CLEAN AVIATION

XDC
Cross Demo Capabilities

- Final Workshop -
20th – 21st of September 2023

Parametric Structural Modelling for Aeroelastic and Aeroacoustic Analyses of an Aircraft Rear Fuselage

presented by

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DLR Institute of Aeroelasticity, Göttingen

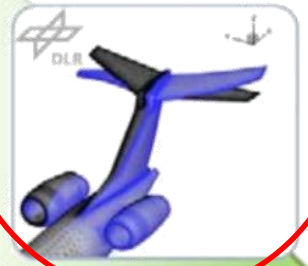
Co-funded by
the European Union

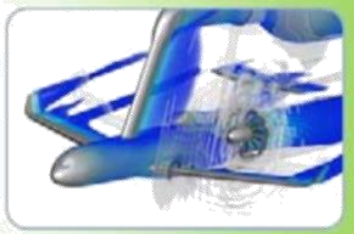
CLEAN AVIATION

DLR

PROPULSION TECHNOLOGIES PROPOSED TO REACH FLIGHTPATH 2050 GOALS

COMMON NUMERICAL METHODS
(PREDICTION AND OPTIMIZATION)

STRUCTURE


FLOWFIELD


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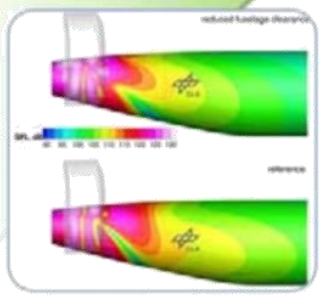
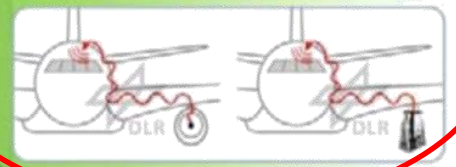


COMMON EXPERIMENTAL MEANS
(VALIDATION AND OPTIMIZATION)

FLOWFIELD


STRUCTURE


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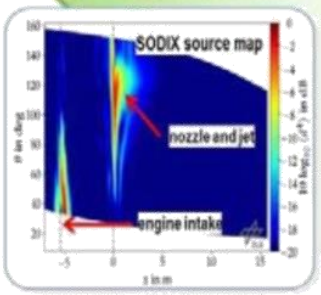

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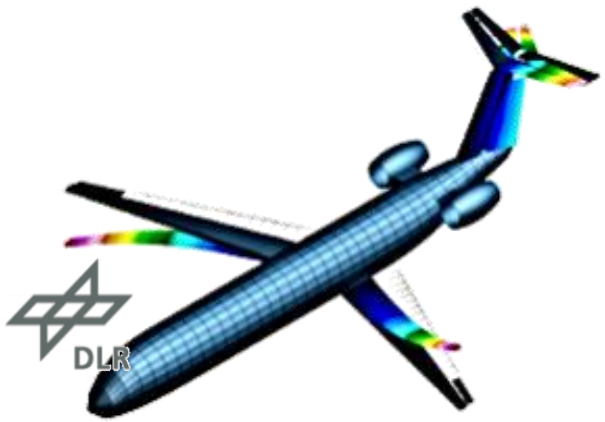
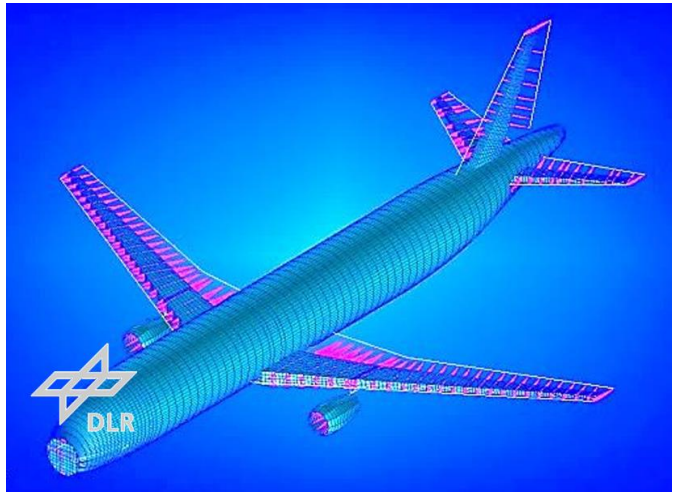
XDC
Cross Demo Capabilities

General Objectives





Integration of novel engine concepts into airframe structures:

- **reliable aircraft models required**
- **suitable degree of detail**
- **often: basic models available, but lack of necessary level of detail or models confidential**

→ **generation of representative A/C models for aeroelastic and aeroacoustic investigations, freely exchangable among project partners**

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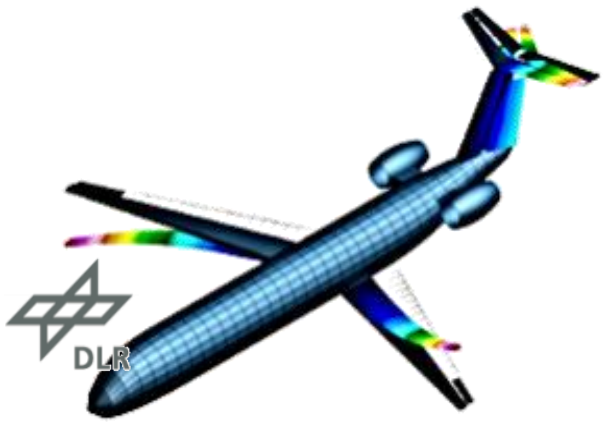
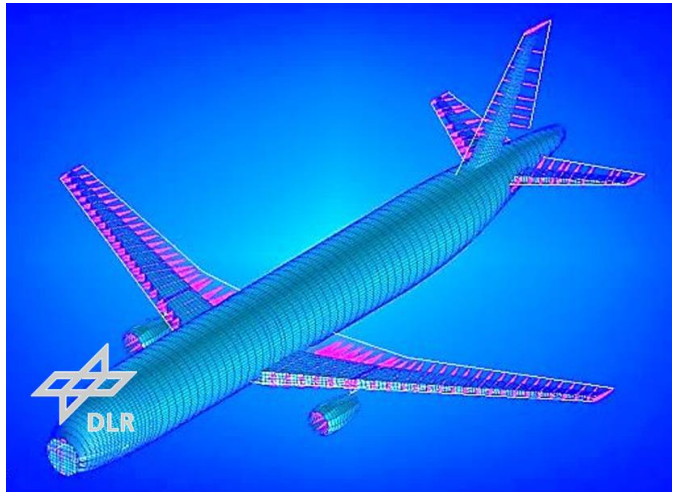
General Objectives





→ **make use of expertise on parametric modelling for aeroelastic applications**

→ **improve existing approach and use for loads analysis**

→ **extend the modelling to vibroacoustic applications**

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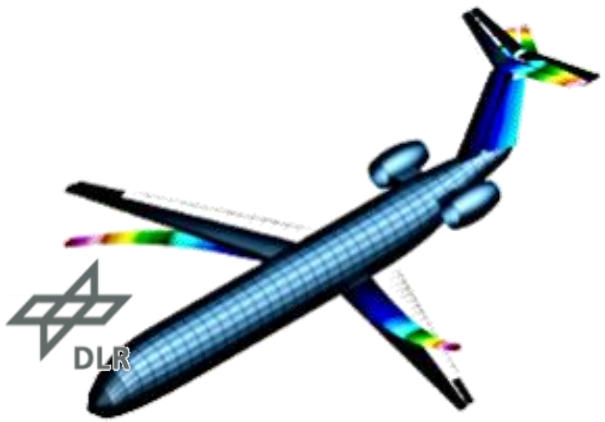
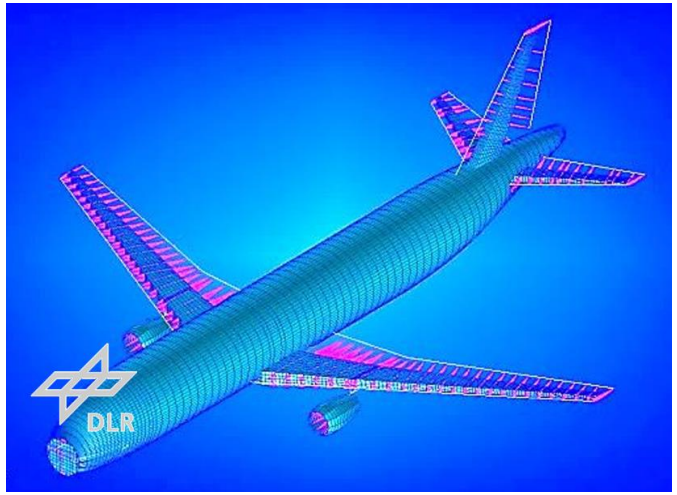
General Objectives





Customers in the project:

- **Loads analysis (LPA WP 1.1.14-10), with a focus on rear end loads**
- **Vibroacoustic analysis (LPA WP 1.1.15-4)**
- **Aeroelastic stability analysis of the tail (LPA WP 1.1.14-6)**
- **Aeroelastic investigations of the influence of under-wing mounted very large UHBR engines on the flutter speed (LPA WP 1.5)**

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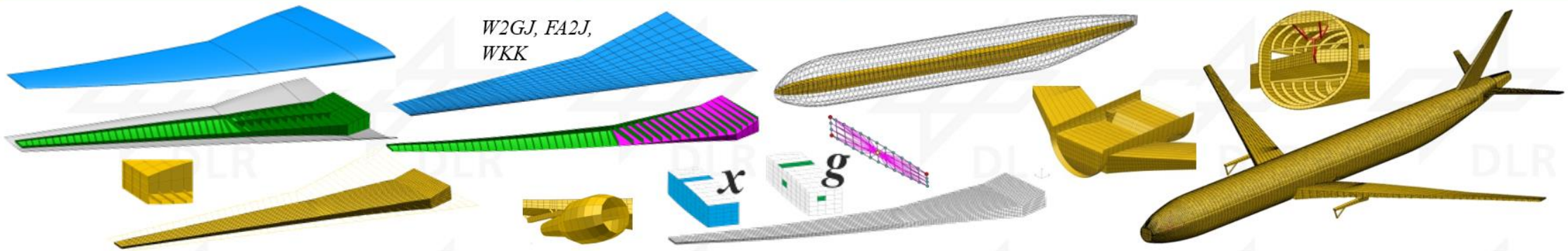
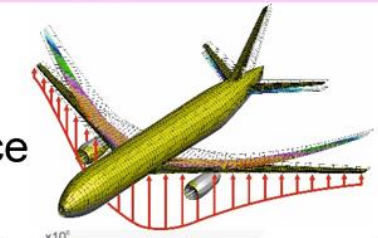
Model Generation: Parametric Modelling Process MONA

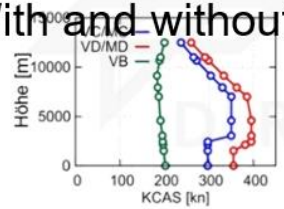
Parametric Set-Up of Simulation and Optimization Models (ModGen)

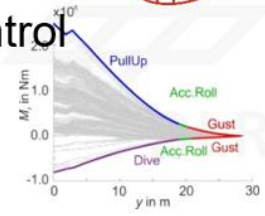


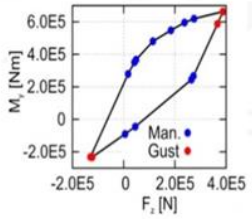
Loads Analysis (e.g. MSC Nastran)

- Maneuver
- Gust
- Continuous turbulence
- Ground and landing
- With and without control



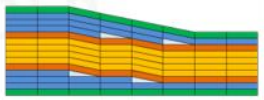






Structural Optimization (MSC Nastran)

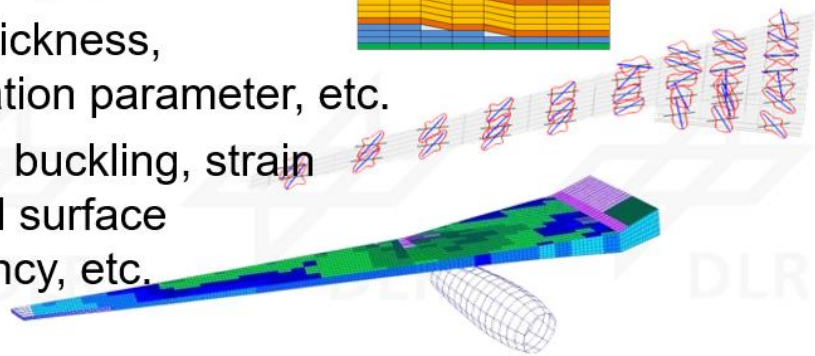
$$Min\,\{f(\boldsymbol{x})|\boldsymbol{g}_j(\boldsymbol{x}) \geq 0\}$$



$\boldsymbol{x}$: skin thickness, lamination parameter, etc.

$\boldsymbol{g}$: stress, buckling, strain control surface efficiency, etc.

f: mass



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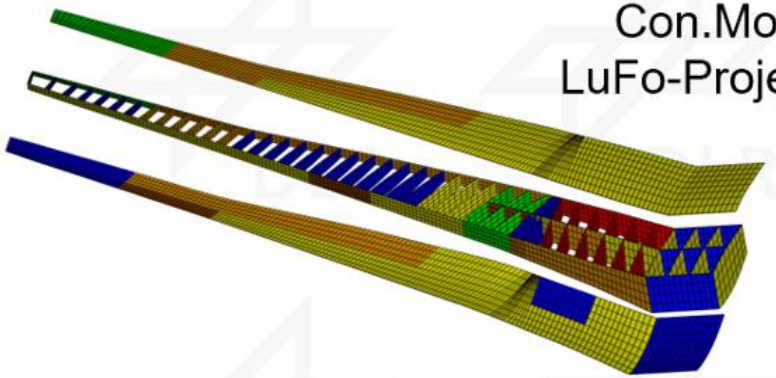
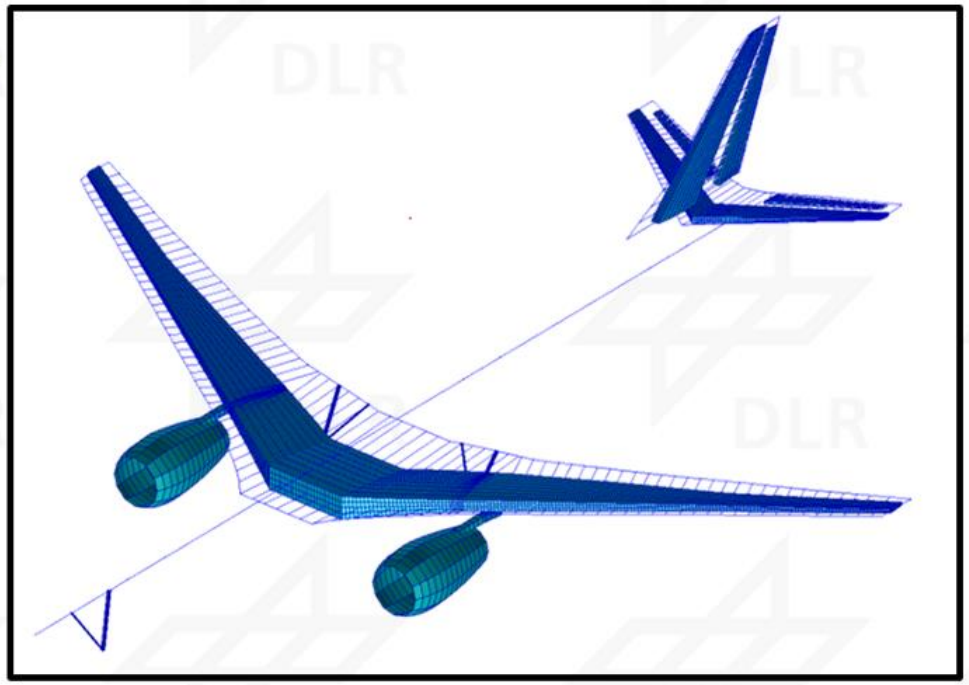
Model Generation: Parametric Modelling Process MONA

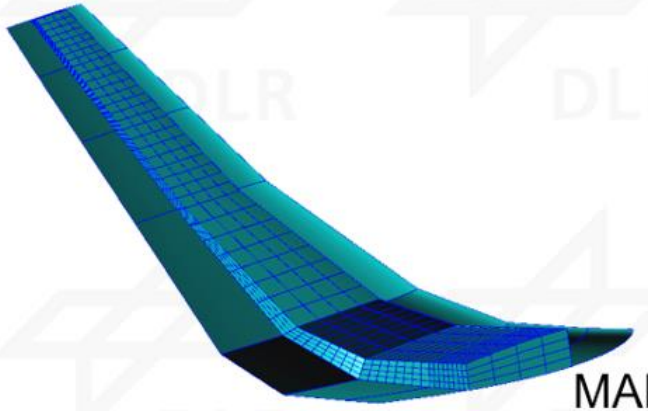
Con.Move
LuFo-Project



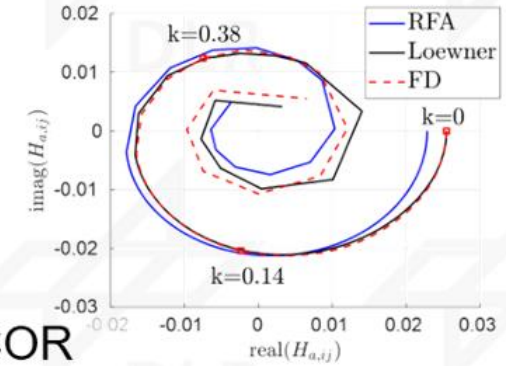
XRF1-DLR-CFK



LPA
EU Project



MANTA
EU-Project



NACOR
EU-Project

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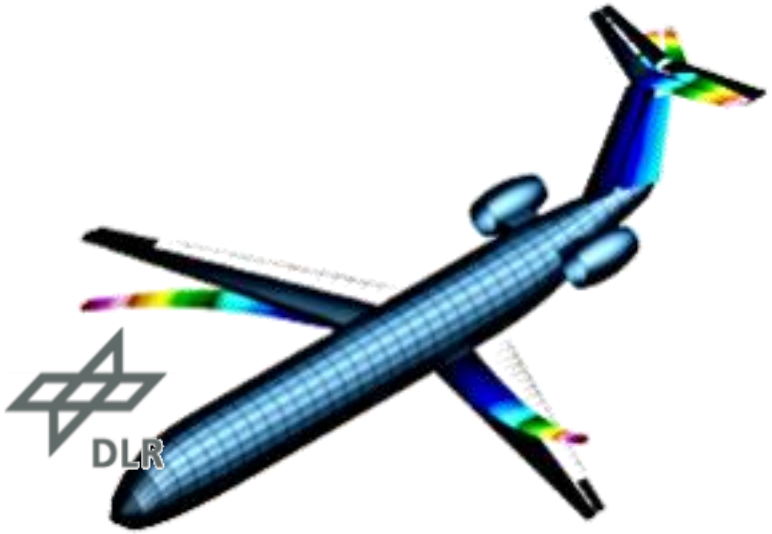
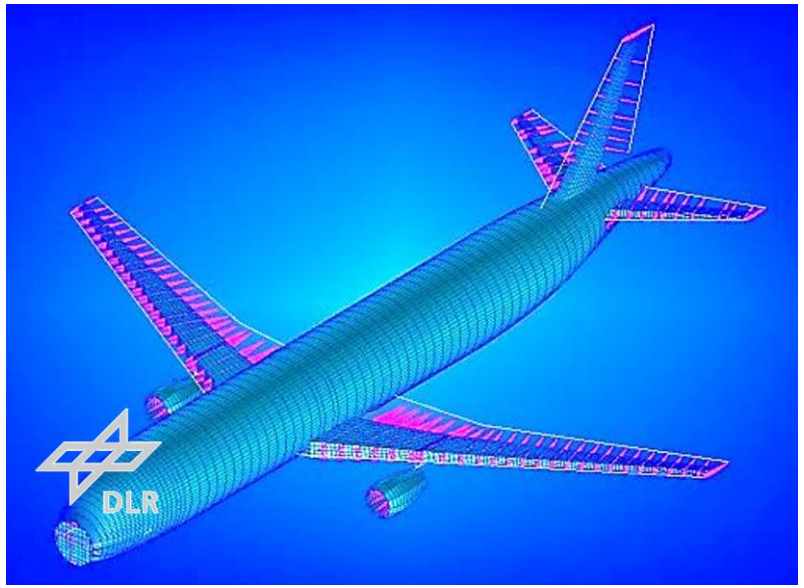
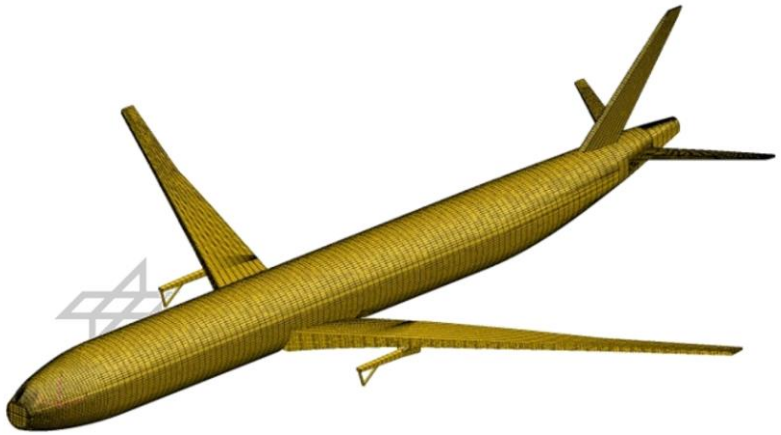
Generated LPA Configurations



T-tail-configuration
(ALLEGRA/LamAir)



SMR configuration
DLR-D150



LR configuration
XRF1-DLR-C

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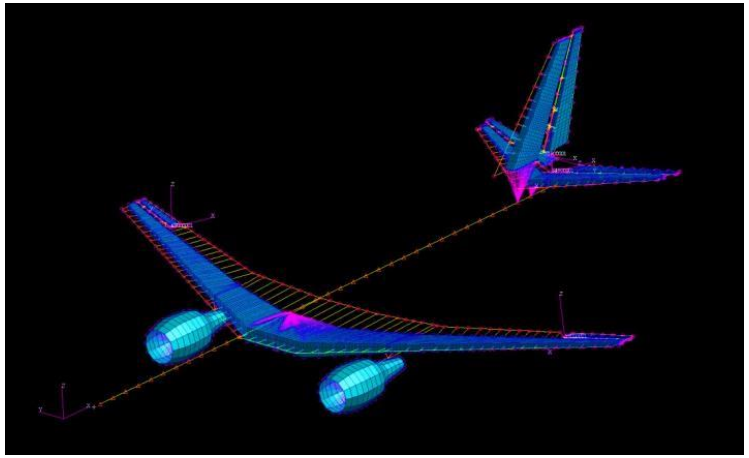
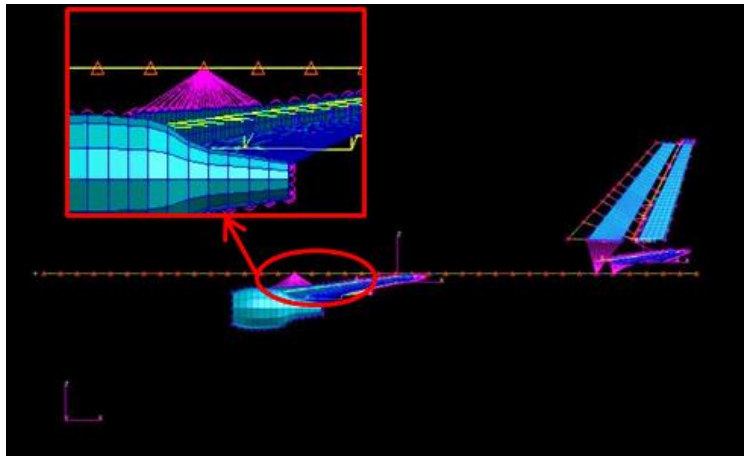
Model Generation: Reference A/C



DLR D-150-PRE aircraft FEM



Wing & fuselage rigid element connection

Status at beginning of XDC:

- **DLR-D150 aircraft, preliminary design level (-PRE)**
- **MTOW: 72,5 t**
- **Wing Span: 34 m**
- **Passengers: ~150**
- **Model Generation: DLR CPACS-MONA process**
- **FEM:**
  - **13,790 nodes**
  - **2-D shell & beam elements (wings & control surfaces)**
  - **Beam elements (fuselage)**
  - **Wing & fuselage: rigid element connection**
- **For flight loads analysis / flutter analysis**
- **Load path wing to fuselage unrealistic**

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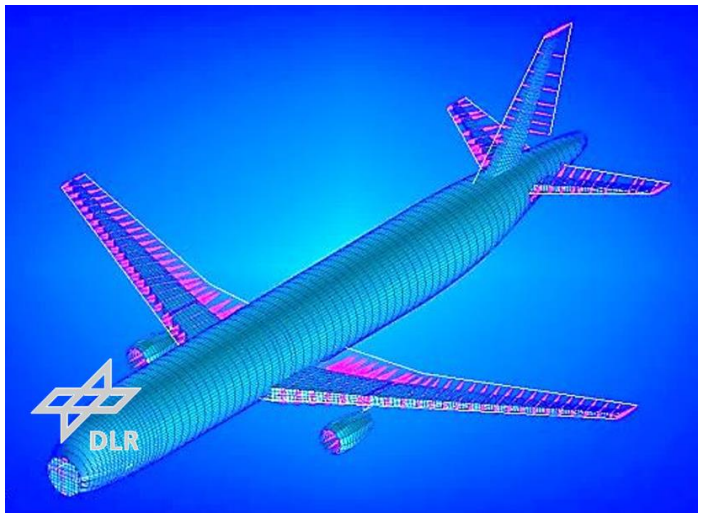
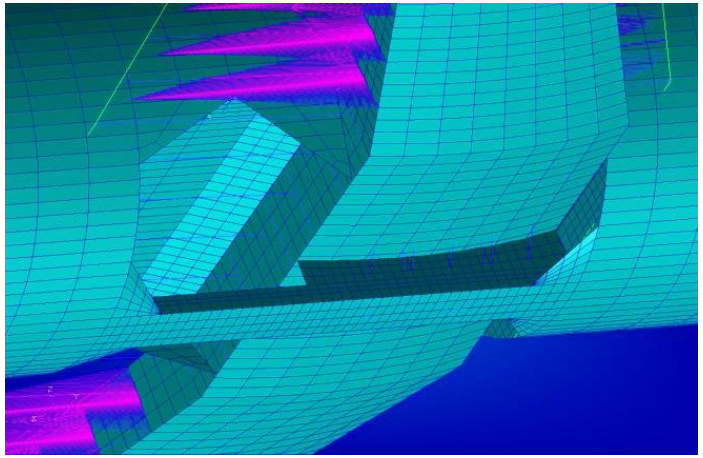
Model Generation: Model Development in XDC



DLR D-150-GFEM aircraft



Wing & fuselage FE connection

Final reference aircraft model for XDC:

- **Reference aircraft: DLR-D150 aircraft, GFEM level**
- **MTOW: 72,5 t**
- **Wing Span: 34 m**
- **Passengers: ~150**
- **Model generation: DLR CPACS-MONA process**
- **FEM:**
  - **34,268 nodes**
  - **2-D shell & beam elements (wings & control surfaces)**
  - **2-D shell & beam elements (fuselage skin panels, frames, floors and LG bays)**
  - **Wing & fuselage connection: detailed FE connection**
- **For ground loads analysis and towards vibroacoustic modelling**

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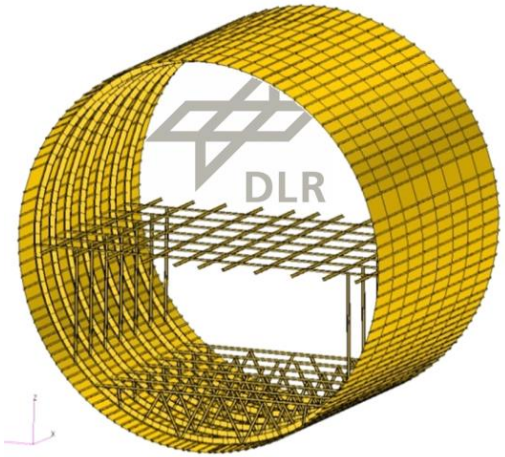
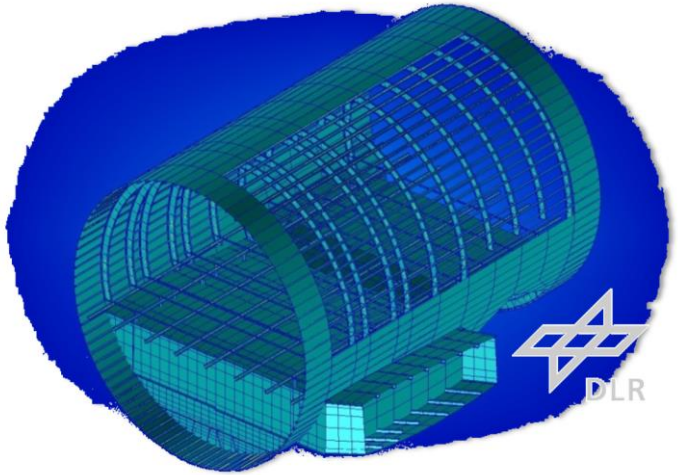
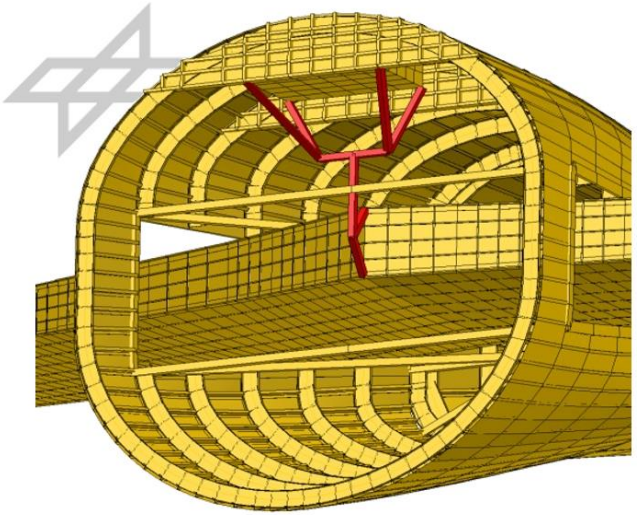
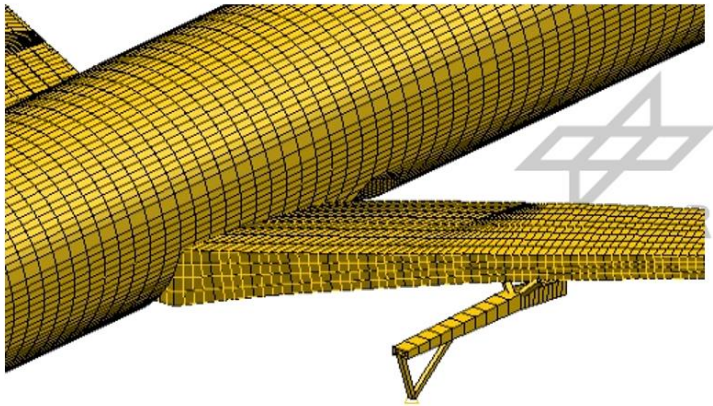
Simulation Model: Details



- **Fuselage**
- **Center section**
- **Rear fuselage**
- **Pylon**







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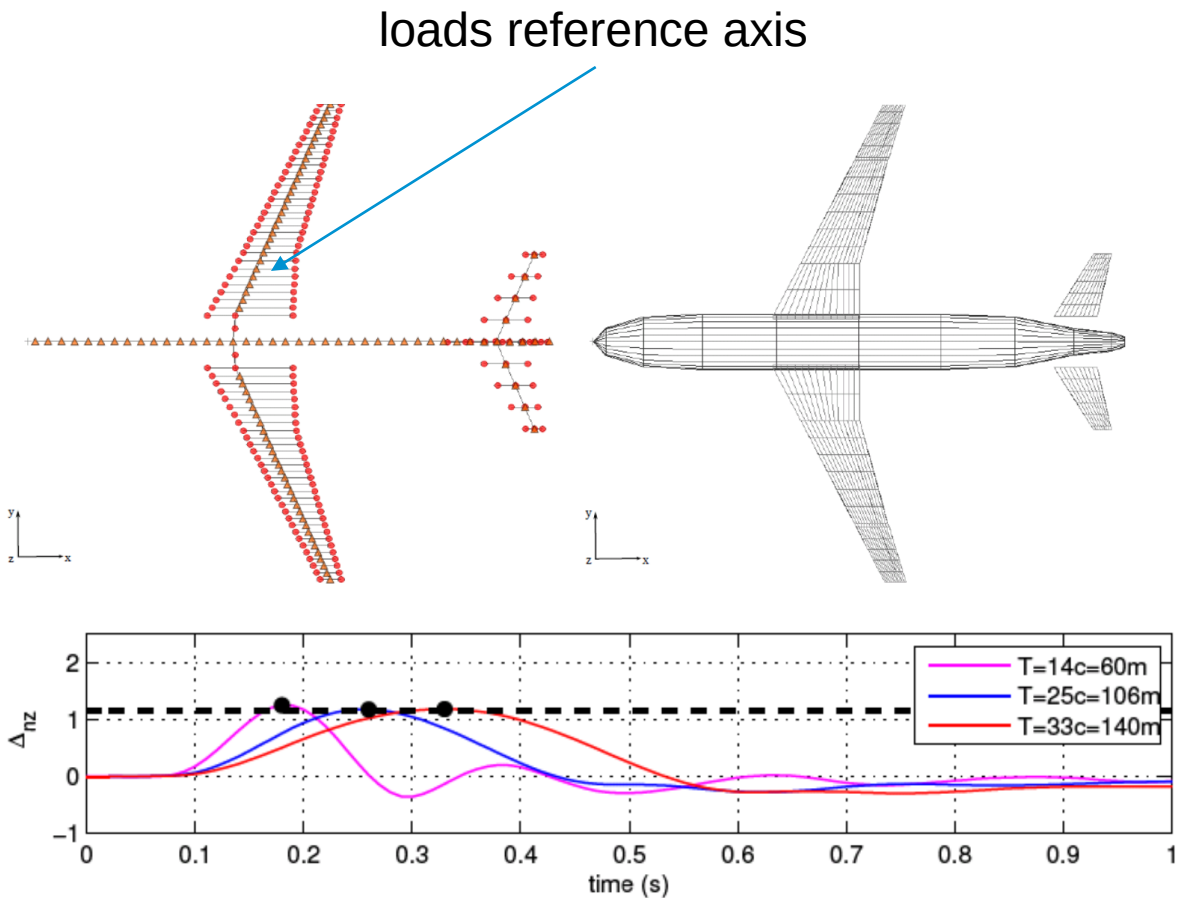
XDC Cross Demo Capabilities

Application: Flight Loads Analysis



- **Verification study: Pratt gust vs. 1-cos-gust**

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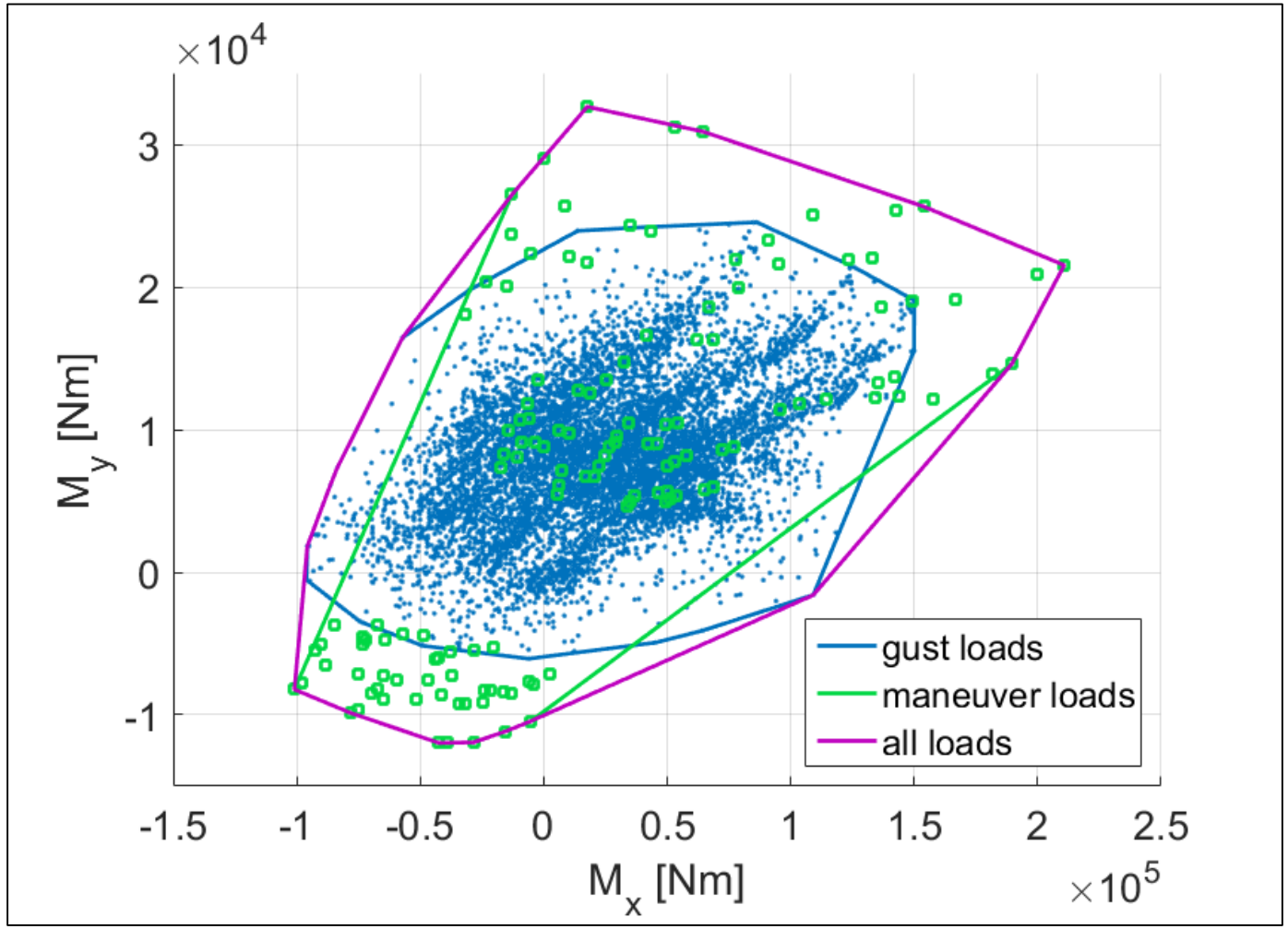
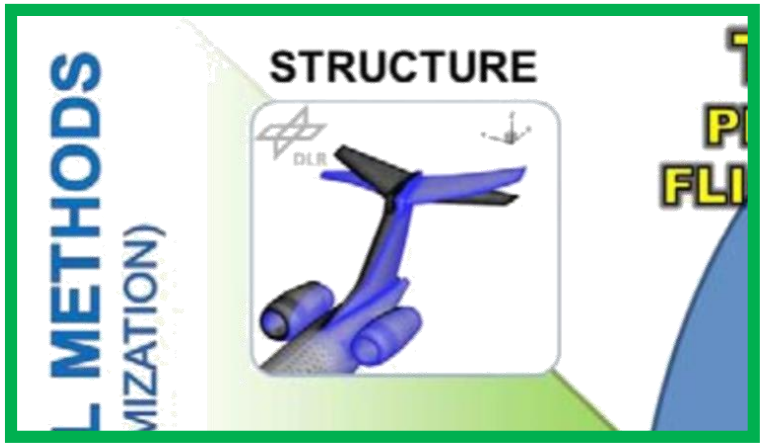
Application: Analysis of Sizing Tail Loads



- **Analysis of tail loads (HTP, flight loads)**



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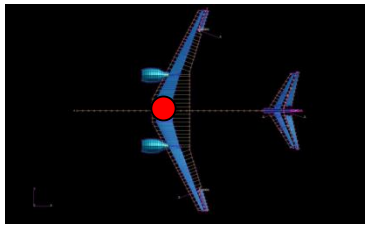
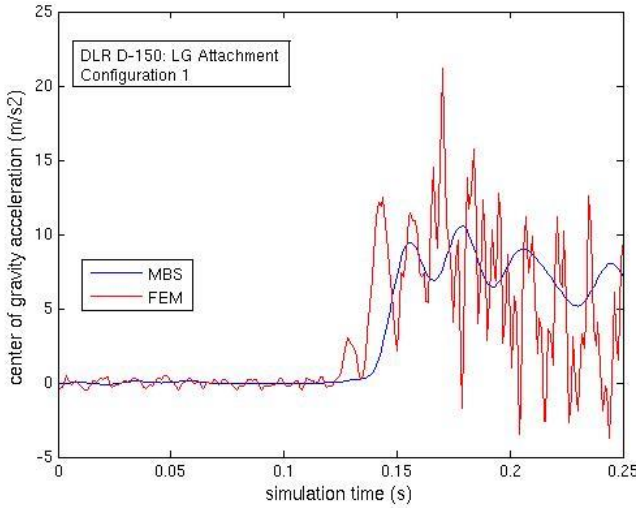
Application: Ground Loads Analysis

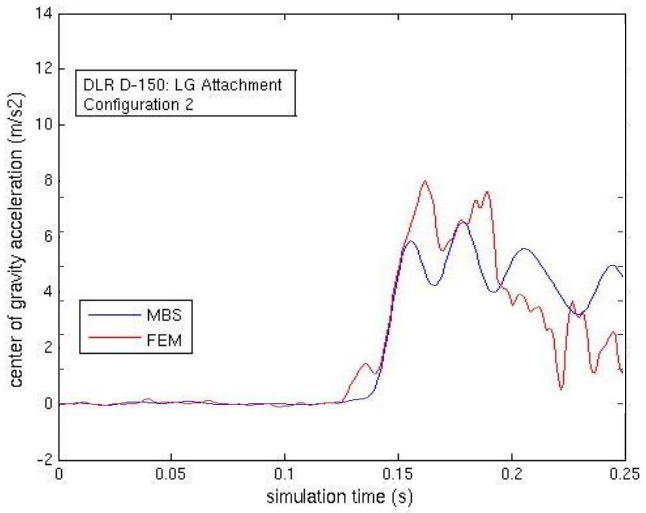
C.G.



Config. 1



Config. 2



Result from MBS model (blue) and full FEM model (red)

- **Comparison of landing loads at CG for modelling approaches**
- **Center section model plus more realistic LG attachment**

  → **Improved load path**
- **Landing loads from MBS / transient solution in MSC NASTRAN**

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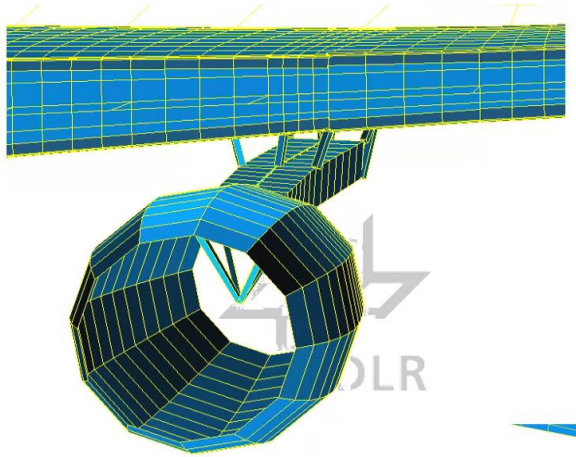
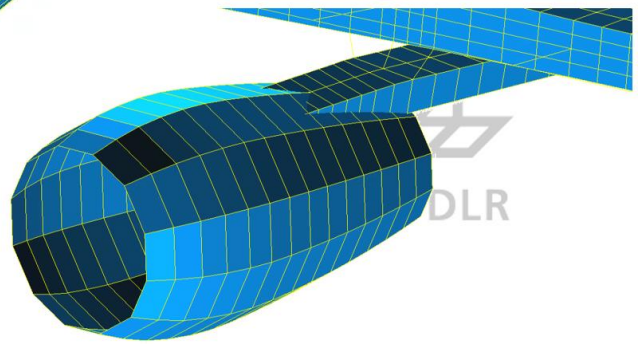
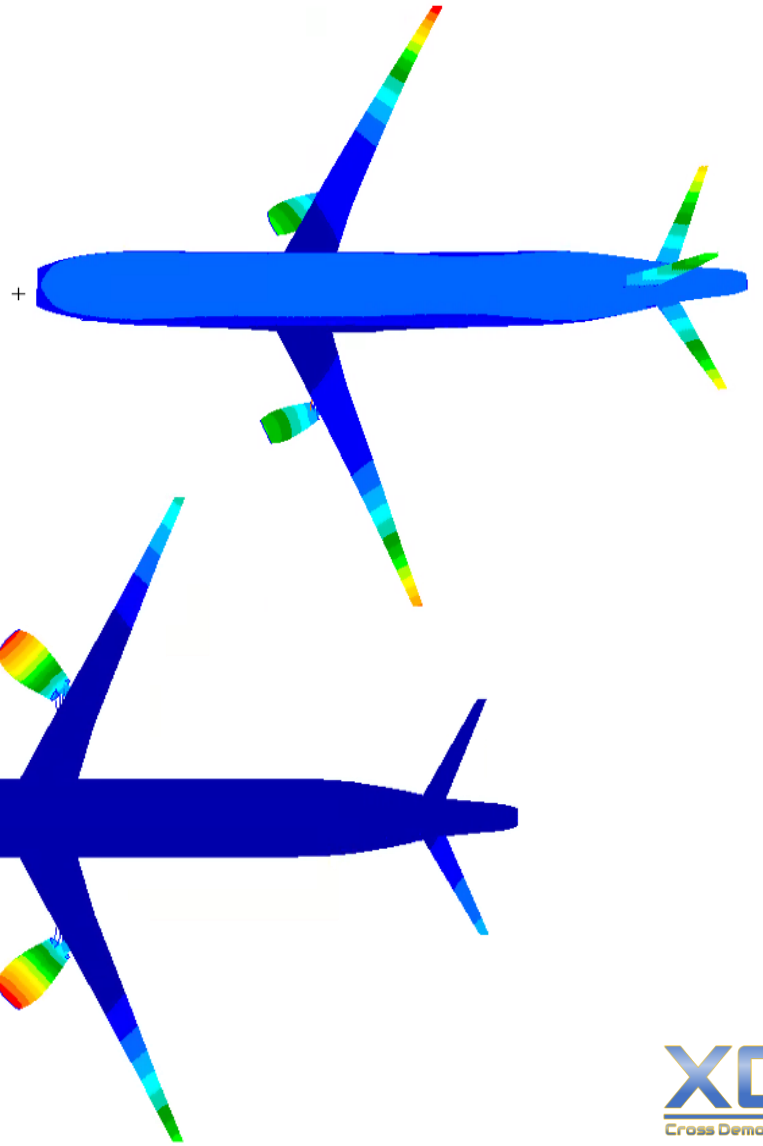
Modelling for Vibroacoustic Analysis





- **Pylon modelling: large influence on wing dynamics and acoustics**



for D01, Wing vibration test
(presentation S. Zettel tomorrow)

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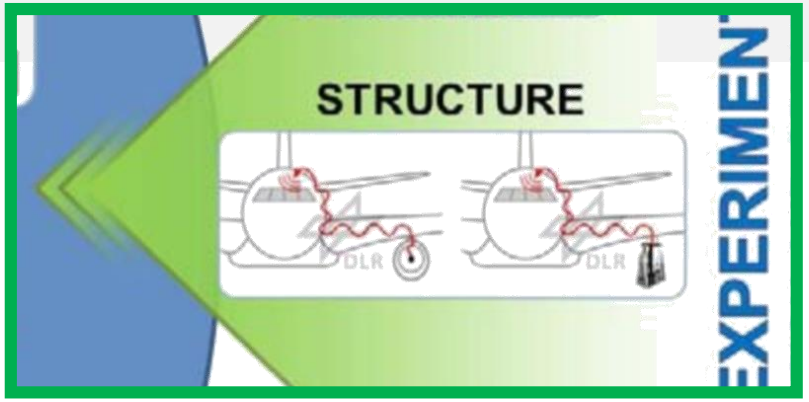
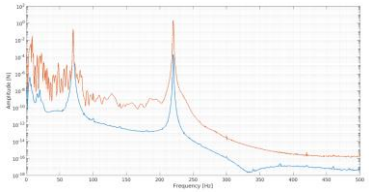
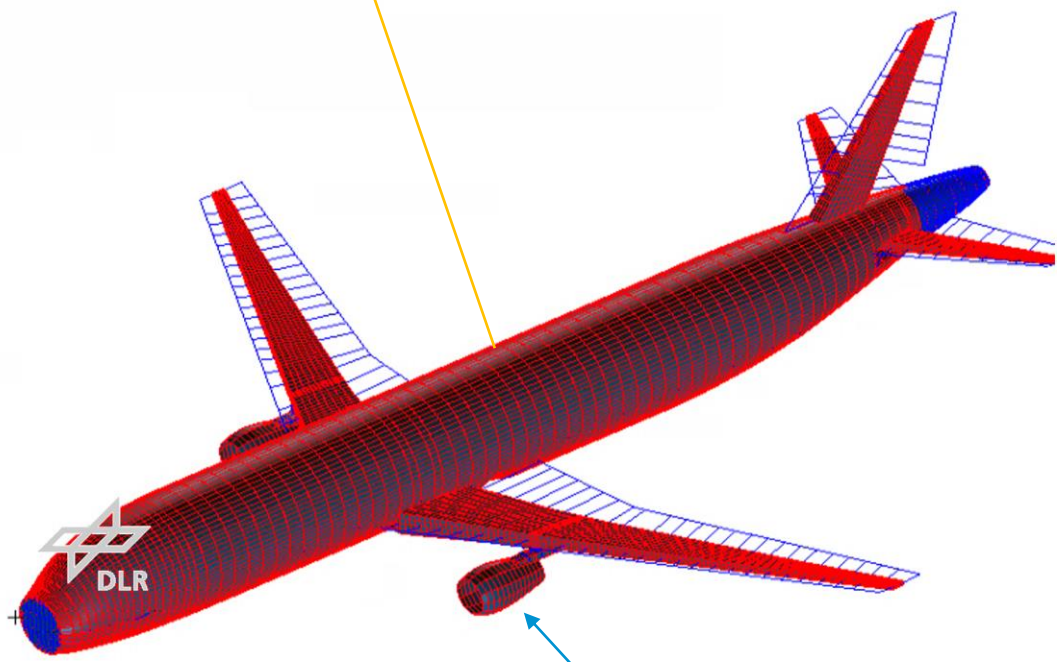
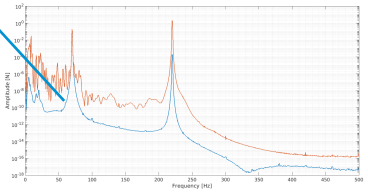
Modelling for Vibroacoustic Analysis

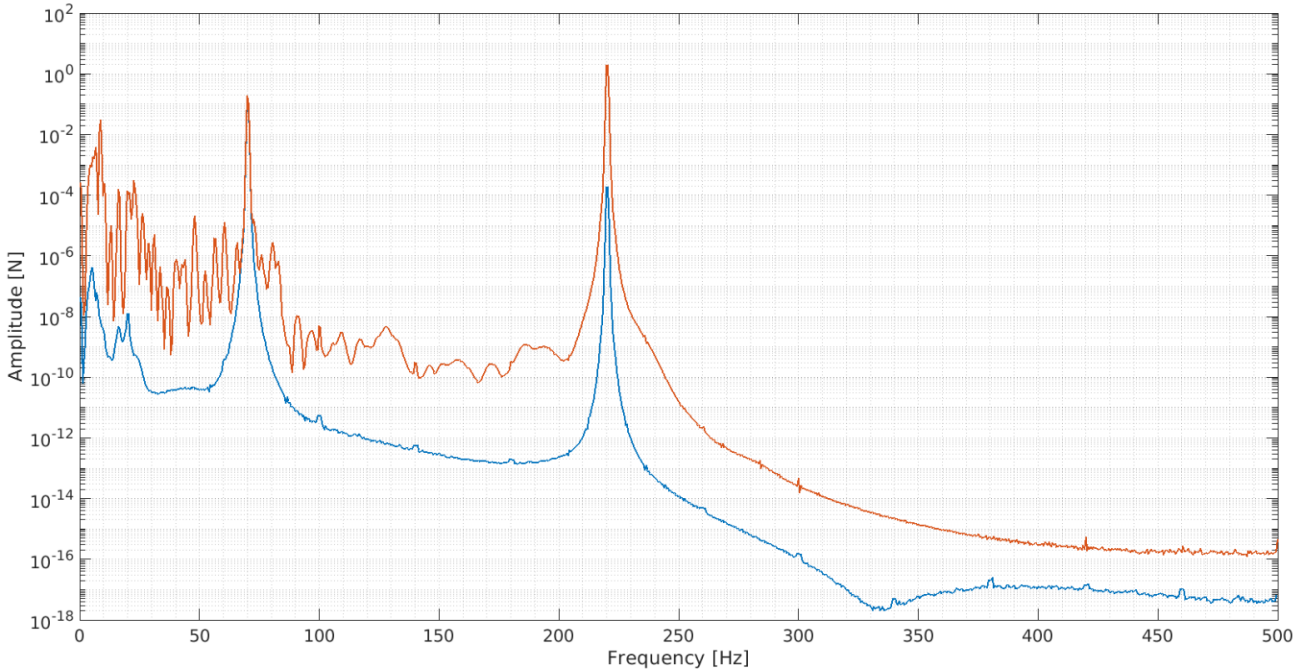


- **Transfer path for vibroacoustic analysis**









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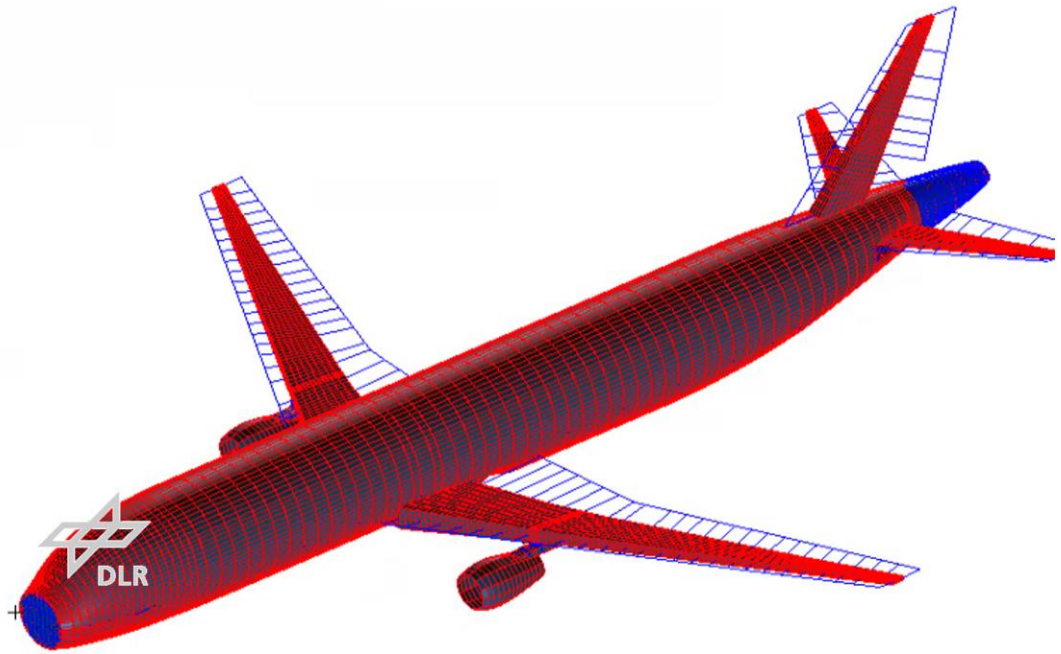
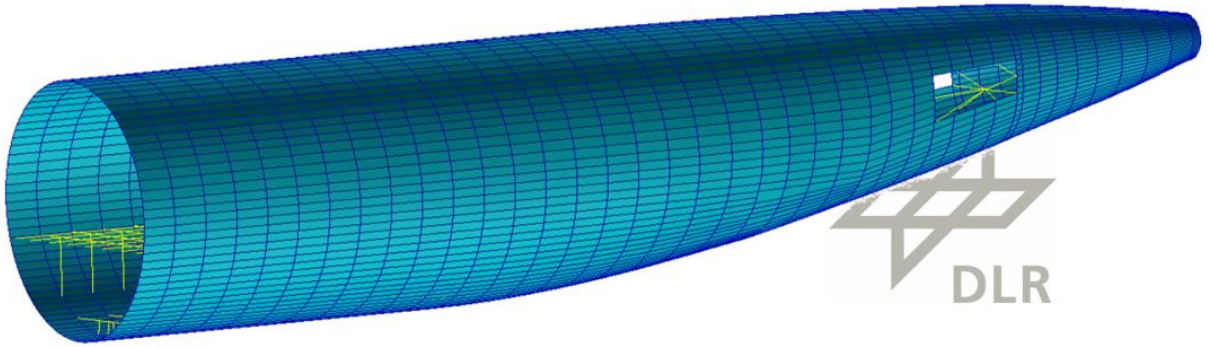
Modelling for Vibroacoustic Analysis

- **Fuselage Modelling: towards FlightLab hardware demonstrator**



D150 rear fuselage model



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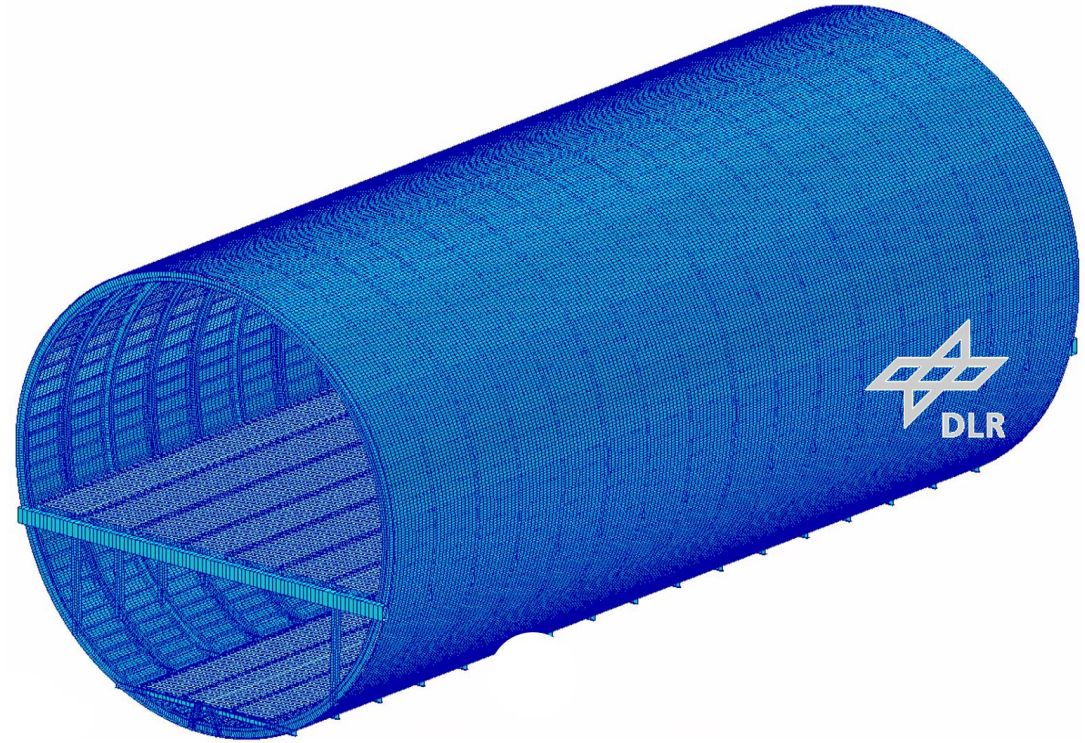
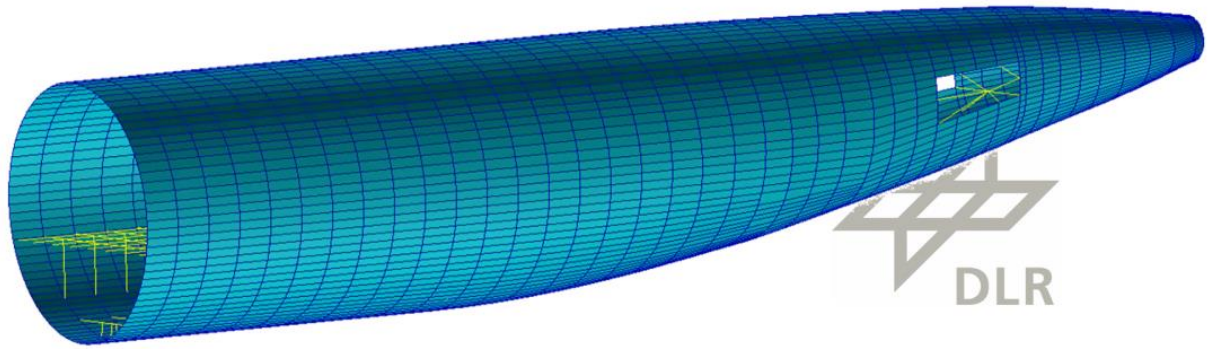
Application: Flight Lab Vibroacoustic Analysis

FlightLab acoustic demonstrator

- **Fuselage Modelling: towards FlightLab hardware demonstrator**





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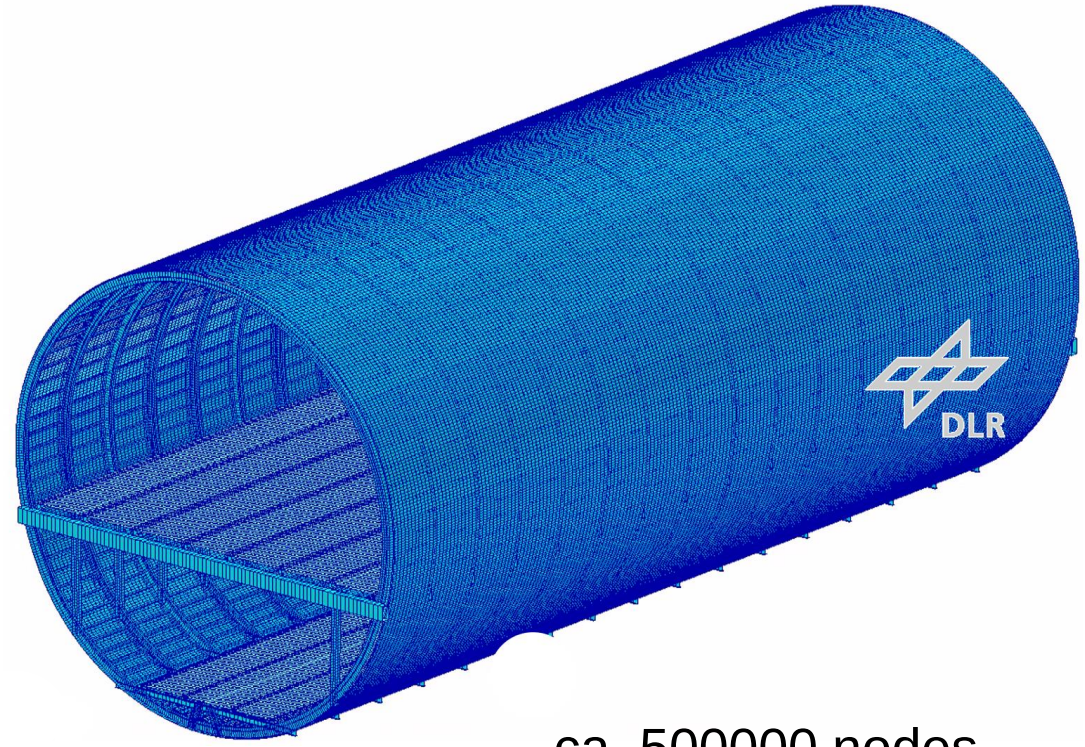
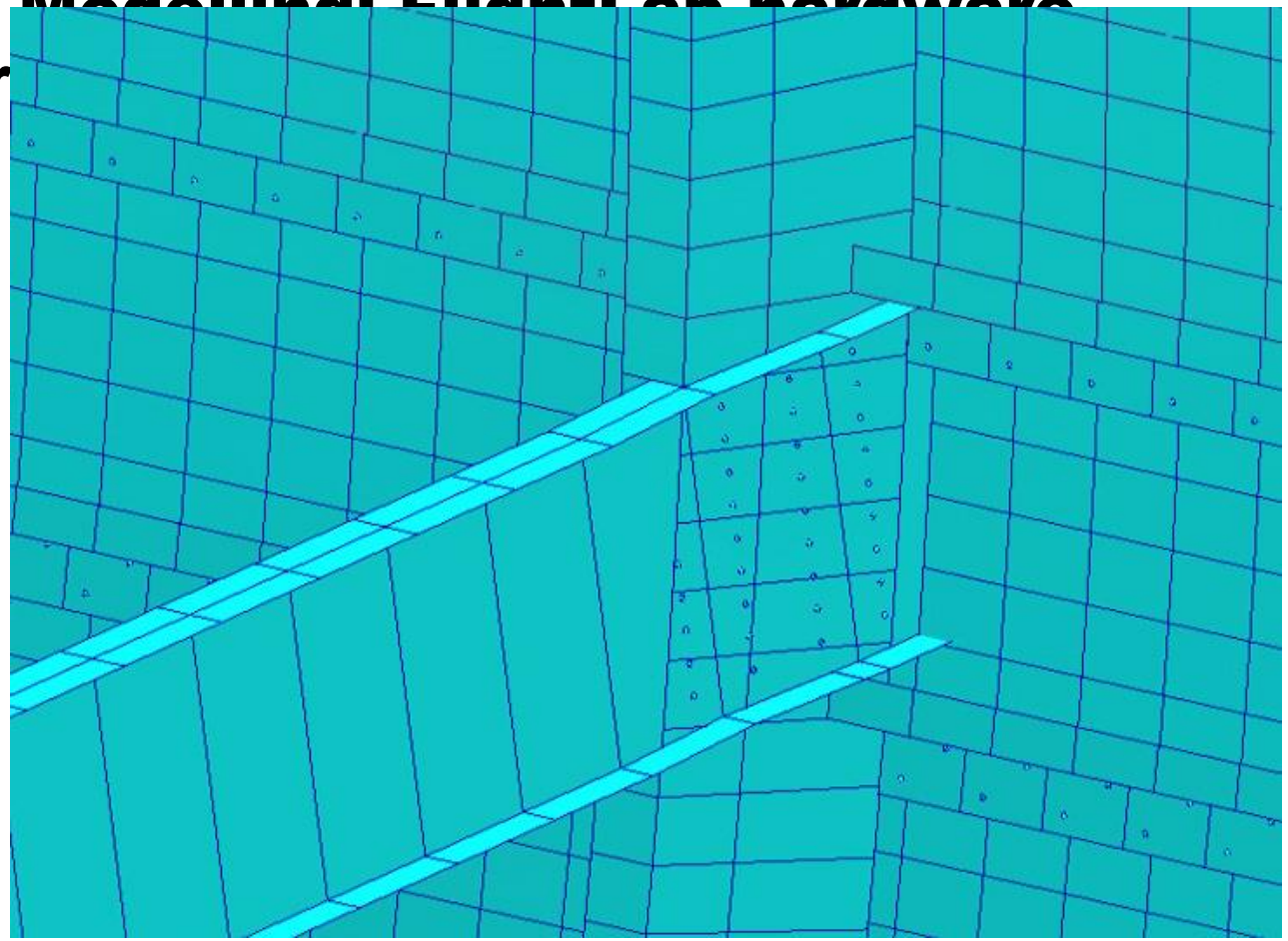
Application: Flight Lab Vibroacoustic Analysis

- **Fuselage Modelling: FlightLab hardware demonstr**

FlightLab acoustic demonstrator



ca. 500000 nodes



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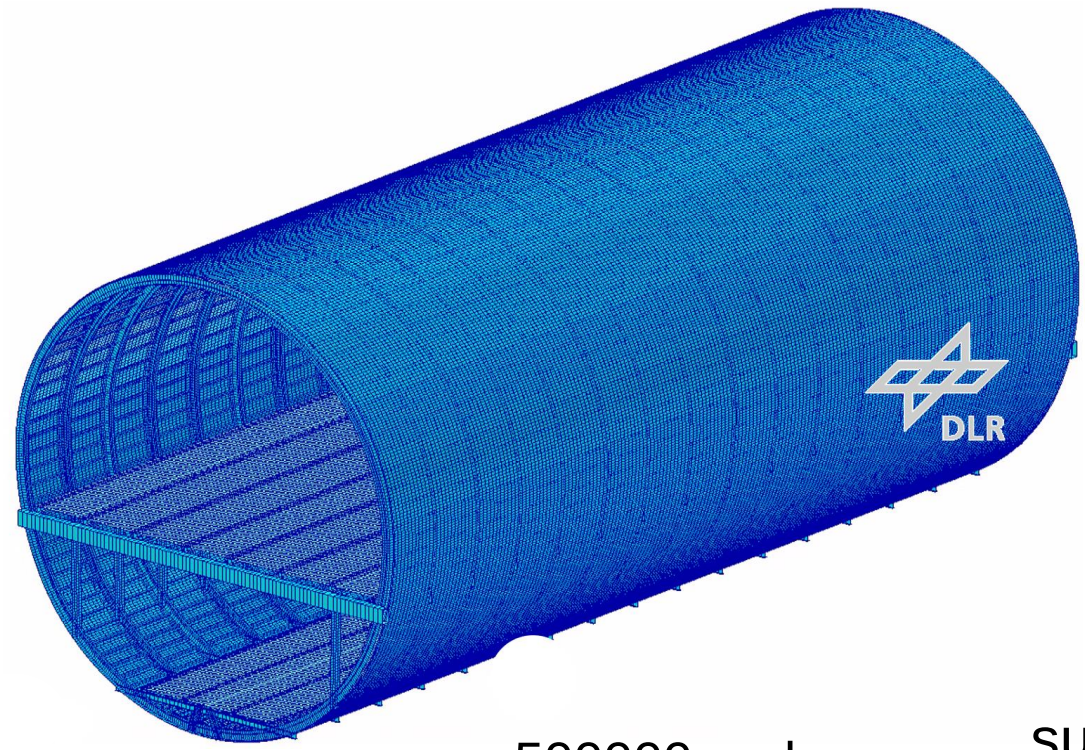
Application: Flight Lab Vibroacoustic Analysis

- **Fuselage Modelling: FlightLab hardware demonstrator**

FlightLab acoustic demonstrator



ca. 500000 nodes

support of experiment and development of numerial methods for vibroacoustic analysis

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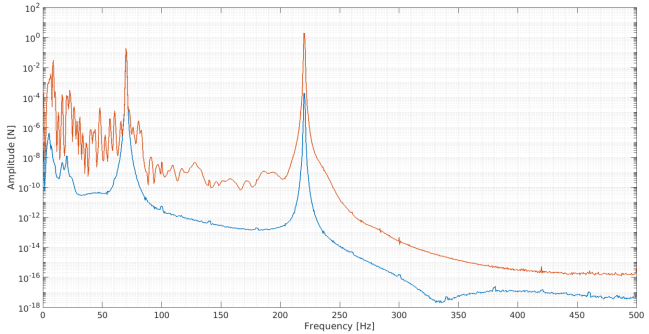
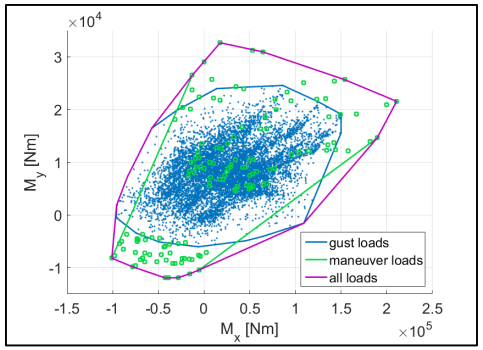
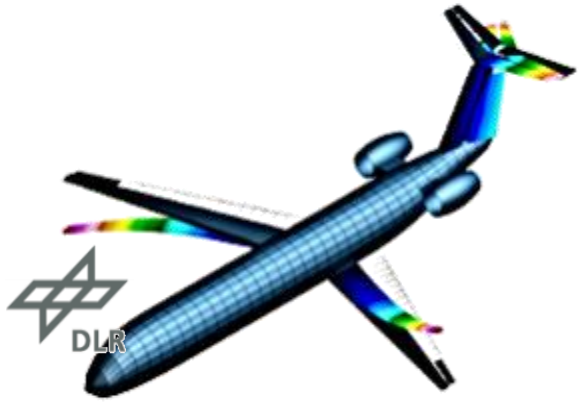
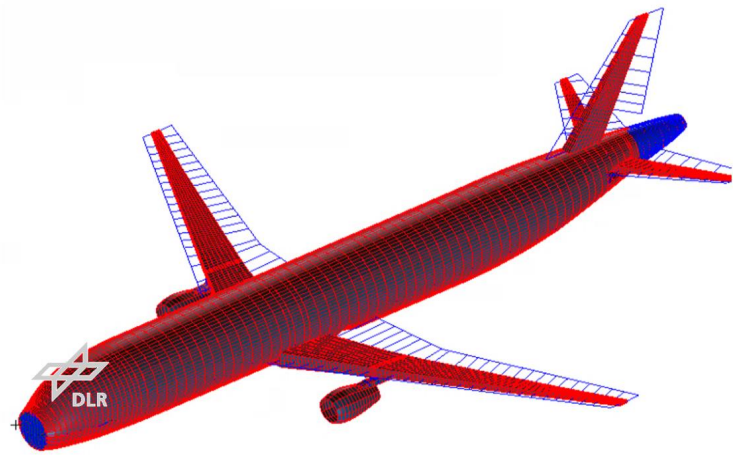
Thank you for your attention









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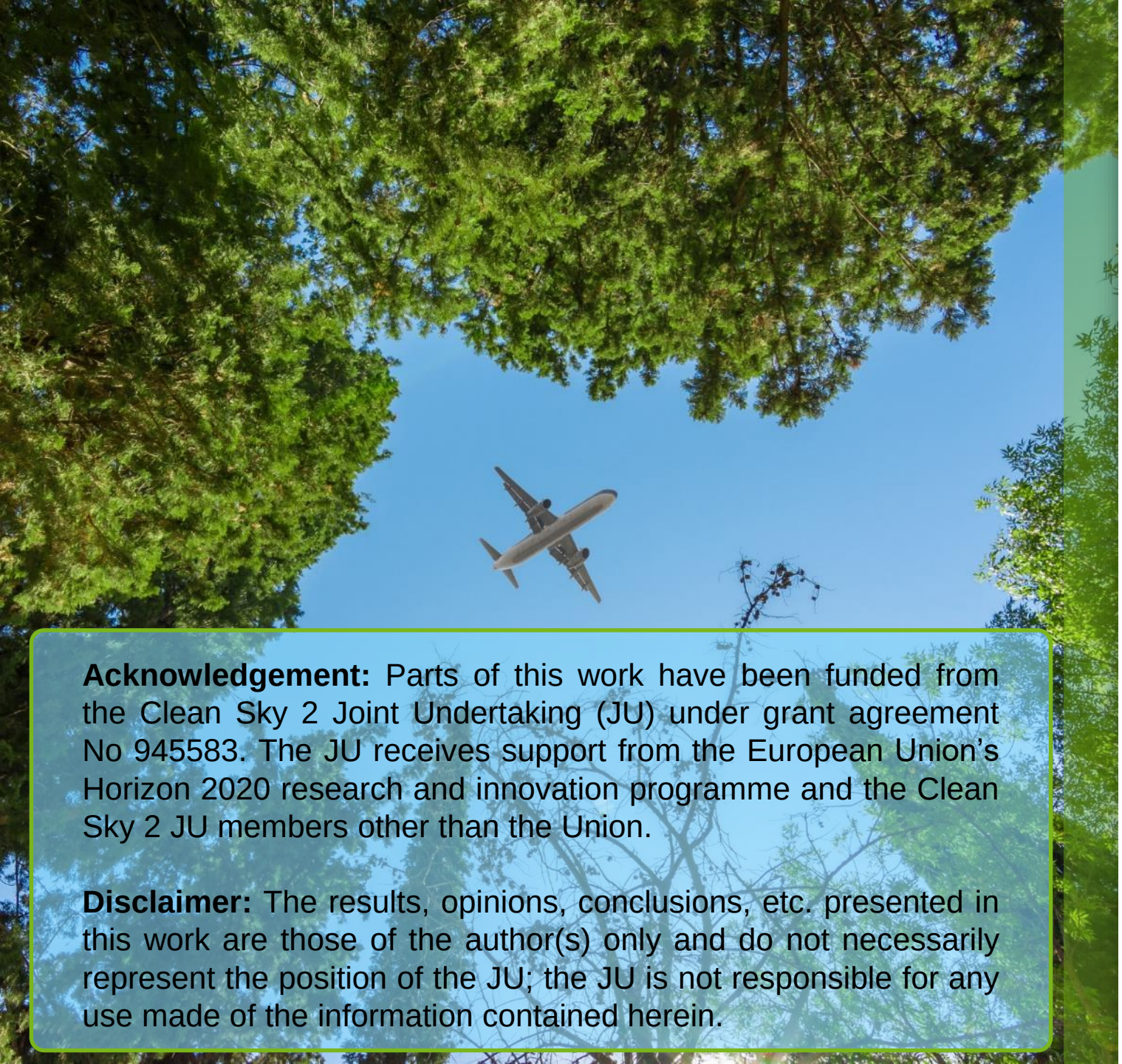

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