Qt World Summit 2016

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Radical changes in the aircraft design process through software technology

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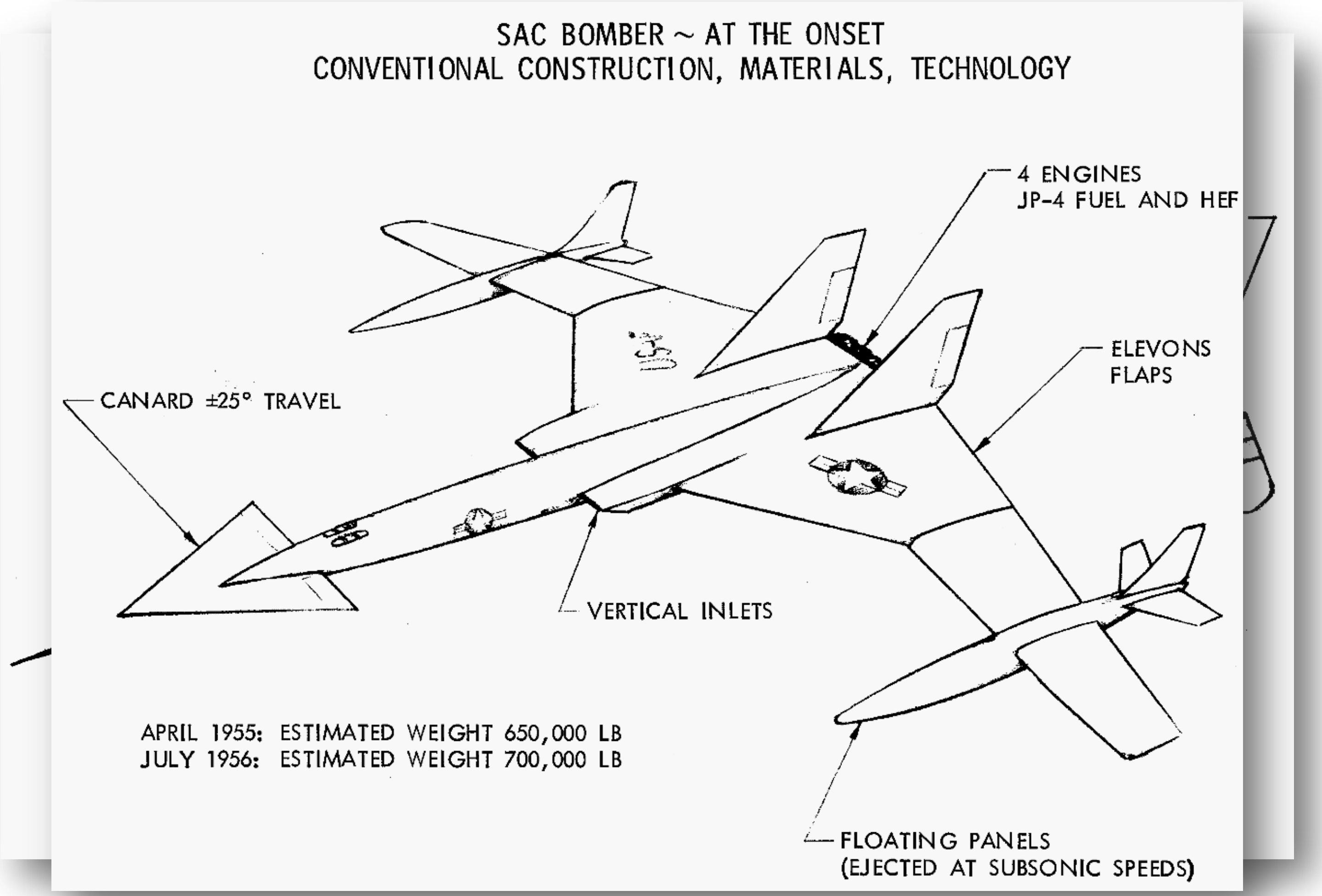
DLR

Outline

- Traditional aircraft design
- Software enabled aircraft design
- Projects at the German Aerospace Center (DLR)
- Software-Tools
- Built with Qt

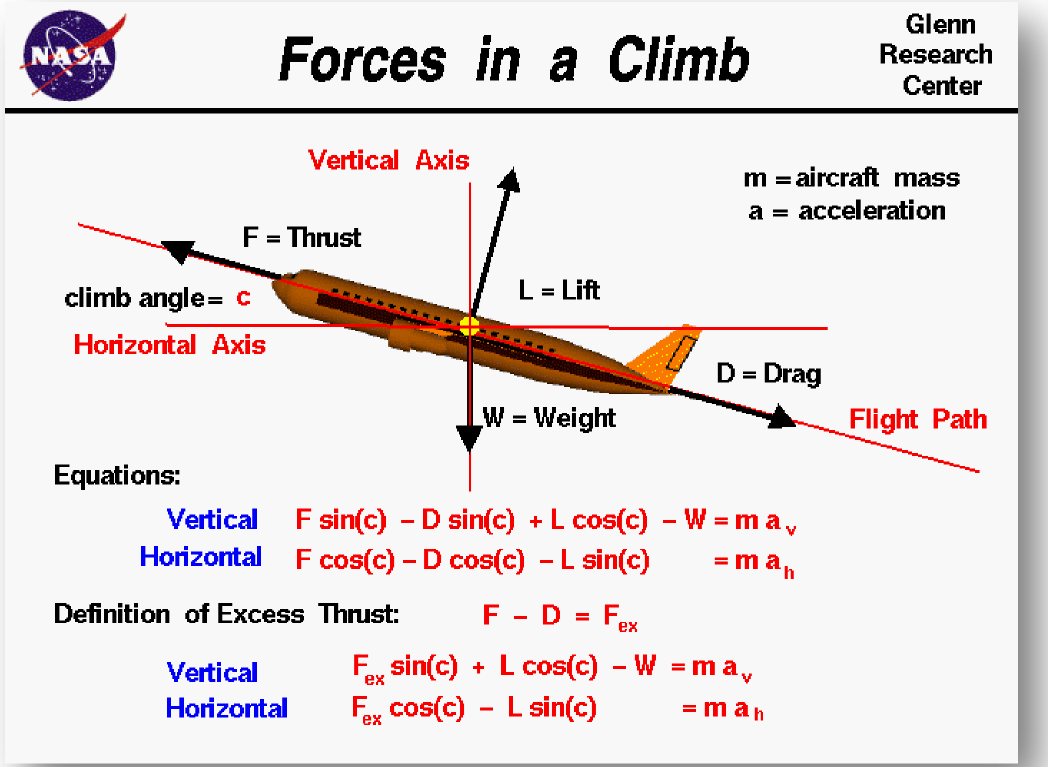
Traditional aircraft design

Conceptual design
Sketchpad

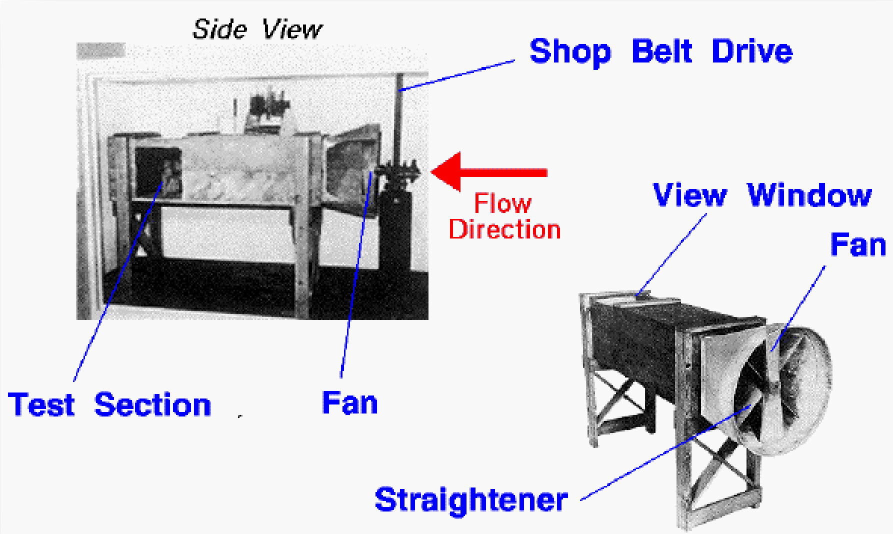


Conceptual design
Handbook formulae

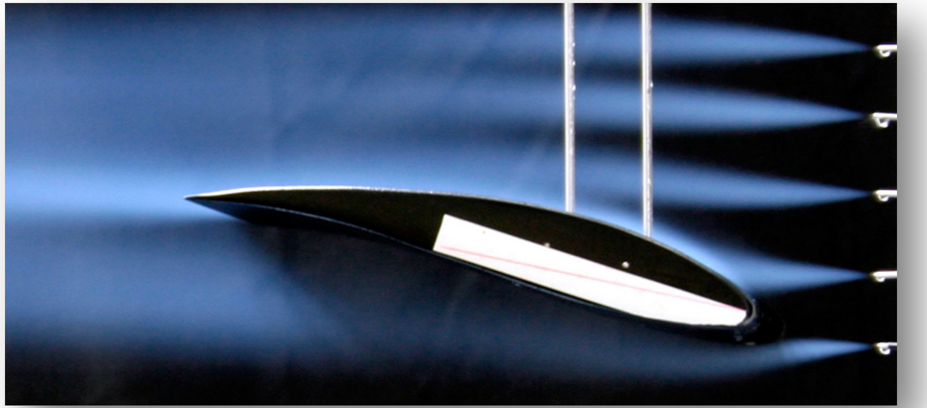
- Collection of simple Equations
- Particularly useful for traditional designs
- Based on simplified physics or empirics
- Rough estimates for e.g.:
  - Amount of lift
  - Structural loads
  - Total mass
  - Tank size

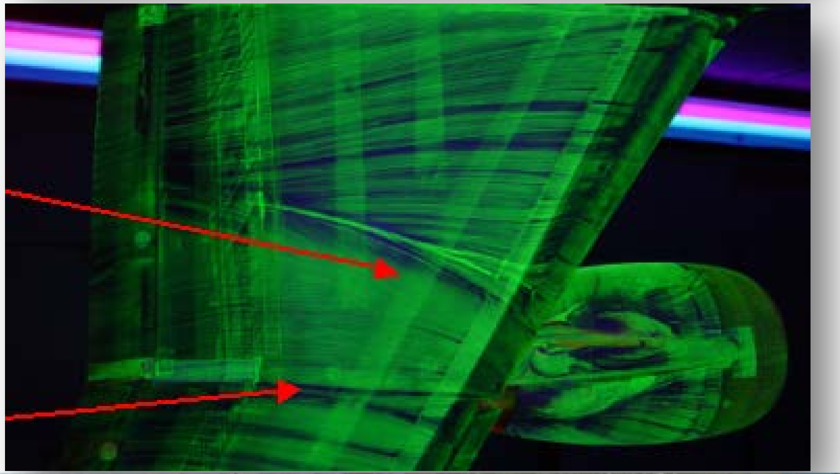


Preliminary design
Models + Wind tunnel experiments



Wright Brothers (1901)





Detailed design

Prototypes + Test flights

X-1 (1946)

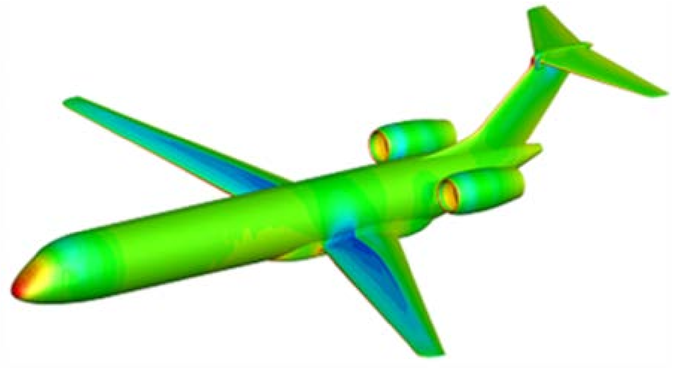
Rockwell XVF-12 (1981)

X-15 (Neil Armstrong, 1960)

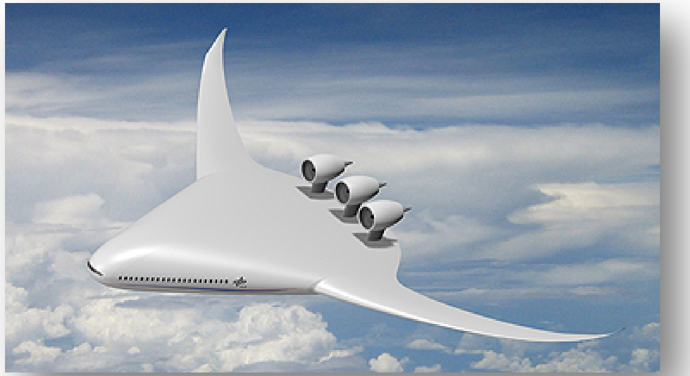
X-29 (1984)

Software-enabled aircraft design

Software-aided design: unconventional designs



- Building aircraft prototypes is time consuming and expensive
- Software allows to:
    - Find strengths and weaknesses of new designs
    - Simulate, if all requirements can be met
    - Explore many different concepts
    - Simulate even unconventional aircraft designs accurately where no human experience is available

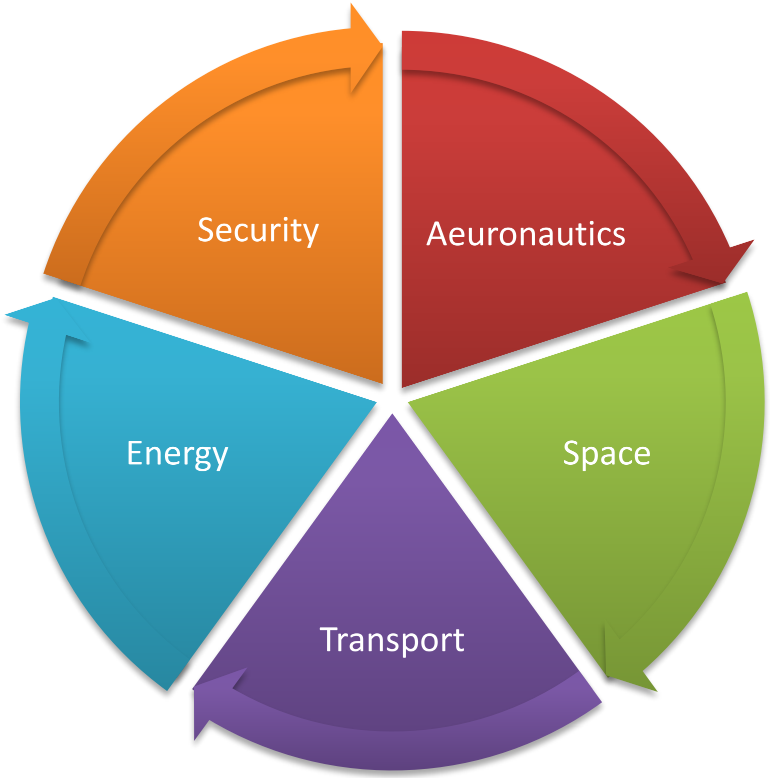


Software-aided design: conventional designs

- Improve fuel efficiency
- Squeeze the margins
- Improve reliability and safety
- No low hanging fruits anymore → Optimization software explores the whole design space for a few percent improvement

Design projects at the DLR

The German Aerospace Center (DLR)



SOFTWARE?

Project FrEACs

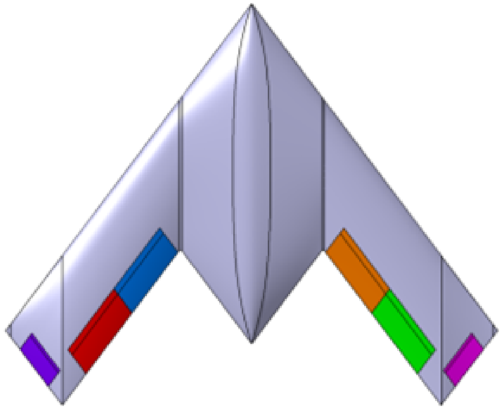
- The aircraft of tomorrow
- Unconventional designs:
  - Blended Wing Body
  - Strut-braced wing
- Track uncertainties throughout whole simulation chain

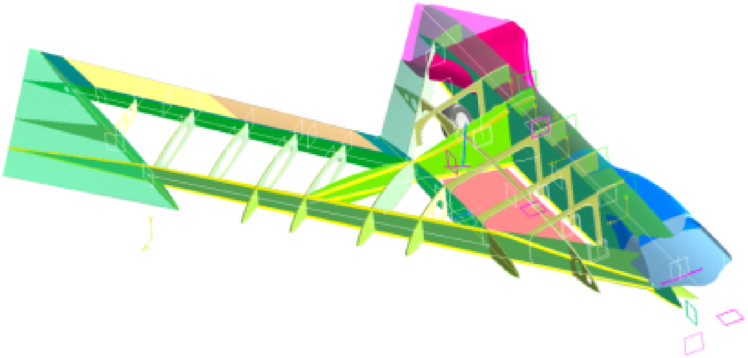
Project Digital-X

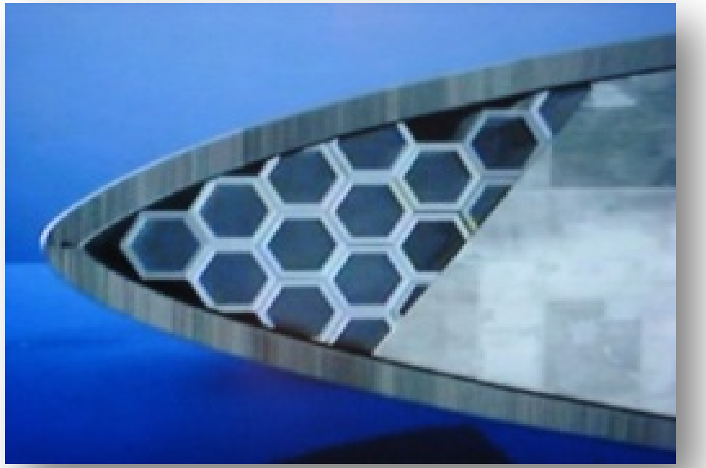
- Complete Simulation of aircraft and helicopters
- Very high accuracy / small errors
- Development of a new CFD simulation code
- Optimize aircraft to improve fuel efficiency
- Flying the virtual aircraft prior to the first flight
- Use HPC systems used for simulations

Project Mephisto

- Simulation of unmanned combat aircraft (drones)
- Novel flap and aileron concepts
- Explore new stealth materials
- Compute and minimize probability of detection



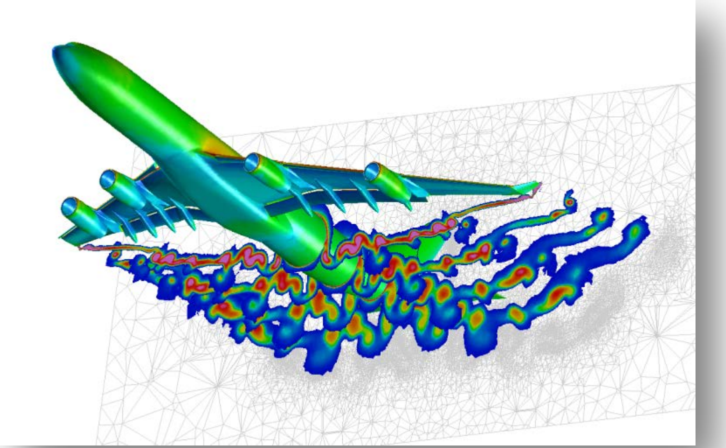


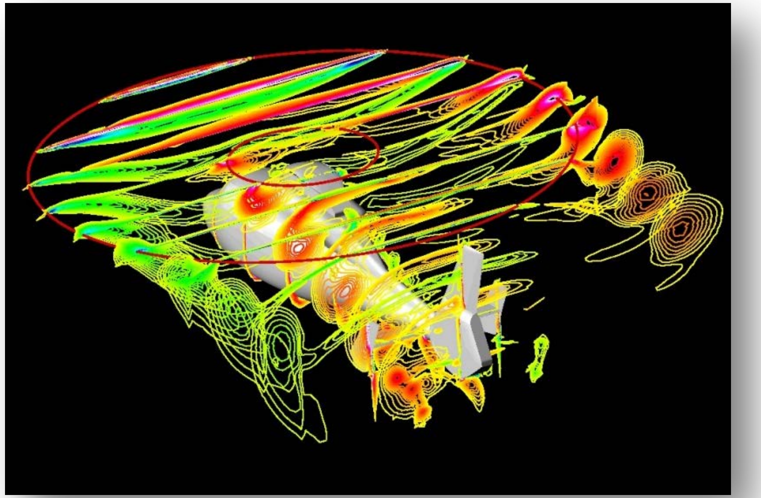


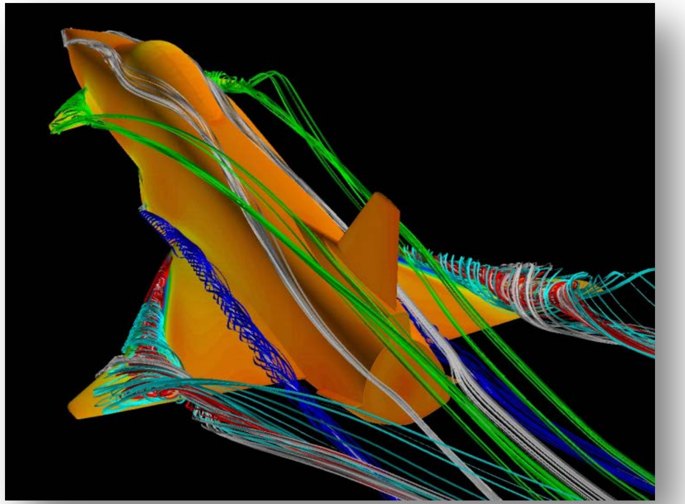
Software Tools

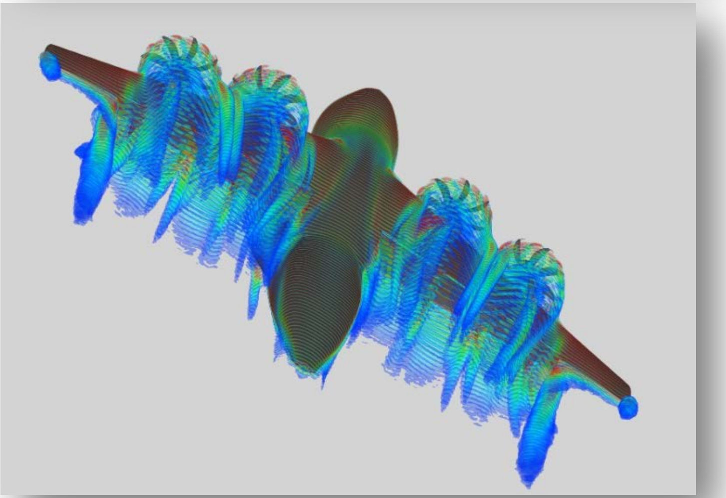
Aerodynamics simulation (CFD)

- High precision flow simulation
- HPC architectures
- Computation time: hours – days!



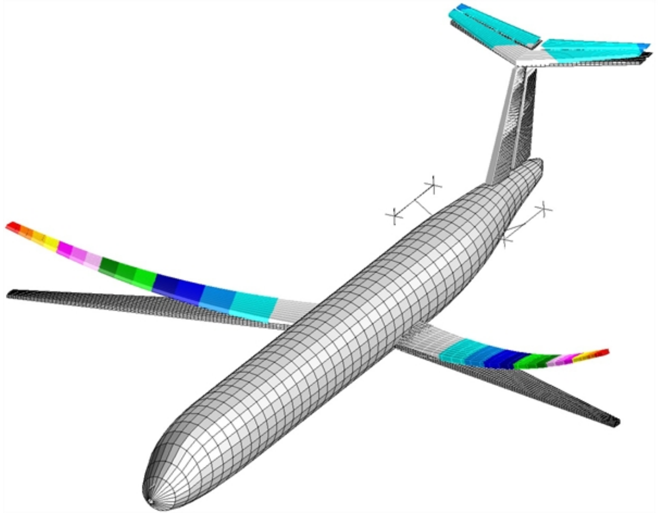


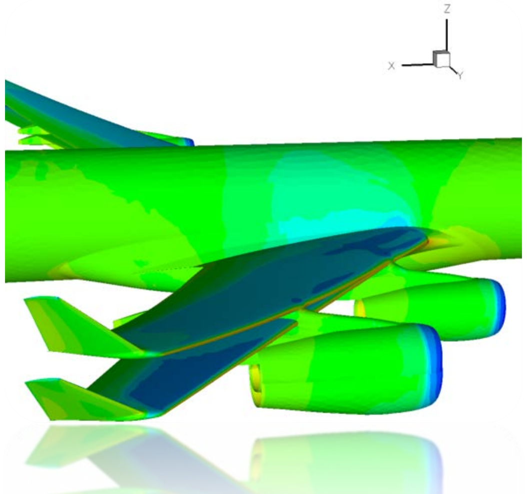




Simulation of the aircraft structure

- Simulation of mechanical loads
- Estimation of the aircraft structure’s mass
- Simulation of wing deformation / deflection by loads
- **Changes solution of the CFD simulations**

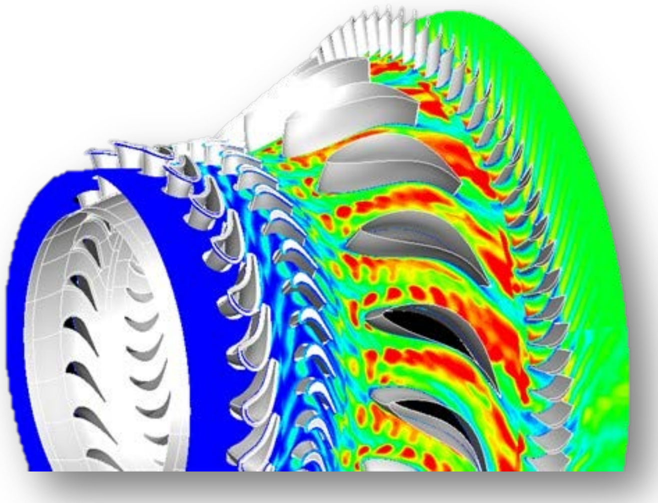


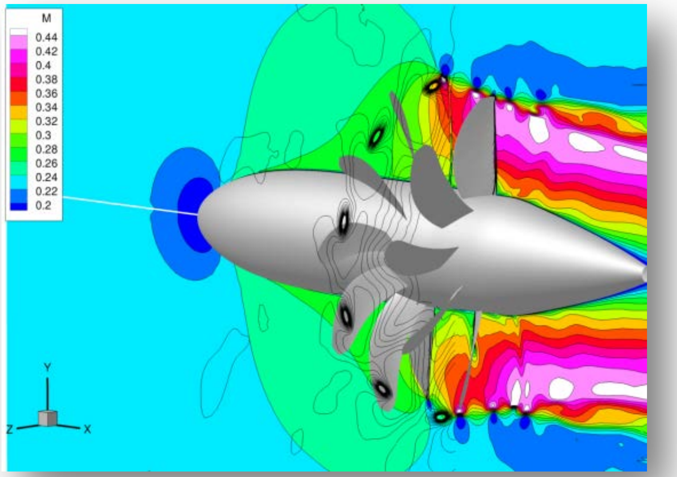


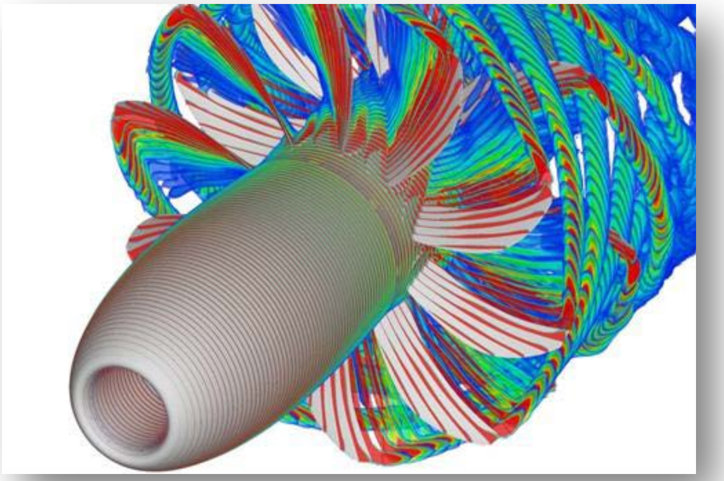
Engine simulation

- High precision simulation of aircraft engine
- Estimation of engine behavior (efficiency, thrust, speed)
- Airflow simulation
- Combustion
- Aeroacoustics
- Engine design optimization

TRACE

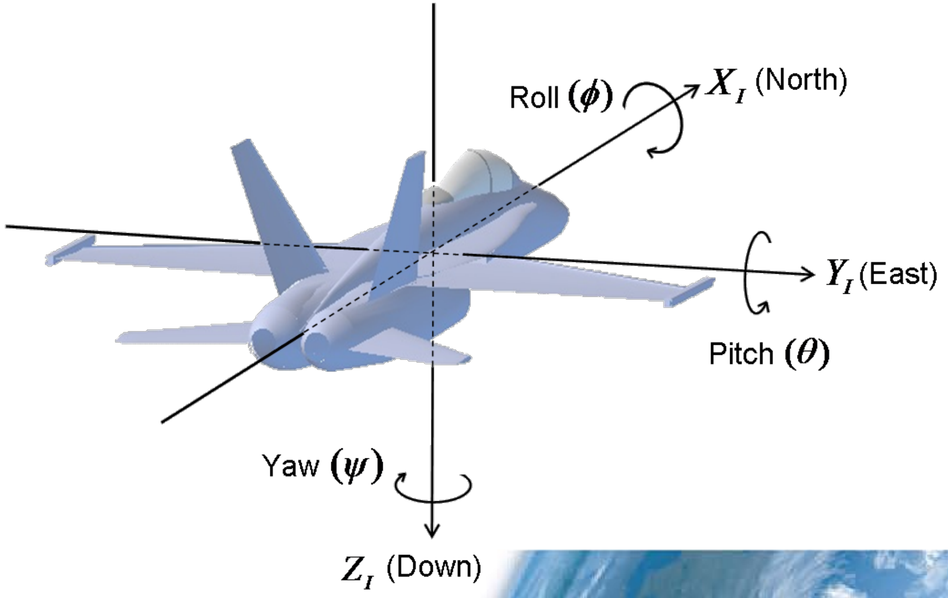






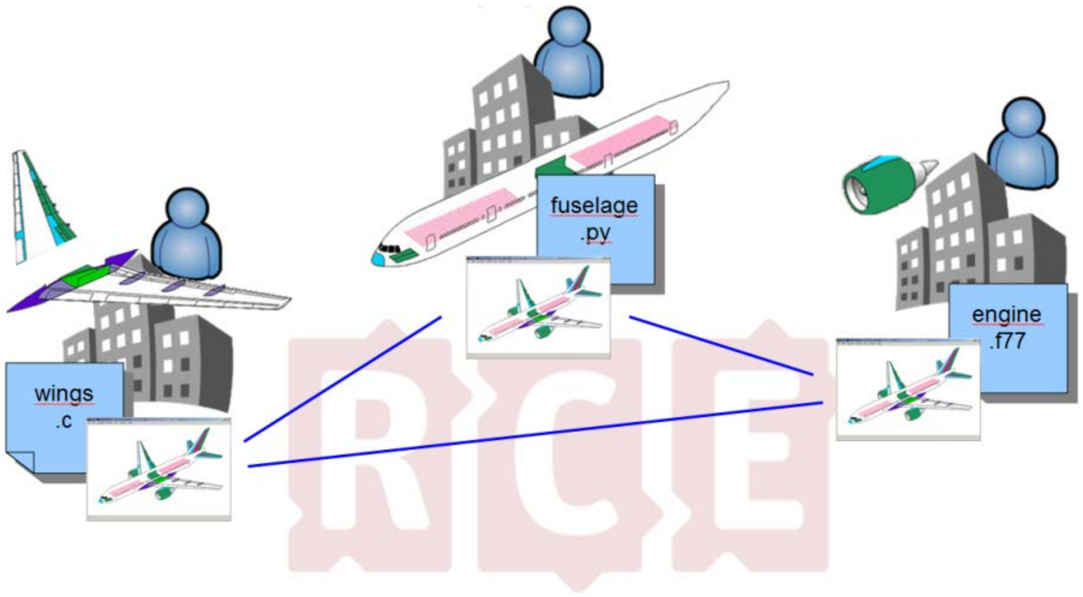
Aircraft dynamics and control

- Simulation of aircraft movements
- Estimates forces during a maneuver
- Allows to estimate, whether aircraft behaves as planned
- Active control simulation



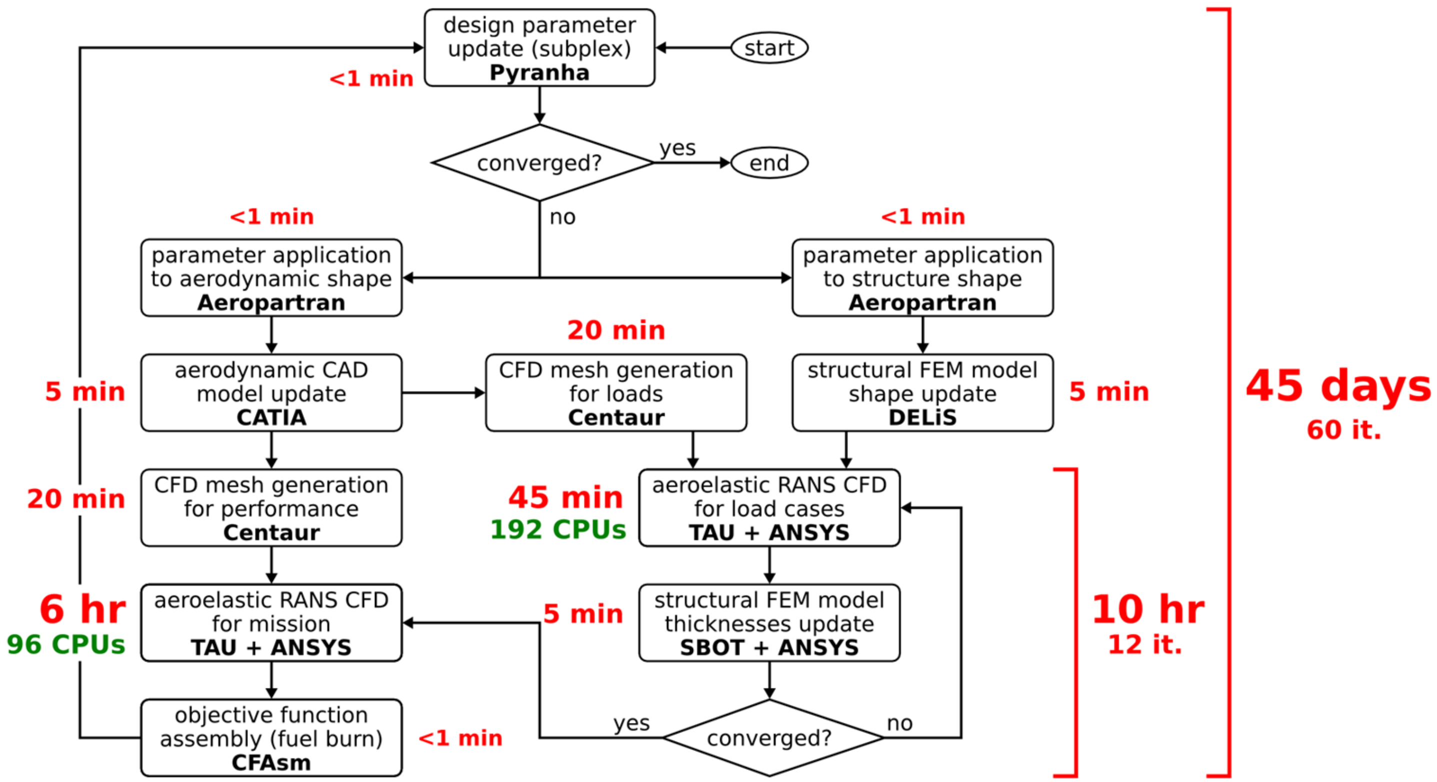
RCE – Workflow-driven Integration Environment

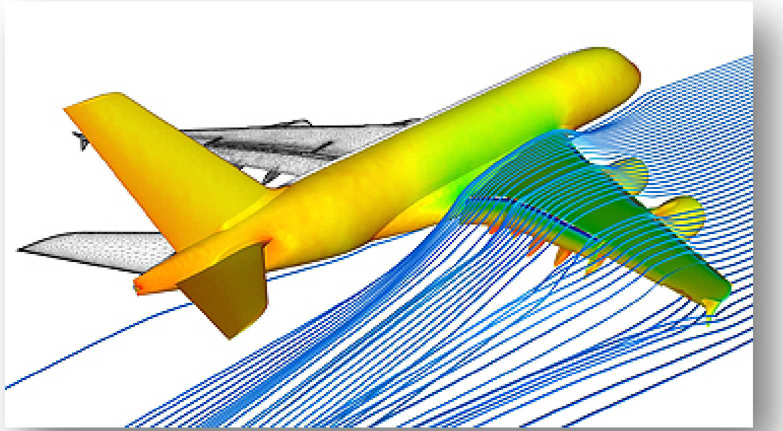
- Software framework to integrate and solve multidisciplinary design analysis and optimization (MDAO) problems
- Provides a workflow management for coupling simulation codes in a graphical user interface
- Create and execute workflows easily
- Provides secure and uniform access of data in a distributed environment (also at different sites)
- Connection to HPC facilities possible



RCE – Workflow-driven Integration Environment RCE

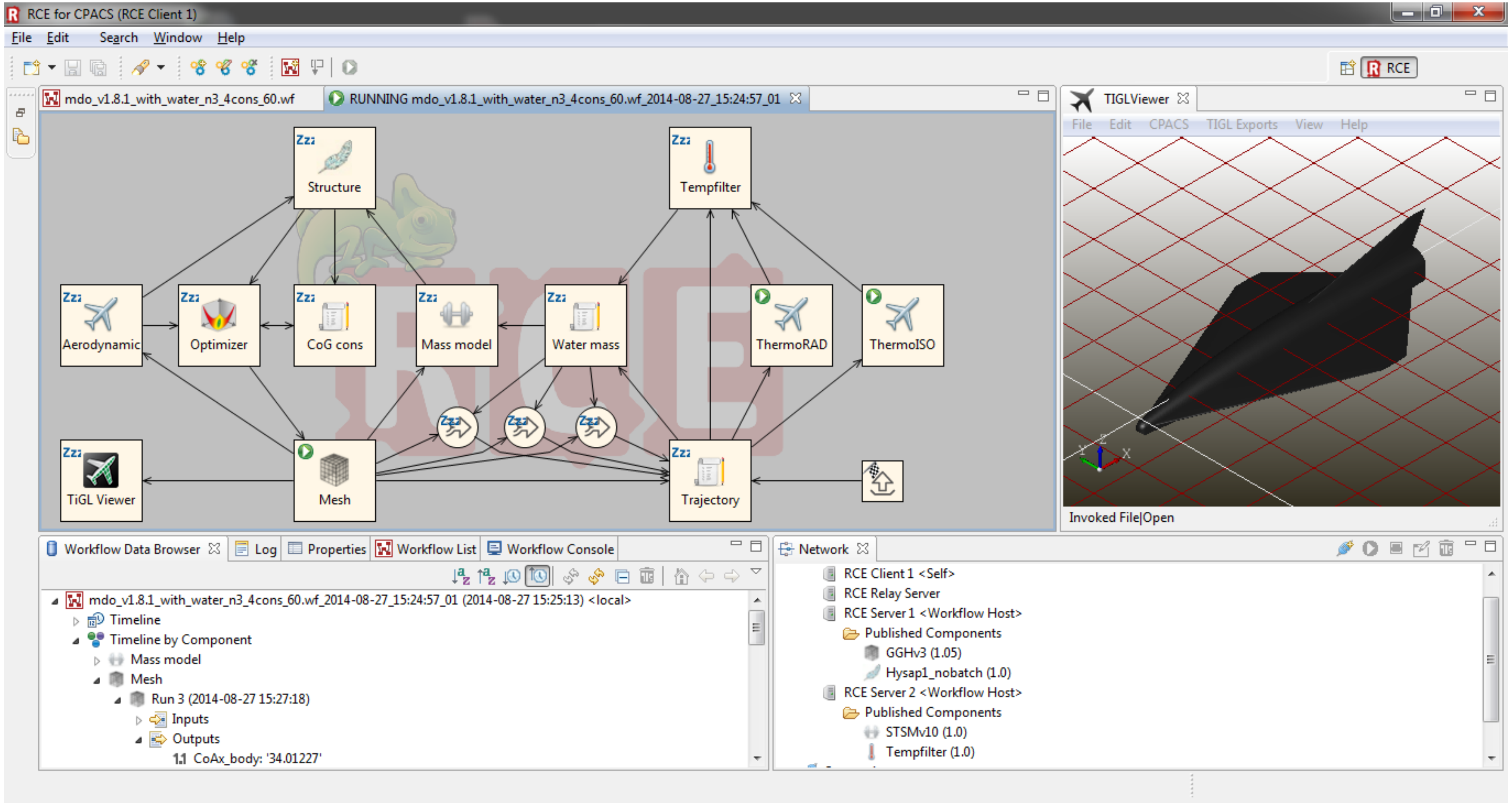
Distributed Multidisciplinary, Multi-Level Aircraft Design





Distributed Multidisciplinary, Multi-Level Optimization Chain

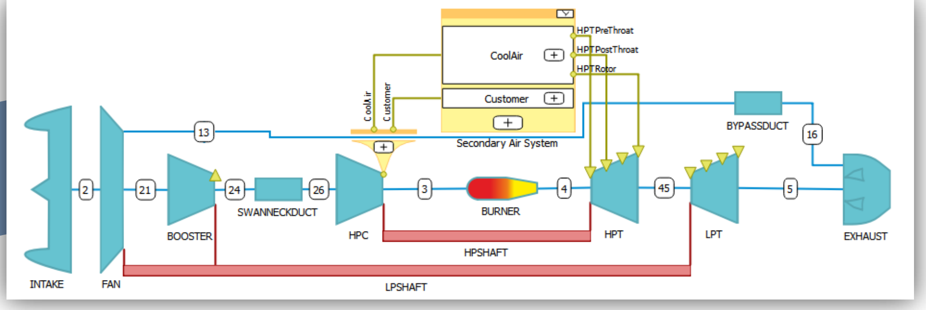
RCE – Workflow-driven Integration Environment RCE



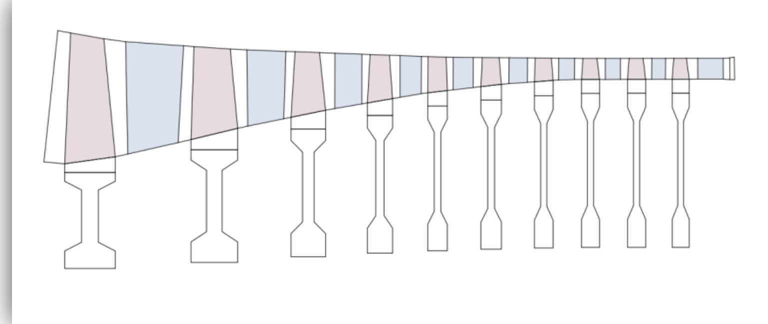
Built with Qt

Built with Qt
GTlab – Gas Turbine Laboratory

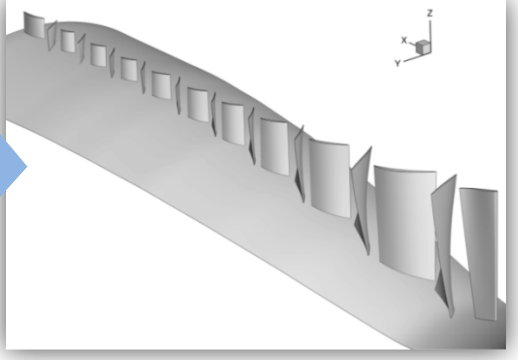
Interactive, cross platform simulation and design environment for aircraft engines and gas turbines.



GT Lab PERFORMANCE

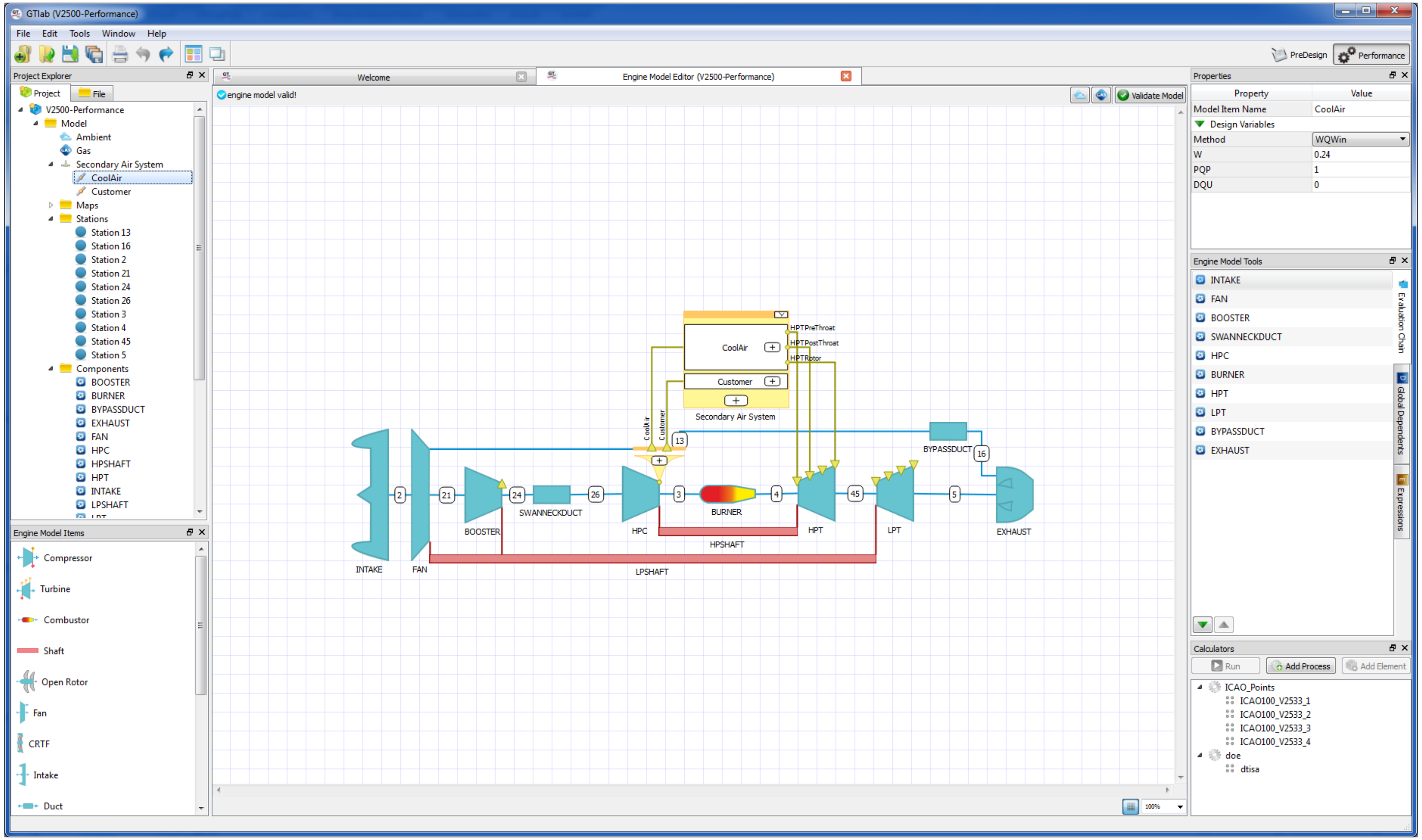


GT Lab Sketchpad



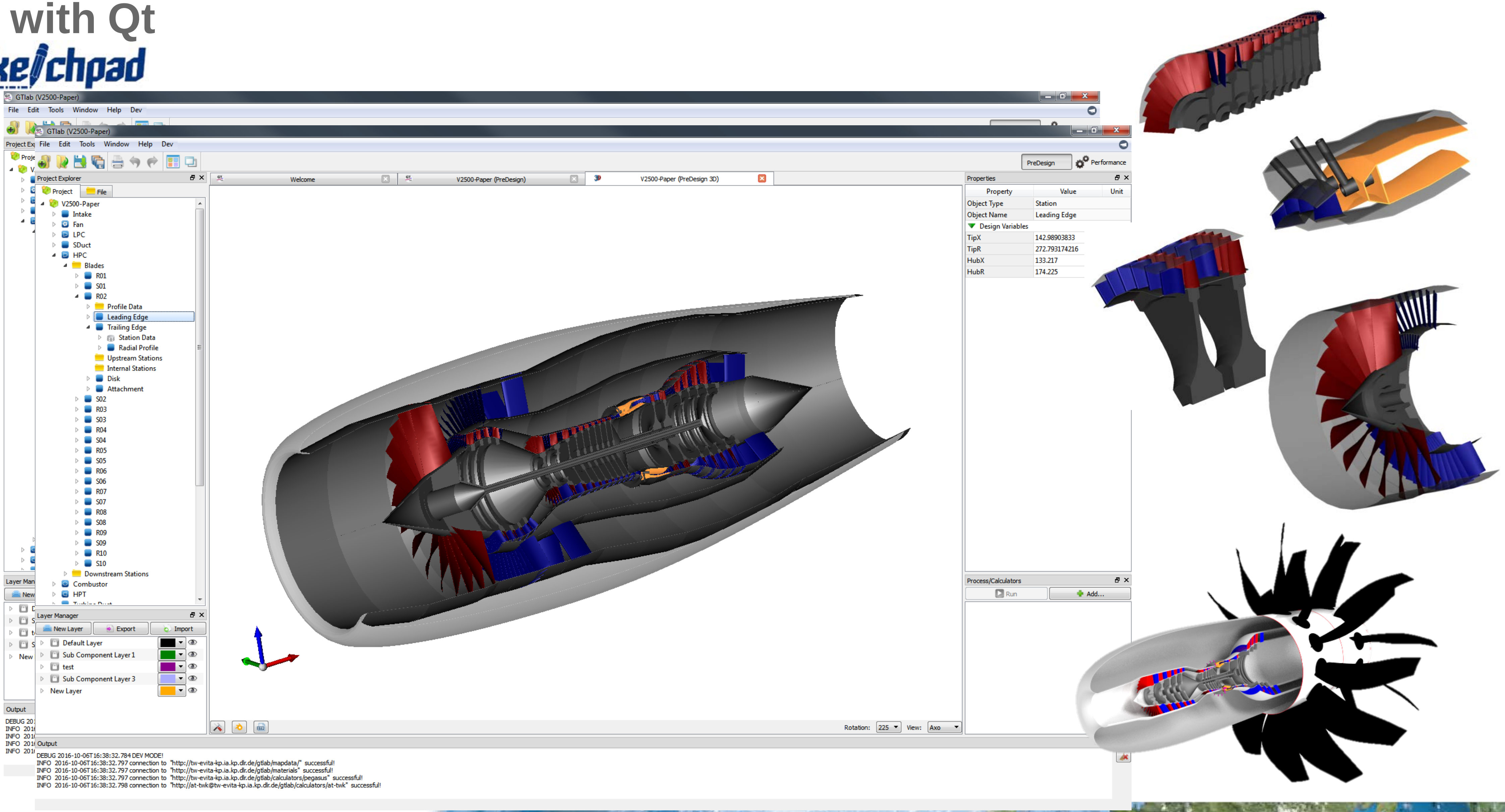
Built with Qt

GT PERFORMANCE Lab



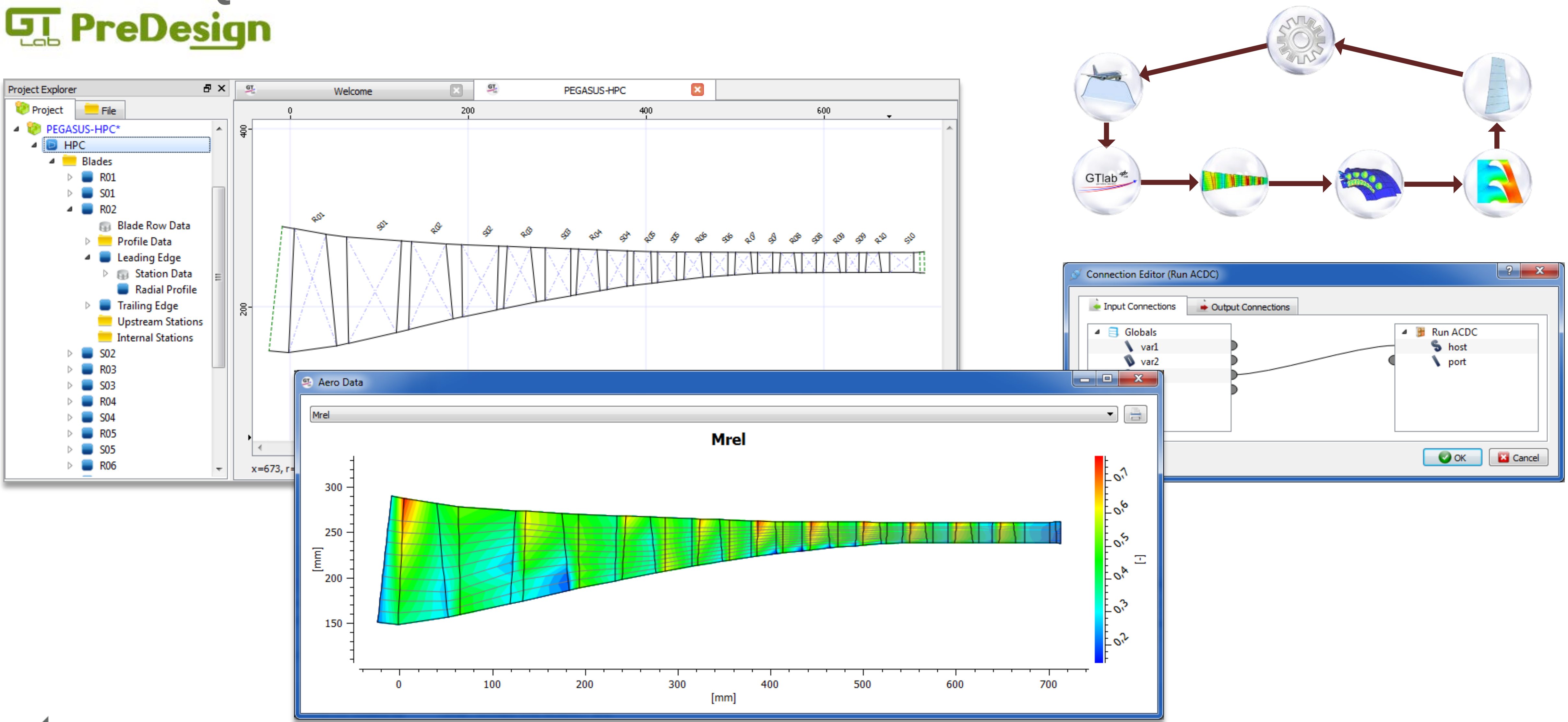
Built with Qt

GT Sketchpad



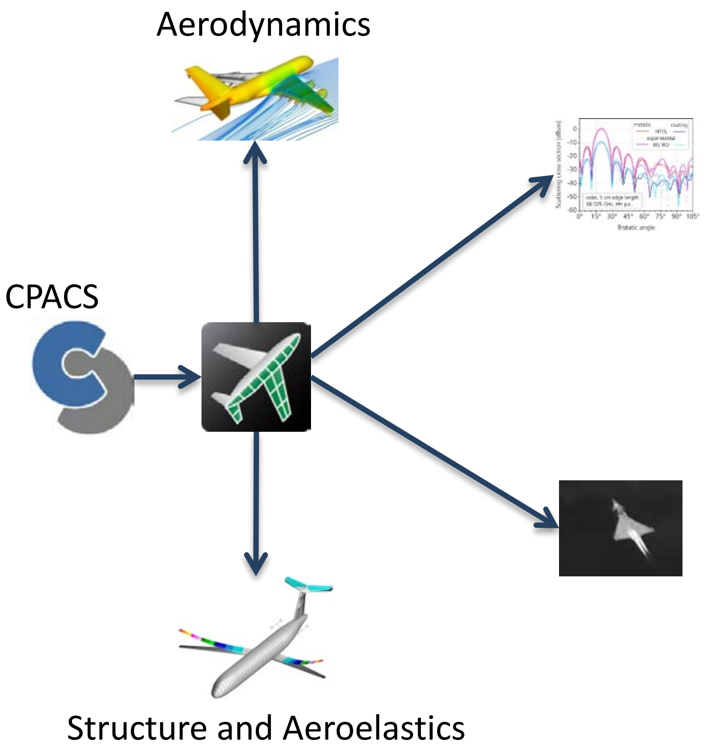
Built with Qt

GTlab PreDesign

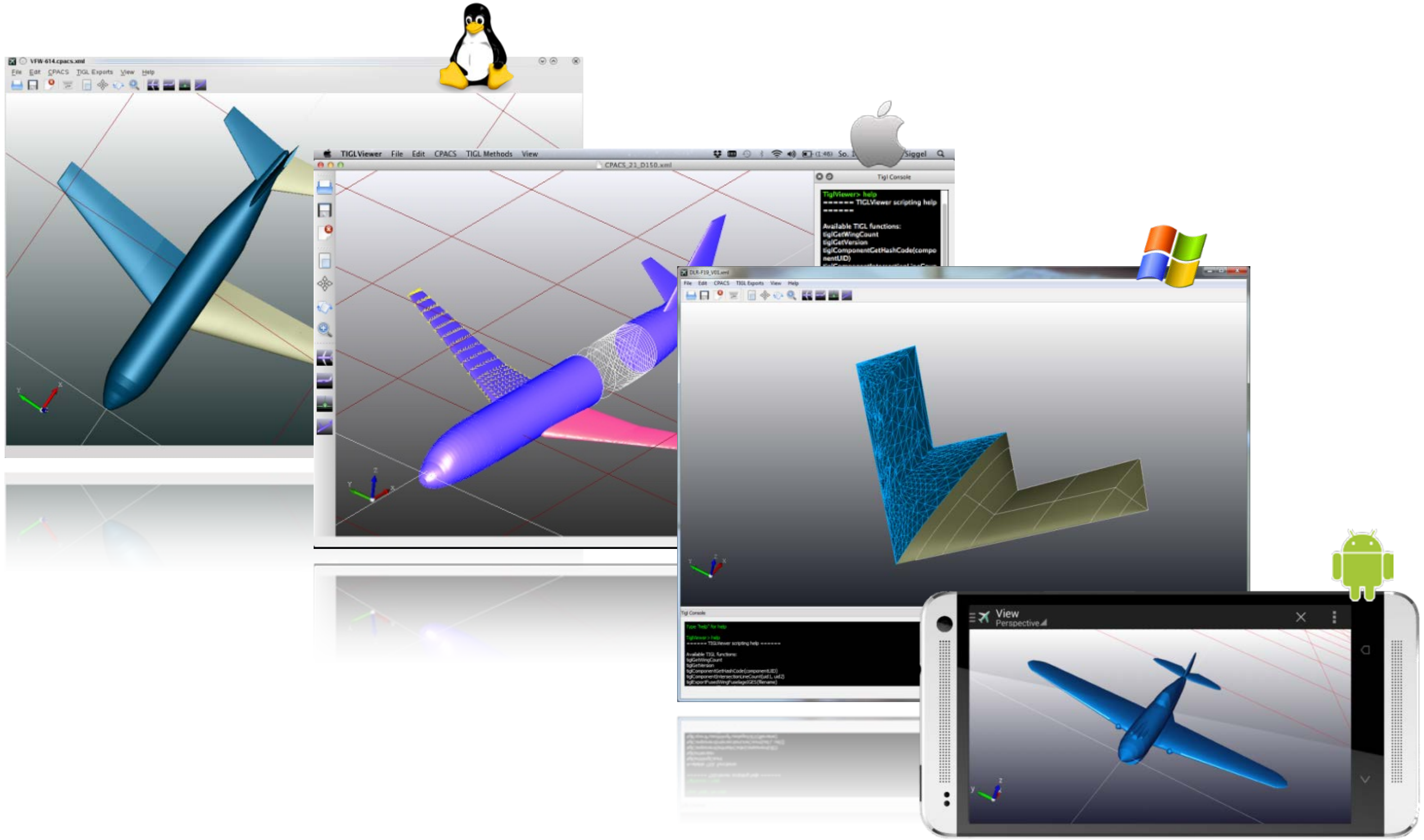


Built with Qt
TiGL – Geometry generation

- Central geometry library used by many simulation tools in DLR for aircraft design
- Multipurpose
- Multilanguage – Python, C/C++, MATLAB, Java, FORTRAN
- Multiplatform – Win, Linux, OS X, Android (experimental)
- Open Source, Apache 2.0
- Based on CAD kernel OpenCASCADE

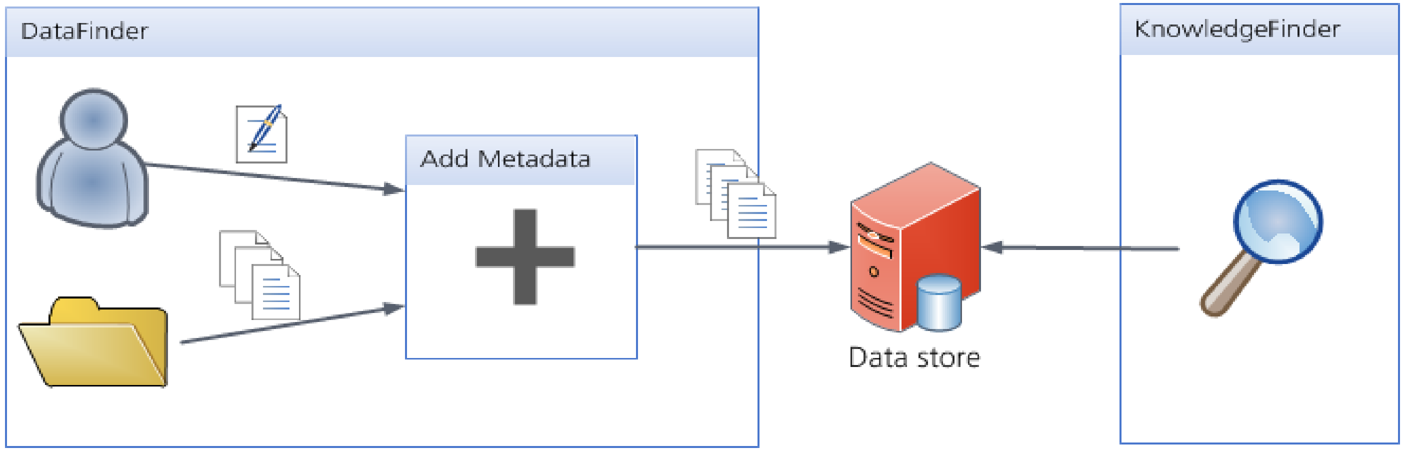


Built with Qt
TiGL – Platform independent Geometry Viewer

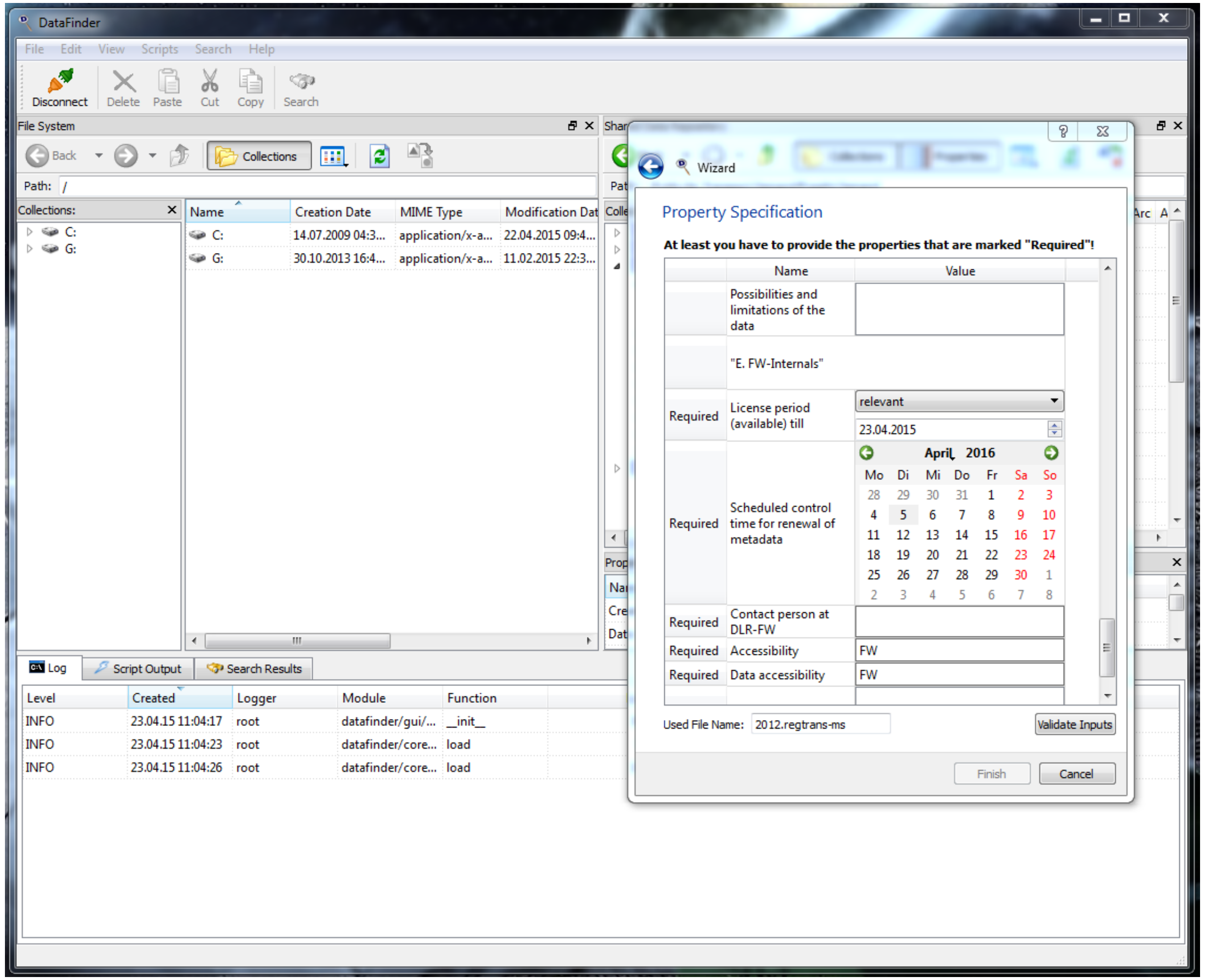


Built with Qt
DataFinder – Data store for simulation results

- Data management software
- Storage of all simulation data
- Tag based data search
- WebDAV backend
- Implemented in Python + Qt
- Open Source

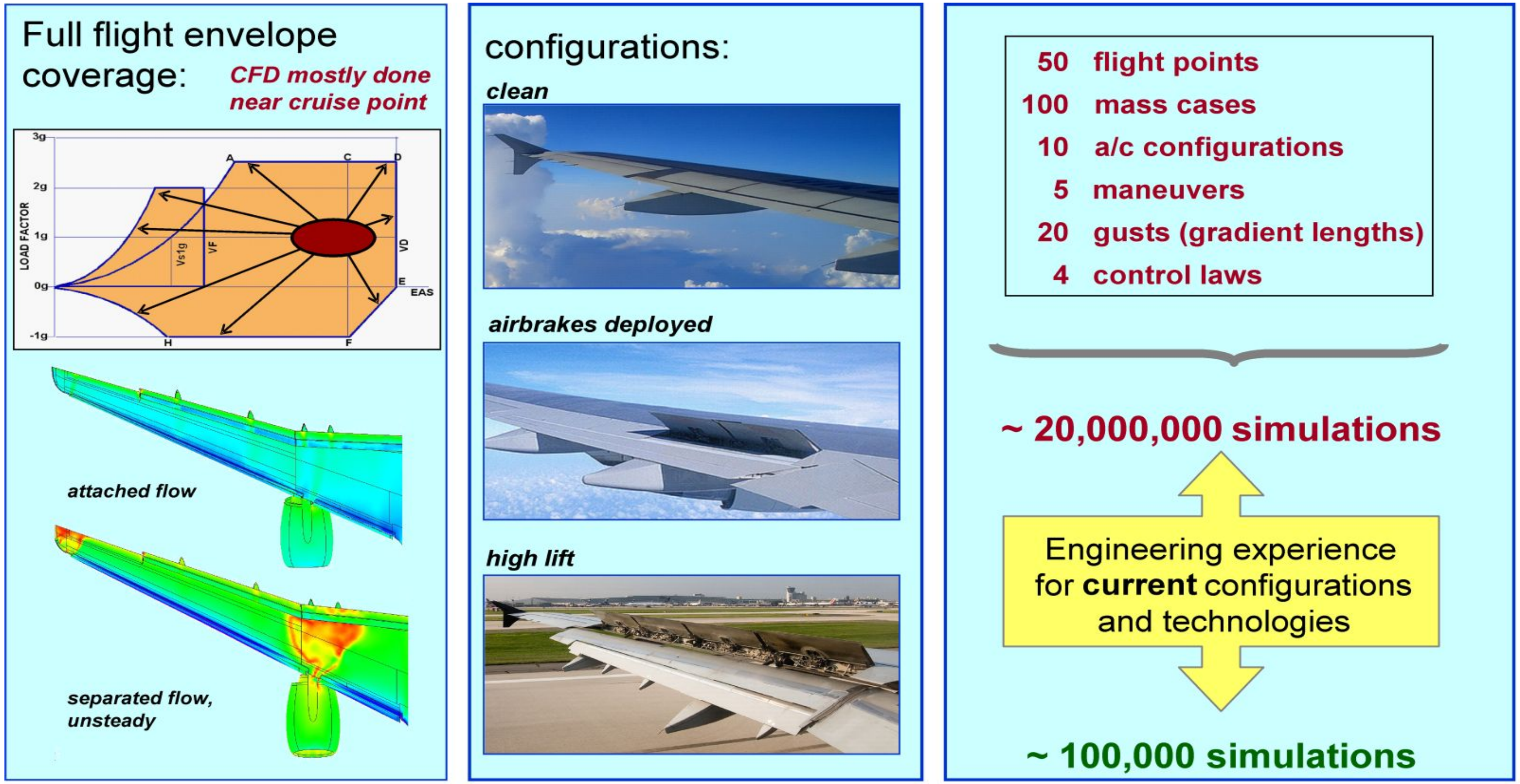


Built with Qt
DataFinder – Data store for simulation results



Wrap up

The Digital Aircraft Vision



Wrap-up

- Software technology, HPC hardware and algorithms have large impact on aircraft design
- Software is used in all phases of aircraft design
- Still major challenge: Simulation of the virtual aircraft

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