NOVEL SHAPING OF JET ENGINE COMPRESSOR BLADES

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MOTIVATION FOR RESEARCH

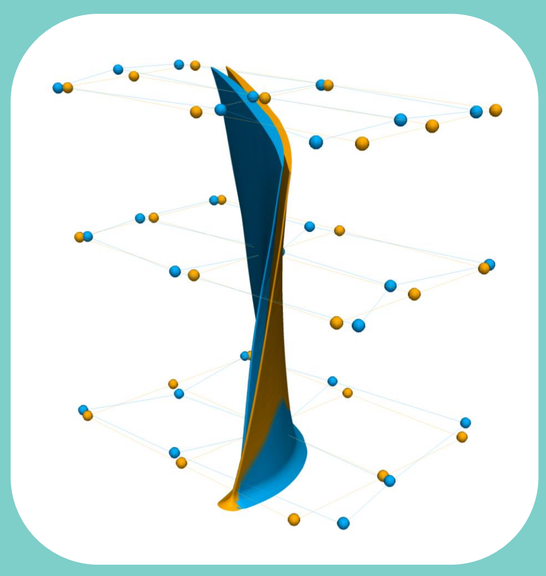
- Strict aircraft emissions targets
- Drive to reduce jet engine fuel consumption
- How to improve an already well designed engine?

PROJECT AIM

Use insight and understanding of complex flow physics
+
Number crunching power of super-computers to search thousands of designs
↓
Find an improved compressor blade design

METHODOLOGY – OPTIMISATION

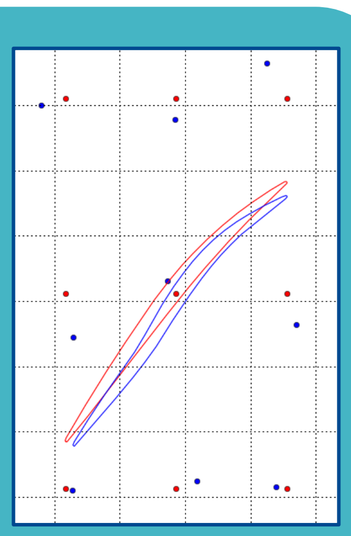
Datum blade
↓
Free-Form-Deformation modifies the geometry
↓
Computational Fluid Dynamics analyses the resulting blade design
↓
Optimiser searches for and selects improved design
↓
Optimised design



Free-From-Deformation
(Control point movement deforms geometry
orange = datum, blue = optimised)

RESULT – NOVEL BLADE DESIGN

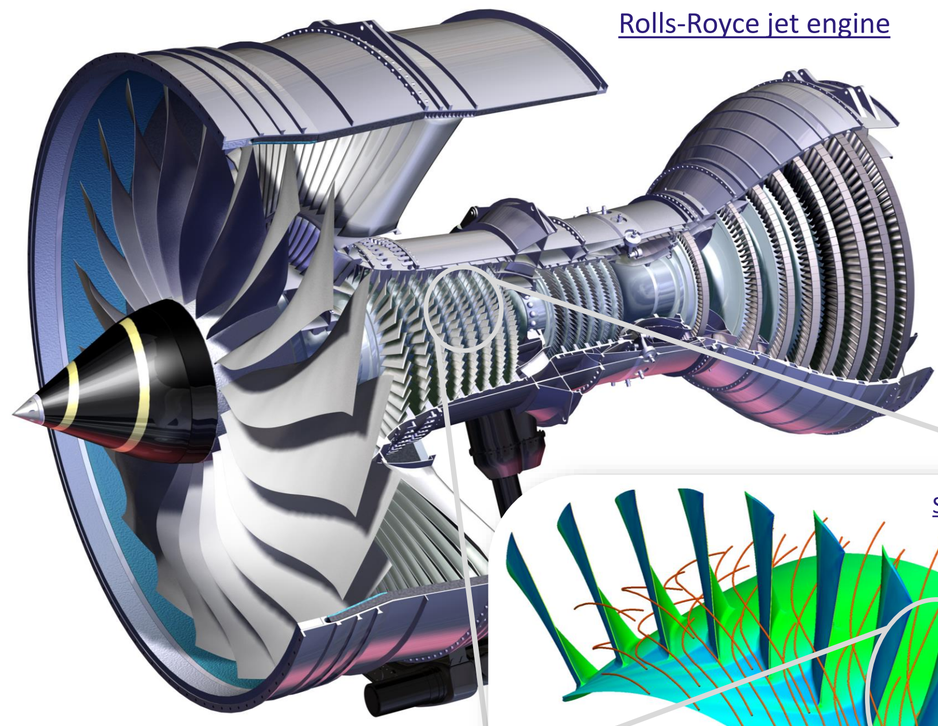
- Blade design produced with novel S-shape at mid-height
- S-shape weakens the shock
- Reduces separation and losses
- Significant efficiency improvement
- Demonstrates the benefit achievable through novel shaping and shock control



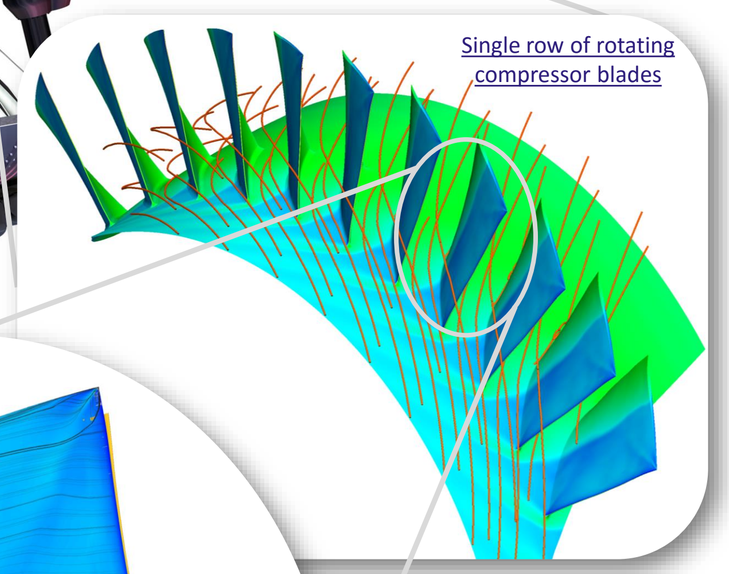
2D slice showing novel, S-shaped geometry (in blue)

IMPACT

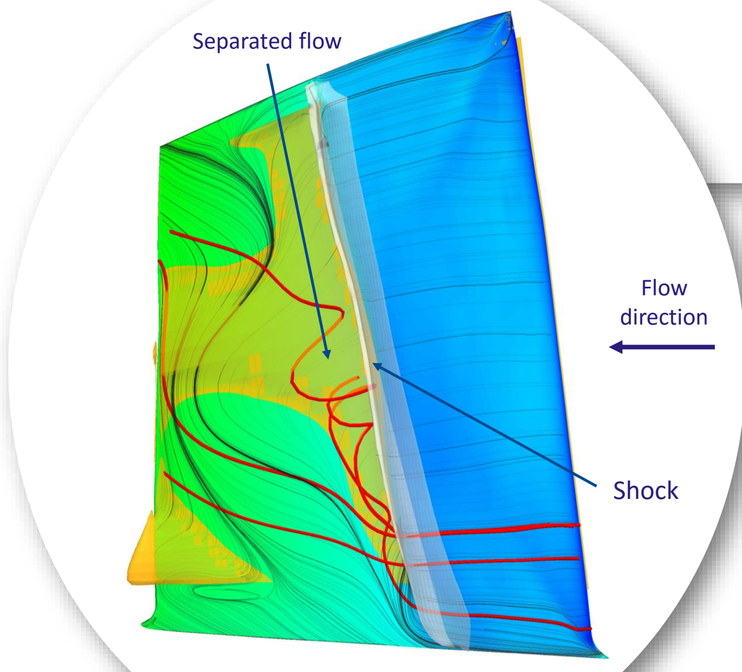
- Novel shaping method (Free-Form-Deformation) provides superior results to other shaping methods
- Novel shaping combined with optimisation allows designers to realise the true potential of blade designs
- Shock control provides benefit on transonic compressors – no adverse effects
- State of the art UK research such as this helps to maintain Rolls-Royce's position as manufacturer of the best jet engines in the world



Rolls-Royce jet engine



Single row of rotating compressor blades



CFD analysis of single blade

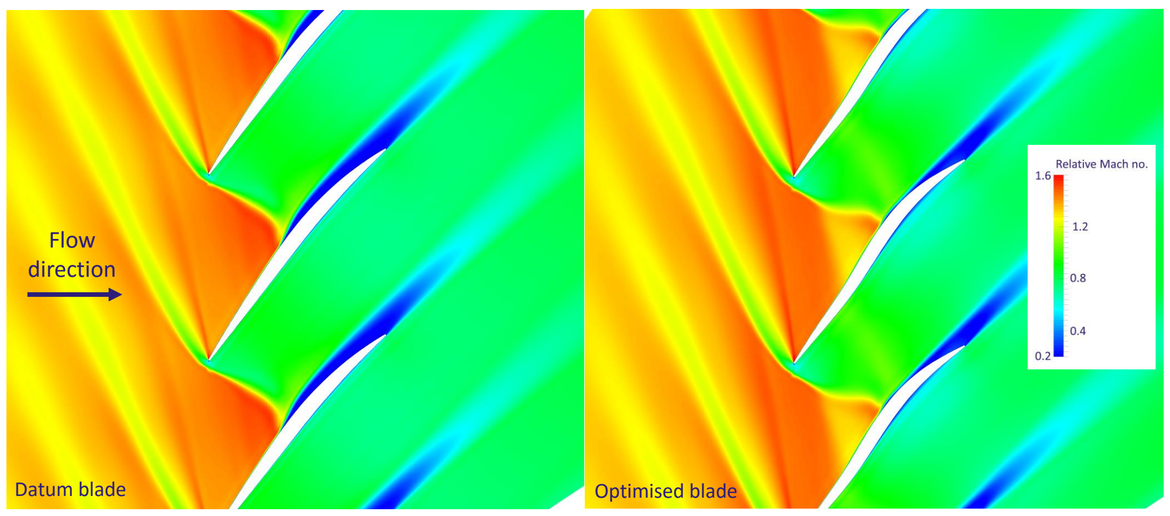
CFD SIMULATION

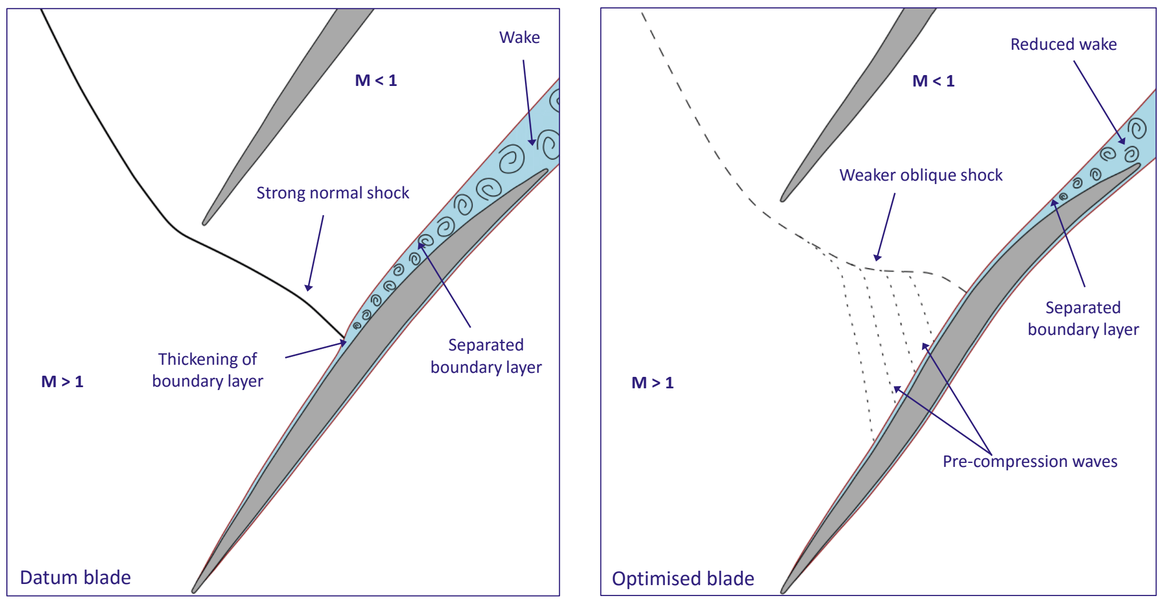
- Computational Fluid Dynamics
- Predicts blade performance
- Analyses physics and losses
- Single blade can be simulated

SHOCK WAVES

- Compressor blades force air through the engine to increase its pressure
- The blades rotate at over 1000mph!
- The resulting flow velocity is greater than the speed of sound
- Shock waves are created as a result
- These cause flow separation, generate losses and reduce efficiency

Effect of novel S-shaped blade on the shock:





ASME Turbo Expo 2016 conference paper accepted and to be presented in Seoul, South-Korea this June: "Alleviation Of Shock-Wave Effects On A Highly Loaded Axial Compressor Through Novel Blade Shaping"

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