Modern optimization of production processes through coordinate metrology at Rolls-Royce

Martin Harding, Rolls-Royce Deutschland Ltd. & Co. KG

November, 23rd 2016

1st 3D Measurement Conference, Aachen

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Private – Rolls-Royce Data

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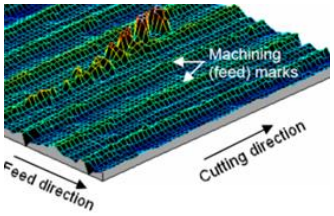
Outline

Rolls-Royce

Technical challenges in measurement of modern aero engine components

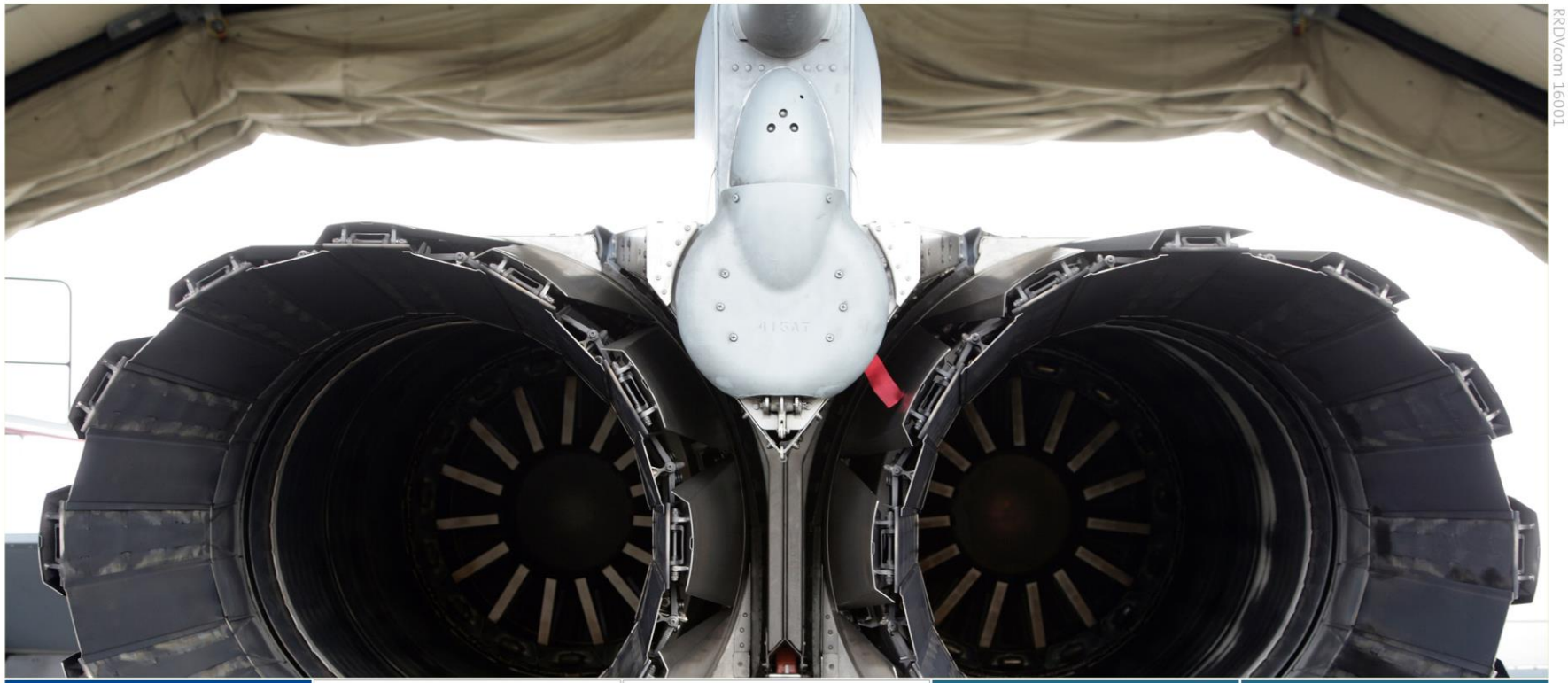
Examples



Outlook

Rolls-Royce

Latest (2015) financial highlights



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order book	underlying revenue	underlying profit	employees	countries where present
£76.4bn	£13.4bn	£1.4bn	50,500	46

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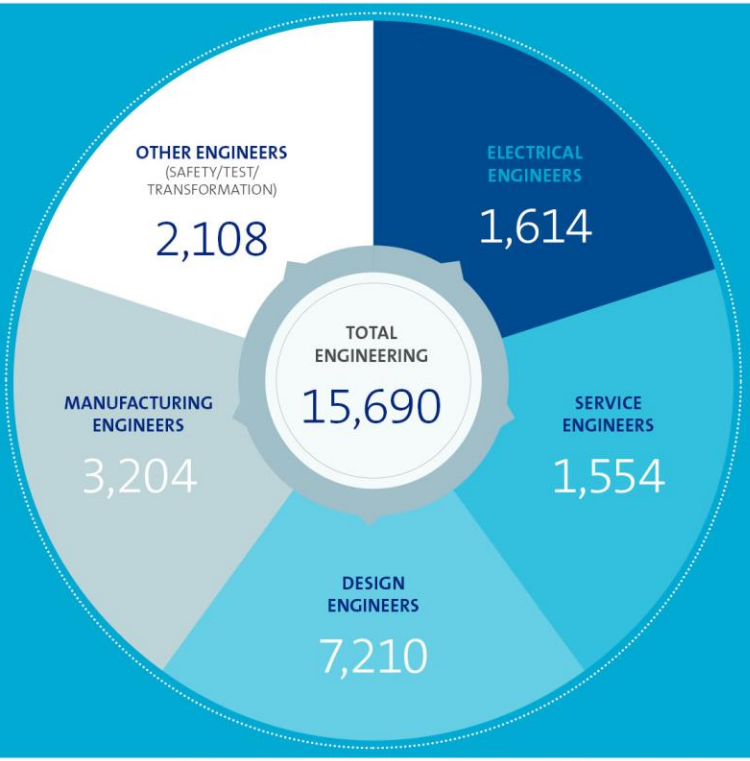
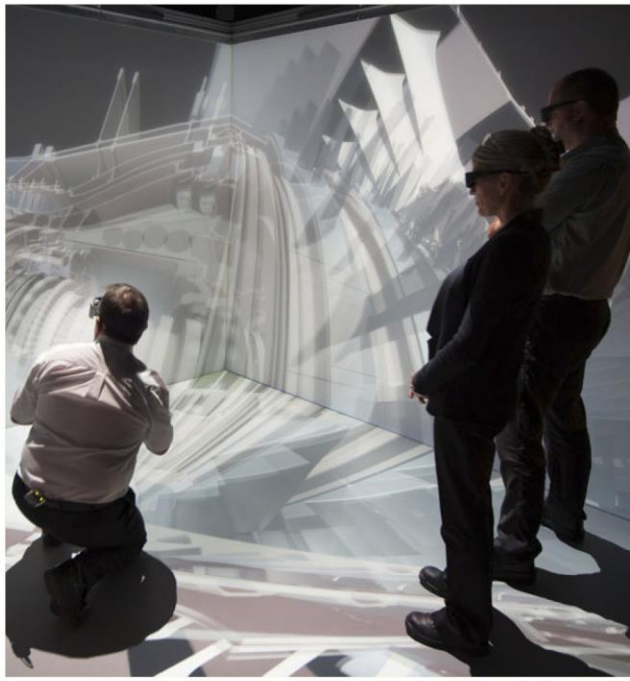
Engineering excellence





'Vision 20'
Our approach to technology and product development over a 20-year cycle

Research and development	University Technology Centres	Advanced Manufacturing Centres
£1.2bn	31	7

2015 financial data

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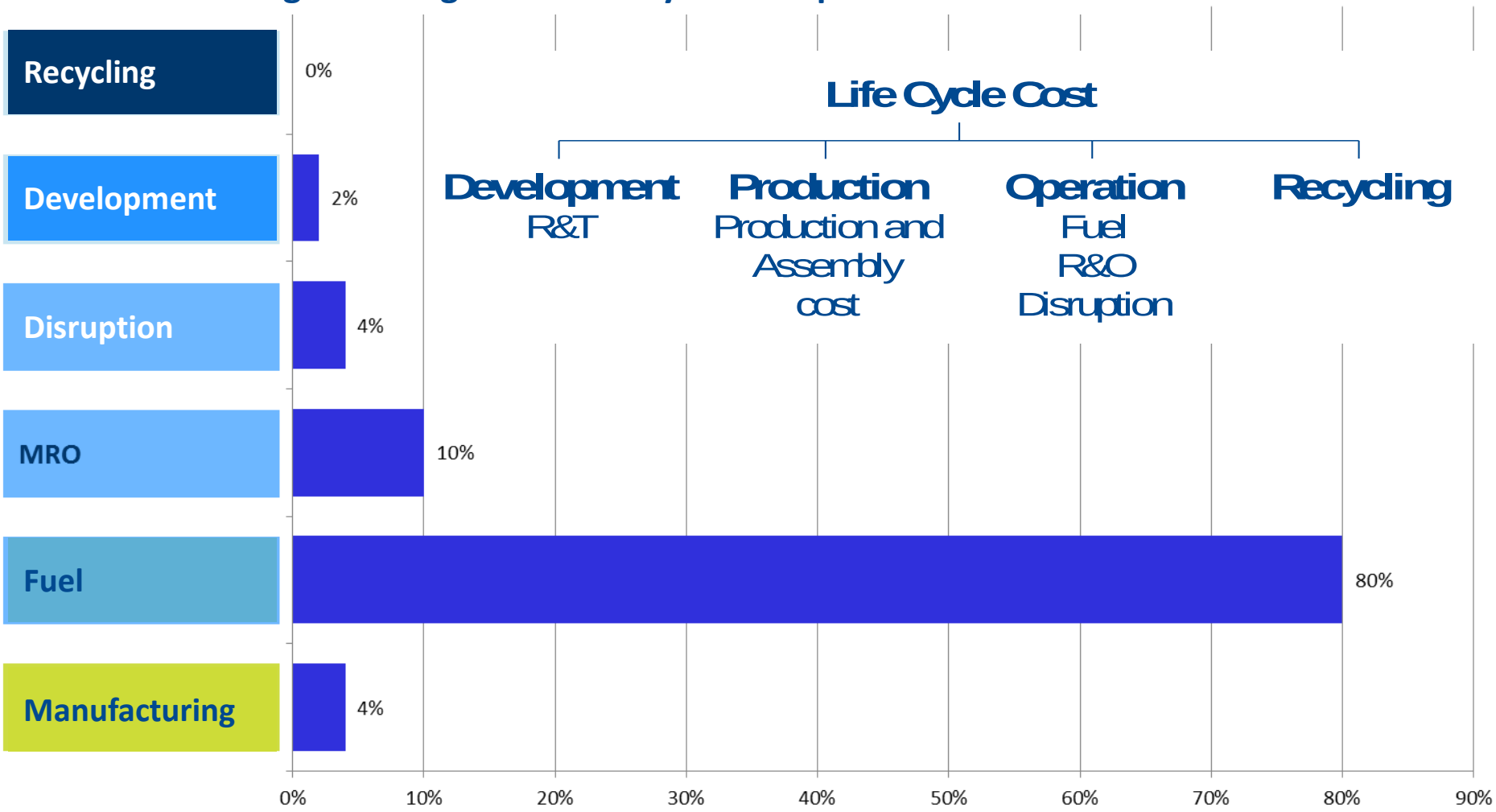
Typical lifecycle costs

Cost share for large civil engines over 25 years of operation



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Fundamental capability drivers for Aerospace

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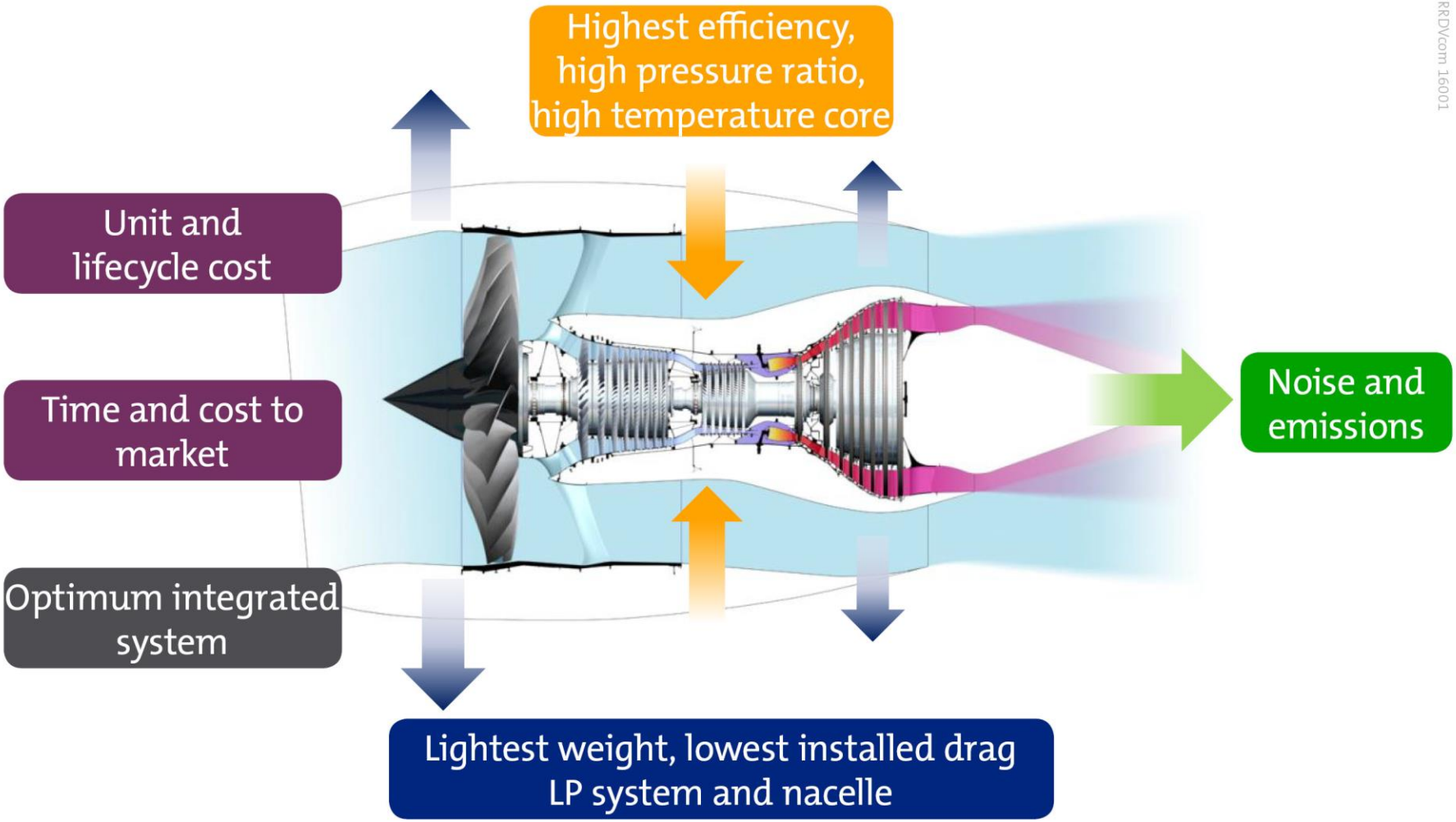
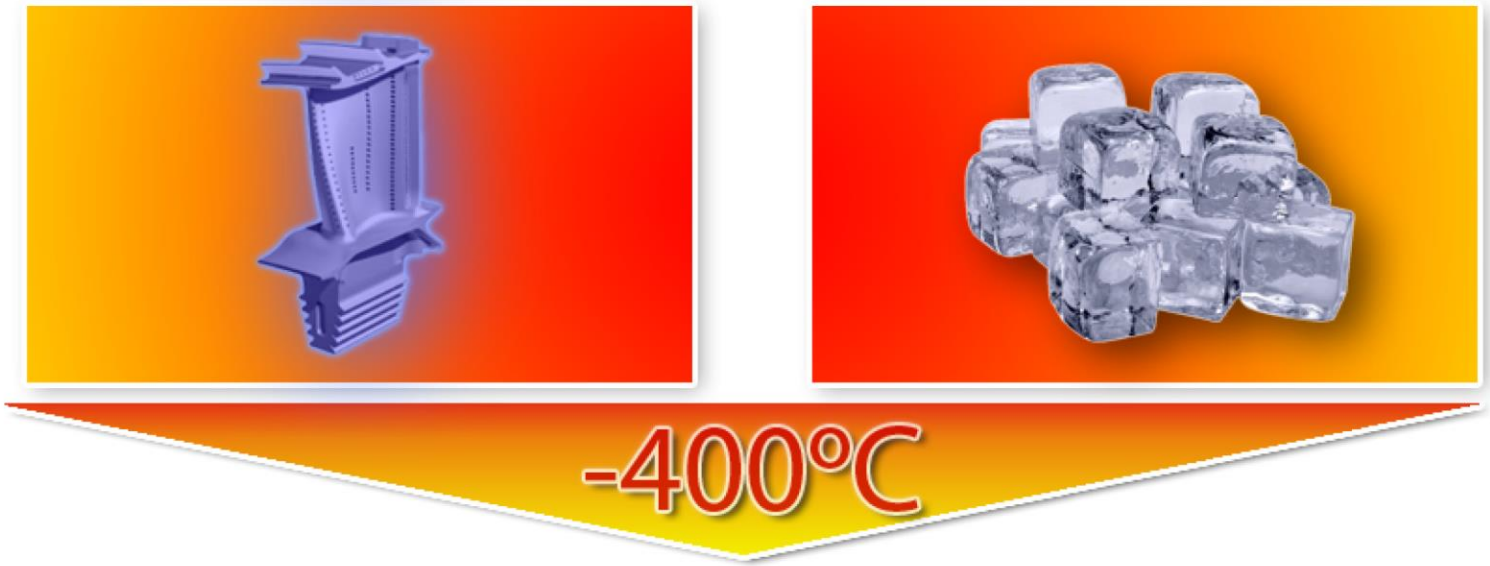


Did you know...?

=

The centrifugal force on each turbine blade is equivalent to hanging a London bus from the tip (10 tons)

Did you know...?



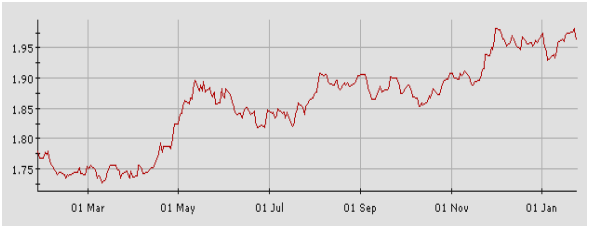
If our turbine cooling technology were applied to an ice cube it would remain frozen indefinitely - even when being 'cooked' at the highest setting of a domestic oven

Manufacturing Technology Challenges

Product Challenges

- Future Volume Programmes
- More complex designs
- New materials, difficult to process (more composites, hybrids etc)
- New processes
- Tighter quality specifications
- Compliance to safety & environmental targets
- Detailed aftermarket requirements

Business Challenges



- Aggressive cost targets
- Improved process capability
- Improved Safety
- Reduced NPI lead times
- Improved delivery adherence
- Escalating material costs
- Currency challenges
- Globalisation

Need new capabilities to remain competitive: New Materials & Manufacturing Technologies, Modern Equipment & Methods, Improved Process Understanding

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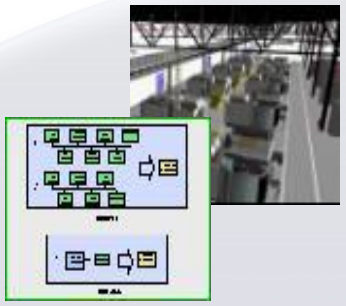
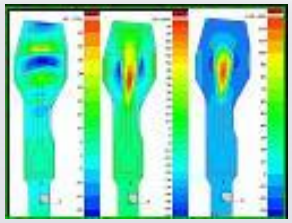
High Performance Manufacturing

A collection of advanced technologies deployed into a modern and competitive MoM

Scientific Approach to Modern Manufacturing



Simplified Operations route



Process Modelling and cutting strategy to predict part distortion

Fixture FE Modelling / Analysis to understand part behaviour

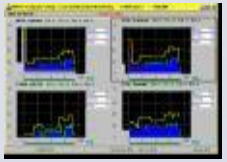
Technology Integration

mill, turn, deburr, inspection …

High Speed Multi Functional 5-axis Machine platform

In-cycle probing and adaptive machining

Green Button process design to minimise manual intervention



Process & Machine tool condition monitoring

Half the current value added time, double the productivity and achieve 6σ process capability

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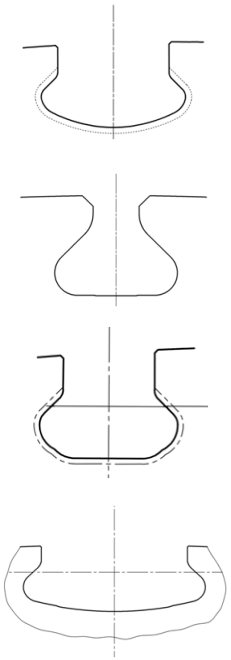
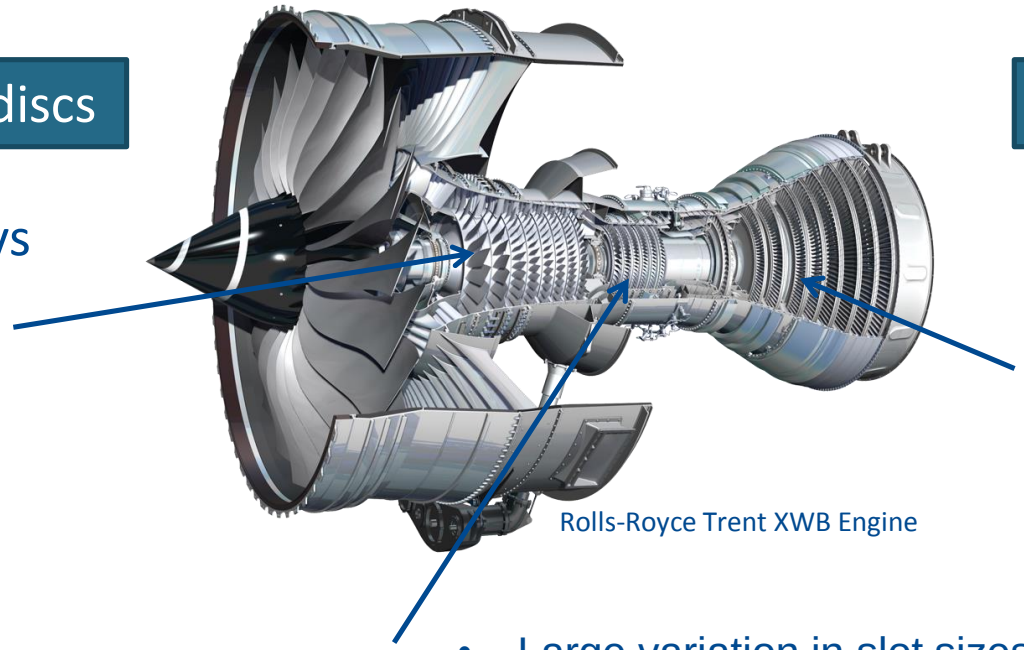
Typical dovetail and firtree Slot applications in Aero Engines to be inspected

Compressor discs

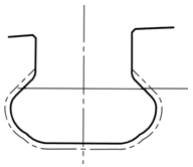
Titanium alloys





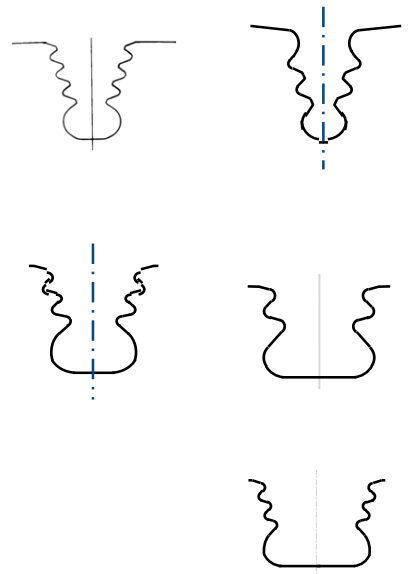
Rolls-Royce Trent XWB Engine

Nickel based alloys



Turbine discs

Nickel based alloys



- Large variation in slot sizes and aspect ratios
- Tight tolerances to be met
- Tight limits for surface drag, white layer, roughness
- Angled / curved slots for high load applications

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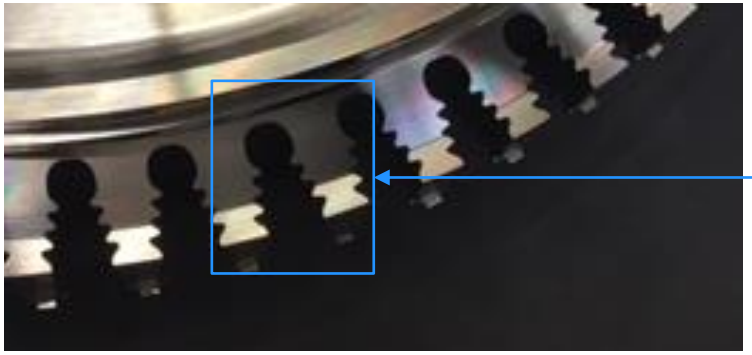
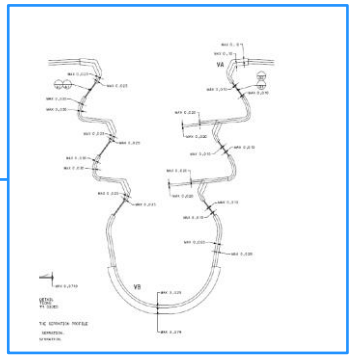
CMM slot inspection on turbine disc slots replaced manual legacy methods





Anforderungen

- Surface finish Ra = 0,8
- Profile of a surface ± 0,005
- Angularity 0,025

legacy: Broaching → Profile check shadow graph → Position and Orientation gauges and fixtures

today: Broaching → CMM measurement

CMM inspection replaces more and more legacy methods and shortens the process chain

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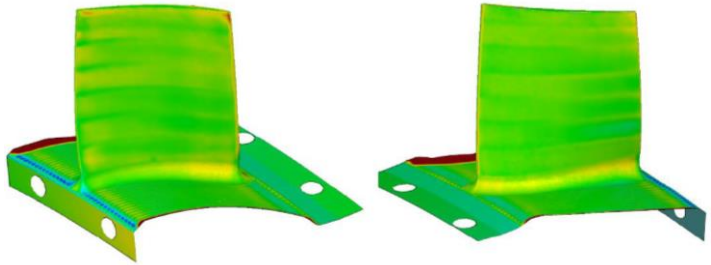
Optical 3D measurements support NC programming e.g. on blisk aero foils



Offline NC programming → Manufacturing test → 3D measurement → Adjustment NC program

Optical 3D measurements provide more information then conventional tactile CMM for the NC programming of complex components and reduce costly iterations

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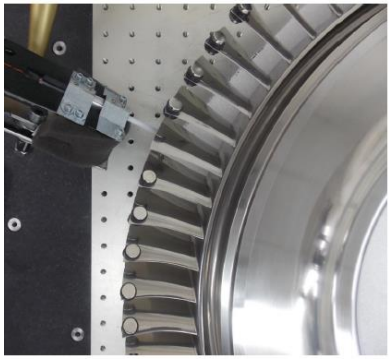
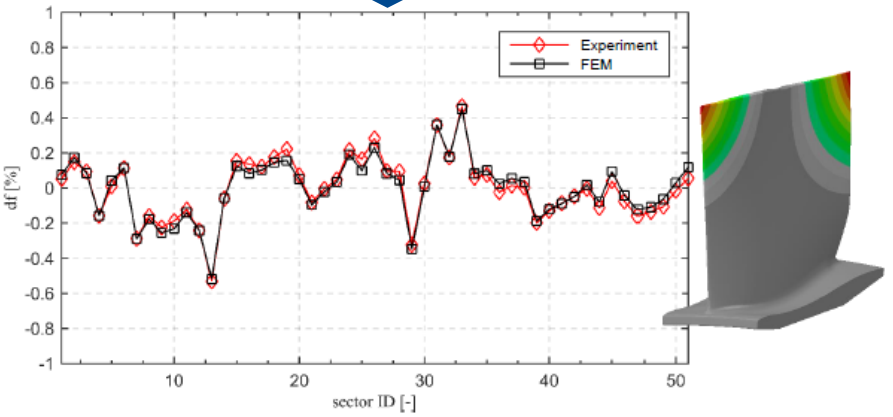
Optical 3D measurements provide information for simulations

Geometric measurement

Vibration measurement



Update FE Model with measured 3D Data



Optical 3D measurement is an enabler to feed back manufacturing deviations into simulations

*joint research program "COOREFLEX-turbo (AG Turbo)". The work was supported by the Bundesministerium für Wirtschaft und Energie (BMWi) under FKZ 03ET7021.

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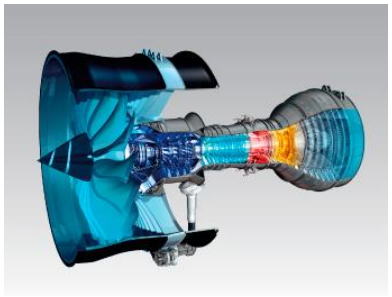
Summary






- Pressure on productivity and cost – lead time challenge
- Increasing attention to detail in process understanding, by simulation, tool specification and quality control with suppliers
- Intelligent adaptive machining to reduce variability and to improve SFC
- Integrated more automated high performance methods of measurement to enable efficient, monitored and controlled operations
- Cutting-edge technology development through integrated academic and research network

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Thank You

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