Agenda – Workshop

- Introduction Digital Twins
  - A working Digital Twin
  - Business models – Discussion

- Modules for the digital Twin
  - Data analysis
  - Simulation
  - Understand, Learn, Reasoning, Optimize
  - Surrogate models
  - How to build a digital Twin – Discussion

- „Wrap up“

Computer aided model

Of a … object

For different purposes

Digital Twin – Benefits

...

Understanding

Learning

Reasoning

Optimizing

...

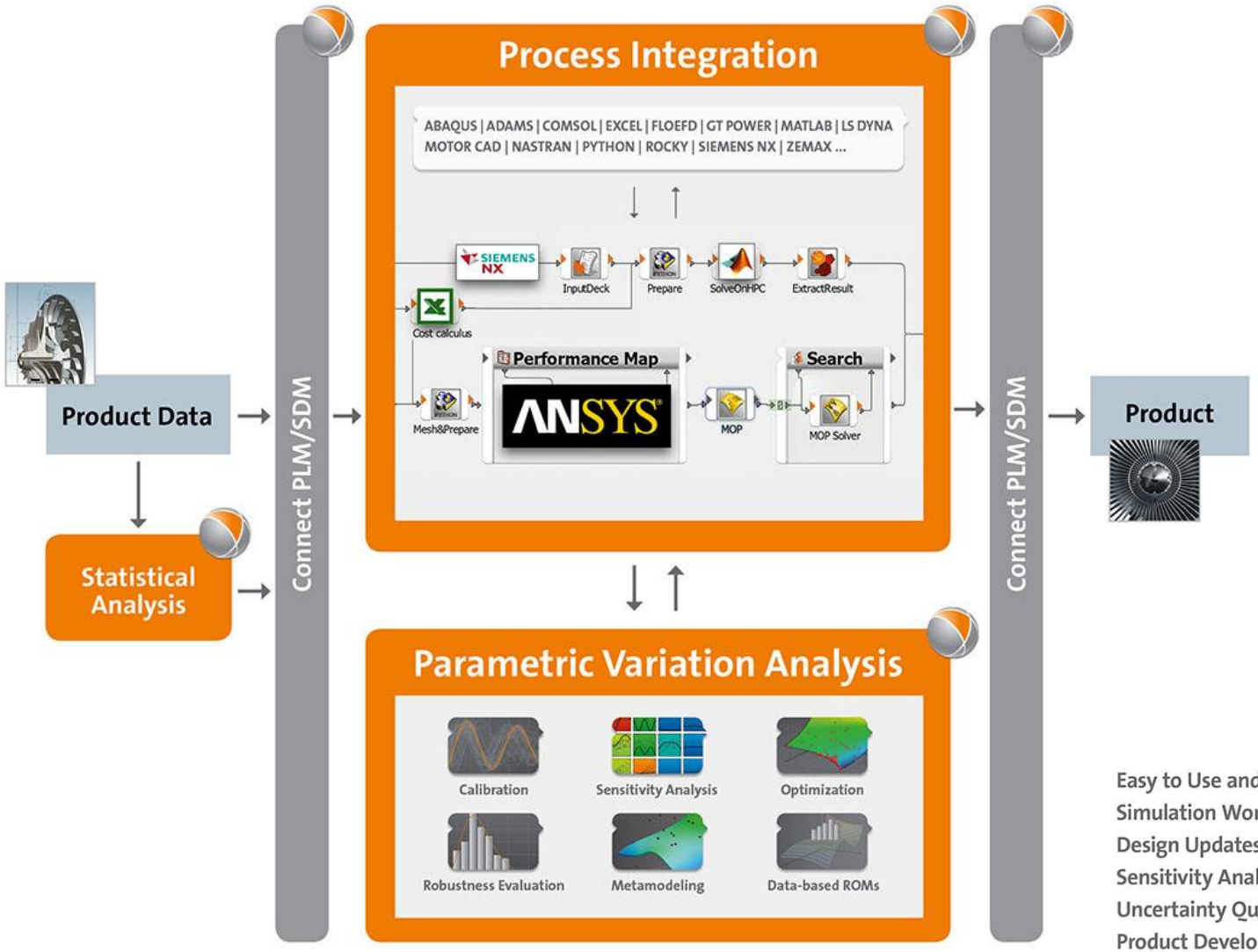
Reasoning

Understanding

Improving

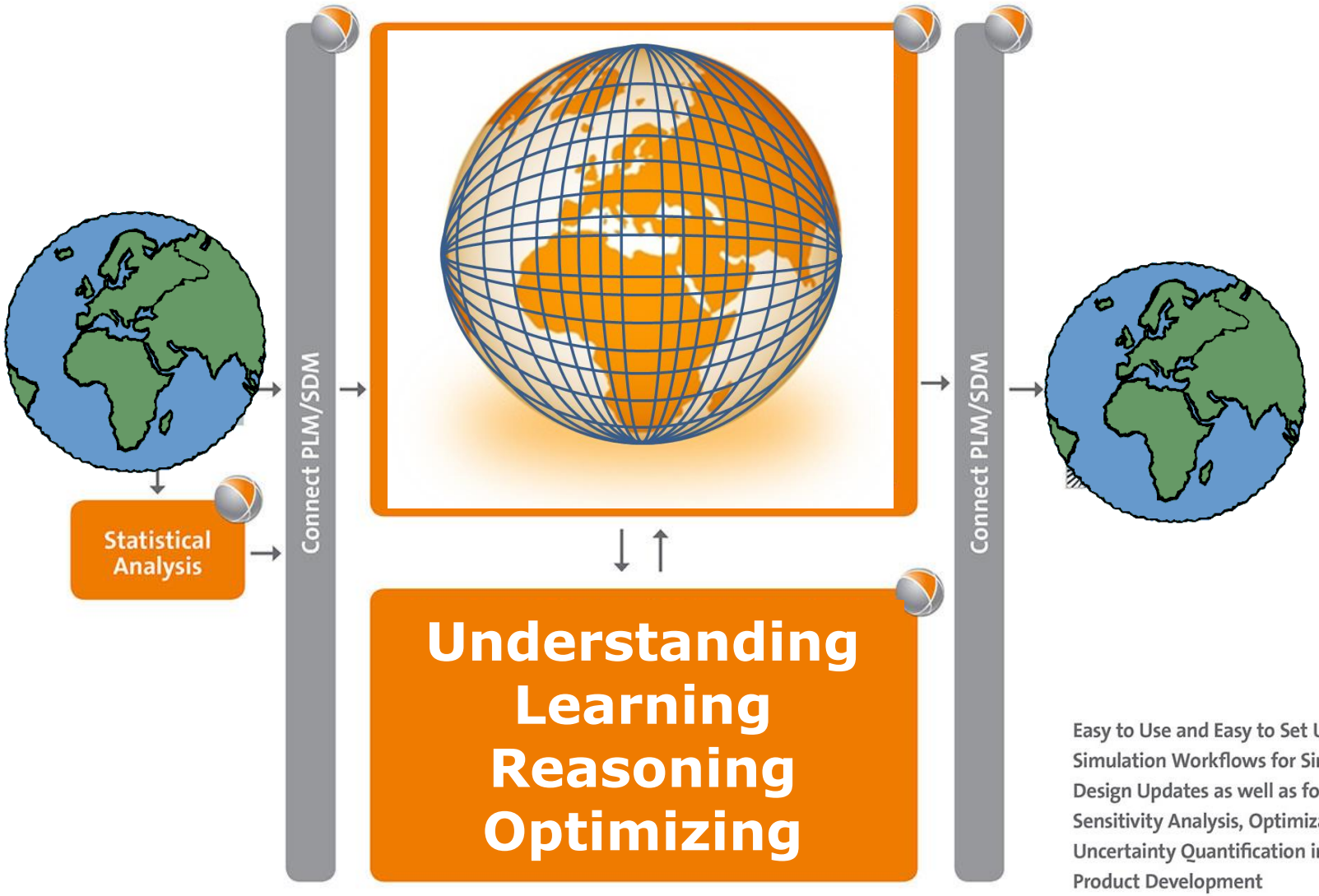
Learning

optiSLang connects



Easy to Use and Easy to Set Up Simulation Workflows for Single Design Updates as well as for Sensitivity Analysis, Optimization, Uncertainty Quantification in Virtual Product Development

optiSLang connects



Easy to Use and Easy to Set Up Simulation Workflows for Single Design Updates as well as for Sensitivity Analysis, Optimization, Uncertainty Quantification in Virtual Product Development

Let's concentrate on

existing

real world counterparts

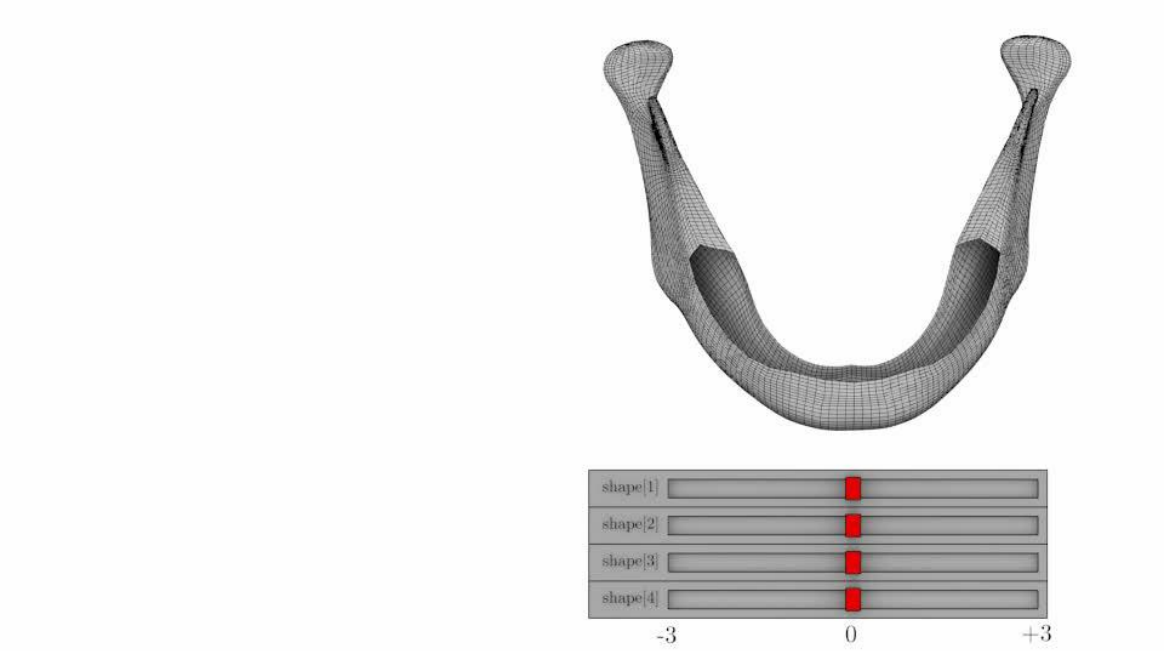
Data analysis

- Use from Webinar

- And other methods

Use case
Autoparameterization of geometric variations

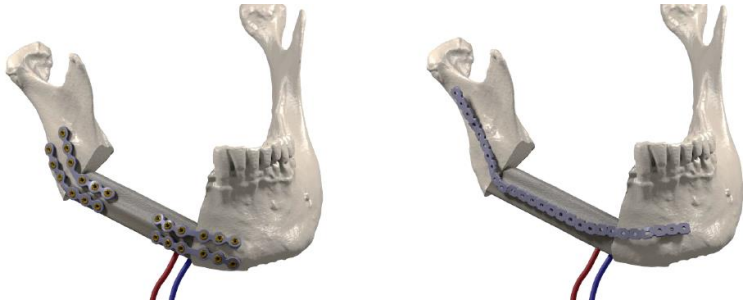
- Input: 60 Measurements of human mandible bones
- Task: Find an optimal parameterization of natural geometric variation patterns based on measurements

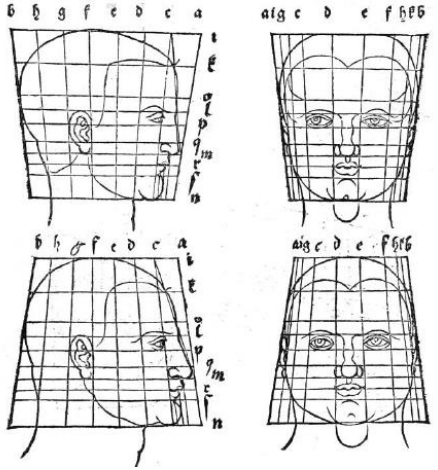


With courtesy of UK Aachen (Source: S. Raith, WOST 2015)

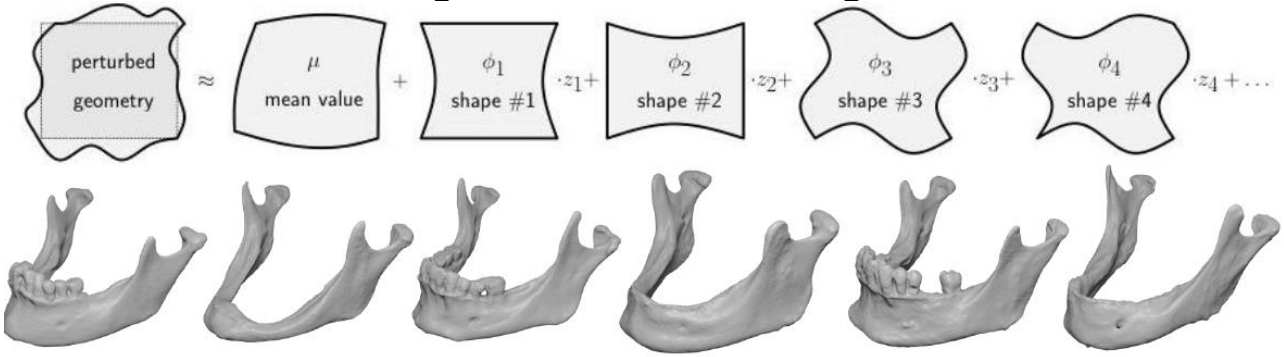
Identify shapes of Differences using SoS

- Reconstruction with bone transplants
- **Problem:** Transplant bone shapes are predefined and don‘t match the mandible shape
  -> could lead to fracture and other problems

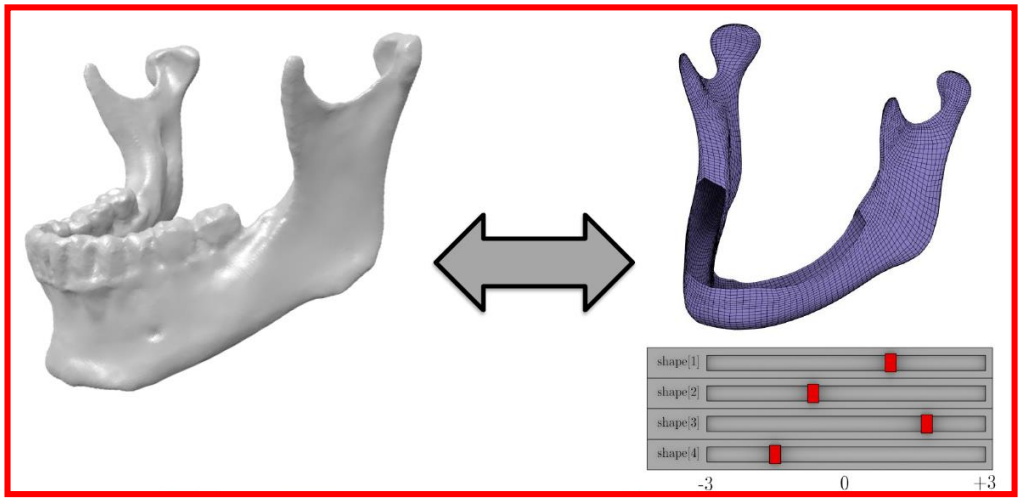


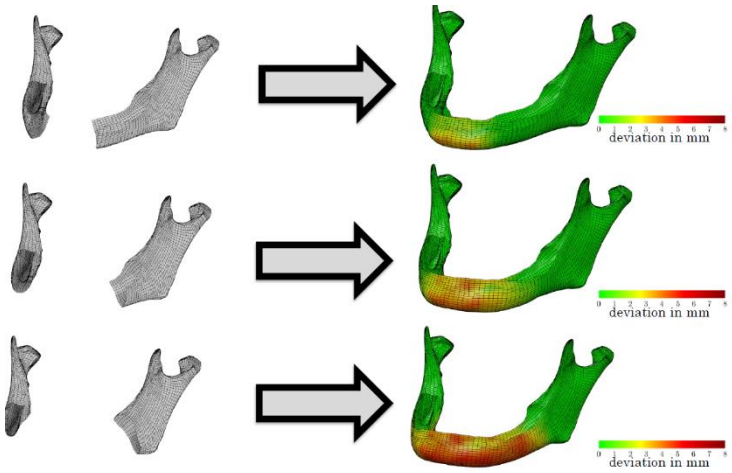


- 63 human mandibles were investigated: Volumetric images of CT scans

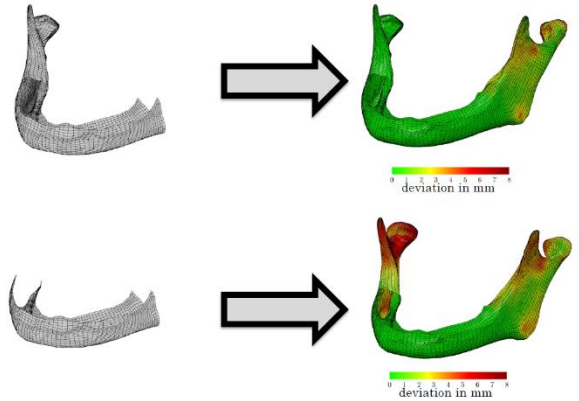


Identify shapes of Differences using SoS

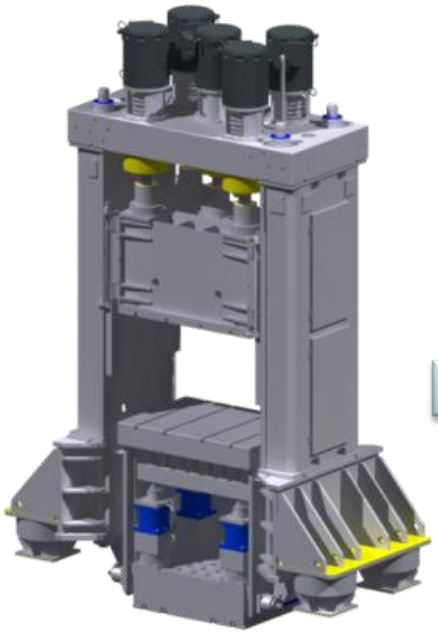




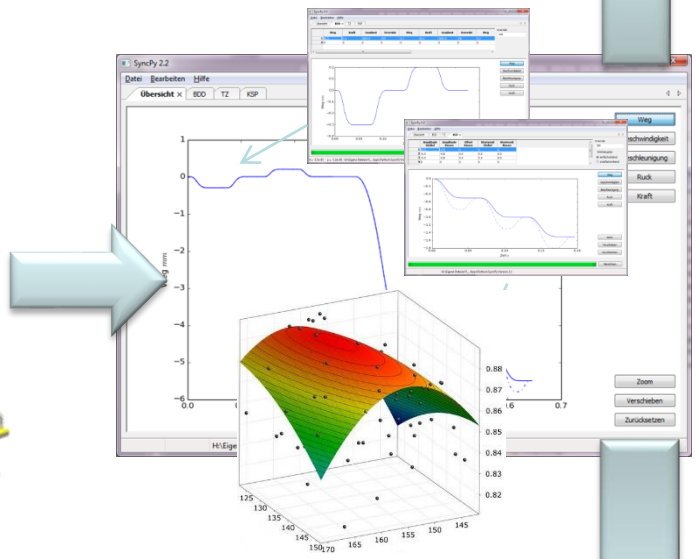
- Calculation of amplitudes that are suitable for best matches between standard geometry and actual mandible shapes

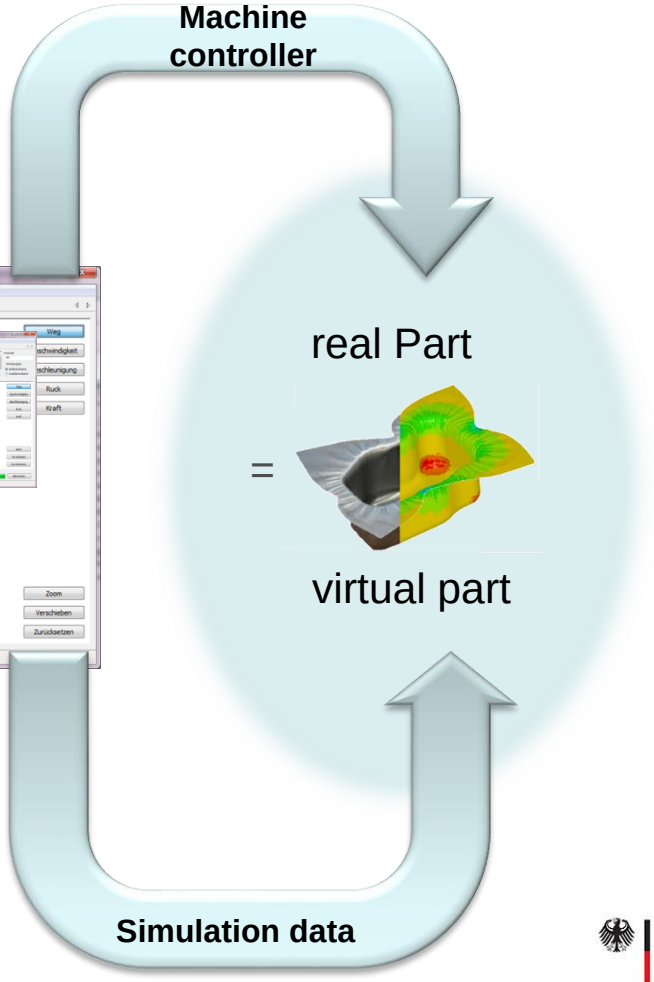


Machine control using metamodels



Process parameter:
- Amplitude
- time
- Force





1. Calibrate simulation model with test results
2. Run sensitivity analysis in virtual world and generate MOP for machine control
3. Use MOP to control the dynamic process and optimize forming result online

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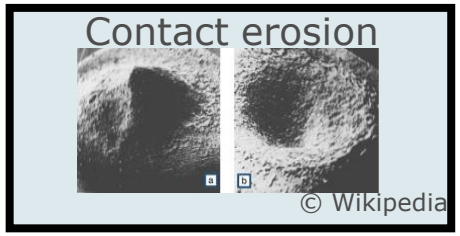
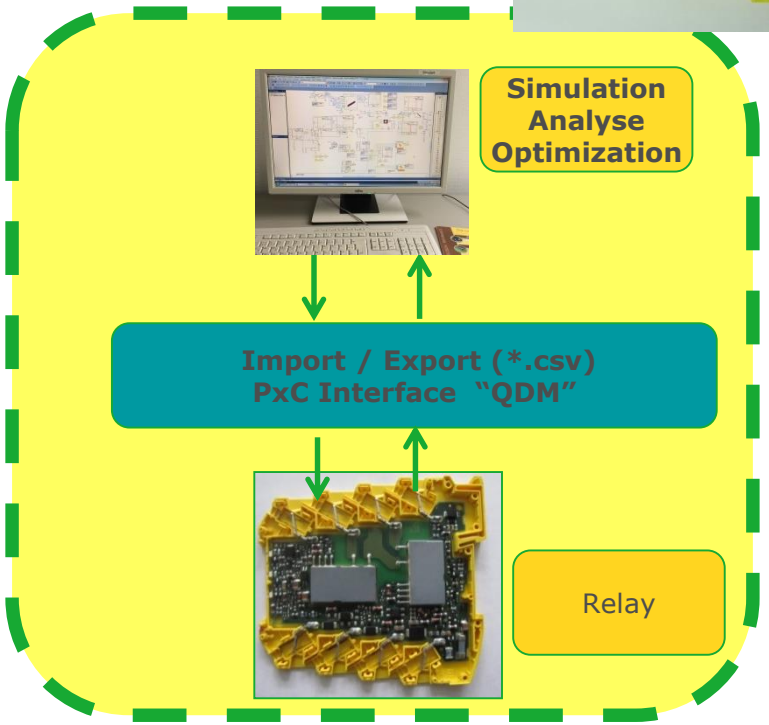
by courtesy of Fraunhofer IWU

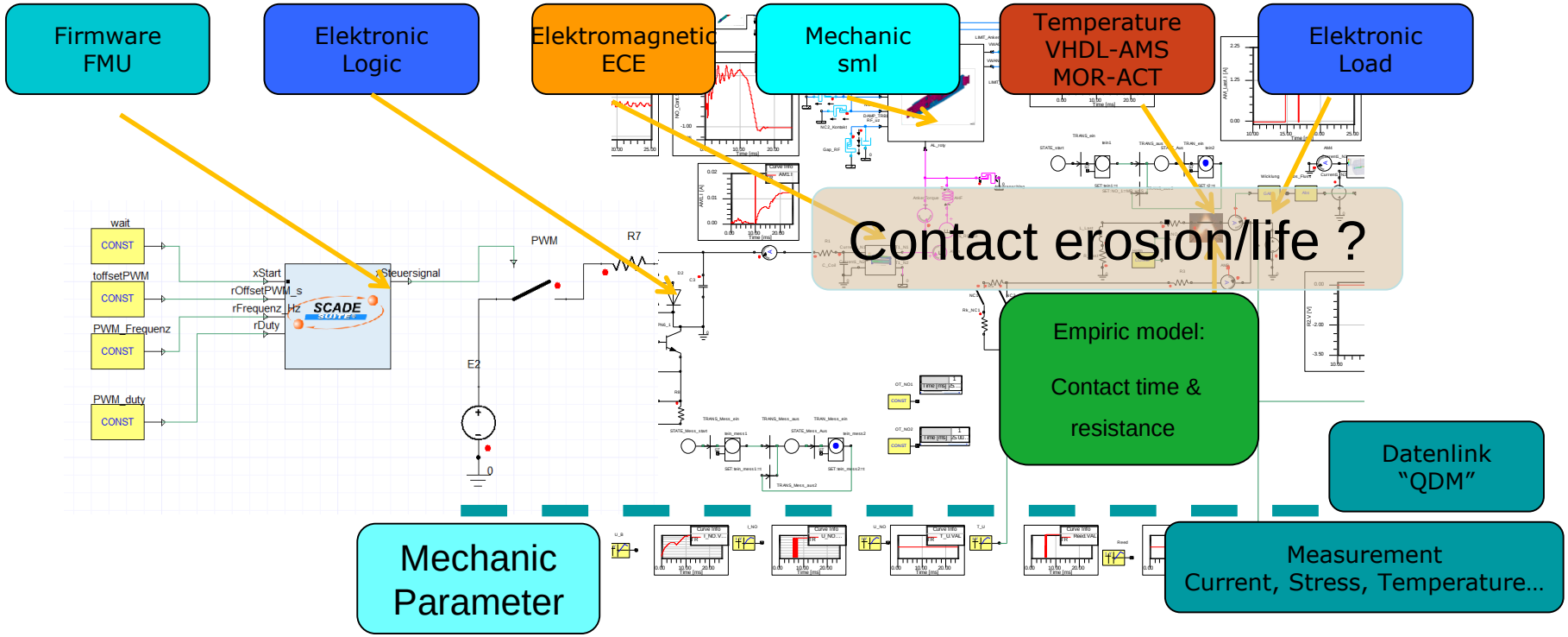
digital twin of a Relay

- Relay is safety critical
- Life of Relay is driven by contact erosion while safety shutdown
- Relay operate in harsh environment, because of housing no inside measures possible
- Today relay needs to be replaced when a 10% probability of end of life is estimated (very conservative)
- From possible measures of "relay in use" like current, voltage, temperature a „digital twin" should track the remaining life
- With working digital twin remaining life and replacement cycle can be tracked and optimized





Relay Simulation model in Simplorer

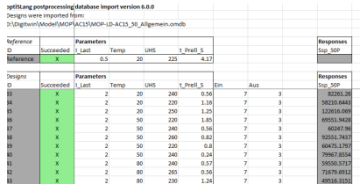


System simulation model was build.

To be used for digital twin contact life and mechanical parameter need to be identified automatically.

by courtesy of PHOENIX CONTACT

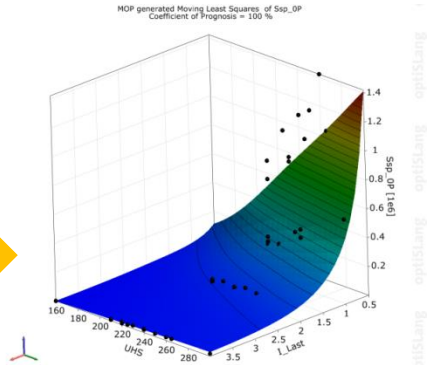
Contact life of the Relay with data based ROM's



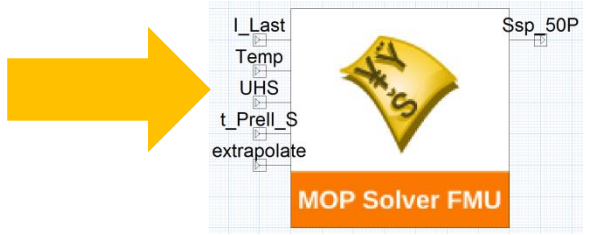
Relay values for
- Load
- Environmental conditions
- failure rate

Measurement

Excel Add-In

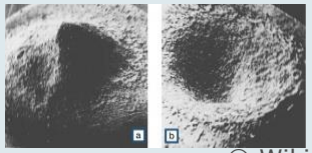


MoP



FMU

Contact erosion



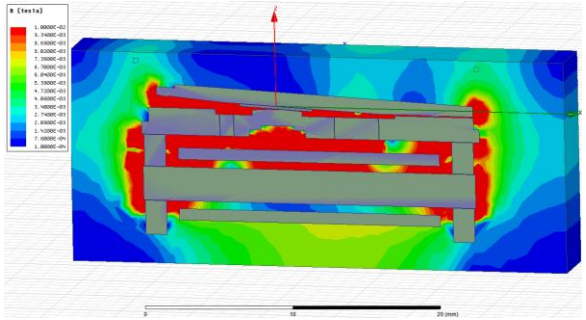
© Wikipedia

Measurements in the window of operation give the data base to approximate contact erosion and life.

by courtesy of PHOENIX CONTACT

Mechanical Parameter of relay in action cannot be measured in field!

Identify mechanical parameter (throw) from magnetic field.



by courtesy of PHOENIX CONTACT

„Echtzeit“

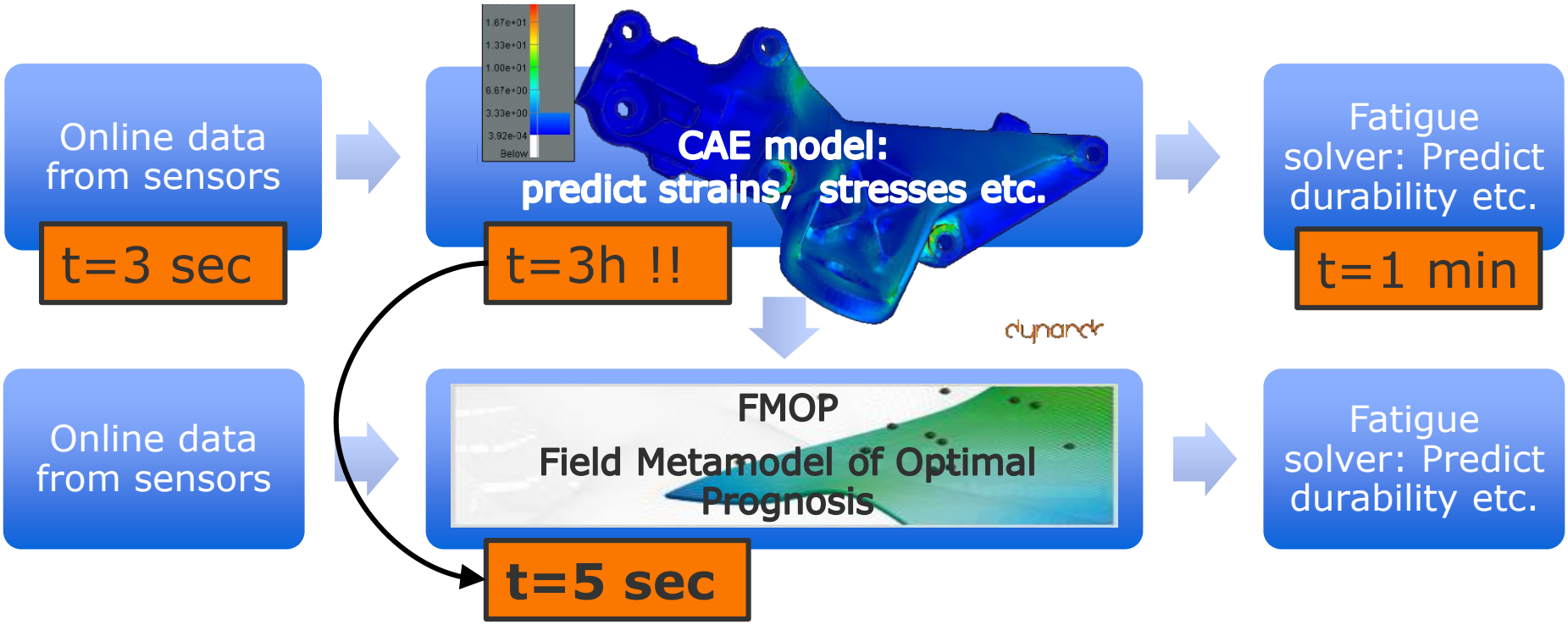
- „All machines: Stopp“
- Rules, Codes, …
- Possible maintenance intervalls
- Possible measurement intervalls
- Decision processes
- Approval processes
- …

➔ Which decisions are influenced by the twin?

➔ When and how fast has the twin to help?

Real-time approximation of FEM solutions

Decisions in embedded devices with sensor data

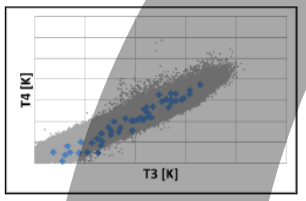


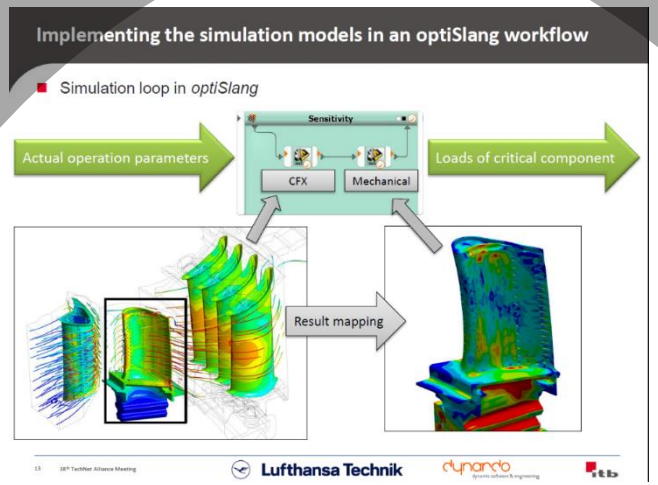
- **Replace** expensive parts of the CAE model by high-accurate meta models
- FMOP/SoS **approximates stress, strain, displacements** etc. for **EACH FEM NODE**; needs DOE to create data driven models
- FMOP is fast and needs little memory, suitable for large-scale systems

With courtesy of MAGNA (Image source: R. Lampert, International FEMFAT User Meeting 2016)

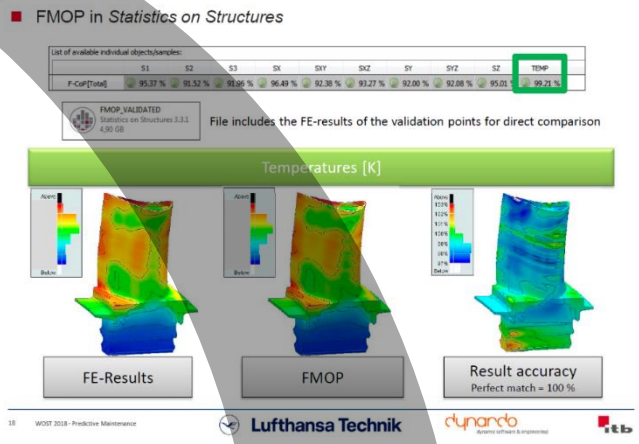
The sample set is calculated with high fidelity ANSYS CAE for temperature, stress and life effects on blades.
1 selected DOE sample runs 15 hours at HPC cluster.

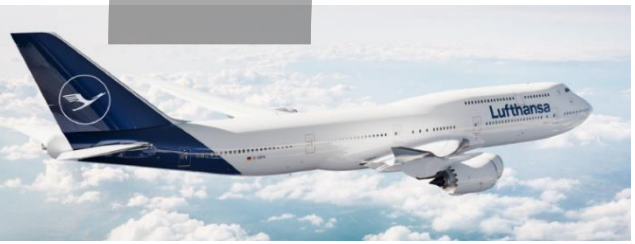
DOE Generation: Based on available flight schedules a representative set of flight is selected





The forecast quality is quantified to be very good!

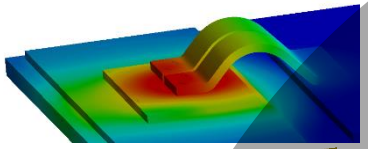


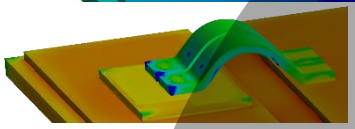


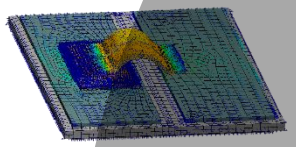
Field ROM ready for system simulation and digital twins

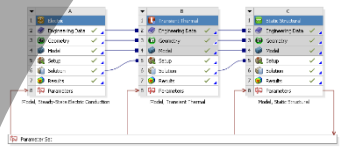
- Shared library and ANS C interface for usage in C++, Python, Matlab, Twin builder
- One flight forecast evaluation runs in seconds

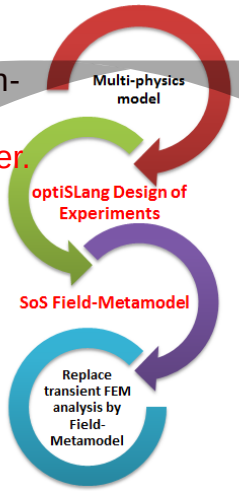
A DOE of relevant loading is created and is calculated with high fidelity ANSYS based non-linear electric-thermal-mechanic simulation.
9 seconds of loading runs 1 day at HPC cluster.



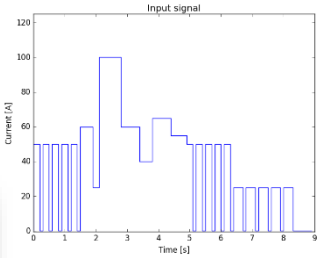


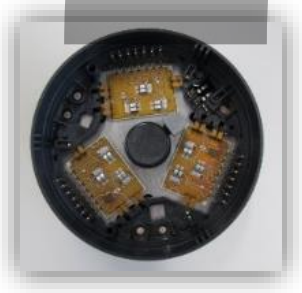






Parametric Signal represent possible electric loading of ECU unit



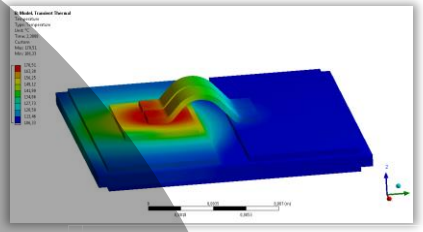


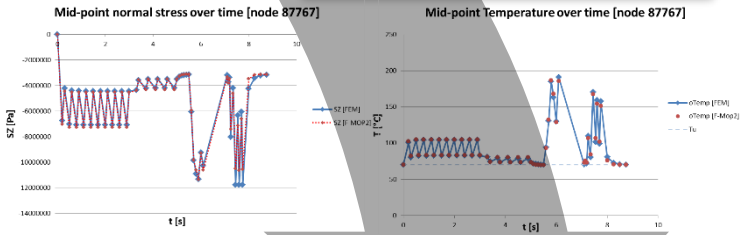
dynardo

BOSCH

Excellent approximation quality for transient temperature and contact stresses!

BOSCH_SoS_algorithm





Field ROM ready for system simulation, digital twins

- Shared library and ANS C interface for usage in C++, Python, Matlab, Twin builder, optiSLang

Faster than real time: 9 seconds of loading run in 6 seconds using Field ROM.

Scalar ROM's

ROM's based on scalar input and scalar output values

FMU/FMI/DLL based integration

From ANSYS Solver …
From DX
From optiSLang
From any external source providing FMU/FMI/DLL interfacing

Signal ROM's

ROM's based on inputs or outputs as time depended (transient) or frequency depended ROMS

DLL based integration

From ANSYS Solver …

From optiSLang/SOS
Data (sensor) & CAE solver agnostic
(Note: Dynardo has successfully done for MATLAB Simulink, same procedure should work for twin builder, DLL/API can be provided to test)

Field ROM's

ROM's based on inputs or outputs as 2D (surface) or 3D (volume) field data

DLL based Integration

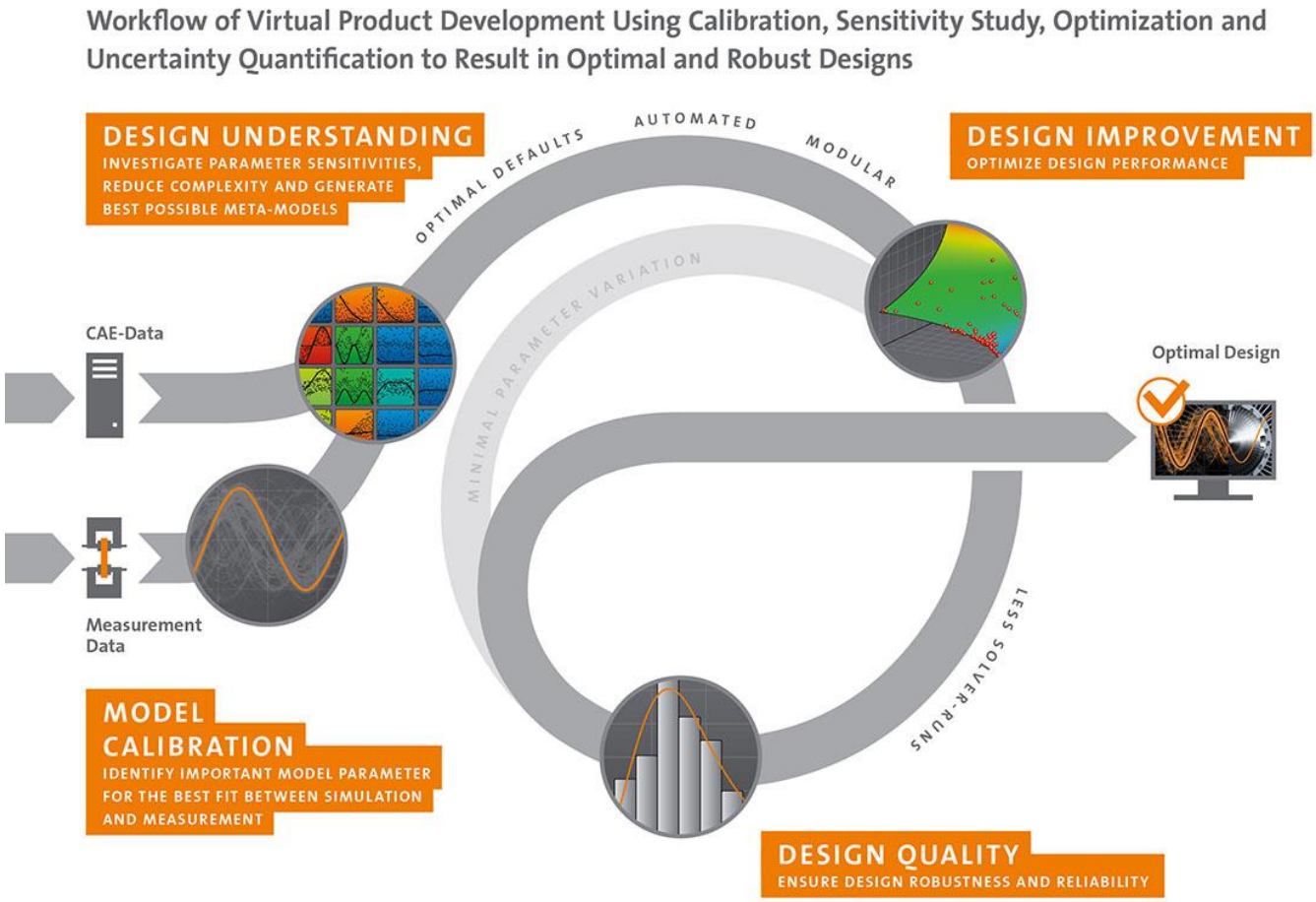
From ANSYS Solver

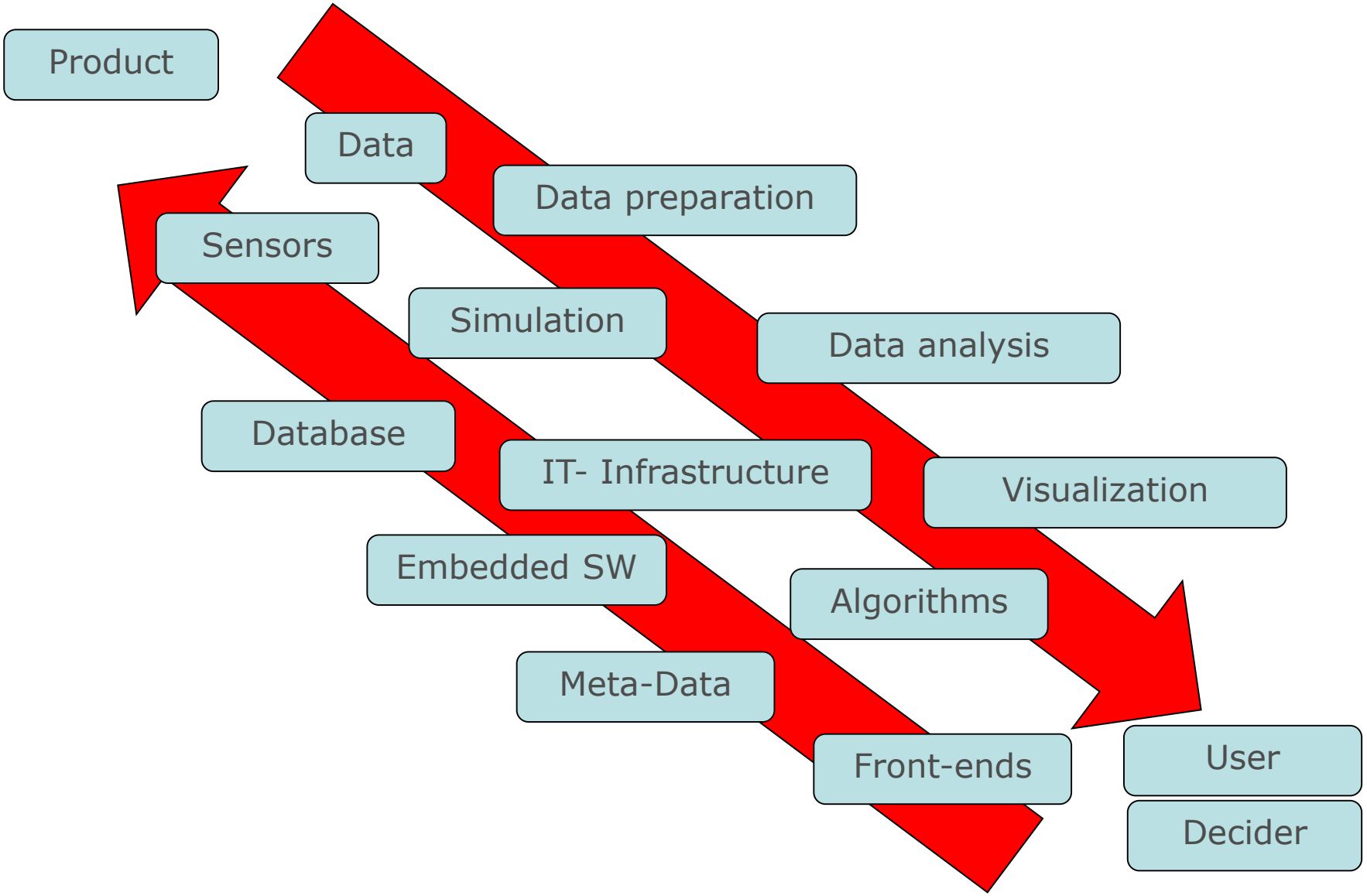
From optiSLang/SOS
Data (STL, foto,..) & CAE solver agnostic
(Note: Dynardo has successfully done for MATLAB Simulink, same procedure should work for twin builder, DLL/API can be provided to test)

Understand, Learn, Reasoning, Optimize

- Calibrate

- Understand
- What if
- Optimize
- Verify





Conditions

User of Digital Twin is
- No optiSLang expert
- No Sensor expert
- No Simulation expert
- No Data analysis expert

➔ Need user friendly interface

Operator needs
- Maintenance improvement of DT
- Standard process
- Traceable processes

➔ PLM/SPDM

All
- No installation of all tools
- No licenses, …
- No time to install, .. maintain

➔ Central (Web-)interface

Brainstorming: Our digital twin

- Do you have a running Twin?
- Where can you/your customers consider Digital Twin‘s help?
  (where is it just „nice technics“?)
- Which (sensor-) data do you already measure, store, „manage“ in system, …
- Which modules do you have already?
- Which additional technical issues to be have considered
- Who has to be involved?
- What is a possible roadmap?