



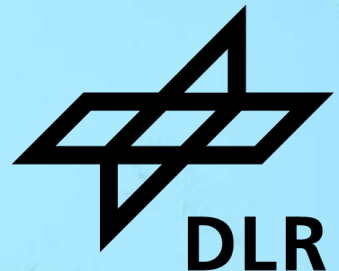
CFD IN COLLABORATIVE, MULTIDISCIPLINARY DESIGN OF PROPULSION SYSTEM AND STATIONARY GAS TURBINES

TRACE User Conference 2025

2025/11/27

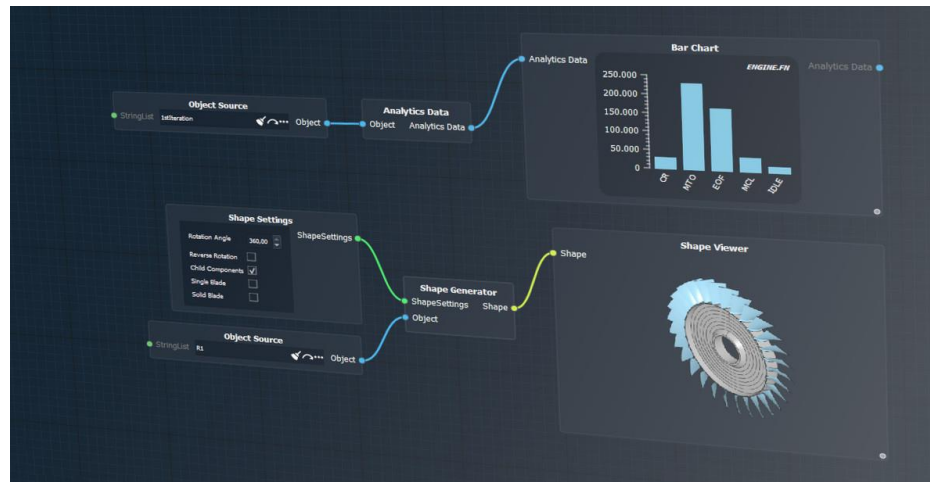
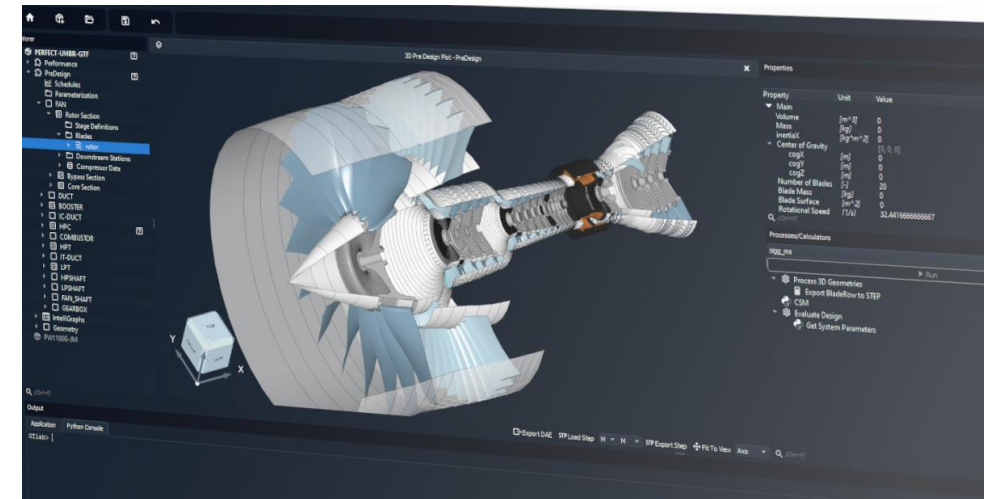
Martin Siggel, Matthias Schuff, Marius Messerschmitt

German Aerospace Center





- GTlab = DLR's **Virtual Engine Platform**
Design, Analysis + Optimization of aircraft engines + stationary gas turbines
- **Multidisciplinary, Collaborative, Interactive**
- Central Data Hub + Data Processing
- Automation via Workflows



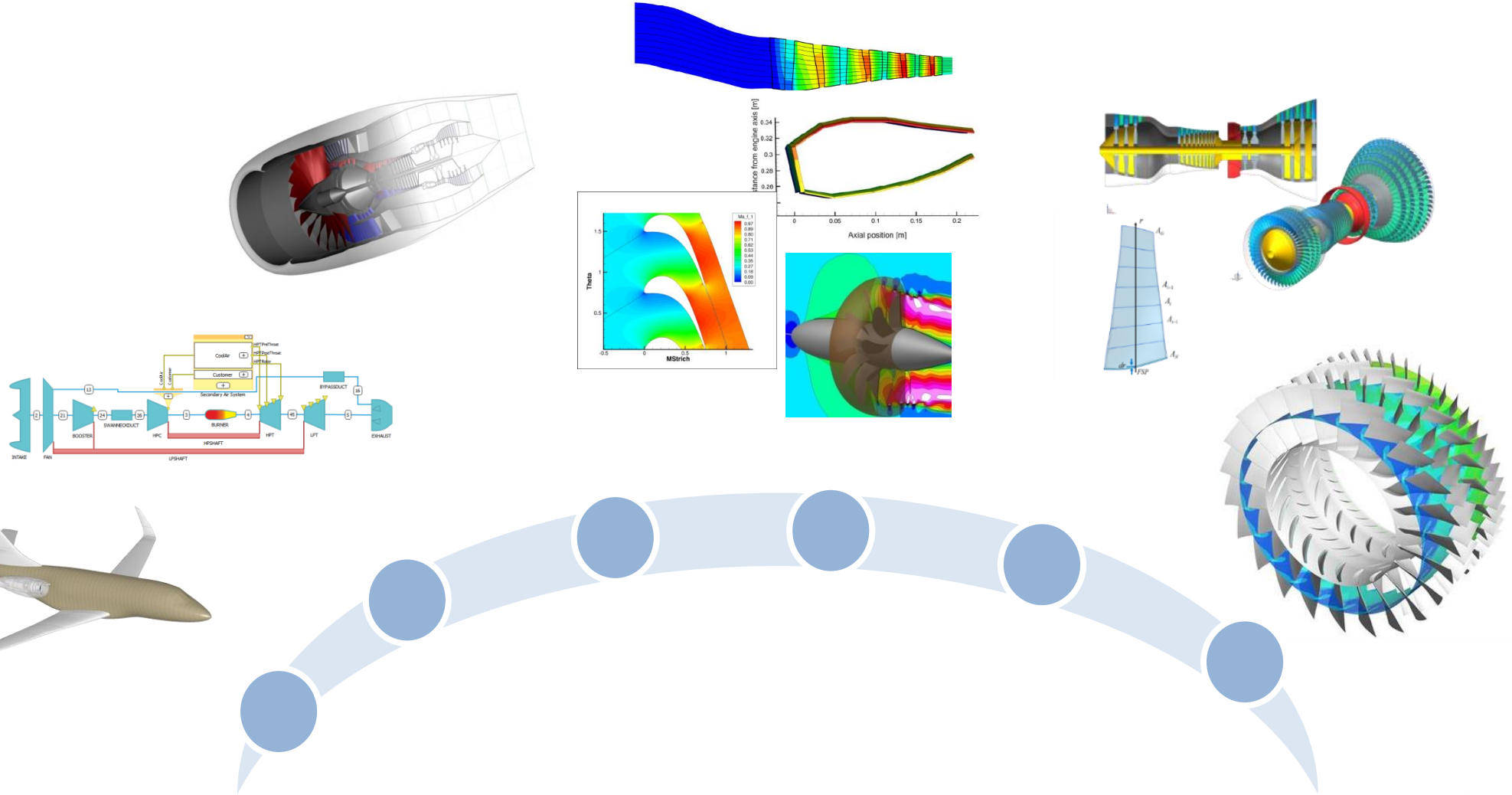
- Flexible + modular Framework (OS), extensible via “Modules” (Apps)
- Many parts as Open Source Software

<https://www.gtlab.de>
<https://github.com/dlr-gtlab>



SCAN ME

Goal: Realization of the Virtual Engine

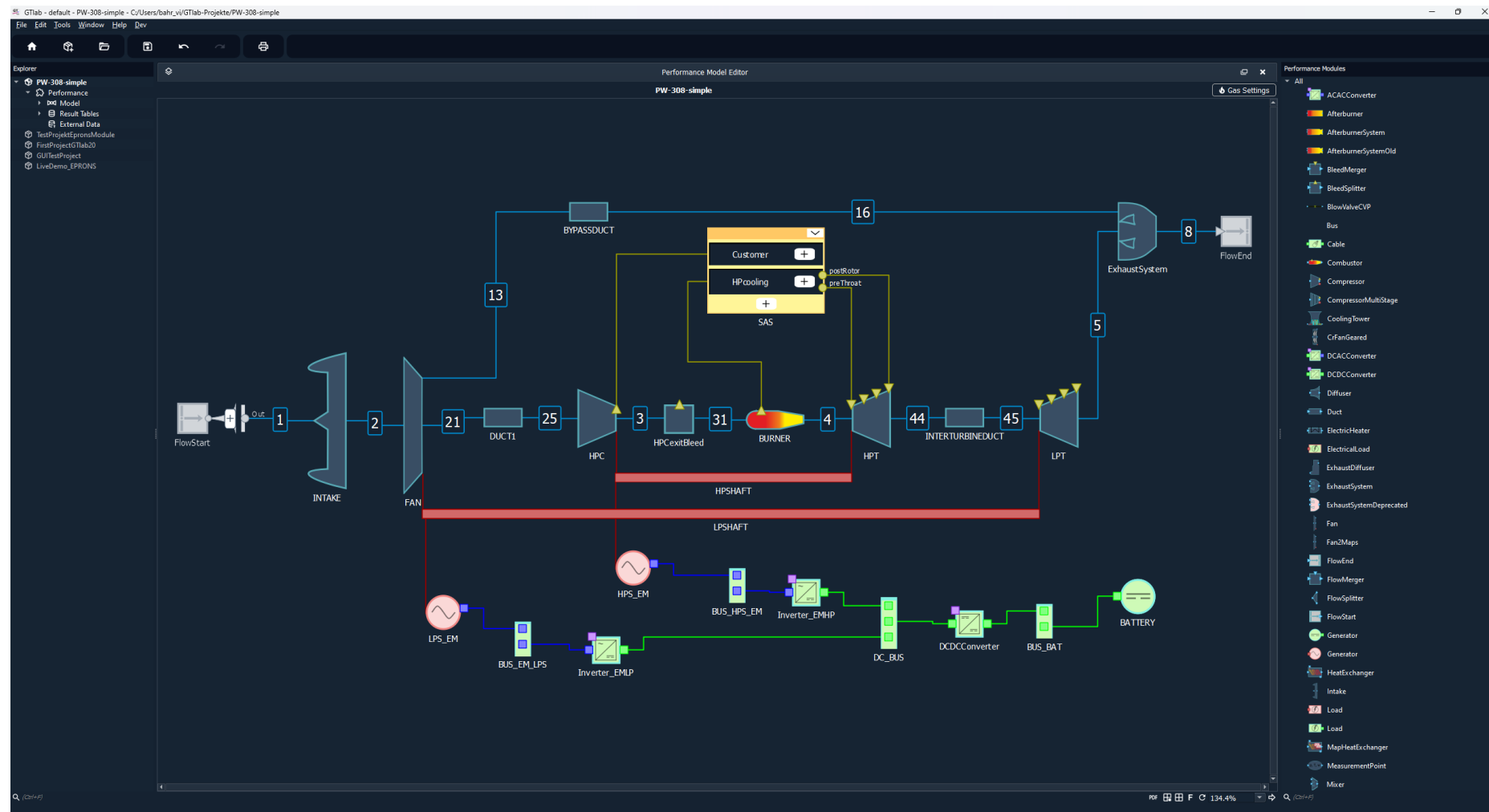


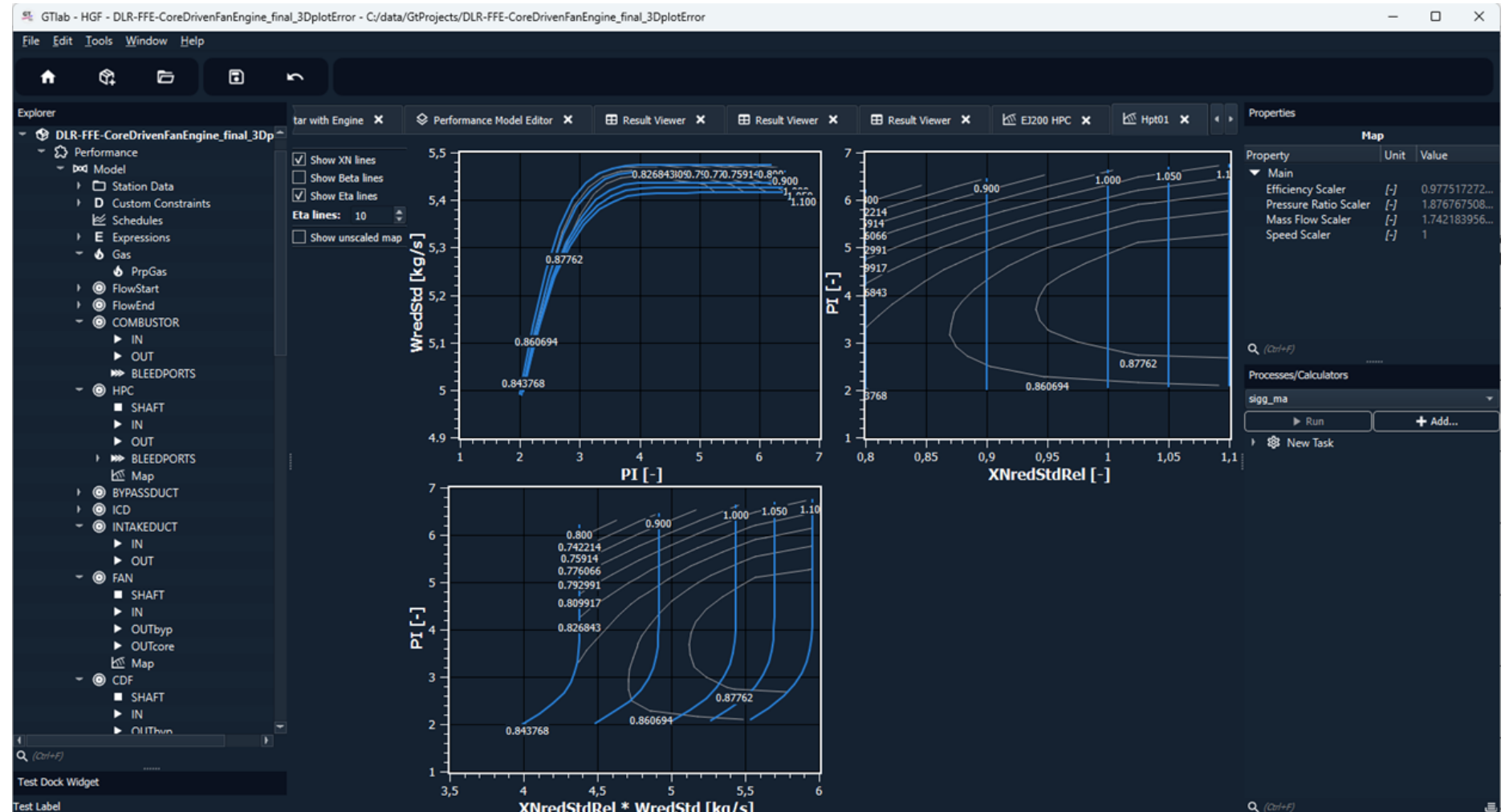


Multidisciplinary Design



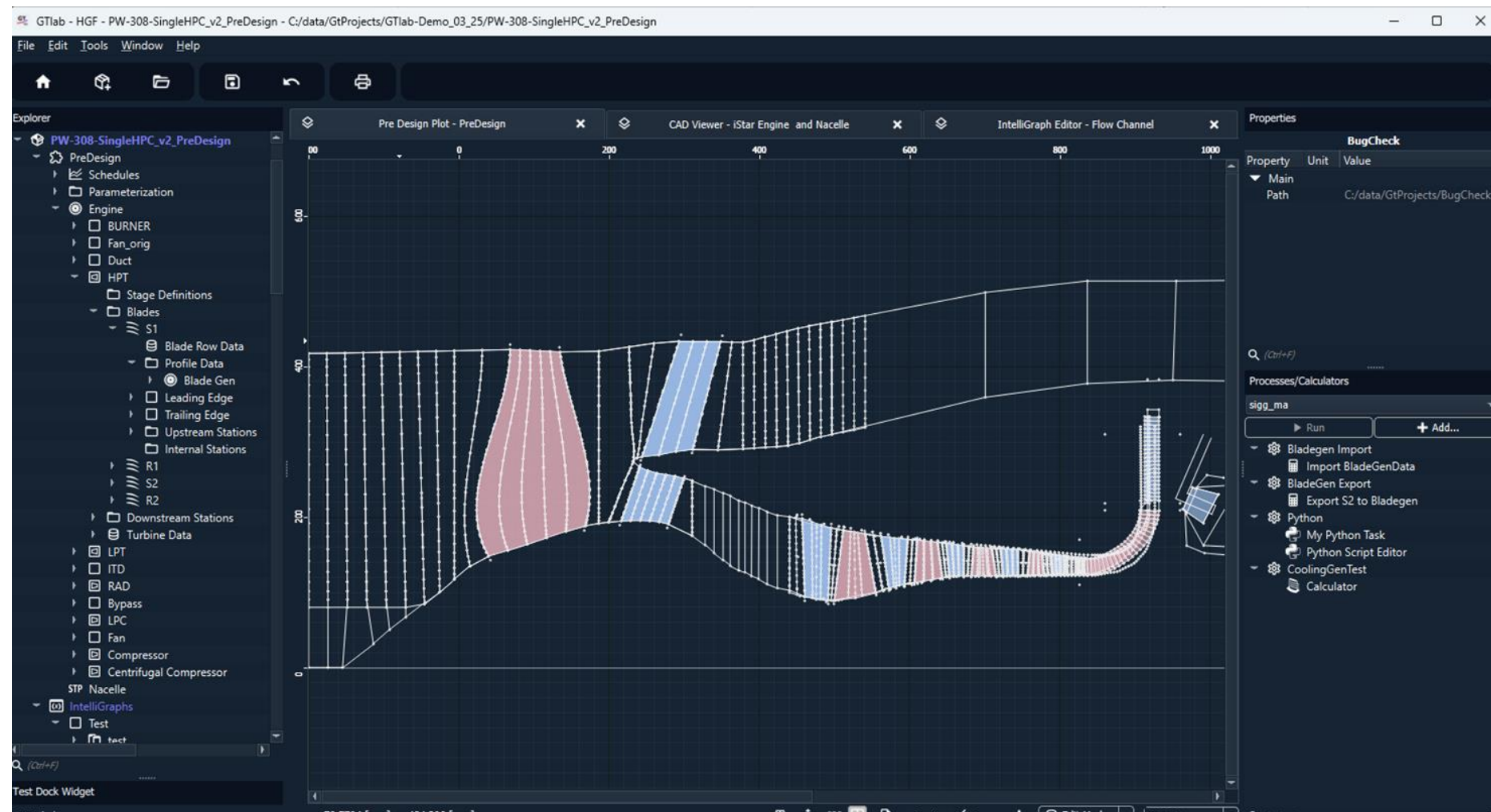
Multidisciplinary Design





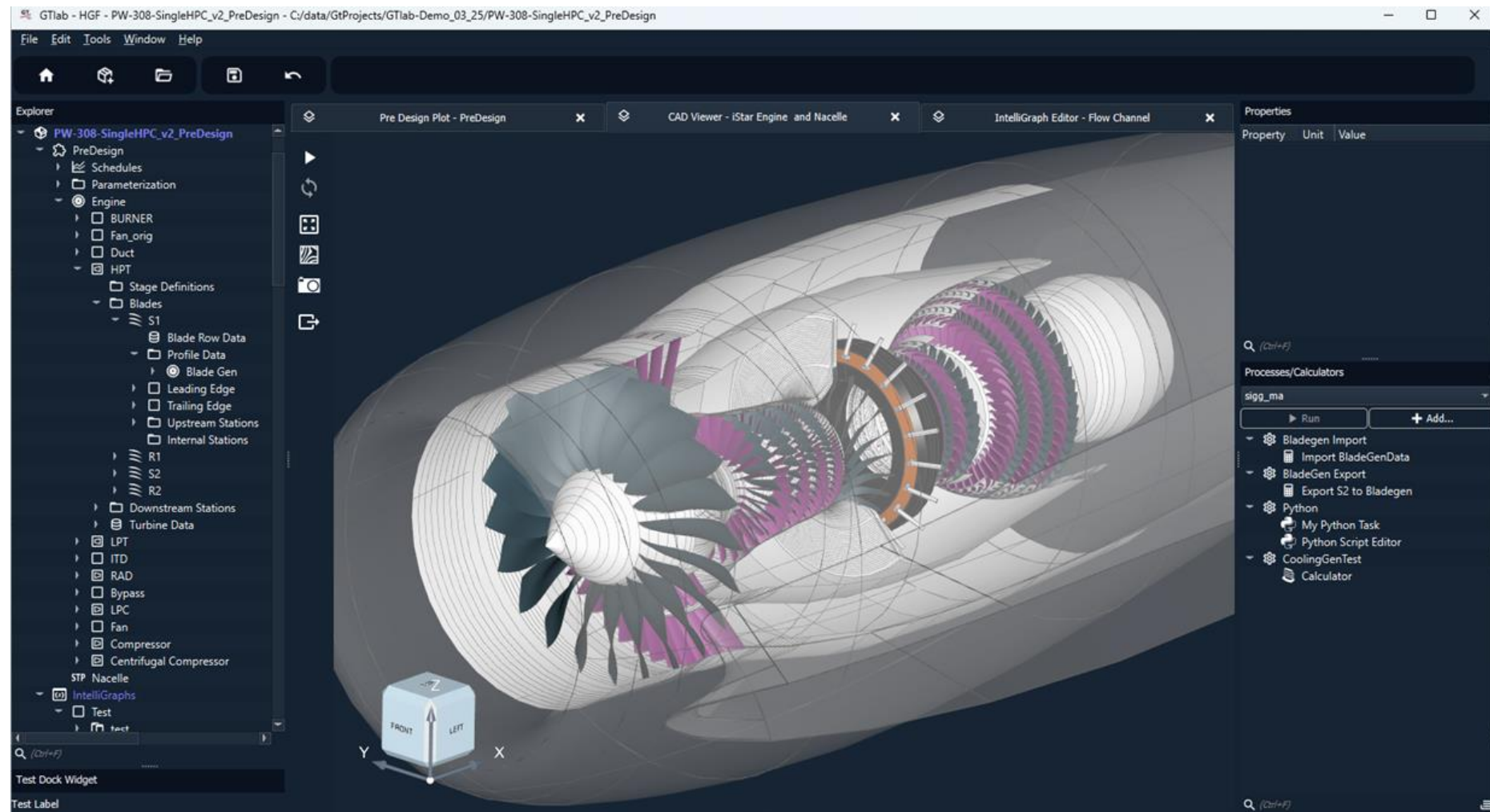


Multidisciplinary Design – Sketching

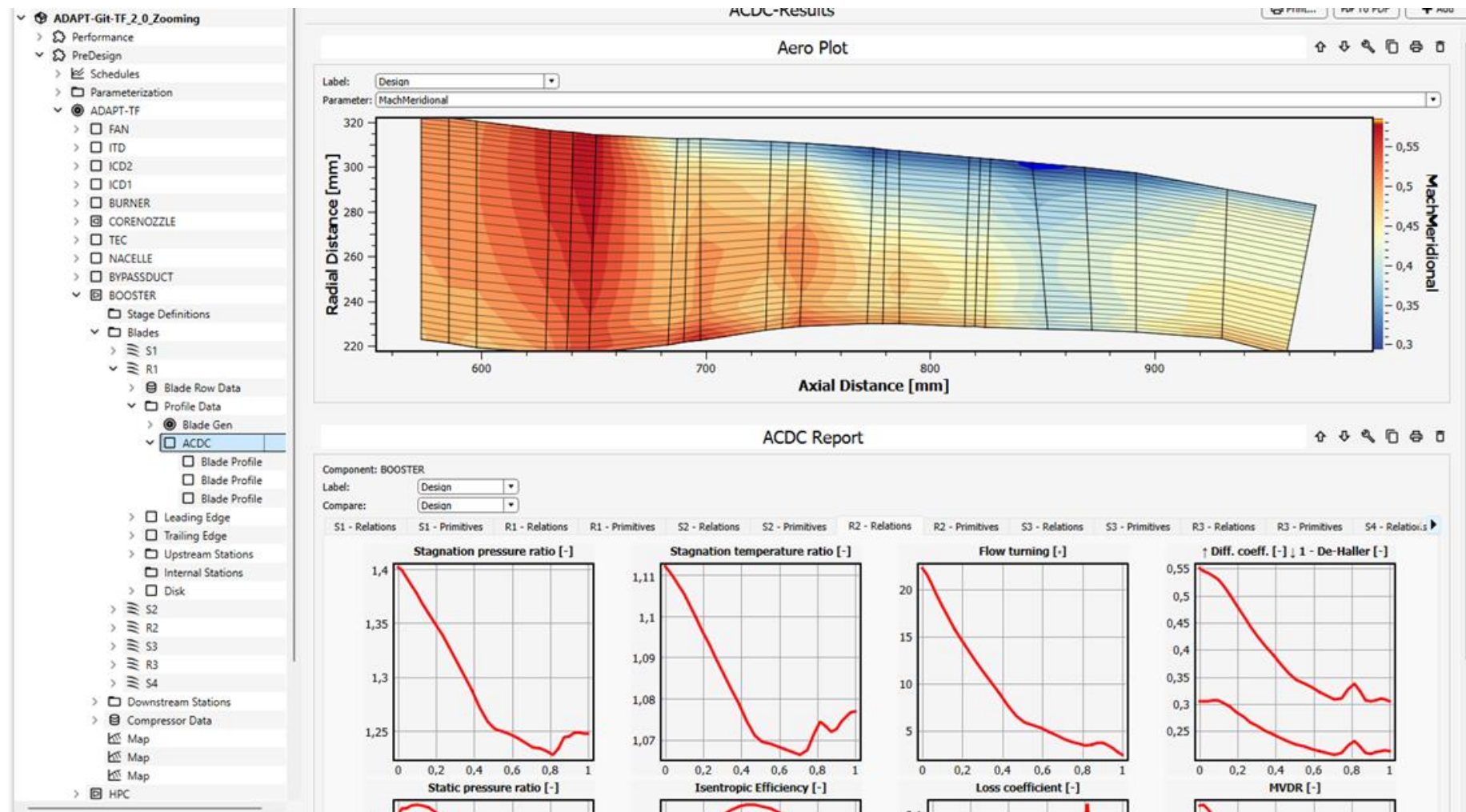




Multidisciplinary Design – 3D Geometry

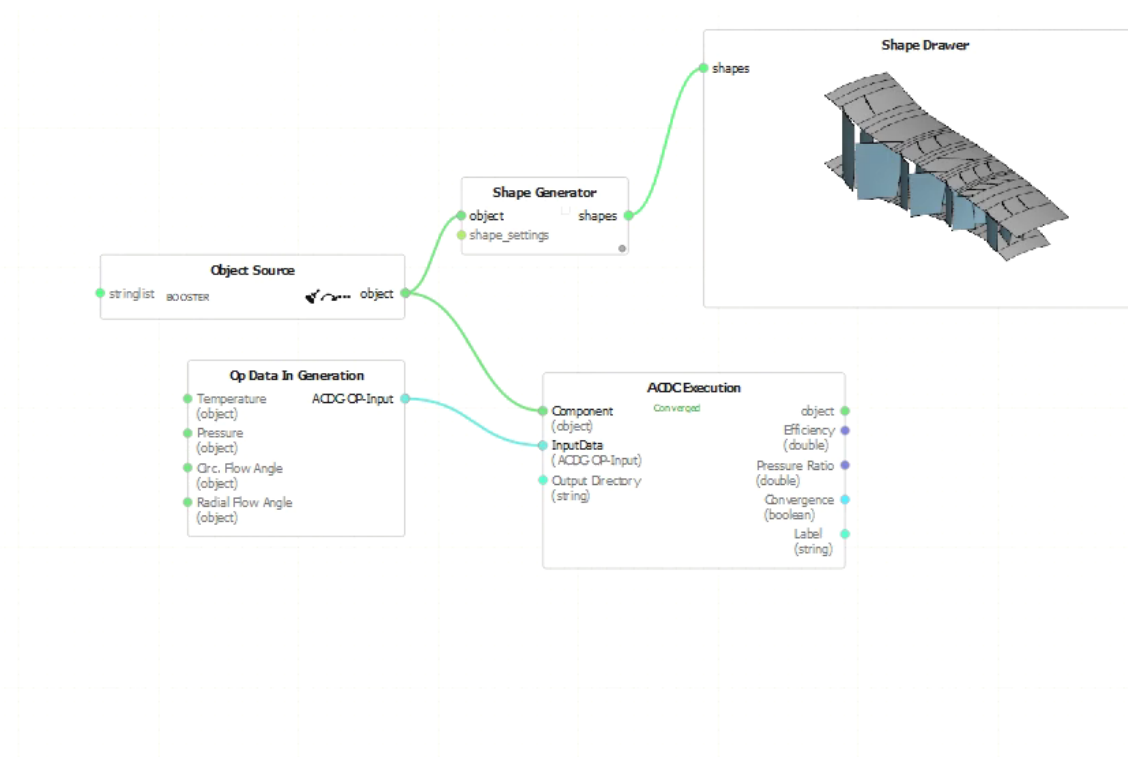


Multidisciplinary Design – Rapid Analysis



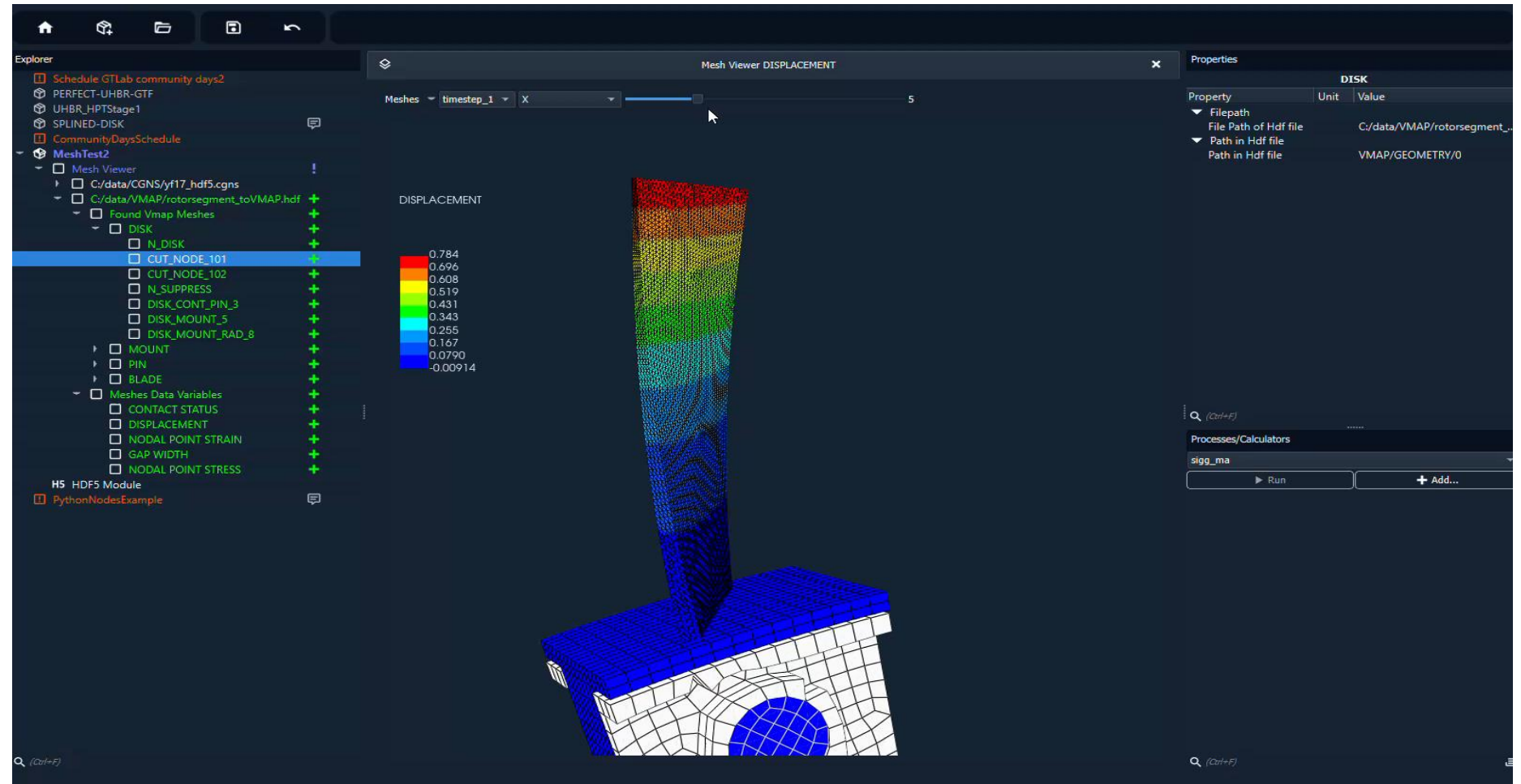


Interactive Analysis





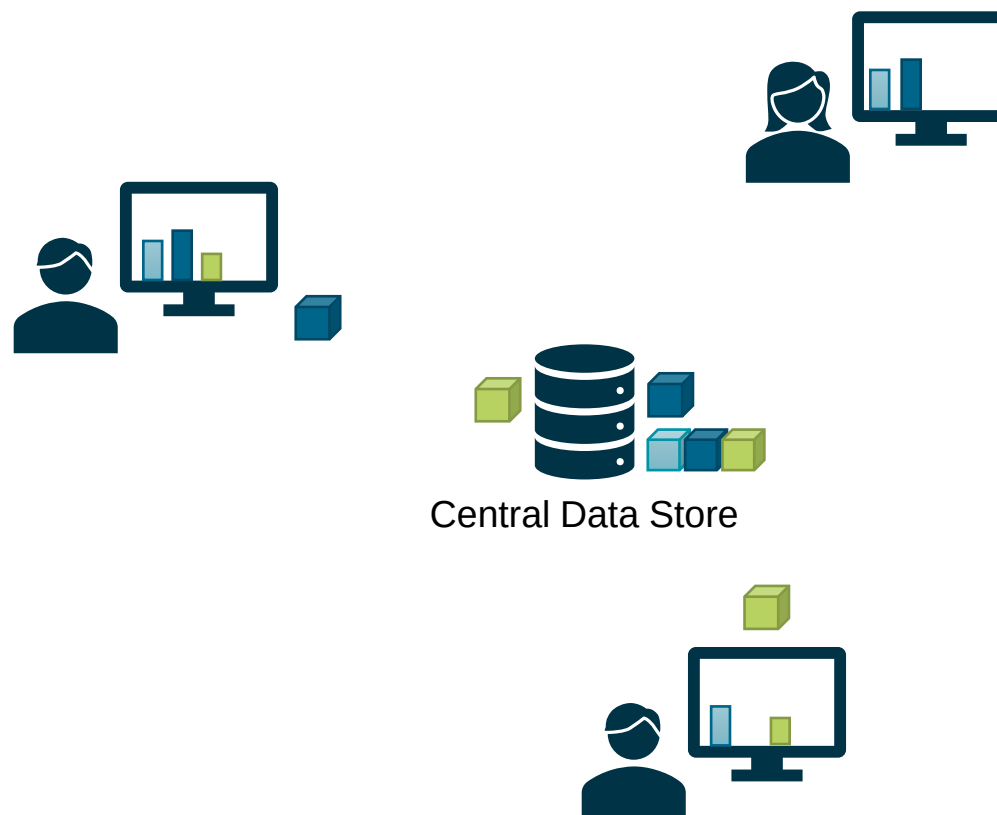
Structural Mechanics Analysis



Oliver Kunc, Nicolai Forsthofer, DLR BT

Collaborative Design

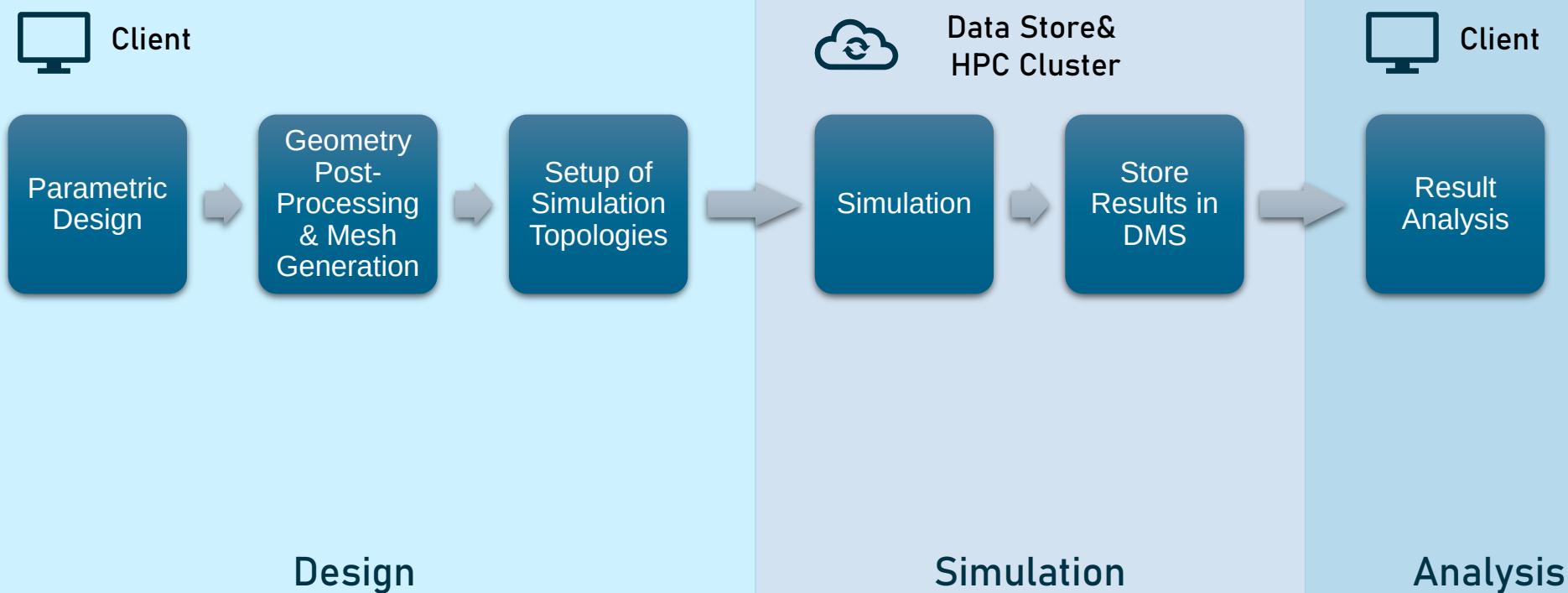
Collaborative Design



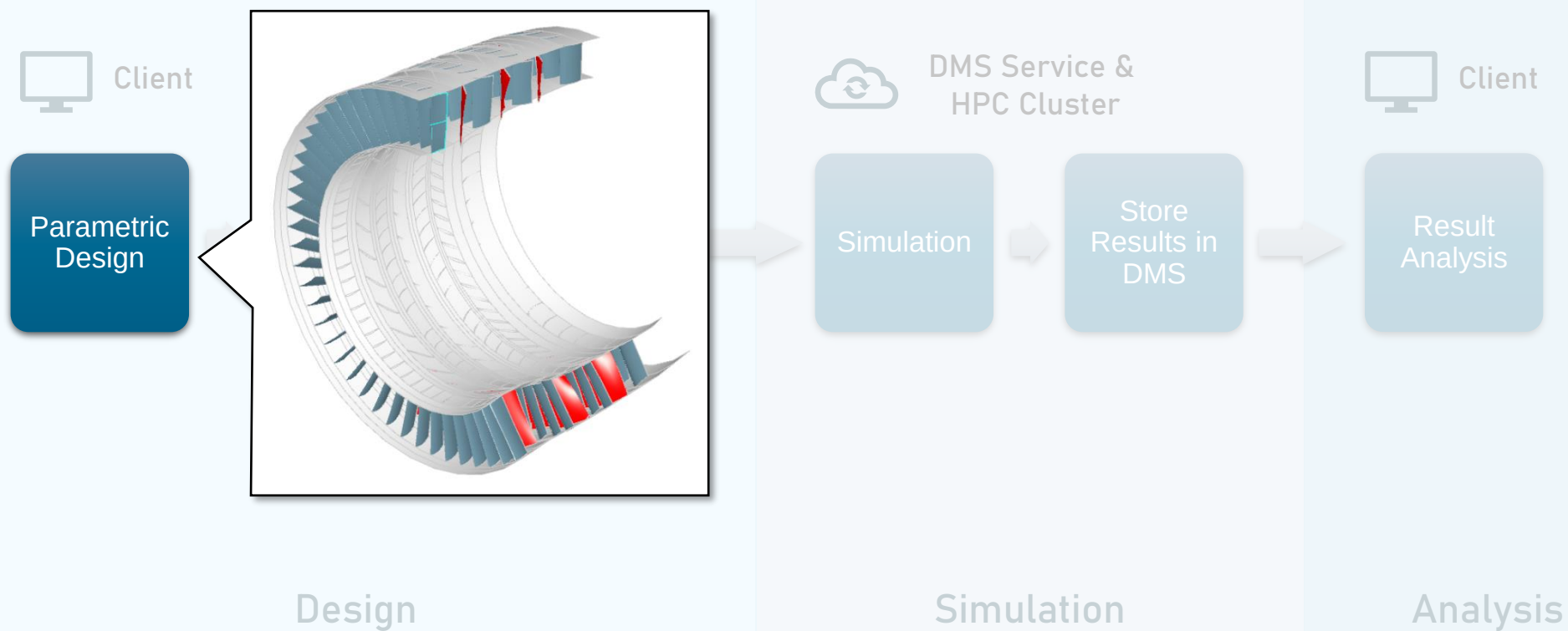
- **Push** changes to server
- **Pull** updates from server
- Works great, if data / changes are small
- Inefficient for large binary data (> 100 MB)

➤ Large CFD data are a challenge in collaborative environments!

The CFD workflow



The CFD workflow





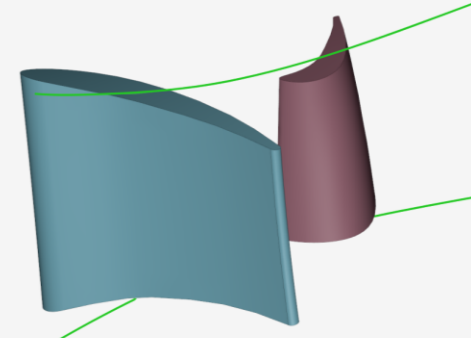
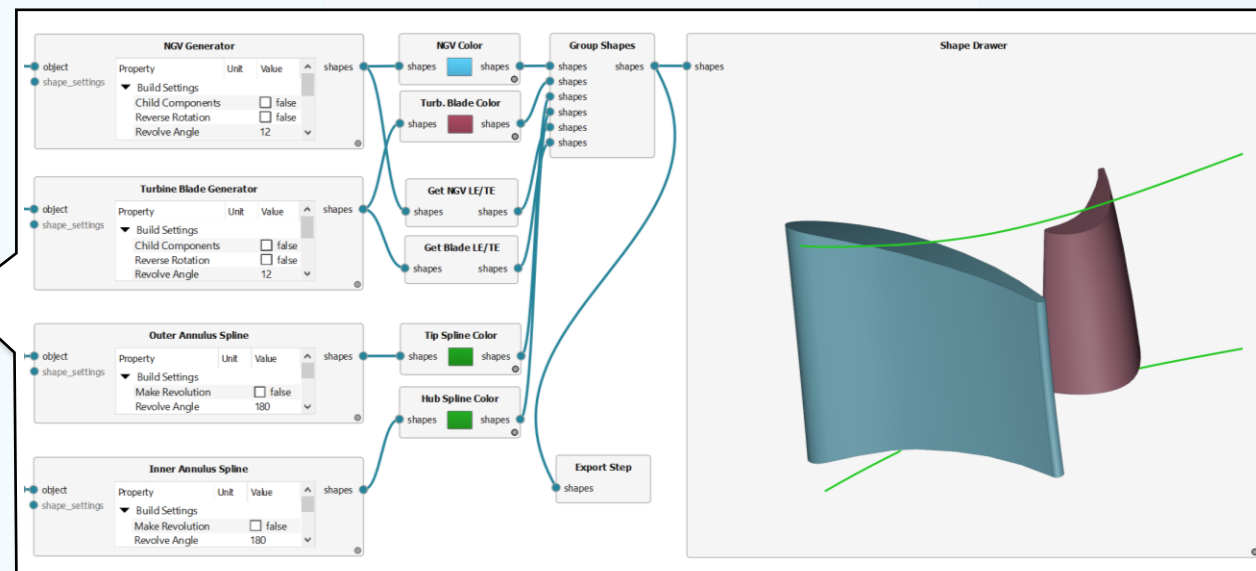
The CFD workflow



Client

Parametric Design

Geometry
Post-Processing
& Mesh
Generation



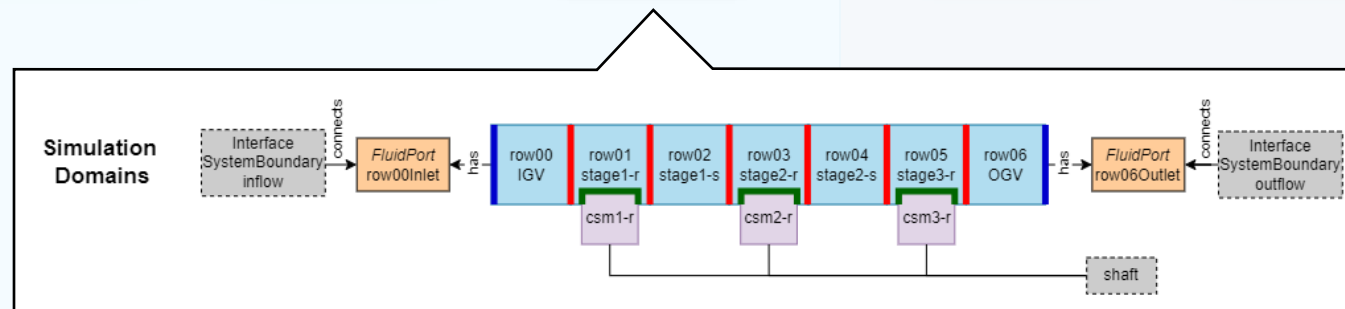
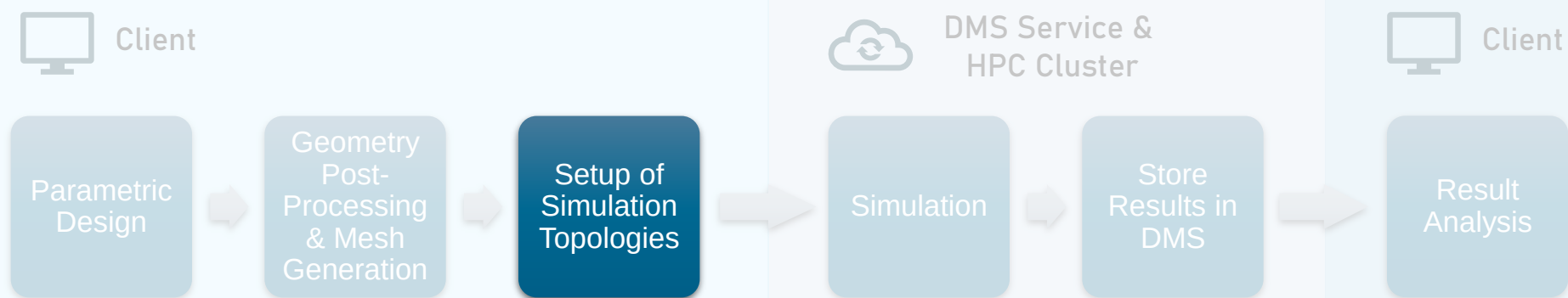
Design

Simulation

Analysis



The CFD workflow

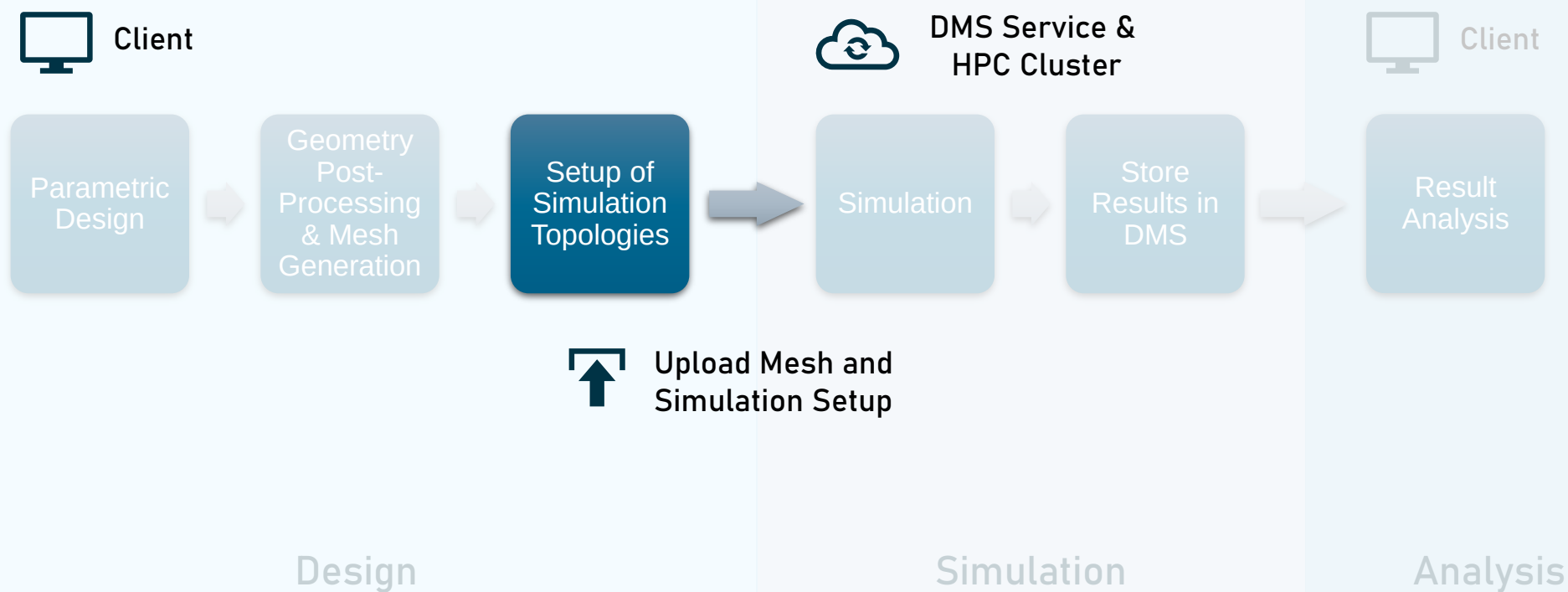


Design

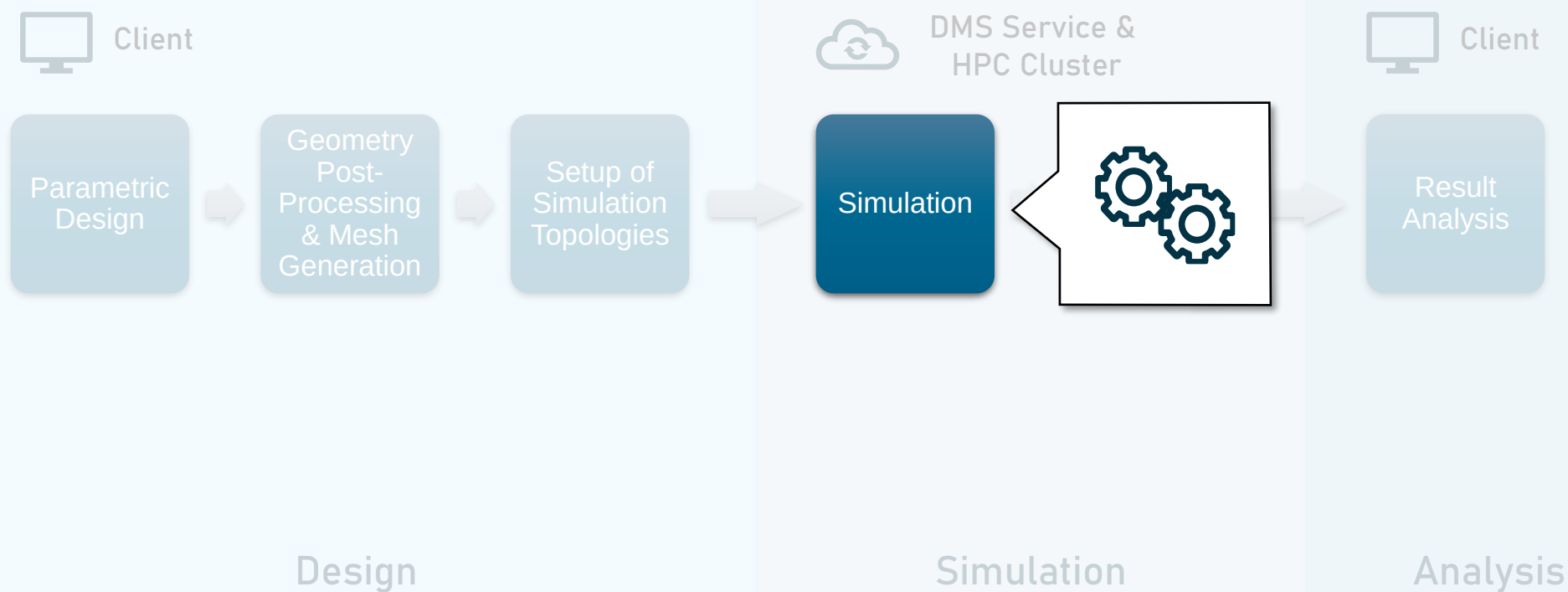
Simulation

Analysis

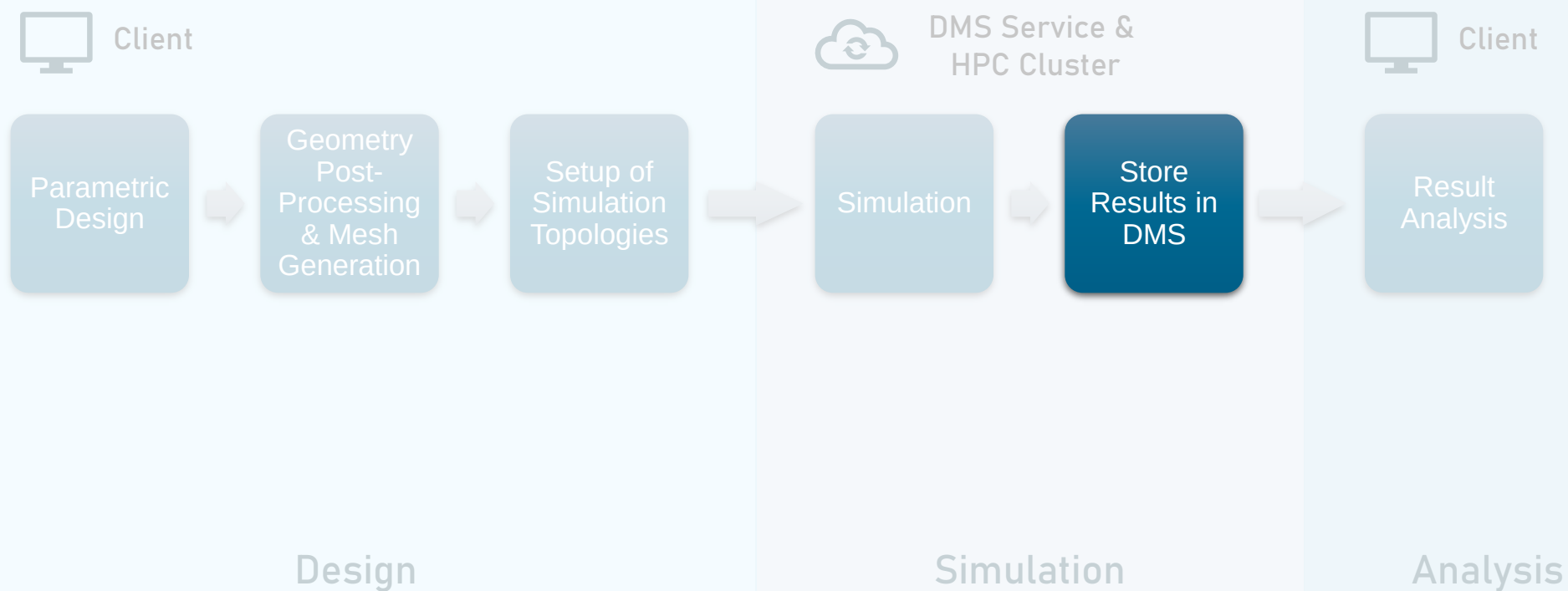
The CFD workflow



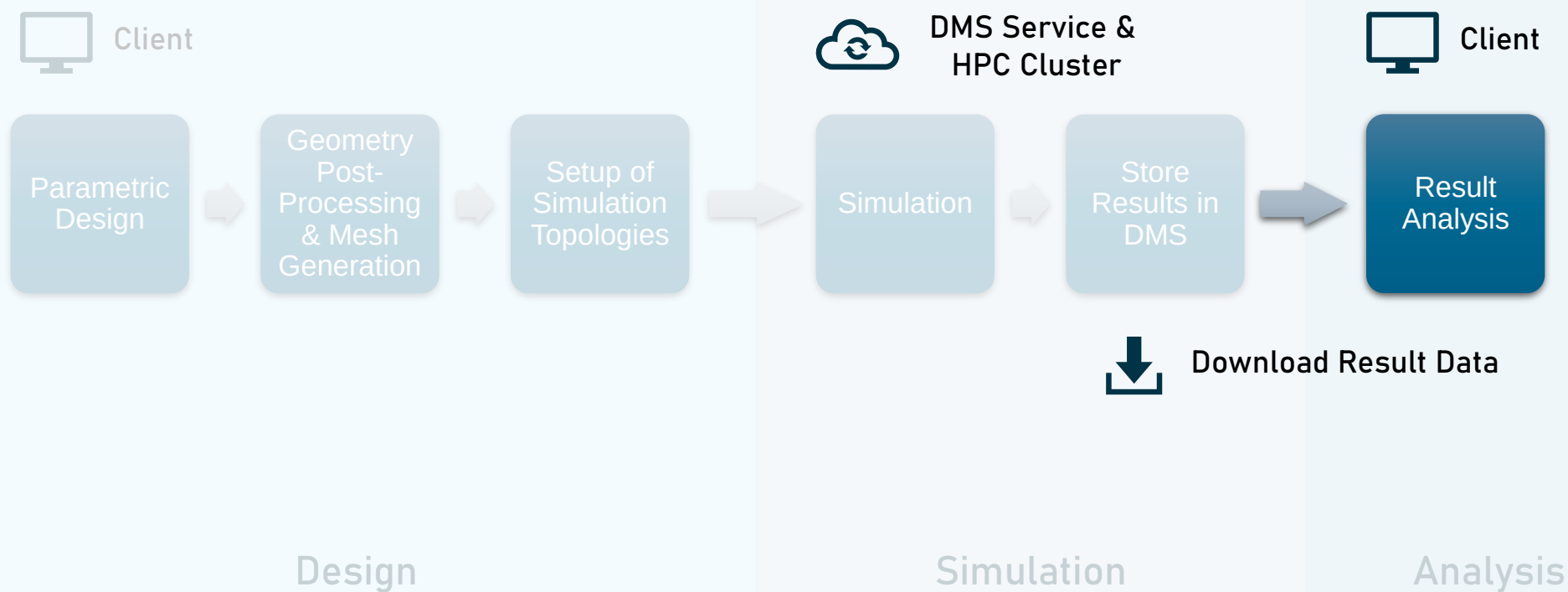
The CFD workflow



The CFD workflow



The CFD workflow



The CFD workflow



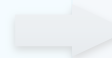
Parametric
Design



Geometry
Post-
Processing
& Mesh
Generation



Setup of
Simulation
Topologies



Result
Analysis

Design

Simulation

Analysis

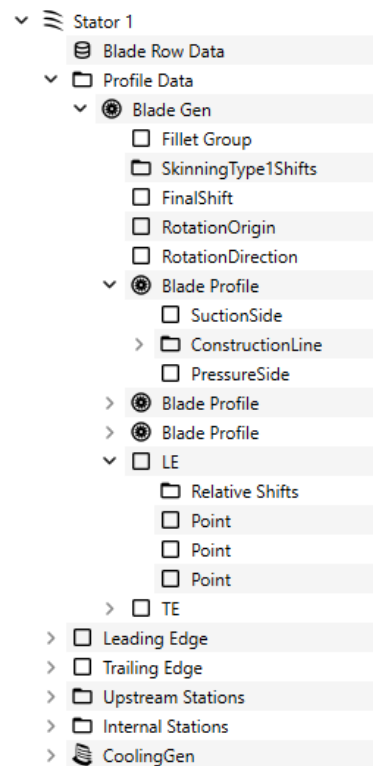


The CFD workflow - challenges



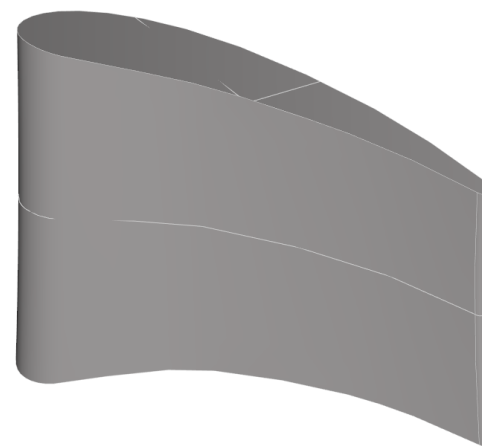
1. Different Simulations (CSM, CFD...) require different Geometries
2. Large data transfers are time consuming / inefficient
3. TRACE simulations should be executed on a HPC system

Geometry Parametrization & Generation

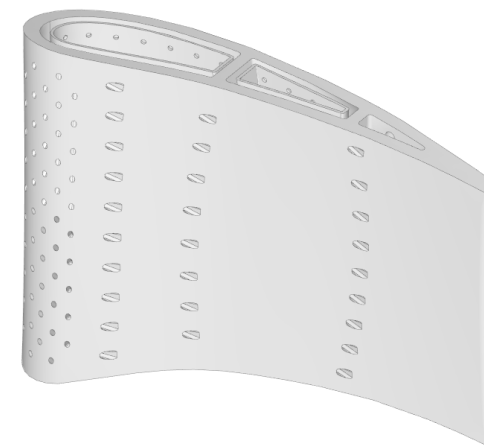


**Blade Parametrization
in Data Hub**

Creates



Aero Shape

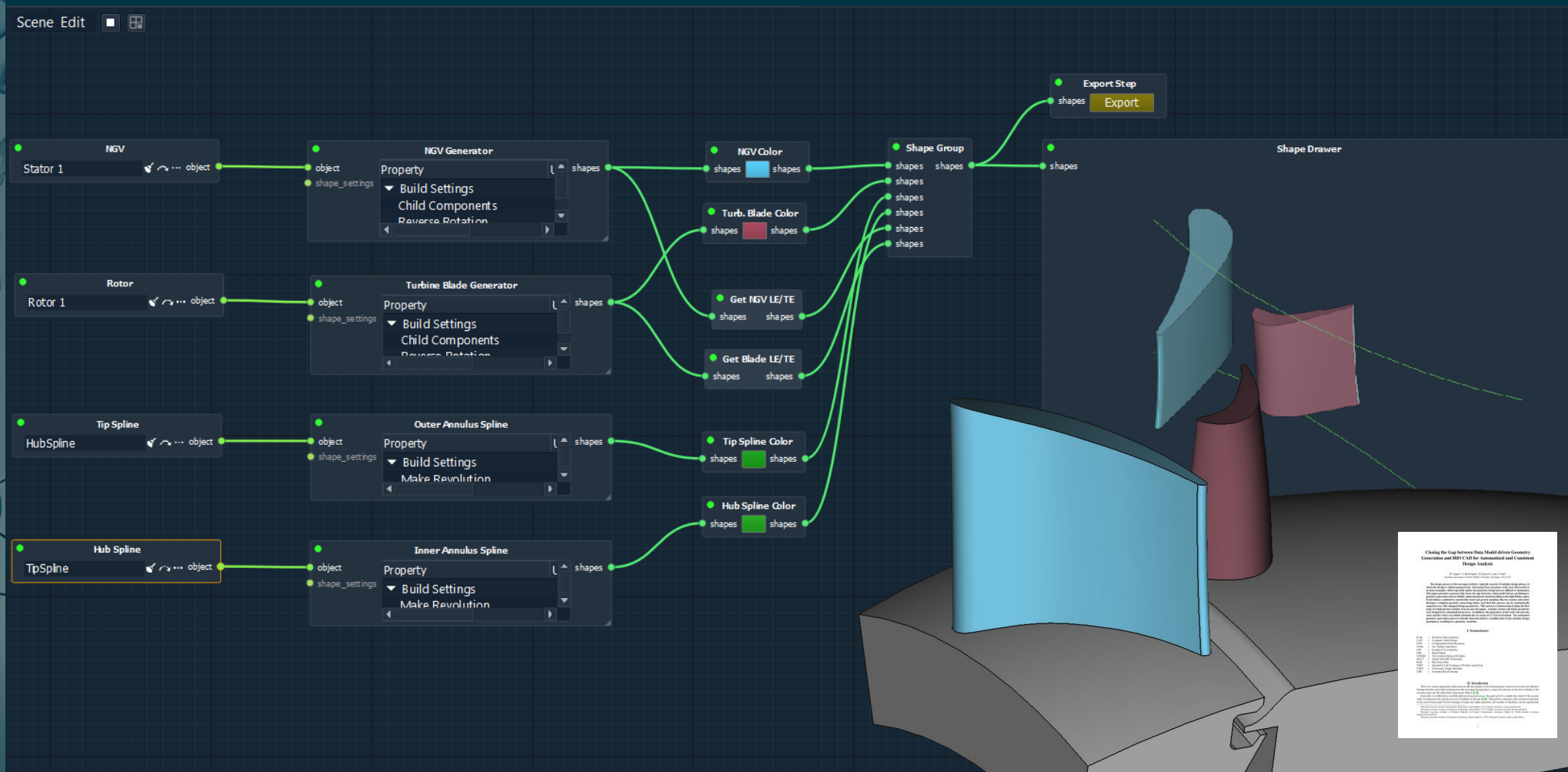


Cooling Design

Multiple Variations

Robin Schöffler, Andreas Pahn

Geometry Post-Processing



*Siggel et al., *Closing the Gap between Data Model driven Geometry Generation and HiFi CAD for Automated and Consistent Design Analysis*, AIAA Scitech 2024

CAD Tool Interoperability

Geometry

Exchange of geometries between tools using the **STEP file format** (ISO 10303 standard)

Metadata

Additional JSON file contains additional **metadata** :

- Name
- ID
- Color
- ...

```
{
  "id": "{21bfeb18-5f44-4510-97cf-3100866c9125}",
  "id_as_color_in_step": "COLOUR_RGB(' ',0.95893797,0.53867399,0.69732204)",
  "type": "solid",
  "metadata": {
    "name": "Vane 1",
    "color": "#73caea",
    "layer": "0"
  },
  "topo_faces": [
    {
      "id": "{21bfeb18-5f44-4510-97cf-3100866c9125}::FA1",
      "id_as_color_in_step": "COLOUR_RGB(' ',0.18200961,0.3897612,0.82752728)",
      "metadata": {
        "name": "Flow Surface",
        "a_custom_value": 3.14159265,
        ...
      },
      "type": "face"
    },
    ...
  ],
  "topo_shells": [...],
  "topo_wires": [...],
  "topo_edges": [...],
},
...
```

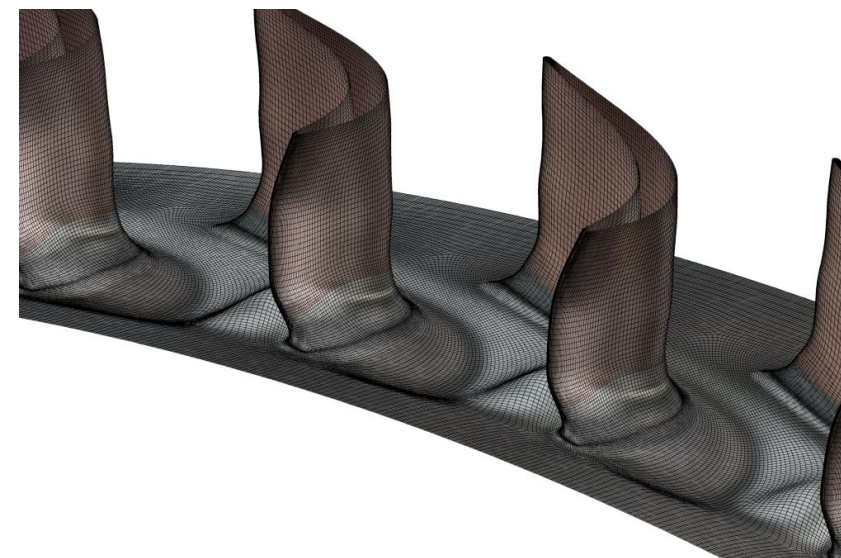

Mesh Generation

Structured Grids

- Workflow Component for **NUMECA AutoGrid** Mesh Generator

Unstructured Grids

- Geometry Generator for the fluid, blades, contours
- Step Export with annotated Metadata (inflow, boundaries ...)
- Used in **Centaur**, **Ansys** ...



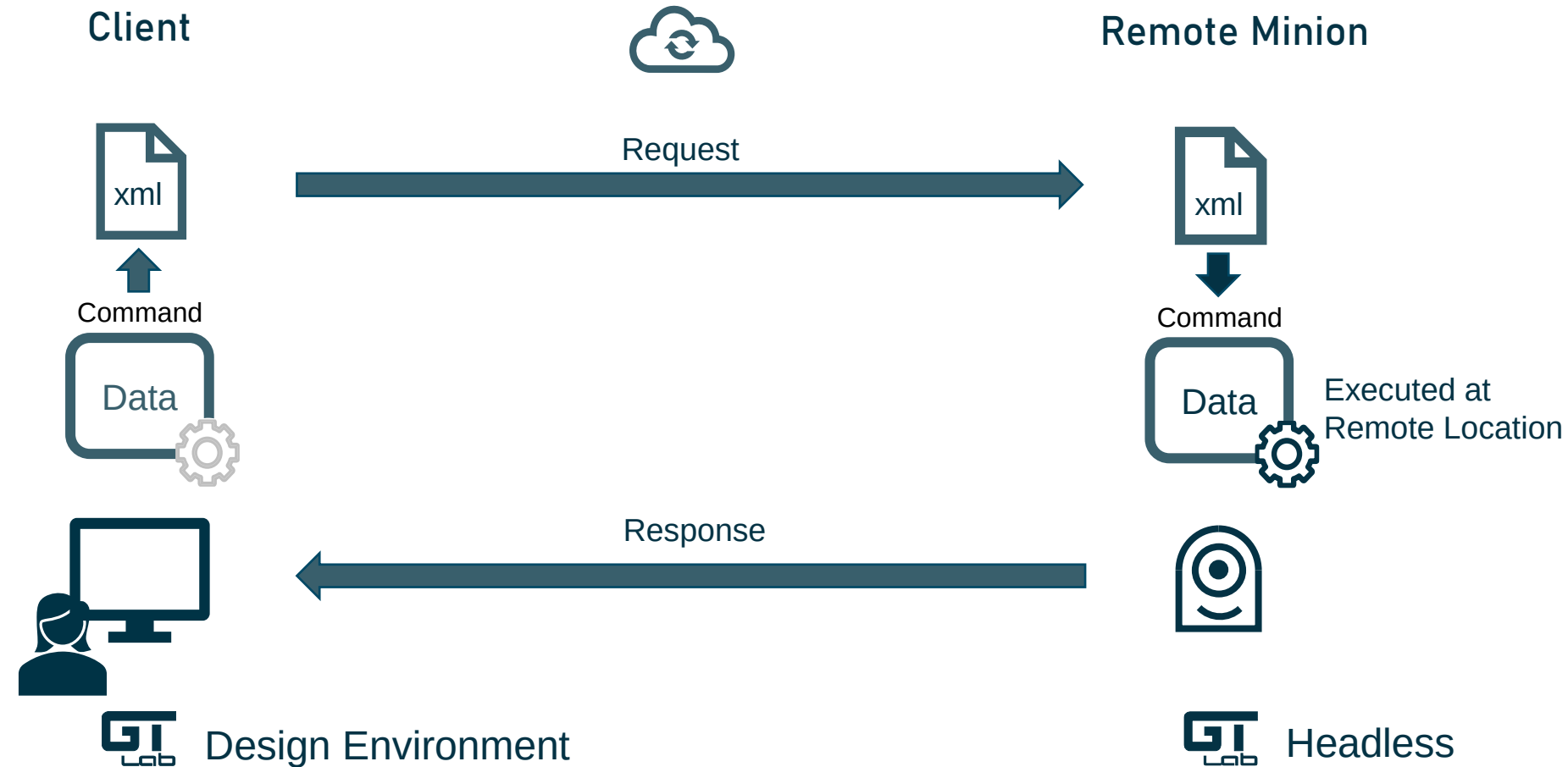
Copyright NUMECA



Remote Data / Processing

PERFECT-UHBR-GTF

- Performance
- PreDesign
- Schedules
- Parameterization
- FAN
- ▼ Rotor Section
 - Stage Definitions
 - ▼ Blades
 - ▶ **rotor**
 - ▶ Downstream Stations
 - ▶ Compressor Data
- ▼ Bypass Section
 - Stage Definitions
 - ▼ Blades
 - ▶ **stator**
 - ▶ Downstream Stations
 - ▶ Compressor Data
- ▶ Core Section
- DUCT
- BOOSTER
- IC-DUCT
- HPC
- COMBUSTOR
- HPT
- IT-DUCT
- LPT
- HPSHAFT
- LPSHAFT
- FAN_SHAFT

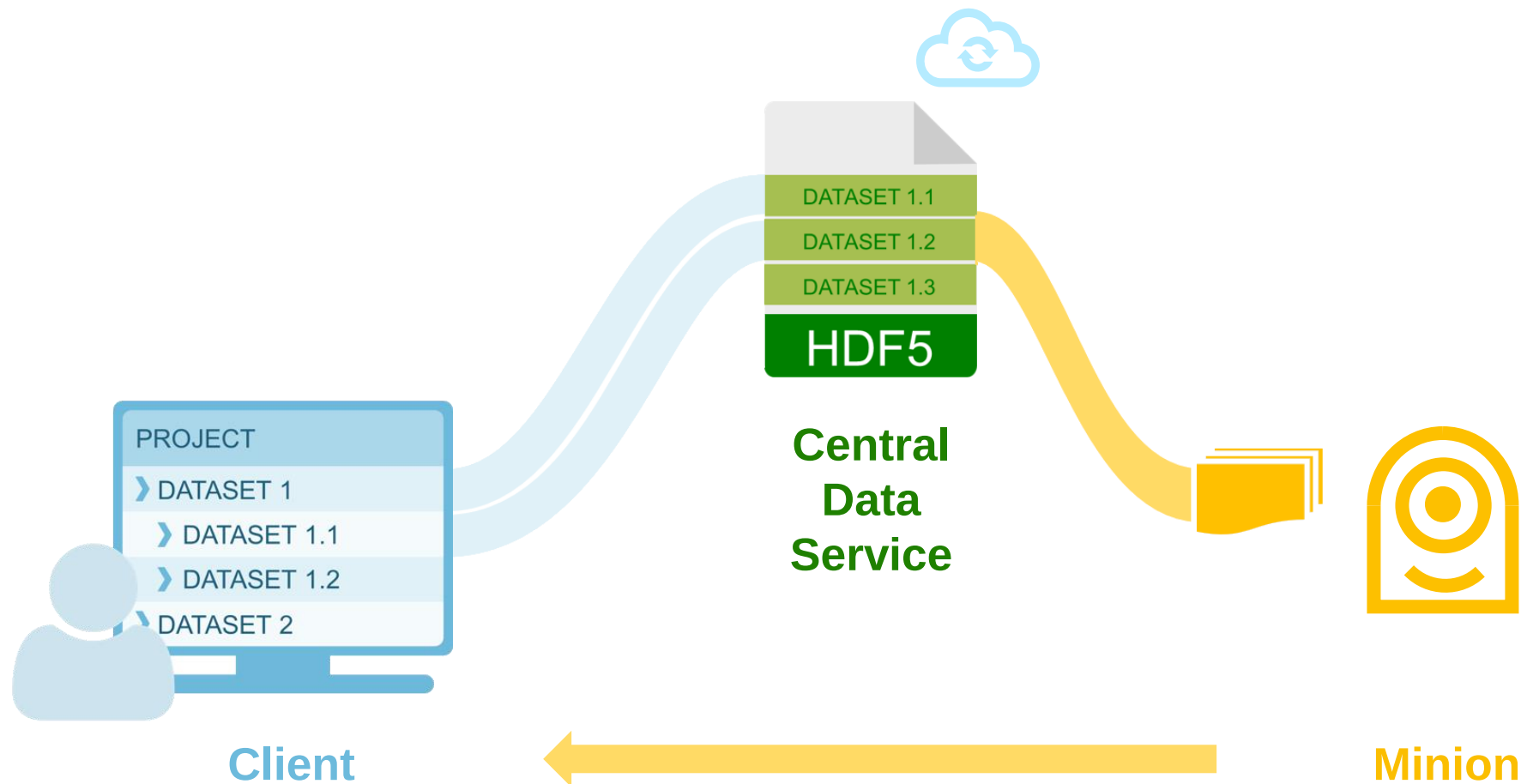




Remote HDF5 access

PERFECT-UHBR-GTF

- Performance
- PreDesign
- Schedules
- Parameterization
- FAN
 - Rotor Section
 - Stage Definitions
 - Blades
 - rotor
 - Downstream Stations
 - Compressor Data
 - Bypass Section
 - Stage Definitions
 - Blades
 - stator
 - Downstream Stations
 - Compressor Data
 - Core Section
- DUCT
- BOOSTER
- IC-DUCT
- HPC
- COMBUSTOR
- HPT
- IT-DUCT
- LPT
- HPSHAFT
- LPSHAFT
- FAN_SHAFT





Remote HDF5 access

PERFECT-UHBR-GTF

- Performance
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 - Blades
 - stator
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- IC-DUCT
- HPC
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- IT-DUCT
- LPT
- HPSHAFT
- LPSHAFT
- FAN_SHAFT

File Edit Tools Window Help Dev



Explorer

- Remote-hdf5
 - H5 HDF5 Module
 - M Mesh Viewer
 - M 1097
 - H5 CGNS File
 - Mesheres
 - M Zone1
 - M Density
 - M Enthalpy
 - M EnthalpyStagnation
 - M Mach
 - M Pressure
 - M PressureStagnation
 - M SpecificHeatPressure
 - M THERMX
 - M Temperature
 - M TemperatureStagnation
 - M ThermalConductivity
 - M VelocitySoundSquared
 - M VelocityX01234
 - M VelocityY
 - M VelocityZ
 - M ViscosityMolecular

Q (Ctrl+F)

Properties

Zone1 - gtmesh::CGNSMeshObject

Property Unit Value

Main

Path in Hdf file Base/Zone1

Q (Ctrl+F)

Output

Application Python Console

Level Time ID Message

14:47:25 Core saving project remote-hdf5 ...

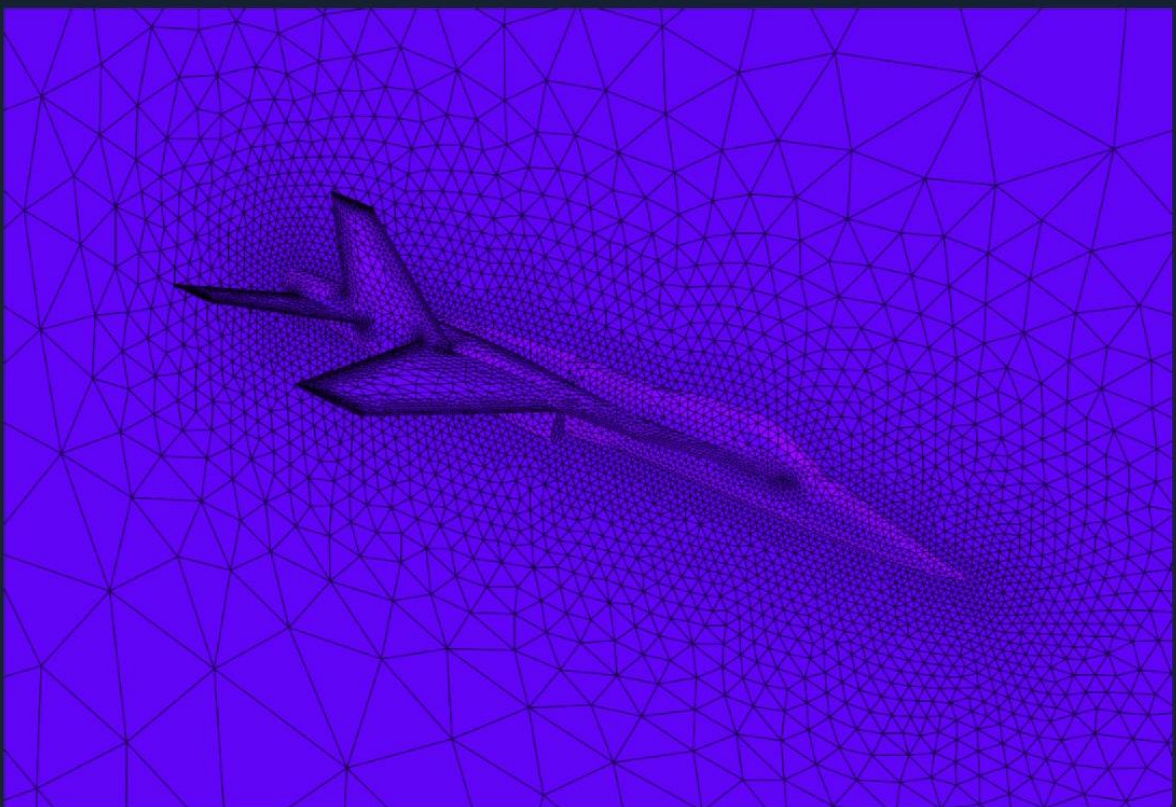
14:47:25 Core saving module data "HDF5 Module" ...

14:47:25 Core saving module data "GTMesh" ...

14:47:25 Gui Remote-hdf5 saved!

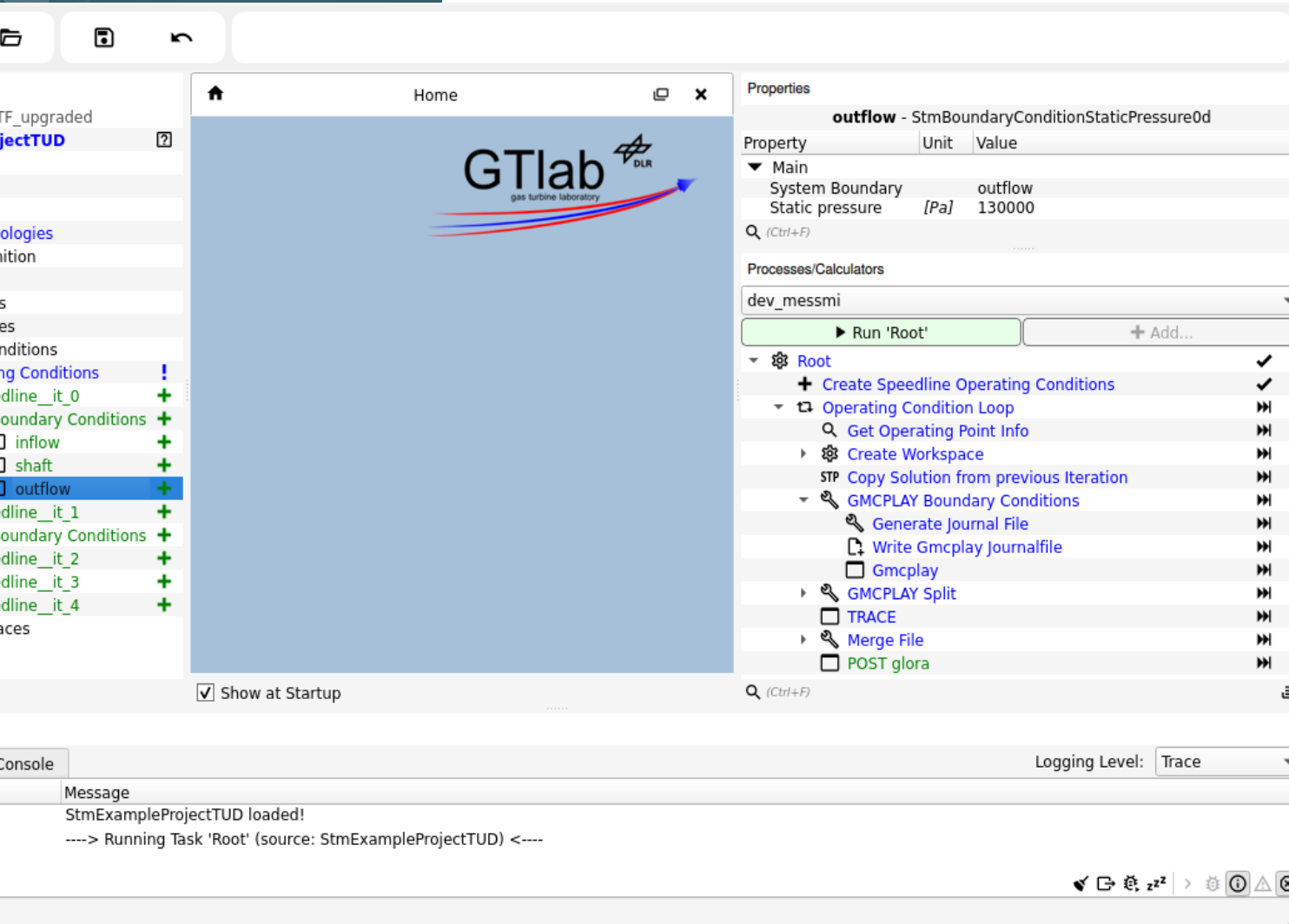
Home

Mesheres



```
(venv) (base) sigg_majat-twk-ha19000:~/pronghorn$ pronghorn-server
INFO: Will watch for changes in these directories: ['/home/sigg_ma/pronghorn']
INFO: Unicorn running on http://0.0.0.0:8050 (Press CTRL+C to quit)
INFO: Started reloader process [1393992] using WatchFiles
INFO: Started server process [1394010]
INFO: Waiting for application startup.
INFO: Application startup complete.
... done.
INFO: 129.247.105.50:50517 - "POST /api/files/1097?operation=Info&fileType=H5"
fsUseH5Inions=true&lock=false HTTP/1.1" 200 OK
... done.
INFO: 129.247.105.50:50518 - "POST /api/files/1097?operation=Info&fileType=H5"
fsUseH5Inions=true&lock=false HTTP/1.1" 200 OK
... done.
INFO: 129.247.105.50:50519 - "POST /api/files/1097?operation=Info&fileType=H5"
fsUseH5Inions=true&lock=false HTTP/1.1" 200 OK
... done.
INFO: 129.247.105.50:50520 - "POST /api/files/1097?operation=Info&fileType=H5"
fsUseH5Inions=true&lock=false HTTP/1.1" 200 OK
... done.
INFO: 129.247.105.50:50521 - "POST /api/files/1097?operation=Info&fileType=H5"
fsUseH5Inions=true&lock=false HTTP/1.1" 200 OK
... done.
INFO: 129.247.105.50:50522 - "POST /api/files/1097?operation=Info&fileType=H5"
fsUseH5Inions=true&lock=false HTTP/1.1" 200 OK
... done.
INFO: 129.247.105.50:50523 - "POST /api/files/1097?operation=Info&fileType=H5"
fsUseH5Inions=true&lock=false HTTP/1.1" 200 OK
... done.
INFO: 129.247.105.50:50524 - "POST /api/files/1097?operation=Info&fileType=H5"
fsUseH5Inions=true&lock=false HTTP/1.1" 200 OK
... done.
INFO: 129.247.105.50:50525 - "POST /api/files/1097?operation=Info&fileType=H5"
fsUseH5Inions=true&lock=false HTTP/1.1" 200 OK
... done.
INFO: 129.247.105.50:50526 - "POST /api/files/1097?operation=Info&fileType=H5"
fsUseH5Inions=true&lock=false HTTP/1.1" 200 OK
... done.
INFO: 129.247.105.50:50527 - "POST /api/files/1097?operation=Info&fileType=H5"
fsUseH5Inions=true&lock=false HTTP/1.1" 200 OK
... done.
INFO: 129.247.105.50:50528 - "POST /api/files/1097?operation=Info&fileType=H5"
fsUseH5Inions=true&lock=false HTTP/1.1" 200 OK
... done.
INFO: 129.247.105.50:50529 - "POST /api/files/1097?operation=Info&fileType=H5"
fsUseH5Inions=true&lock=false HTTP/1.1" 200 OK
... done.
INFO: 129.247.105.50:50530 - "POST /api/files/1097?operation=Info&fileType=H5"
fsUseH5Inions=true&lock=false HTTP/1.1" 200 OK
... done.
INFO: 129.247.105.50:50531 - "POST /api/files/1097?operation=Info&fileType=H5"
fsUseH5Inions=true&lock=false HTTP/1.1" 200 OK
... done.
INFO: 129.247.105.50:50532 - "POST /api/files/1097?operation=Info&fileType=H5"
fsUseH5Inions=true&lock=false HTTP/1.1" 200 OK
```

TRACE Suite Integration



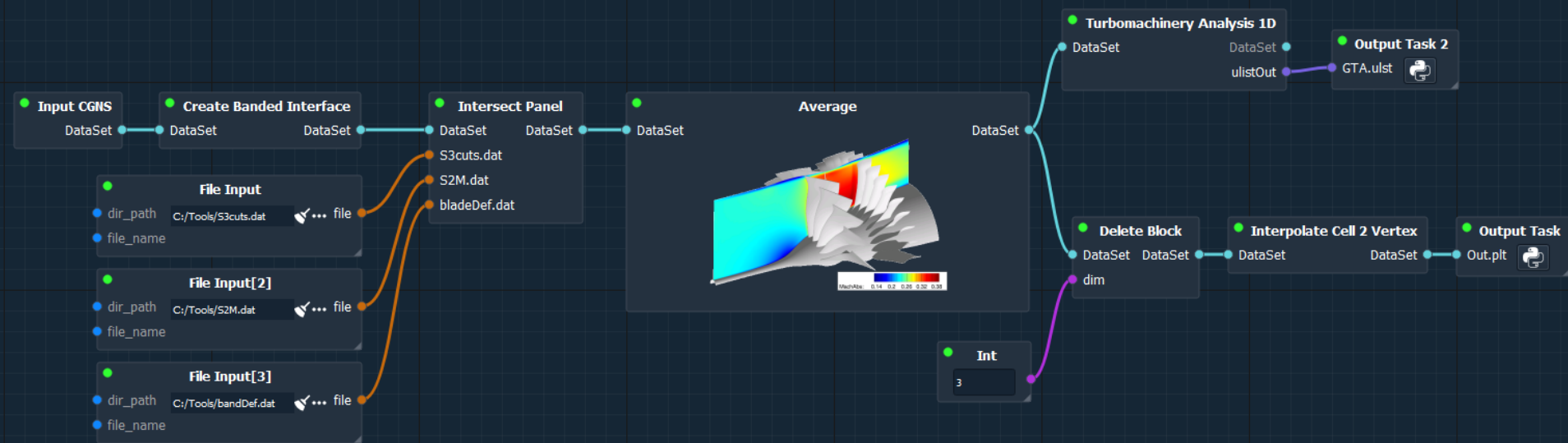
Demonstrator

Goal: Speedline Computation

- Pre-Processing via GMCPLAY
- Local MPI-parallel TRACE execution
- Post-Processing via POST
 - GTA Analysis
 - Speedline Plot Generation
 - Result storage into Data Hub



Outlook: Interactive TRACE Post Vision

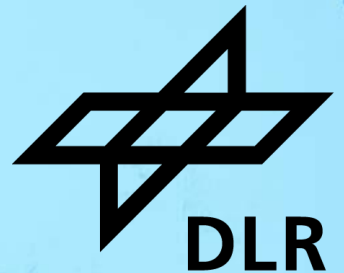




Thank you!

Martin Siggel

Institute of Propulsion Technology
German Aerospace Center (DLR)
✉ martin.siggel@dlr.de



Topic: **CFD in Collaborative, Multidisciplinary Design of Propulsion Systems and Stationary Gas Turbines**
Presentation during TRACE User Conference 2025

Date: 27.11.2025

Author: Dr. Martin Siggel

Institute: Institut of Propulsion Technology – Engine Department

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