Development of a Virtual Turbofan Engine in Sweden

Marcus Lejon
Principal Research Engineer, GKN Aerospace

Export control

Export Control

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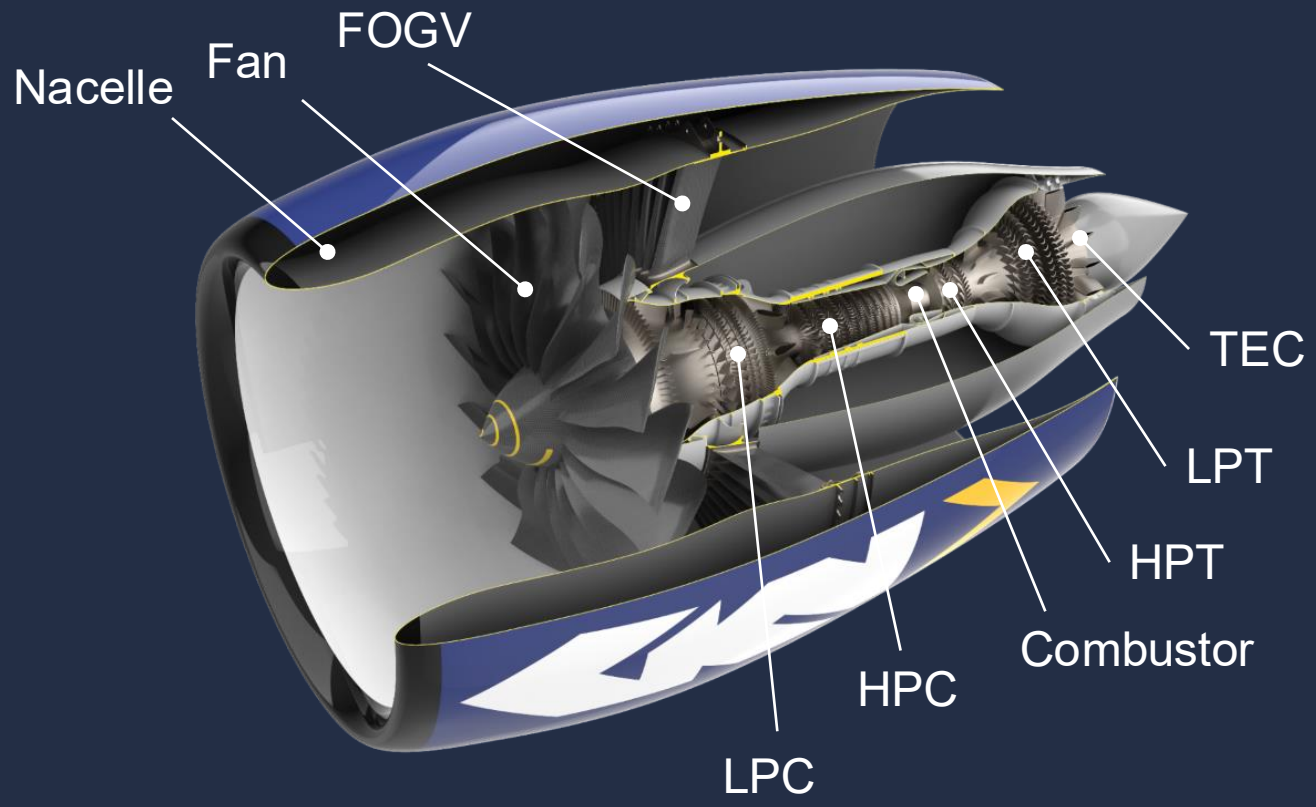
RM400

- **Large (virtual) geared turbofan**
  - 3.2 meter fan diameter
  - High thrust level (engine suitable for Airbus A350)
- **Virtual engine**
  - Developed jointly by senior researchers at
    - GKN Aerospace
    - KTH Royal Institute of Technology
    - Chalmers University of Technology
    - Lund University
    - (RISE)
  - Financed by VINNOVA through projects in the National Aeronautics Research Programme (NFFP)
- **Technology level**
  - Entry into service 2035
  - By pass ratio: 15
    - Current state of the art ~12



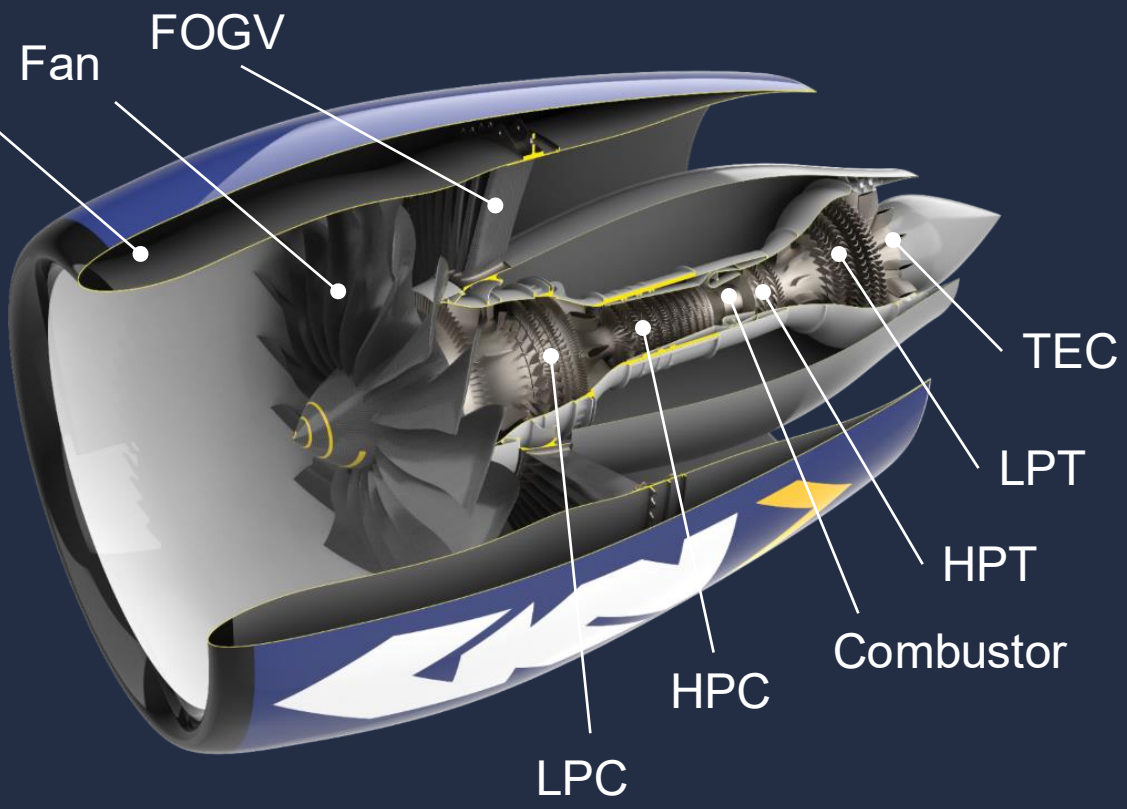
* Image from https://www.airbus.com/en/products-services/commercial-aircraft/passenger-aircraft/a350-family

Why?

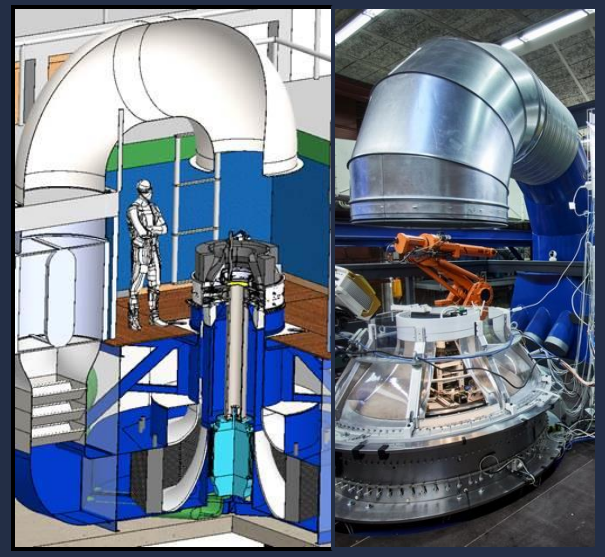
- **Engine realistic and can be published**
  - Geometries and boundary conditions
  - Method development

- **Industry – Academia**
  - Research projects
    - National and European
    - PhD students
  - Master thesis projects

- **Experimental testing of subsystems**

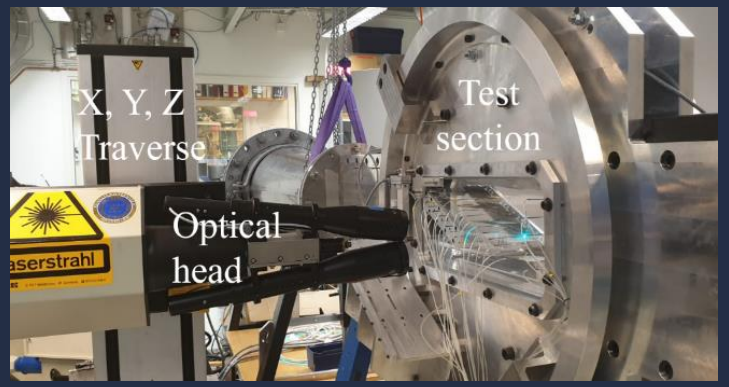


Hardware based on RM400



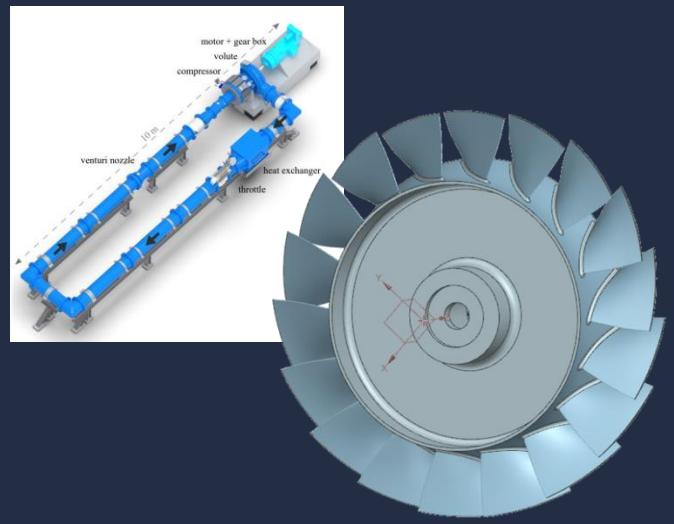
Chalmers Compressor Rig

- Based on the two rear stages of the RM400 LPC



KTH Transonic Linear Cascade

- 95% Span Section of RM400 LPC Rotor 1



Julia-blisk in Stuttgart

- RM400 LPC stage 1 re-designed to specifications for an existing rig

Resarch projects

National research projects

DARLING – Damaged and Repaired Blade Modeling with in-situ Experiments
ELSAA – Efficient Large Scale Aerodynamic Analysis
ADiSS – Aeroelastic damping in separated flow
ADiSS 2.0 – Aeroelastic damping in separated flow 2.0
ADiSS 3.0 – Aeroelastic damping in separated flow 3.0
CoFAS – Fan and compressor aeroelasticity and stability limits
CoFAS-2 – Fan and compressor aeroelasticity and stability limits
InGe – Integrated electric Generator and motor

European Projects

Horizon 2020 Research Project:
ENABLEH2 – ENABLing cryogEnic Hydrogen based CO2 free air transport

Publications

(2025) **Aeroelastic Design of a Large-Diameter Composite Fan Blade – To be Published**
ISUAAAT17-91. November 16th-21st, 2025, Melbourne, Australia

(2024) **Analysis of Blade Aspect Ratio's Influence on High-Speed Axial Compressor Performance**
Aerospace. 11. 276. 10.3390/aerospace11040276

(2024) **Aerodynamic design, optimization and acoustic analysis of a turbine rear structure.**
Master thesis

(2023) **The heat transfer potential of compressor vanes on a hydrogen fueled turbofan engine. Applied Thermal Engineering**
236. 10.1016/j.applthermaleng.2023.121722.

(2022) **Blade oscillation mechanism for aerodynamic dampin measurements at high reduced frequencies**
E3S Web of Conferences. 345. 03002. 10.1051/e3sconf/202234503002

(2021) **Design and Pre-Test Evaluation of a Low-Pressure Compressor Test Facility for Cryogenic Hydrogen Fuel Integratio** 10.1115/GT2021-58946

(2021) **Aerothermal performance of fan outlet guide vanes in modern geared turbofan engines**
Master thesis.

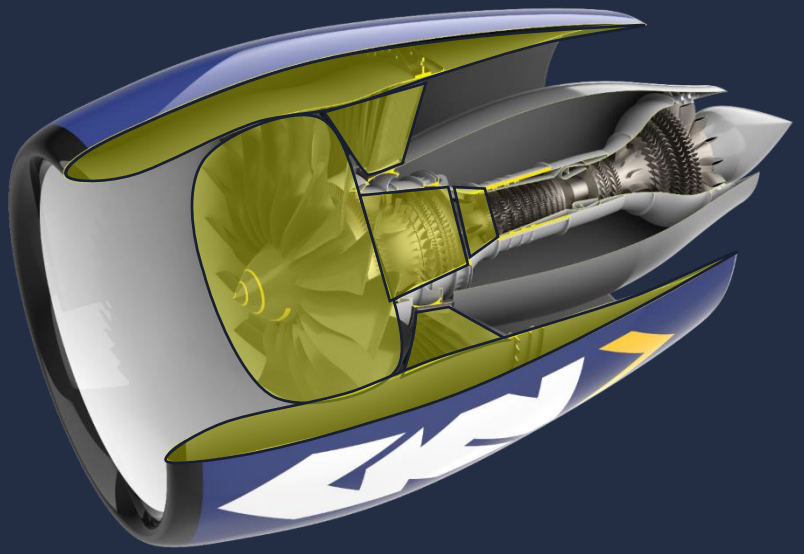
(2021) **Design of a high subsonic nozzle for a transonic linear cascade operating at near stall conditions**
10.13140/RG.2.2.26067.14884.

(2020) **Feasibility Study of a Radical Vane-Integrated Heat Exchanger for Turbofan Engine Applications**
10.1115/GT2020-15243

(2017) **Multidisciplinary Design of a Three Stage High Speed Booster**
V02BT41A037. 10.1115/GT2017-64466

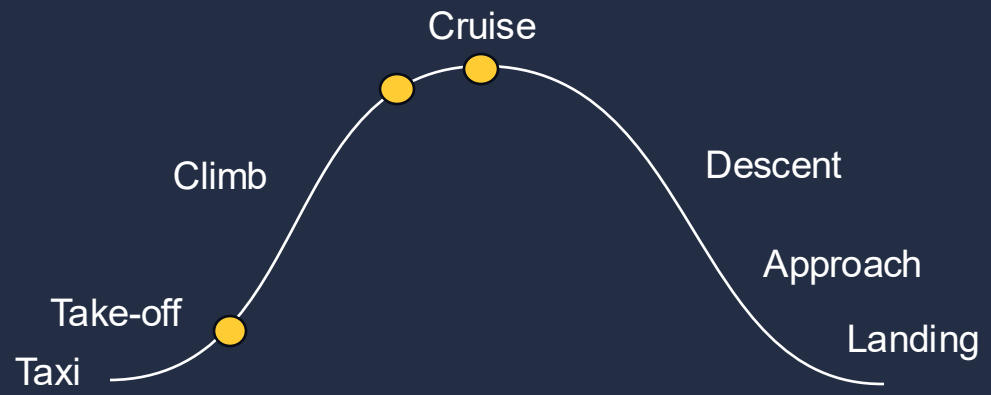
The starting point
VINK

The starting point



VINK – Virtual Integrated Compressor Demonstrator

- Starting from a blank paper
- First engine performance model

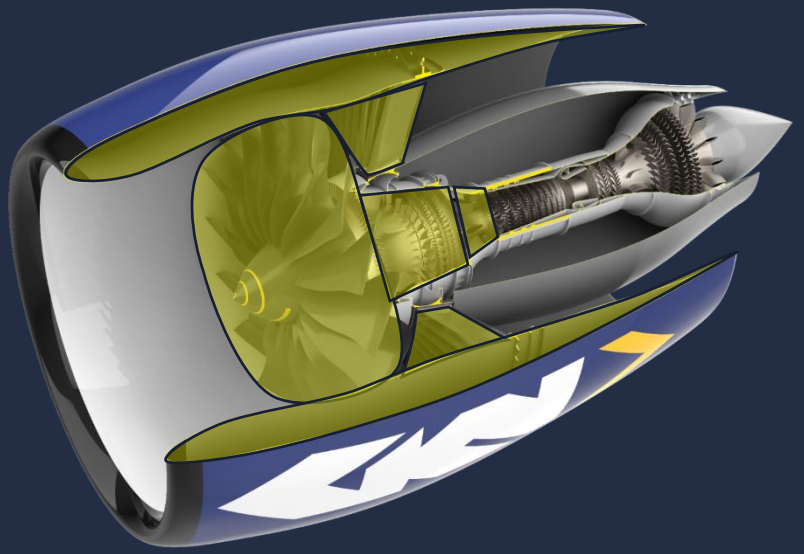


VINK

2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025

The National Aeronautics Research Programme (NFFP)

The starting point



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- First engine performance model
- First aerodynamic design of the nacelle, fan, fan outlet guide vanes

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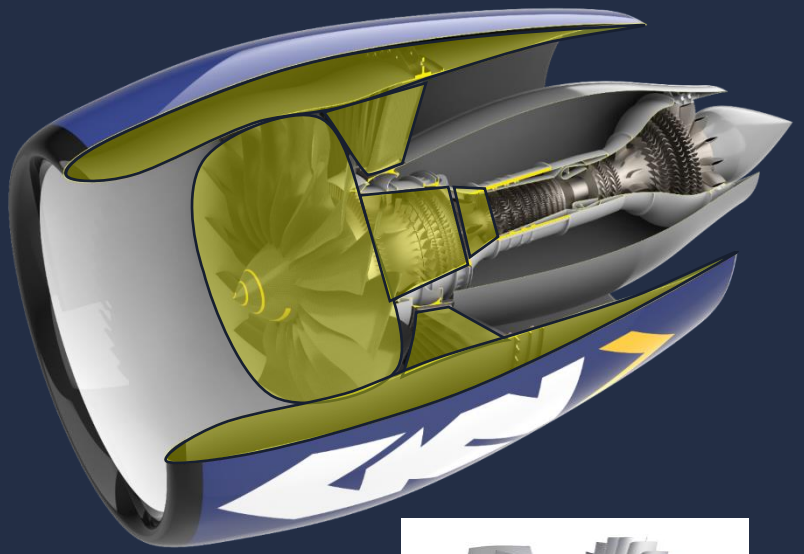
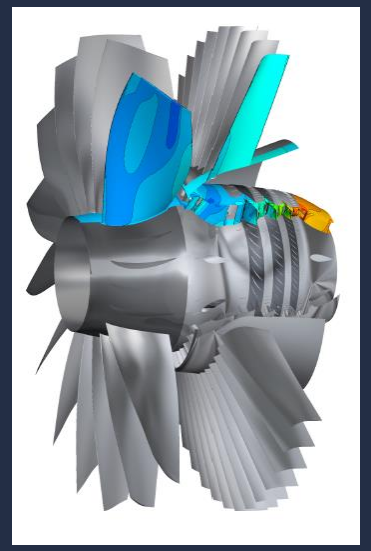


VINK – Virtual Integrated Compressor Demonstrator

- Starting from a blank paper
- First engine performance model
- First aerodynamic design of the nacelle, fan, fan outlet guide vanes
- First design of the low-pressure compressor (LPC) and intermediate compressor duct (ICD)
  - Detailed aerodynamic design
  - Structural analysis of the first LPC rotor
  - Joint publication: Multidisciplinary Design of a Three-stage High Speed Booster. ASME Turbo Expo 2017. GT2017-64466



VINK

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The National Aeronautics Research Programme (NFFP)

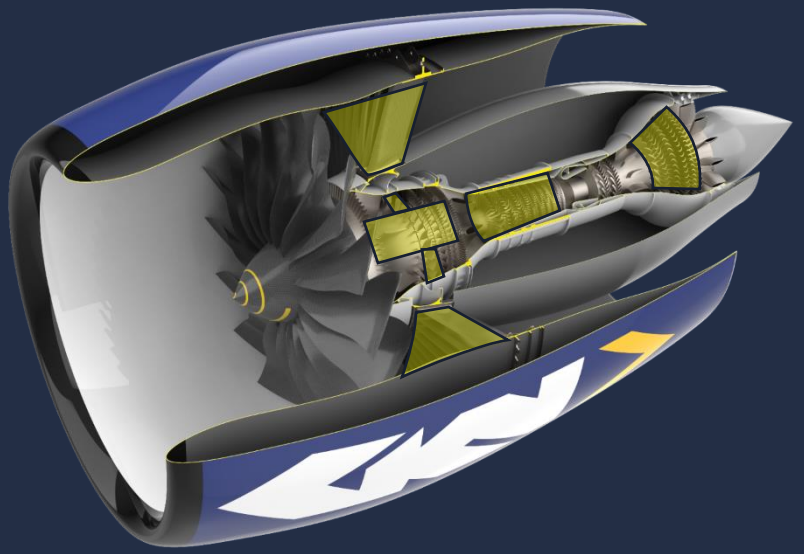
GKN AEROSPACE

The continuation

VIND

MAKING THINGS FLY

The continuation

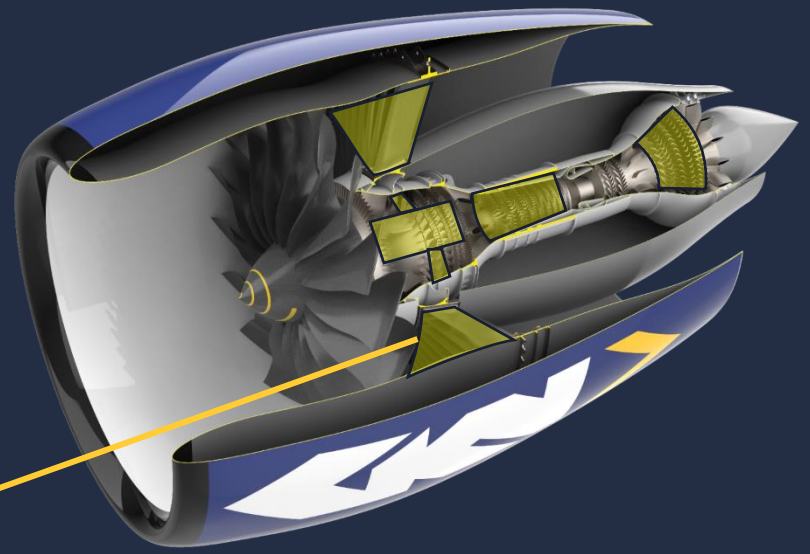


VIND – Virtual Integrated Demonstrator for Turbomachinery

- Updated engine performance model

The National Aeronautics Research Programme (NFFP)

The continuation



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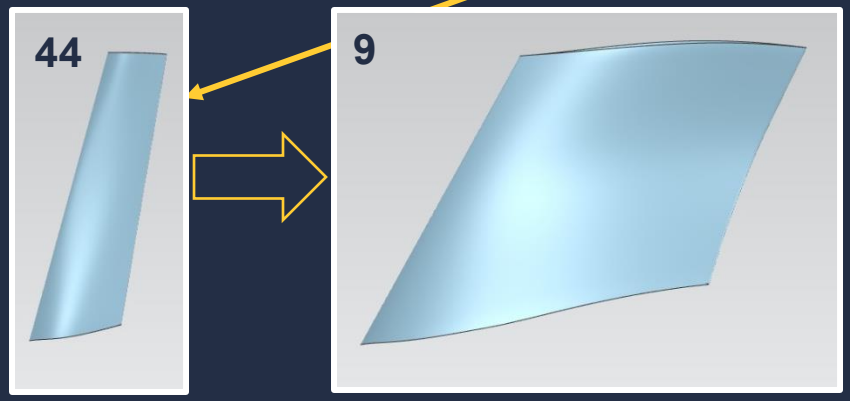
- Updated engine performance model
- Ultra-low count Fan Outlet Guide Vane Design (44 → 9)



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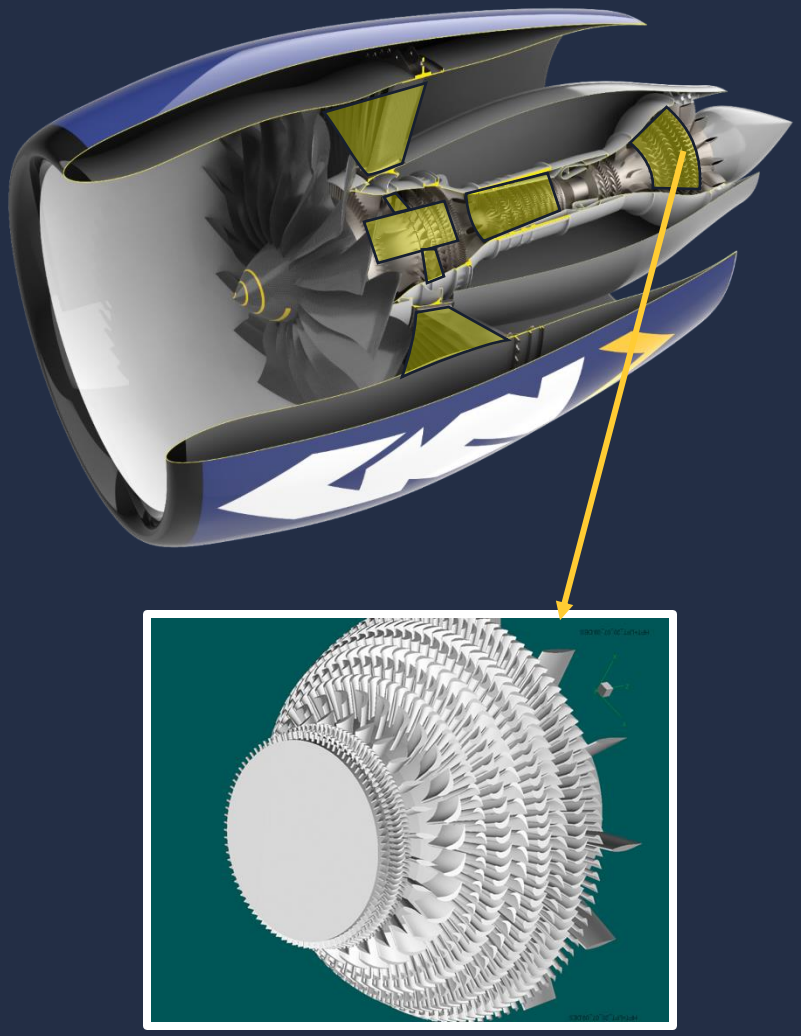
The continuation



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- Updated engine performance model
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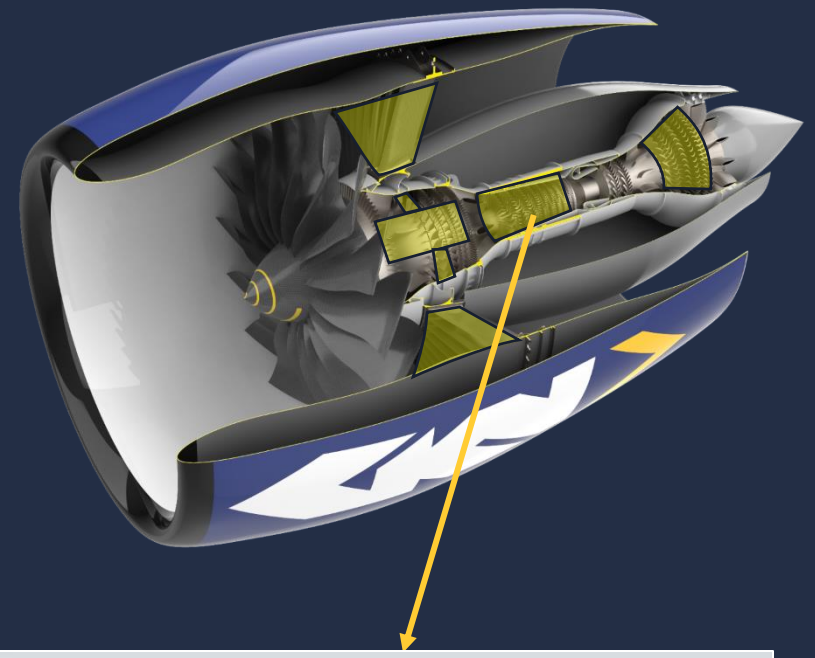
The continuation



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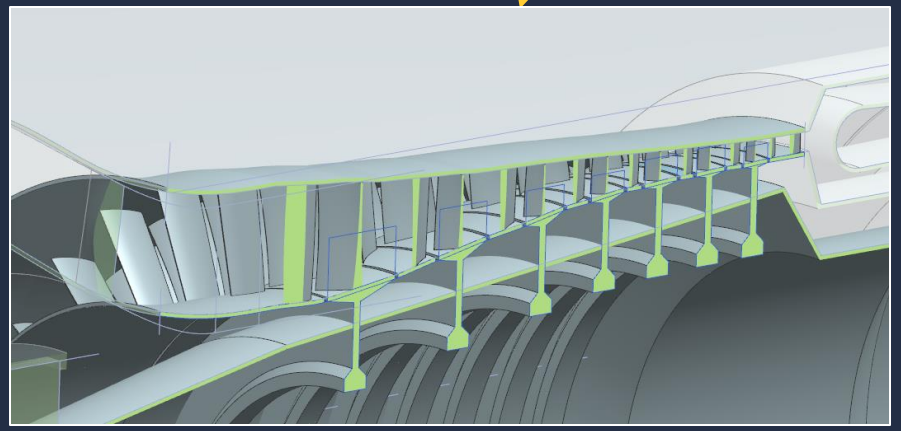
- First aerodynamic design of the High-Pressure Compressor (HPC)



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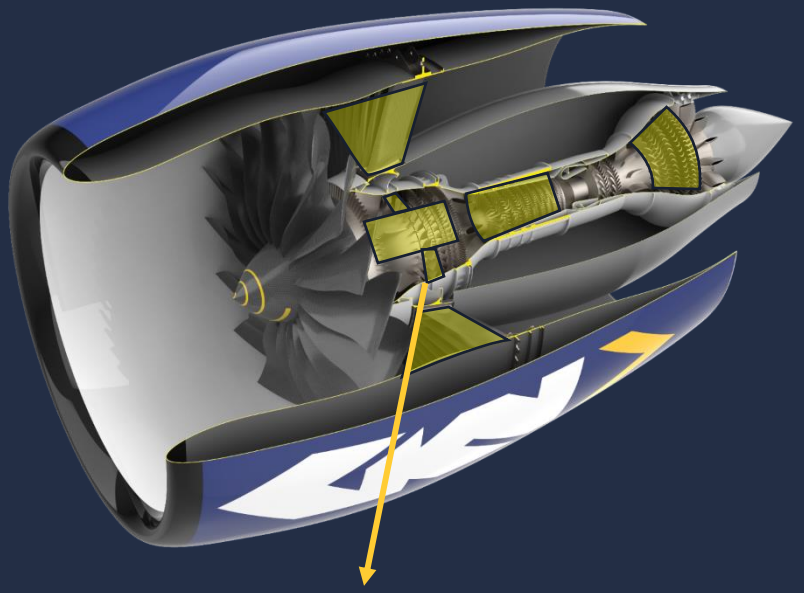

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- First aerodynamic design of the Low-Pressure Turbine (LPT)
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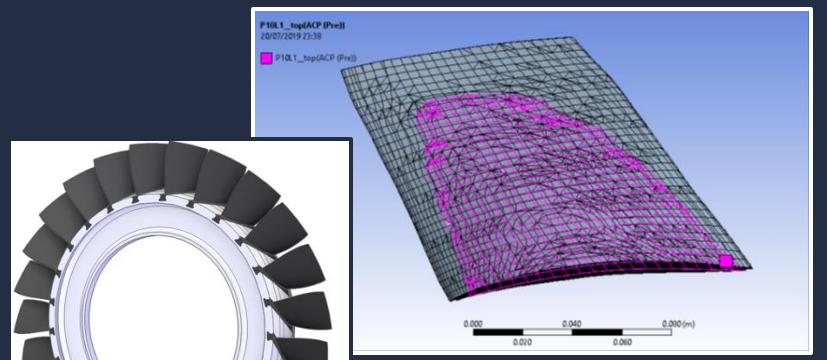
- Carbon fibre layup of the first rotor in the Low-Pressure Compressor (LPC)



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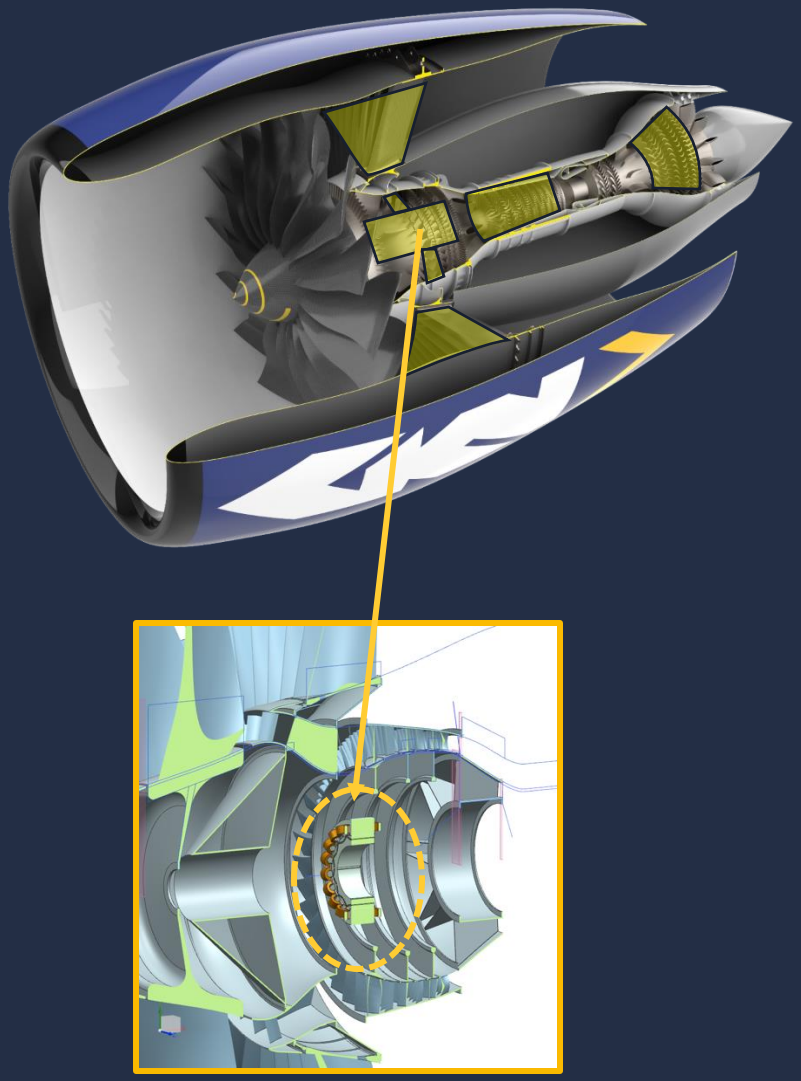

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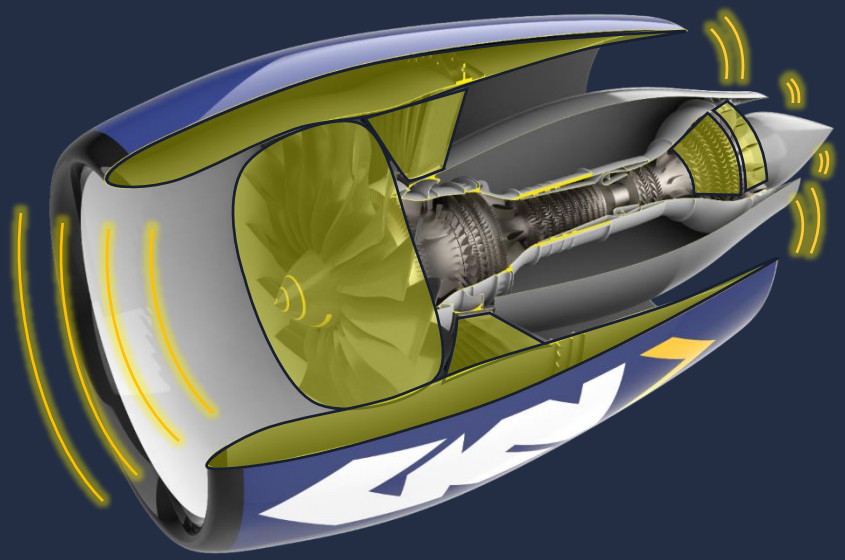
- First aerodynamic design of the Low-Pressure Turbine (LPT)
- First aerodynamic design of the High-Pressure Compressor (HPC)
- Carbon fibre layup of the first rotor in the Low-Pressure Compressor (LPC)
- Integration of an electric motor/generator
  - First step towards “more electric”
  - More on potential benefits on electric motor and generator integration in the next presentation in this session

The National Aeronautics Research Programme (NFFP)

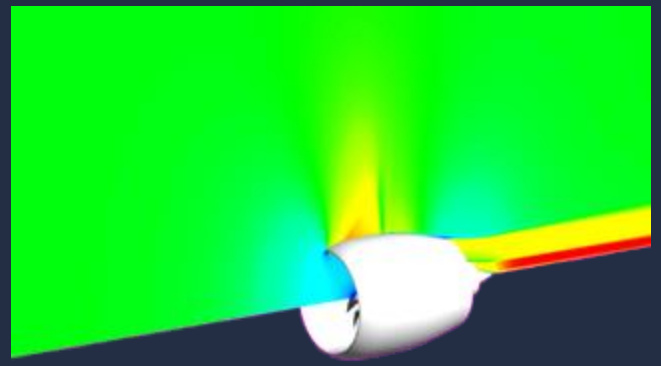
Pre-studies
VIFT

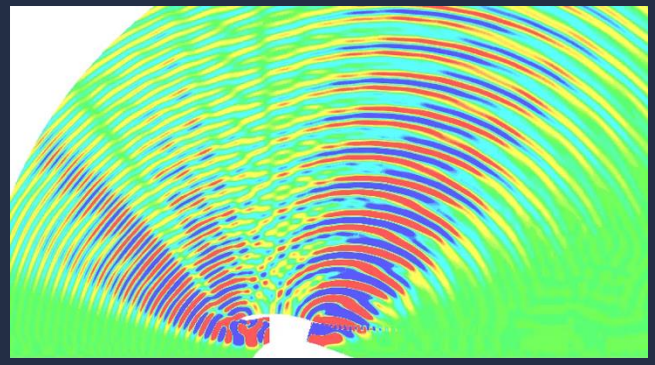
Pre-studies



VIFT – Virtual Integrated Fan and Turbine

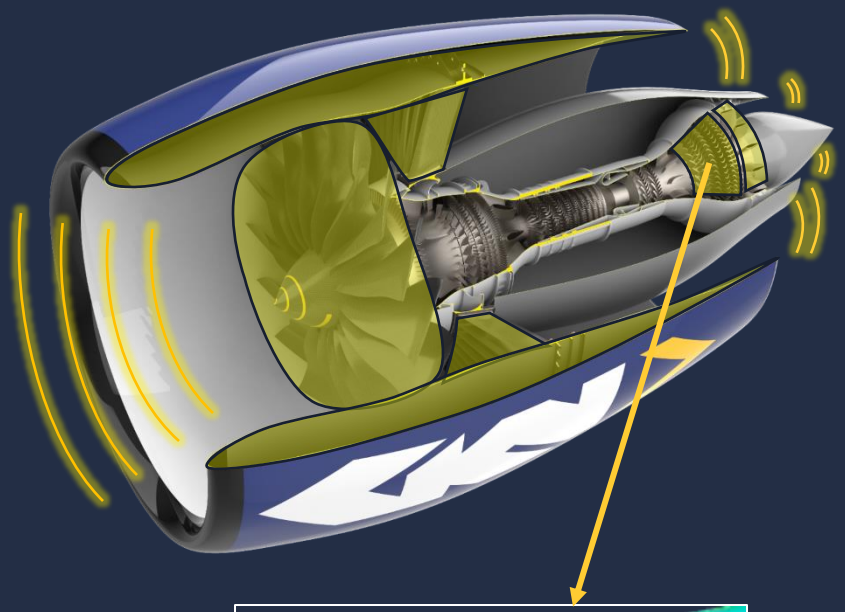
- Pre-studies for a longer project
- Aerodynamic re-design of Fan, FOGV and nacelle
- System level noise model and noise propagation from detailed analysis





The National Aeronautics Research Programme (NFFP)

Pre-studies



VIFT – Virtual Integrated Fan and Turbine

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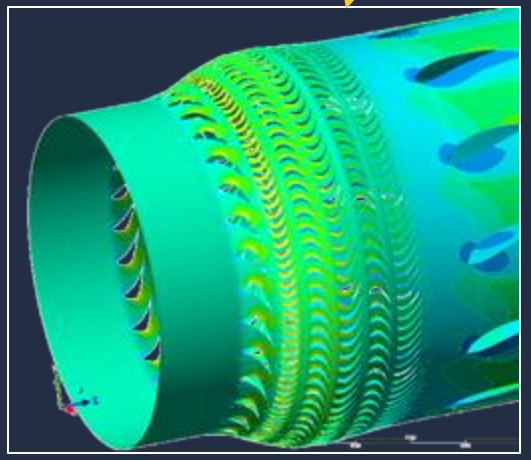
- Design exploration: Low-Pressure Turbine (LPT) with an uncooled first rotor



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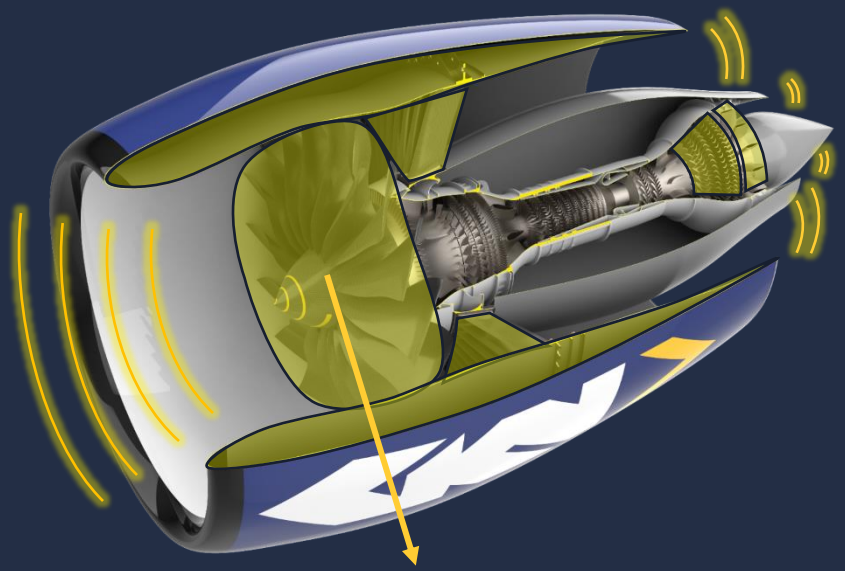

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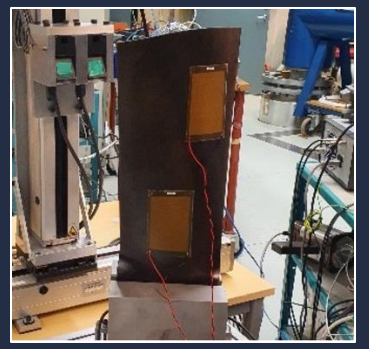

The National Aeronautics Research Programme (NFFP)

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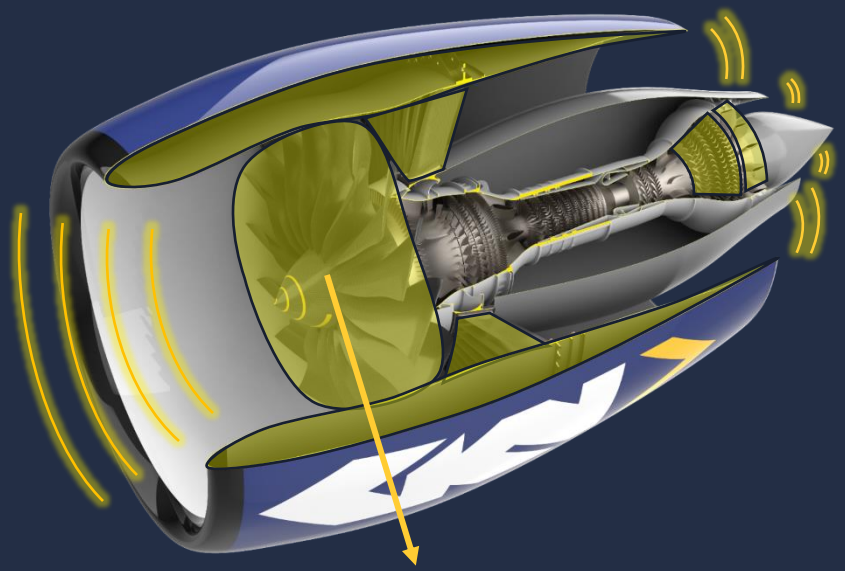

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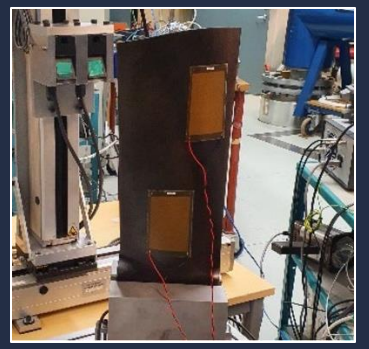
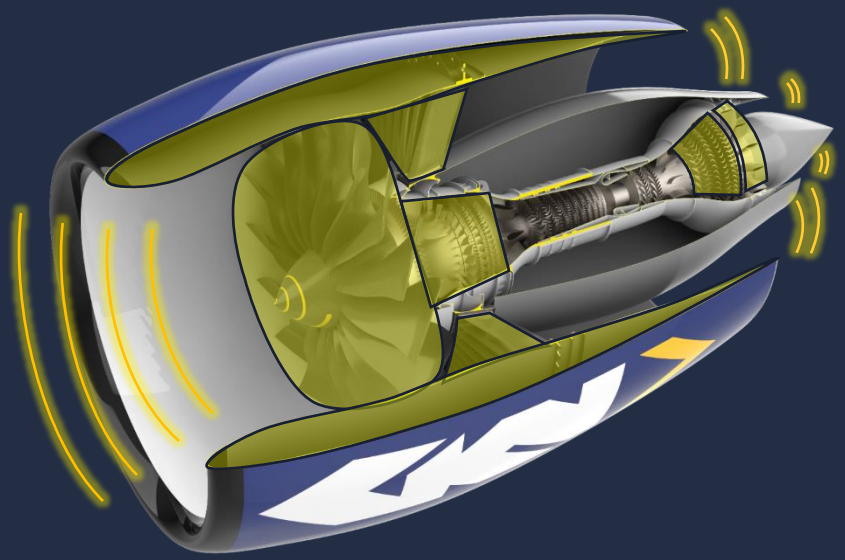


The National Aeronautics Research Programme (NFFP)

The on-going project

VILD

The on-going project



VILD – Virtual Integrated soLutions for future Demonstrators and products

- Detailed aerodynamic nacelle design: Three different lengths
  - Containment
  - Aeromechanical analysis of a phenomena called “flutter-bite”
- Aerodynamic re-design the Low-Pressure Compressor
- Aerodynamic design of a bleed system
- VIFT Continuation: System level noise model and noise propagation from detailed analysis
- VIFT Continuation: Detailed aerodynamic design of Low-Pressure Turbine (LPT) with an uncooled first rotor
- VIFT Continuation: Fan blade – Carbon fibre layup optimization

The National Aeronautics Research Programme (NFFP)

Summary

- **On-going development of a virtual turbofan in collaboration between GKN Aerospace, Chalmers University of Technology, KTH Royal Institute of Technology and Lund University**
  - Continuity
  - Fan, fan outlet guide vanes, low-pressure compressor, intermediate compressor duct, high pressure compressor, low-pressure turbine, turbine exhaust case, nacelle, …
  - Academic partners can apply their expertise to a design relevant to industry
- **Can be used for research (Can be published without normalizing all the data)**
- **Experimental test rigs are based on parts of the engine**

In the near future

- **Conference presentations**
  - *(2025) Aeroelastic Design of a Large-Diameter Composite Fan Blade – To be Published ISUAAAT17-91. November 16th-21st, 2025, Melbourne, Australia*
  - GKN Aerospace - National Aeronautics Research Programme (NFFP) Conference. *November 4-5th 2025, Trollhättan, Sweden*

- **Master thesis January – June 2026**
  - *Simulation of a carbon fibre fan blade off event*
    Collaboration between GKN Aerospace and KTH Royal institute of Technology

Thank you for your attention!

Questions?