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

JSOL CAEフォーラム 2023

November 29th, 2023

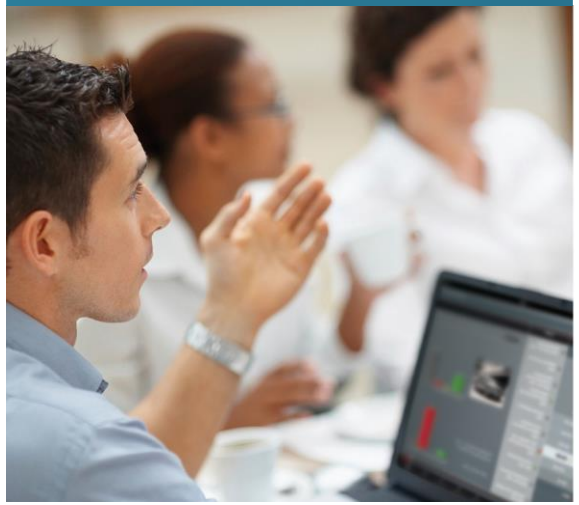
JSOL CORPORATION SCALE

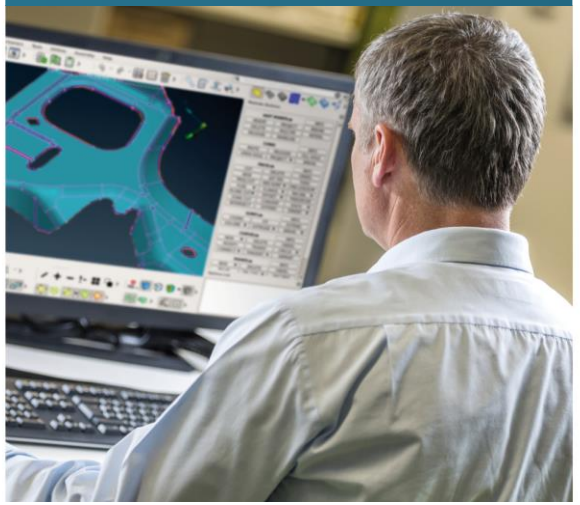
IT-Solutions for CAE

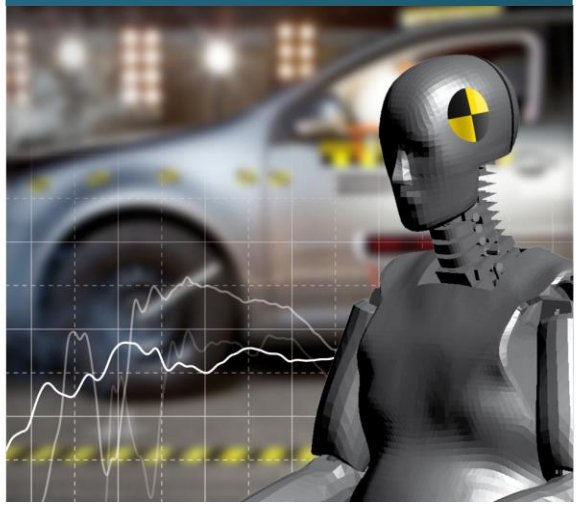
SCALE.sdm

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

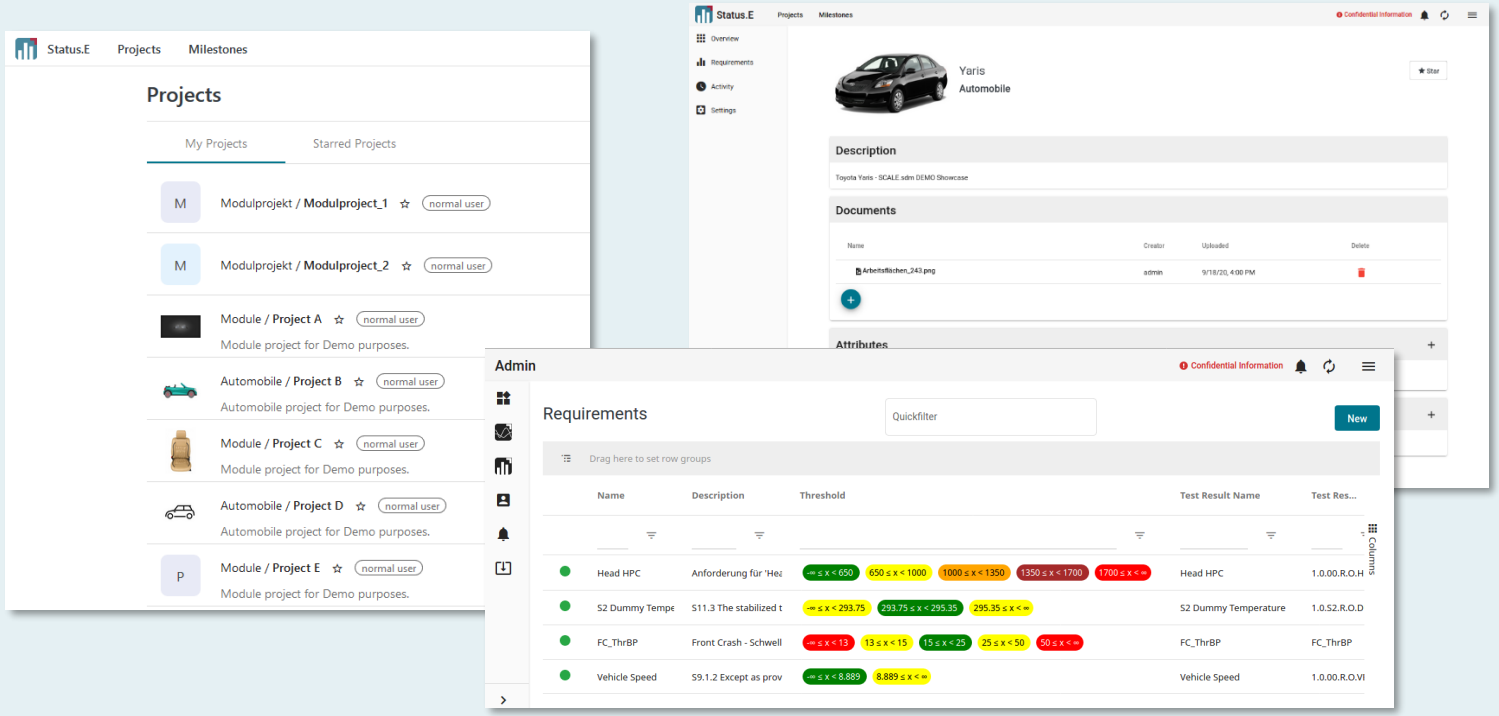
SCALE.project
Status.E

SCALE.model
LoCo

SCALE.result
CAViT

SCALE.project
Status.E

Setup of Project
↓
Define Responsibilities
↓
Specify Milestones
↓
Prescribe Requirements



SCALE.sdm → Software Solution for Simulation Data Management

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Import CAD or Meshes

↓

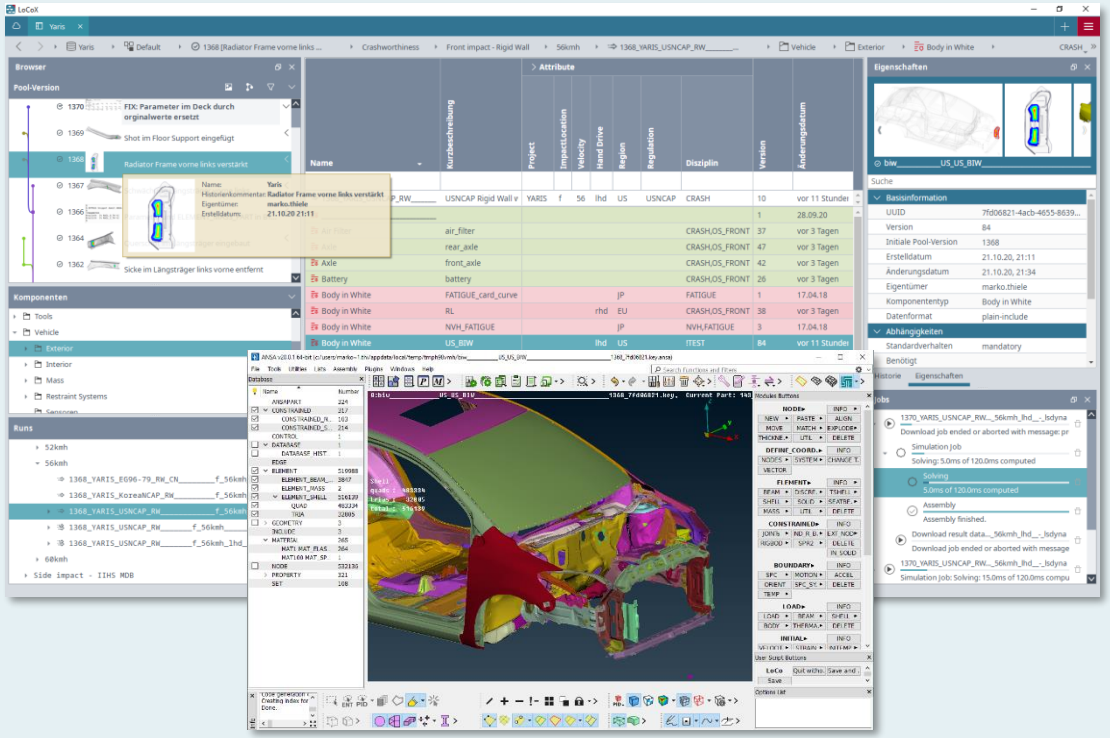
Prepare Models

↓

Define Load Cases

↓

Run Simulations



SCALE.sdm → Software Solution for Simulation Data Management

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Extraction and Evaluation of results

↓

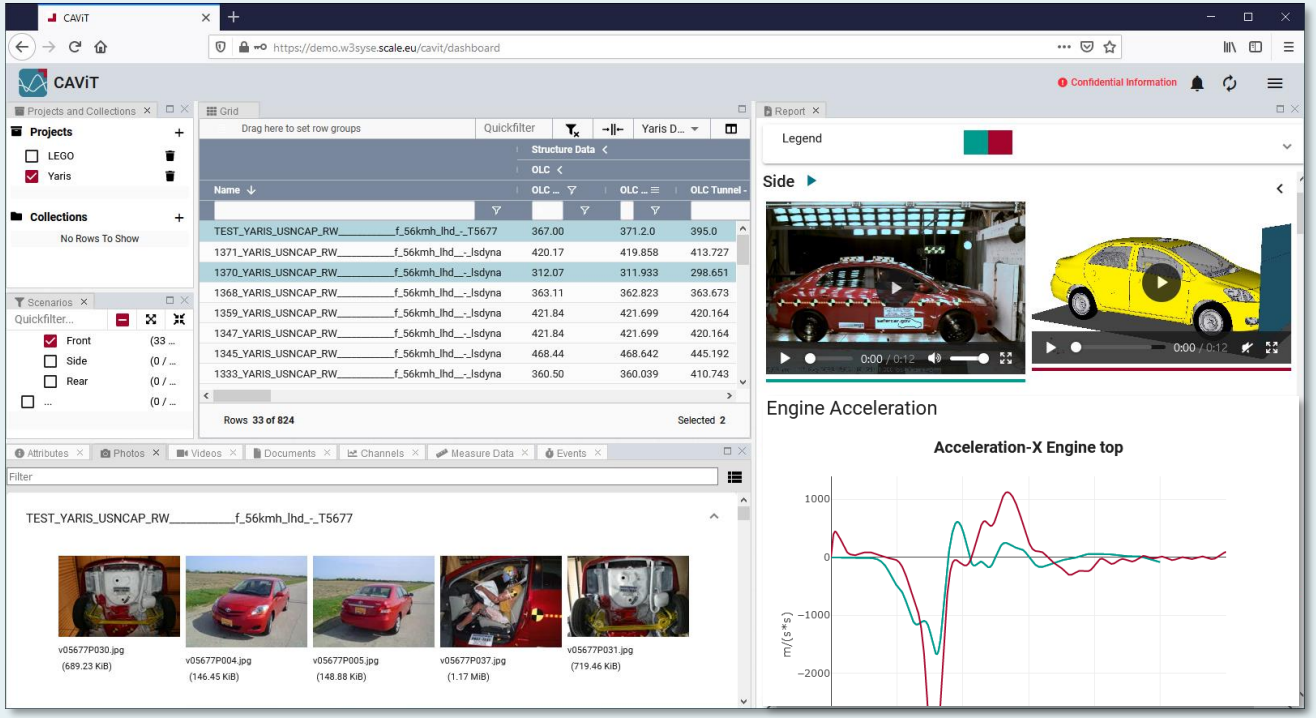
Management of Post Data

↓

Correlation Test vs Simulation

↓

Assessment and Reporting



SCALE.sdm

SCALE.sdm → Software Solution for Simulation Data Management

SCALE.project
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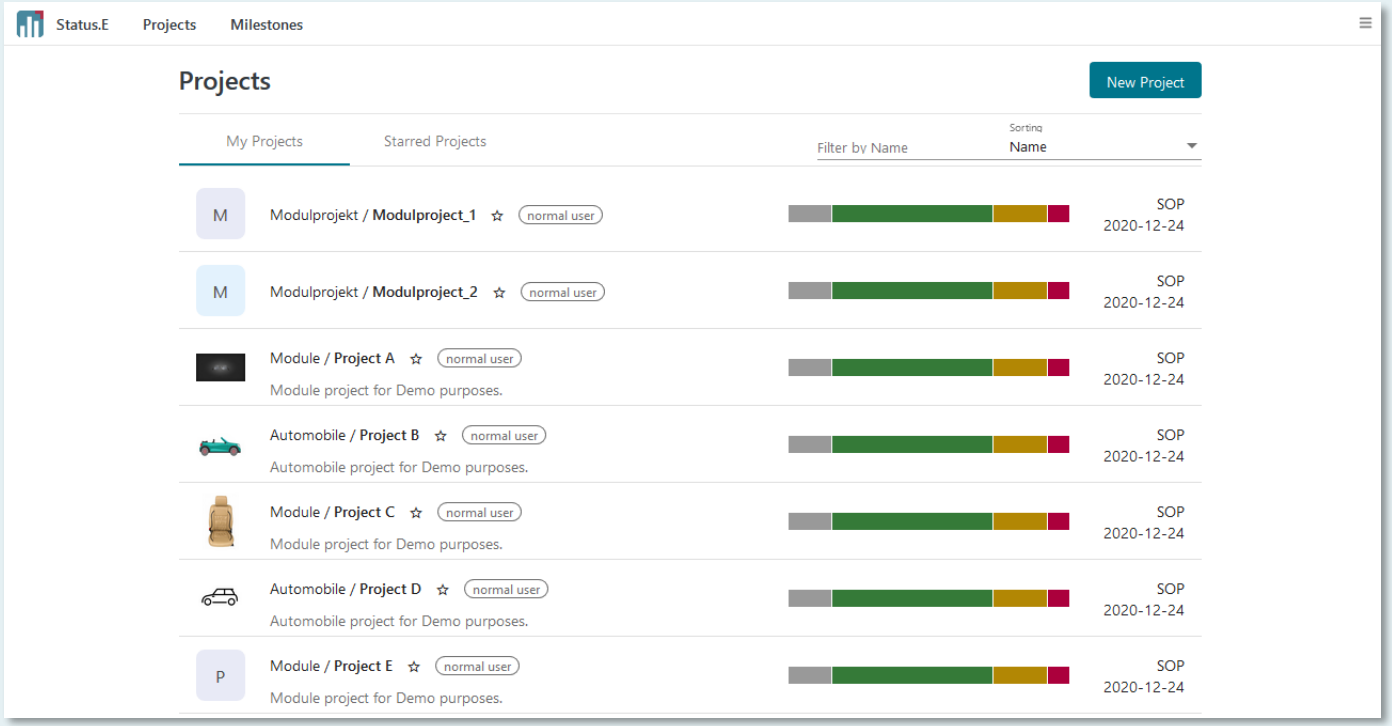
SCALE.result
CAViT

SCALE.project
Status.E

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

LDraw.org
Centralised LDraw Resources
http://www.ldraw.org/

LeoCAD
https://www.leocad.org

bricklink
https://www.bricklink.com

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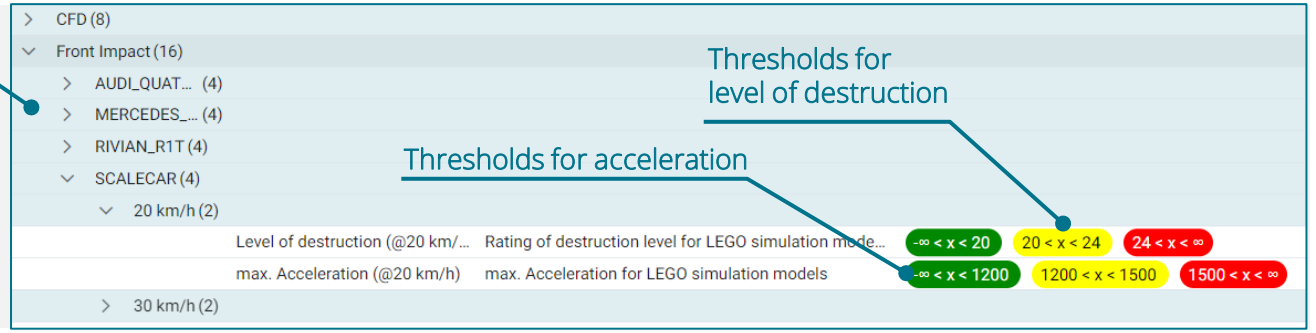
Setup Requirements for the Project

Requirements
technical targets for the project

Structured by category, vehicle and velocity

Thresholds for level of destruction

Thresholds for acceleration

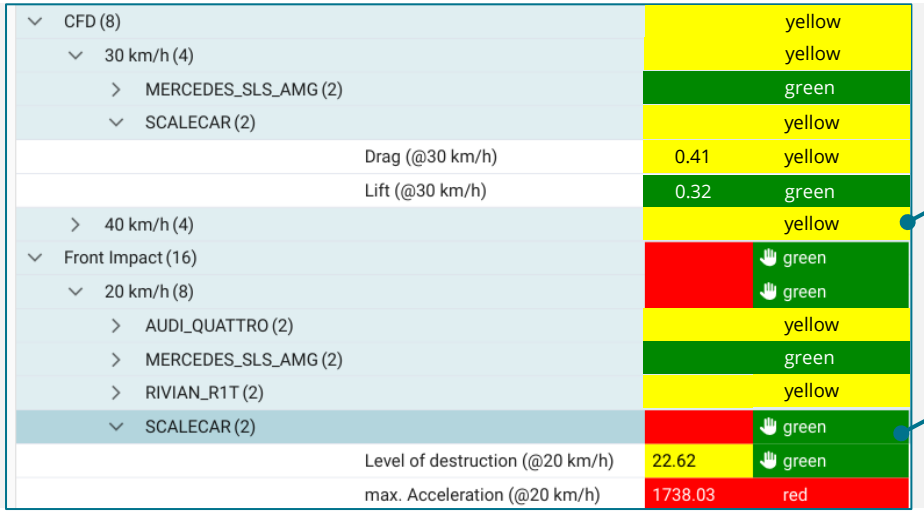


Milestones
definition of all project milestones and targets

Monitoring
transparent project status at any time

Assessment
individual assessment by users

Project Status
aggregated on each level of requirements



Aggregated status

User assessment

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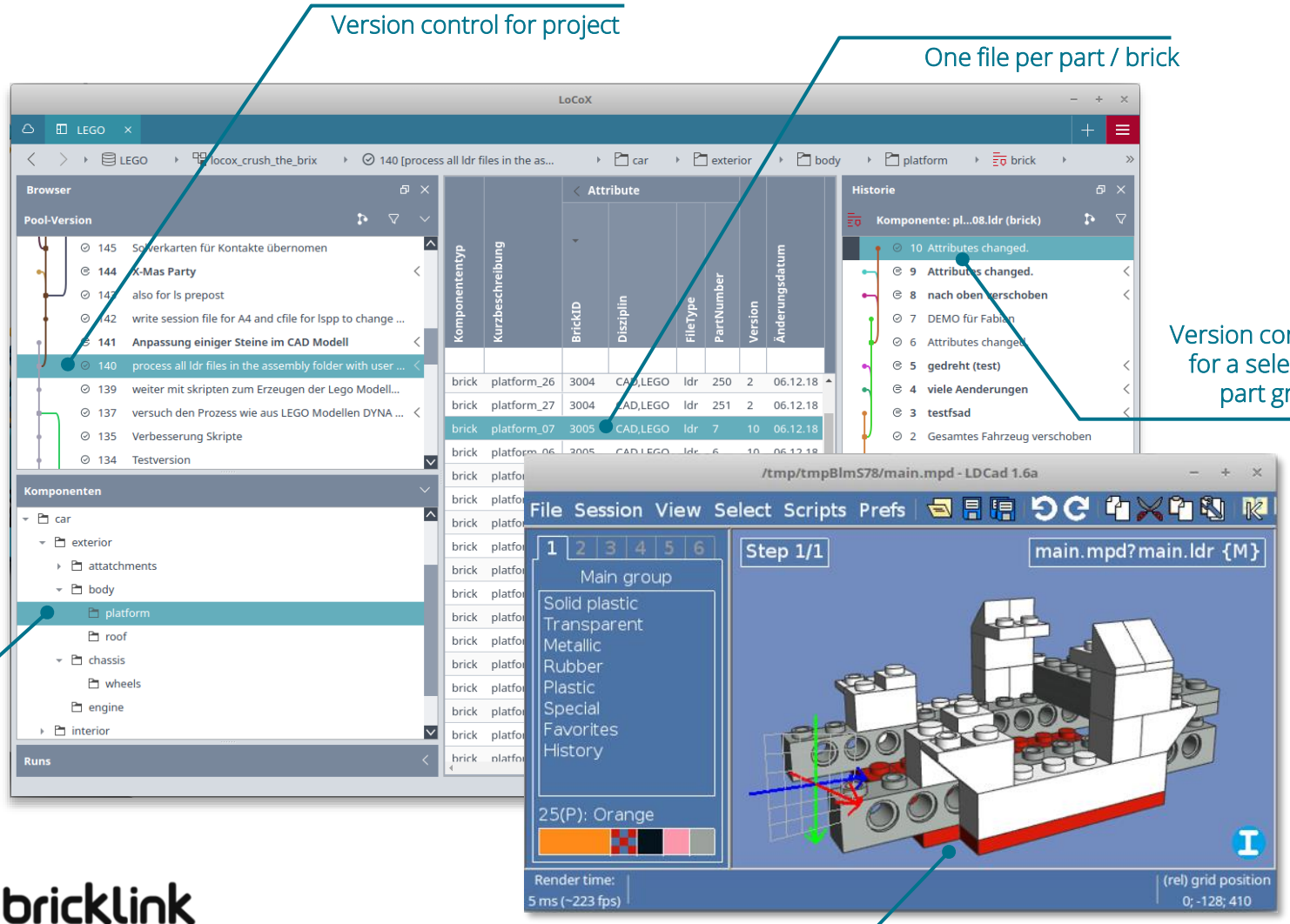
Manage CAD data in the SDM-System[1]

- **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



LDraw.org Centralised LDraw Resources
http://www.ldraw.org/

LeoCAD
https://www.leocad.org

bricklink
https://www.bricklink.com

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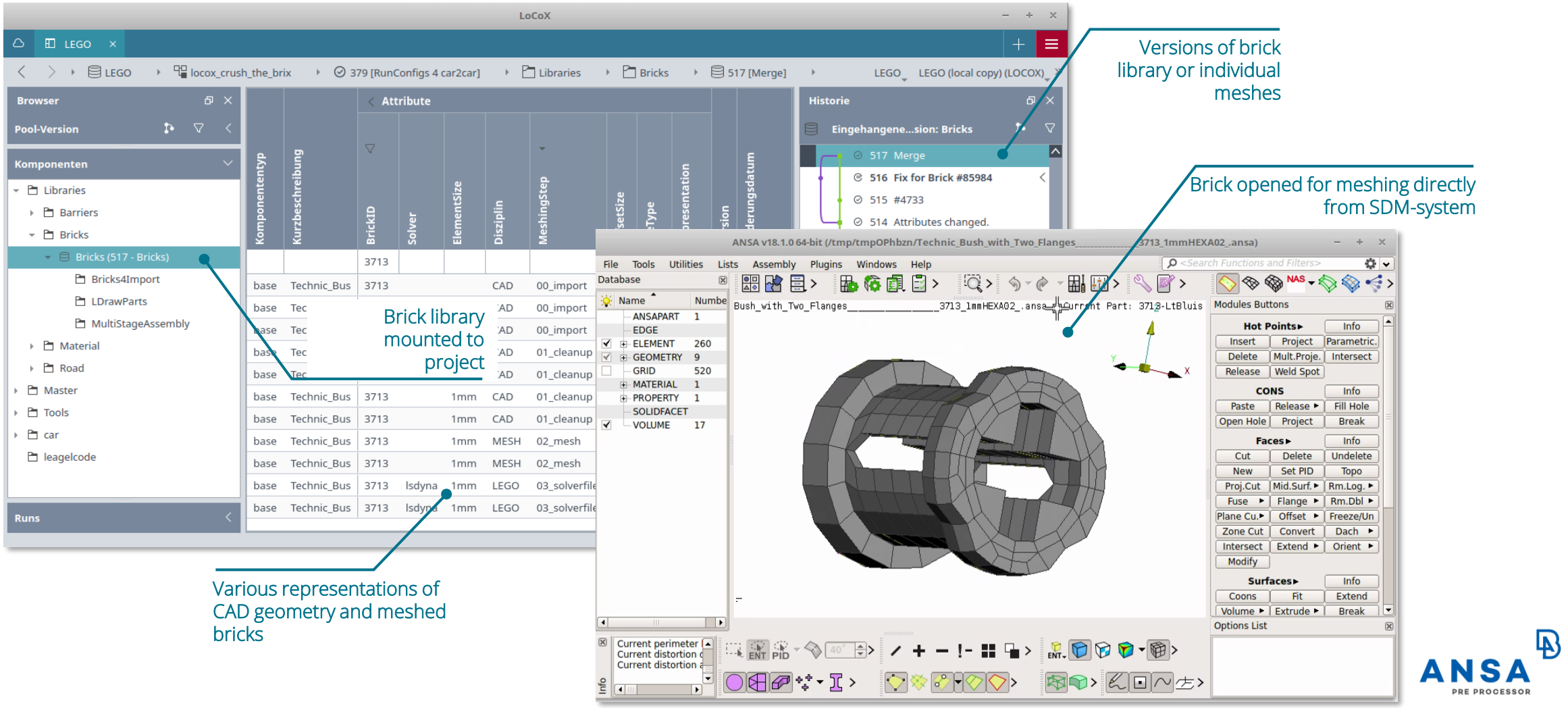
[1] C. Knehler, M. Thiele, D. Matthus, P. Friedrich, "Prospects of integrating CAD and CAE in Simulation Data Management", NAFEMS European Conference Simulation Process and Data Management (SPDM), 28-29 November 2018, Munich, Germany

Meshing of CAD Data[1]



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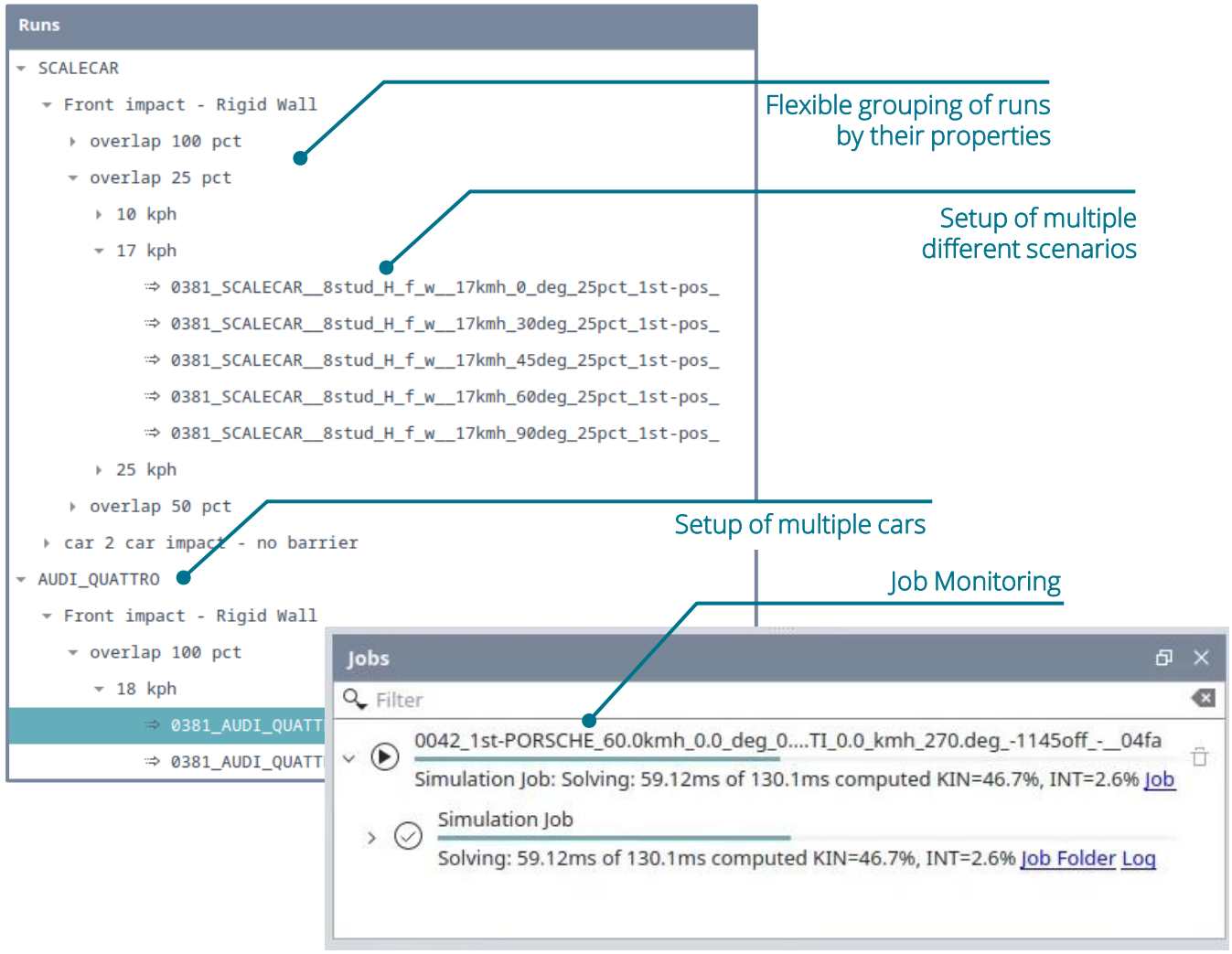
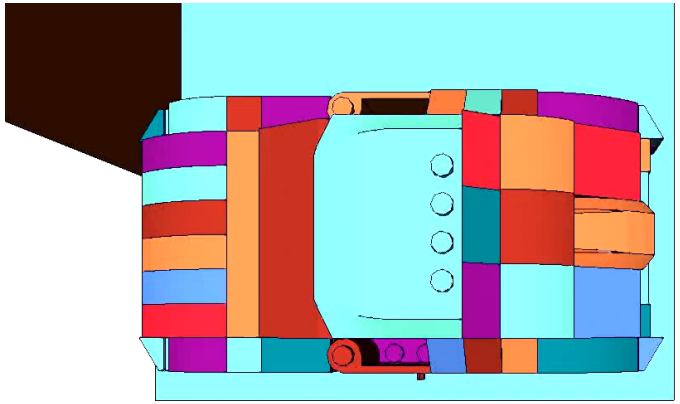
Setup of Load Cases and Solving

Ansys / LS-DYNA





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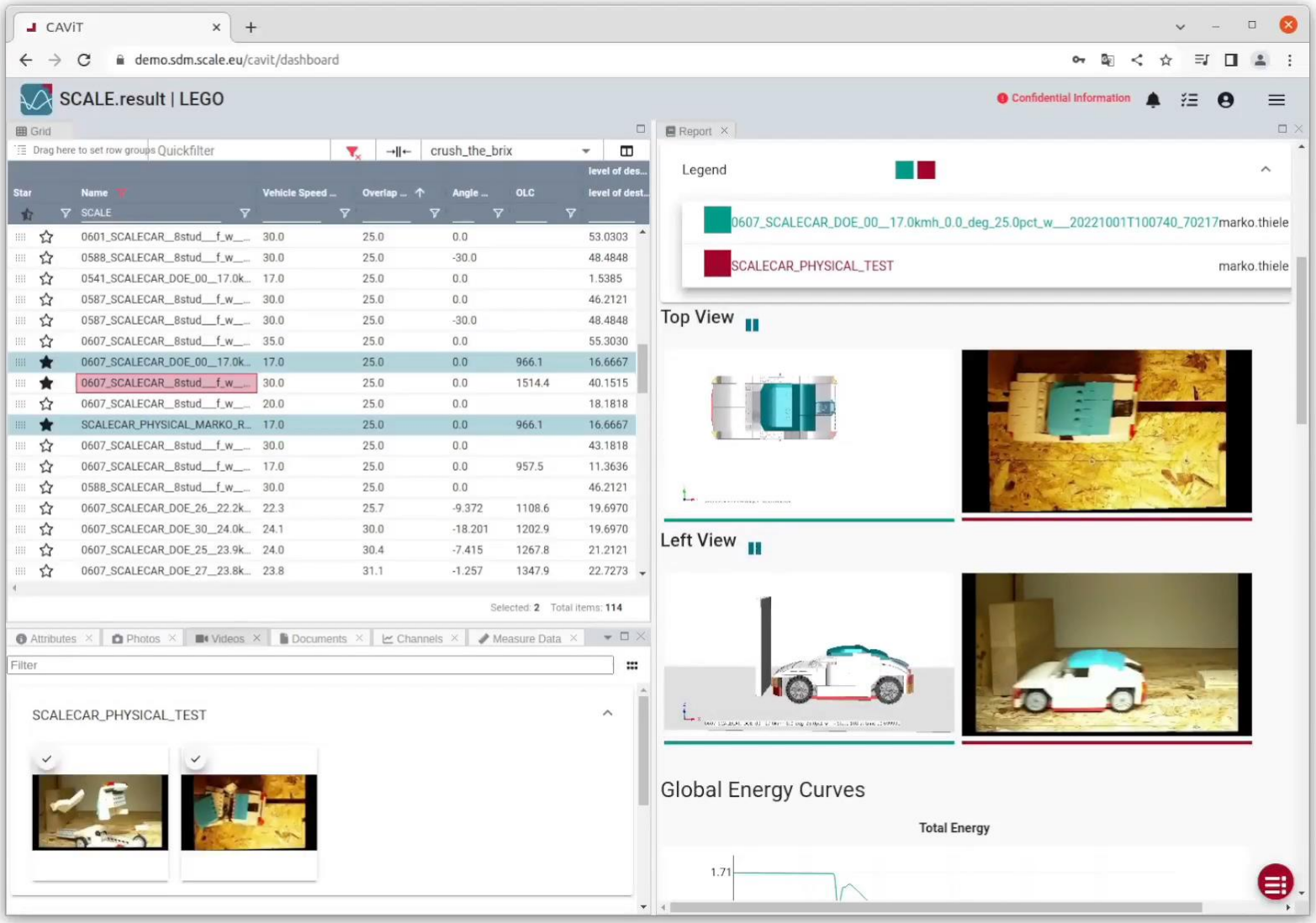
Simulation Results compared to Test



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

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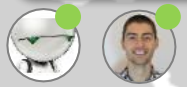
Model created by collaboration with SDM

DYNAmore Corporation USA
- Nils (LS-DYNA®)
- Thomas (meshing)

SCALE GmbH Dresden
- David (software)
- Peter (process, submitting to HPC)

SCALE GmbH Ingolstadt
- Alexandru (model)
- Marko (LEGO® CAD, process, model, ...)



DYNAmore France SAS
- **Pierre** (meshing, LS-DYNA®)

DYNAmore GmbH Stuttgart
- Andre (organization)
- Thorsten (meshing, LS-DYNA®)
- David (materials)

Porsche:
2704 bricks
182 different bricks

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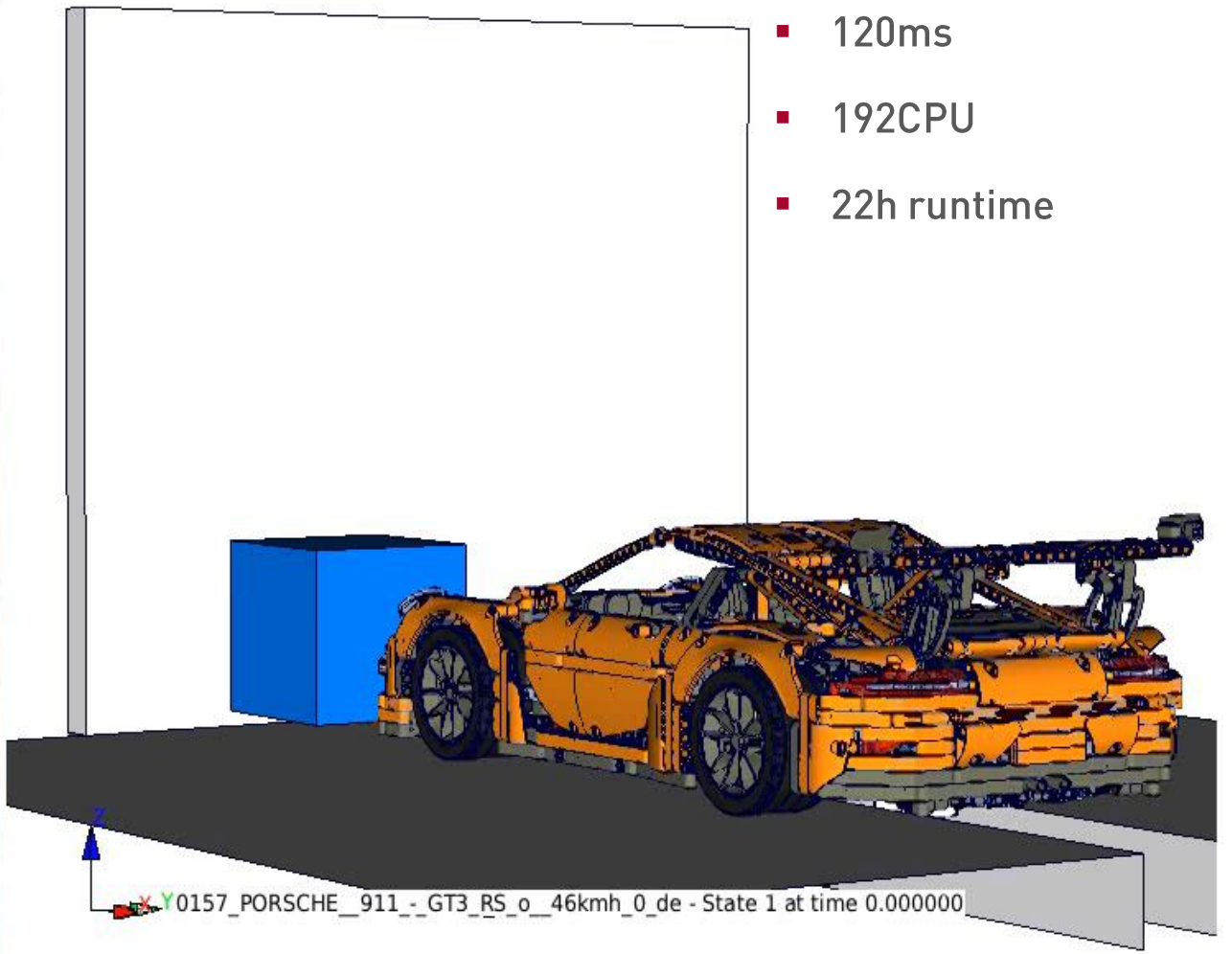
Simulation Results

LEGO® is a trademark of the LEGO Group of companies which does not sponsor, authorize or endorse these investigations.

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



Simulation Results

Ansys / LS-DYNA

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

https://youtu.be/LyJ5B---Zdo

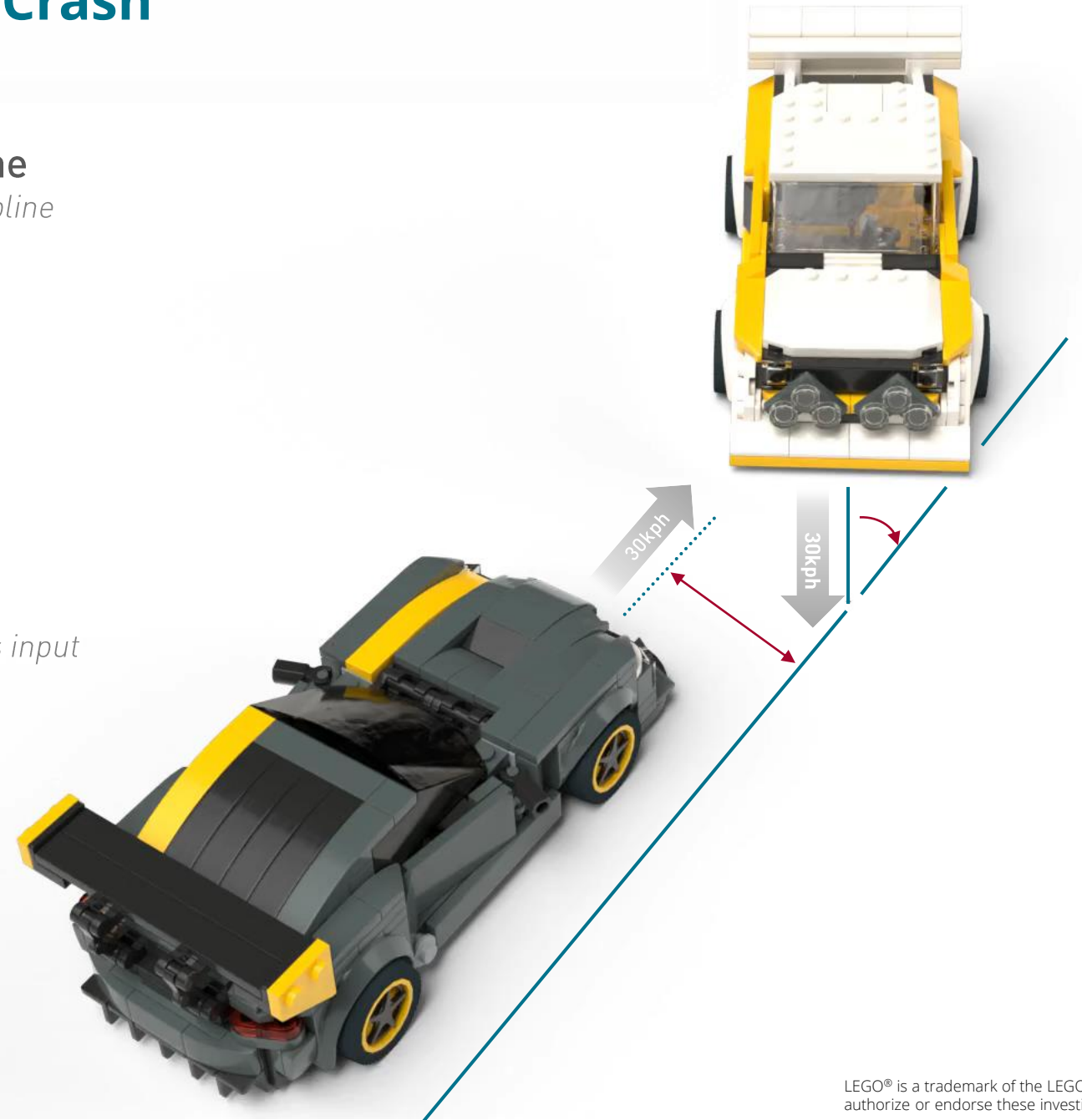
The LEGO® Challenge
#legowette

Discipline – Car 2 Car Crash

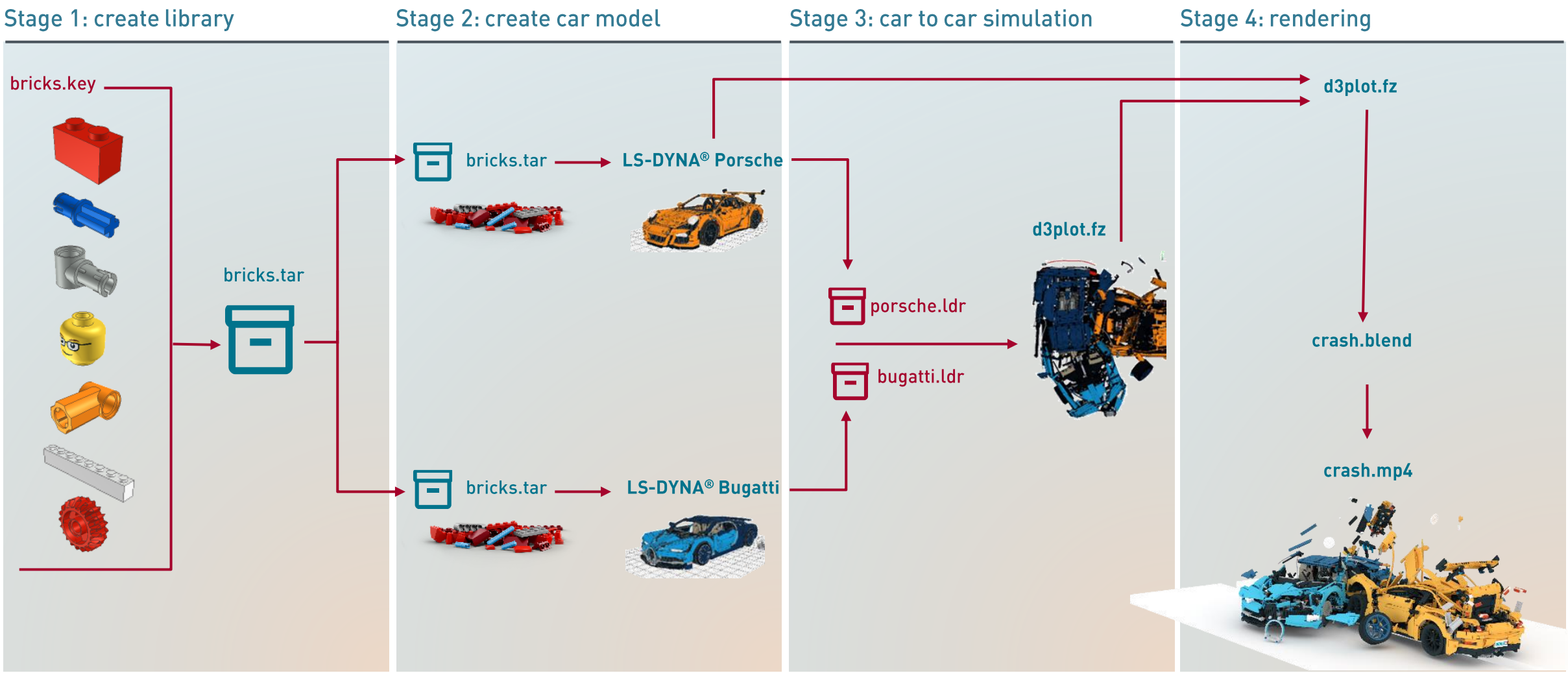
- Separate project & discipline
  car to car crash as simulation discipline

- Parameterization
  velocity, angle, offset, ...
  - DOE studies
  - Data analysis

- Multi-stage-assembly
  references individual car projects as input



Multi Stage Assembly



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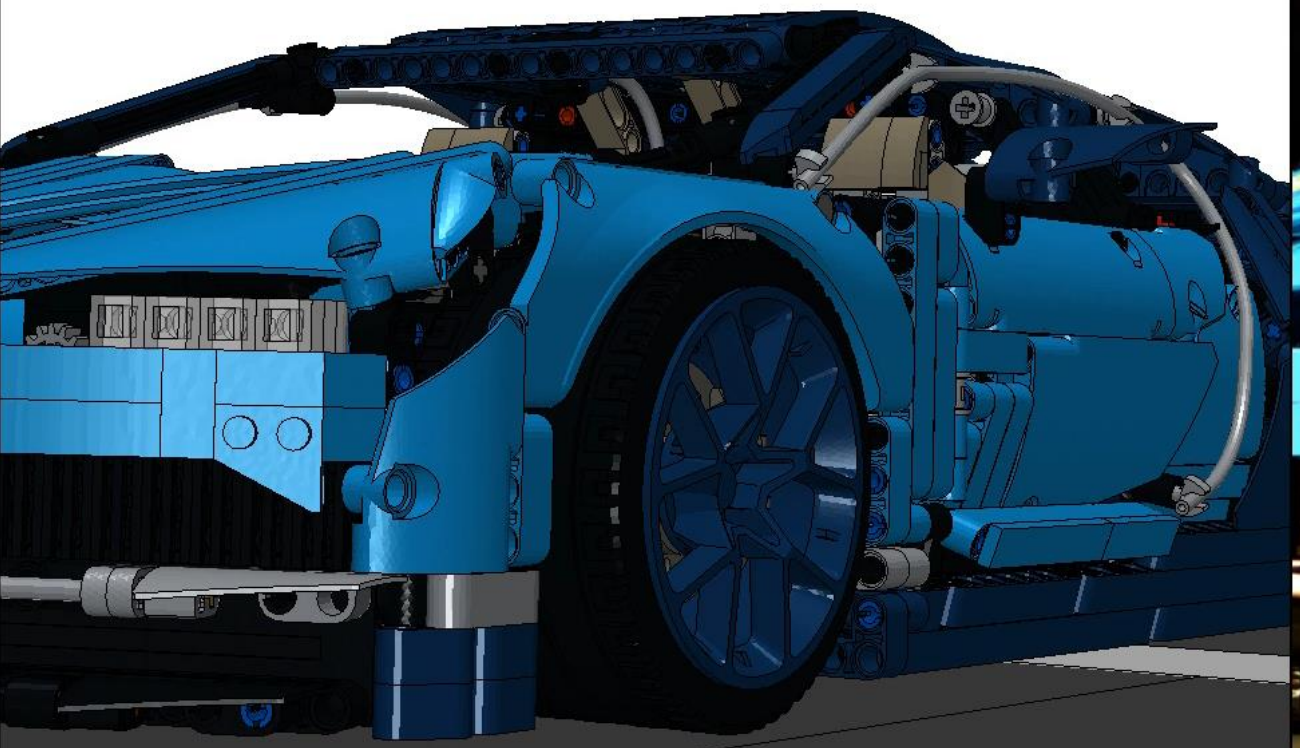
Simulation Results

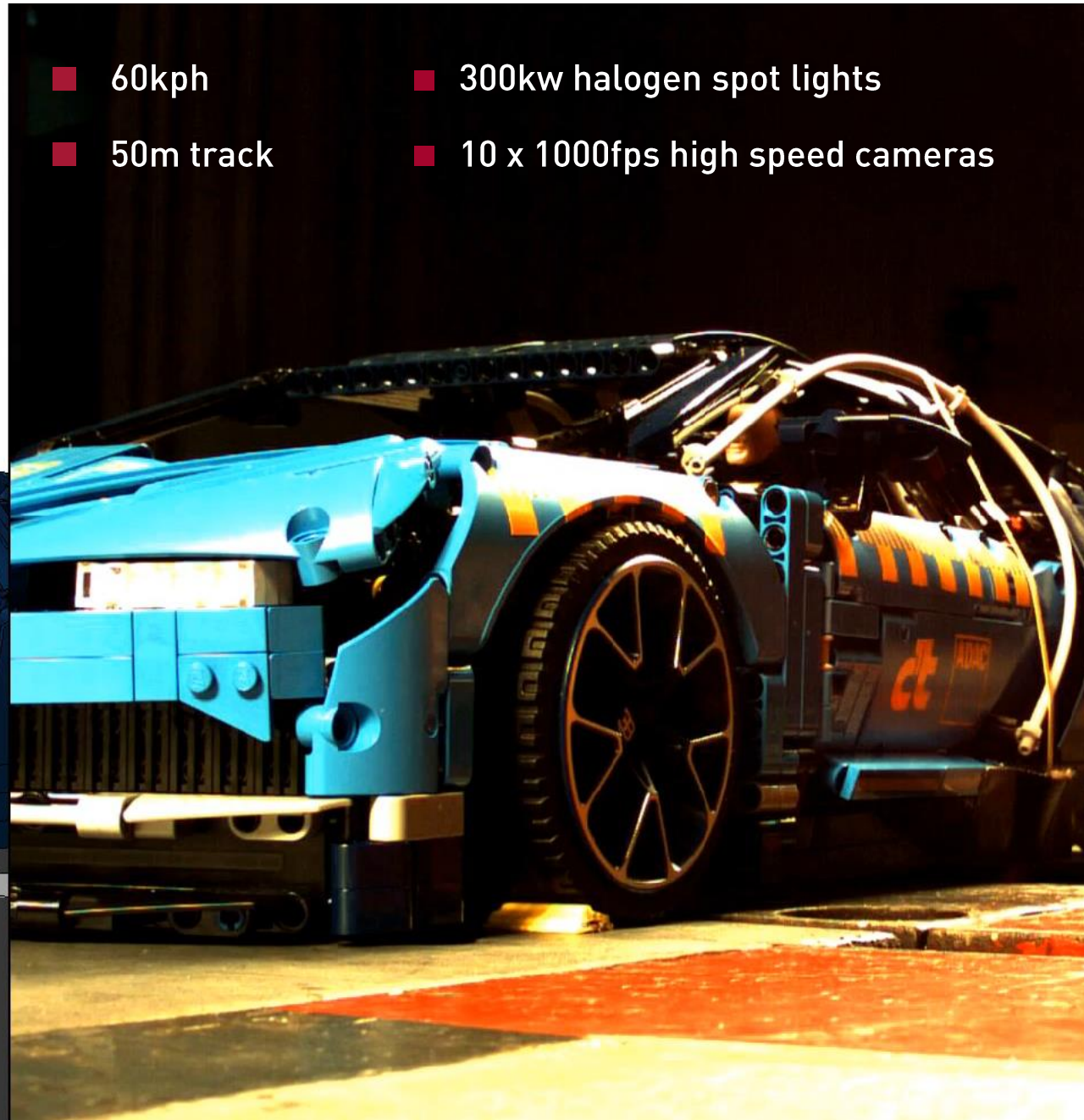
- 6303 parts (bricks)
- 45.8M elements
- 130ms
- 192CPU
- 54h runtime

Simulation Results

Ansys / LS-DYNA

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

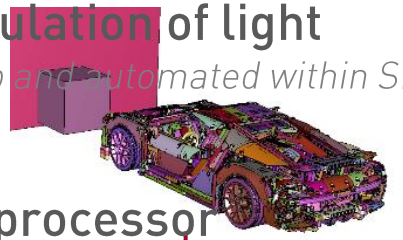




CAE DISCIPLINE: Rendering

LS-DYNA®

- Simulation of light
  setup and automated within SDM-System



- Preprocessor
  - Blender
    for studio and lighting setup
  - *.blend files
    managed in SDM-system

simulation

d3plot.fz

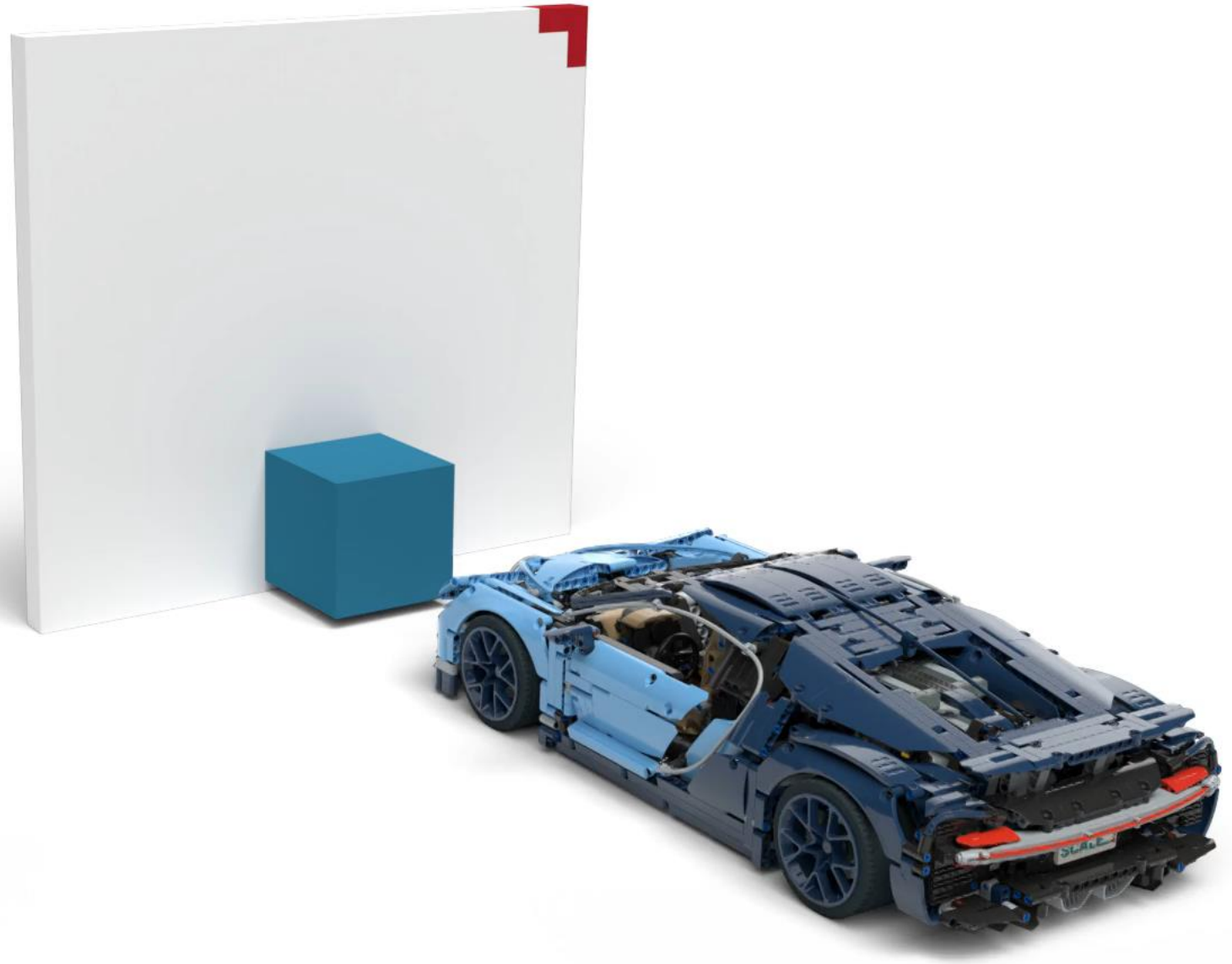
convert

- Solving
  - d3plot.fz from LS-DYNA
    *converted to *.blend in ~1 week*
  - Solver: Blender
    ~2 days on GPU for 911 frames
  - Camera perspectives as load cases
  - Videos as results

*.blend

render

BLENDER



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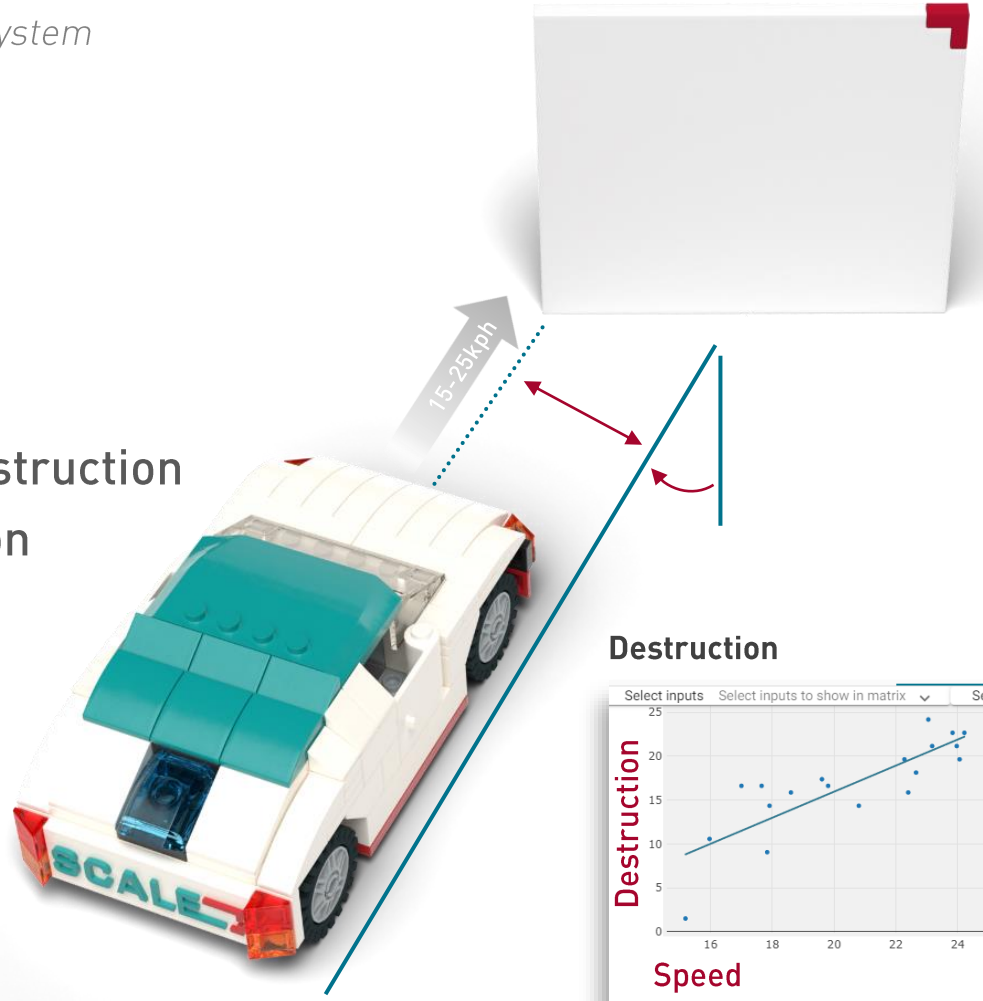
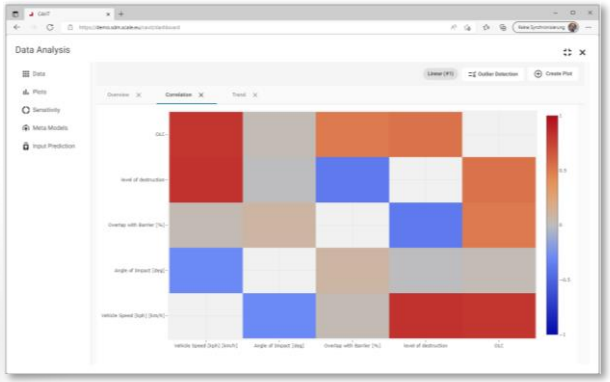
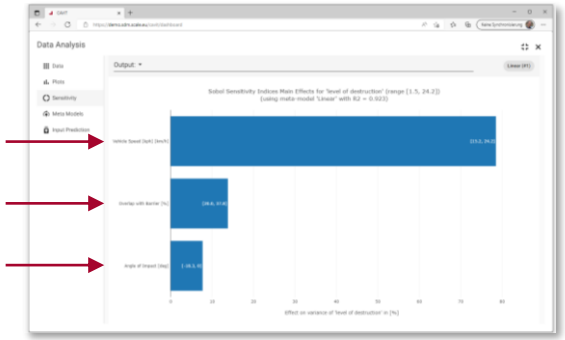
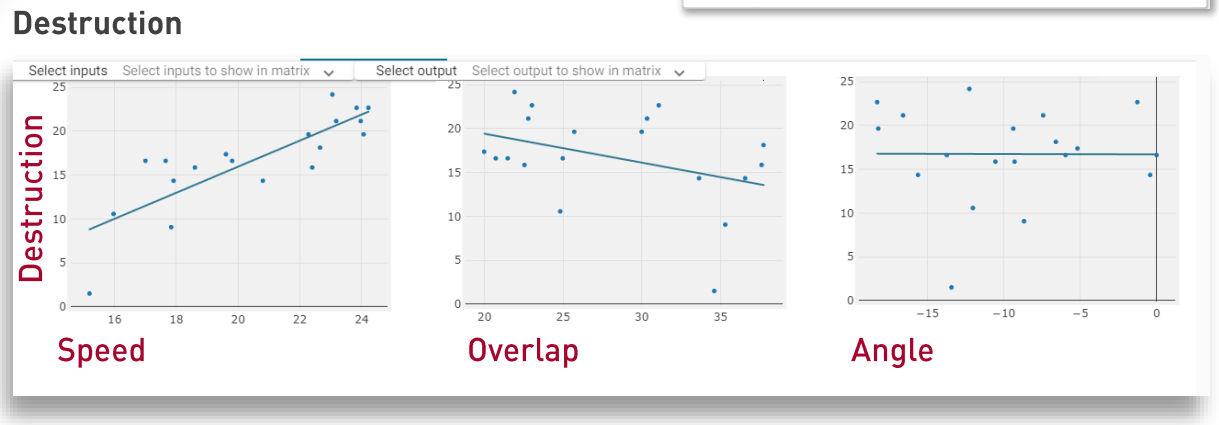
Data Analysis

- DOE and data-analysis
  setup easy within SDM-System
  - Input
    - Speed
    - Offset
    - Angle
  - Output
    - Level of destruction
    - Deceleration
- Analysis
  correlation, trends, meta-models









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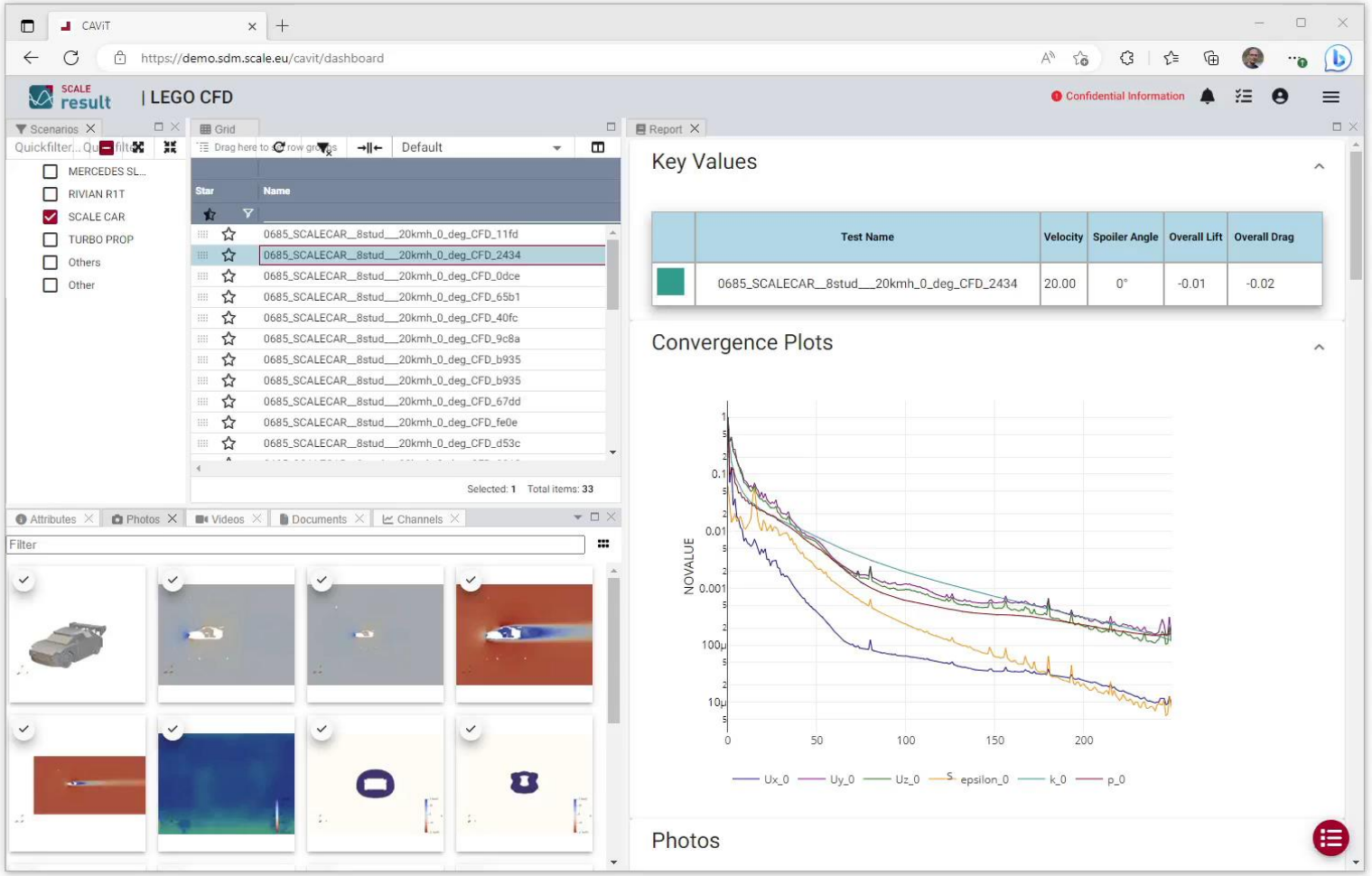
Discipline – CFD

- 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



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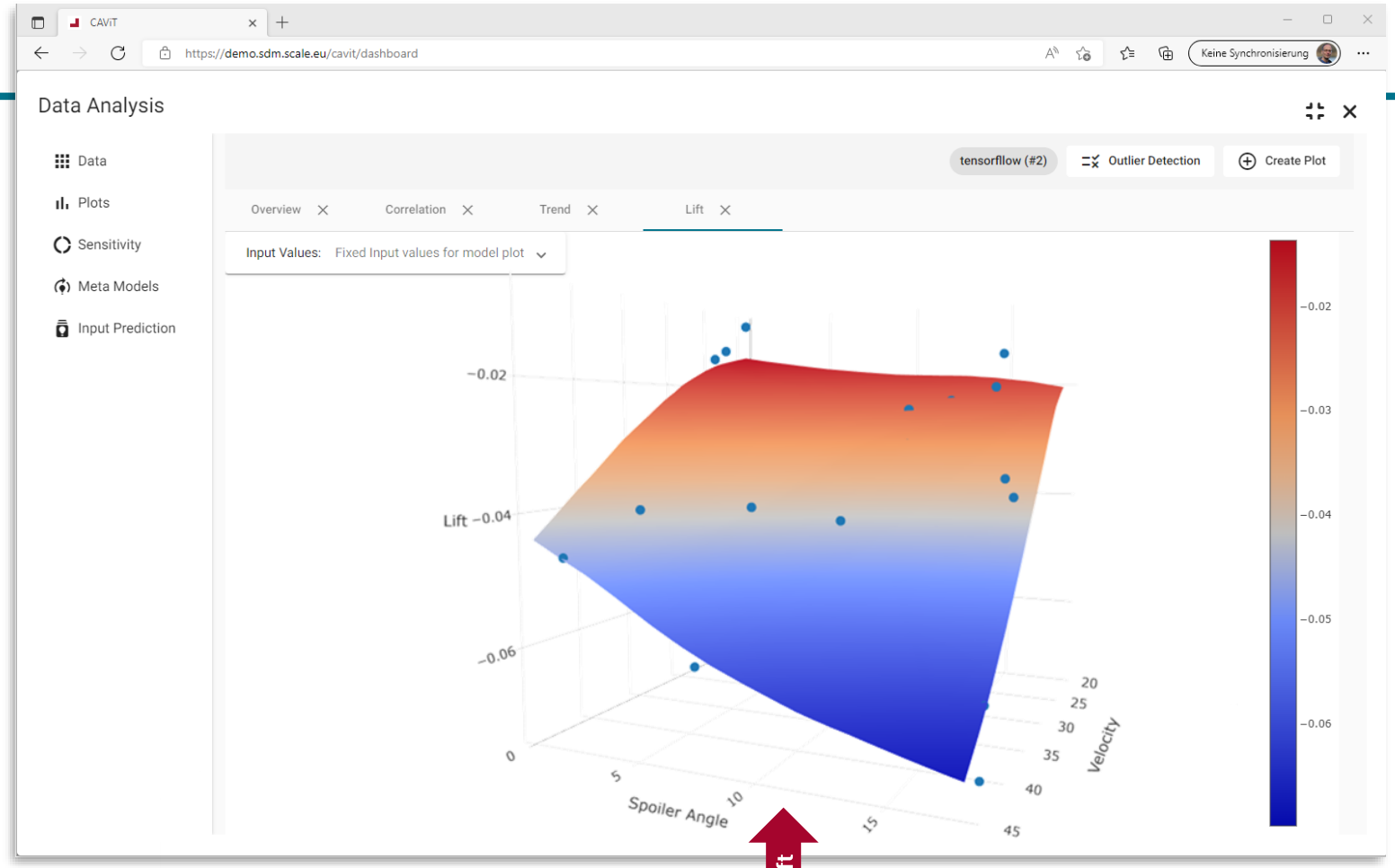
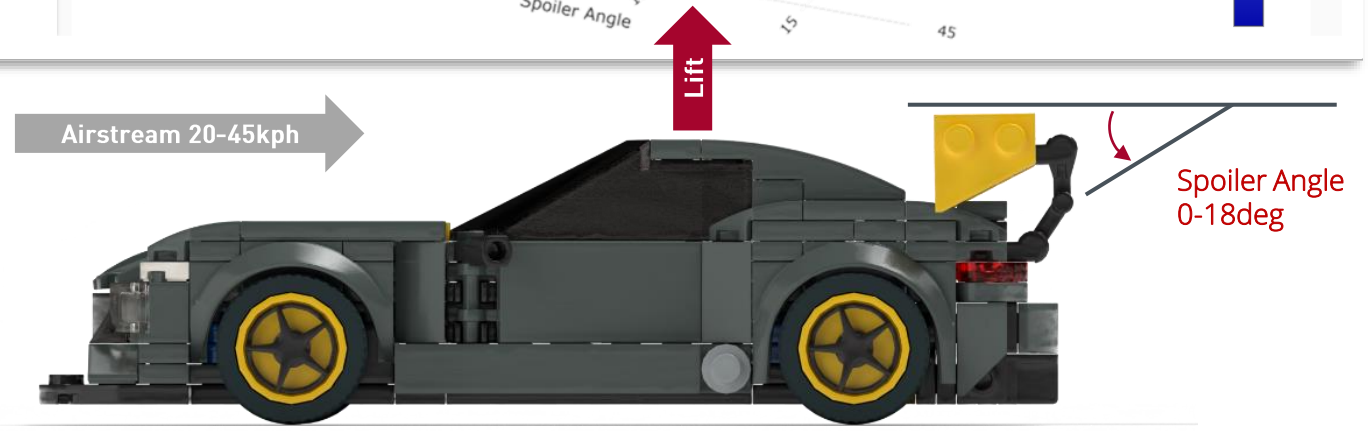
Data Analysis

- **DOE and Data-Analysis**
  setup easy within SDM-System
  - Input:
    - Velocity
    - Spoiler Angle
  - Output:
    - Drag
    - Lift
- **Analysis**
  correlation, trends, meta-models





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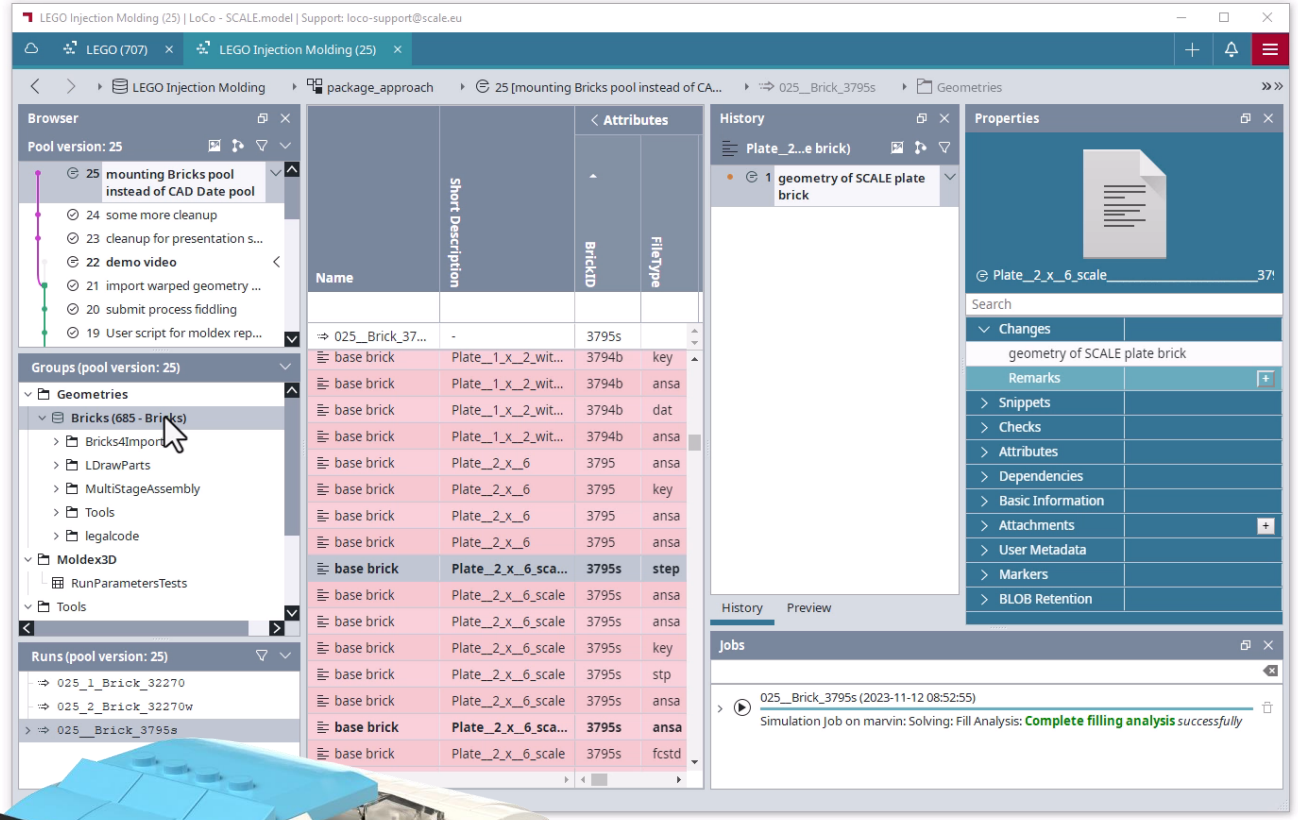
Discipline – Injection Molding *(production of custom brick)*

Moldex3D

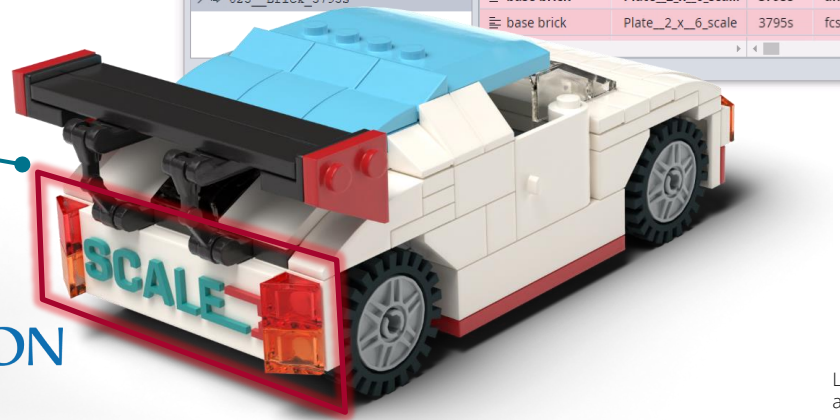
- Using same geometry as crash
  same Bricks Pool mounted in all simulation disciplines

- 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



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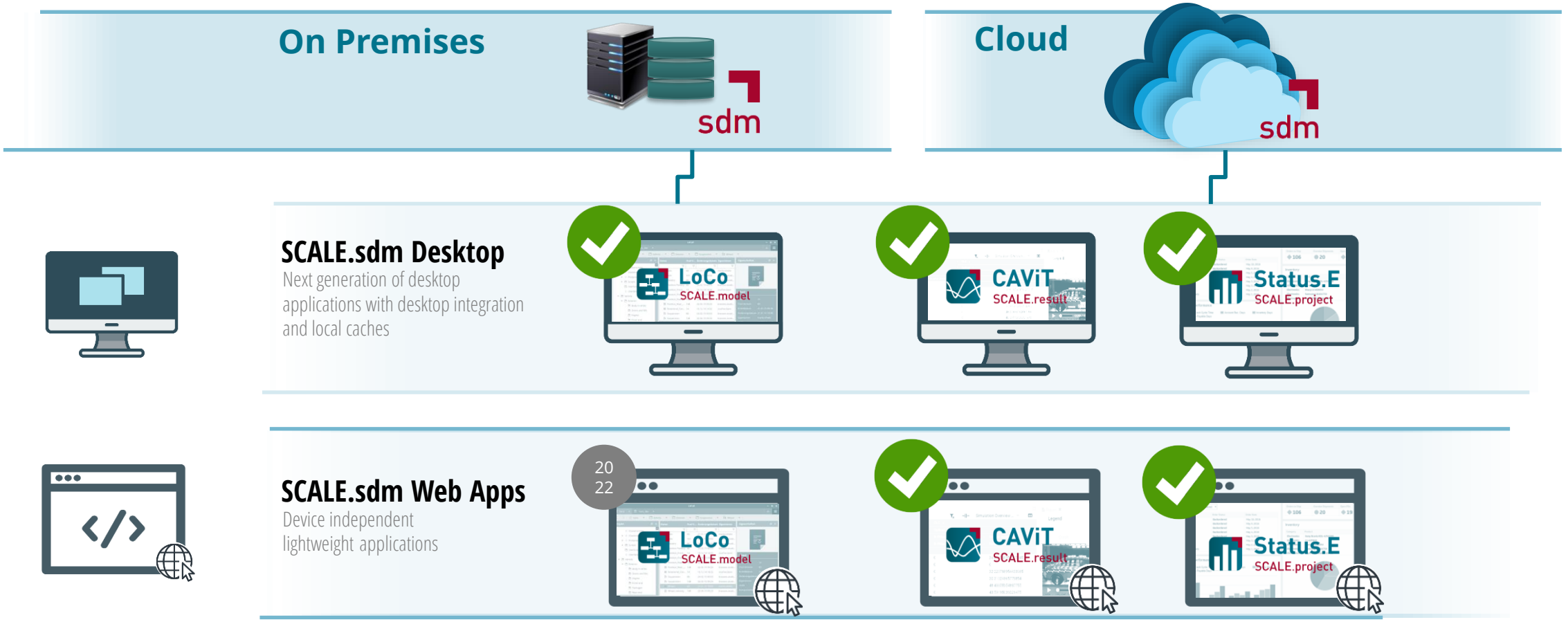
IT Architecture



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 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/

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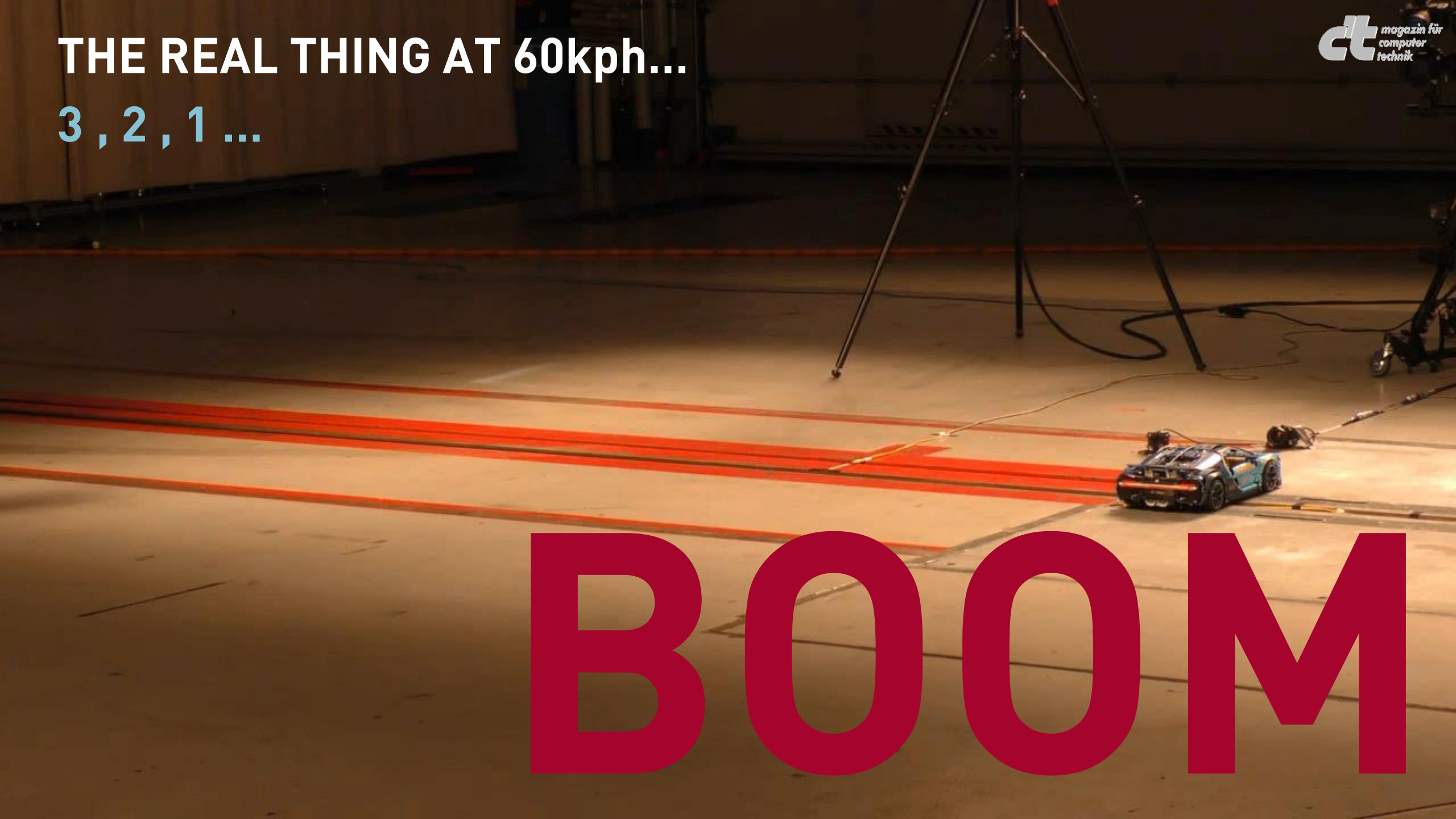
SCALE
IT-Solutions for CAE


THE REAL THING AT 60kph...
3 , 2 , 1 ...
BOOM
magazin für computer technik