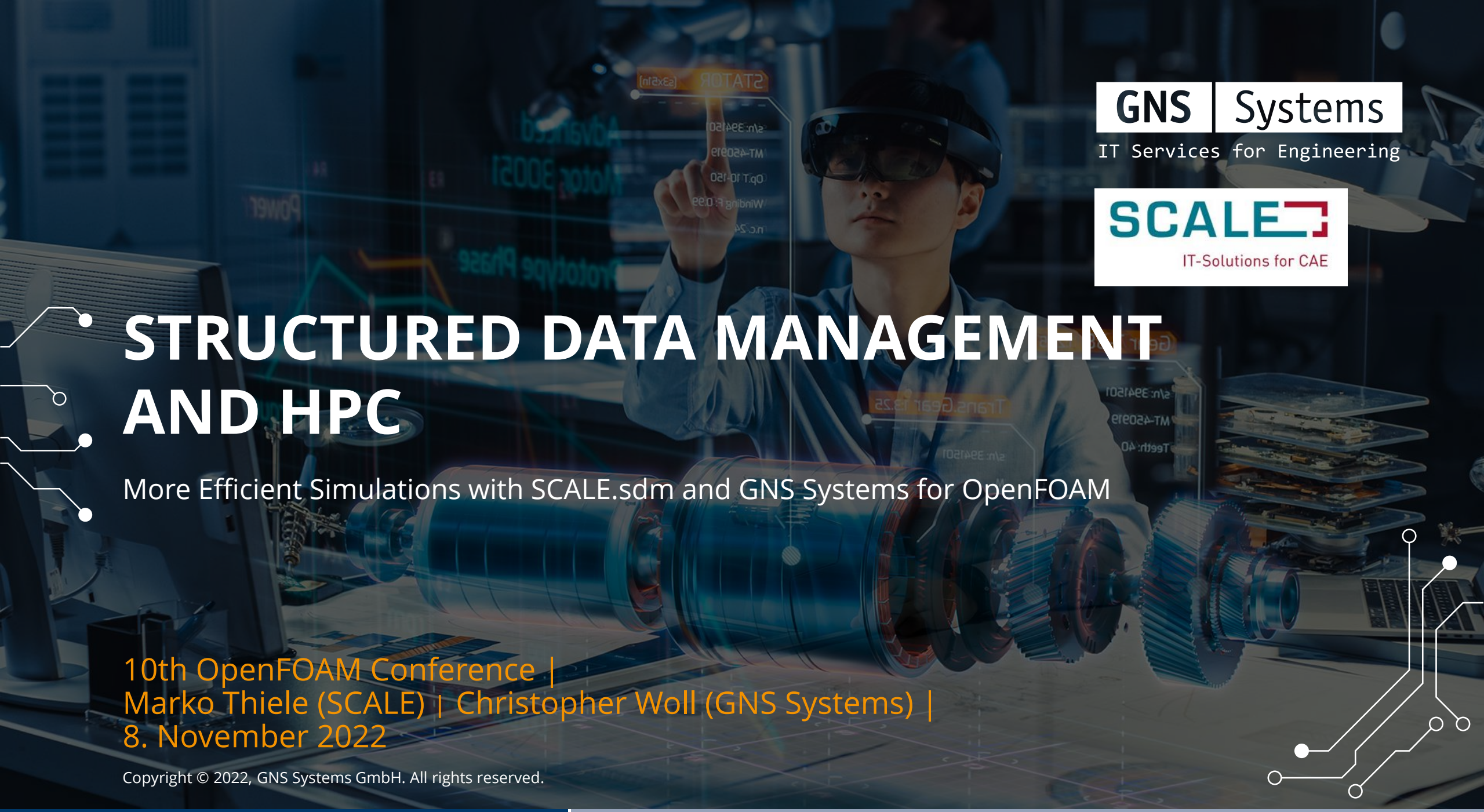


GNS Systems
IT Services for Engineering

SCALE
IT-Solutions for CAE

STRUCTURED DATA MANAGEMENT AND HPC

More Efficient Simulations with SCALE.sdm and GNS Systems for OpenFOAM

10th OpenFOAM Conference |
Marko Thiele (SCALE) | Christopher Woll (GNS Systems) |
8. November 2022

Agenda

GNS Systems
IT Services for Engineering

SCALE

- **GNS Systems – Who We Are**
- **SCALE - Who We Are**
- **High Performance Computing and Simulation**
  - Short Presentation of Tasks and Results of GNS Systems Lego®* Model
- **SCALE.sdm for OpenFOAM**
  - Environment for End-to-End Simulation Data and Process Management
- **Process Automation via CI/CD-Pipeline**
- **Conclusion**

Located in Germany – Worldwide Service

GNS Systems

Proudly Serving Market Leading Companies in Automotive, Life Science, Manufacturing and Chemistry Since 1997

„Development of innovative functions, tools or services is based on the knowledge provided by automated process and data “

GNS Systems

IT for Virtual Engineering

Independent Specialist
for Value Added HPC and Big Compute

GNS Group
about 250 IT Specialists and Simulation Experts Worldwide

Broad Partner Network
with Special Cloud Expertise

HPC Infrastructures & Workflows:
Complete automation of engineering processes - on-premises, hybrid or in the cloud

Dedicated Cloud Expertise:
Microsoft / AWS Partner

CAE/CAD Data Management & Analytics:
The Intelligent Use of Data and smart Platform for Best Practises

Software Engineering:
Enterprise Class, Agile Software Development

SCALE – Experts in Simulation Data Management

Product Portfolio Includes the System Solution **SCALE.sdm**

PRODUCTS

Standard software solutions for
CAE process and data management

sdm

Requirements ▸ Modelling ▸ Solving ▸ Evaluation ▸ Monitoring

- SCALE.project – Status.E
- SCALE.model – LoCo
- SCALE.result – CAViT

SERVICES

Individual software projects on customer order

- Requirement analysis
- Conceptual design, planning
- Specifications
- Implementation and project management
- Focus on IT projects related to simulation methods and processes

CONSULTING

- CAE-processes
- Machine Learning and AI-methods in CAE
- Introduction of SDM
- Software design

Structured Data Management and HPC

High Performance Computing and Simulation

Short Presentation of Tasks and Results of GNS Systems Lego®* Model

Structured Data Management and HPC

Improving OpenFOAM® on All Layers

We Want to Run OpenFOAM® at Its Best

Technology Stack

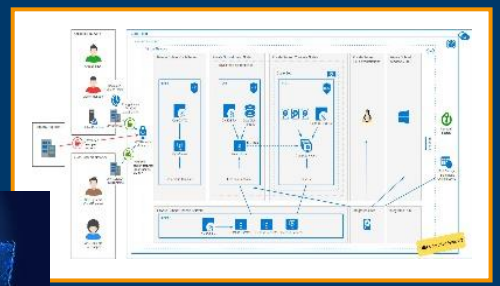
- User
- Workflows
- Apps
- Middleware
- OS
- Hardware / Cloud

Expertise from our projects

1. Running in the cloud – Up to 10.000 cores and more

2. Tuning the application

3. Efficiency by Simulation Data Management



Best fit solutions for industry needs

The Framework

Computing Infrastructure

Azure

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

intel AMD eDCV Linux JGen

OpenFOAM® ParaView

Create Our Lego®* Model

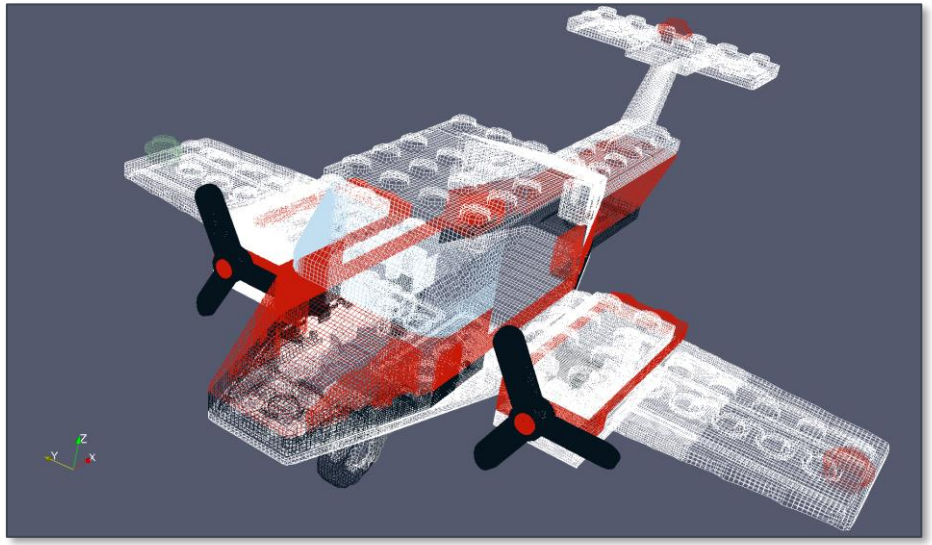
CAD | Pre-Processing | Meshing

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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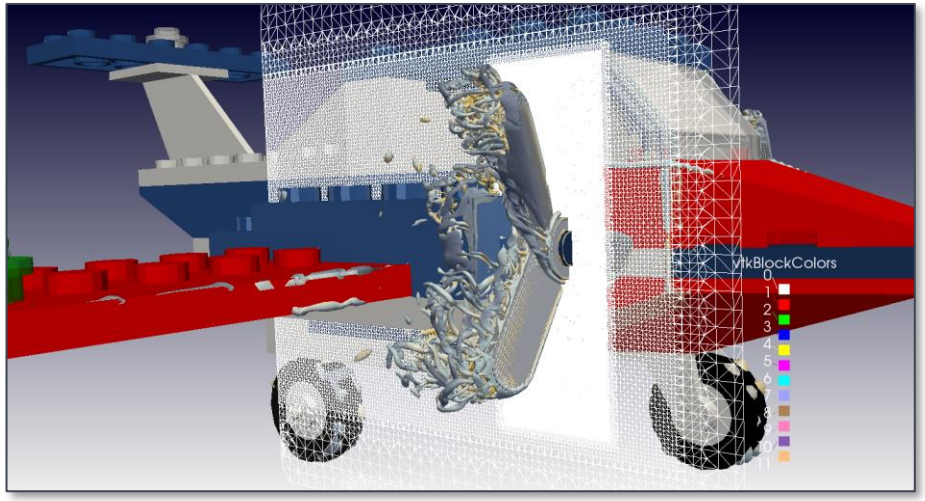
Create Our Lego®* Model

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 (~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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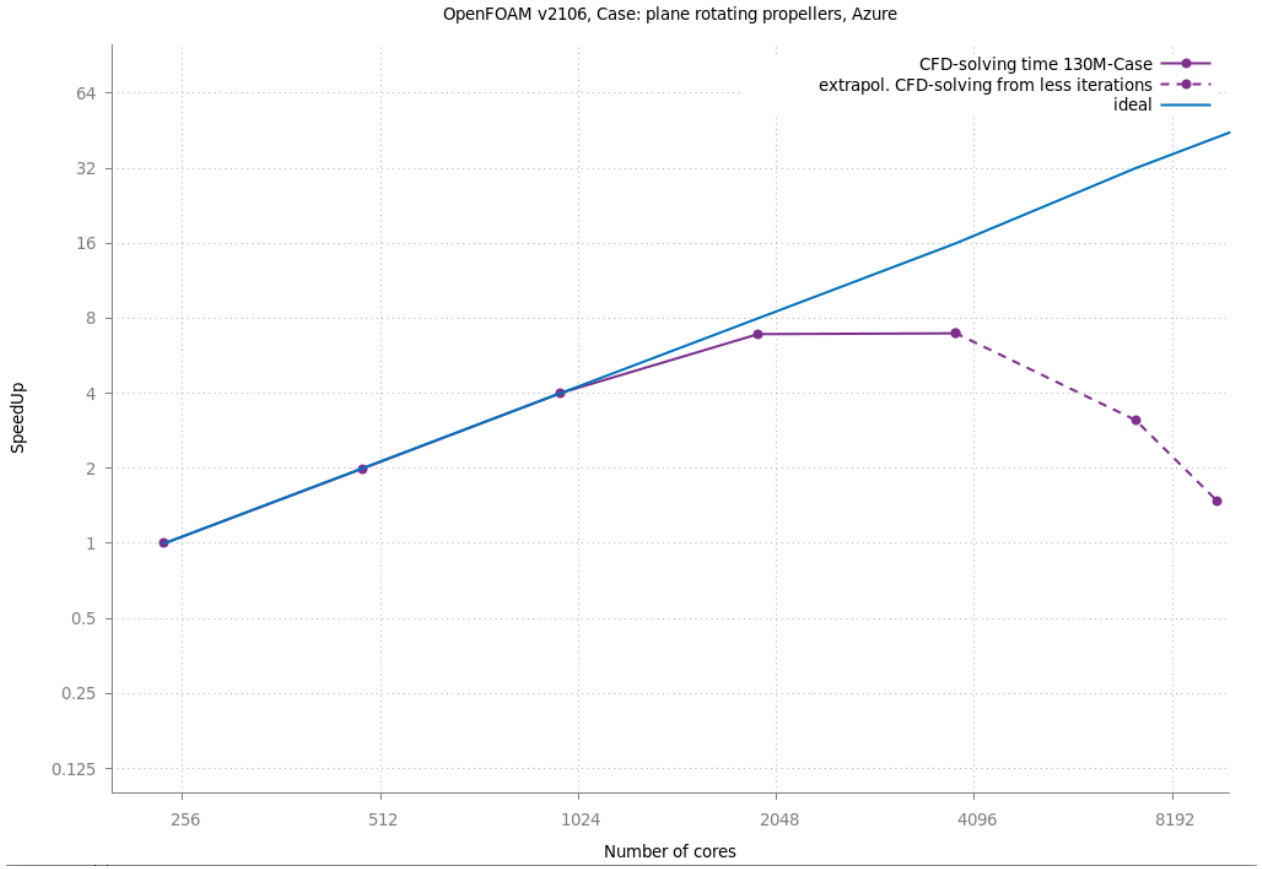
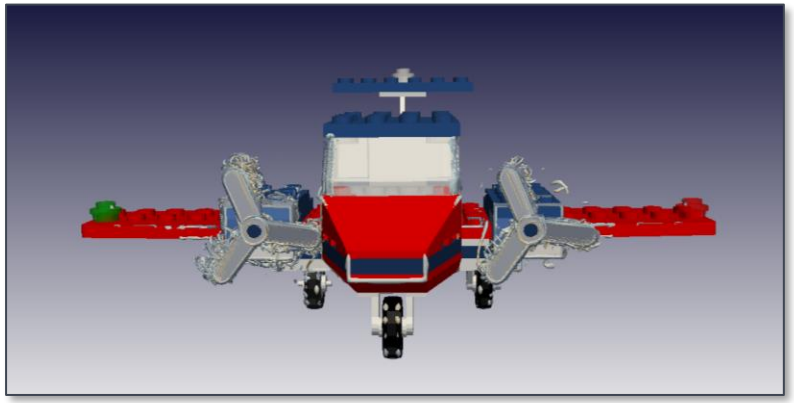
Reaching High Performance

With OpenFOAM® in the Cloud

SpeedUp



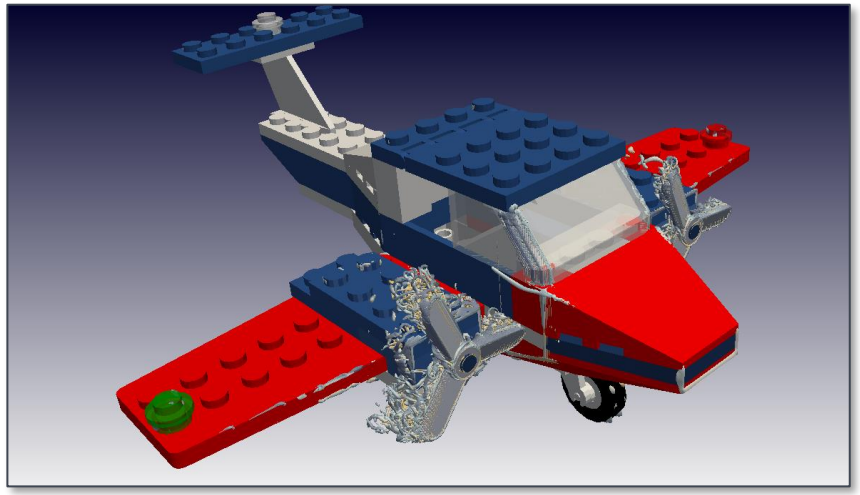
Unlimited Capacities
in the Cloud

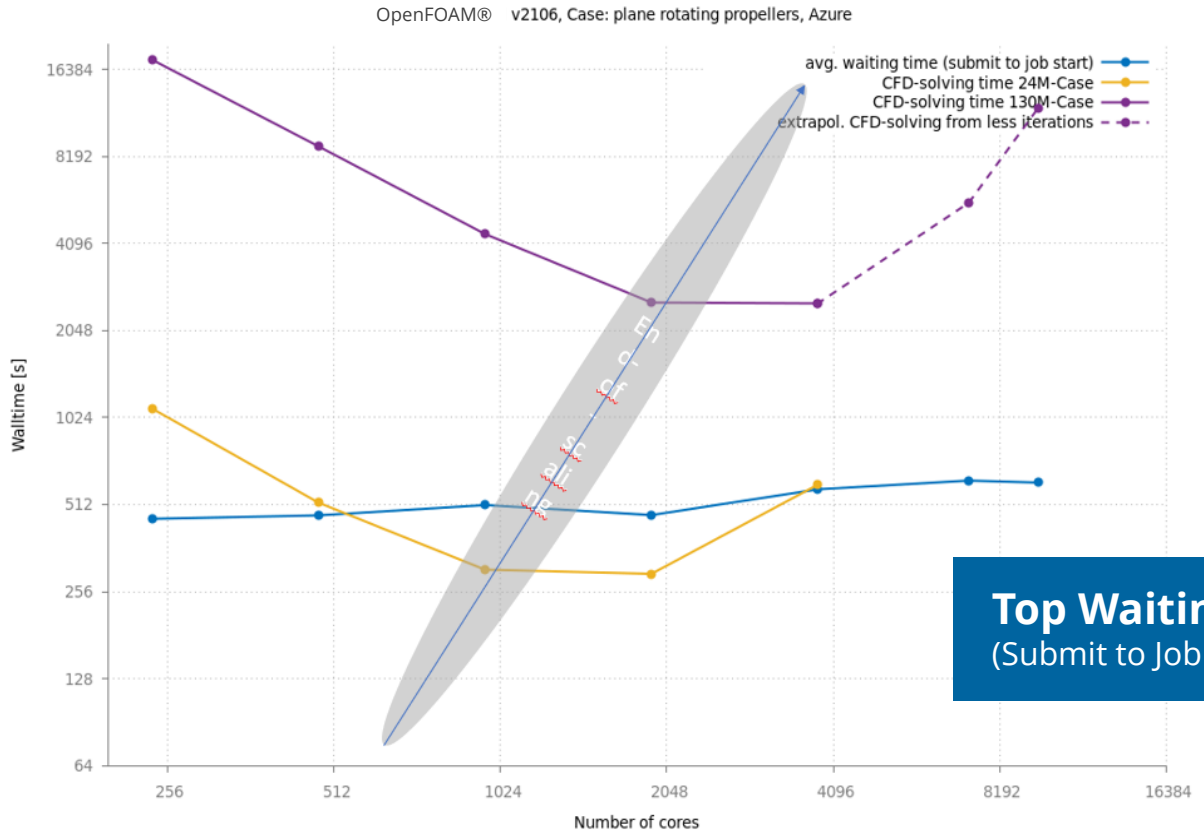


OpenFOAM® Automated Workflow

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





Top Waiting Time!
(Submit to Job Start)

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.

SCALE

Structured Data Management and HPC

SCALE.sdm for OpenFOAM

Environment for End-to-End Simulation Data and Process Management

Simulation Data Management

SCALE.sdm → Software Solution for Simulation Data Management

SCALE.project Status.E	SCALE.model LoCo	SCALE.result CAViT	SCALE.project Status.E

Import CAD or Meshes

↓

Prepare Models

↓

Define Load Cases

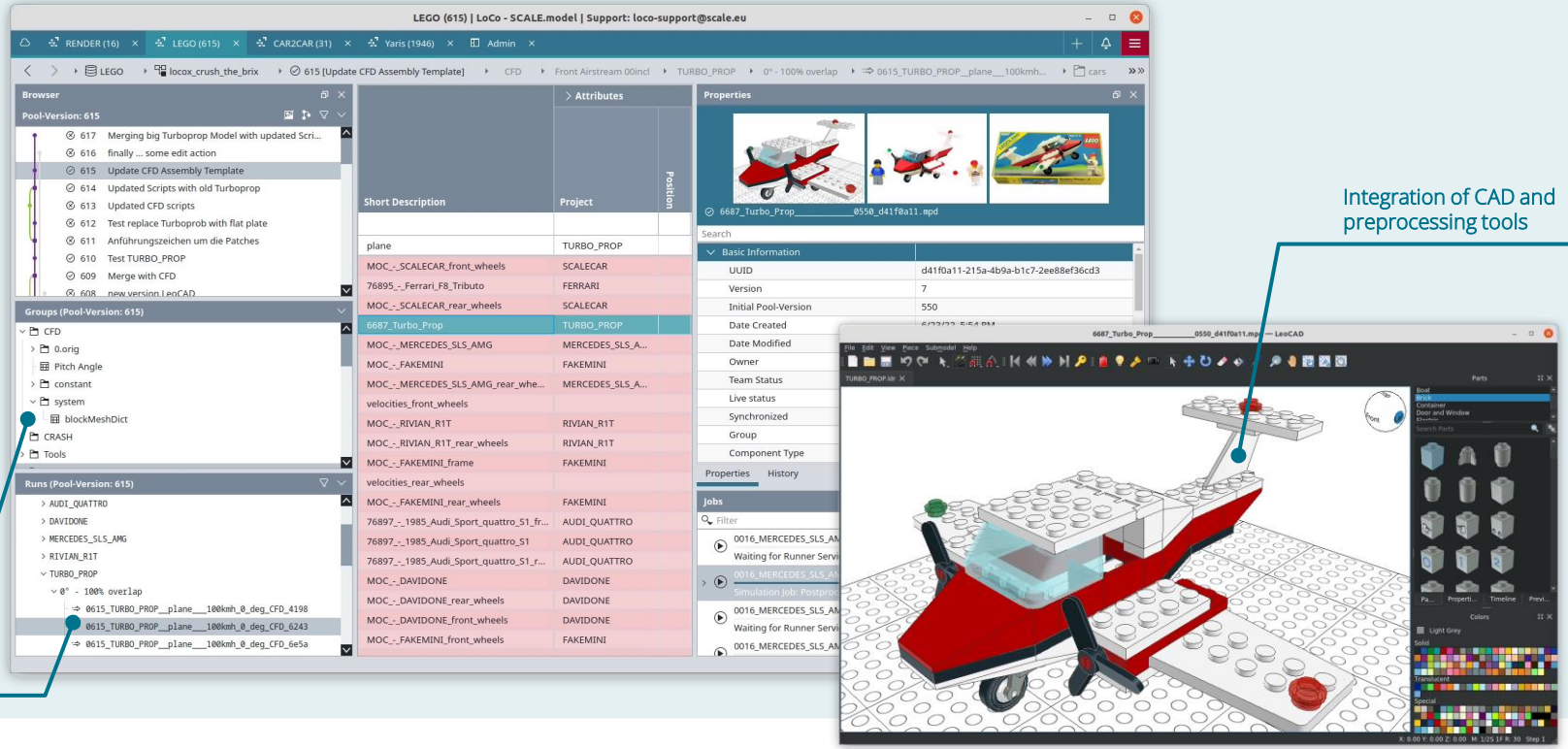
↓

Run Simulations

Open FOAM CFD case definition

Load cases

Integration of CAD and preprocessing tools



Simulation Data Management

SCALE.sdm → Software Solution for Simulation Data Management

SCALE.project Status.E	SCALE.model LoCo	SCALE.result CAViT	SCALE.project Status.E

Extraction and Evaluation of results

↓

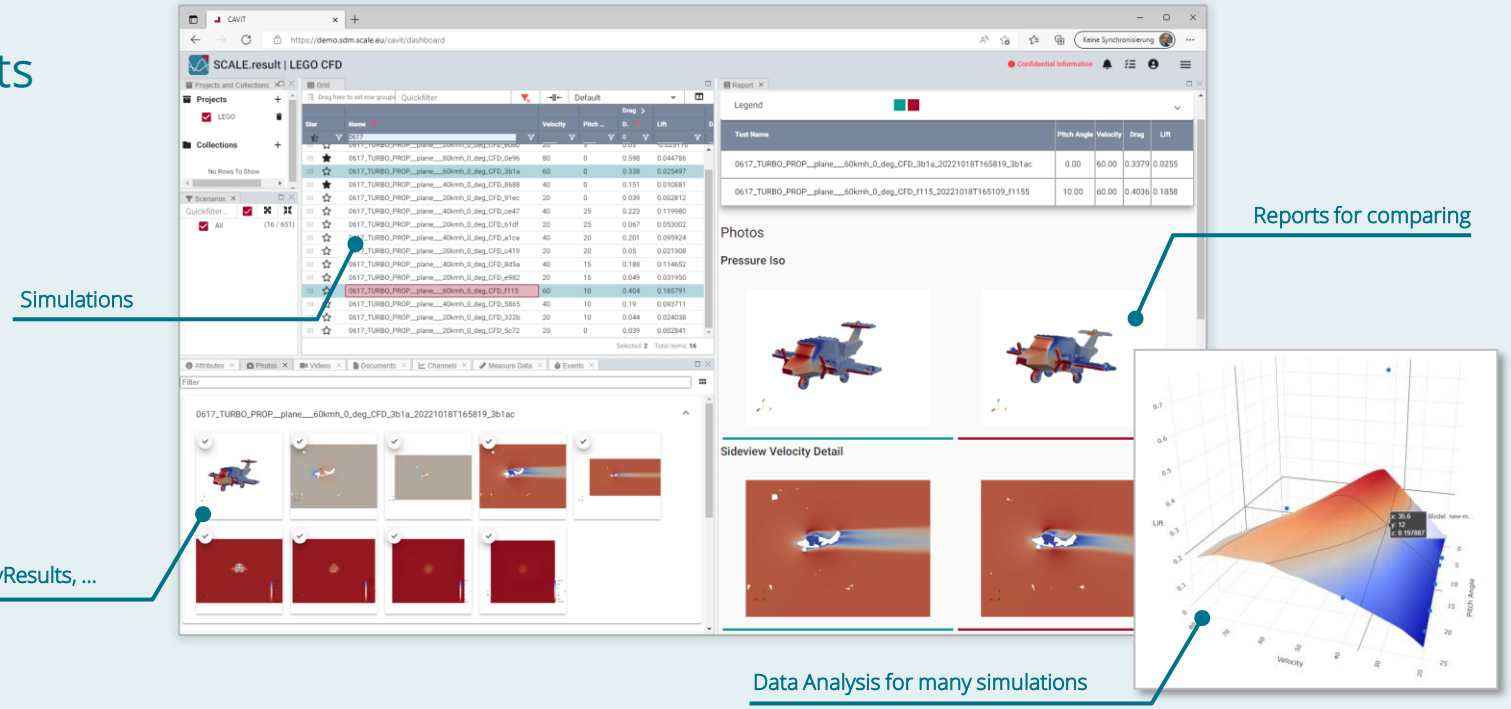
Management of Post Data

↓

Correlation Test vs Simulation

↓

Assessment and Reporting



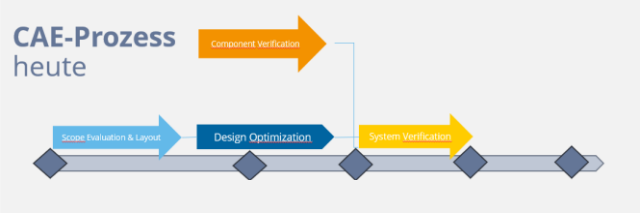
Structured Data Management and HPC

Process Automation via CI/CD-Pipeline

Outlook: What if…

… CAE Processes were Fully Automated?

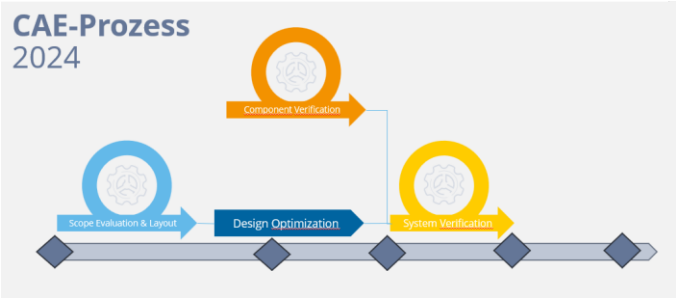
Current CAE Environment



- Manual executable
- Partly automated
- Traditional engineering workflow

2 - 3 years

Digital Engineering Environment



- Integration platform and deployment pipeline
- Fully automated workflows with reusable building blocks
- Traceable from/to product description
- Digital Twins maintenance and tracking

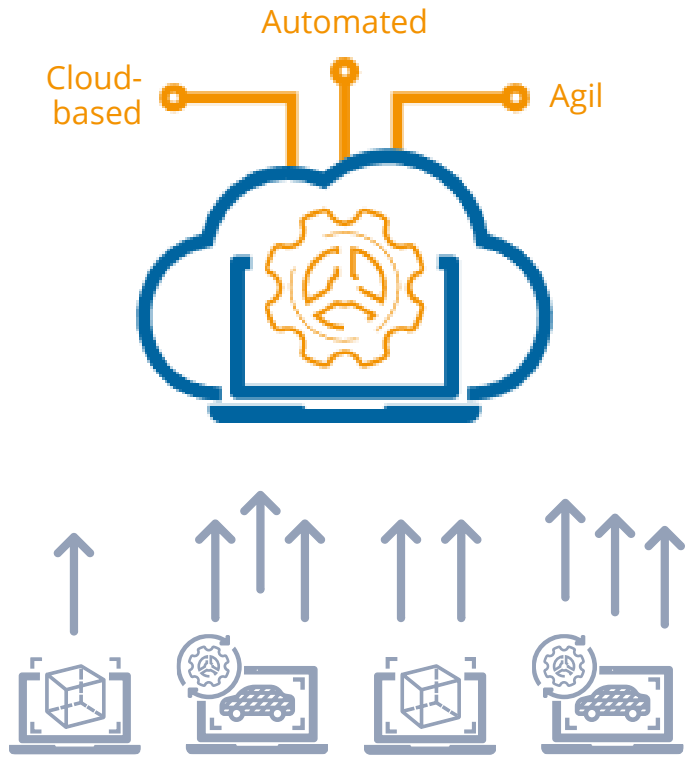
Structured Data Management and HPC

Conclusion & Benefits

Conclusion & Benefits

Structure Data Management & HPC-Automation for OpenFoam

- **Massive cost savings**
  through simulation-driven virtual product development
- **Increased competitiveness**
  through better products
- **Faster time-to-market**
  through automatization with SDM and massive parallelization in the cloud
- **Improved collaboration**
  through unified tools integrated in an SDM system
  and a common mindset across organizational boundaries
- **Standards & Compliance**
  in IT & Engineering Processes



Klick … Computation in Progress … Data Managed

Take Off!

THANKS FOR YOUR ATTENTION!

SCALE
IT-Solutions for CAE

GNS Systems
IT Services for Engineering

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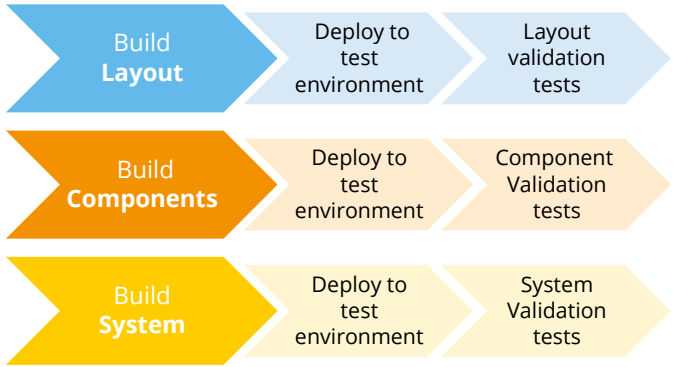
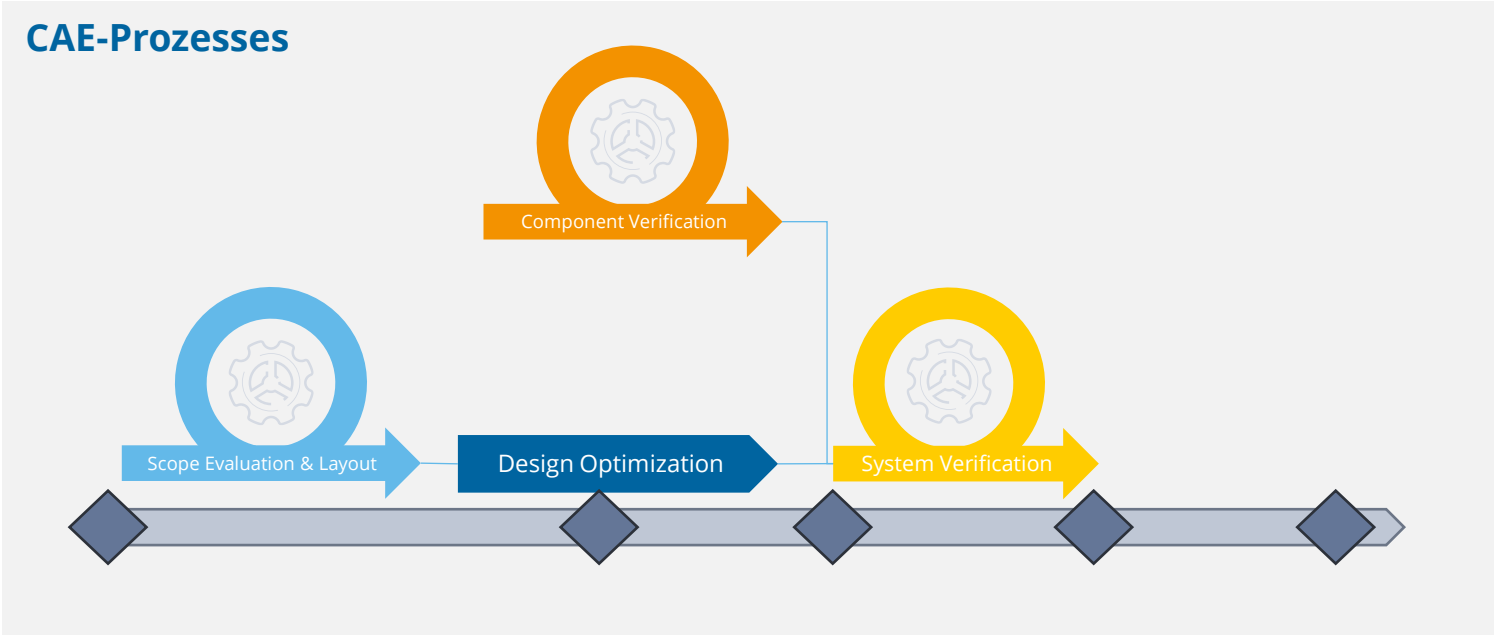
High-Level Architecture

Improve the Level of Automation in CAE Processes

Fully automated process pipelines enable **continuous integration and delivery** of results (CI/CD)

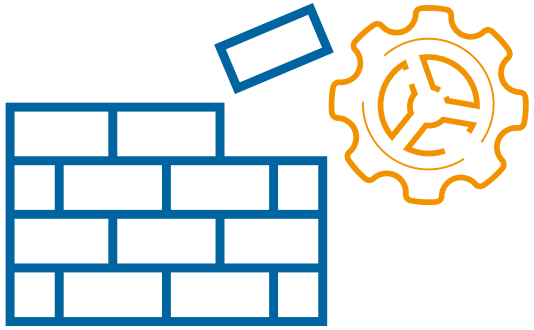




- ✓ Maximum reduction of manual steps
- ✓ Achieve results faster through automated processes
- ✓ Continuous and seamless interaction of tools

Building Blocks

For a Digital Engineering Ecosystem



Tools	Digital Twin Requirements Management:	AzureBoards or Alternative
	Digital Twin Architecture Management:	Customer-decision
	Model/System Assembly (Twin Builder):	Custom-made or Evaluation
Automation	Validation Pipelines:	AzurePipelines or SPDM integrated
	Workflow Management/Engine:	JGen, Volta, BPM tools, …
HPC	Supplementary HPC applications:	Abaqus, Matlab/Simulink, GT Cool, FMI/FMU, Python
	Postprocessings:	CAE Apps, automatisiert
Data	Test Data Management and Evaluation:	Customer-decision
	Simulation (Process) Data Management: CAEBench/SimManager,…	Minvera, SCALE.sdm, SimDataManager, Volta,
	Interfaces for data access/exchange:	Integrated with Data Management Solutions

Platform for Digital Engineering by GNS Systems

Your Multifunctional Digital Engineering Platform in Cloud, Hybrid 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

Require-ments → Twin Architecture → Twin/Model Assembly → Virtual Validation → Analytics → Report

Use State of the Art Software & Tools

Azure Boards | Cameo | Twin Builder | Matlab/ Simulink | BI | StarCCM

SPDM – Data Backbone

HPC Backbone

Accelerate with Maximum Compute Power and Performance

Cloud | Hybrid | On-Premises

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

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

Require-ments → Design → Digital Twin → **Simulation** → Data Management → Data Analytics

Use State of the Art Software & Tools

OpenFOAM®

Archi-tecture | 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