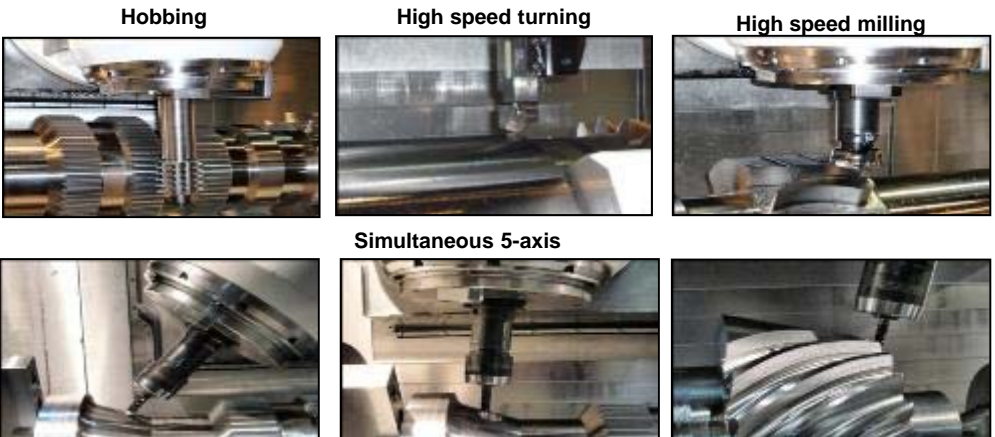


Process integration on Multi-Tasking machines It's all about you

- Consolidation of many specialist operations
- Single machine process for shaft machining



- Many different types of components produced on multi-tasking machines



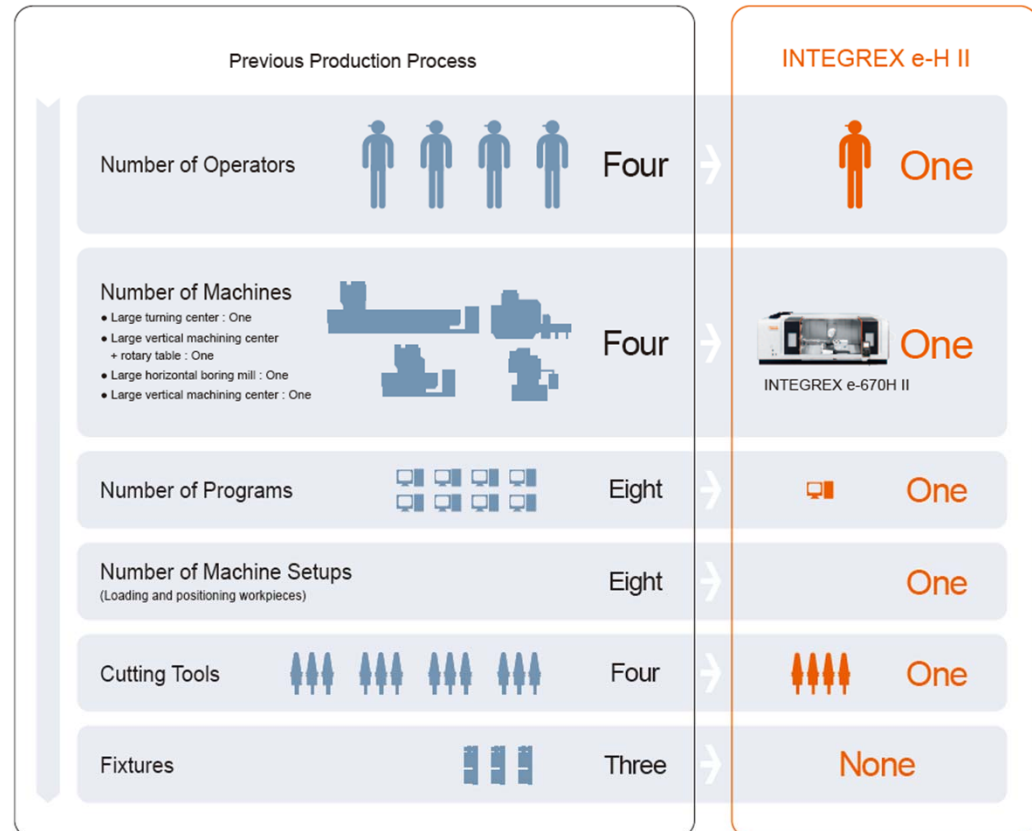
Process integration

It's all about you



workpiece length : 2500 mm

This printing machinery roll component with its high accuracy machining requirements was previously processed by several different machine tools requiring multiple setups and workpiece handlings



Large capacity machining centres

It's all about you

Vertical spindle



10 x 3.1 m table capacity
43 tonnes max cpt weight



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Horizontal spindle profiler



4.2 x 1.5 m table capacity



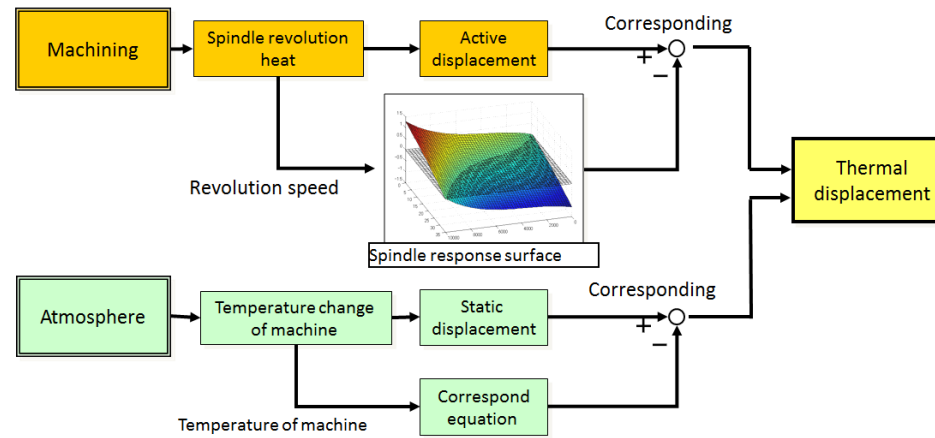
Current trends -Thermal compensation

It's all about you



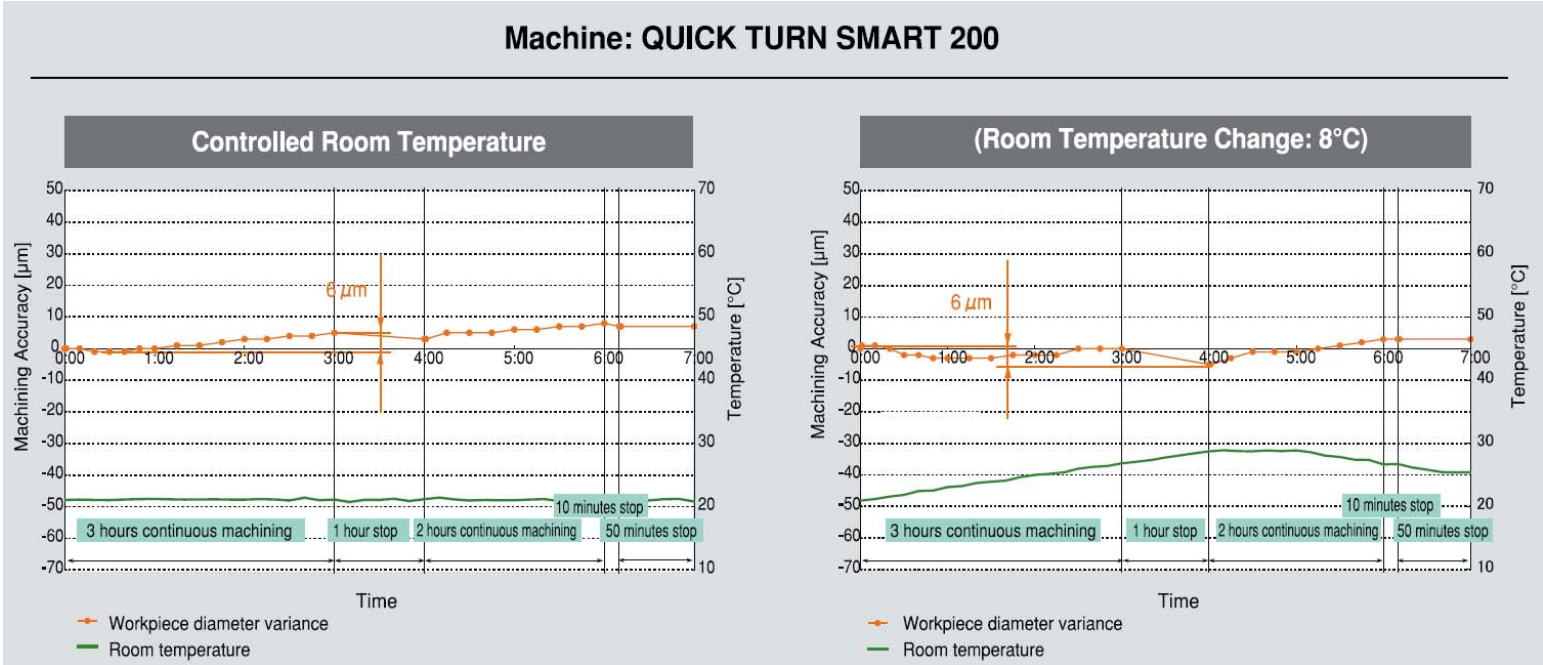
ITS

- Intelligent Thermal Shield - Sensors are positioned on the machine structure & spindle and feedback data to the CNC which then compensates axis positions accordingly



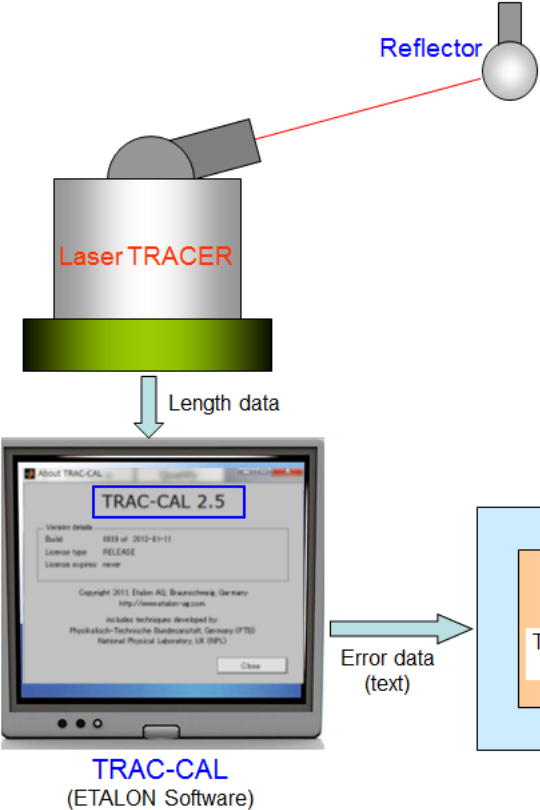
Current trends - Thermal compensation

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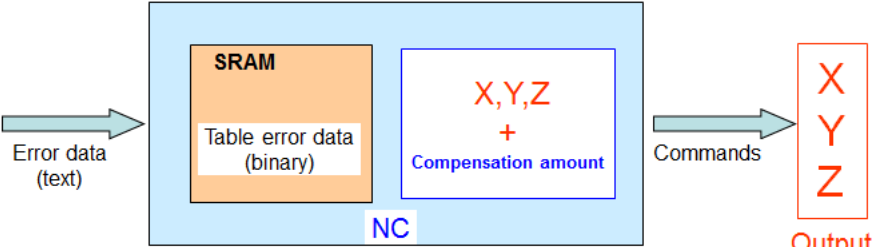


Current trends - Volumetric compensation

It's all about you



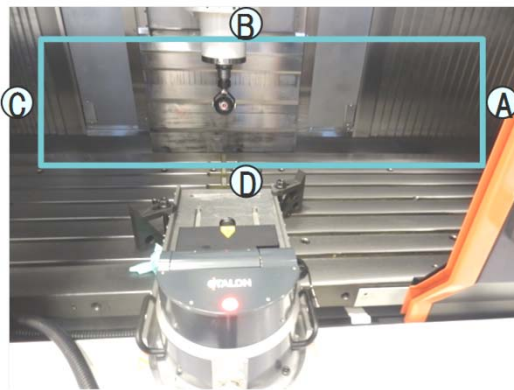
- Volumetric compensation is available as a special option on many of our larger machines
- Calibration is carried out with an Etalon laser tracker system but it is a time consuming & costly activity
- Technique & customer understanding is still in the early stages of acceptance



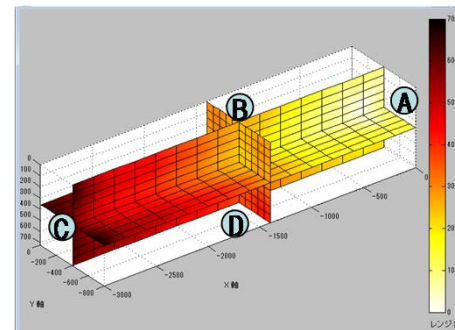
Current trends - Volumetric compensation

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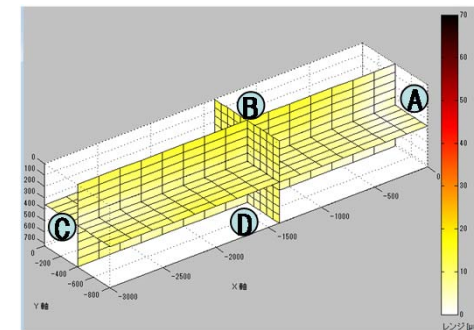
- Vertical travelling column machining centre
- X=3000mm, Y=800mm, Z=720mm



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No compensation

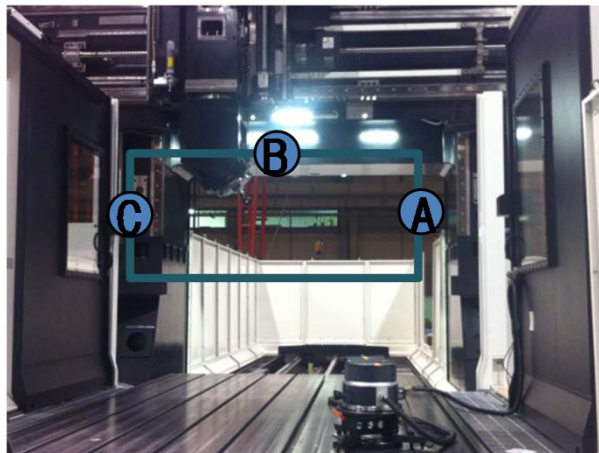


With compensation

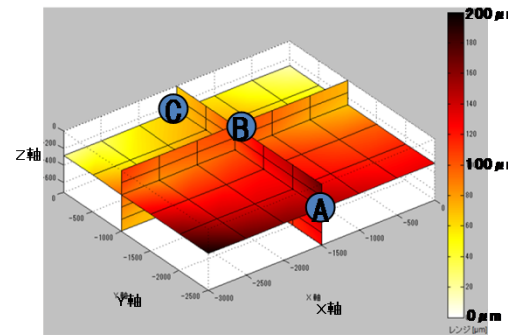
Current trends - Volumetric compensation

It's all about you

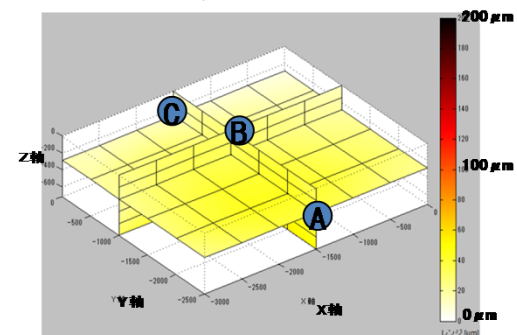
- Bridge type vertical machining centre
- X=6000mm, Y=3800mm, Z=710mm



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No compensation



With compensation

Current trends in Multi-Tasking

It's all about you

- Production of gear forms
- Additive manufacturing



Production of gear forms - hobbing

It's all about you

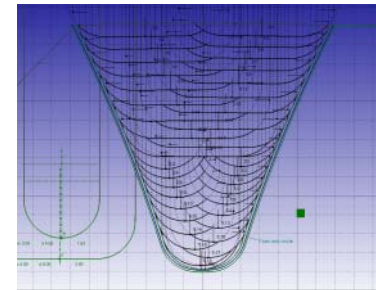
- Gear & spline hobbing
 - Multiple features with differing helix angles and modules – one setting
 - Finish machining of 30° pressure angle involute splines
 - Rapid set up
 - Fastest method of producing gear teeth (pre-grind)



Production of gear forms - milling

It's all about you

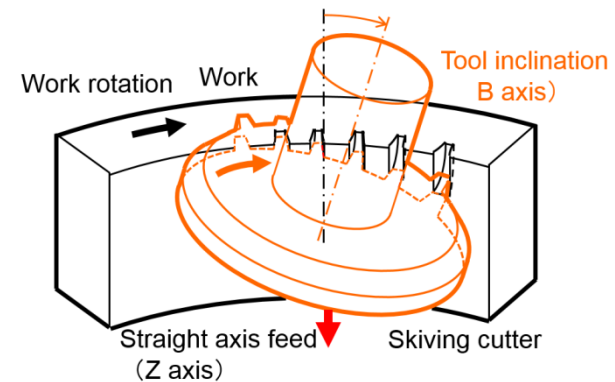
- Gear milling by parametric software generated toolpaths using a ball nose or conventional end mill
 - Simple programming via a CAD/CAM system
 - Standard milling tooling / minimal setting
 - Herringbone, Helical, Crowned and Spiral bevel gears
 - Soft and hard gear machining



Production of gear forms – power skiving

It's all about you

- Intermittent milling process of the gear tooth profile - a mixture of hobbing and shaping
- Considerable reduction in cycle time compared to other methods
- Machine requirements –
 - robust structure
 - accurate synchronisation between work spindle and milling spindle
- Forecasted by tooling suppliers that over the next 5 years power skiving will significantly replace broaching, shaping, shaving and hobbing for many commercial transmission applications



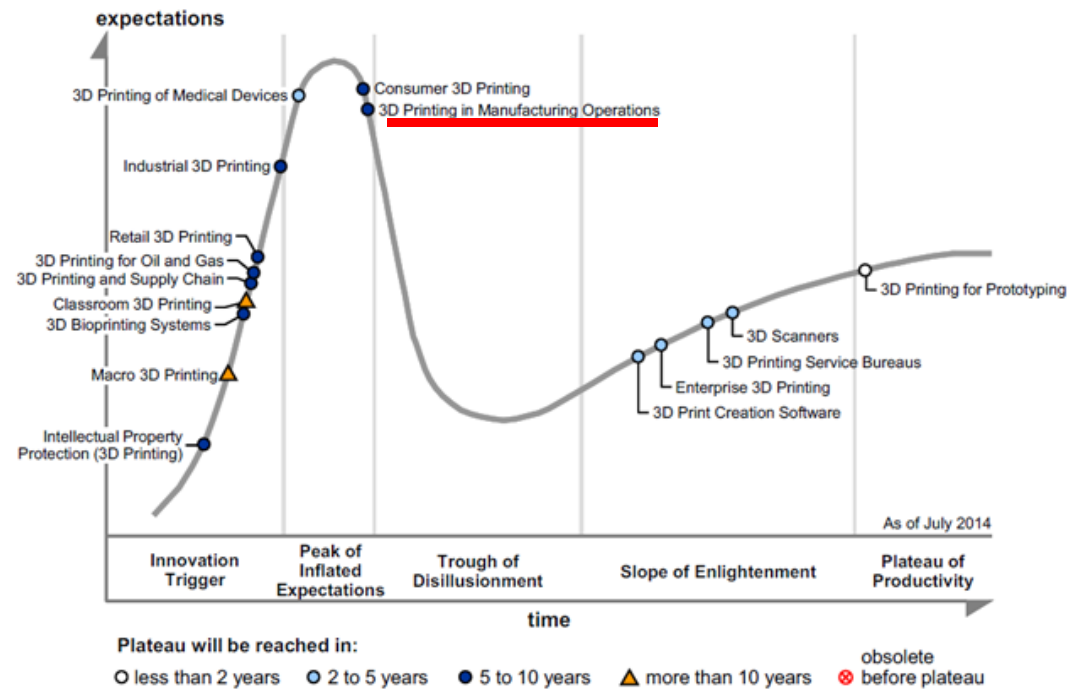
Additive Manufacturing AM

It's all about you

- Hype cycle for 3D printing (AM)
- Two main types being developed
 - Selective Laser Melting

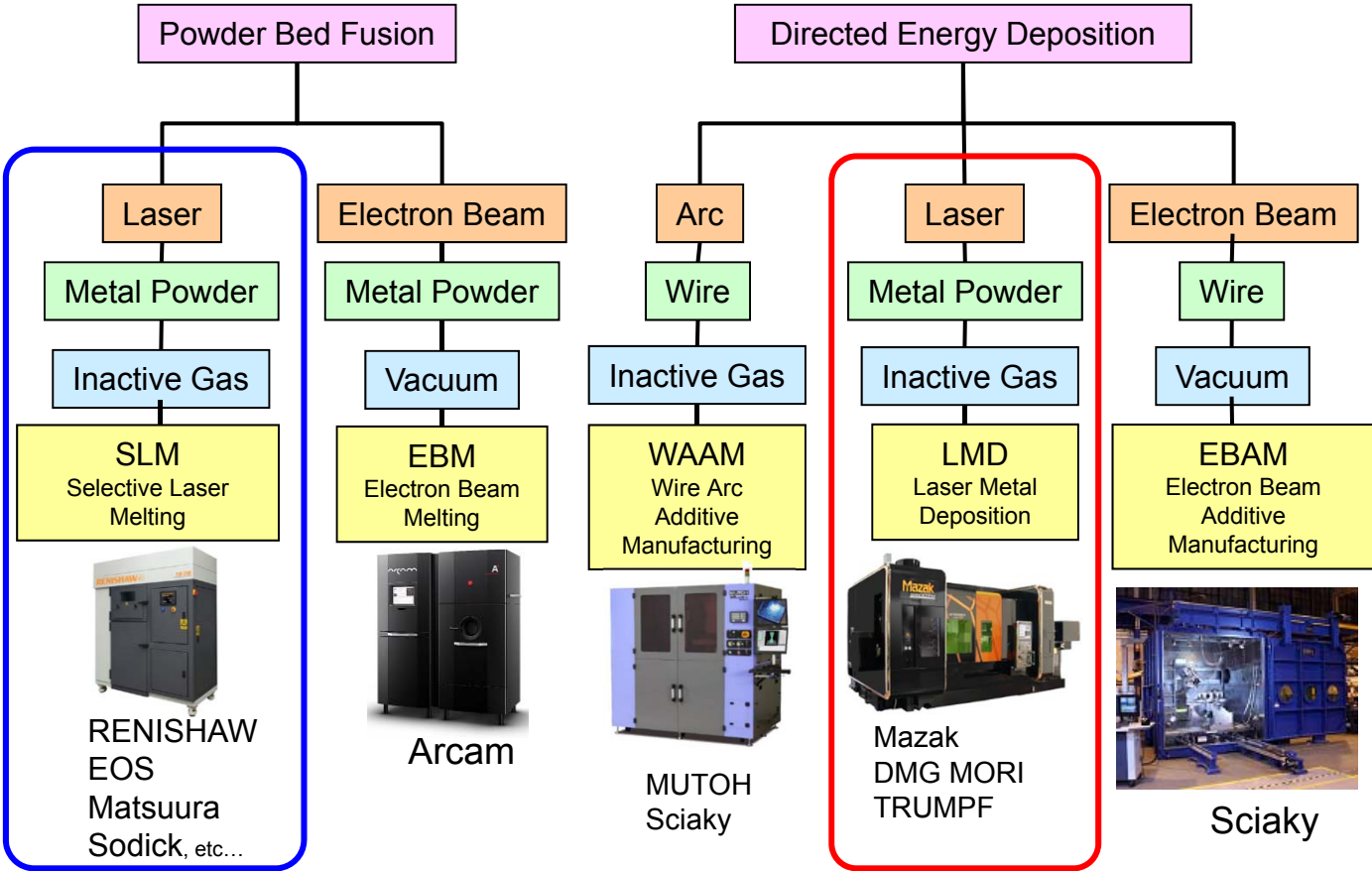


- Laser Metal Deposition



Metal AM Types & Makers

It's all about you

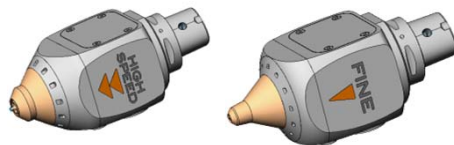


Hybrid Manufacturing

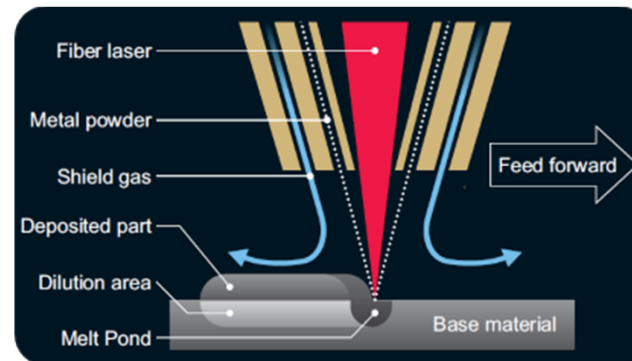
It's all about you

- Hybrid technologies will deliver the benefits of both subtractive and additive technologies.
 - Reduced material usage
 - High accuracy / surface finish
 - Mixed material properties
 - Greater geometrical freedom
 - Enhanced productivity.

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INTEGREX i400AM



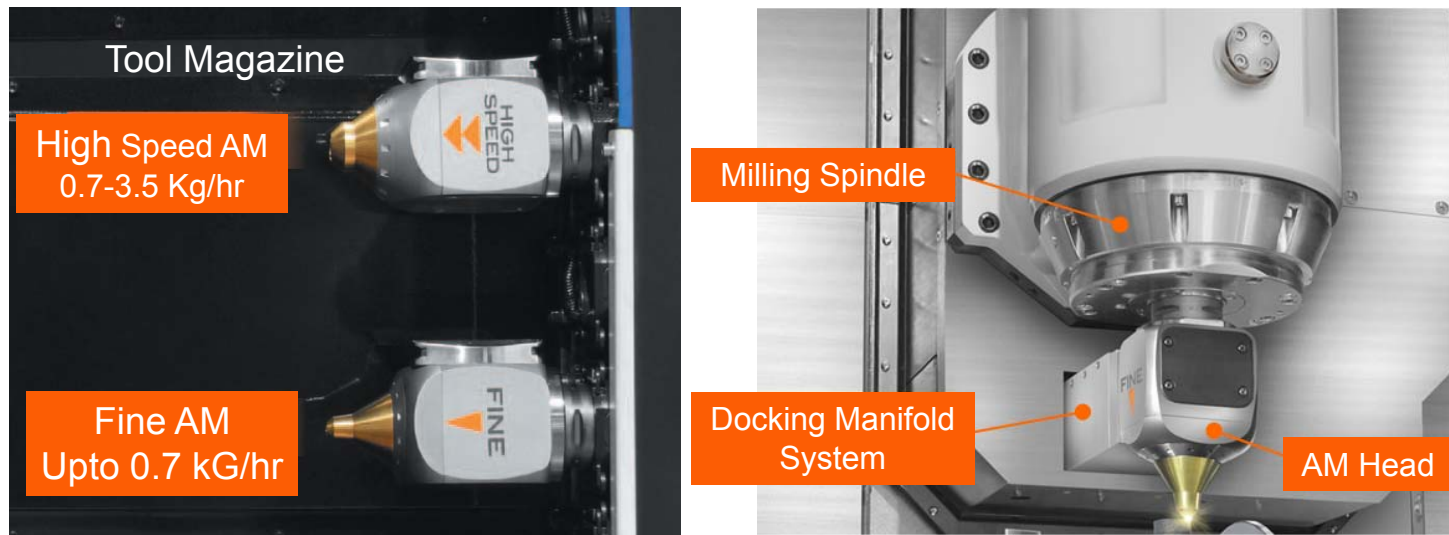
3D DED Additive cladding



Finished Machined Part.

AM Heads

It's all about you



- ATC-able AM heads (stored in tool magazine)
- Optimize AM conditions for many applications (AM features size, Metal powder materials and etc...) by changing different characterized AM head

Demonstration Part: Drill Bit Cutter Coating

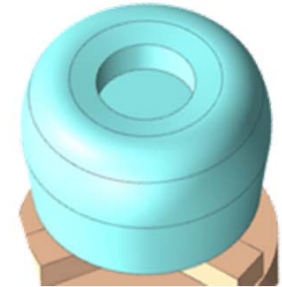
It's all about you

Material (Substrate) : C45

+ AM : Inconel 718



OD:250×ID:130×L:110mm



Material	Metal Cutting Only
AM	Hybrid Process

Manufacturing challenges

It's all about you

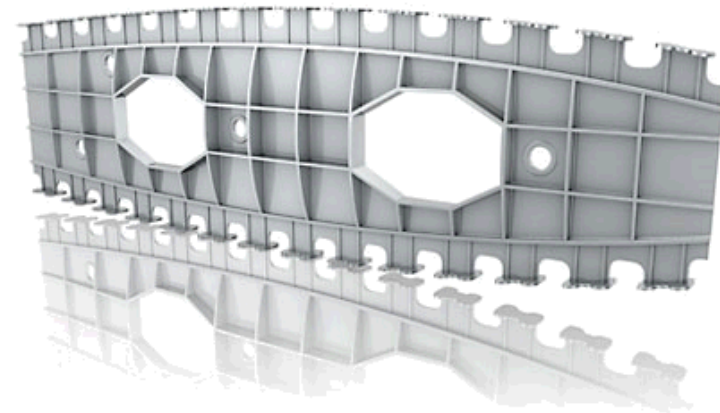
- The aerospace sector is driving many current machine tool developments particularly with respect to part complexity & materials



Aerospace - Part Complexity

It's all about you 

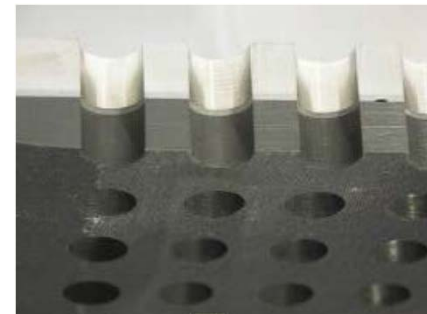
- The size and increasing complexity of components challenges machine tool manufacturers to develop
 - platforms that balance machine speed and dynamics with rigidity and accuracy.
 - leveraging the performance of the latest state of the art control technology.
- The buy to fly ratio is a key driver



Aerospace - Materials

It's all about you

- Increasing use of CFRP materials and metallic composite stacks.
 - De-weighting enhanced strength / weight ratio
 - Corrosion resistant
- Requires new approach to machining to ensure.
 - No material delamination.
 - Surface Integrity maintained.
- Machine design must ensure
 - Particulate evacuation
 - Protection of motion and electrical systems
 - Effective handling of dust / swarf
- Close partnerships with tooling suppliers critical for developing best methods



Materials

It's all about you

- Increasing use of titanium parts per aircraft require emphasis on machine structure and spindle design for optimised machining performance.
 - Boeing 707 – 0.5% of total aircraft weight
 - Current airframes – 10% of total aircraft weight
- Development of innovative cutting strategies for example Trochoidal & High performance 5 Axis toolpaths.
- Enhanced cooling technologies for example Cryogenic, high flood or indeed as now under research Minimum Quantity Lubrication (MQL) – Titanium
 - Enhance tool life.
 - Environmental considerations.



Mazak UK manufacturing challenge

It's all about you

- Single piece cast iron bed
- 5 face machining on Mazak bridge type vertical machining centre with pallet changer



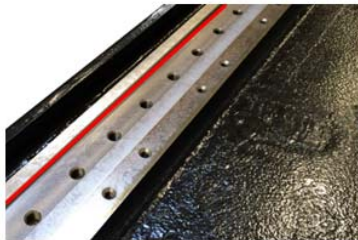
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Bed parallelism

It's all about you

- Owing to increased parallelism tolerances required for roller linear bearings we have to maintain a 10 μm parallelism tolerance over the rail span of approx 1500mm along the length of the rail, approx 4000mm



- Measured with bridge plate and Dial Test Indicator
 - Prone to error and demands high skill level
 - Bed can be measured several times during machining and assembly

Thank you – Any questions?