

Integrated Compressor Duct Aerodynamics

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Elias Mikael Vagn Siggeirsson

Chalmers University of Technology

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Agenda

1 Introduction

2 The Project

3 Final Words



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1 Introduction

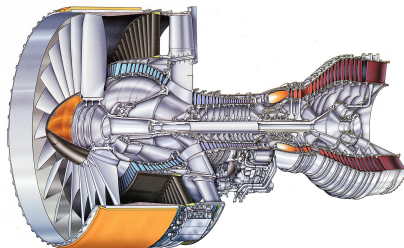
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Introduction

- High aircraft engine efficiency demand has pushed developers to seek further improvements

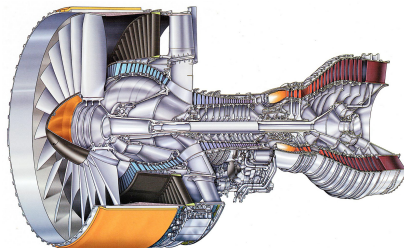


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- Led to the development of high-bypass-ratio turbo-fan engine

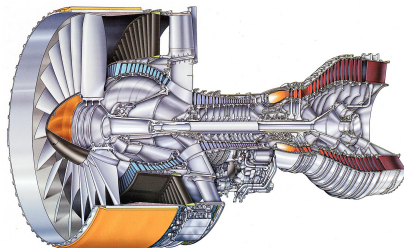


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- Jet engine design is a very complex, multidisciplinary problem

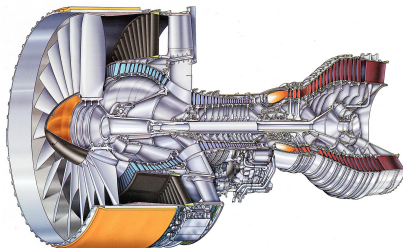


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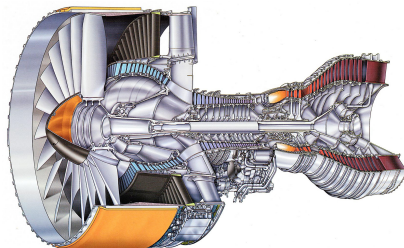


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- Led to the development of high-bypass-ratio turbo-fan engine
- Jet engine design is a very complex, multidisciplinary problem
- Split up into several sub-components
- Has been successful during the last decades



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Further Improvements

- Further improvements can be hard to obtain



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- Sub-components designed in isolation



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- Limited design space



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Further Improvements

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- Sub-components designed in isolation
- Limited design space
- Can lead to a sub-optimal design even though each component is highly optimized
- To achieve significant performance improvements a more integrated design approach between sub-components is necessary



Integrated Design

- Where to apply this integrated design approach?



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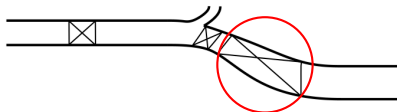
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- The integrated design of the compressor duct, including the bleed system and the rear low-pressure compressor stages, becomes an interesting system to analyze



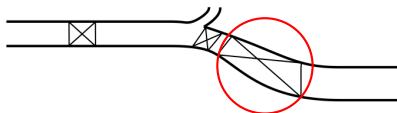
Compressor Duct

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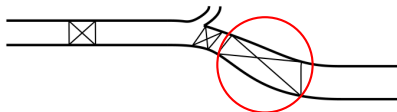
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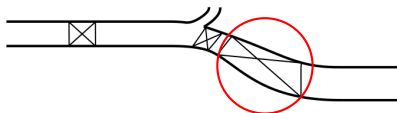
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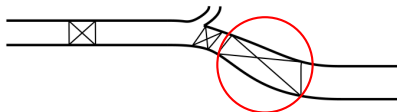
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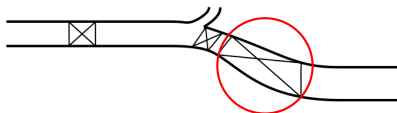
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 - Radially offset the flow



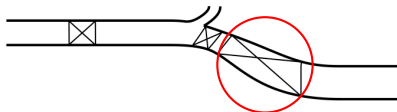
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 - Radially offset the flow
 - Make it as short as possible without flow separation
 - Shorter engine results in a lighter engine



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The Project

- Integrated Duct Aerodynamics



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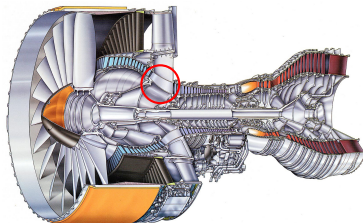


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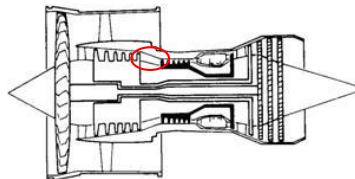
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 - Chalmers - GKN Aerospace → Rolls Royce - Loughborough University



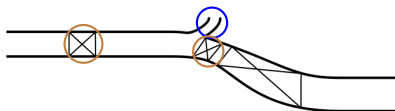
Experimental Test Rig



Turbofan engine ©2014 United Technologies Corporation - Pratt & Whitney Division



Simplified 2D drawing of the turbofan engine



Experimental test rig: Compressor duct with upstream **bleed tube** and **guide vanes**



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- Can lead to a sub-optimal design
- Higher details for more realistic simulations
- The complex interaction between components
- The upstream compressor stage and the bleed system will influence the duct performance



Planned Work

- The G3D::FLOW Computational Fluid Dynamics code is used

G3D::Flow



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- Advanced unsteady Computational Fluid Dynamics are used to simulate the complex interaction effects
- Experiments are used to validate the simulations

G3D::Flow



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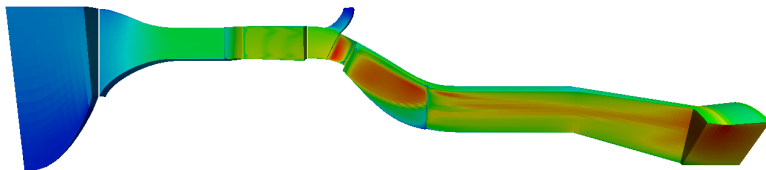
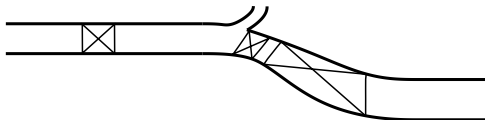


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- More detailed analysis of complicated time dependent flow mechanism



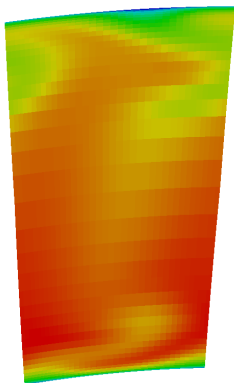
Integrated Compressor Duct



Comparison between the 2D schematic and a geometry for a 3D simulations



Inlet Boundary Condition



Before component interface



After component interface



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Gains From Project

- Develop and enhance existing design and analyzing methodology for design of integrated duct concepts



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- Better understanding of the complicated flow mechanism of the compressor duct and its interaction to nearest components



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Gains From Project

- Develop and enhance existing design and analyzing methodology for design of integrated duct concepts
- Better understanding of the complicated flow mechanism of the compressor duct and its interaction to nearest components
- More optimal design earlier in design process
- Swedish-UK partnership



Project Questions

- Which methodology should be deployed in order to obtain an efficient integrated system including compressor-stage(s), bleed system and duct



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- What limits and design rules can be established for efficient integrated designs



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- Which methodology should be deployed in order to obtain an efficient integrated system including compressor-stage(s), bleed system and duct
- What limits and design rules can be established for efficient integrated designs
- What is the potential efficiency gain from adopting an integrated design concept and what would the impact be on the global engine performance



Acknowledgement



Thank you!

Questions?

