

Simulation Data Management from CAD to Result for Large LEGO® Crash Models

JSOL CAEフォーラム 2023

November 29th, 2023

JSOL CORPORATION **SCALE**

IT-Solutions for CAE

SCALE.sdm → Software Solution for Simulation Data Management

 SCALE.project
Status.E

 SCALE.model
LoCo

 SCALE.result
CAViT

 SCALE.project
Status.E

Project



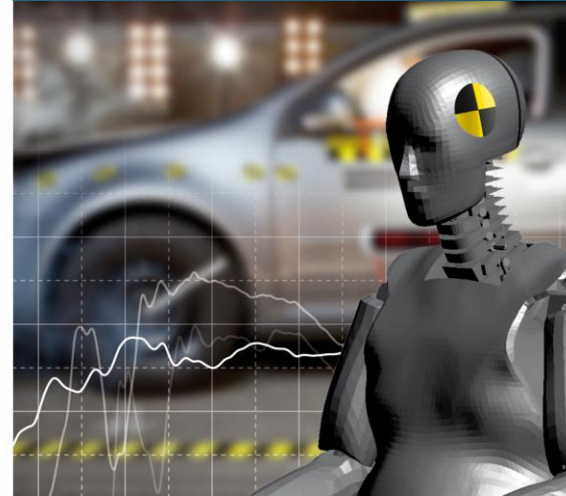
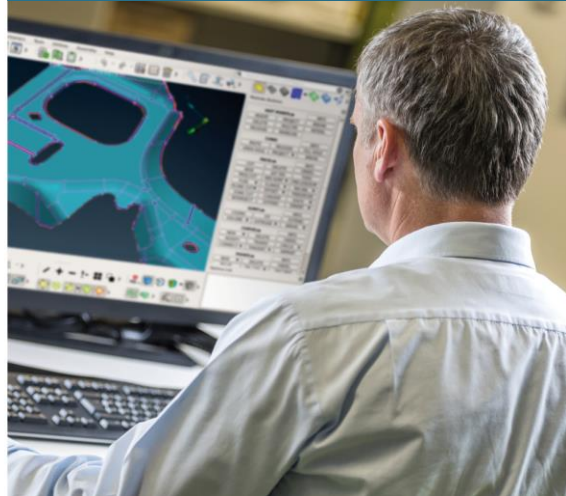
Simulation



Assessment



Targets



SCALE.sdm → Software Solution for Simulation Data Management



Setup of Project



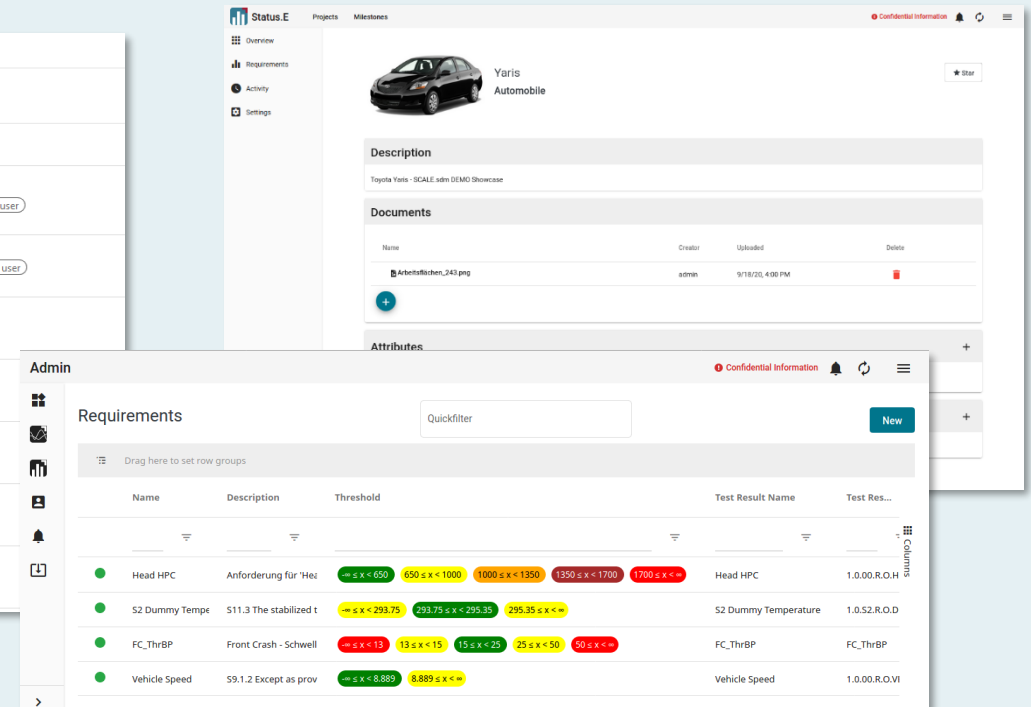
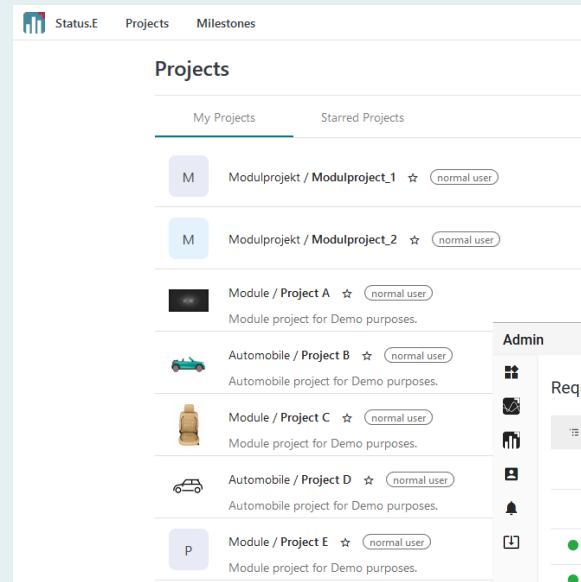
Define Responsibilities



Specify Milestones



Prescribe Requirements



SCALE.sdm → Software Solution for Simulation Data Management



Import CAD or Meshes



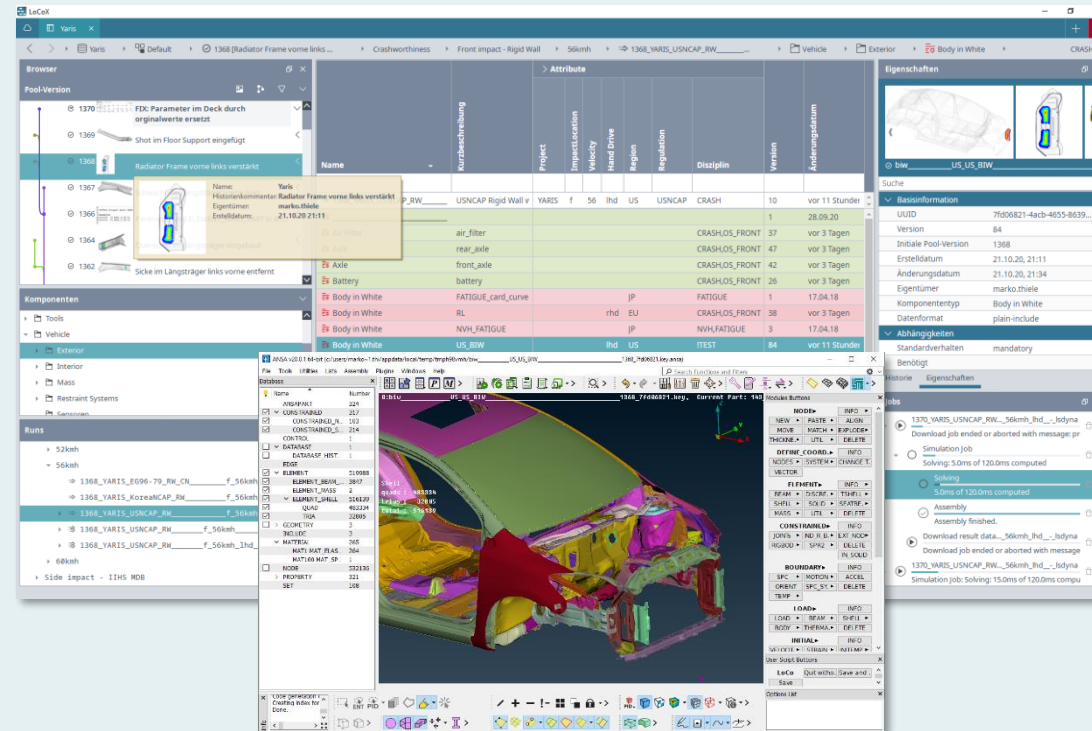
Prepare Models



Define Load Cases



Run Simulations



SCALE.sdm → Software Solution for Simulation Data Management



Extraction and Evaluation of results



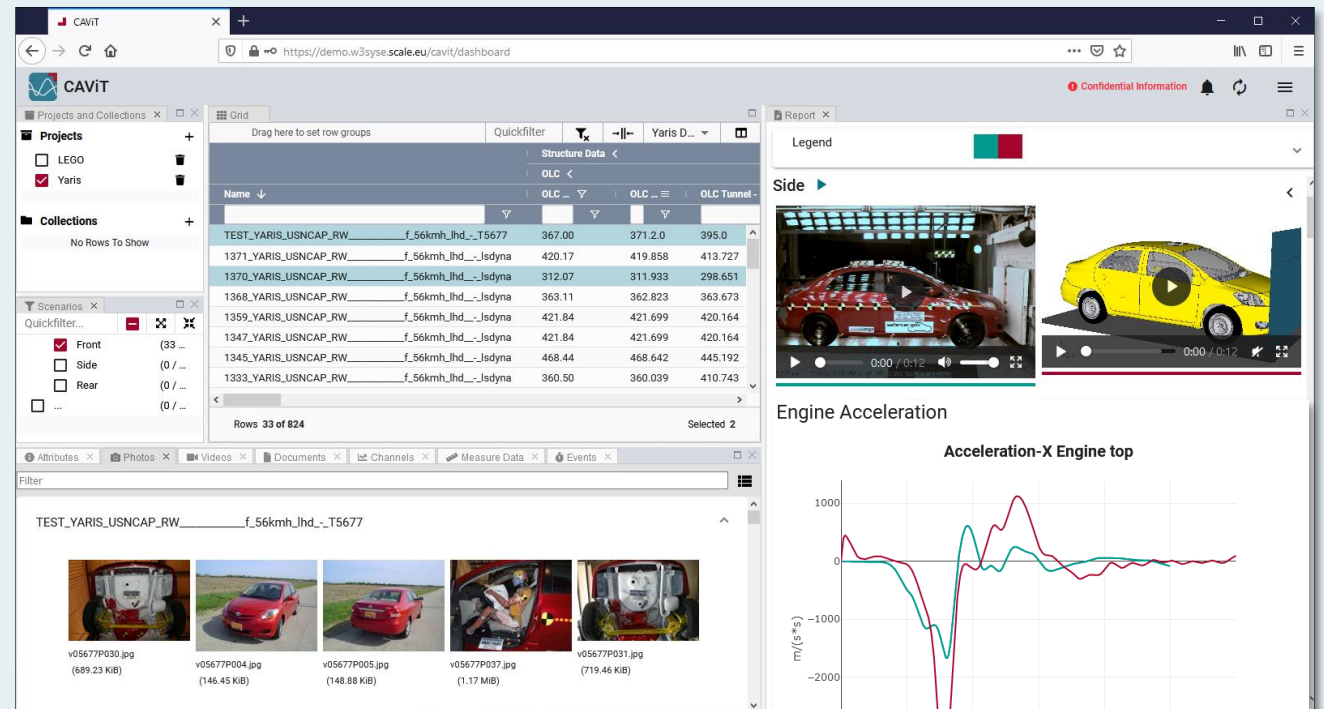
Management of Post Data



Correlation Test vs Simulation



Assessment and Reporting



SCALE.sdm → Software Solution for Simulation Data Management



Import of Key Results



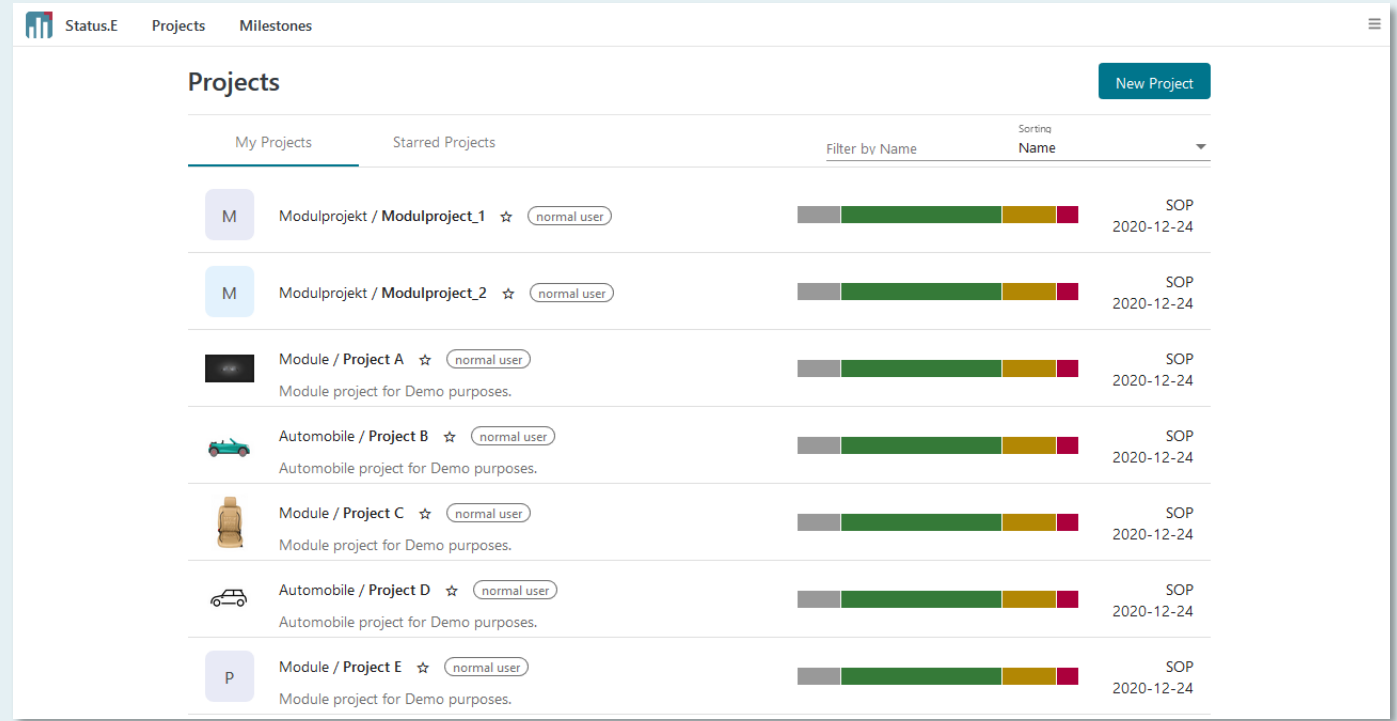
Monitor Project Status



Analyse Maturity Level



Decision for Approval



The LEGO® Challenge

WHAT WILL
HAPPEN?



WE SHOULD BE ABLE TO PREDICT THIS
WITH SIMULATION!

First attempts to set up LEGO® Models

Prototype



Modeling in CAD

CAD



Rendering

Rendering



Physical Build

Real World Model



<http://www.ldraw.org/>



<https://www.leocad.org>



<https://www.bricklink.com>

SCALE

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Setup Requirements for the Project

Requirements
technical targets for the project

Structured by
category, vehicle
and velocity

> CFD (8)	
Front Impact (16)	
> AUDI_QUAT... (4)	
> MERCEDES_... (4)	
> RIVIAN_R1T (4)	
SCALECAR (4)	
20 km/h (2)	
	Level of destruction (@20 km/... Rating of destruction level for LEGO simulation mode...
	max. Acceleration (@20 km/h) max. Acceleration for LEGO simulation models
> 30 km/h (2)	

Thresholds for level of destruction

Thresholds for acceleration

Level of destruction thresholds: $-\infty < x < 20$ (green), $20 < x < 24$ (yellow), $24 < x < \infty$ (red)

Acceleration thresholds: $-\infty < x < 1200$ (green), $1200 < x < 1500$ (yellow), $1500 < x < \infty$ (red)

Milestones
definition of all project milestones and targets



Monitoring
transparent project status at any time

Assessment
individual assessment by users

Project Status
aggregated on each level of requirements

CFD (8)	yellow
30 km/h (4)	yellow
MERCEDES_SLS_AMG (2)	green
SCALECAR (2)	yellow
Drag (@30 km/h)	0.41 yellow
Lift (@30 km/h)	0.32 green
40 km/h (4)	yellow
Front Impact (16)	green
20 km/h (8)	green
AUDI_QUATTRO (2)	yellow
MERCEDES_SLS_AMG (2)	green
RIVIAN_R1T (2)	yellow
SCALECAR (2)	green
Level of destruction (@20 km/h)	22.62 green
max. Acceleration (@20 km/h)	1738.03 red

Aggregated status

User assessment

Manage CAD data in the SDM-System^[1]

- CAD data in the SDM-system
imported, versioned, managed
- Product structure
disassembled into groups to allow teamwork
- Integrated CAD tools
can be opened and worked with directly
- Teamwork
changes automatically synced to all team members

Product structure rebuild
from LDraw model



<http://www.ldraw.org/>



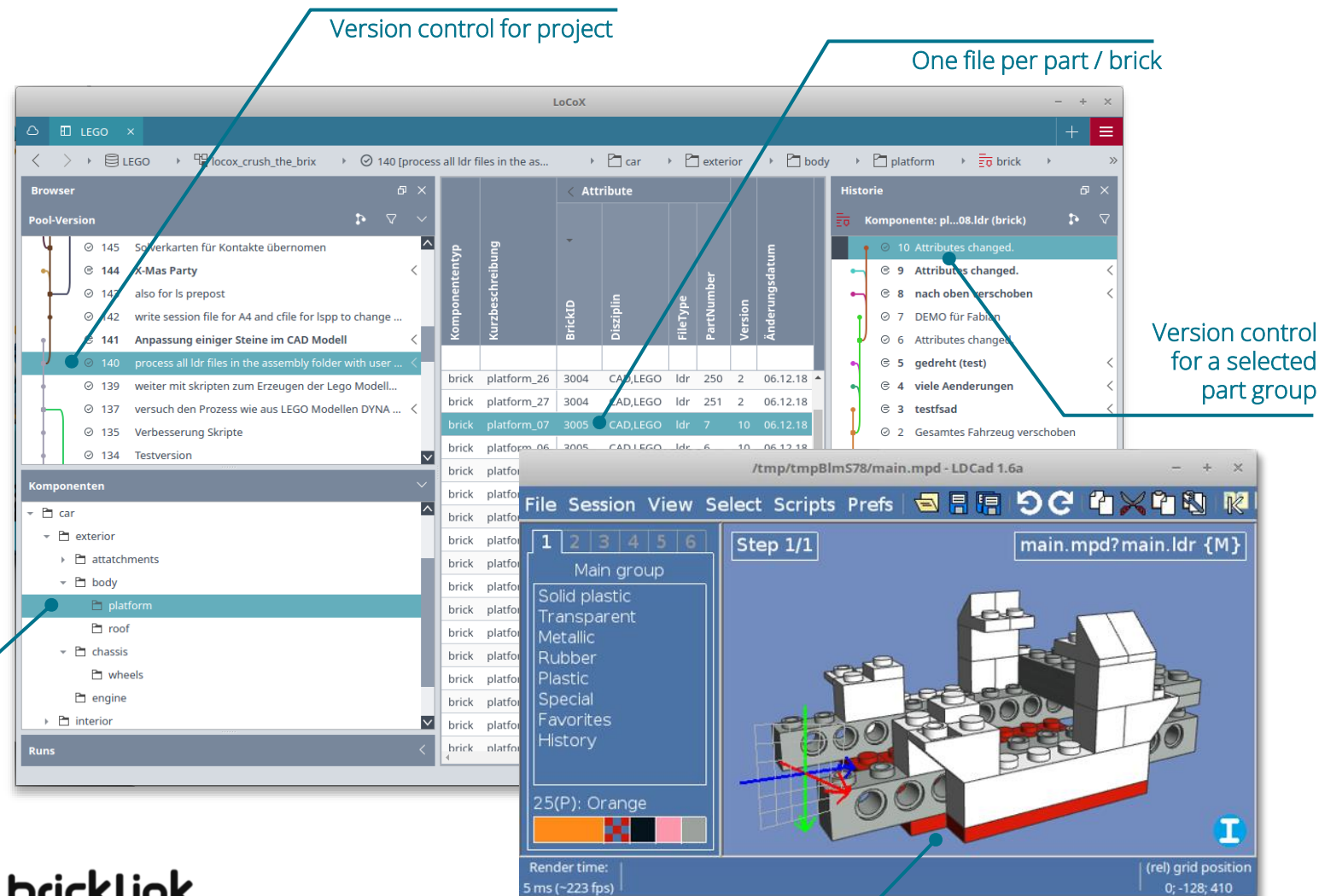
<https://www.leocad.org>



<https://www.bricklink.com>

SCALE

[1] C. Knebler, M. Thiele, D. Matthus, P. Friedrich, "Prospects of integrating CAD and CAE in Simulation Data Management", NAFEMS European Conference Simulation Process and Data Management (SPDM), 28-29 November 2018, Munich, Germany



Opening and working with CAD
assemblies from within SCALE.sdm

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Meshing of CAD Data^[1]

The image displays two software windows. The top window is LoCoX, showing a project browser on the left with a tree structure including 'Libraries', 'Barriers', 'Bricks', and 'Bricks (517 - Bricks)'. The main area shows a table of components with columns for 'Komponententyp', 'Kurzbeschreibung', 'BrickID', 'Solver', 'ElementSize', 'Disziplin', 'MeshingStep', 'setSize', 'Type', 'presentation', and 'sion'. A table of components is visible, listing various 'Technic_Bus' parts with their respective IDs, sizes, and meshing steps.

The bottom window is ANSA v18.1.0, showing a 3D model of a mechanical part (a bush with two flanges) that has been meshed. The mesh is displayed as a gray, faceted surface. The ANSA interface includes a menu bar, a toolbar, and a right-hand panel with various tool buttons for meshing and analysis.

Annotations with arrows point to specific features:

- Brick library mounted to project:** Points to the 'Bricks (517 - Bricks)' folder in the LoCoX browser.
- Various representations of CAD geometry and meshed bricks:** Points to the 3D model in ANSA, which shows both the original CAD geometry and the resulting mesh.
- Versions of brick library or individual meshes:** Points to the 'Historie' (History) panel in LoCoX, which lists operations like '517 Merge', '516 Fix for Brick #85984', '515 #4733', and '514 Attributes changed'.
- Brick opened for meshing directly from SDM-system:** Points to the '3713_1mmHEXA02_ansa' file in the ANSA interface.



Setup of Load Cases and Solving

Runs

- ▼ SCALECAR
 - ▼ Front impact - Rigid Wall
 - ▶ overlap 100 pct
 - ▼ overlap 25 pct
 - ▶ 10 kph
 - ▼ 17 kph
 - ⇒ 0381_SCALECAR_8stud_H_f_w_17kmh_0_deg_25pct_1st-pos_
 - ⇒ 0381_SCALECAR_8stud_H_f_w_17kmh_30deg_25pct_1st-pos_
 - ⇒ 0381_SCALECAR_8stud_H_f_w_17kmh_45deg_25pct_1st-pos_
 - ⇒ 0381_SCALECAR_8stud_H_f_w_17kmh_60deg_25pct_1st-pos_
 - ⇒ 0381_SCALECAR_8stud_H_f_w_17kmh_90deg_25pct_1st-pos_
 - ▶ 25 kph
 - ▶ overlap 50 pct
 - ▶ car 2 car impact - no barrier
 - ▼ AUDI_QUATTRO
 - ▼ Front impact - Rigid Wall
 - ▼ overlap 100 pct
 - ▼ 18 kph
 - ⇒ 0381_AUDI_QUATT
 - ⇒ 0381_AUDI_QUATT

Flexible grouping of runs by their properties

Setup of multiple different scenarios

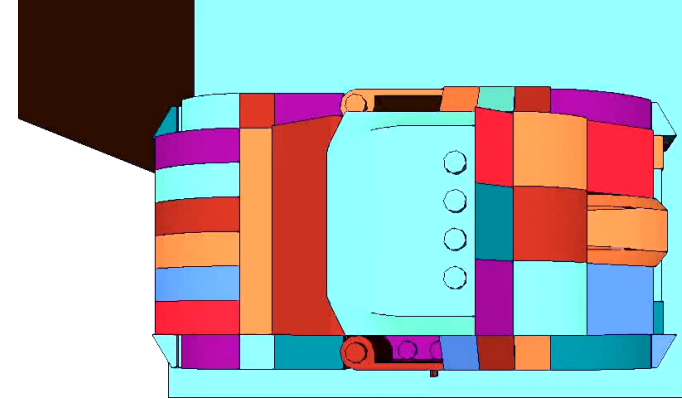
Setup of multiple cars

Job Monitoring

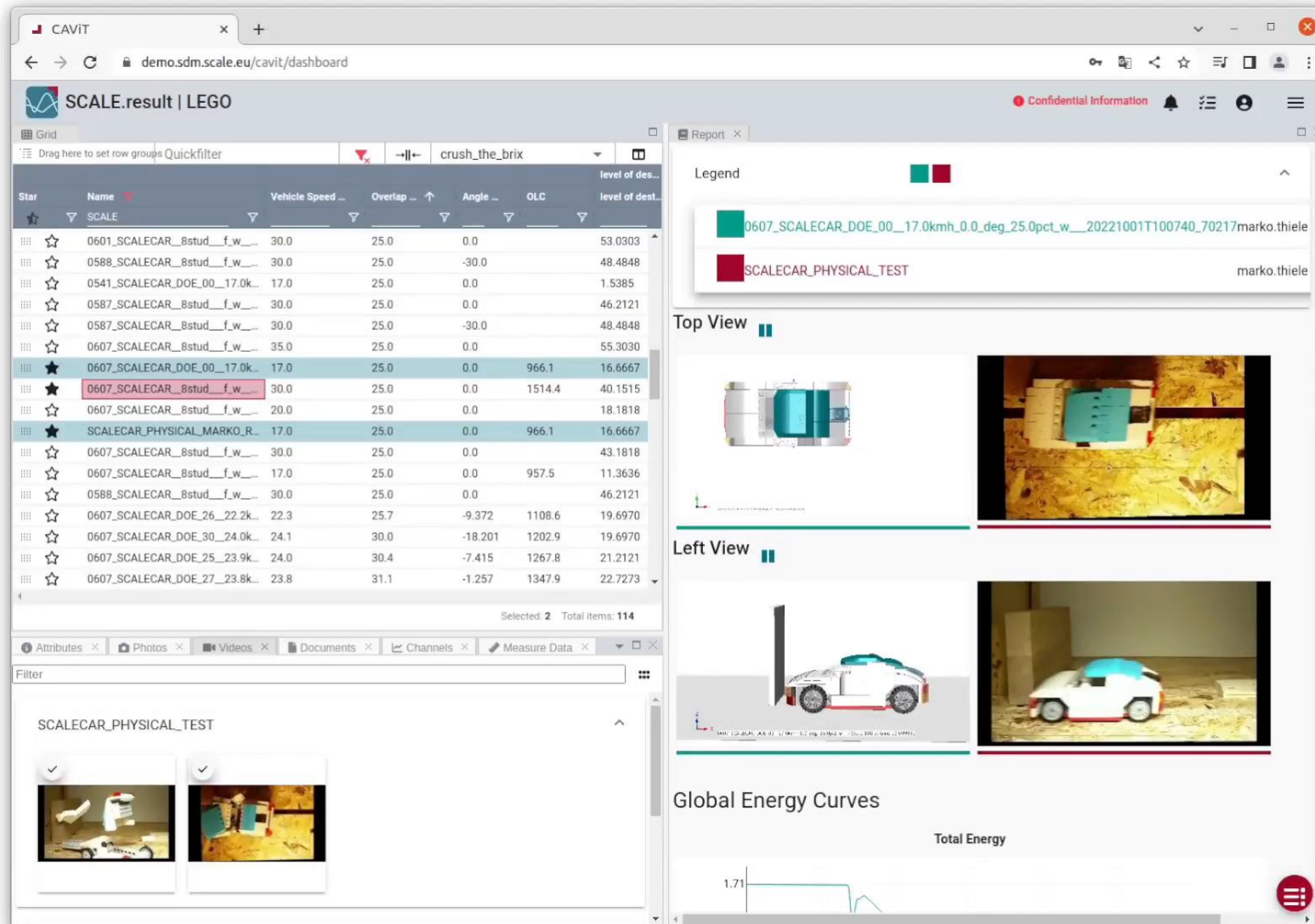
Jobs

Filter

 - ▶ 0042_1st-PORSCHE_60.0kmh_0.0_deg_0....TI_0.0_kmh_270.deg_-1145off_-_04fa
 - Simulation Job: Solving: 59.12ms of 130.1ms computed KIN=46.7%, INT=2.6% [Job](#)
 - Simulation Job
 - Solving: 59.12ms of 130.1ms computed KIN=46.7%, INT=2.6% [Job Folder Log](#)

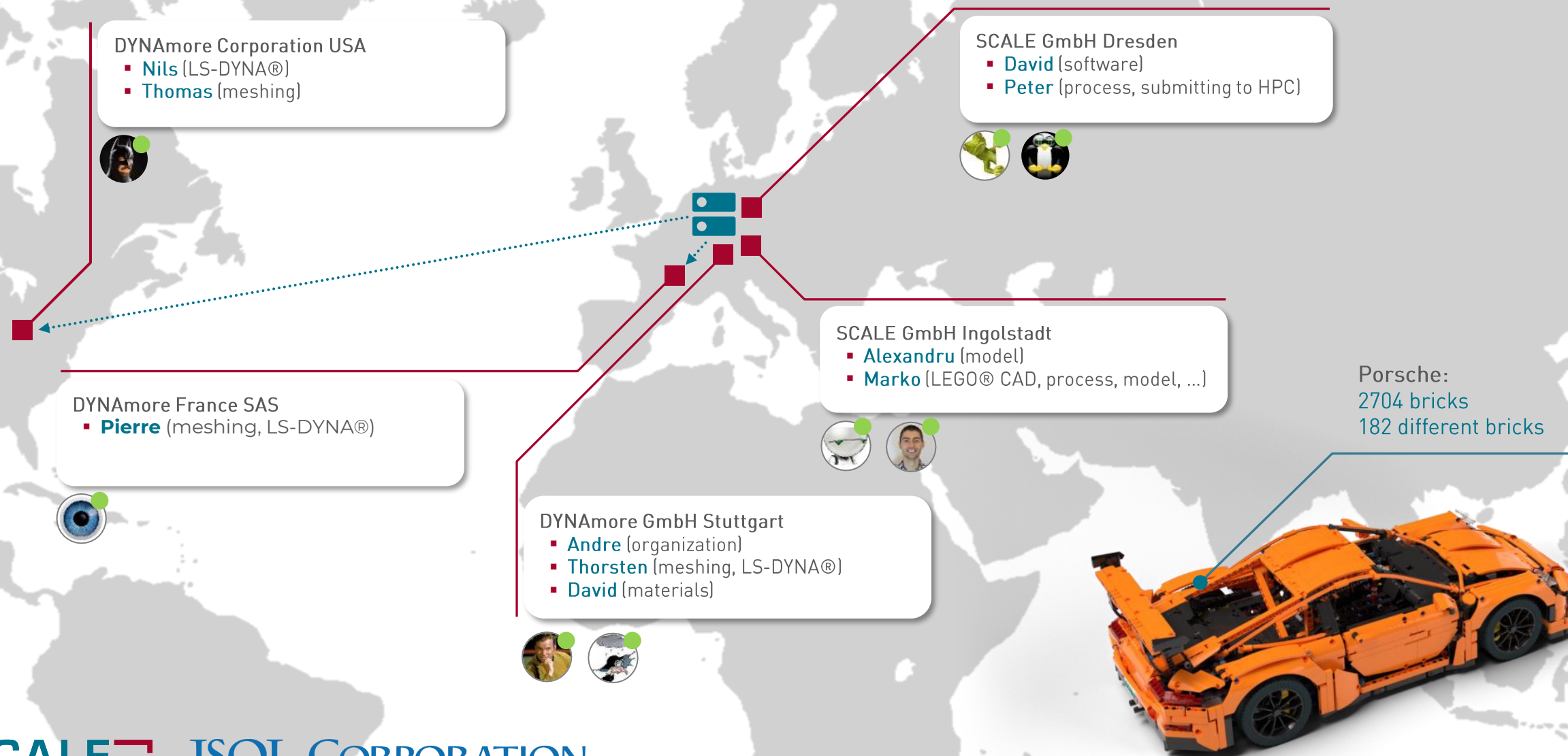


Simulation Results compared to Test



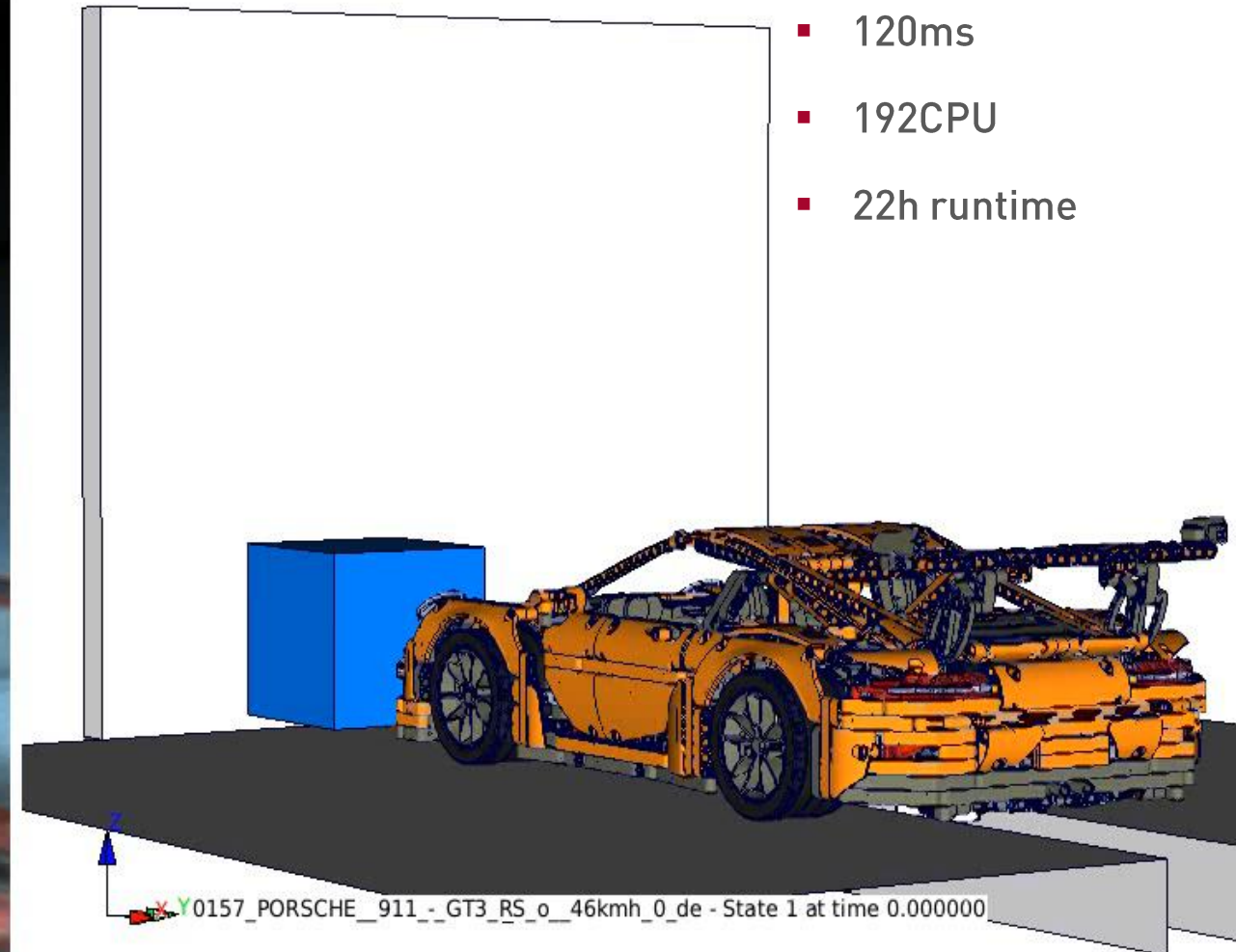
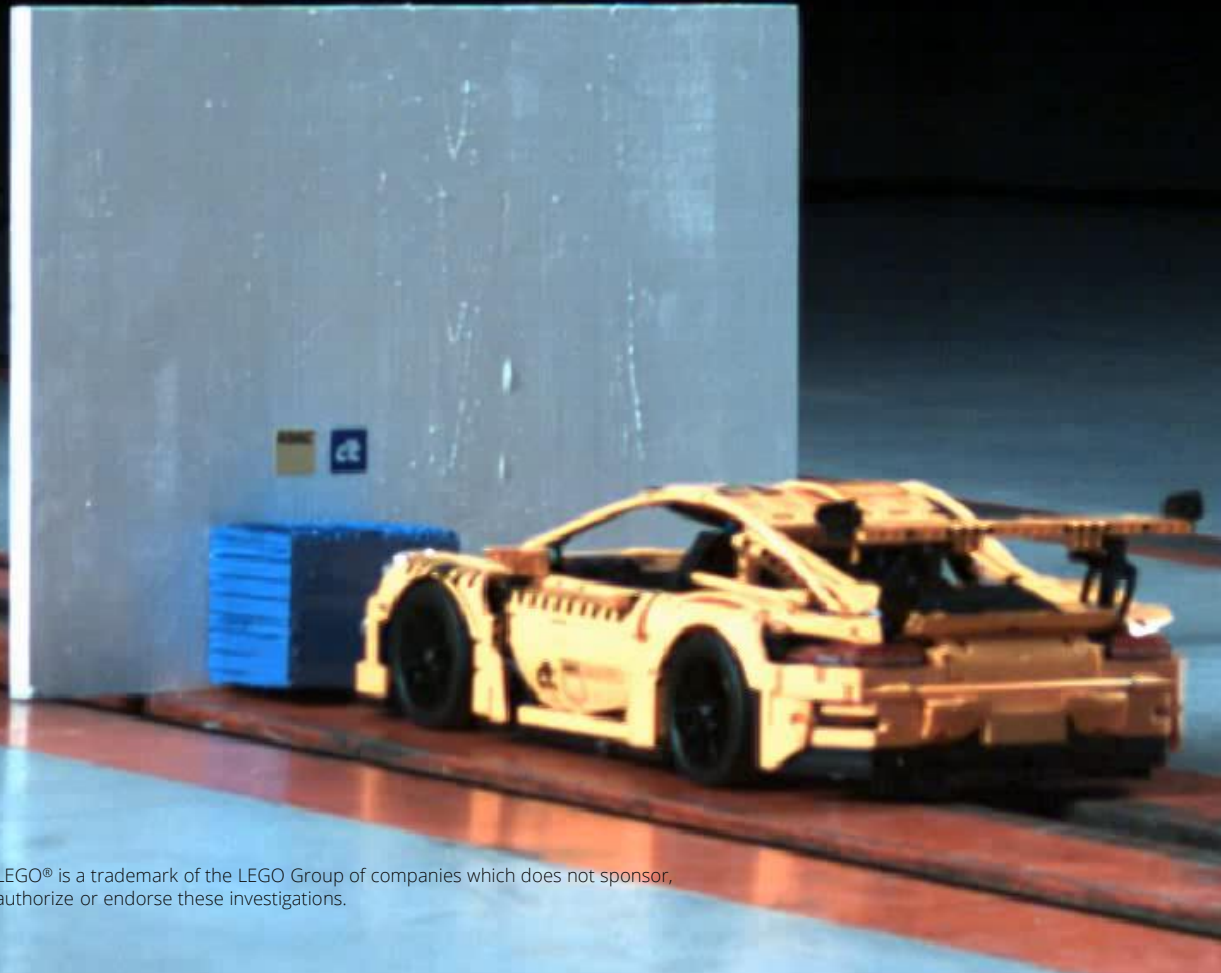
- Simulations correlated with test videos
- Parameters for validation
 - Friction
 - Clamping force
 - DTSTIF
- Basis to start more complex challenges

Model created by collaboration with SDM



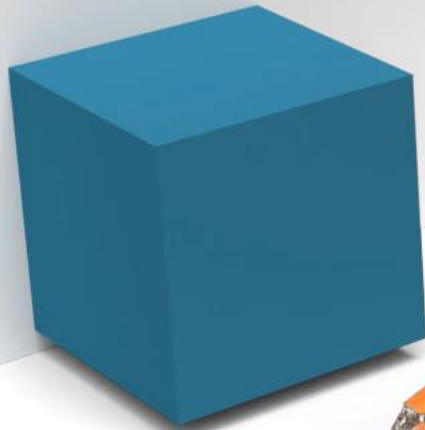
Simulation Results

- 2704 parts (bricks)
- 19.5M elements
- 120ms
- 192CPU
- 22h runtime



Simulation Results

- 2704 parts (bricks)
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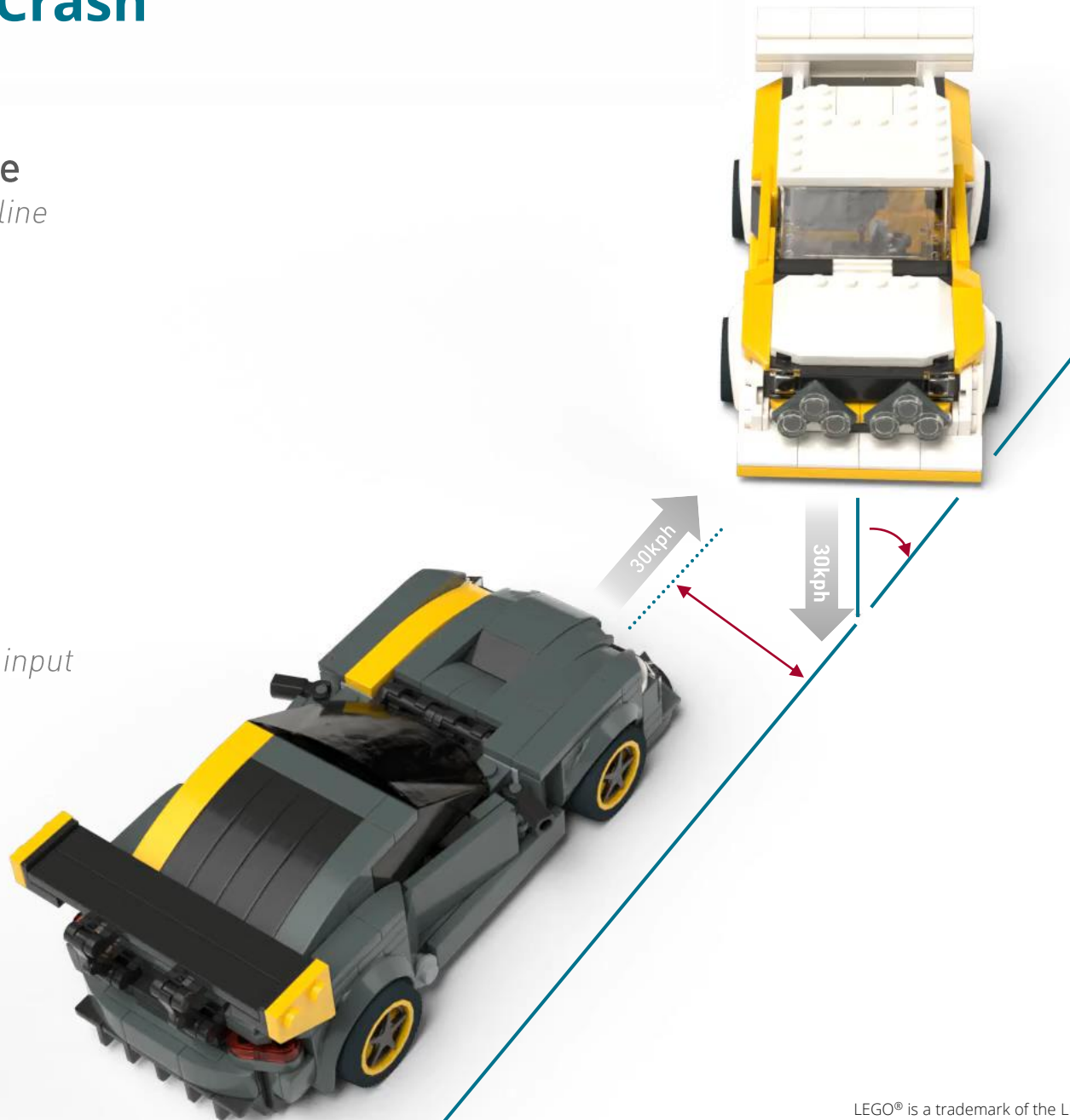
The LEGO® Challenge

#legowette



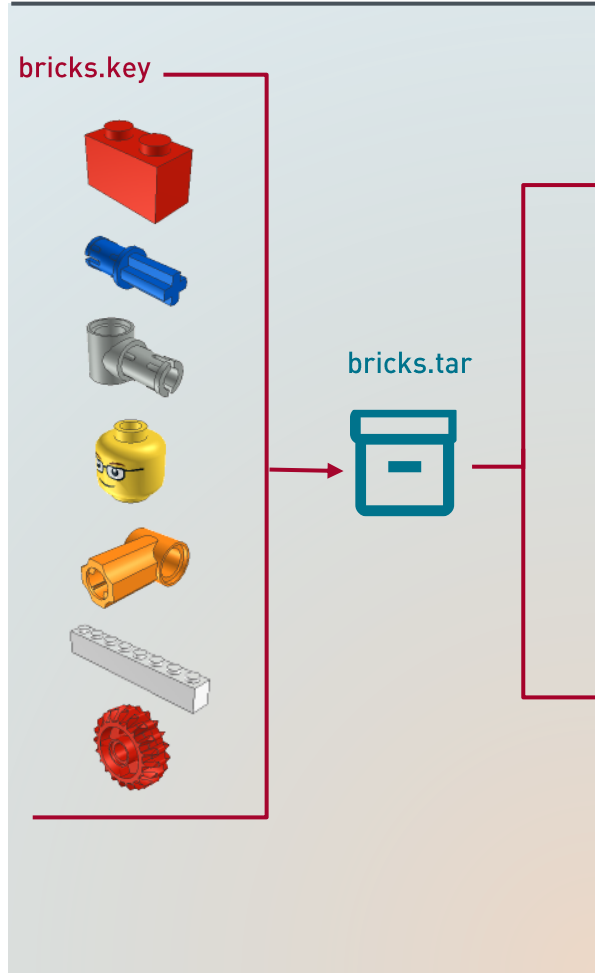
Discipline – Car 2 Car Crash

- **Separate project & discipline**
car to car crash as simulation discipline
- **Parameterization**
velocity, angle, offset, ...
 - DOE studies
 - Data analysis
- **Multi-stage-assembly**
references individual car projects as input

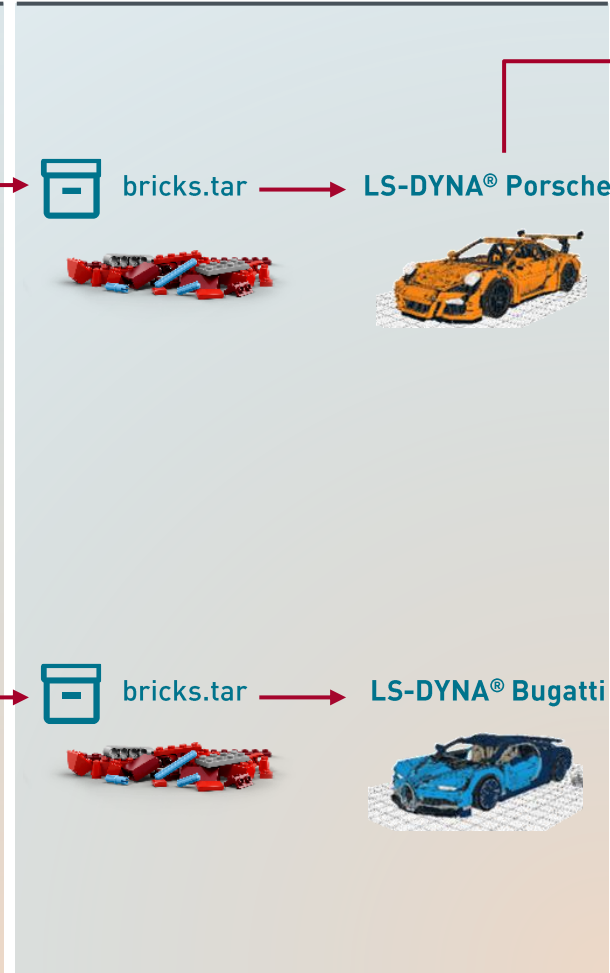


Multi Stage Assembly

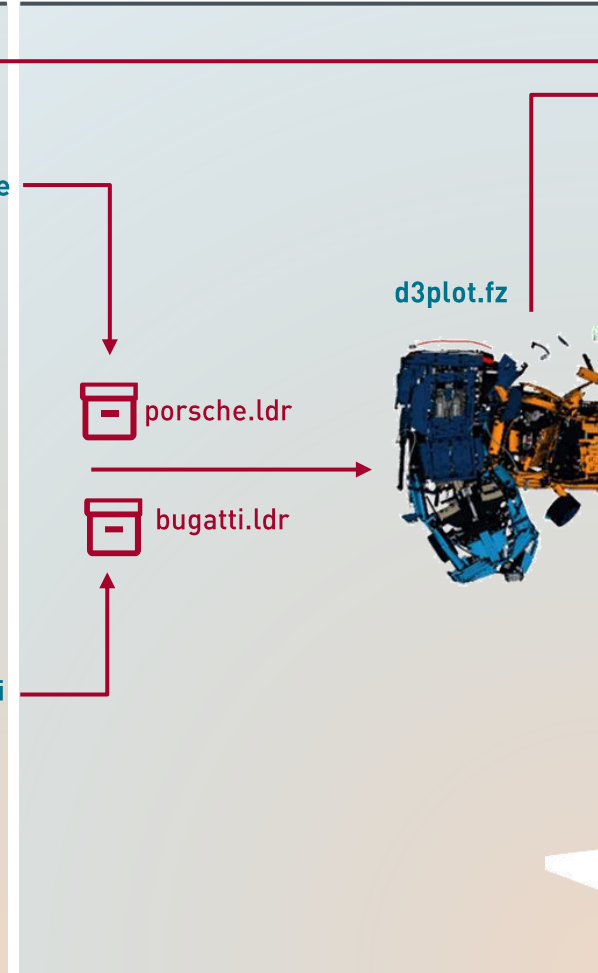
Stage 1: create library



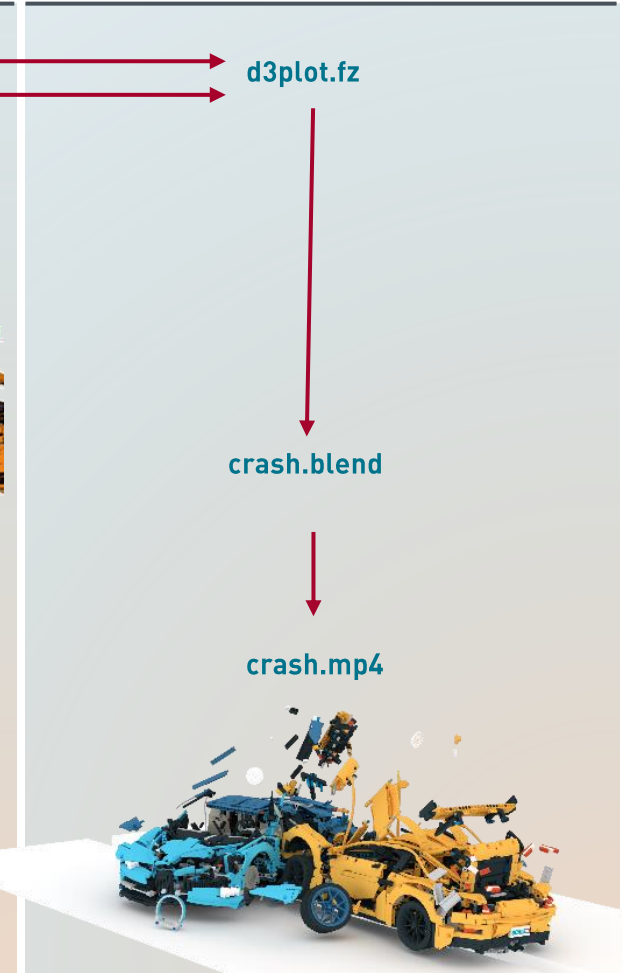
Stage 2: create car model



Stage 3: car to car simulation



Stage 4: rendering

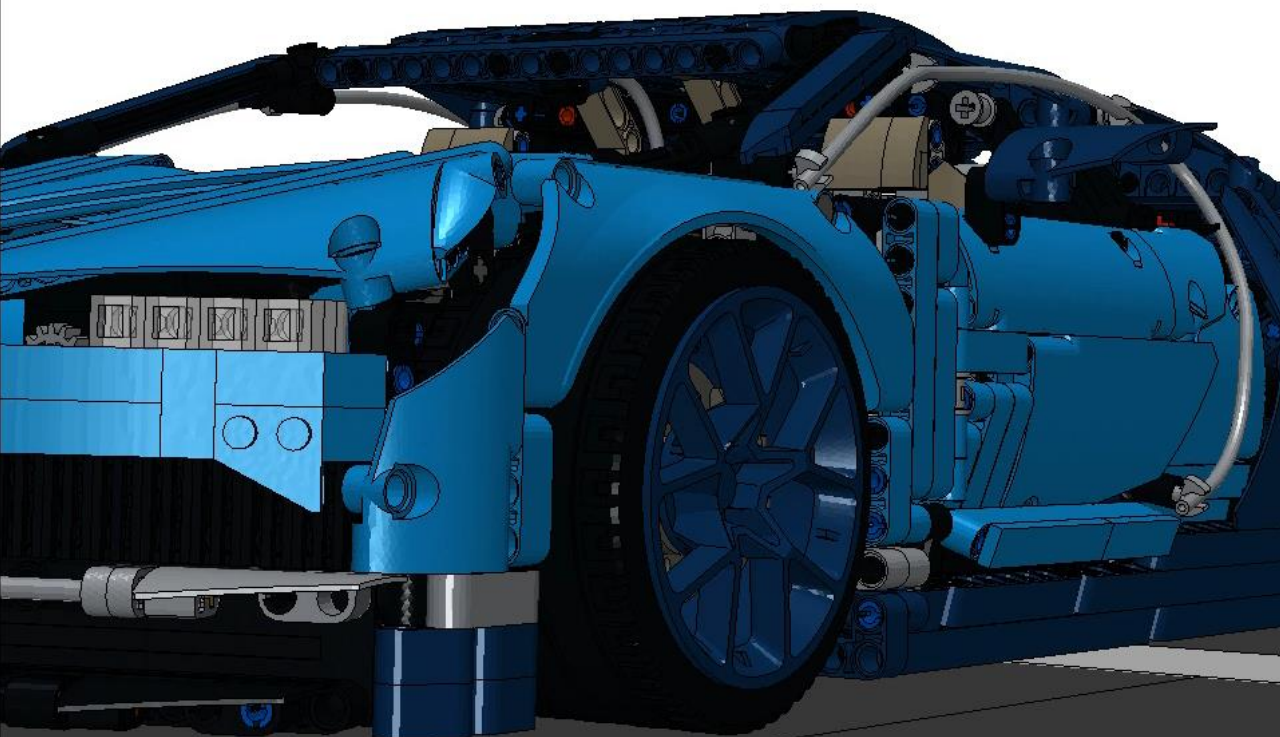


Simulation Results

- 6303 parts (bricks)
- 45.8M elements
- 130ms
- 192CPU
- 54h runtime



Simulation Results

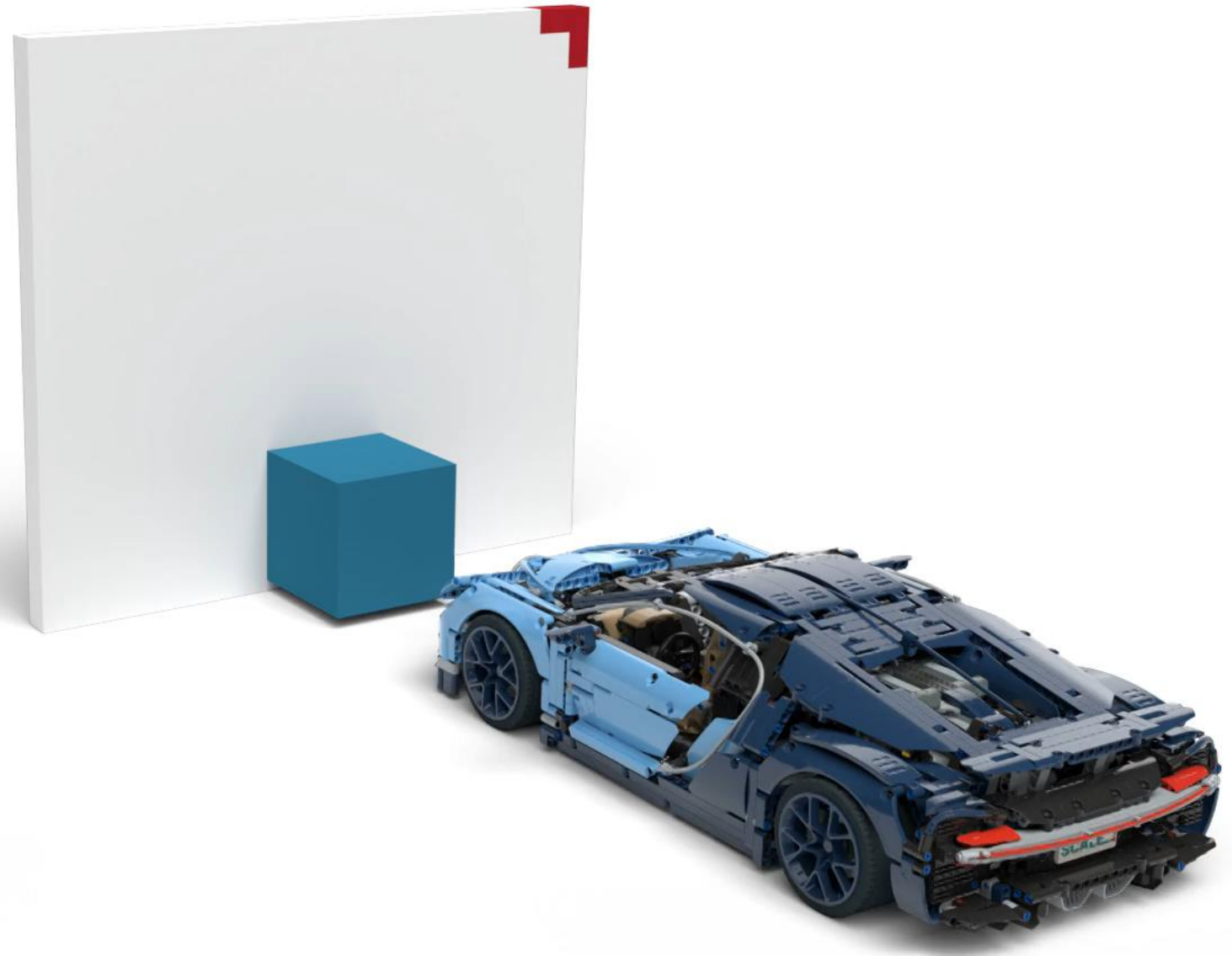


- 60kph
- 300kw halogen spot lights
- 50m track
- 10 x 1000fps high speed cameras



CAE DISCIPLINE: Rendering

- **Simulation of light**
setup and automated within SDM-System
- **Preprocessor**
 - **Blender** *simulation*
for studio and lighting setup
 - ***.blend files** *d3plot.fz*
managed in SDM-system
convert
- **Solving**
 - ***.blend**
d3plot.fz from LS-DYNA
converted to 175 blender in ~1 week
 - **Solver: Blender**
~2 day on 640 CPU for 911 frames
BLENDER
 - **Camera perspectives as load cases**
 - **Videos as results**



Data Analysis

■ DOE and data-analysis

setup easy within SDM-System

■ Input

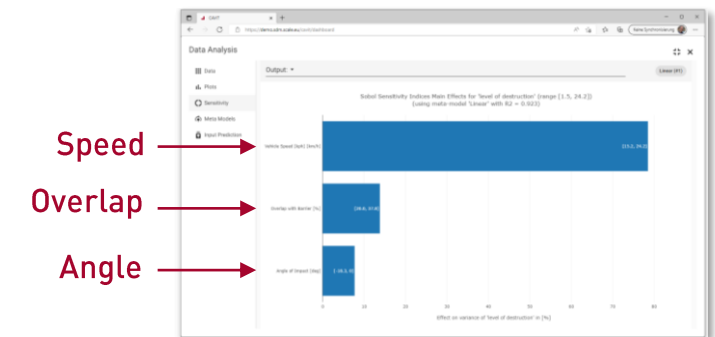
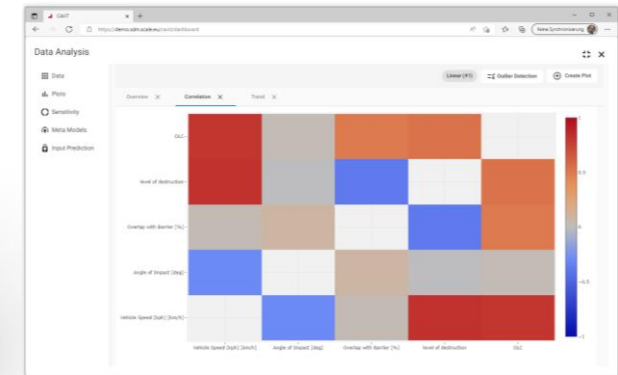
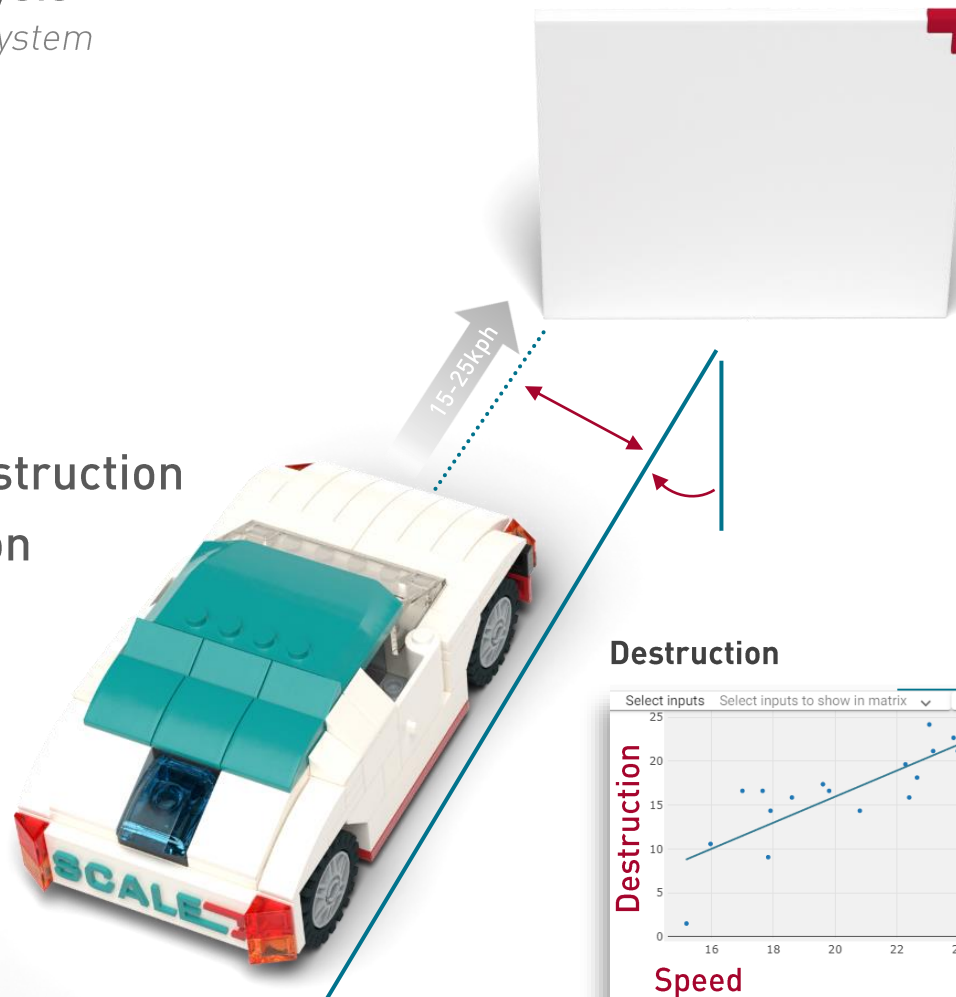
- Speed
- Offset
- Angle

■ Output

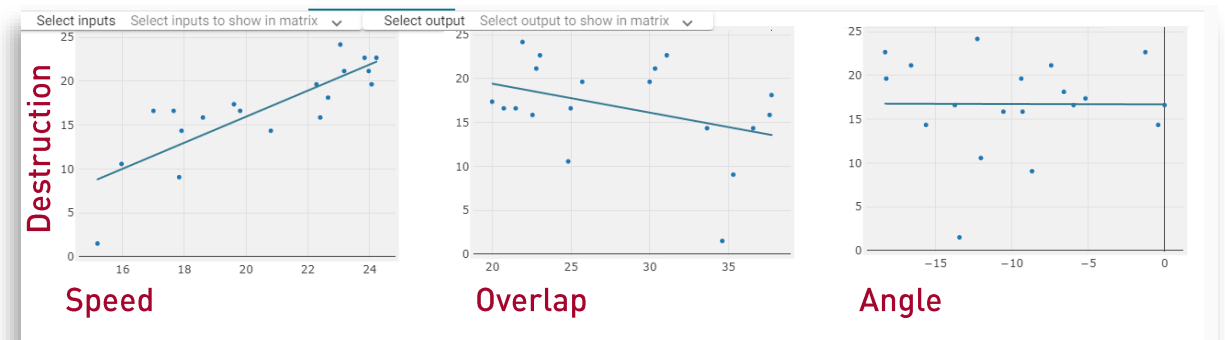
- Level of destruction
- Deceleration

■ Analysis

*correlation, trends,
meta-models*

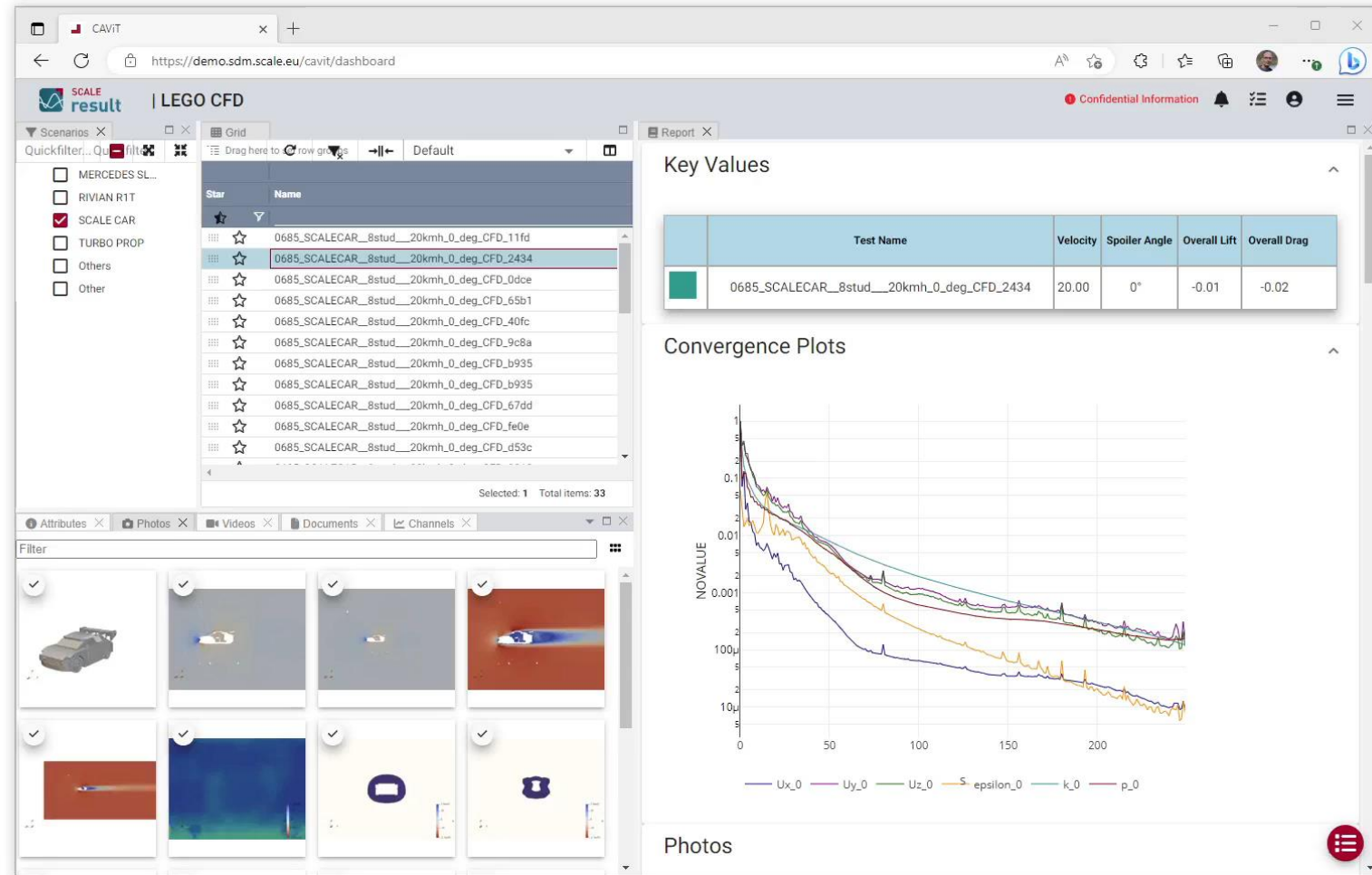


Destruction



Discipline – CFD

- Using same geometry as crash
separate simulation discipline
- Fully automatized
runs directly after changing CAD geometry
 - Snappy hexmesh
 - OpenFOAM
- Postprocessing
automatic extraction
 - Paraview
 - Images, videos, key-results, ...
 - Data cached remotely
accessible through VDI workstation

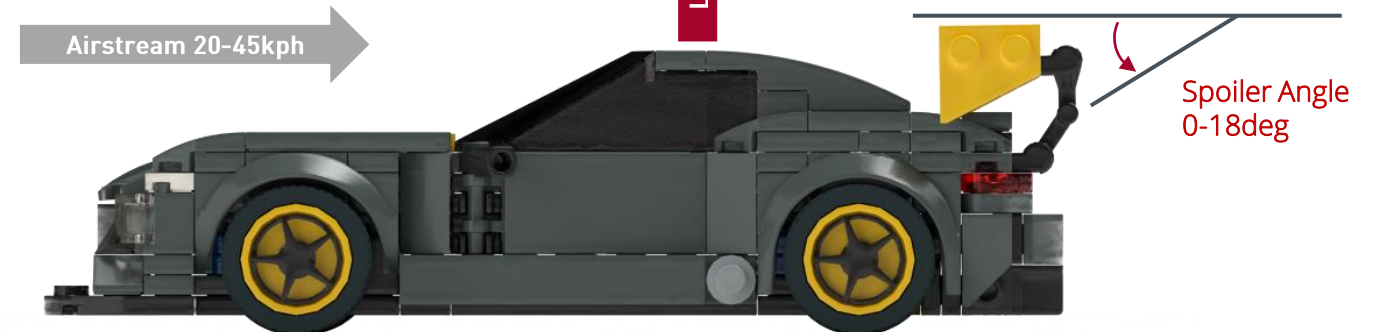
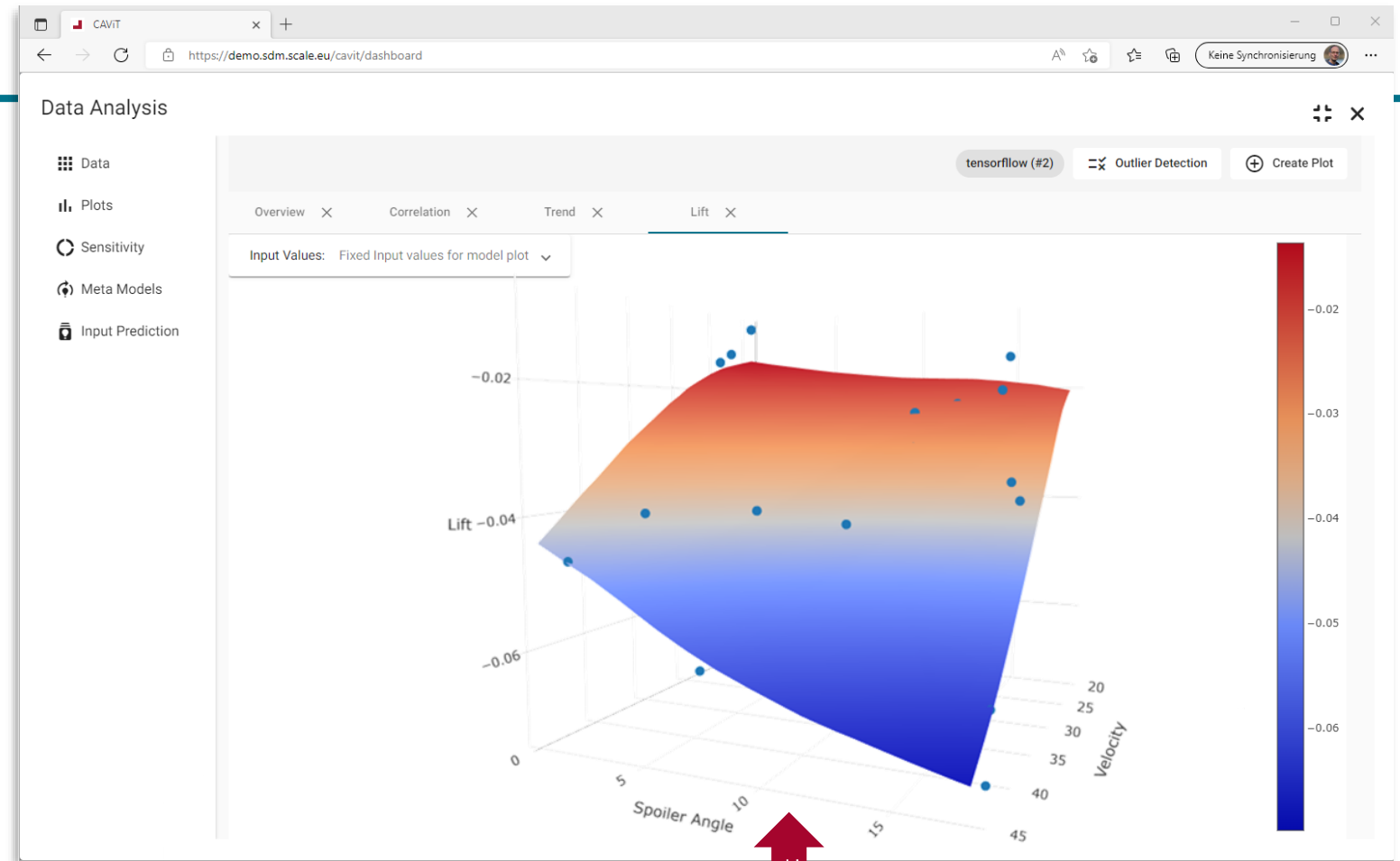


Data Analysis

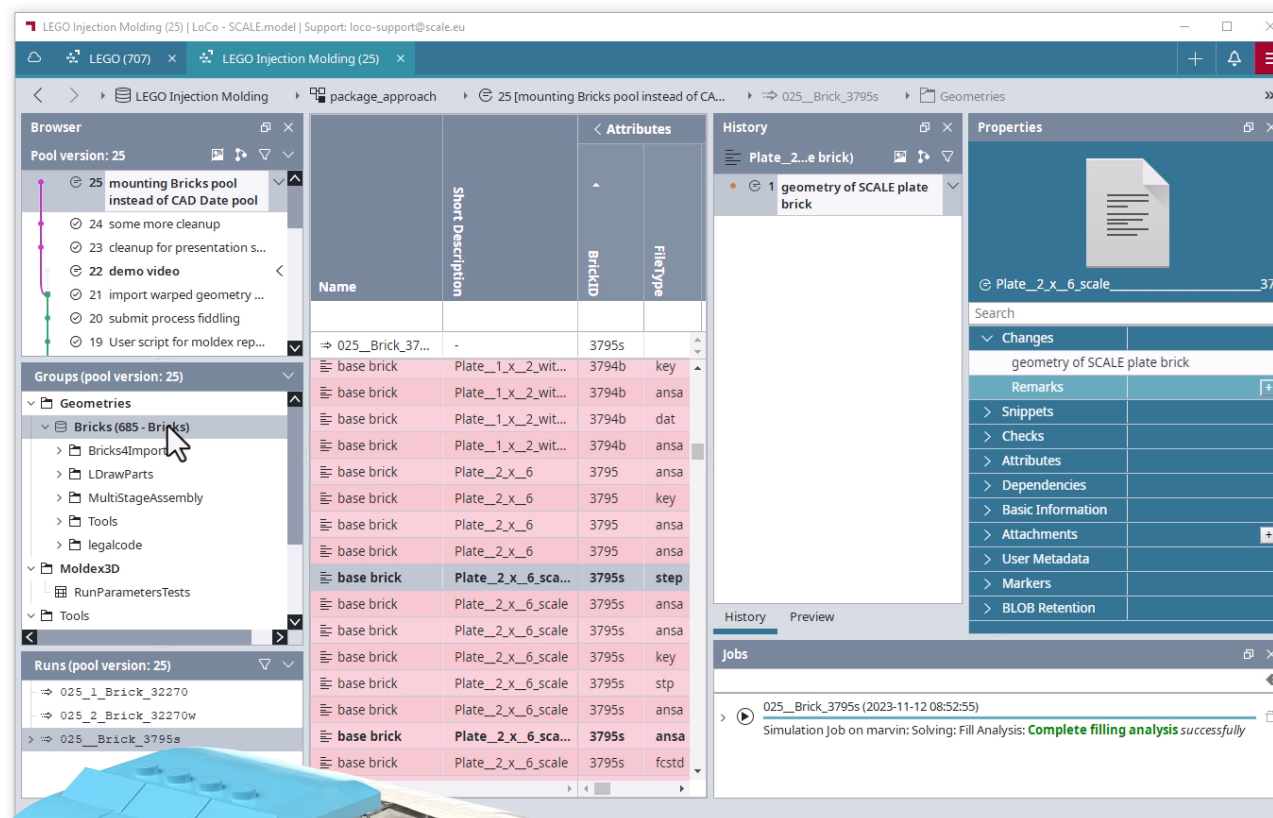
DOE and Data-Analysis *setup easy within SDM-System*

- Input:
 - Velocity
 - Spoiler Angle
- Output:
 - Drag
 - Lift

Analysis *correlation, trends, meta-models*



- Using same geometry as crash
same Bricks Pool mounted in all simulation disciplines
- Integration of Moldex3D
 - Create Moldex3D case from geometry
 - Open and Work with Moldex3D
 - Submit Simulations
- Postprocessing
automatic extraction
 - Use Moldex3D templates on HPC
 - Images, videos, key-results, ...



Production of custom brick



IT Architecture

On Premises

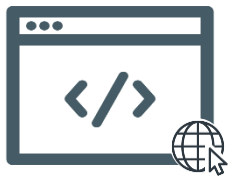


Cloud



SCALE.sdm Desktop

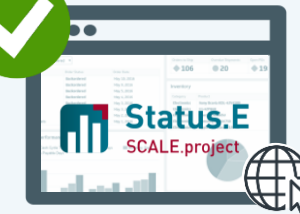
Next generation of desktop applications with desktop integration and local caches



SCALE.sdm Web Apps

Device independent lightweight applications

20
22



SDM
Simulation Models

Eval. / Assessment
Reporting

Requirement Setup
Project Monitoring

What's Next

- More models
 - Technic #42115 @ xmas
 - 8 stud wide MOCs
- More simulation disciplines
 - Powertrain
 - Multi body dynamics (MBD)
 - Water splashing (SPH)
 - ...
- More fun with simulation...
- Free models for HPC benchmarking and ...

models are licensed [CC BY-NC-SA 4.0](https://creativecommons.org/licenses/by-nc-sa/4.0/) and can be provided for noncommercial use, reach out to info@scale.eu



SO LONG, AND THANKS

FOR ALL THE FISH



<https://www.linkedin.com/company/scale-gmbh/>

JSOL CORPORATION

SCALE

IT-Solutions for CAE

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THE REAL THING AT 60kph...

3, 2, 1 ...

A small blue and black RC car is positioned on a light-colored floor marked with orange lines. In the background, a large black tripod stands. The word 'BOOM' is written in large, bold, red capital letters across the bottom of the image.

BOOM