

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

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Agenda

- **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**

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○ — ● 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



Requirements ► Modelling ► Solving ► Evaluation ► Monitoring



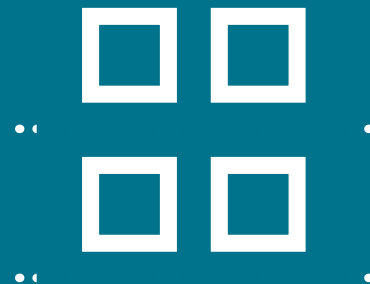
SCALE.project
Status.E



SCALE.model
LoCo



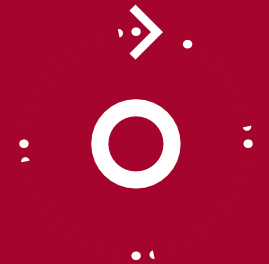
SCALE.result
CAViT



SERVICES

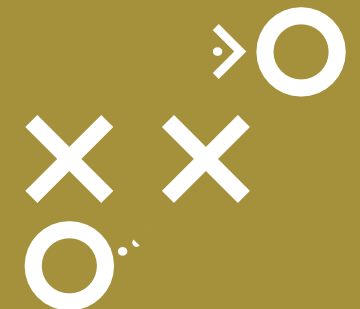
Individual software projects on customer order

- 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

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

Enlight, Femzip, Indeed, Flow3D, TISC, Mathematica, Fire, Hyperworks, Ansa, DARS, VI-Grade, Abaqus, Icem, CFD, CAE, Bench, / SimManager, StarCD, HFSS, DCV, Magma, SBNoise, LS, PrePost, Simulact, Forming, Simdrive, SimDataManager, RSM, Ansys Workbench, RSM, 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, Maple, Forte, Reshape, VisMockup, Radtherm, Simulact, Welding, Femsite, LS Dyna, Catop, Flowmaster, SFE, Concept, Virtualab, Vectis Max, Animator

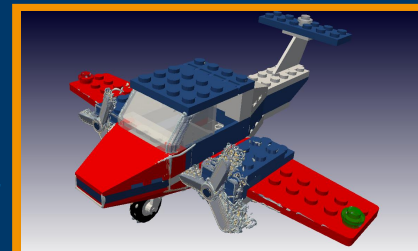
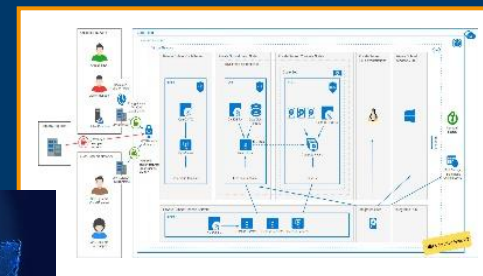


3. Efficiency by Simulation Data Management

2. Tuning the application

1. Running in the cloud - Up to 10.000 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

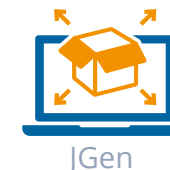
Empowerment

- Workflows
- Benchmarking
- Scaling

Infrastructure Layer



Linux



OpenFOAM®

ParaView

Create Our Lego®* Model

CAD | Pre-Processing | Meshing

Tasks:

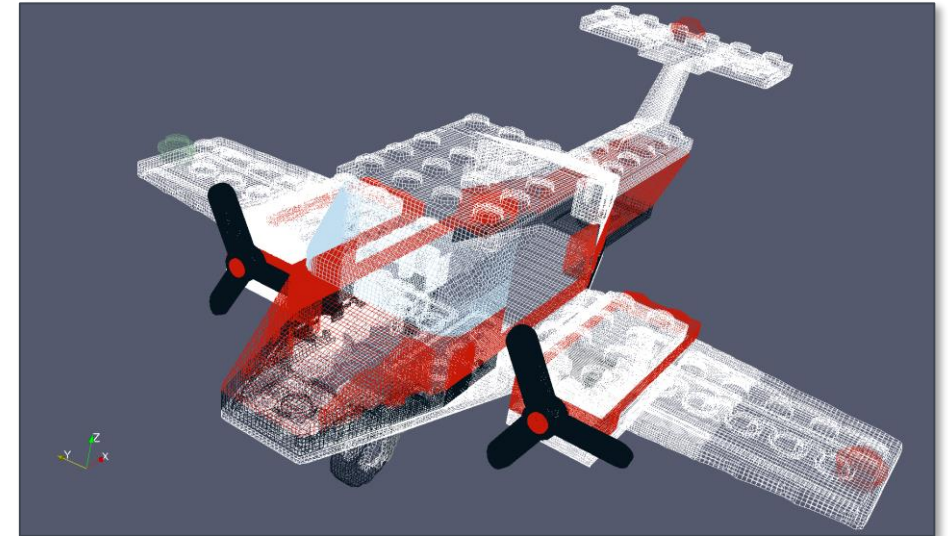
Pre-processing → **Meshing** → Solving (up to ~10.000 cores) → Post-processing

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

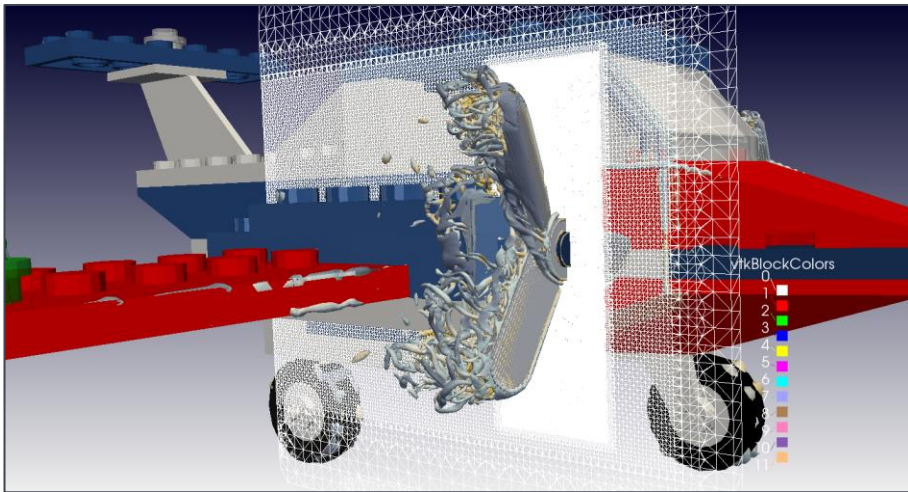


Create Our Lego®* Model

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

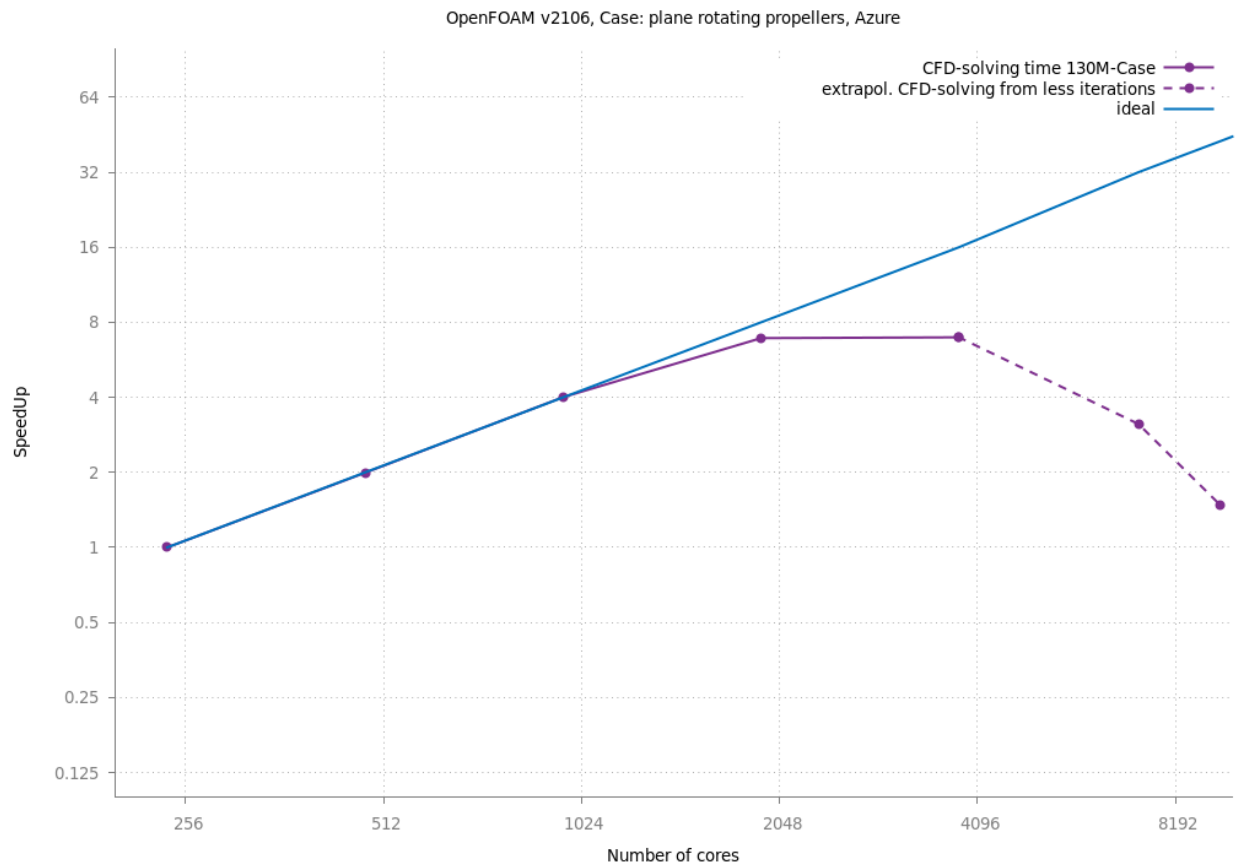
- Result files from solvers
- Deploy to the cloud environment: create the model visualisation
- Automated workflow helps manage large amounts of solver data efficiently
- Goal: Shorten the duration of the process

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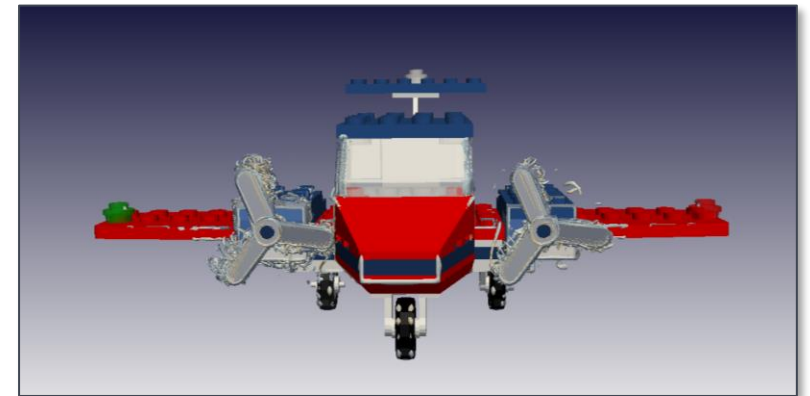
Reaching High Performance

With OpenFOAM® in the Cloud

SpeedUp



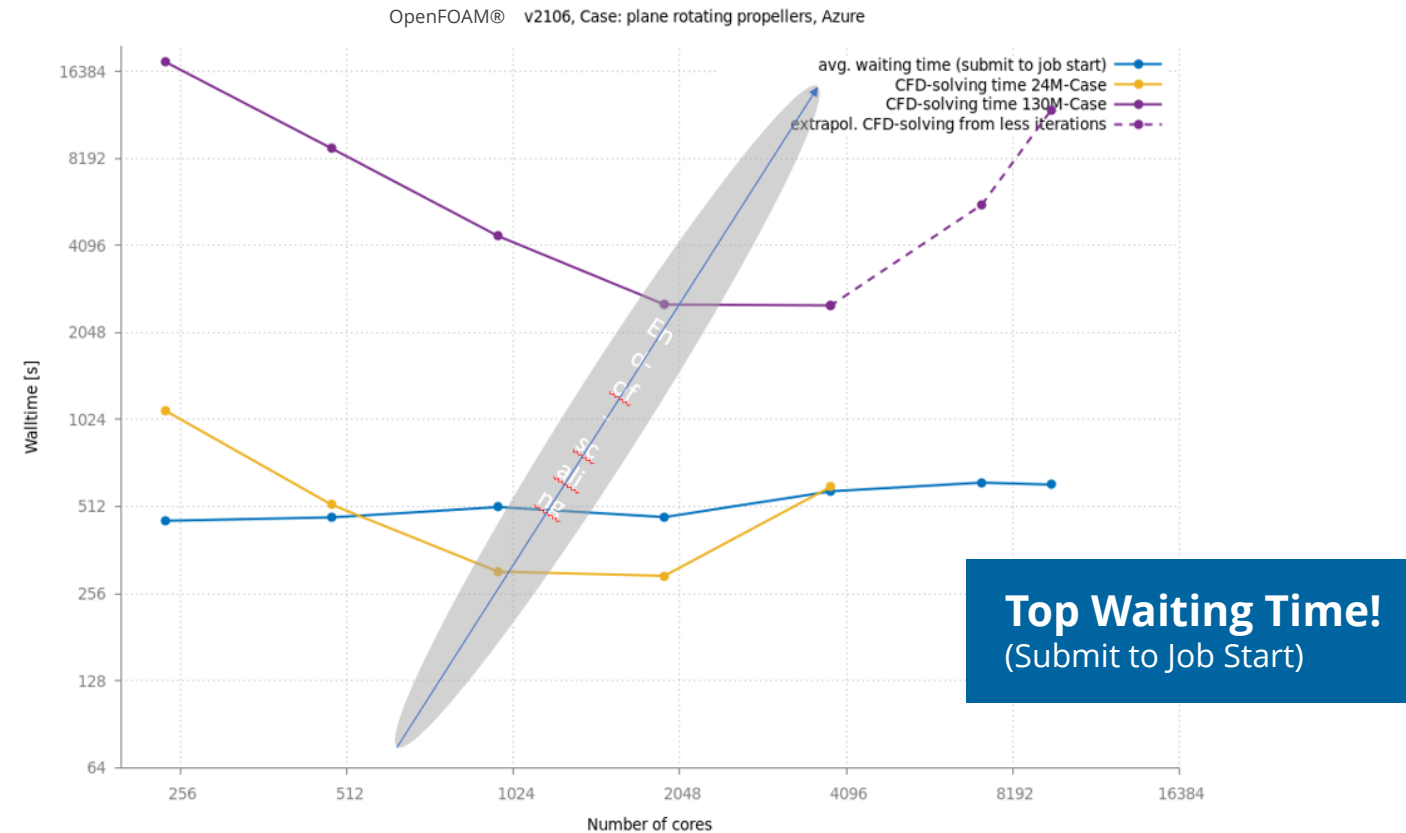
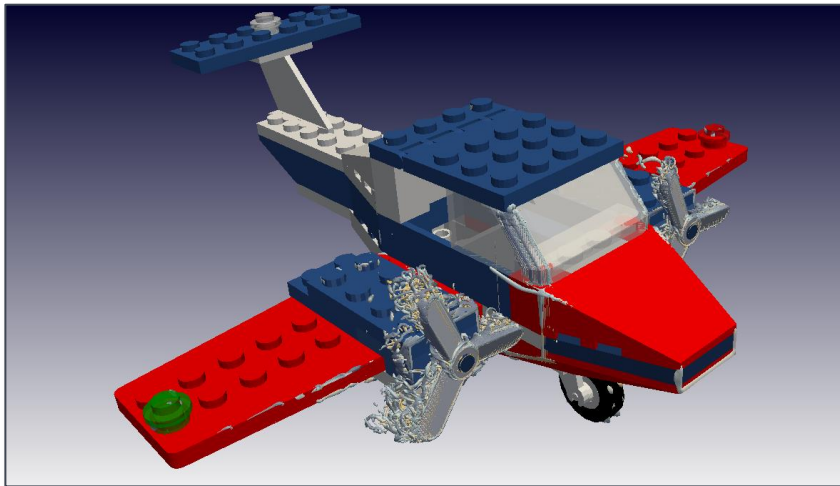
Unlimited Capacities
in the Cloud



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.



Structured Data Management and HPC

SCALE.sdm for OpenFOAM

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

SCALE.sdm → Software Solution for Simulation Data Management



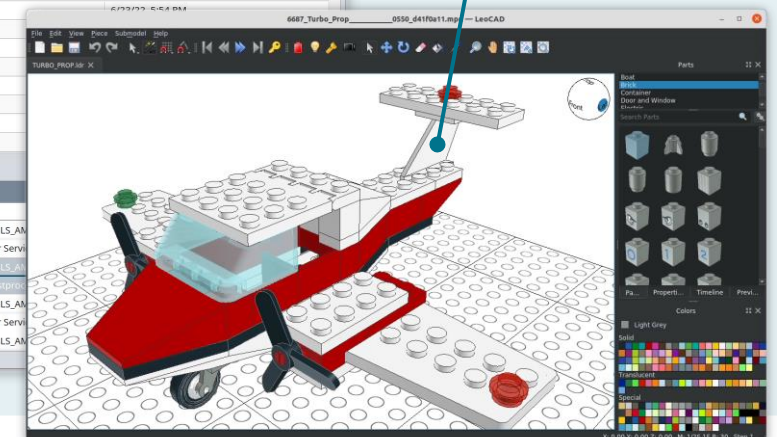
Open FOAM CFD case definition

The screenshot displays the LEGO Co - SCALE.model software interface. The top bar shows the project name 'LEGO [615] | LoCo - SCALE.model | Support: loco-support@scale.eu'. The main workspace is divided into three panels:

- Browser (Left):** A tree view showing the project structure. The '615 [Update CFD Assembly Template]' project is selected, showing sub-projects like 'AUDI_QUATTRO', 'DAVIDONE', 'MERCEDES_SLS_AMG', 'RIVIAN_R1T', and 'TURBO_PROP'. The 'TURBO_PROP' sub-project is expanded, showing a '0° - 100% overlap' view.
- Short Description (Center):** A table listing components and their associated projects. The table has columns for 'Short Description', 'Project', and 'Position'.

Short Description	Project	Position
plane	TURBO_PROP	
MOC_-_SCALECAR_front_wheels	SCALECAR	
76895_-_Ferrari_F8_Tributo	FERRARI	
MOC_-_SCALECAR_rear_wheels	SCALECAR	
6687_Turbo_Prop	TURBO_PROP	
MOC_-_MERCEDES_SLS_AMG	MERCEDES_SLS_A...	
MOC_-_FAKEMINI	FAKEMINI	
MOC_-_MERCEDES_SLS_AMG_rear_whe...	MERCEDES_SLS_A...	
velocities_front_wheels		
MOC_-_RIVIAN_R1T	RIVIAN_R1T	
MOC_-_RIVIAN_R1T_rear_wheels	RIVIAN_R1T	
MOC_-_FAKEMINI_frame	FAKEMINI	
velocities_rear_wheels		
MOC_-_FAKEMINI_rear_wheels	FAKEMINI	
76897_-_1985_Audi_Sport_quattro_S1_fr...	AUDI_QUATTRO	
76897_-_1985_Audi_Sport_quattro_S1_f...	AUDI_QUATTRO	
76897_-_1985_Audi_Sport_quattro_S1_f...	AUDI_QUATTRO	
MOC_-_DAVIDONE	DAVIDONE	
MOC_-_DAVIDONE_rear_wheels	DAVIDONE	
MOC_-_DAVIDONE_front_wheels	DAVIDONE	
MOC_-_FAKEMINI_front_wheels	FAKEMINI	
- Properties (Right):** A panel showing the properties of the selected component. It includes a 'Basic Information' section with fields like 'UUID', 'Version', 'Initial Pool-Version', 'Date Created', 'Date Modified', 'Owner', 'Team Status', 'Live status', 'Synchronized', 'Group', and 'Component Type'. Below this is a 'Jobs' section with a list of simulation jobs, including '0016_MERCEDES_SLS_AMG' and '0016_MERCEDES_SLS_A...'. A small inset image shows a 3D model of a red sports car.

Integration of CAD and preprocessing tools



Simulation Data Management

SCALE.sdm → Software Solution for Simulation Data Management



Extraction and Evaluation of results



Management of Post Data



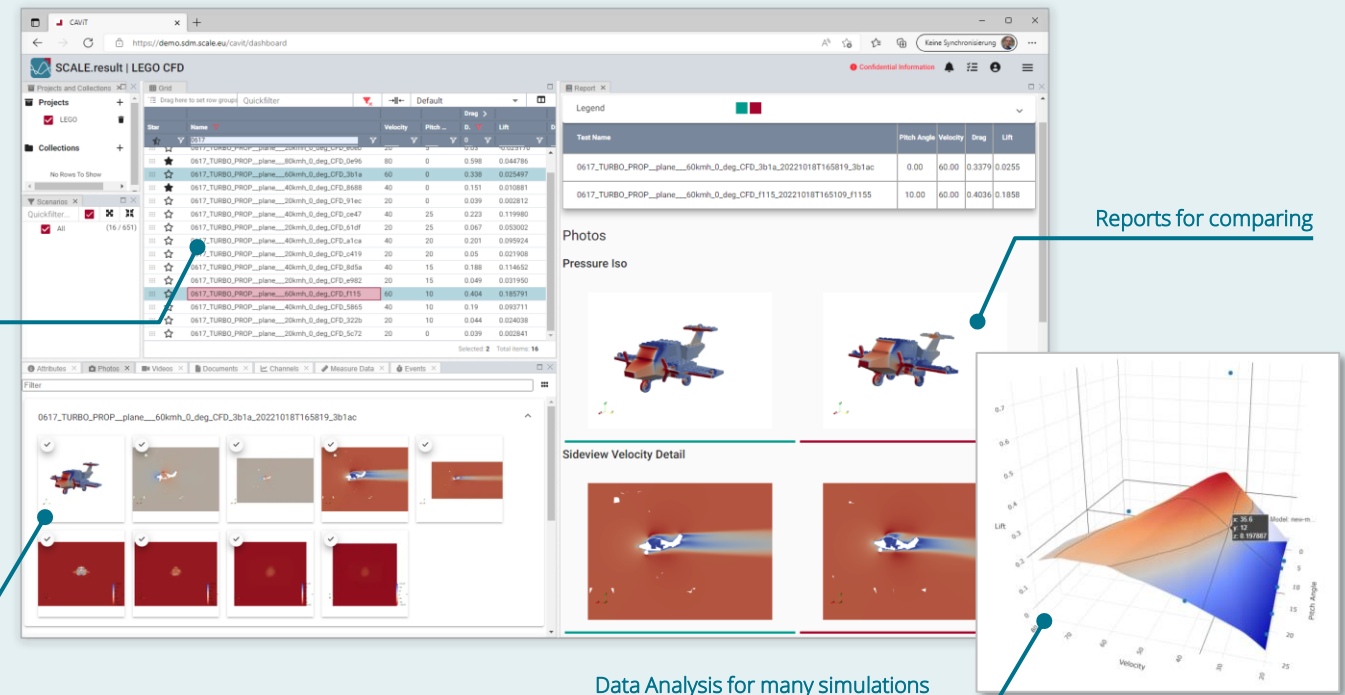
Correlation Test vs Simulation



Assessment and Reporting

Files, Pictures, Videos, KeyResults, ...

Simulations



Reports for comparing

Data Analysis for many simulations



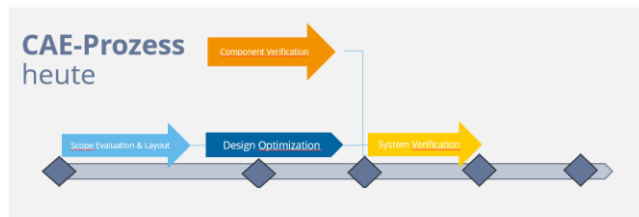
Structured Data Management and HPC

Process Automation via CI/CD-Pipeline

Outlook: What if...

... CAE Processes were Fully Automated?

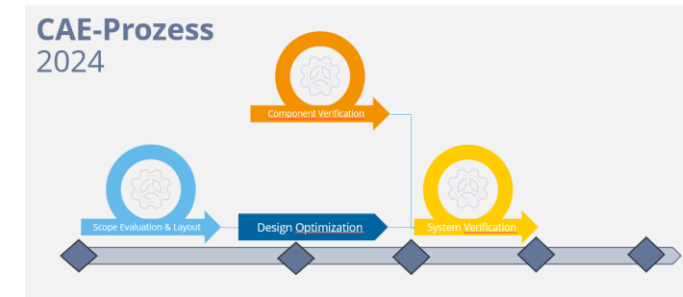
Current CAE Environment



- 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

A decorative line graphic on the left side of the slide. It starts with a horizontal line at the top left, then goes down, then right, then down again, ending in a small circle. Below this, there is another line that goes down, then right, ending in a small circle. A small grey dot is located at the end of this second line.

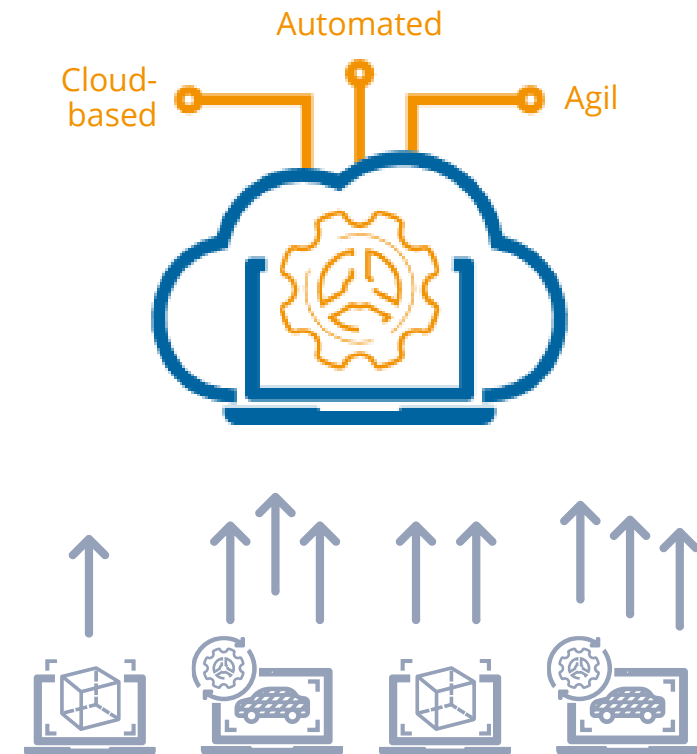
Structured Data Management and HPC

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



Marko Thiele

SCALE GmbH

E-Mail: Marko.Thiele@scale.eu

www.scale.eu

Christopher Woll

GNS Systems GmbH

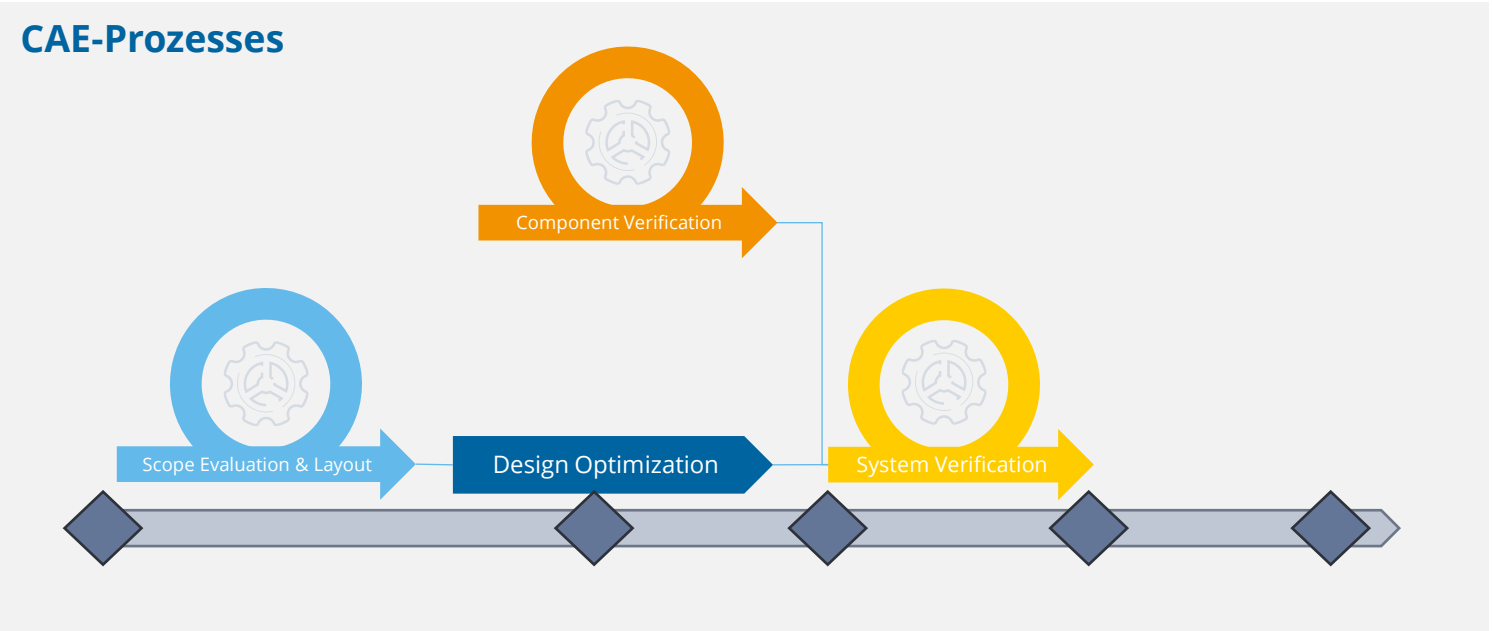
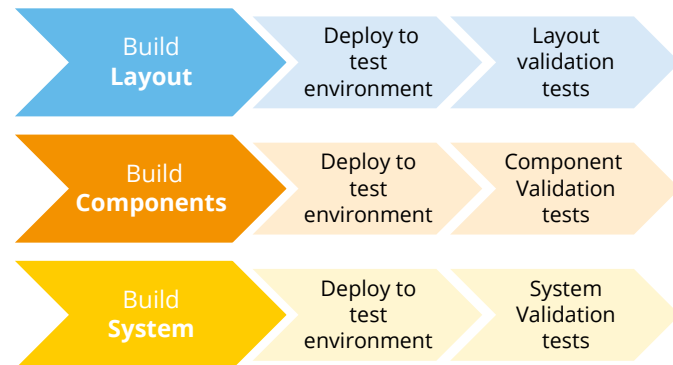
E-Mail: Christopher.Woll@gns-systems.de

www.gns-systems.de

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:
Digital Twin Architecture Management:
Model/System Assembly (Twin Builder):

AzureBoards or Alternative
Customer-decision
Custom-made or Evaluation

Automation

Validation Pipelines:
Workflow Management/Engine:

AzurePipelines or SPDM integrated
JGen, Volta, BPM tools, ...

HPC

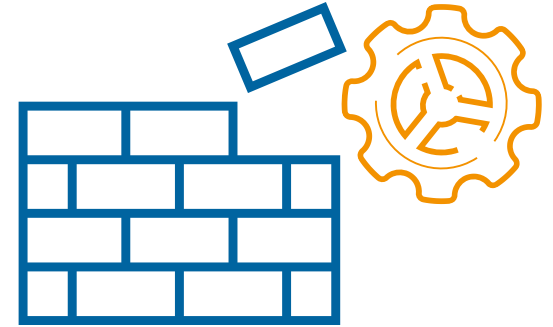
Supplementary HPC applications:
Postprocessings:

Abaqus, Matlab/Simulink, GT Cool, FMI/FMU, Python
CAE Apps, automatisiert

Data

Test Data Management and Evaluation:
Simulation (Process) Data Management:
CAEBench/SimManager,...
Interfaces for data access/exchange:

Customer-decision
Minvera, SCALE.sdm, SimDataManager, Volta,
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



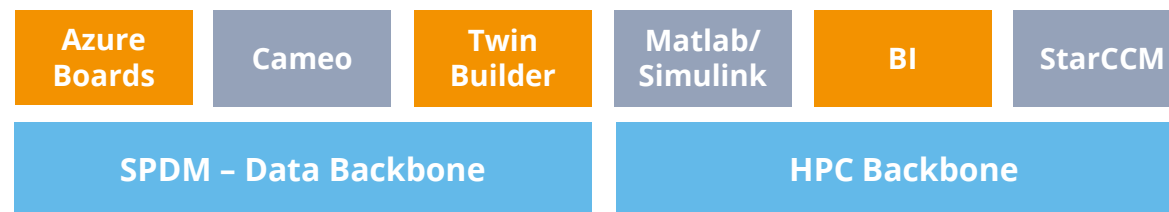
Sensors

Three Levels of Integration

Map the Complete Engineering Process



Use State of the Art Software & Tools



Accelerate with Maximum Compute Power and Performance



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



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