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A python based framework for modelling and structural sizing of transport aircraft

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DLR

Overview

1. **Introduction** – Aircraft predesign
2. **Data Exchange** – CPACS data
3. **Example MDO** – Aircraft predesign at DLR
4. **Tool enviroment** – Fuselage structure sizing at DLR-BT
5. **Summary & Outlook**

Why developing tools for aircraft predesign?

Emissions

[5]

Aerodynamic

[1]

Cargo

[2]

complex

Design

Structure

[3]

Performance

[4]

[1] https://upload.wikimedia.org/wikipedia/commons/7/79/DG1000_glider_crop.jpg
[2] http://assets.geo.de/div/image/61309/02_columbus_popup.jpg
[3] http://www.ultralightnews.com/_frame/elazair-electric-powered-ultralight-aircraft.jpg
[4] https://upload.wikimedia.org/wikipedia/commons/6/68/US_...class_aircraft_carrier_US.jpg
[5] http://globe-net.com/aircraft-co2-standards-one-step-closer-but-no-take-off-yet/

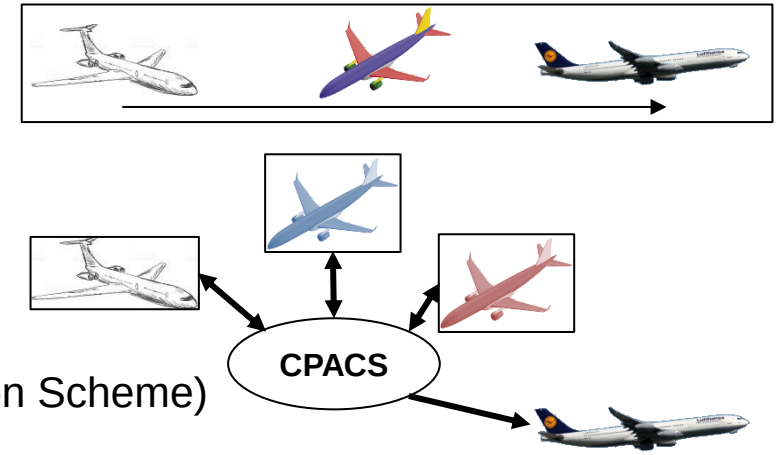
Why developing tools for aircraft predesign?

- **Effort**
  Reduce time to develop new aircraft

- **Efficiency/emissions**
  Estimate e.g. fuel consumption in predesign phase
  - High-precision, numerical methods
  - complex, multidisciplinary interaction

- **Development process**
  - Conventional: stepwise development
  - Prospective: individual, multidisciplinary tools

- **Data exchange**
  XML data as parameter exchange platform
  = **CPACS** (Common Parametric Aircraft Configuration Scheme)

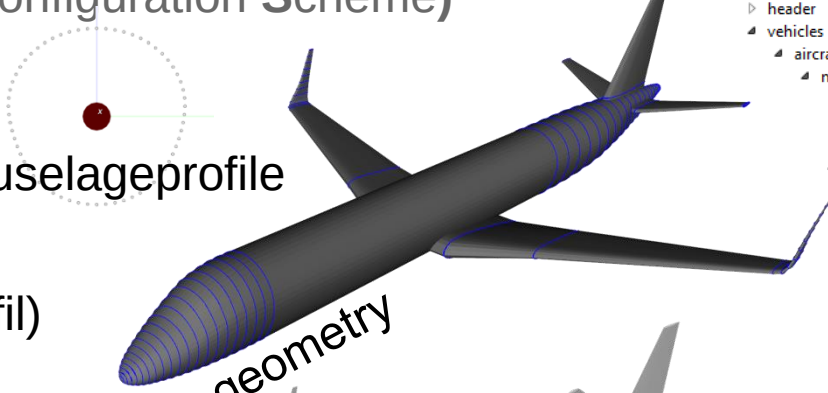


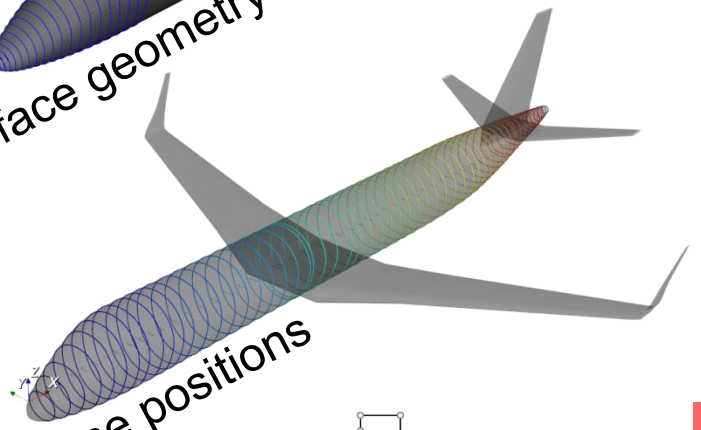
Exchange aircraft parameter using CPACS

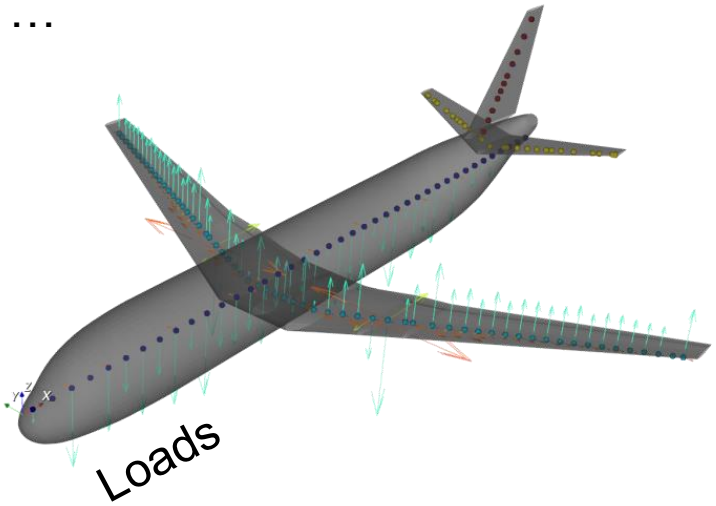
(Common Parametric Aircraft Configuration Scheme)

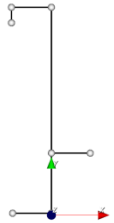
XML-DATA

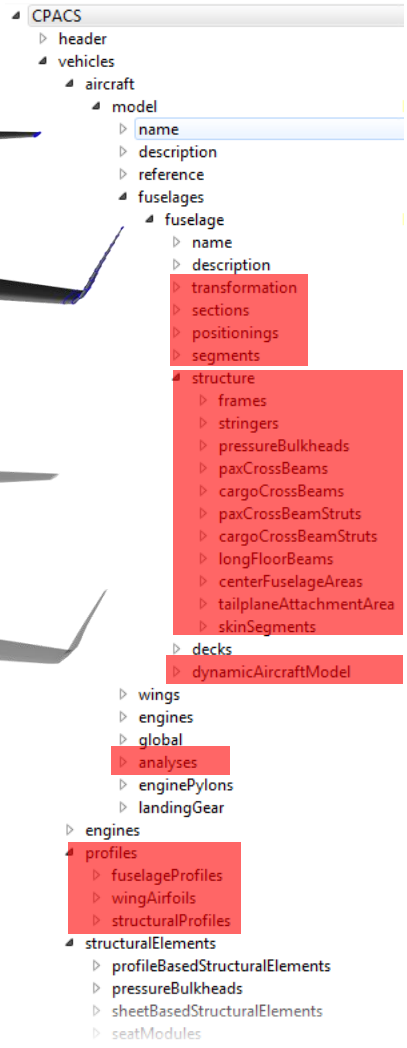
- Geometry (Surface)
- Structure (Definition)
- Profiles (z.B. Frame beamprofil)
- Loads
- Materials
- …



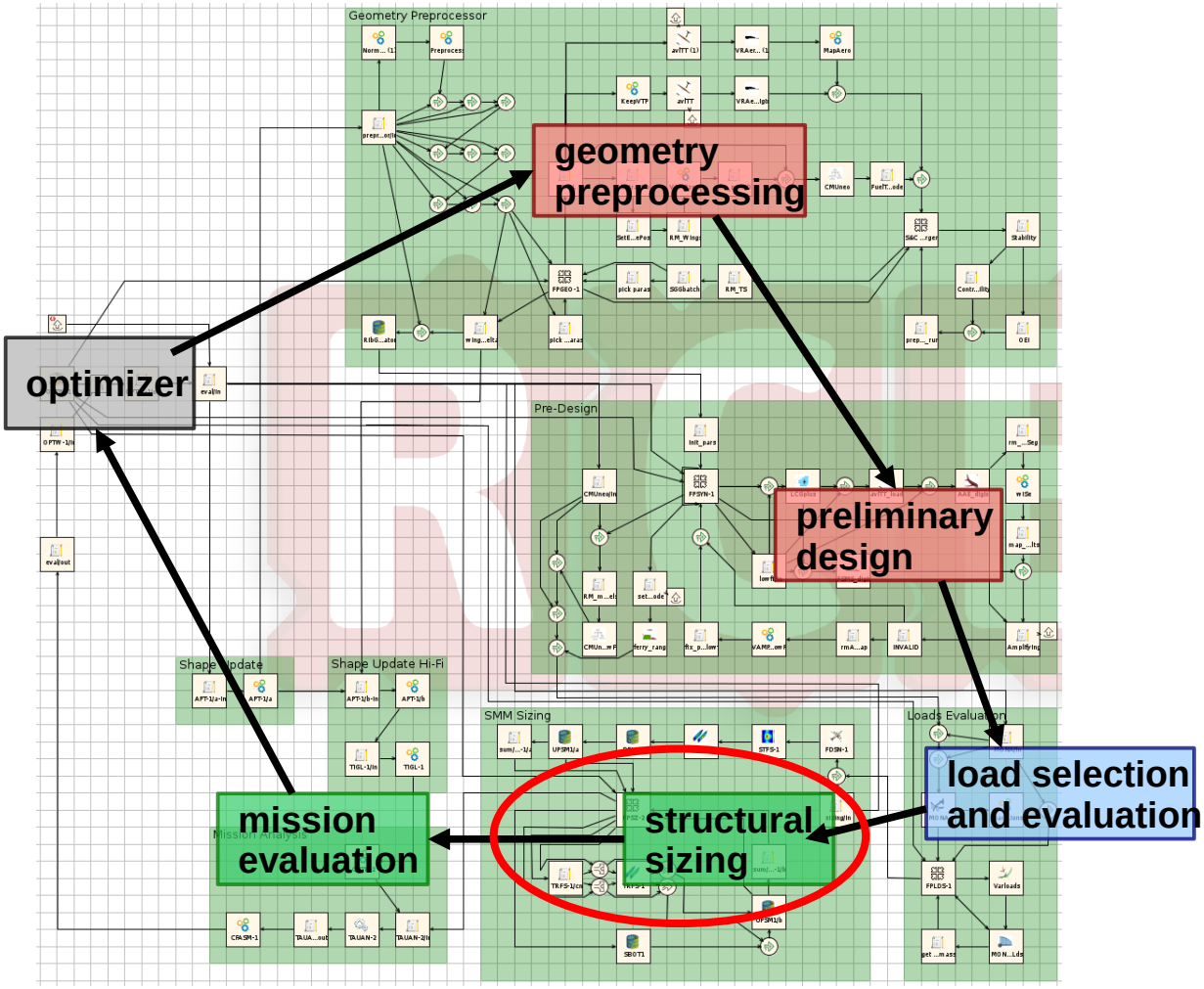








Example of multidisciplinary design optimization at DLR



MDO Workflow (in RCE), S.Görtz, AIAA 2017 Denver

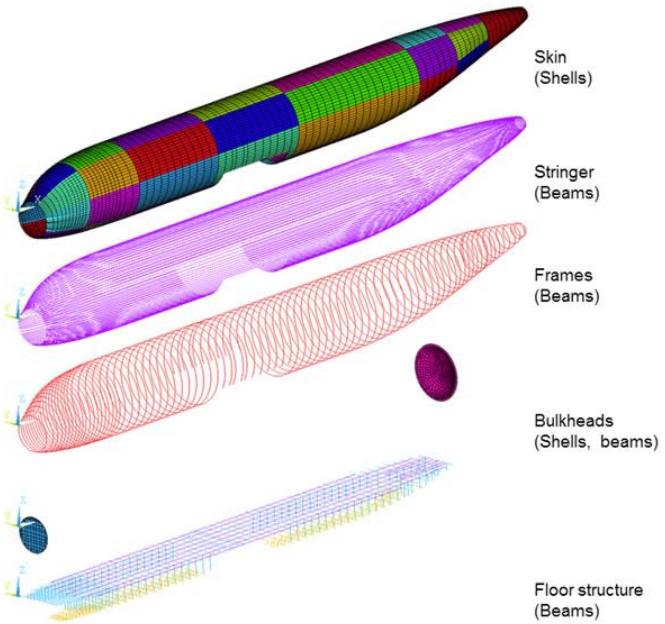
Old tool enviroment

WHY NEW TOOL DEVELOPMENT?

Tool TRAFUMO exist [1]

- ANSYS APDL based → limited, slow
- Exchange complicated
- Inconvenient programming due to APDL

slow & inconvenient



Basic structure components TRAFUMO [1]

CONCLUSION: NEW DEVELOPMENT PANDORA

- **Python** programming
- **Opensource** (Numpy, OCC, VTK, lxml,…)
- **Independent** of commercial software
- **Using any FE solver** possible
- **GUI** – simple usage
- **Modular** – further possibilities
- *Development since 2016…*

fast & flexible

[1] J.SCHERER, D. KOHLGRÜBER, F. DORBATH, M. SOROUR - A FINITE ELEMENT BASED TOOL CHAIN FOR STRUCTURAL SIZING OF TRANSPORT AIRCRAFT IN PRELIMINARY AIRCARFT DESIGN“ DLRK 2013, STUTTGART

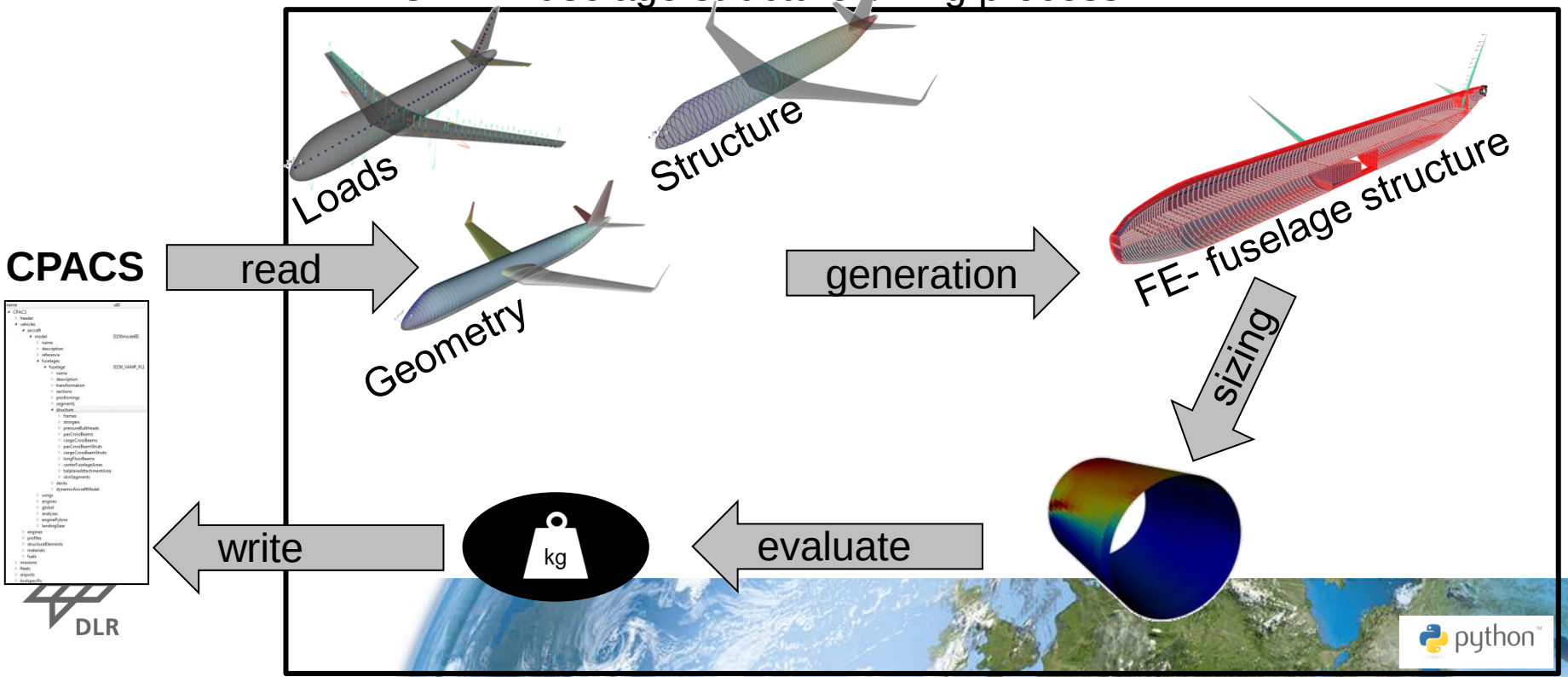
PANDORA – Toolenviroment

(Parametric **N**umerical **D**esign and **O**ptimization **R**outines for **A**ircraft**)**

Main features of PANDORA

- Graphical User Interface (under development)
- Python based and useable via scripting
- General functionalities independent from aircraft design process

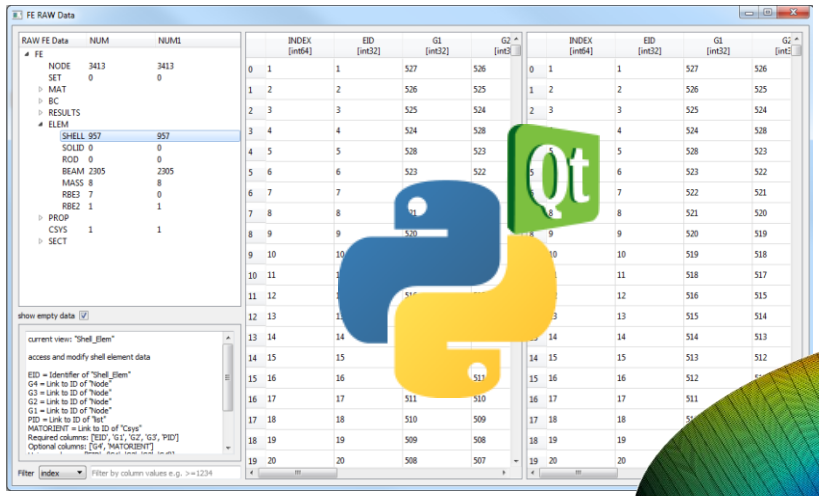
PANDORA - fuselage structure sizing process



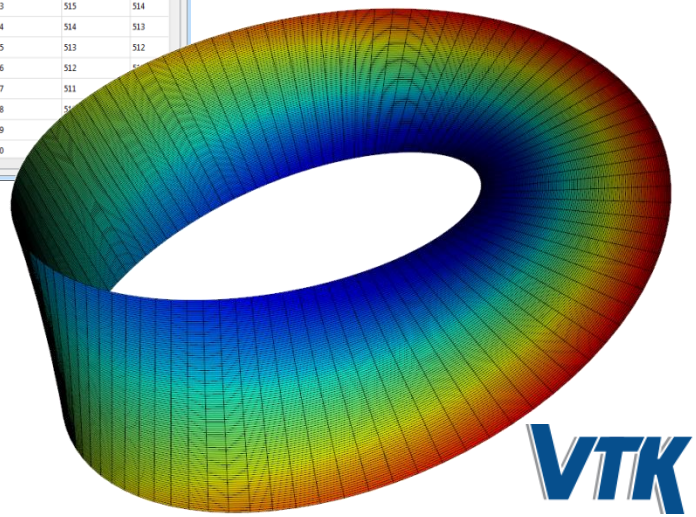
PANDORA – tool environment

(**Pa**rametric **N**umerical **D**esign and **O**ptimization **R**outines for **A**ircraft)

External packages **PyQt** **VTK** **OCC** **lxml** **…**



LXML



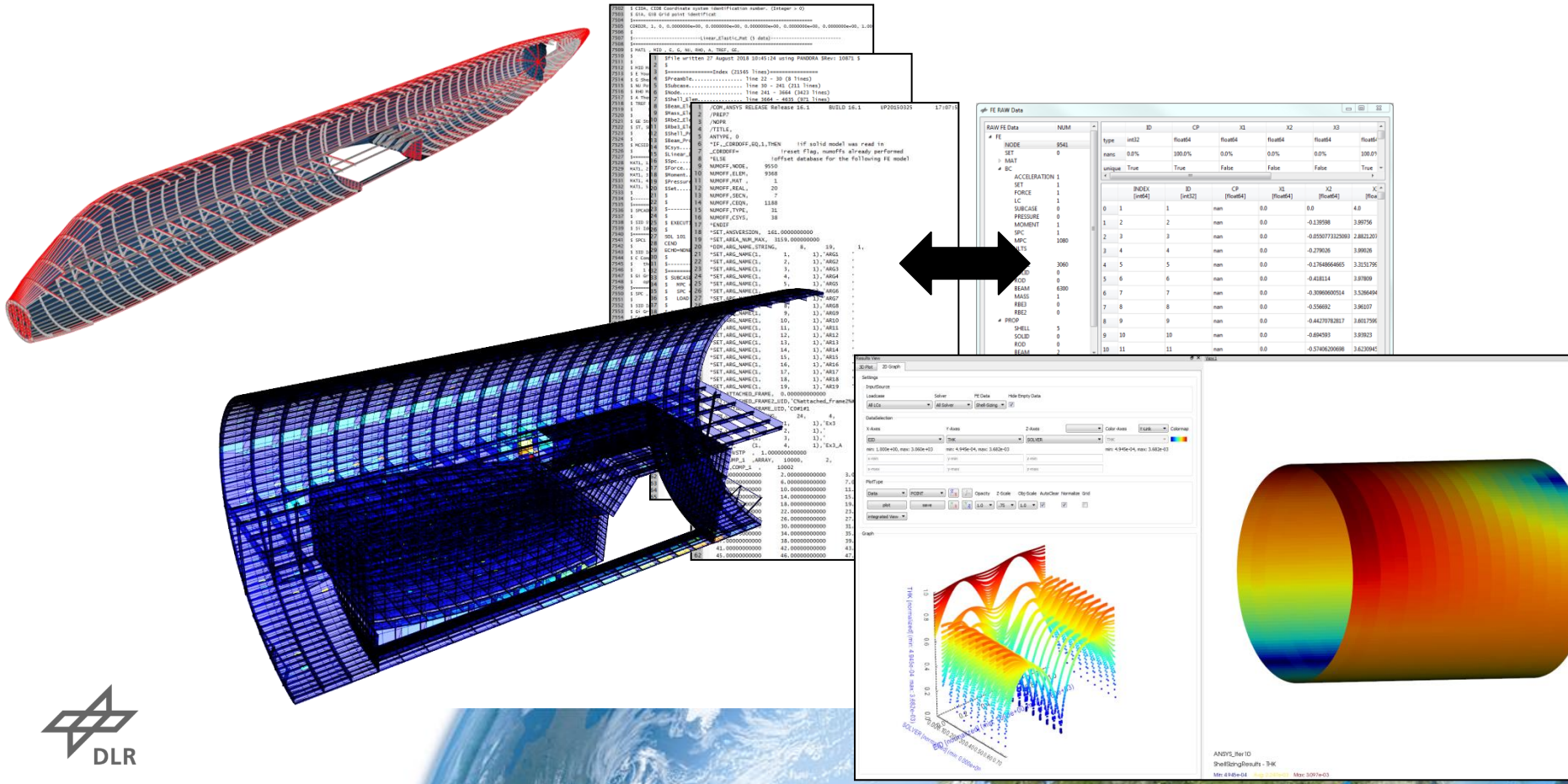
VTK

VISUALIZATION TOOLKIT

PANDORA – tool environment

(**Pa**rametric **N**umerical **D**esign and **O**ptimization **R**outines for **A**ircraft)

PANDORA Pakete | **FE preprocessor** | **FE sizing** | **FE model generator** | **FE converter** | **…**

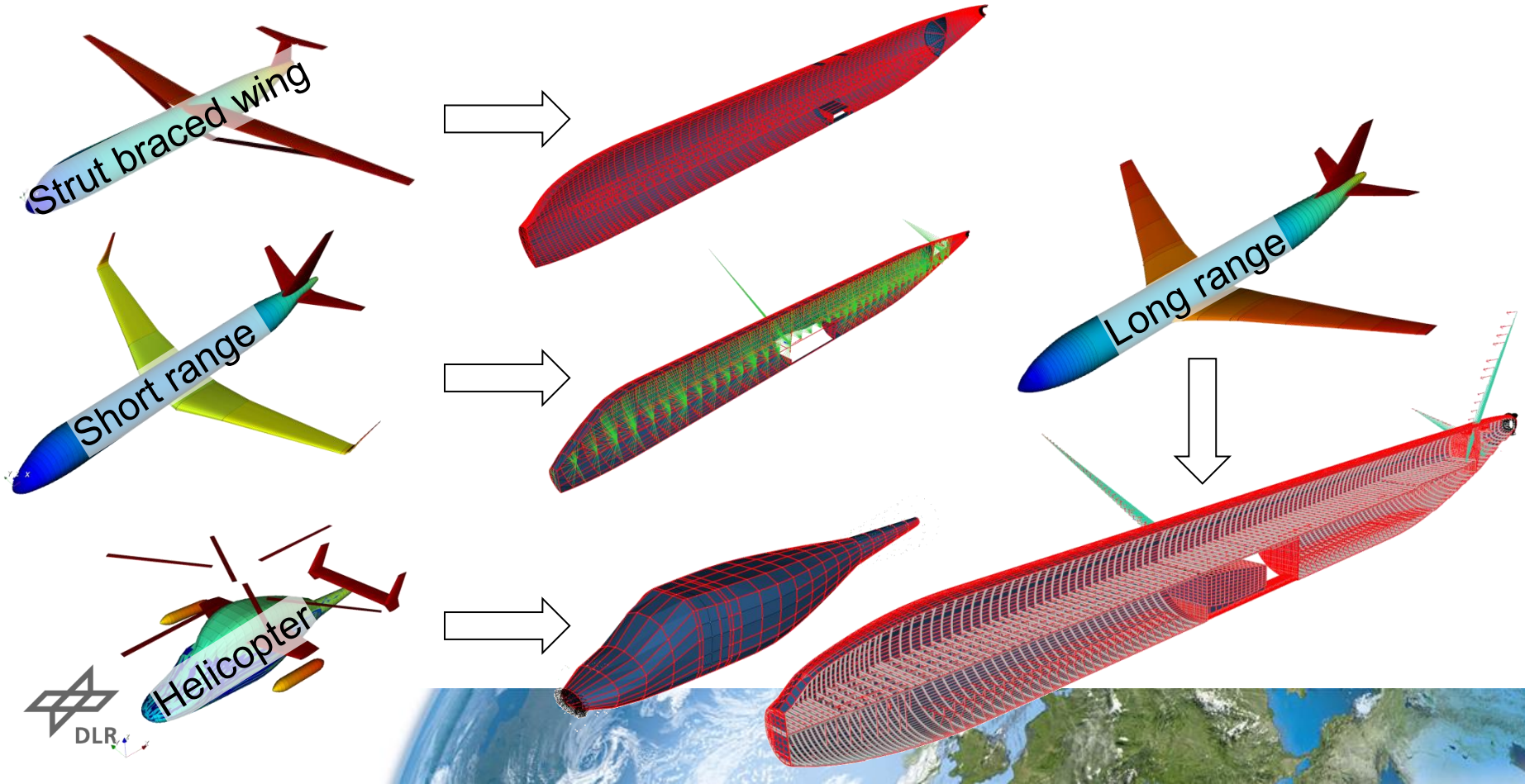


PANDORA – tool environment

(**Pa**rametric **N**umerical **D**esign and **O**ptimization **R**outines for **A**ircraft)

PANDORA Pakete FE preprocessor | FE sizing

FE model generator | FE converter | …

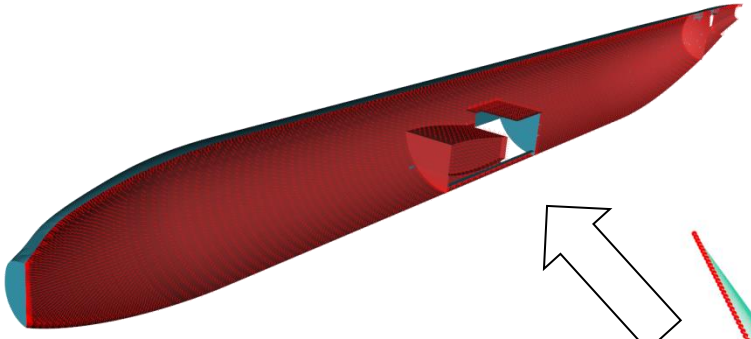


PANDORA – tool environment

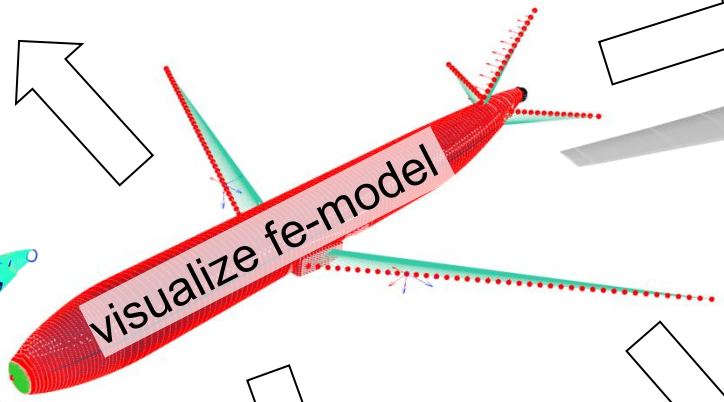
(Parametric Numerical Design and Optimization Routines for Aircraft)

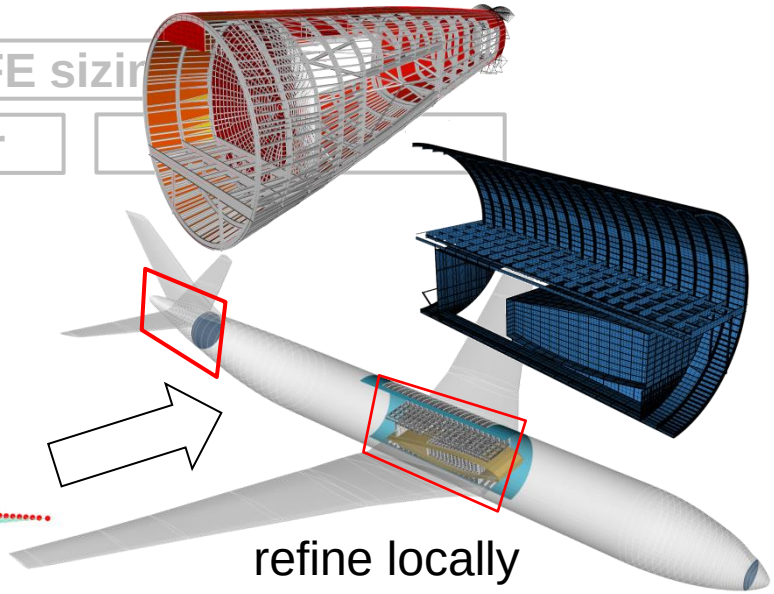
PANDORA Pakete **FE preprocessor** FE sizi

FE model generator FE converter

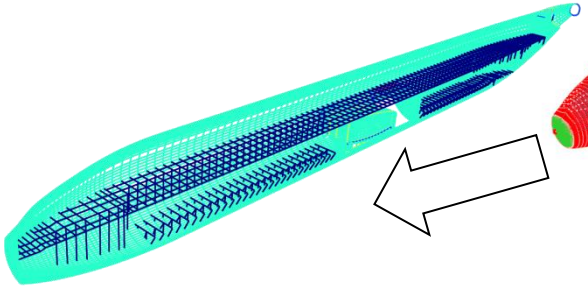


check shell orientation



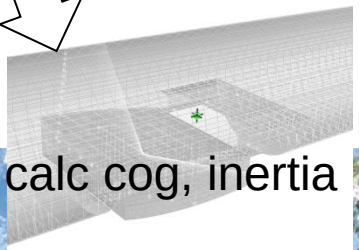


refine locally

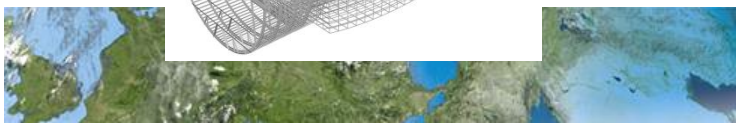


check element connection

visualize beam profiles



calc cog, inertia



PANDORA – tool environment

(Parametric **N**umerical **D**esign and **O**ptimization **R**outines for **A**ircraft**)**

PANDORA Pakete

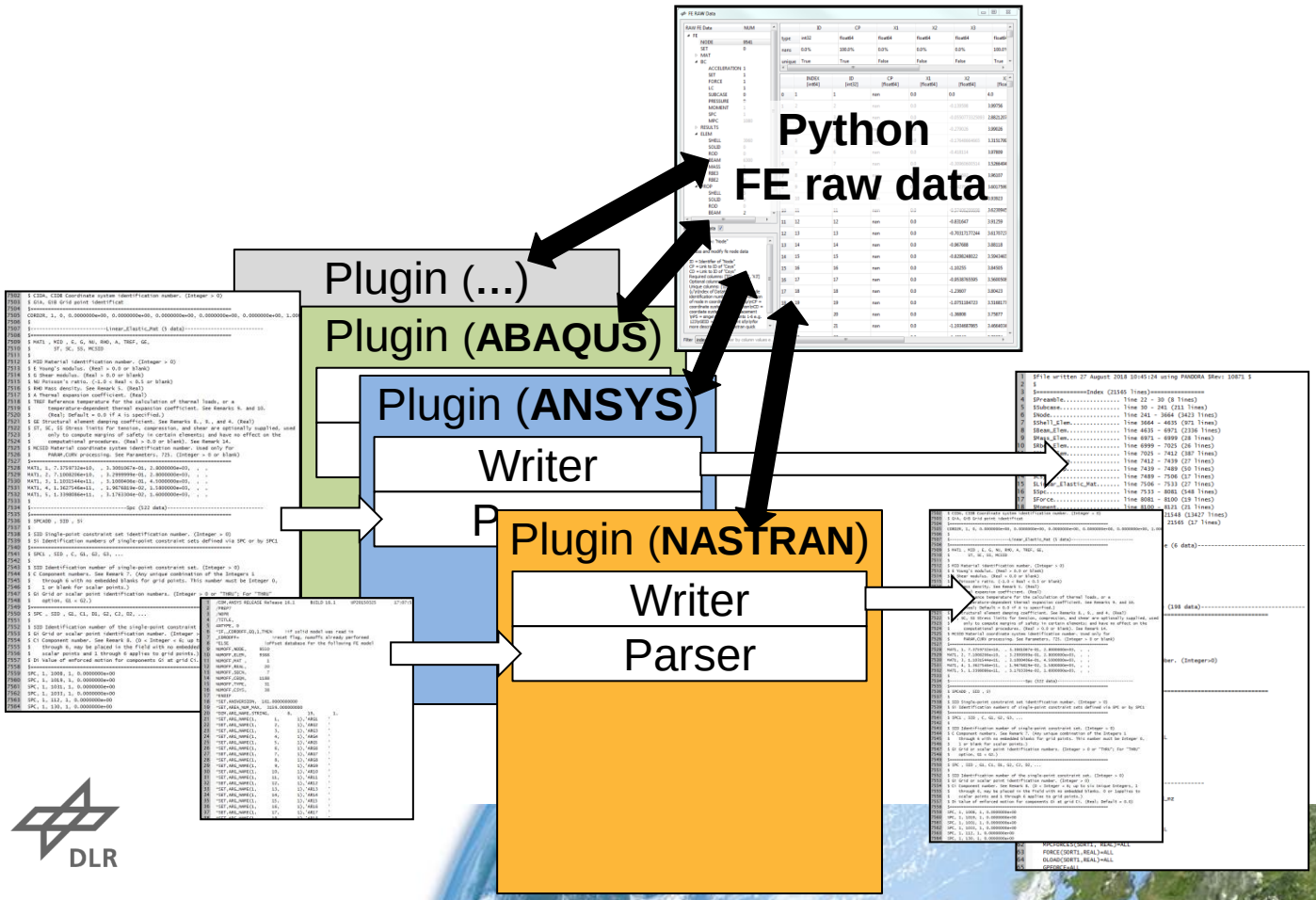
FE preprocessor

FE sizing

FE model generator

FE converter

…

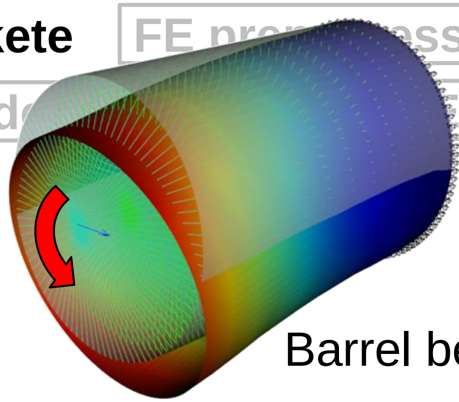


PANDORA – tool environment

(Parametric Numerical Design and Optimization Routines for Aircraft)

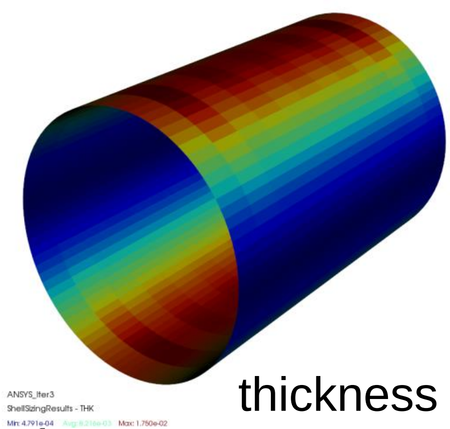
PANDORA Pakete | FE pre…essor | **FE sizing**

FE mode… | …E converter | …



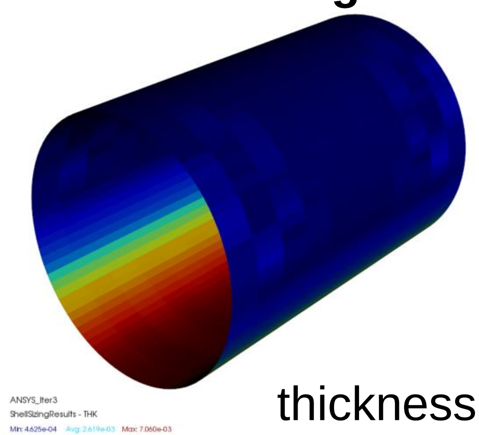
Barrel bending loadcase

Max strength criteria



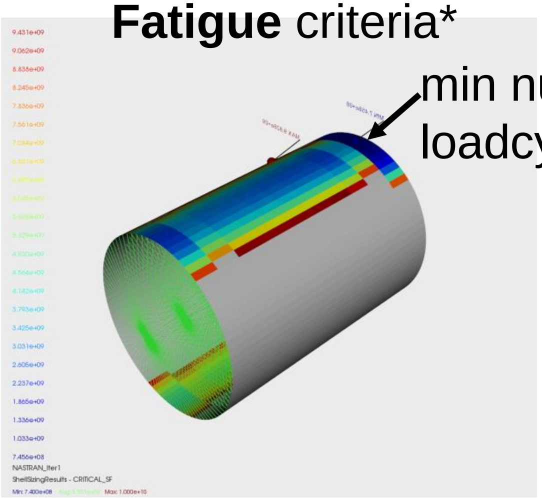
thickness

Bruhn buckling criteria



thickness

Fatigue criteria*



min num of loadcycles

*in development

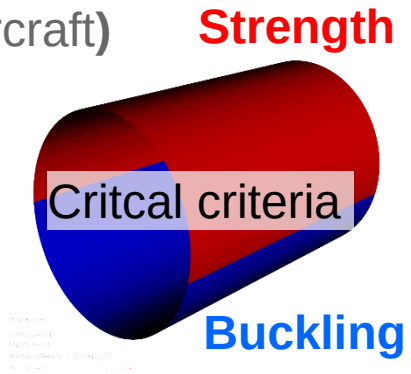
PANDORA – tool environment

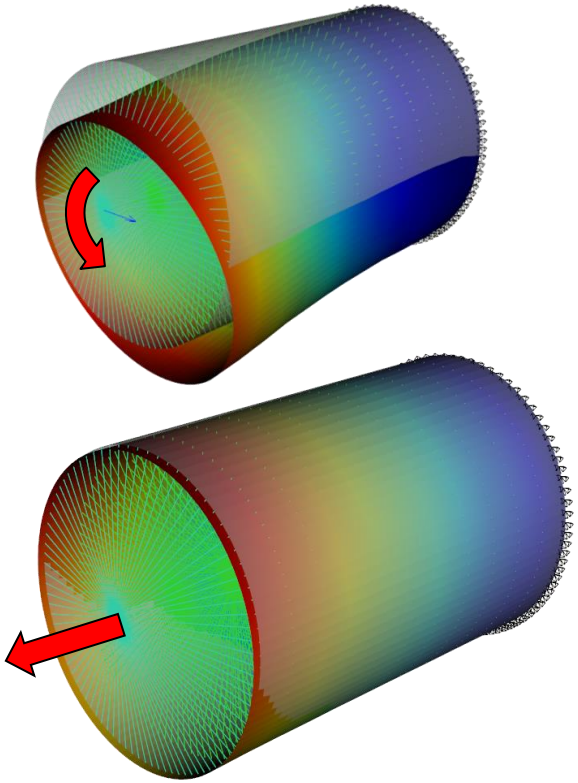
(**Pa**rametric **N**umerical **D**esign and **O**ptimization **R**outines for **A**ircraft)

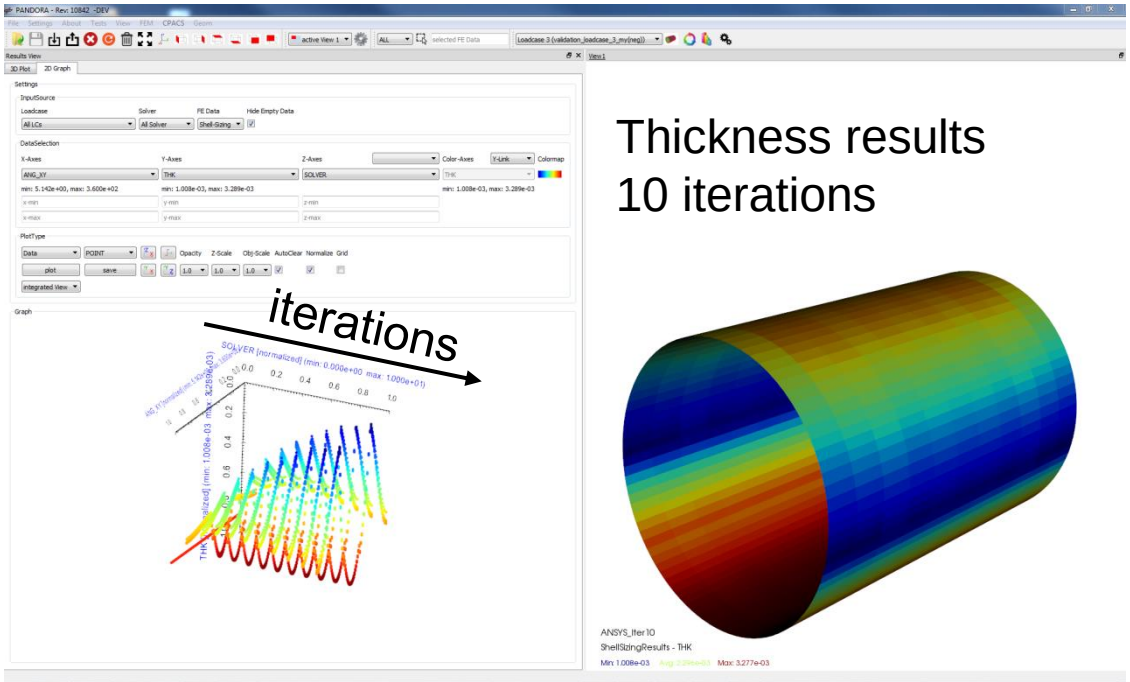
PANDORA Pakete

FE preprocessor | **FE sizing**

FE model generator | FE converter | …







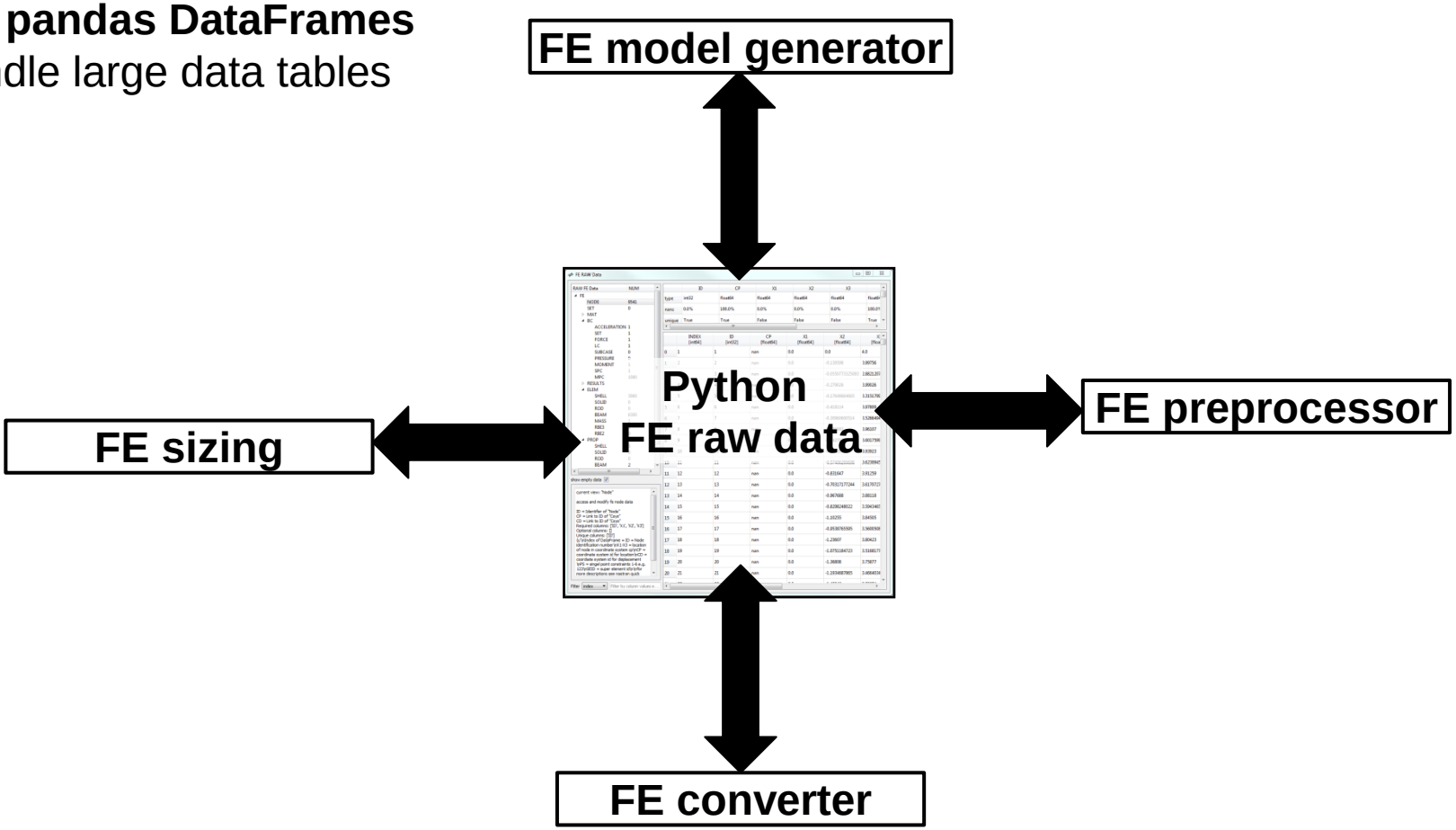
Thickness results
10 iterations

PANDORA – tool environment

(Parametric **N**umerical **D**esign and **O**ptimization **R**outines for **A**ircraft**)**

PANDORA Pakete

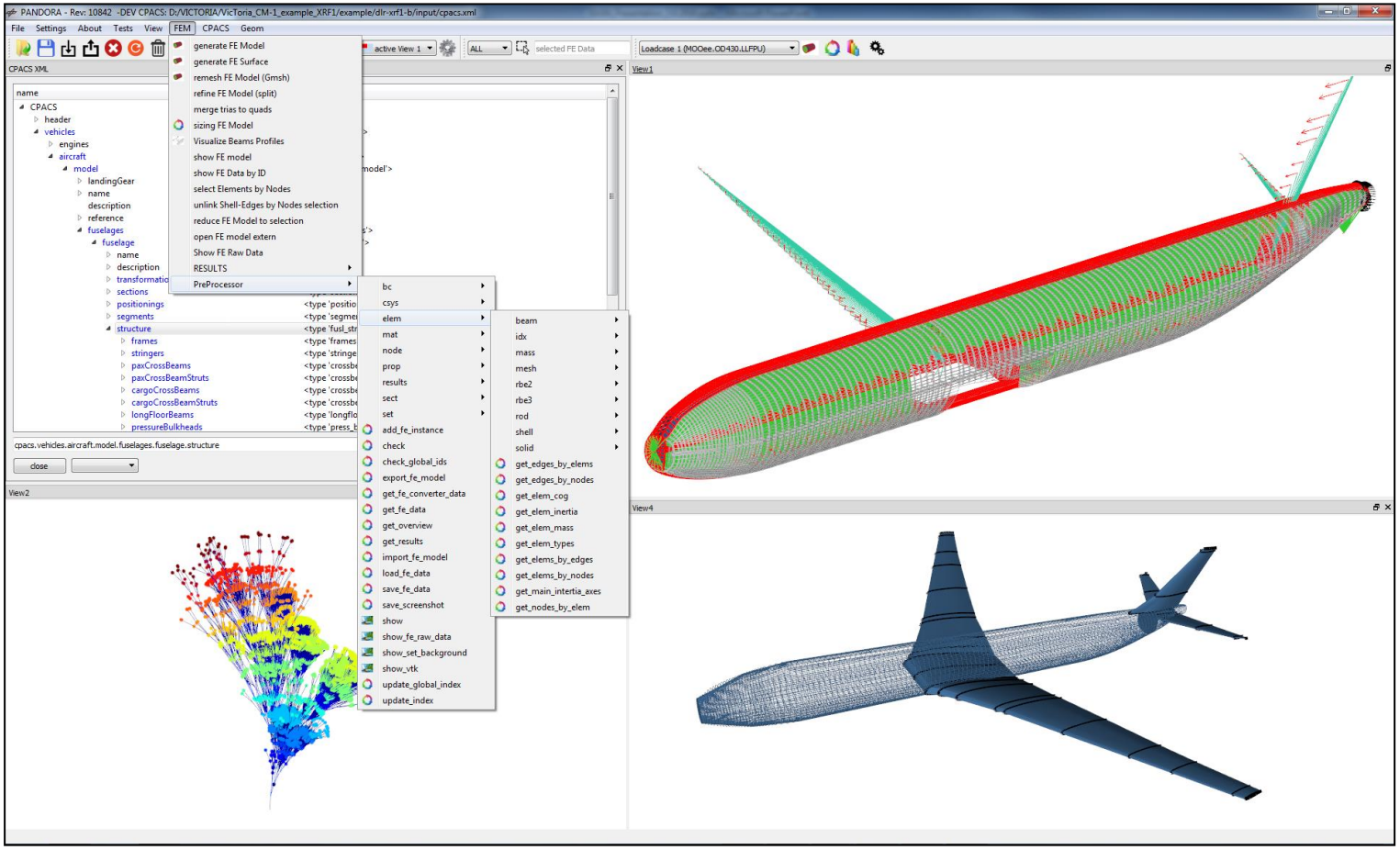
Using **pandas DataFrames**
to handle large data tables



PANDORA – tool environment

(**Pa**rametric **N**umerical **D**esign and **O**ptimization **R**outines for **A**ircraft)

PANDORA GUI – to access main functionalities



Summary & Outlook

Summary

- PANDORA – automated aircraft structure fe generation and sizing
- Python – flexible and opensource

Outlook

- Further GUI development – **usability**
- **Validation** of sizing process
- Expand **sizing criteria** - damage tolerance, anisotropic materials,…
- **Optimization** of structure
- Generate detailed FE models (**crash simulations**)

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Any questions?

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