

3D Measurement of Jet Engine Compressor Aero Foils on Blisks for Vibration Analysis

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



Rolls-Royce

3D Measurement Conference 2017, Aachen

© 2017 Rolls-Royce Deutschland Ltd & Co KG

The information in this document is the property of Rolls-Royce Deutschland Ltd & Co KG and may not be copied or communicated to a third party, or used for any purpose other than that for which it is supplied, without the express written consent of Rolls-Royce Deutschland Ltd & Co KG.

This information is given in good faith based upon the latest information available to Rolls-Royce Deutschland Ltd & Co KG, no warranty or representation is given concerning such information, which must not be taken as establishing any contractual or other commitment binding upon Rolls-Royce Deutschland Ltd & Co KG or any of its subsidiary or associated companies.

Trusted to deliver excellence

Rolls-Royce Deutschland proprietary information – UNCLASSIFIED



Rolls-Royce

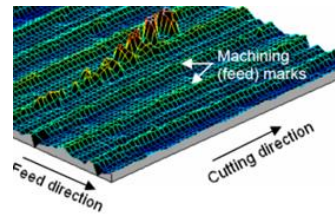
Rolls-Royce



Fundamental capability drivers for Aerospace



Optical 3D inspection on blisk aero foils



Summary



Our businesses

Civil Aerospace
Defence Aerospace
Power Systems
Marine
Nuclear

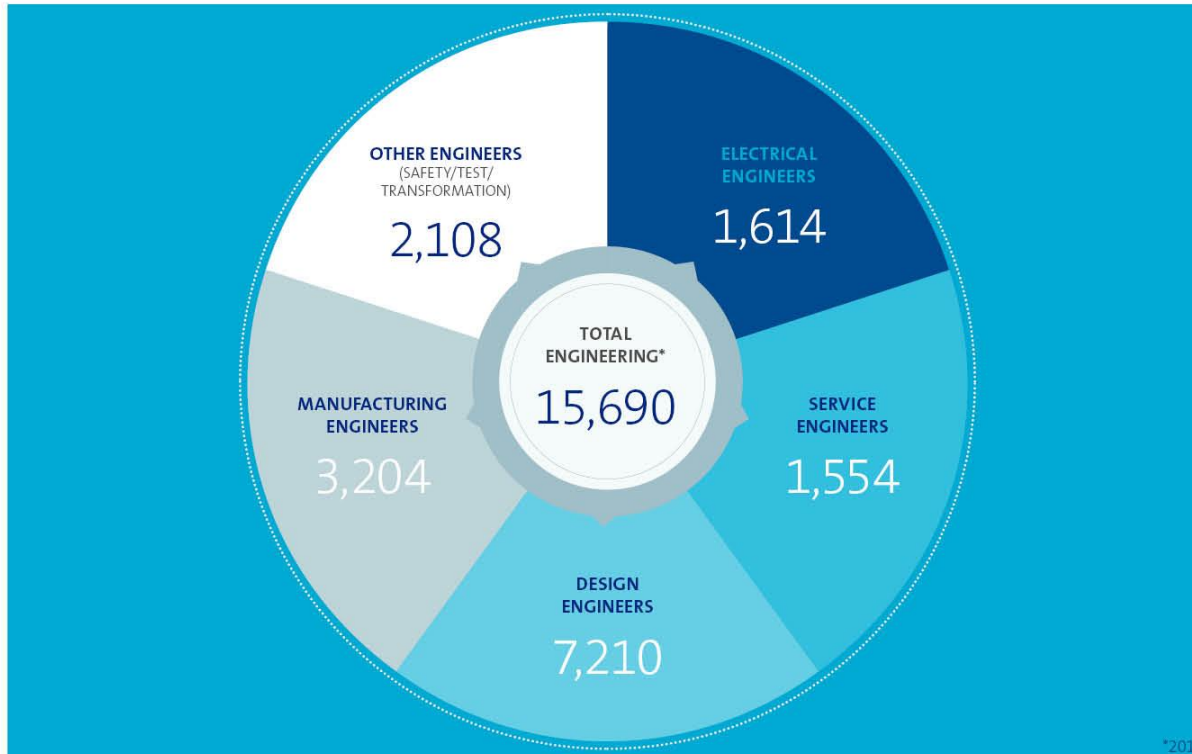


Trusted to deliver excellence



Rolls-Royce

Engineering excellence



'Vision 20'

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

2016 financial data

Research and development

£1.3bn

University Technology Centres

31

Advanced Manufacturing Centres

7

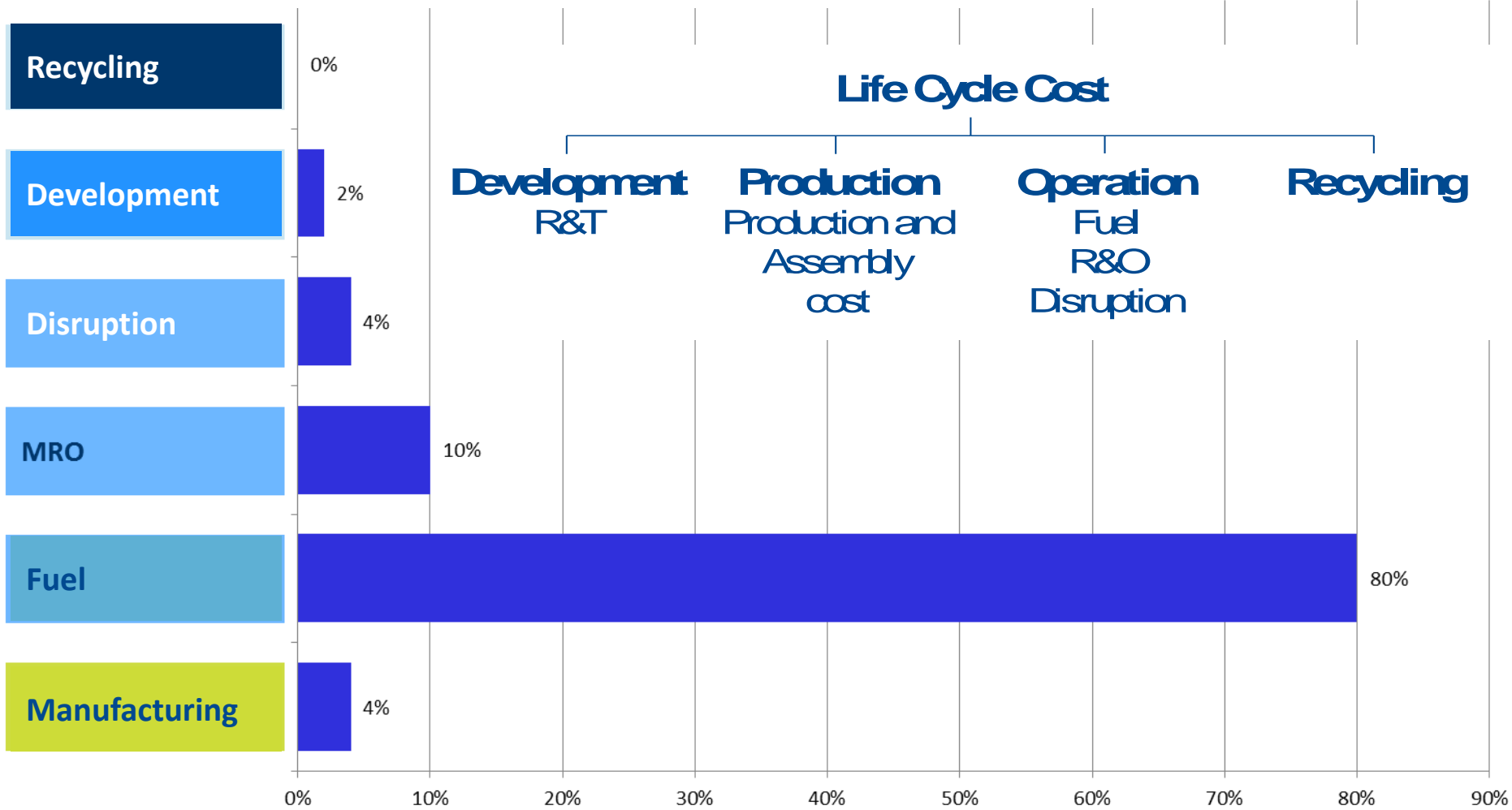
Trusted to deliver excellence



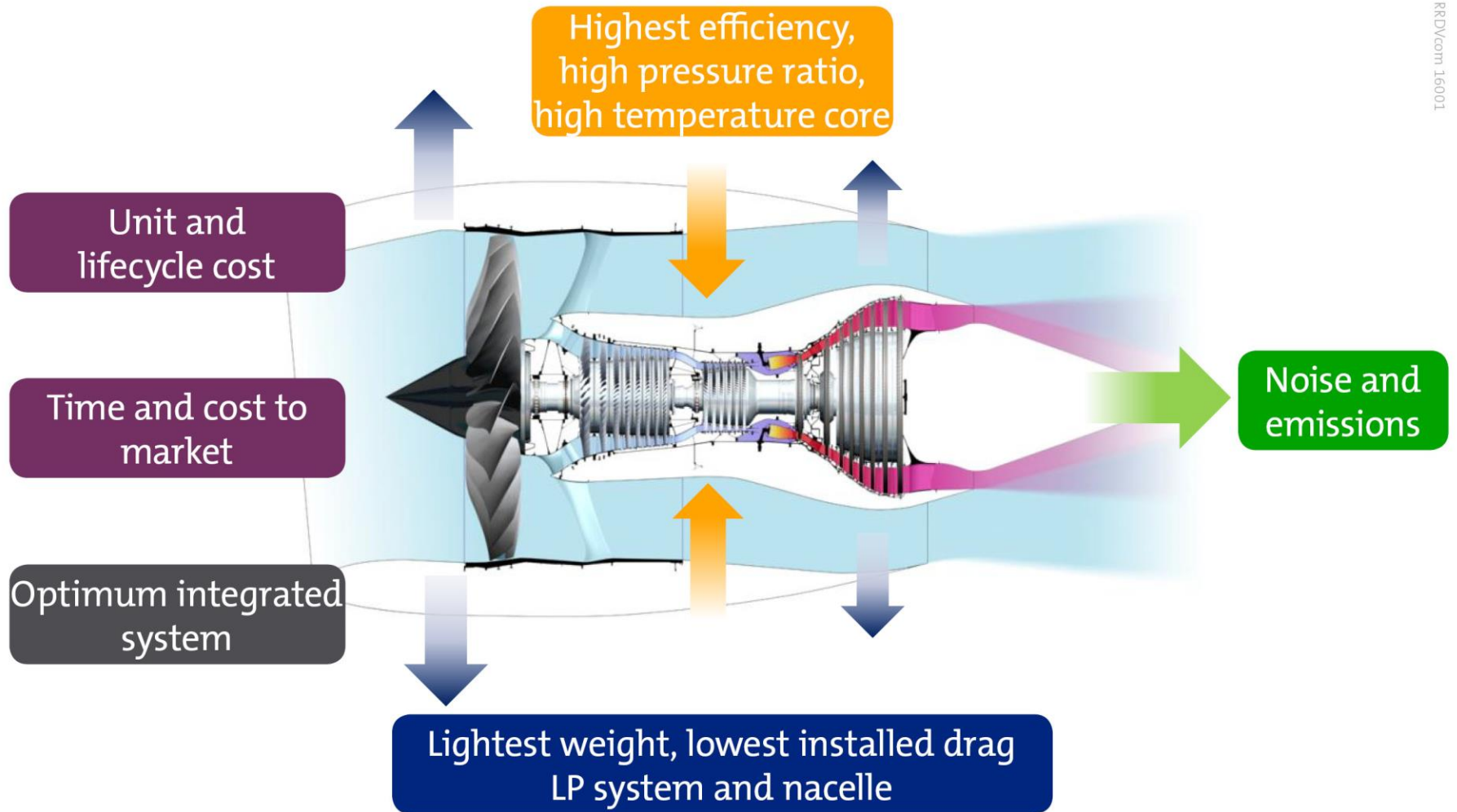
Rolls-Royce

Typical lifecycle costs

Cost share for large civil engines over 25 years of operation



Fundamental capability drivers for Aerospace



Trusted to deliver excellence



Rolls-Royce

Materials

- Comparison of the temperatures in a combustion chamber of a modern aircraft engine and on the surface of the sun

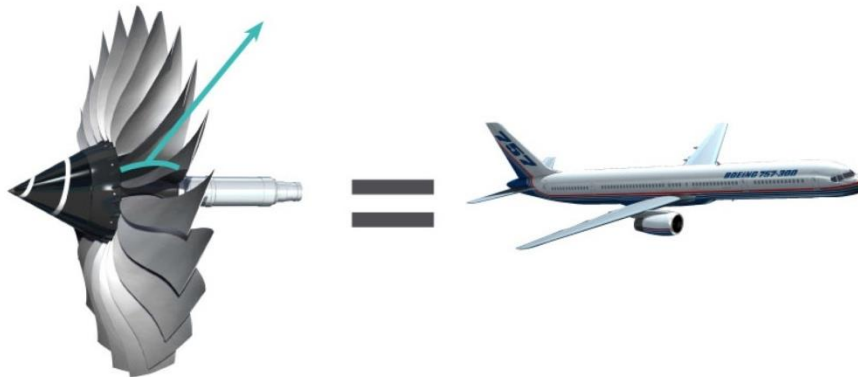


2500 K



6000 K

- Centrifugal forces at the root of a FAN blade



Weight of a
Boeing 757
(57,840 kg)

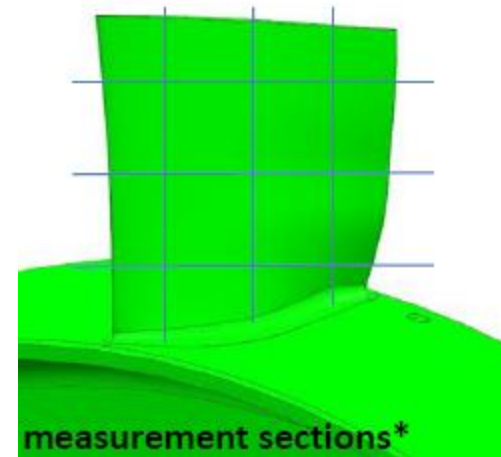
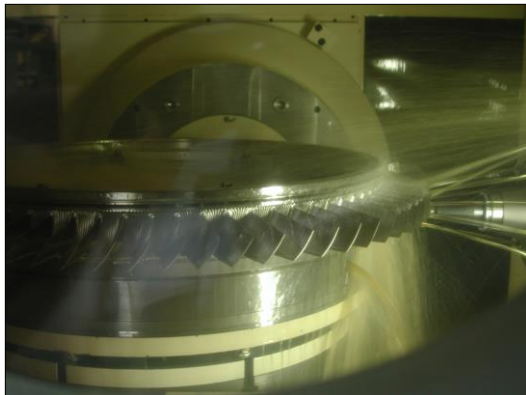
Trusted to deliver excellence



Rolls-Royce

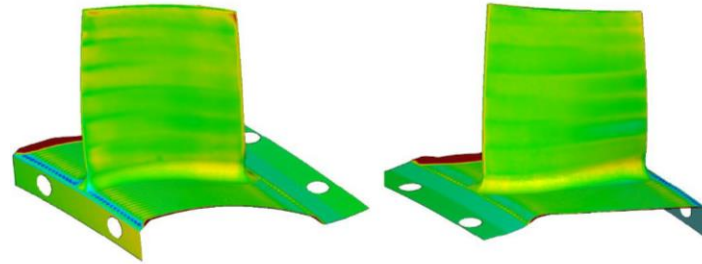
Tactile CMM Inspection for Blisk Inspection

Part of Method of Manufacturing



Well understood conventional tactile CMM Inspection provides just relatively low data density at relatively long lead times

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



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

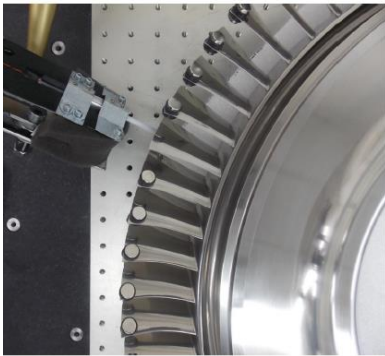
Optical 3D measurements provide information for simulations

Public funded research project by RRD, UTC Cottbus and UTC Dresden: COOREFLEX
 “Probabilistic Aeroelastic Analyses with Focus on Rotor Geometry Variations”*

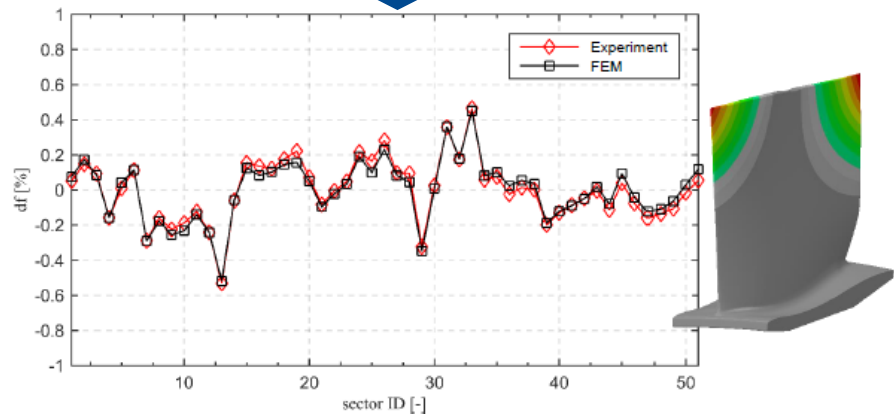
Geometric
measurement



Vibration
measurement



Update FE Model with
measured 3D Data



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

Rolls-Royce Deutschland proprietary information - UNCLASSIFIED



Rolls-Royce

Optical Geometry Scan / Accuracy*



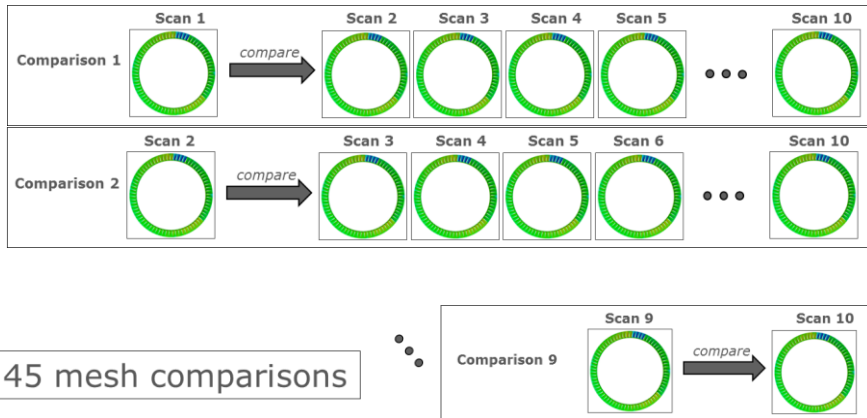
Hardware: GOM Scanbox 5108 incl. ATOS Triple Scan 16M + Photogrammetry ATOS Plus 19M



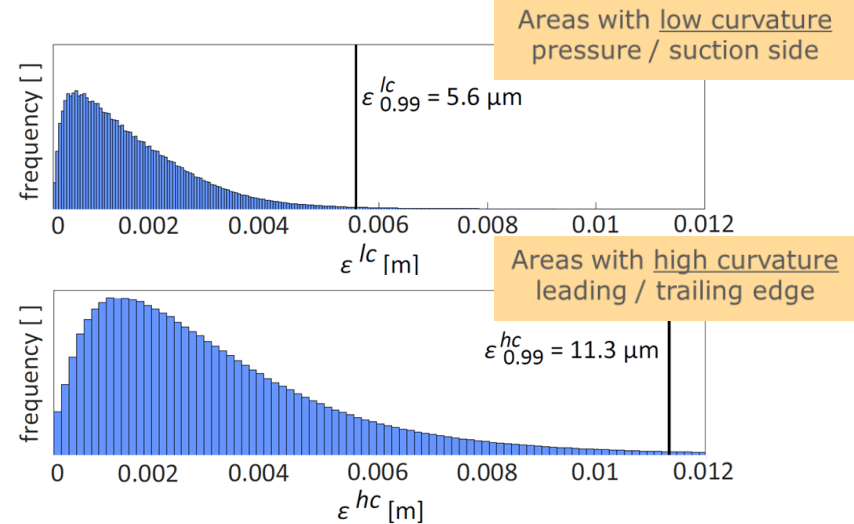
Manual application of matting powder

Accuracy quantification by 10x repetitive measurement campaign (Stg2 blisk)

Scan alignment: best fit alignment to CAD model + Scan comparison

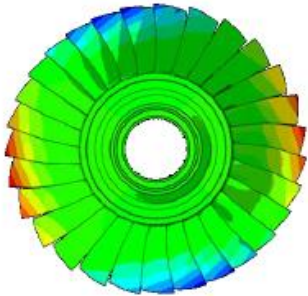


45 mesh comparisons

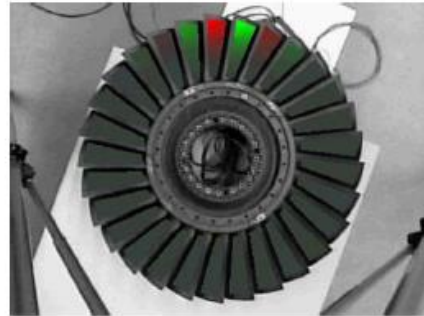


FE-Model Update and Validation (1)

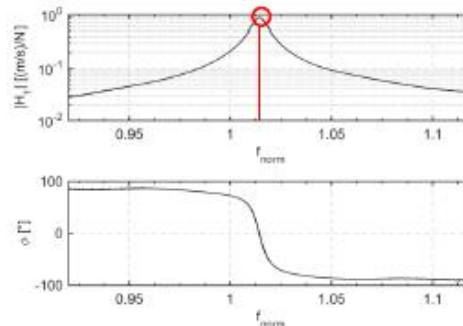
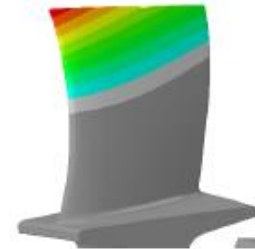
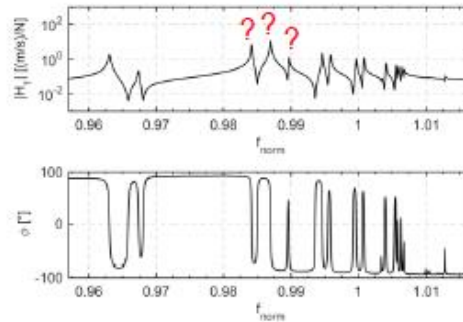
Ideal Design
(Tuned)



Real Part
(Mistuned)



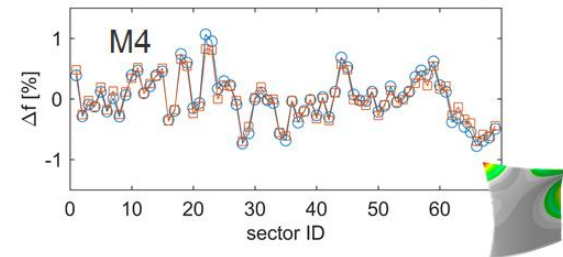
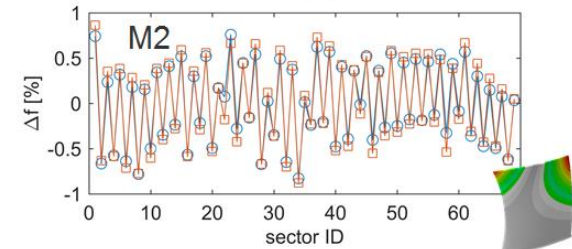
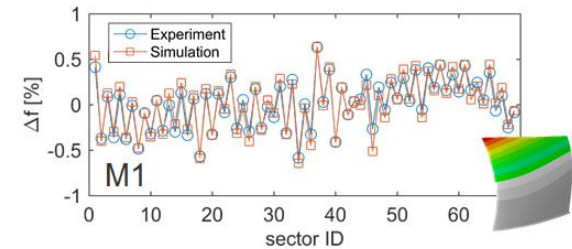
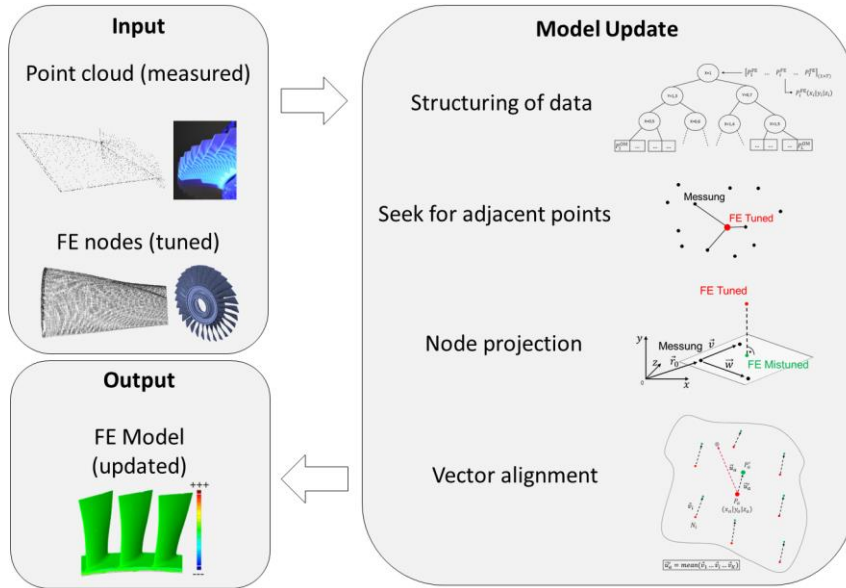
- a) FE-Model update via GOM scan point cloud (Real Geometry FE-model) &
- b) Validation via comparison to „Blade by Blade“ measurements



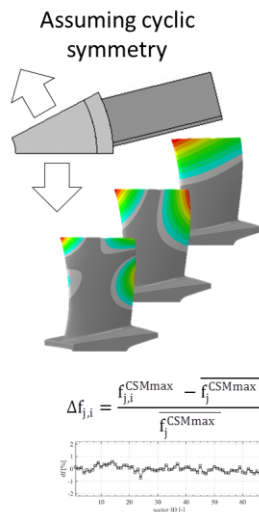
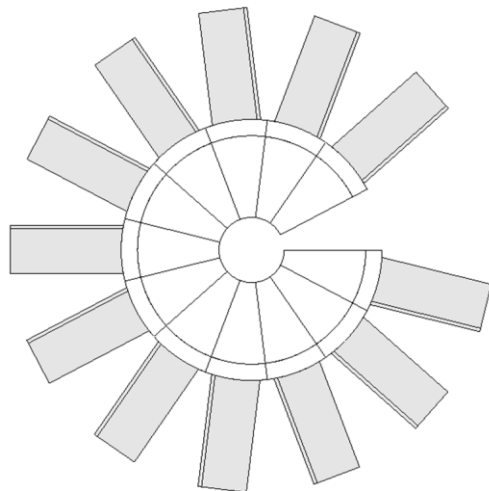
$$\Delta f_{j,i} = \frac{f_{j,i}^{\text{exp}} - \overline{f_j^{\text{exp}}}}{\overline{f_j^{\text{exp}}}}$$

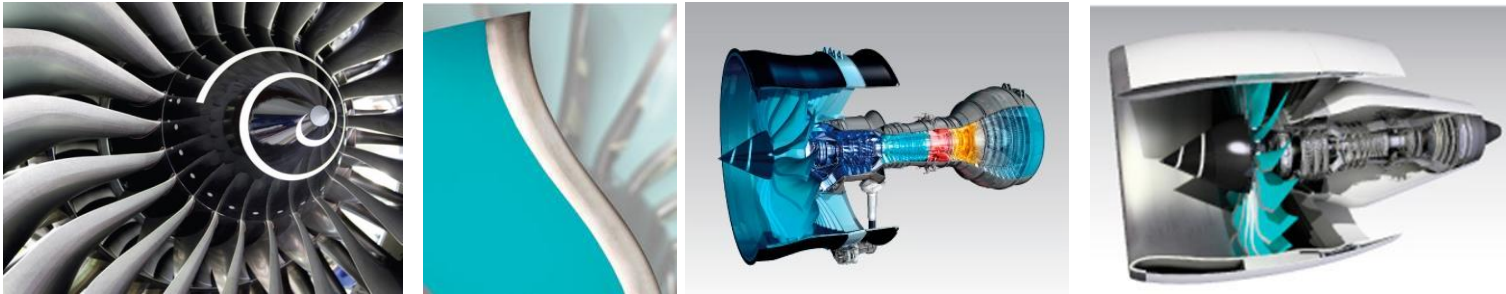


FE-Model Update and Validation (2)



Numerical prediction of mistuning patterns





- Pressure on productivity and cost – lead time challenge
- Increasing attention to detail in process understanding, by simulation, tool specification and quality control with suppliers
- Cutting-edge technology development through integrated academic and research network
- 3D measurement techniques open new spaces for functional orientated simulation and inspection
- Acknowledgements: T. Backhaus (TU Dresden), T. Maywald (TU Cottbus), S. Schrape (RRD), J. Weigand (RRD)

Thank You



Trusted to deliver excellence



Rolls-Royce