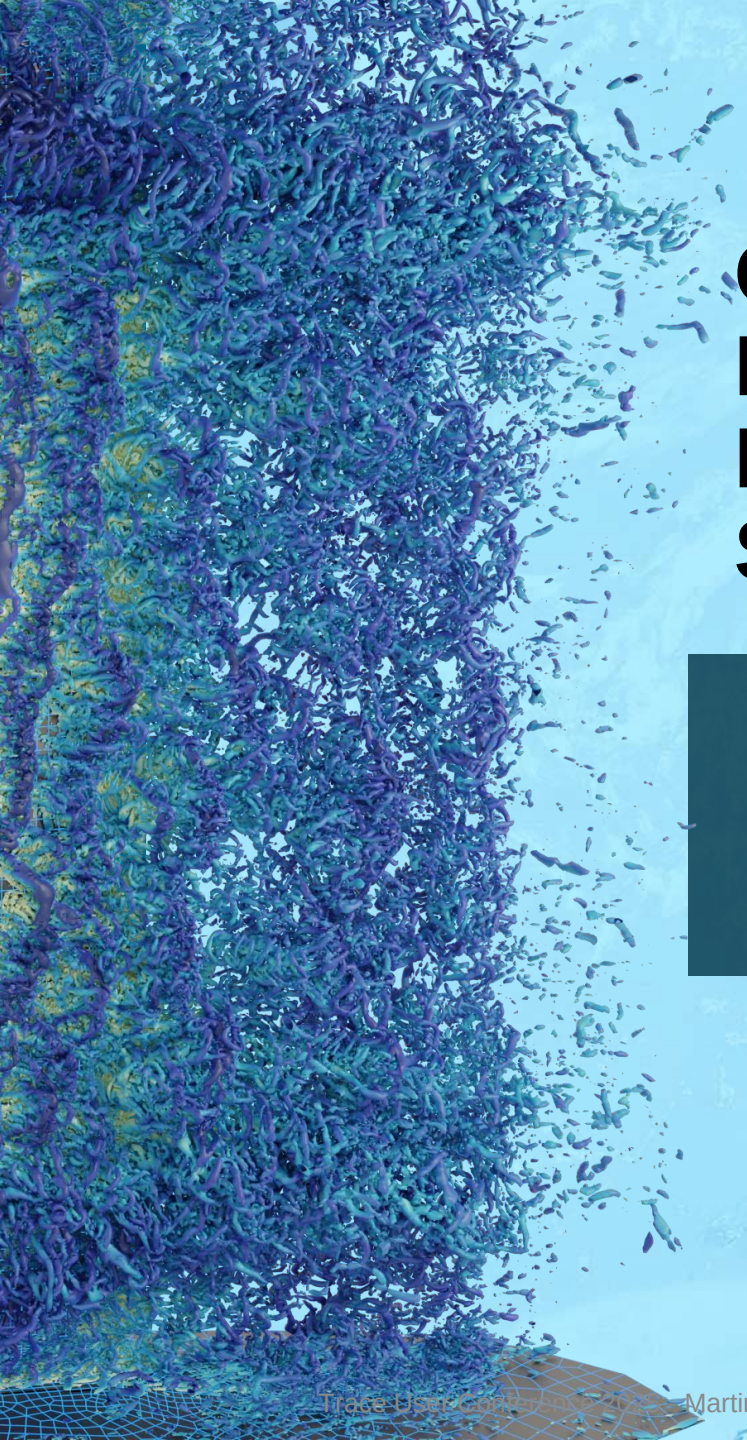


CFD IN COLLABORATIVE, MULTIDISCIPLINARY DESIGN OF PROPULSION SYSTEM AND STATIONARY GAS TURBINES

TRACE User Conference 2025

2025/11/27

Martin Siggel, Matthias Schuff, Marius Messerschmitt

German Aerospace Center

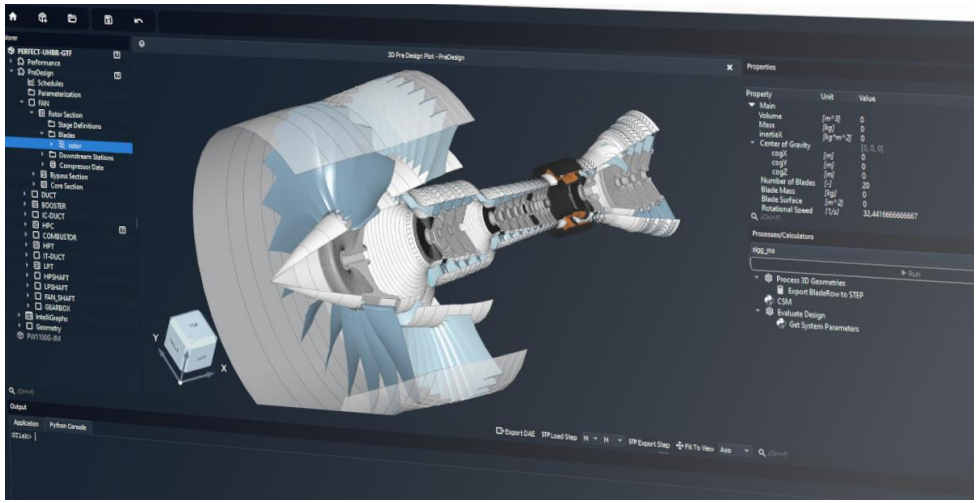
Gas Turbine Laboratory

AI-generated image with DALL-E

- 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



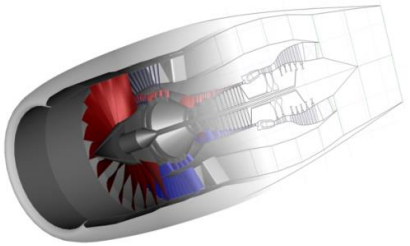
- Flexible + modular Framework (OS), extensible via "Modules" (Apps)
- Many parts as Open Source Software

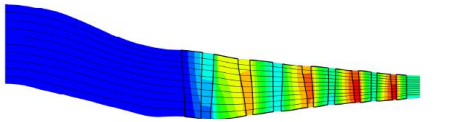
https://www.gtlab.de
https://github.com/dlr-gtlab

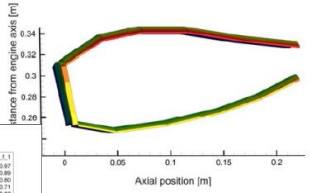
SCAN ME

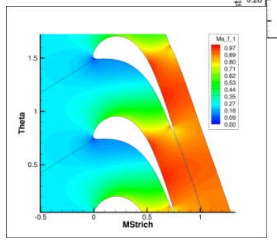
Goal: Realization of the Virtual Engine

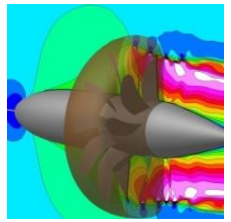
AI-generated image with DALL-E

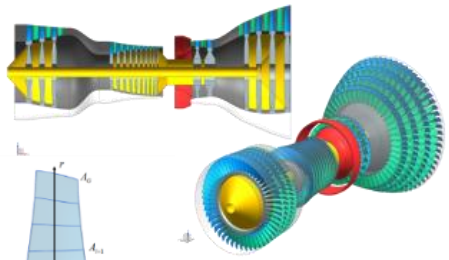


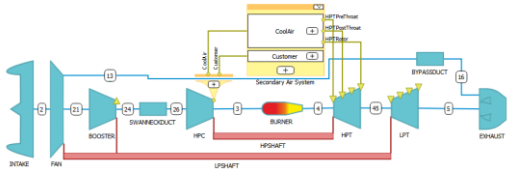


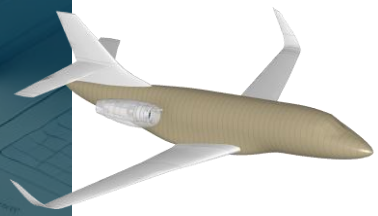


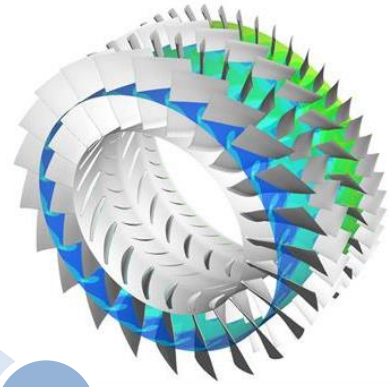








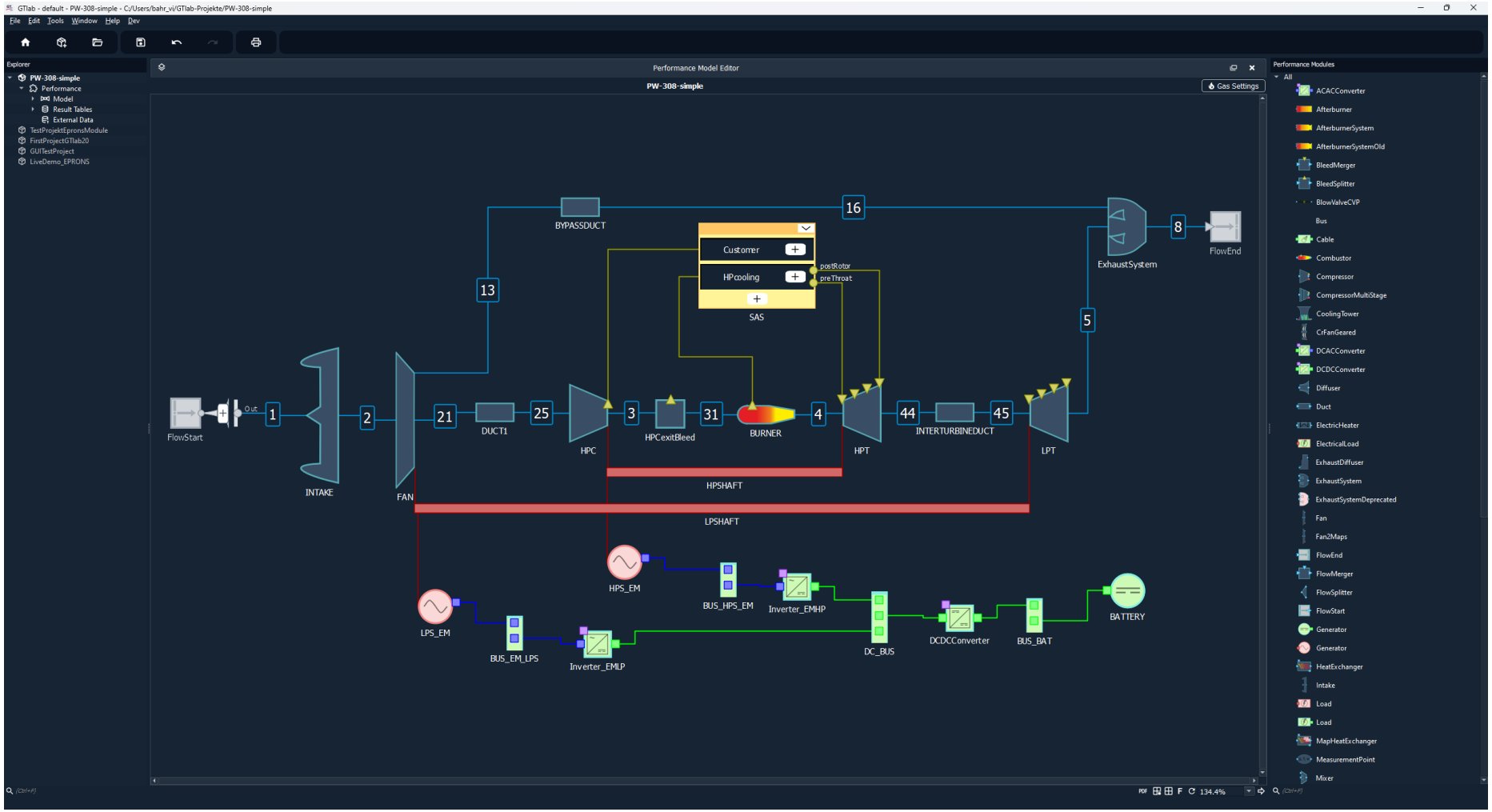




AI-generated image with DALL-E

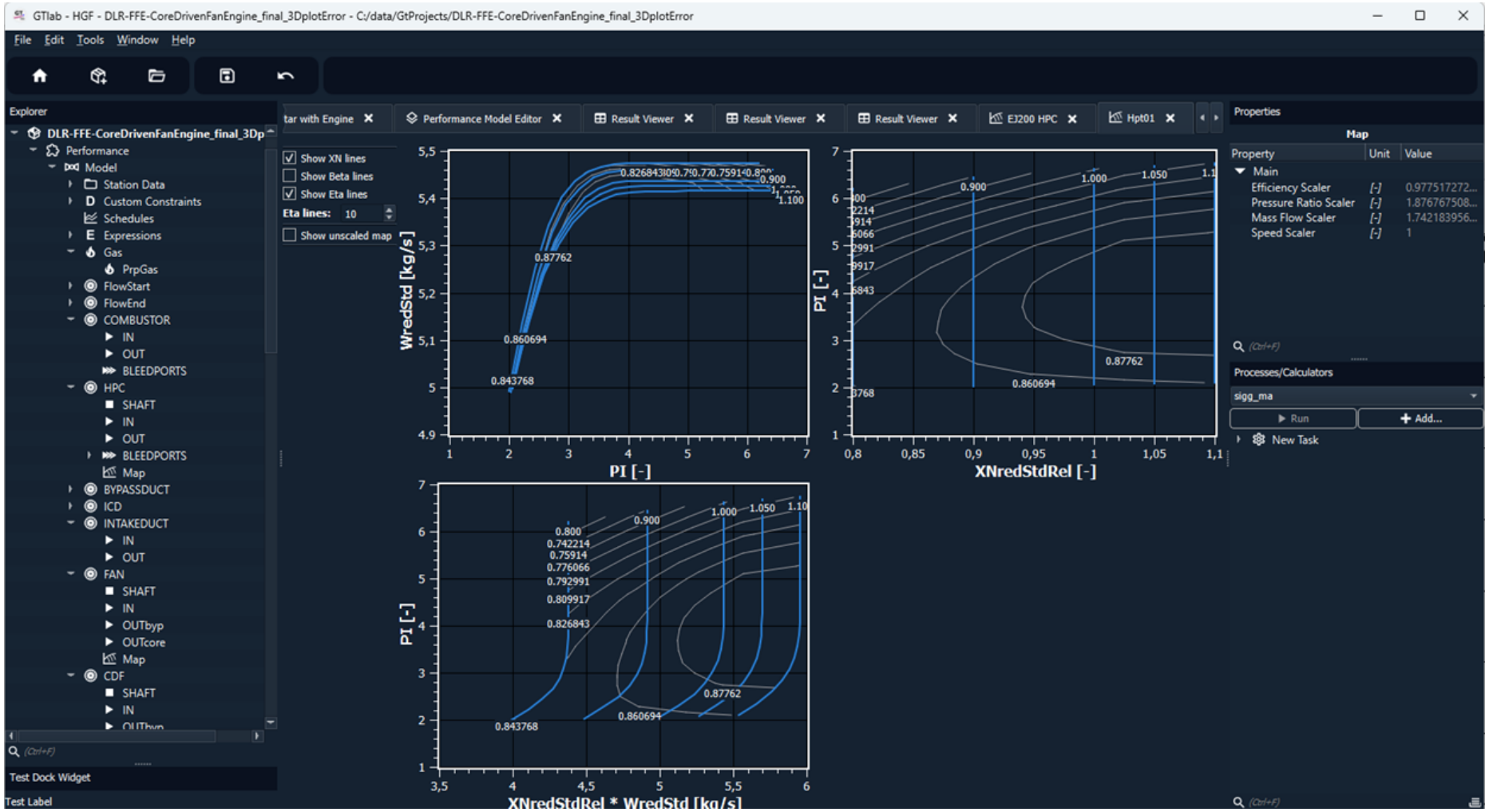
Multidisciplinary Design

Multidisciplinary Design



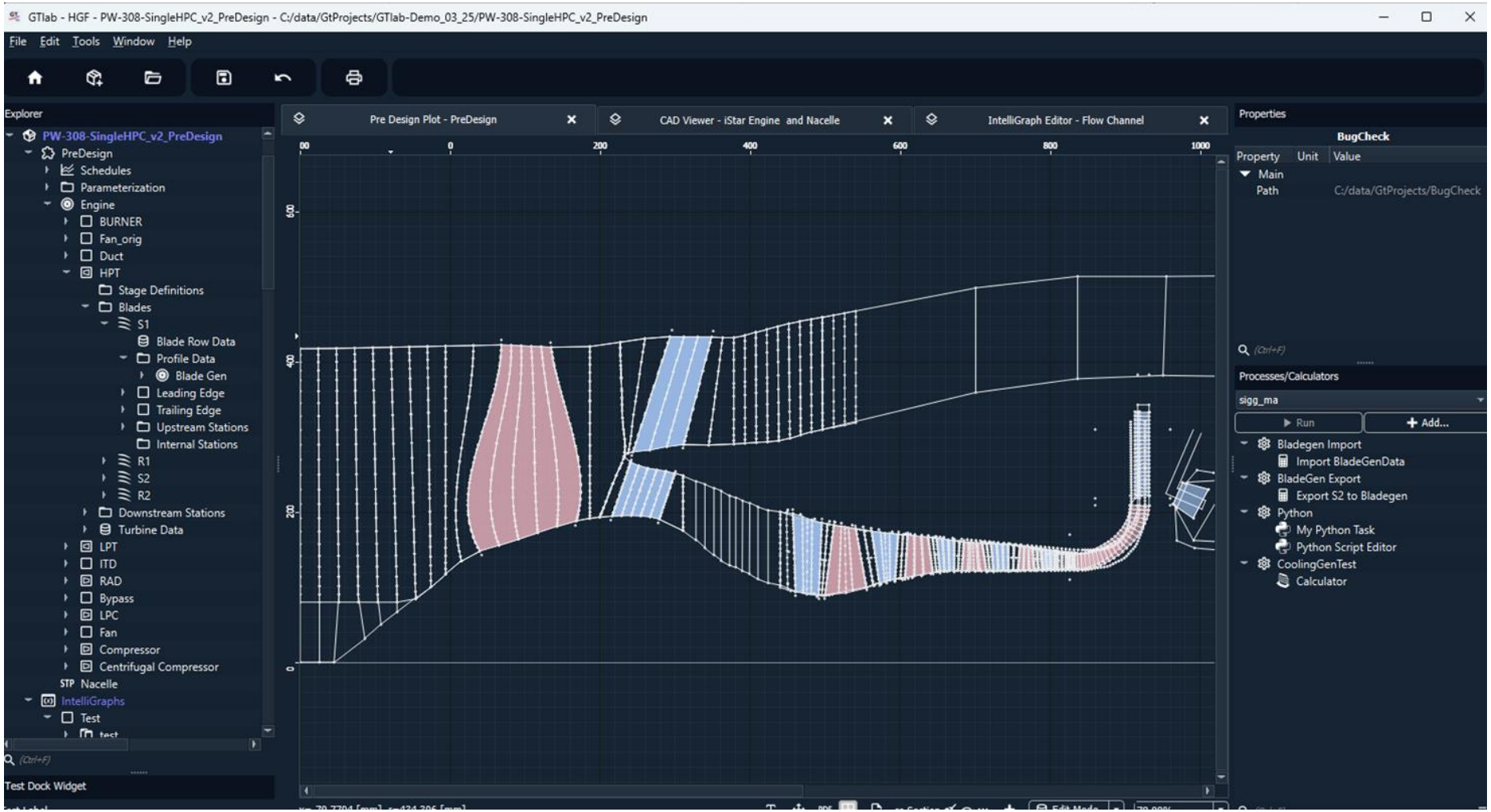
AI-generated image with DALL-E

Multidisciplinary Design – Thermodynamics

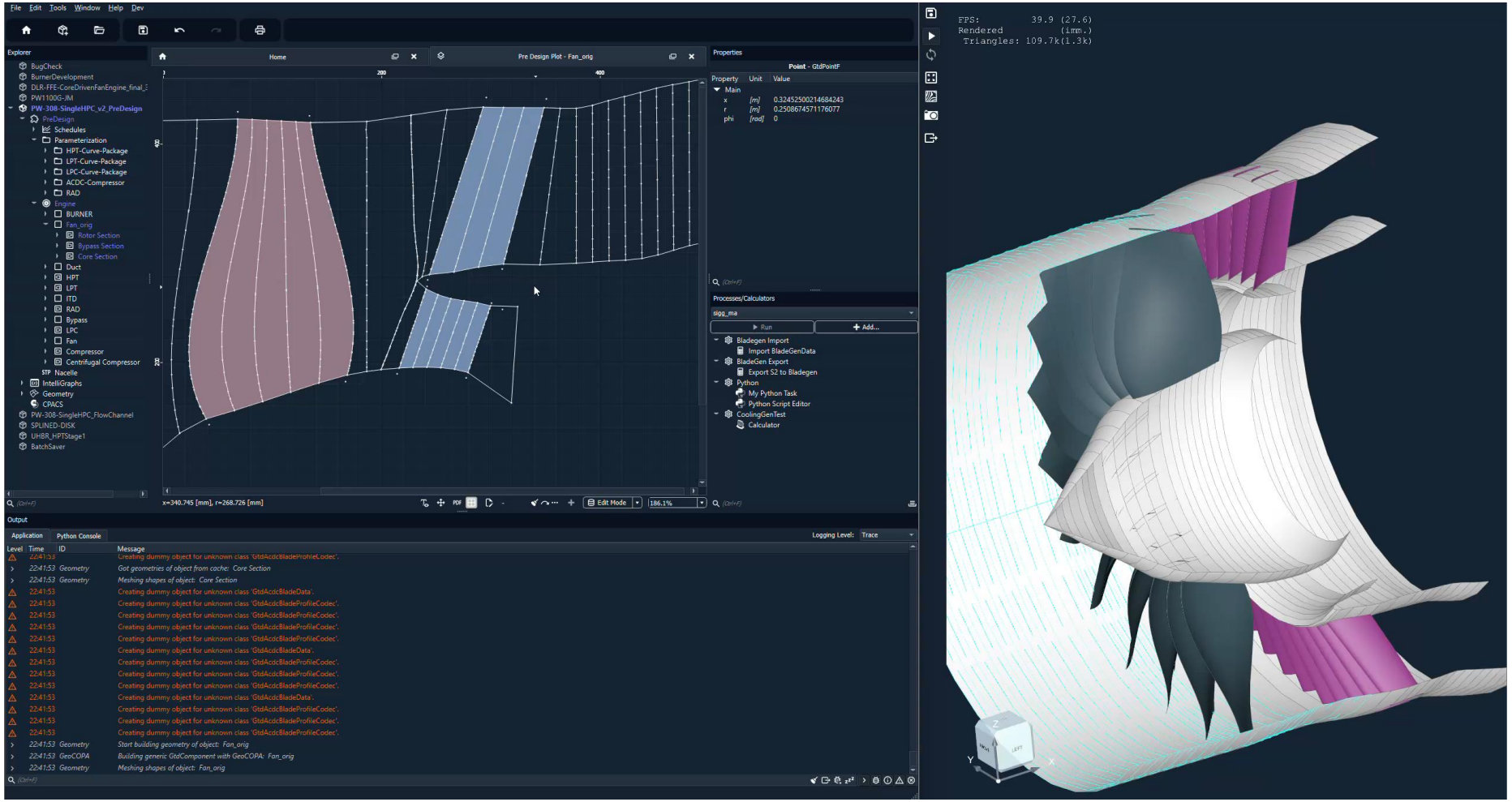


AI-generated image with DALL-E

Multidisciplinary Design – Sketching

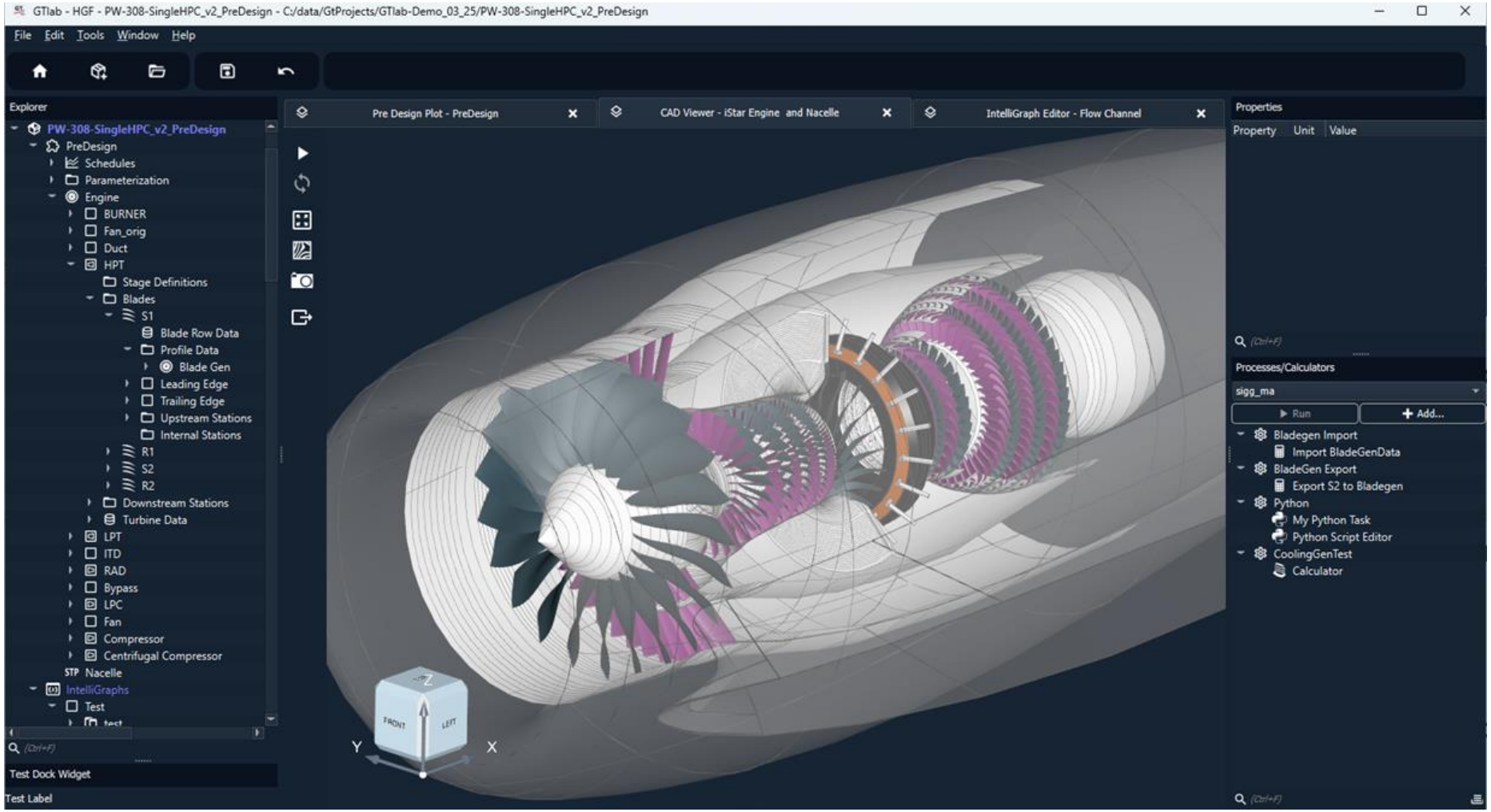


Multidisciplinary Design – Sketching



AI-generated image with DALL-E

Multidisciplinary Design – 3D Geometry



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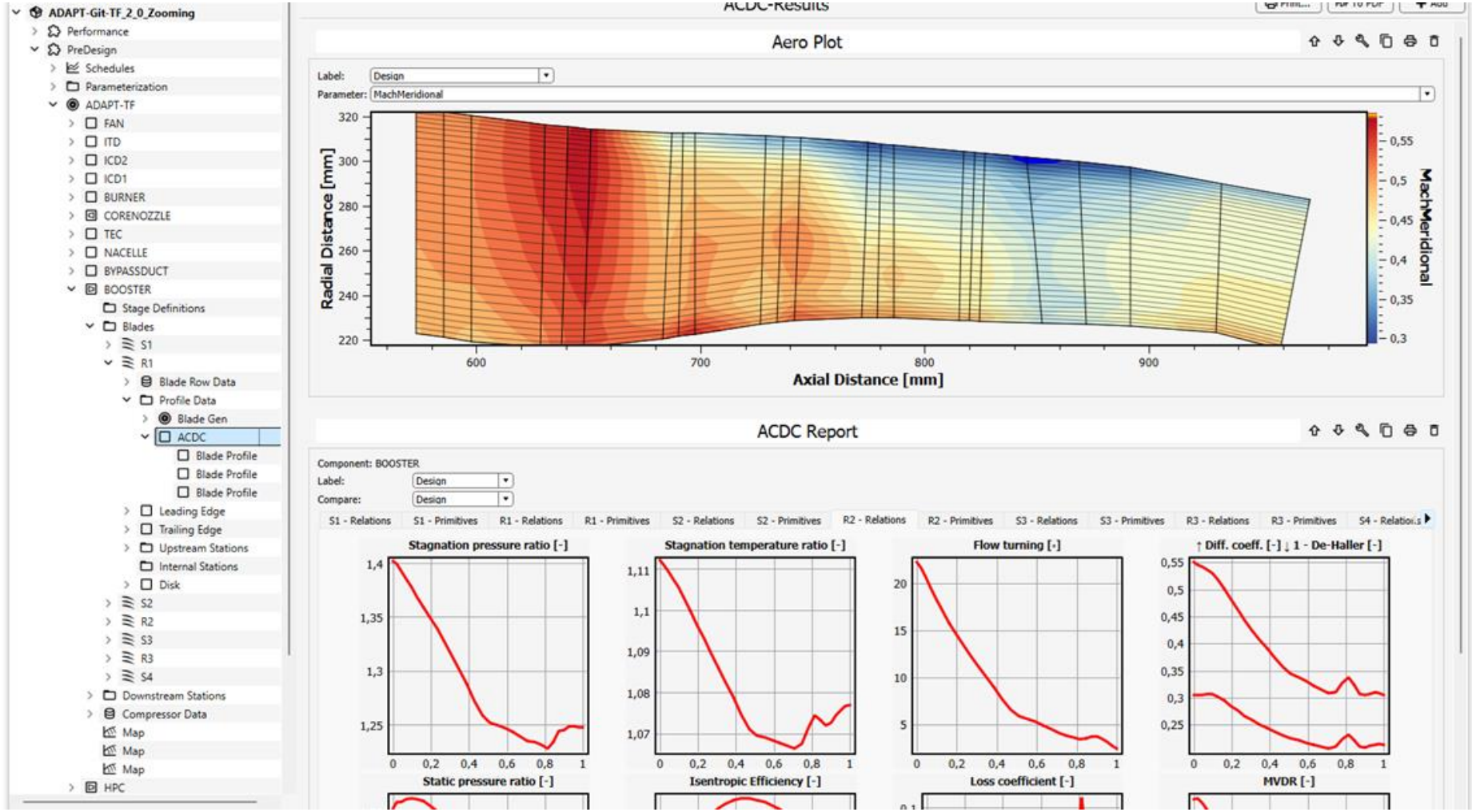
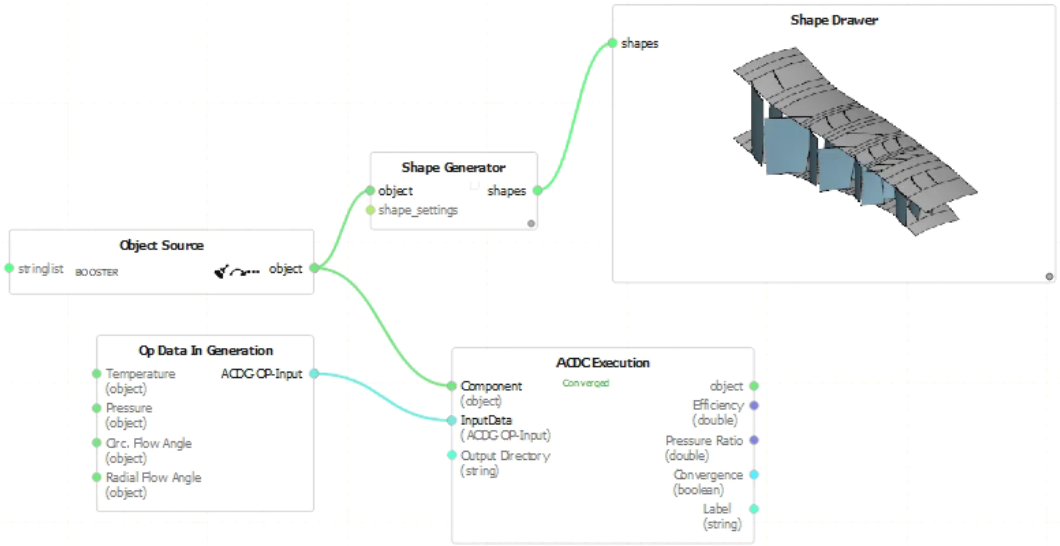
Multidisciplinary Design – Rapid Analysis



Interactive Analysis



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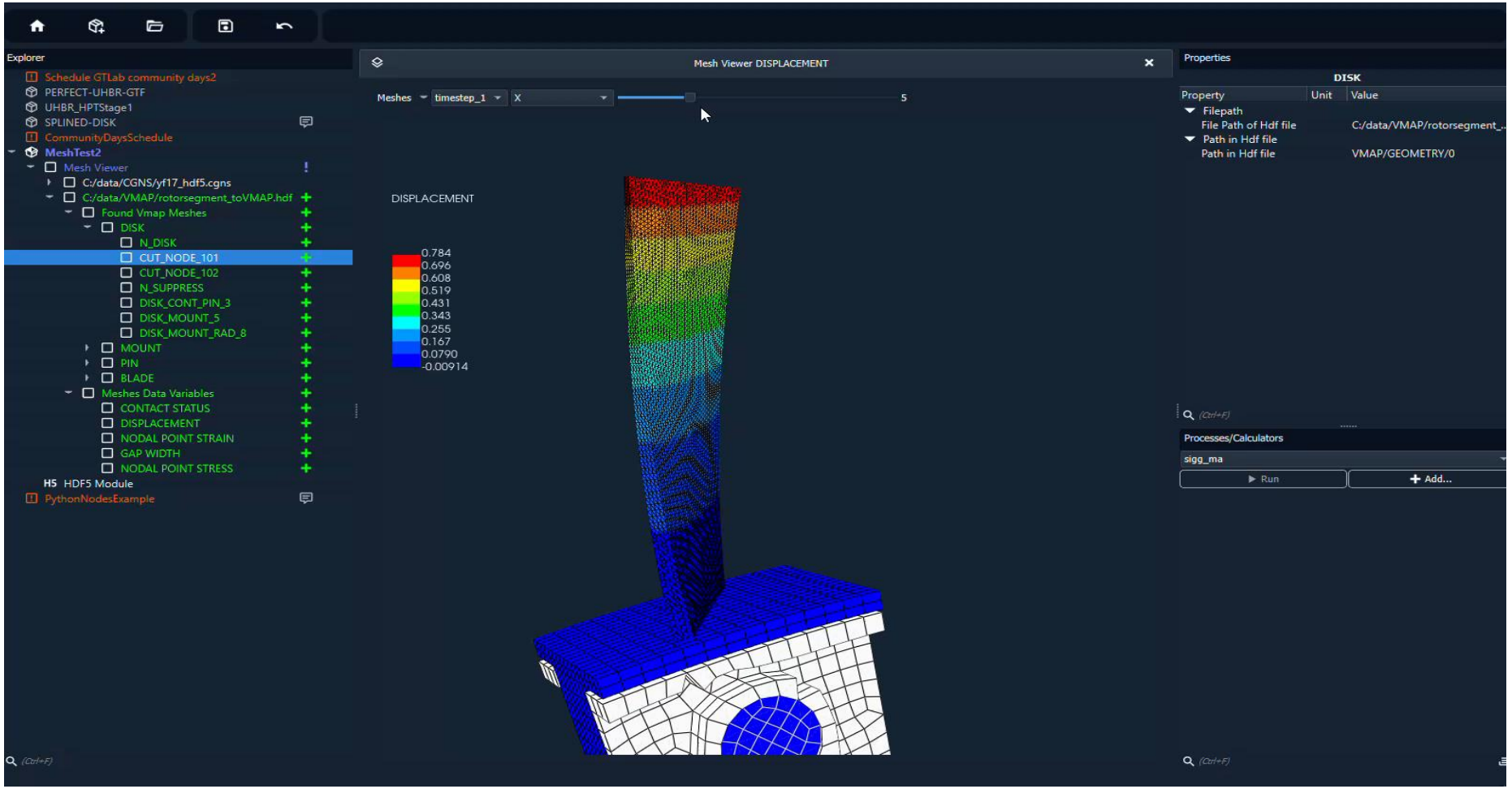
Structural Mechanics Analysis



AI-generated image with DALL-E

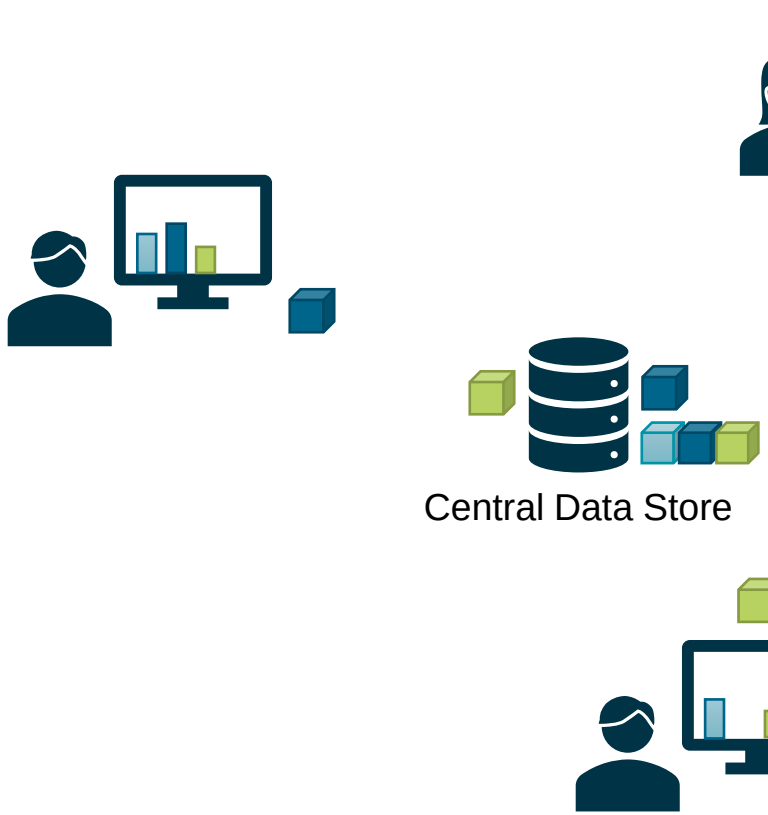
Oliver Kunc, Nicolai Forsthofer, DLR BT

AI-generated image with DALL-E

Collaborative Design

AI-generated image with DALL-E

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 challange in collaborative environments!**

The CFD workflow

AI-generated image with DALL-E

Client

Parametric Design

Geometry Post-Processing & Mesh Generation

Setup of Simulation Topologies

Data Store& HPC Cluster

Simulation

Store Results in DMS

Client

Result Analysis

Design

Simulation

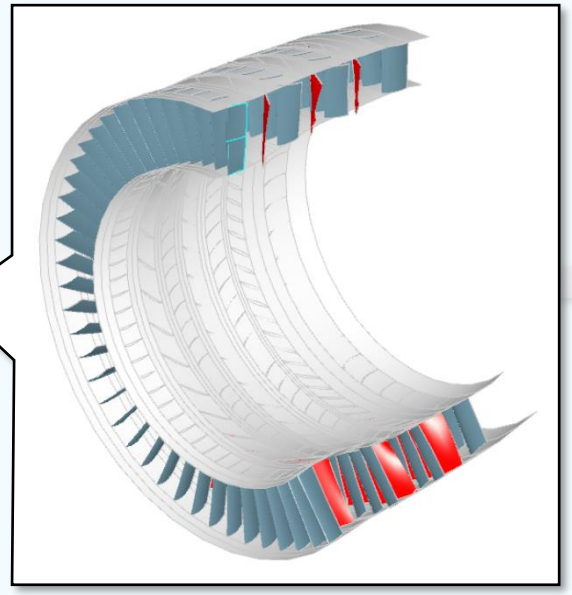
Analysis

The CFD workflow

AI-generated image with DALL-E

Client

Parametric Design



DMS Service & HPC Cluster

Simulation

Store Results in DMS

Client

Result Analysis

Design

Simulation

Analysis

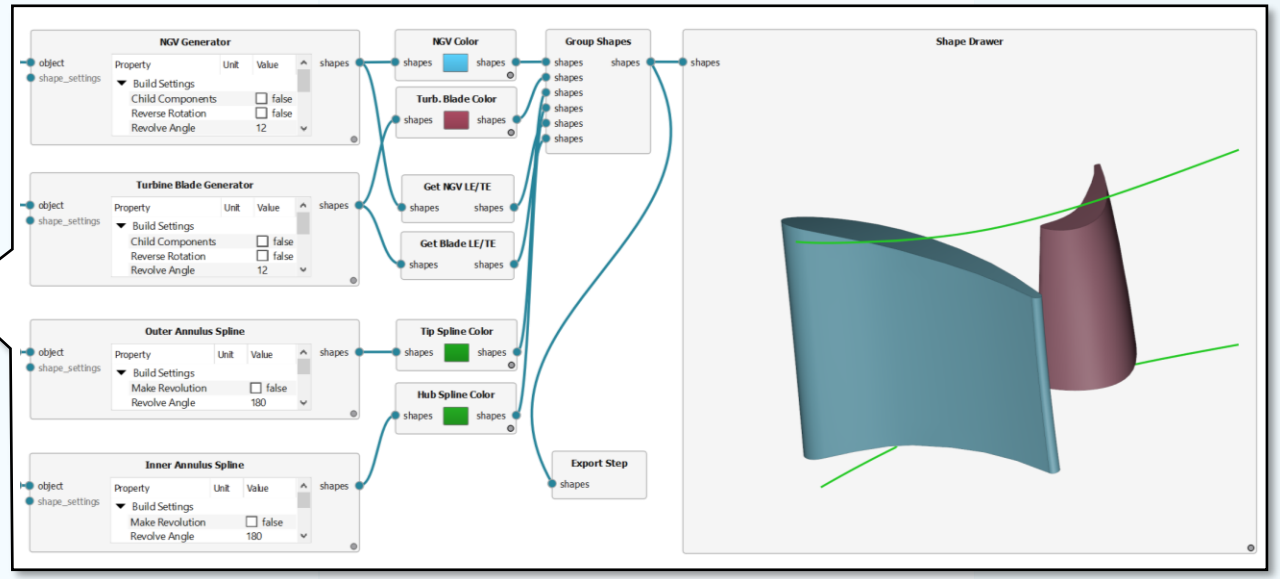
The CFD workflow

AI-generated image with DALL-E

Client

Parametric Design

Geometry Post-Processing & Mesh Generation



Design Simulation Analysis

The CFD workflow

AI-generated image with DALL-E

Client

DMS Service & HPC Cluster

Client

Parametric Design

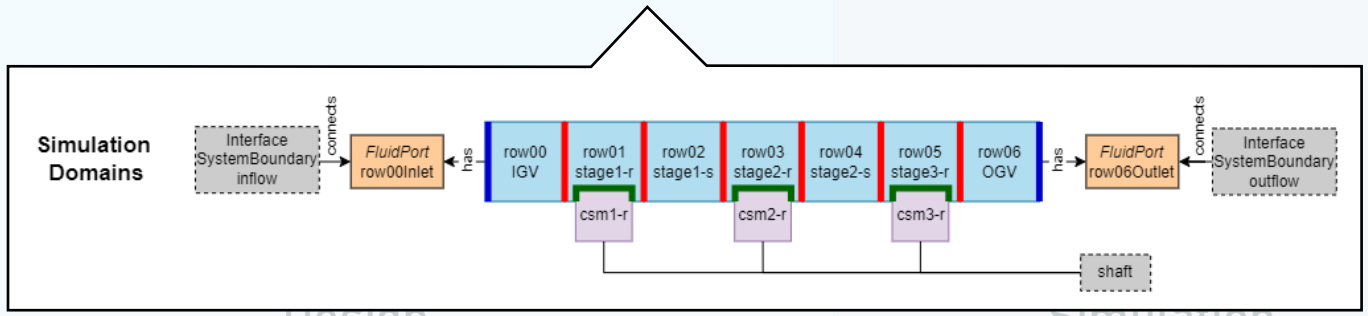
Geometry Post-Processing & Mesh Generation

Setup of Simulation Topologies

Simulation

Store Results in DMS

Result Analysis



Design

Simulation

Analysis

The CFD workflow

AI-generated image with DALL-E

Client

DMS Service & HPC Cluster

Client

Parametric Design

Geometry Post-Processing & Mesh Generation

Setup of Simulation Topologies

Simulation

Store Results in DMS

Result Analysis

Upload Mesh and Simulation Setup

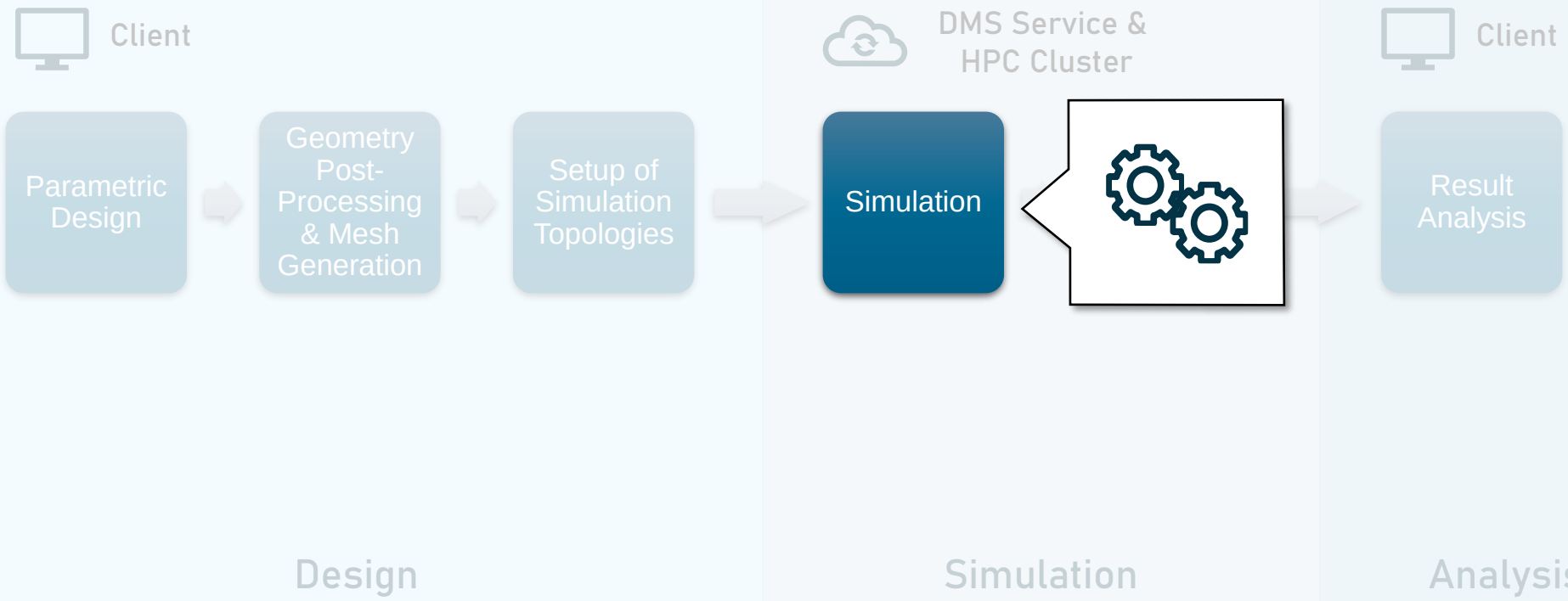
Design

Simulation

Analysis

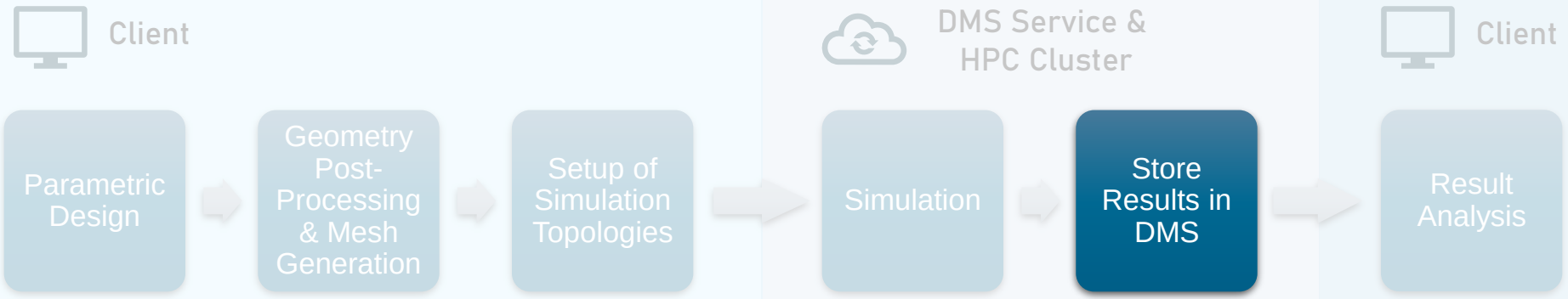
The CFD workflow

AI-generated image with DALL-E



The CFD workflow

AI-generated image with DALL-E



The CFD workflow

AI-generated image with DALL-E

Client

Parametric Design

Geometry Post-Processing & Mesh Generation

Setup of Simulation Topologies

DMS Service & HPC Cluster

Simulation

Store Results in DMS

Client

Result Analysis

Download Result Data

Design

Simulation

Analysis

The CFD workflow

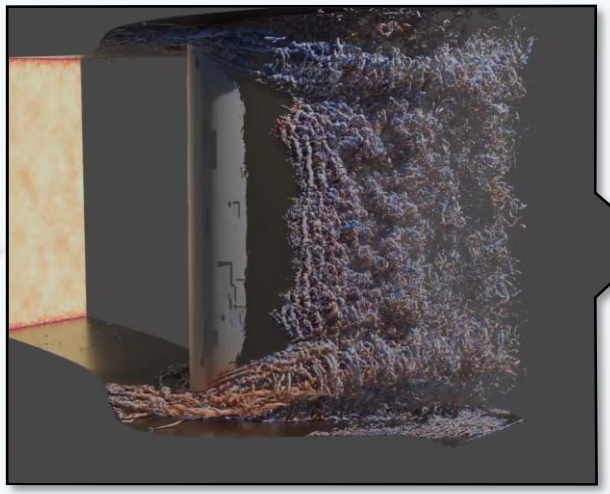
AI-generated image with DALL-E

Client

Parametric Design

Geometry Post-Processing & Mesh Generation

Setup of Simulation Topologies



Client

Result Analysis

Design

Simulation

Analysis

The CFD workflow - challenges

AI-generated image with DALL-E

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

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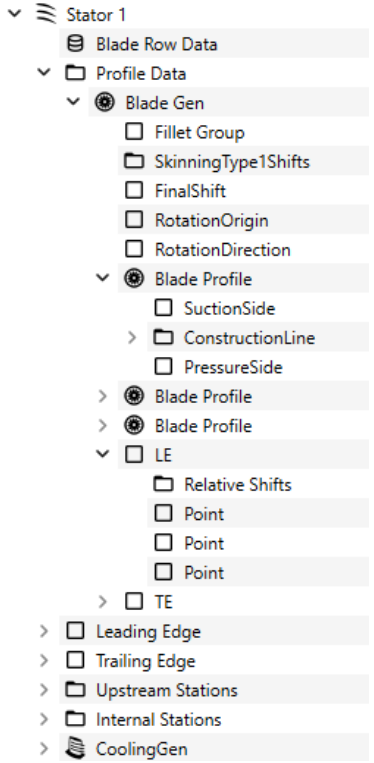
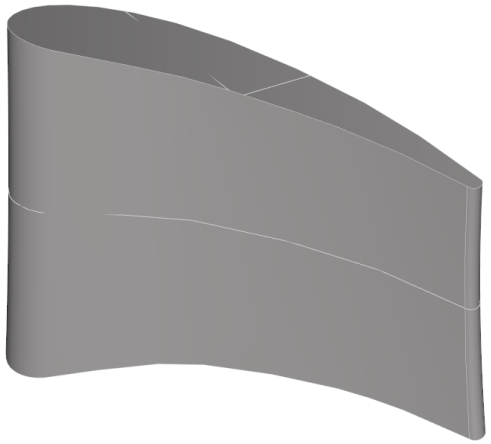
Geometry Parametrization & Generation



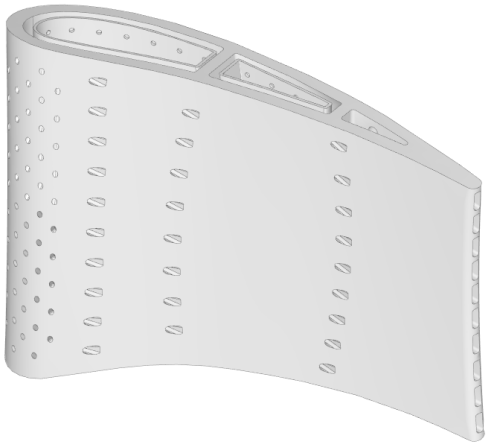
Blade Parametrization in Data Hub

Creates

Multiple Variations



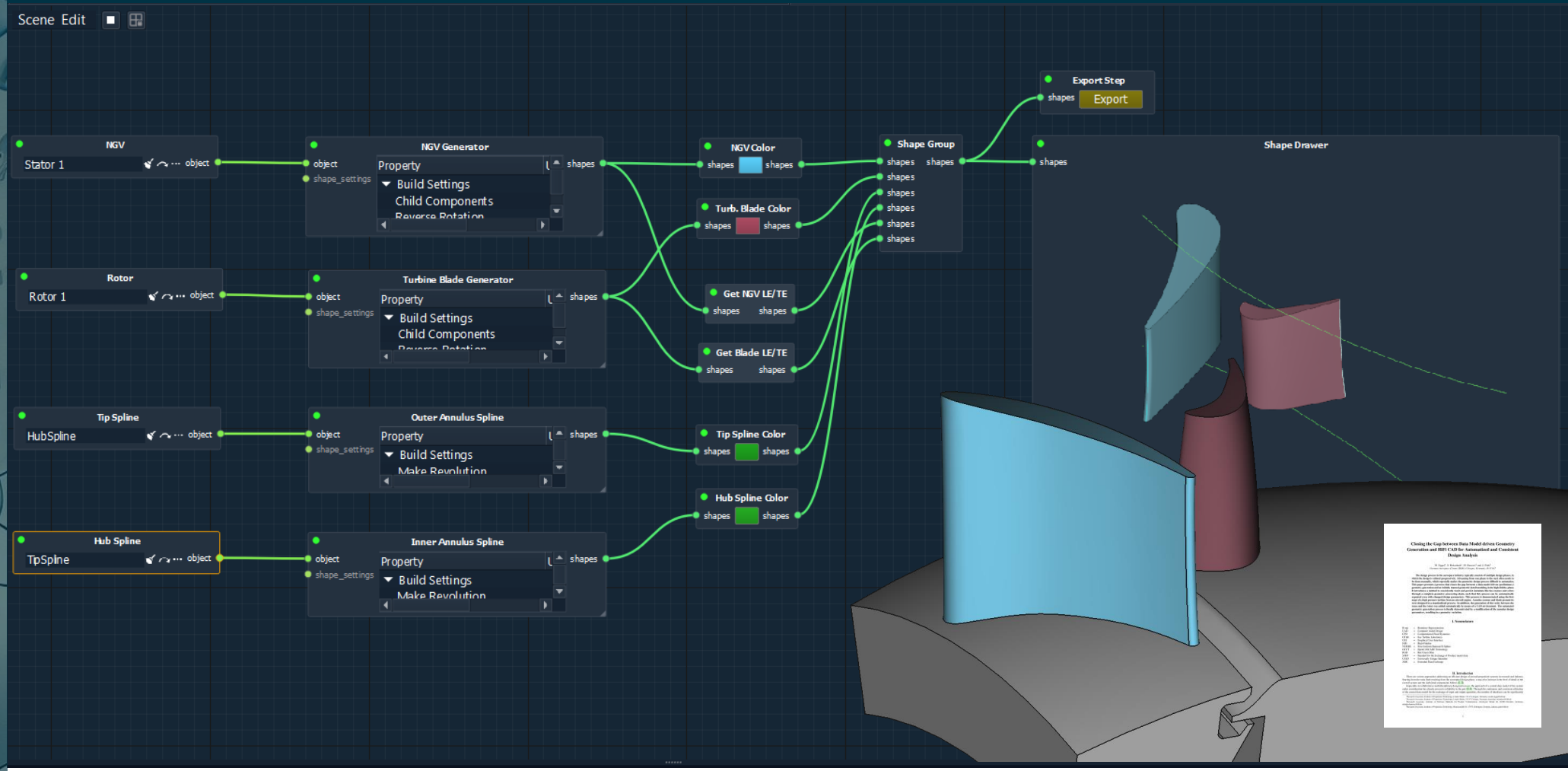
Aero Shape



Cooling Design

Robin Schöffler, Andreas Pahs

Geometry Post-Processing



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

AI-generated image with DALL-E


AI-generated image with DALL-E

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
- …

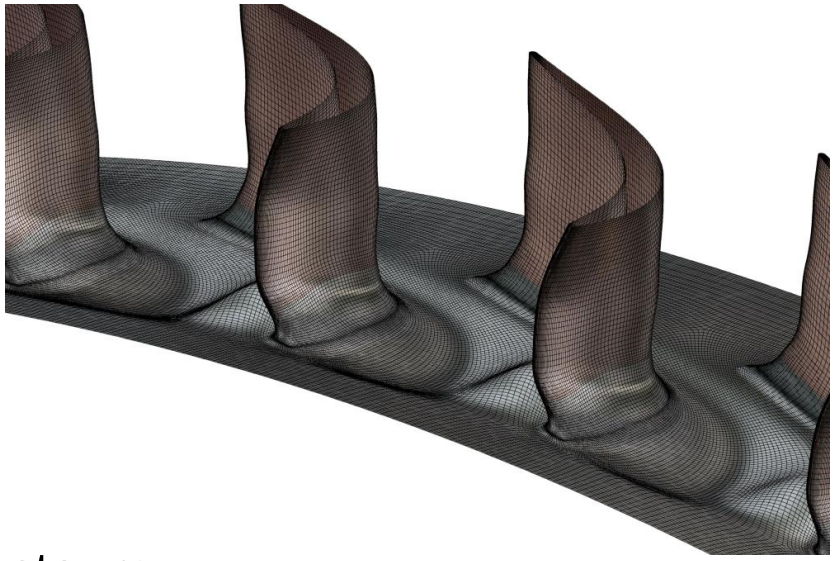
```
{
  "id": "{21bfeb18-5f44-4510-97cf-3100866c9125}",
  "id_as_color_in_step": "COLOUR_RGB('',0.95893797,0.53867399,0.69732204)",
  "type": "solid",
  "metadata": {
    "name": "Vane 1",
    "color": "#73caea",
    "layer": "0"
  },
  "topo_faces": [
    {
      "id": "{21bfeb18-5f44-4510-97cf-3100866c9125}::FA1",
      "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": [...],
},
...
```


AI-generated image with DALL-E

Mesh Generation

Structured Grids

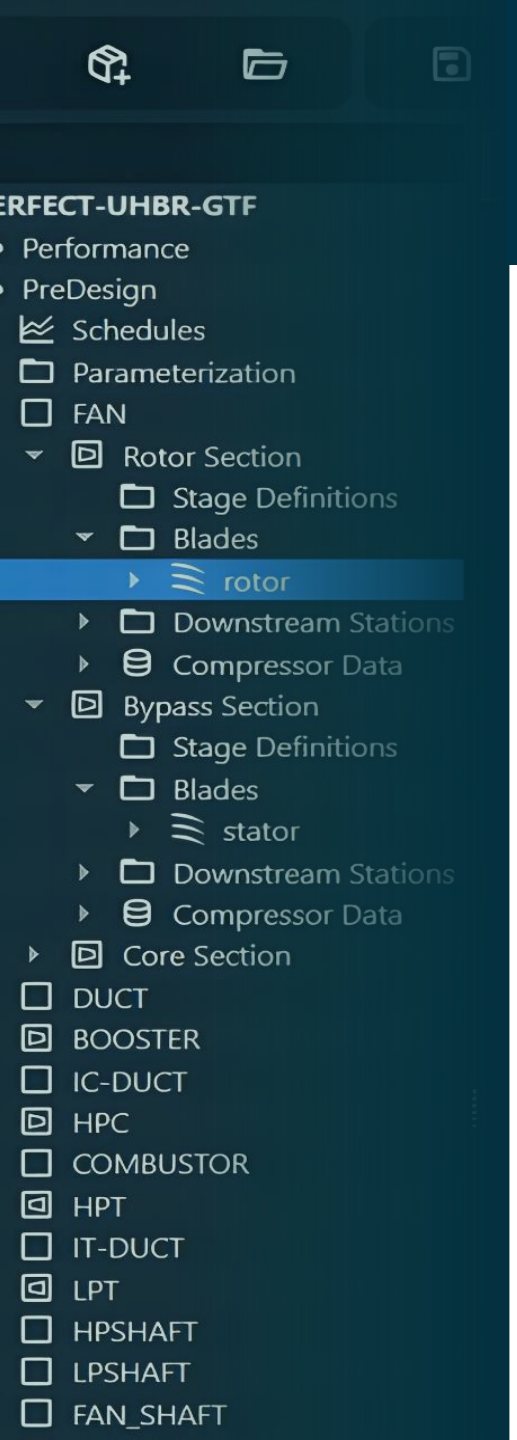
- Workflow Component for **NUMECA AutoGrid** Mesh Generator

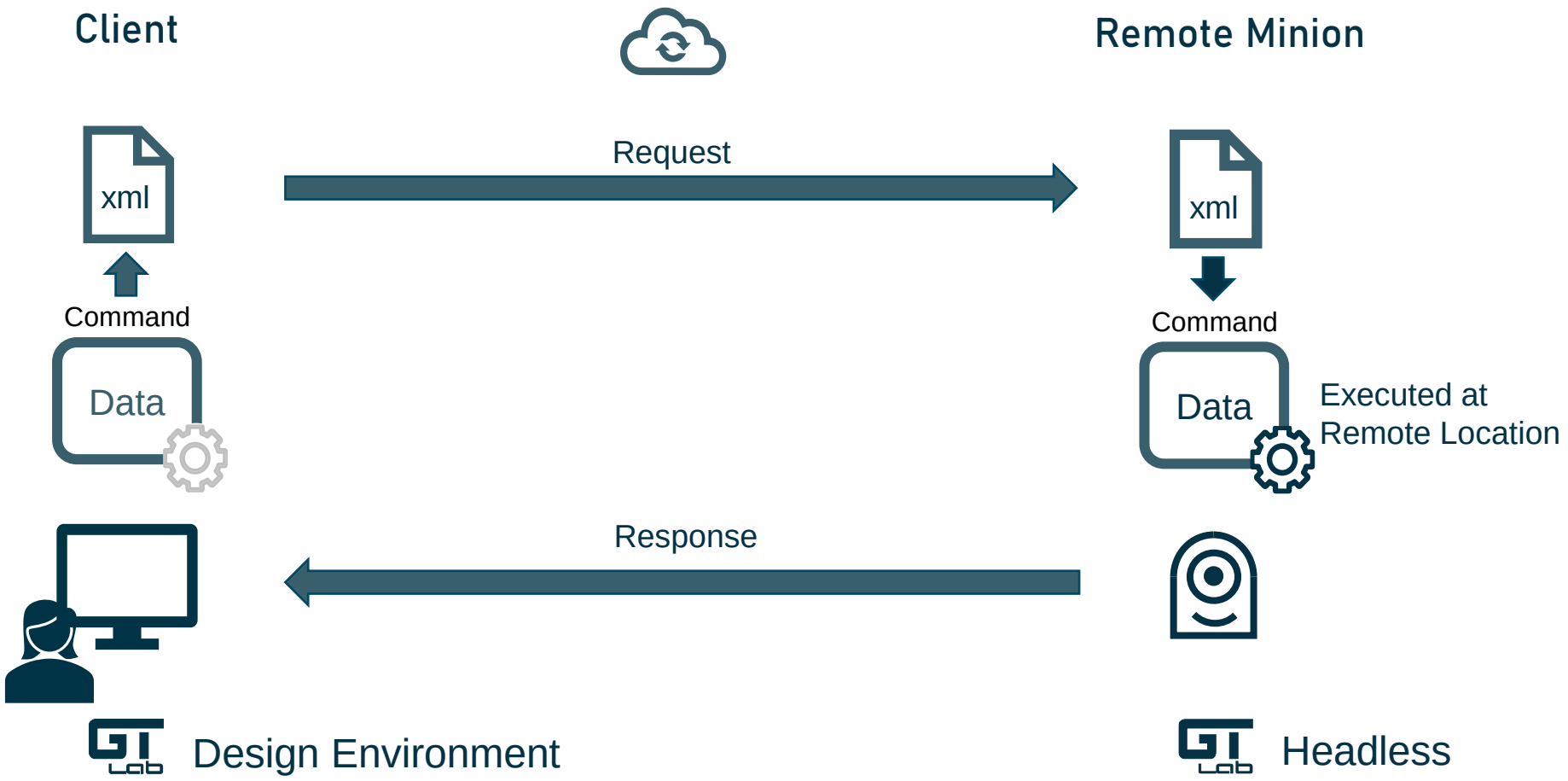

Copyright NUMECA

Unstructured Grids

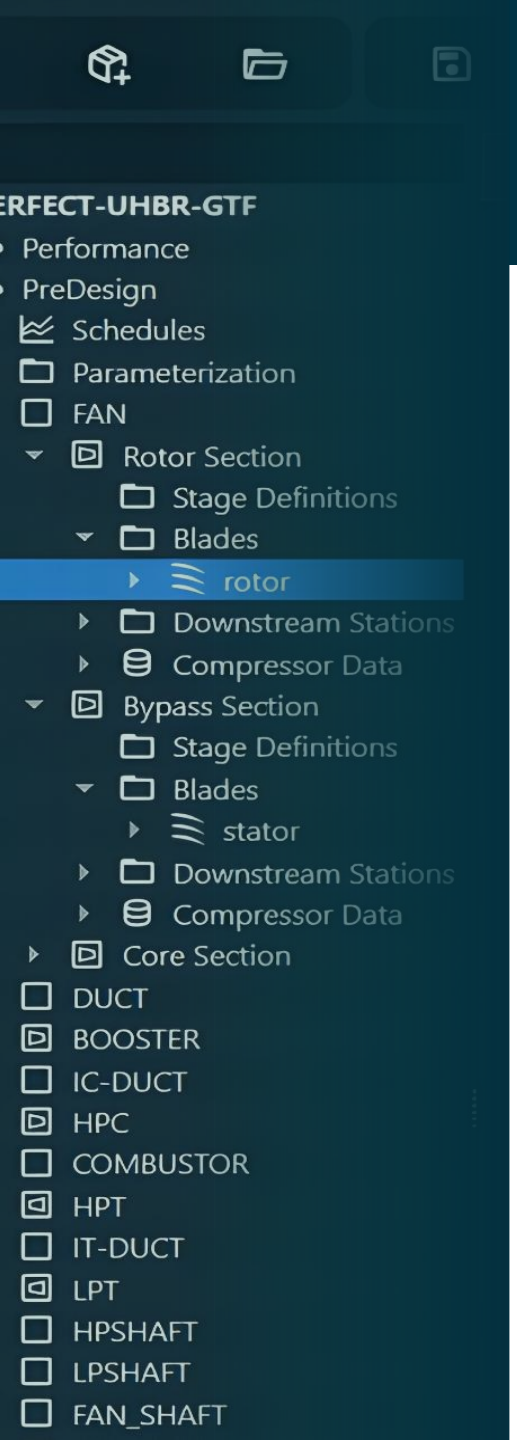
- Geometry Generator for the fluid, blades, contours
- Step Export with annotated Metadata (inflow, boundaries …)
- Used in **Centaur, Ansys** …

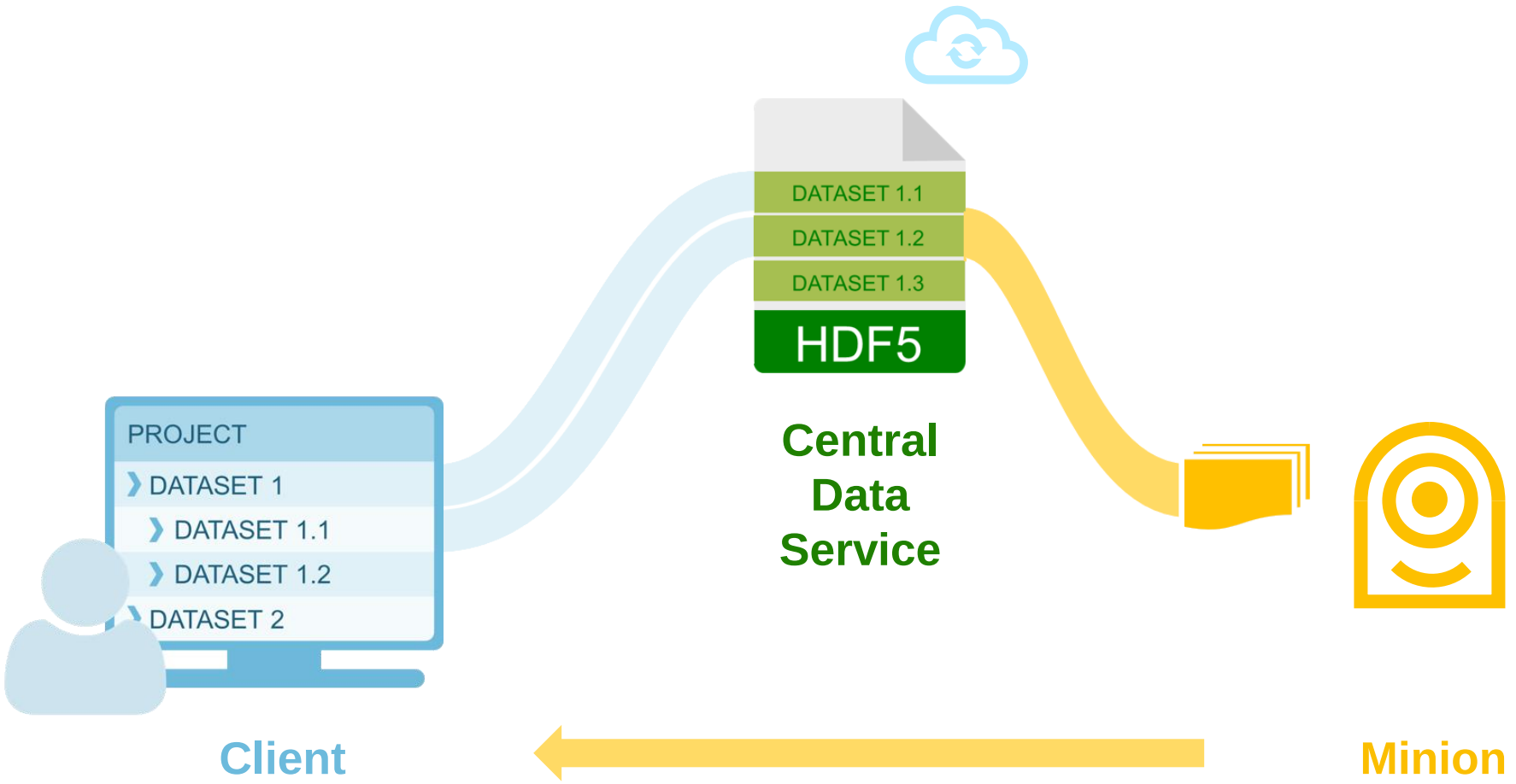
Remote Data / Processing



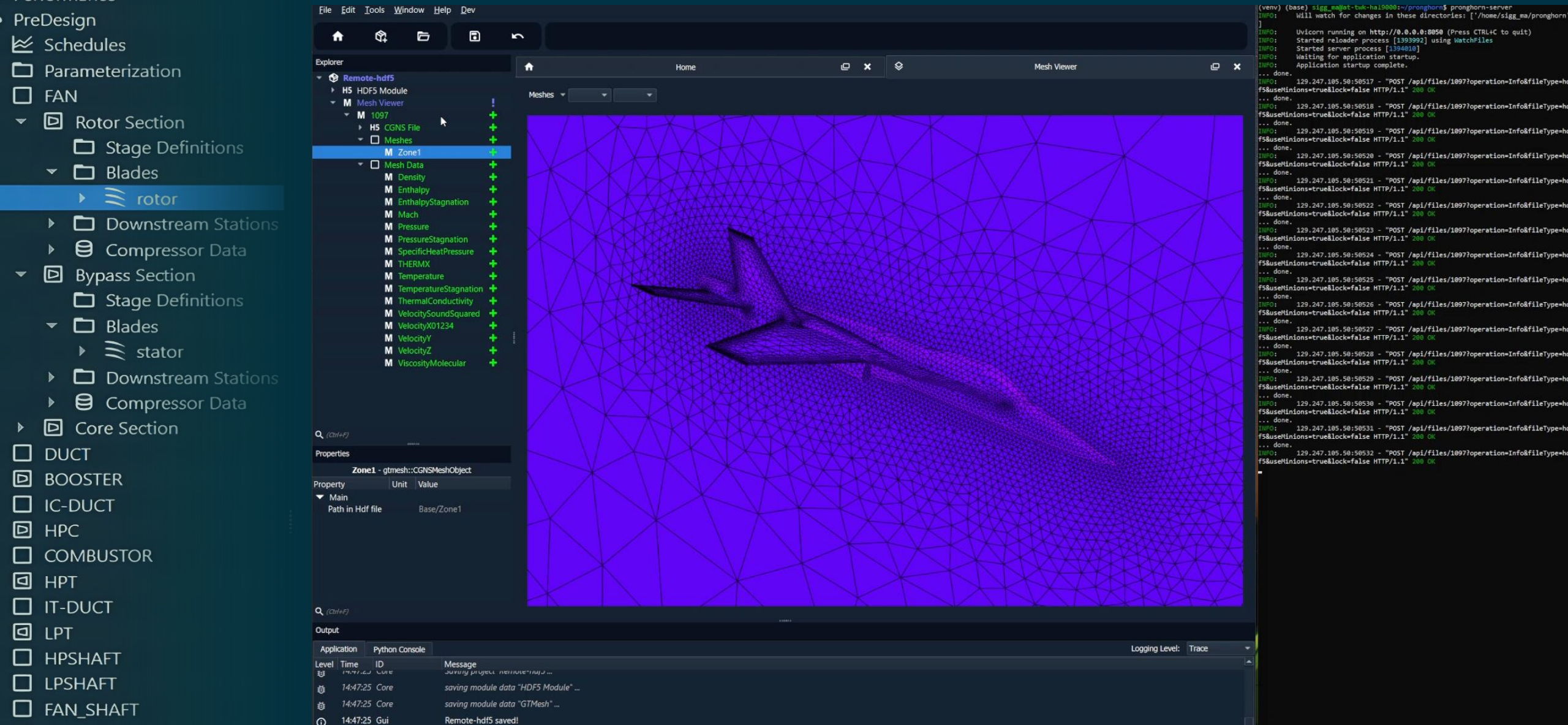


Remote HDF5 access

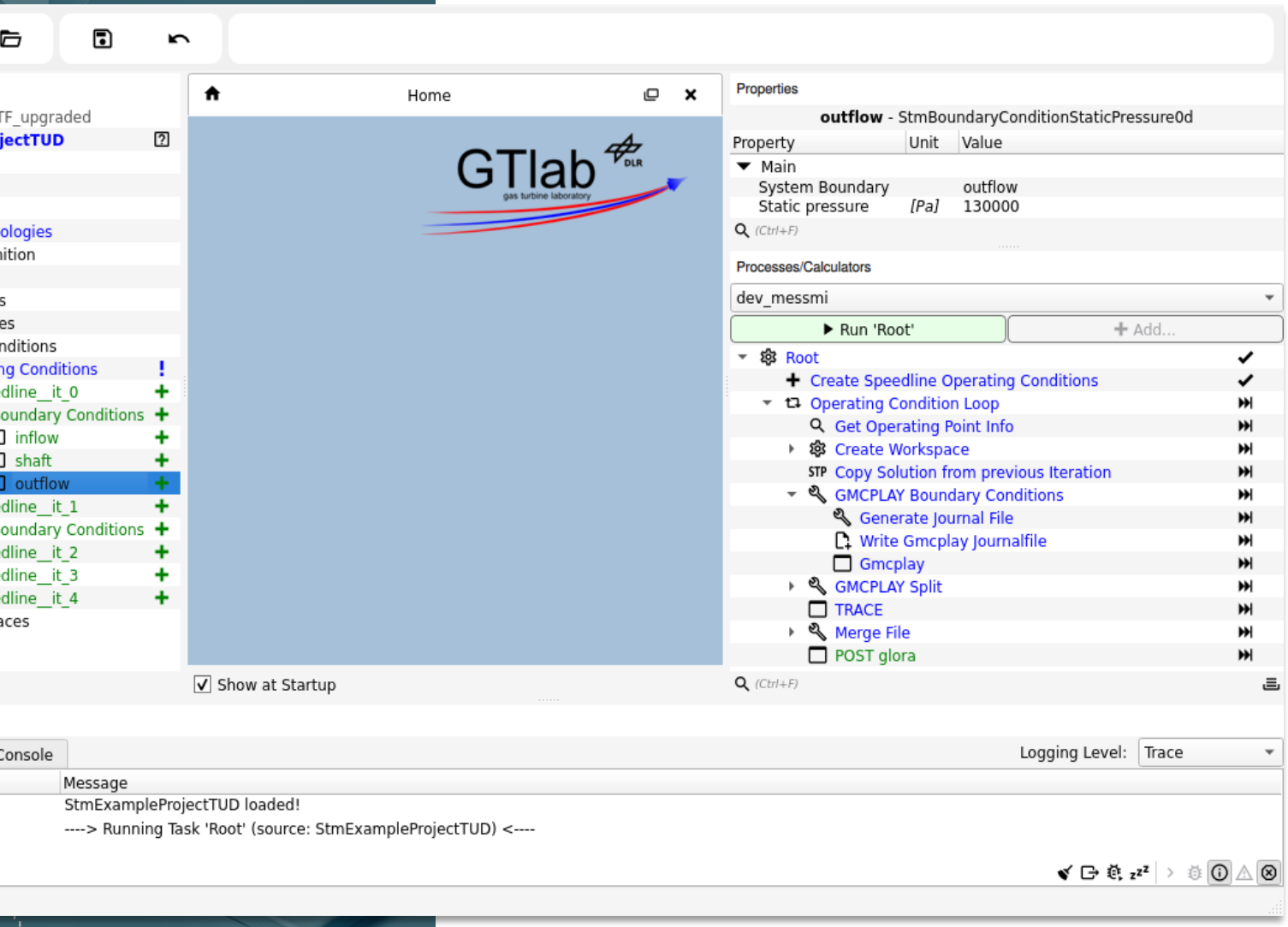




Remote HDF5 access



TRACE Suite Integration



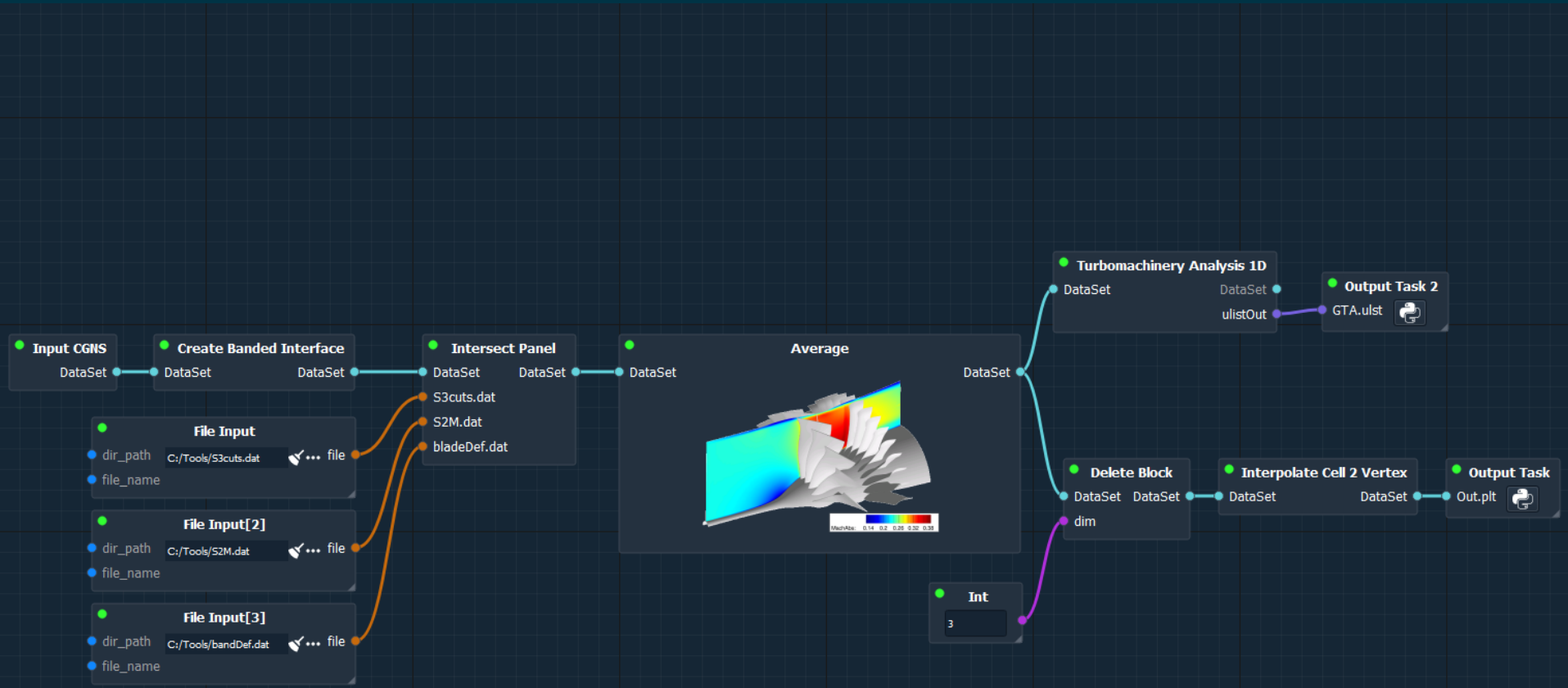
Demonstrator

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

AI-generated image with DALL-E



Thank you!

Martin Siggel

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

Impress

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
Credits:	