

IT'S TIME TO SEEK OUT INNOVATIVE DATA MANAGEMENT

Open Digital Engineering Platform for More Efficient Simulations
with OpenFOAM

GOFUN 2022 | Christopher Woll | Michael Schröter | 23.03.2022



Agenda

- **GNS Systems – Who We Are**
- **Digital Engineering Platform by GNS Systems**
- **High Performance Computing and Simulation**
 - Presentation of Tasks and Results of Our Lego®* Model
- **Importance of Data Management**
 - And How We Control Data Growth

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GNS Systems at a Glance

Located in Germany – Worldwide Service




Open  FOAM®



TISAX and
ITIL certified

Independent Specialist

 for Simulation IT
and Software Engineering

Professional CFD Operations

 In Cloud + On-premise

Dedicated Cloud Expertise

 Microsoft / AWS Partner



Straight DevOps

Lean Architecture
and Agile Mindset



Market Leaders

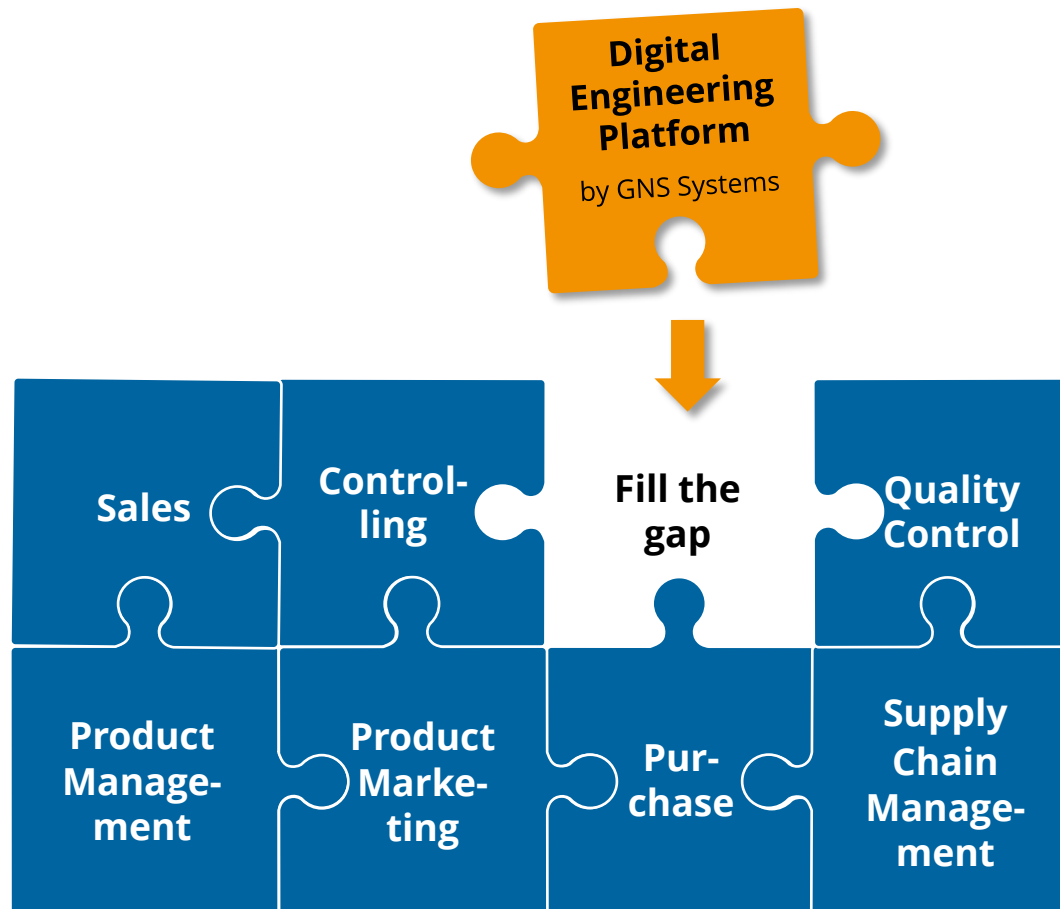
in Their Industries
(Automotive, Life Science,
Manufacturing and Chemistry)
Are Our **Customers**



There Are Many Solutions for CAE and CAD

... But One Module Is Missing

Each solution solves just a part of the problem.



Our open platform

enables multiple data driven applications faster – custom-made, without worrying about various environments.

- ✓ For all engineering tasks
- ✓ For highly customized environments
- ✓ Multi-purpose
- ✓ Hybrid
- ✓ Scalable



Digital Engineering Platform by GNS Systems

Your Multifunctional Digital Engineering Platform in Cloud and On-Premise

Simulation Database



3D



1D



Hardware in the Loop (HiL)



Software in the Loop (SiL)



Test



Sensors

Three Levels of Integration

Map the Complete Engineering Process



Use State of the Art Software & Tools

Open  FOAM®

Architecture

PLM

Twin Builder

CAE HPC

SDM

BI

Accelerate with Maximum Compute Power and Performance

Cloud | Hybrid | On-Premise



Get the most out of a wide range of simulation data in all product development processes

Improving OpenFOAM® on All Layers

We Want to Run OpenFOAM® at Its Best

Technology Stack

User

Workflows

Apps

Middleware

OS

Hardware / Cloud

Expertise from our projects

CAE Applications

Ensign, Femzip, Indeed, Flow3D, TISC, Mathematica, Fire, Hyperworks, Ansa, Simulac, DARS, VI-Grade, Abaqus, Icem, CFD, CAE, Bench, / SimManager, StarCD, HFSS, DCV, LSF, Femfat, Generator, Theseus, FE, TriD, Par, (Sun), Grid Engine, Dymola, Excite, Autoform, Madymo, StarCCM+, Freia, Centaur, GT Power, Fluent, Chemkin, Cfx, Dynaform, Tosca, Marc, FEGraph, Boost, Ffire, Vectis, Matlab, Simufact, Welding, Maple, Forte, Reshape, Flowmaster, VisMockup, Femsite, LS Dyna, Catop, SFE, Concept, Virtualab, Vectis Max, Animator

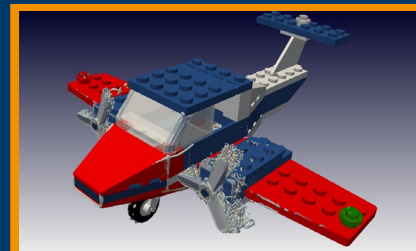
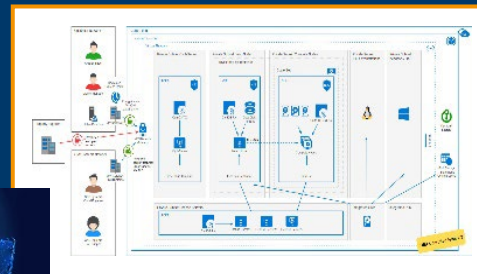


3. Efficiency by innovative Data Management

2. Tuning the application

1. Running in the cloud - Up to 8.000 cores and more

Digital Engineering Center



Best fit solutions for industry needs

The Framework

Computing Infrastructure



Secure Remote Access

- VPN
- Data Encryption
- NiceDCV
- Terradici

Workstations

- NV6 Series with NVIDIA
- JGen
- Full software-stack (OpenFOAM, ParaView, MPI, ...)

Supercomputing

- HPC HB120 v3
- CPU: AMD EPYC 7V13
- 120 Cores/CPU
- 448 GB RAM
- local disk and central high-speed storage

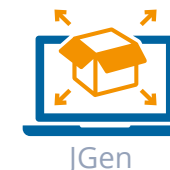
Empowerment

- Workflows
- Benchmarking
- Scaling

Infrastructure Layer



Linux



OpenFOAM®



Create Our Lego®* Model

CAD | Pre-Processing | Meshing

Tasks:

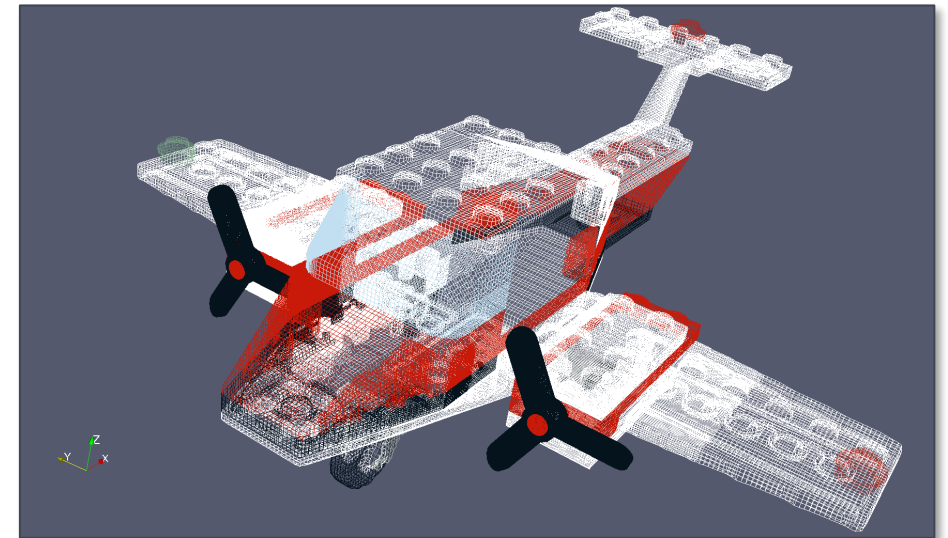
Pre-processing → **Meshing** → Solving (up to ~10.000 cores) → Post-processing

Pre-processing: Geometry Preparation

- Comparison and visualisation of Lego® model
- Brick-by-brick in a Lego® Creator Tool, each brick a solid
- Scale propeller to 95% (small gap between propeller and cabin)
- Quality checks of model

Meshing

- Various representations of CAD geometry
→ size 130 Mio. cells
- AMI interface around right and left propeller
- Multiple levels of refinement around aircraft geometry
- Define physical boundary areas
- CAD files are kept together with solver files



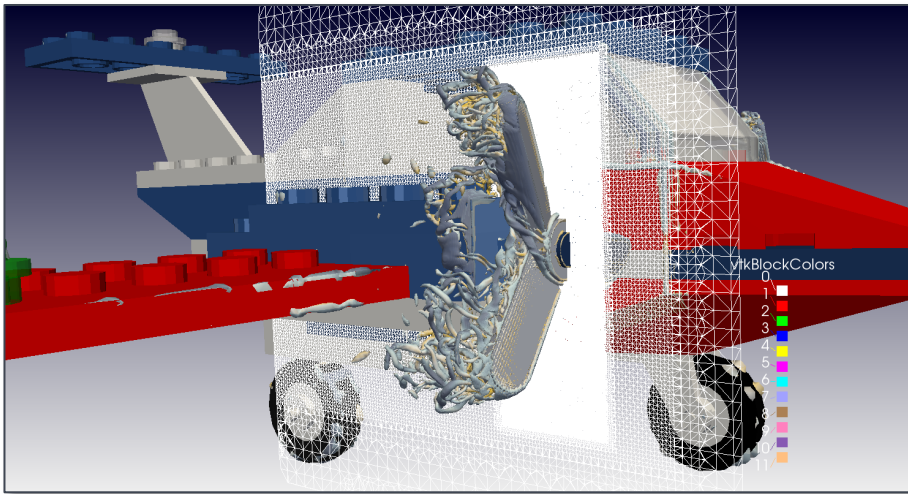
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Create Our Lego®* Model

Solving | Post-Processing

Tasks:

Pre-processing ➡ Meshing ➡ Solving (up to ~10.000 cores) ➡ Post-processing



Solving

- Used up to ~10.000 Cores
 - 83 HB120 Azure Cloud nodes for the largest Job -> 9960 Cores
- Solver pimpleFoam: Adaptive timestep ($\sim 10^{-6}$ s, ~5000 timesteps, ~50 I/O-levels)
- Prepare result data for post-processing
 - e.g., OpenFOAM-functionObjects

Post-processing

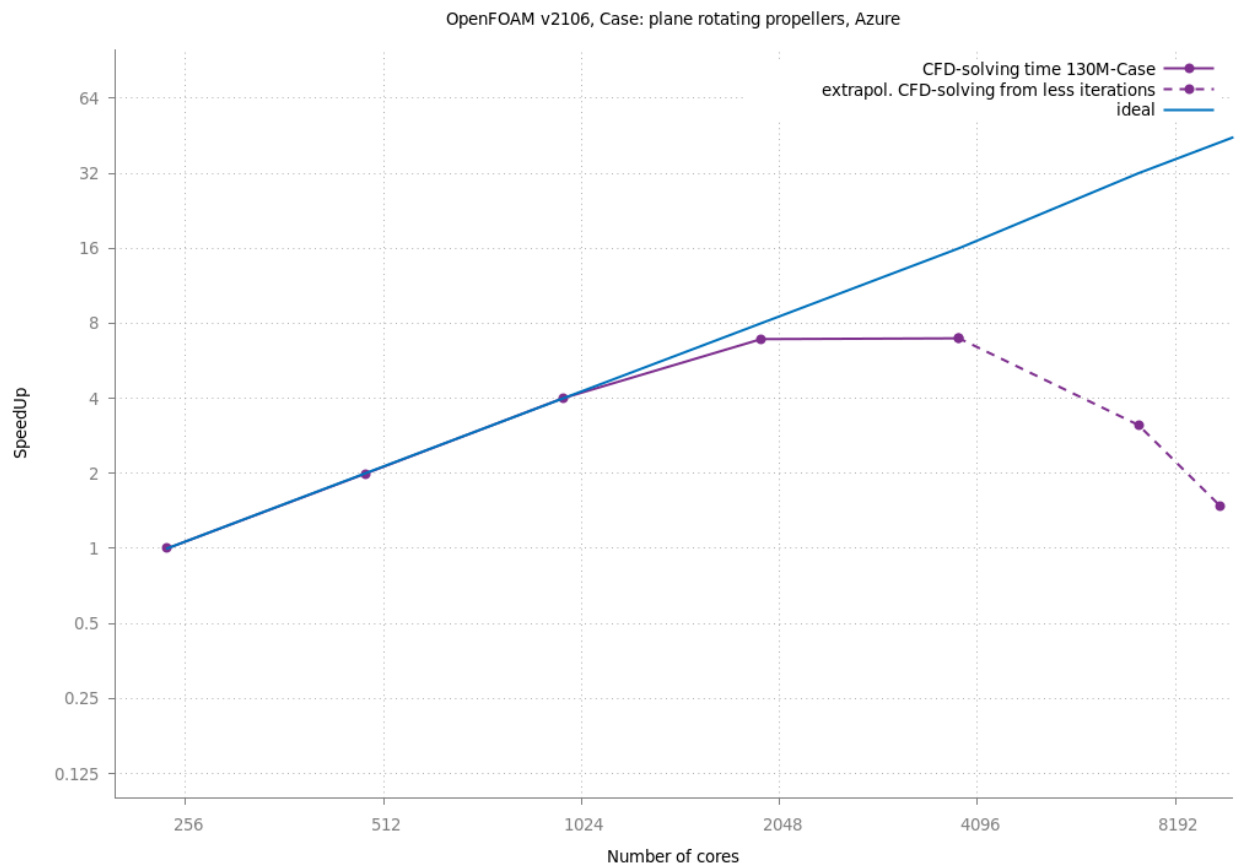
- Result files from solvers
- Deploy to the cloud environment: create the model visualisation
- Automated workflow helps manage large amounts of solver data efficiently
- Goal: Shorten the duration of the process

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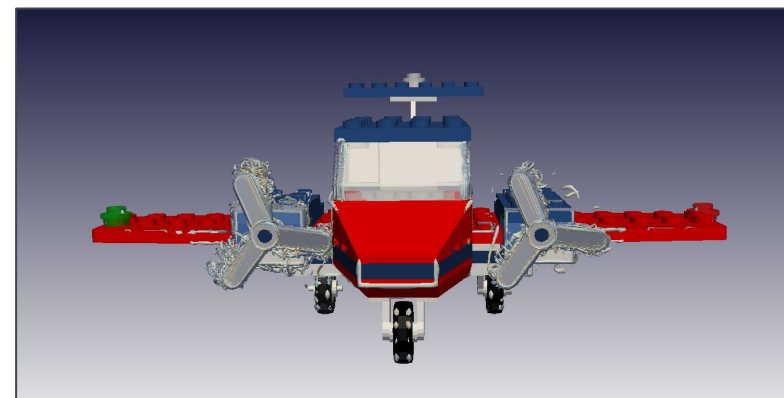
Reaching High Performance

With OpenFOAM® in the Cloud

SpeedUp



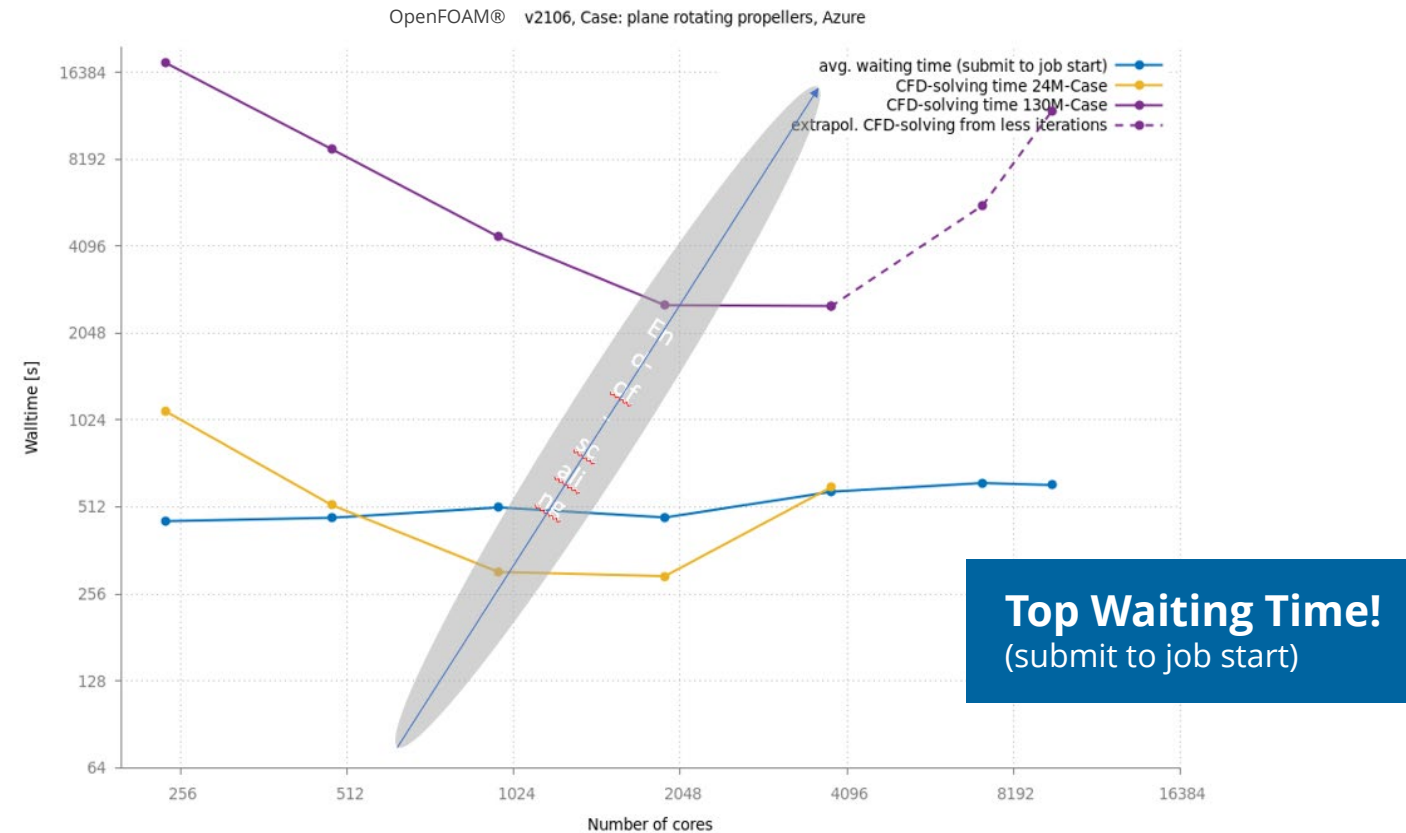
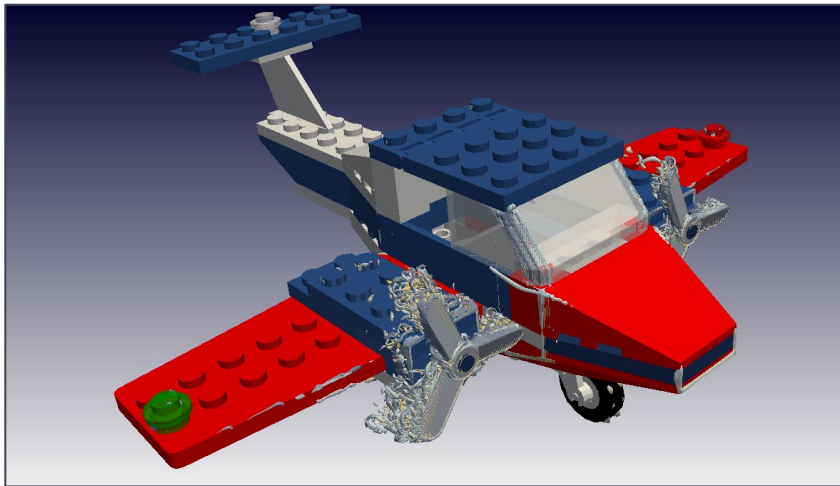
Unlimited capacities
in the cloud



OpenFOAM® Automated Workflow

Maximum Performance Through Parallelisation

- ✓ Automated call of various OpenFOAM® tools
- ✓ Manage generated data from the solver optimally
- ✓ Pre-defined process efficiently distributes jobs to available clusters





Large Scale – Large Data – New Challenges

Used Data in Our Lego®* Model

Just **1 RUN** on **10.000 cores**
produces **~2.6 TeraByte** of data

What we have done:

# of I/O timesteps	Per process	In total (10000 Cores)
1	5 MB	~50 GB
Mesh	2 MB	~20 GB
Field data	3 MB	~30 GB
10	~35 MB	~520 GB
50	~0.175 GB	~2.6 TB

(based on an „130M cells“ setup)

Depends on
AMI size

We are still working on this:
Target Setup 400 Mio. cells

# of I/O timesteps	Per process	In total (10000 Cores)
1	15 MB	~150 GB
Mesh	6 MB	~60 GB
Field data	9 MB	~90 GB
10	~0.16 GB	~1.6TB
50	~0.8 GB	~8 TB

(extrapolated to the target size of 400M cells)

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Data Management – a Dynamic Process ...

1

Actively manage data:

Implementing a framework of methods, processes and technologies.

2

Ensure data quality:

Prepare and present data according to business process requirements.

3

Keep your overview:

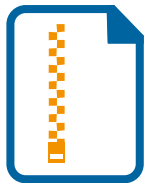
Create suitable architectures that map all processes, data and applications.

Target:

Identify valuable information and patterns from confusing mountains of data in order to profitably generate new business models from them ...

Data Management – How We Solve It...

How We Control Data Growth



Manage data by Data Compression / Conversion

- Integrate fast and efficient data reduction mechanism
- For example compression algorithms
- Gain cost efficiency

Benefit:

Reduce files and data volume by Faktor 10

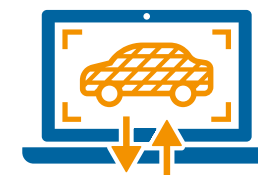


Ensure quality by Checkpoint & Restart

- Integrate fast and efficient data transfer mechanism
- For example HPC interconnects via LLNL-SCR Scaleable Checkpoint & Restart
- Receive resilient HPC clusters

Benefit:

Save weeks of precious work



Keep the overview by Data Management

- Insert a professional Simulation Data Management Systems
- (Search &) Find your data faster
- Ensure traceability and compliance at all times

Benefit:

50% faster data discovery,
Risk mitigation



Klick ... Computation in Progress ... Data Managed

Take Off!



TAKING ENGINEERING TO THE NEXT LEVEL

Thanks for Your Attention!

Want to hear more?

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