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SCALE

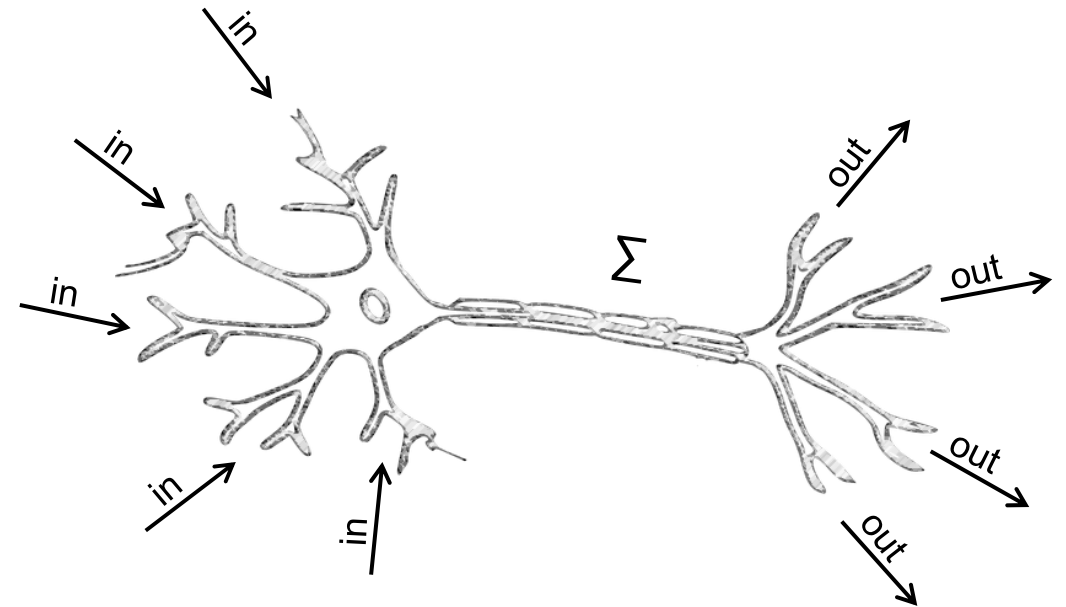
19th NOVEMBER 2019

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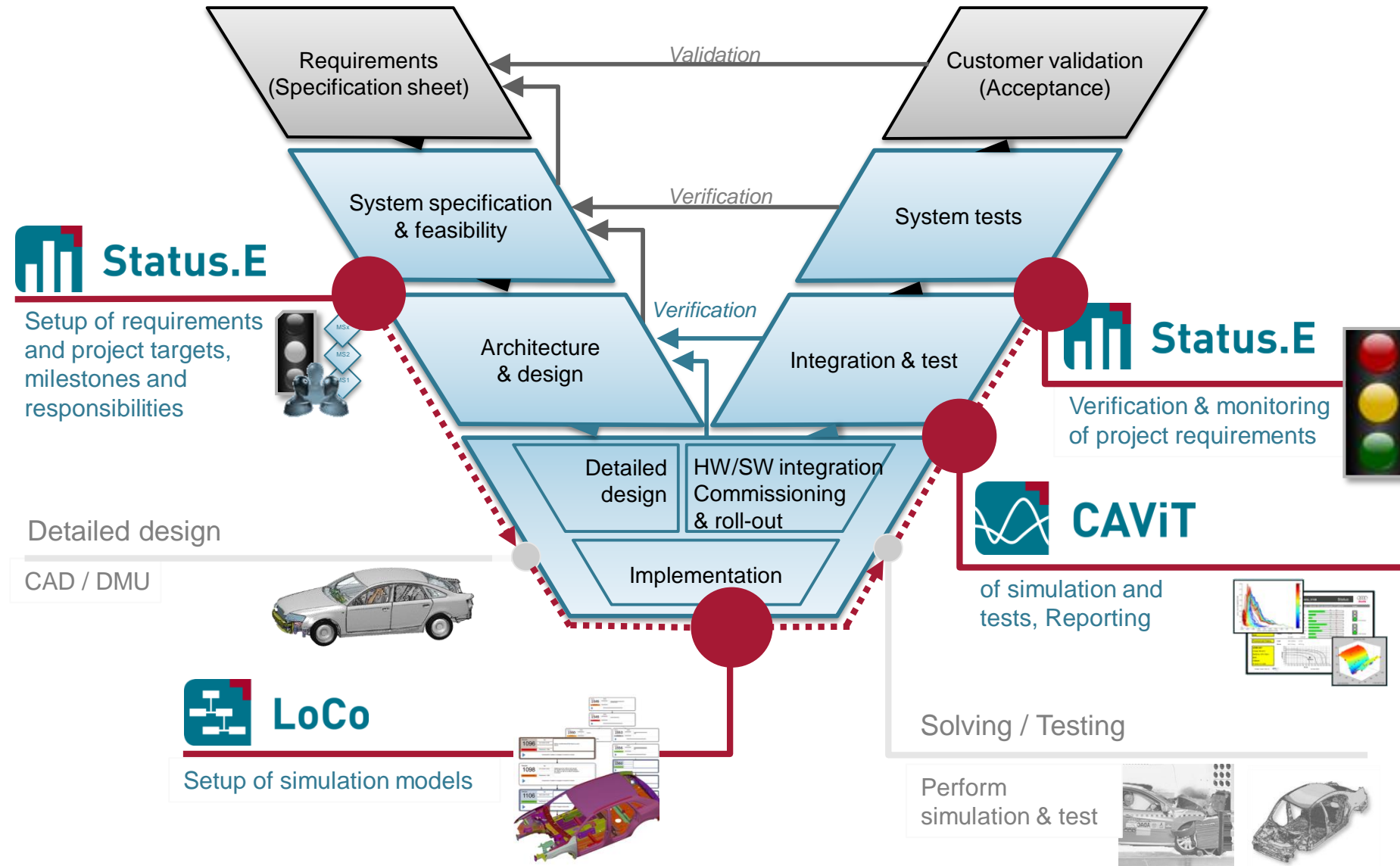
Wissensforum

APPLICATION OF MACHINE LEARNING
TECHNIQUES THROUGH SIMULATION
DATA MANAGEMENT (SDM)

- Loop of virtual Product Development
- Simulation Data Management (SDM)
 - Applying changes
 - Collaboration
 - Result assessment
 - Automatic data processing (results)
- Machine Learning (ML) and SDM
 - What is ML?
 - Examples of ML to solve some narrow tasks
 - Big Data / Data mining

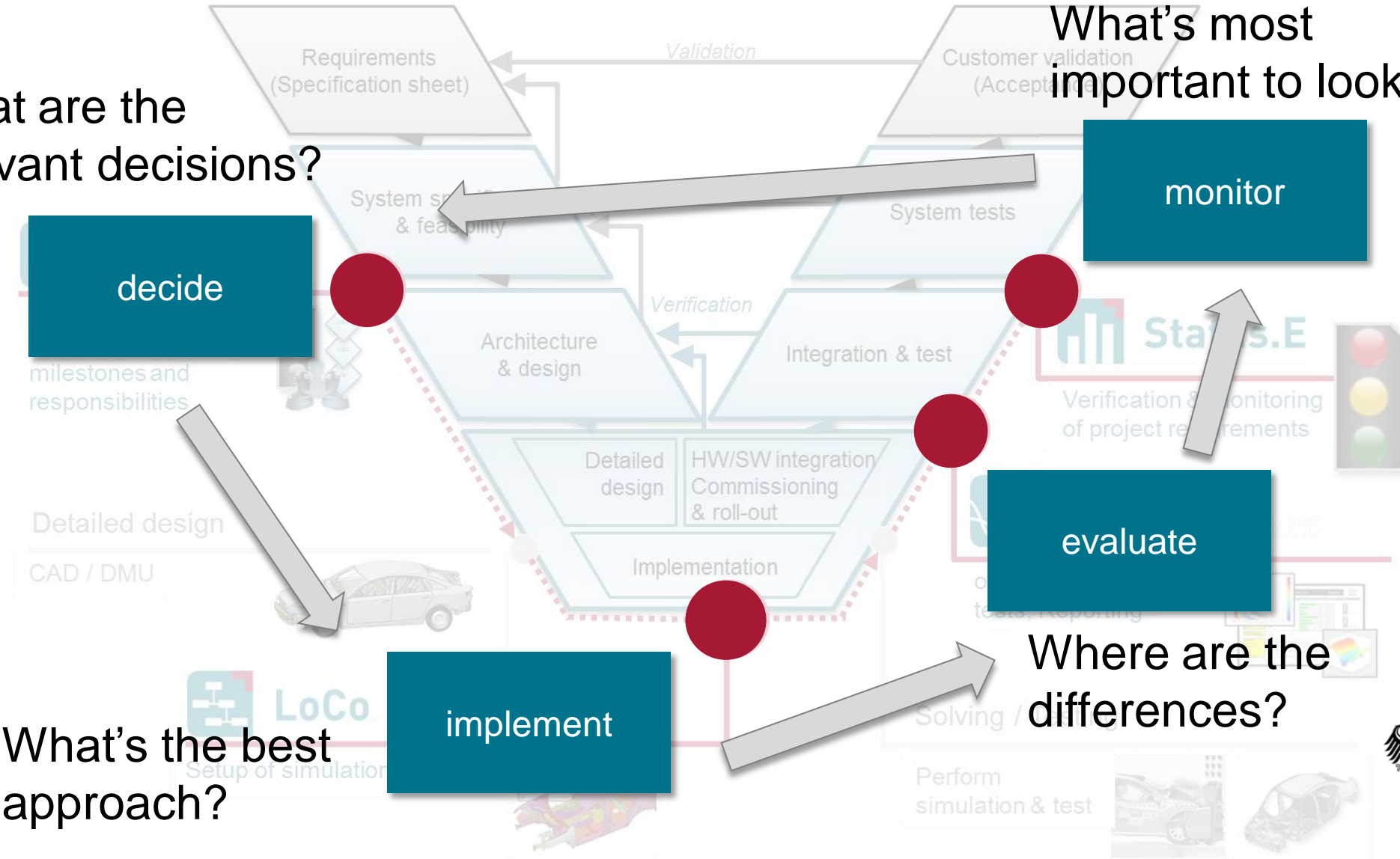


Loop of virtual Product Development



What are the relevant decisions?

What's most important to look at?



decide
milestones and responsibilities

monitor

evaluate

implement

What's the best approach?

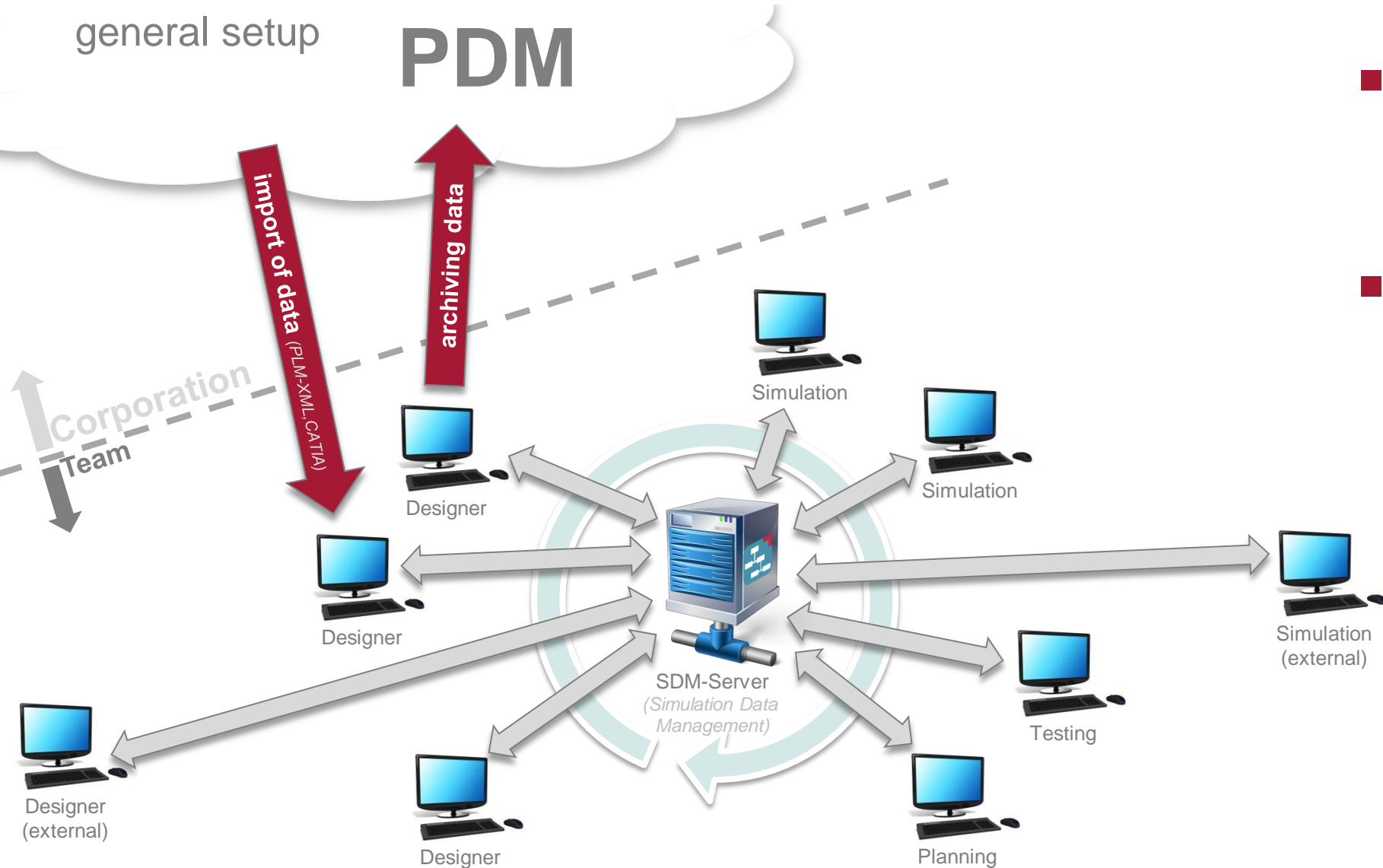
Where are the differences?

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general setup

PDM



- PDM used as data source
 - all data comes from PDM
 - all work results go to PDM
- SDM used for virtual product development
 - Interactive collaboration
(including internal and external team members)
 - All data always at hand for every team member in real time
 - No files, no file system
 - **CAD** and **CAE** directly integrated
 - Tight integration of common tools
(CATIA, ANSA, HW, Animator, META, LSPP, ...)

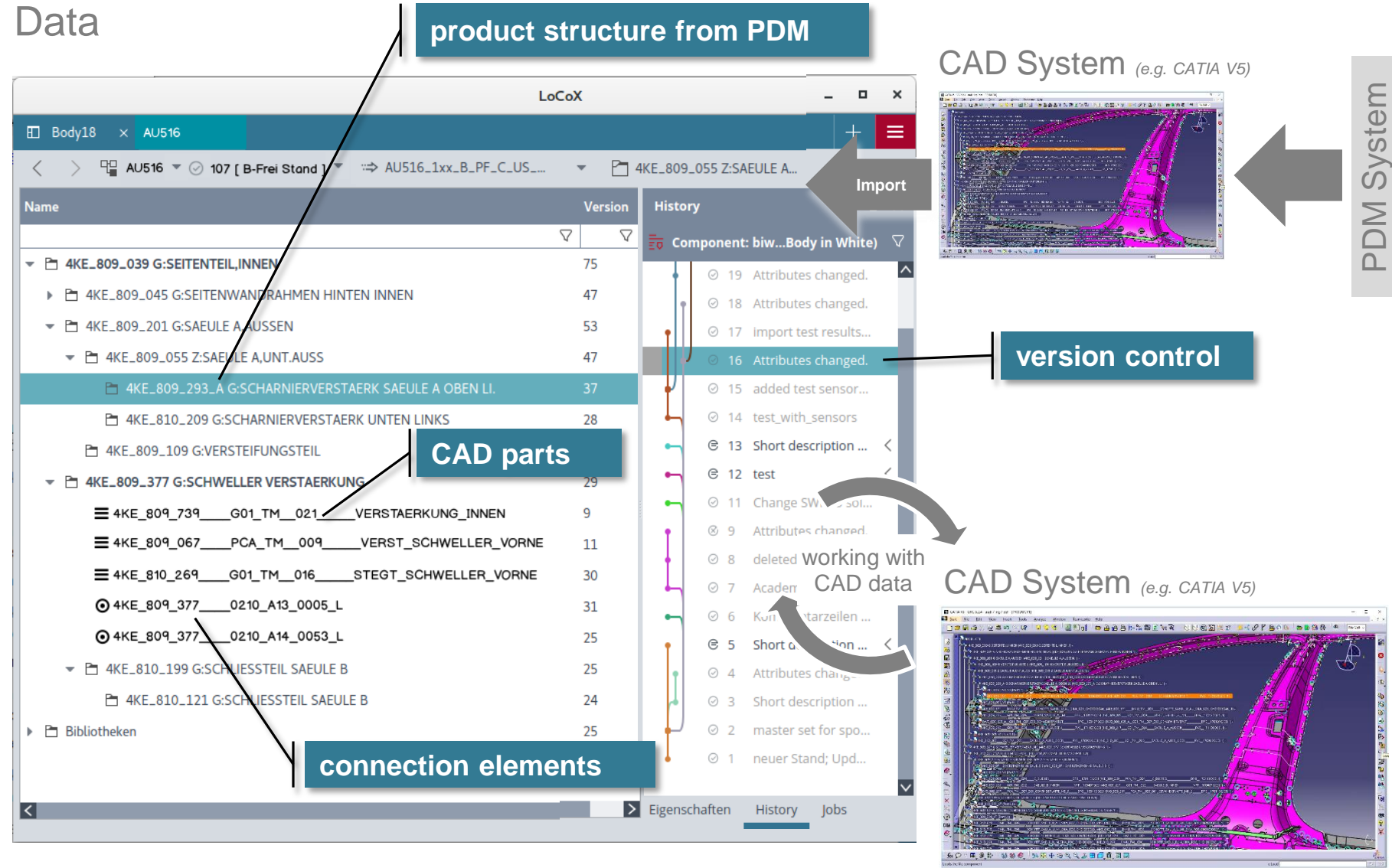
Simulation Data Management

import and work with CAD Data

- Import from PDM system (*interface*)

- Integrate

- Apply changes
- Version control
- No files
 - no file system
 - no up- and downloading
- Connection elements
- Variant control (*which parts are used for what product variants*)



Simulation Data Management

meshing and modelling

- Directly on imported CAD data
- Process
 - CAD Data opened in meshing tools
 - Collaborative working (*multiple users*)
 - Several solver representations for the same meshed data
 - Mesh directly integrated with simulation models.

The screenshot shows the LoCoX software interface. The main window displays a 3D model of a car body with a yellow meshed component highlighted. The interface includes several panels:

- Browser:** Shows a list of components and versions, including '71 Testversion für LOCO-5825' and '70 Different Connections for NVH and Crash'.
- Komponenten:** A tree view showing the structure of the model, including 'body_in_white', 'body_side_left', 'body_side_right', 'body_under', 'front_floor', 'front_section', 'rear_floor', and 'roof'.
- Läufe:** A list of simulation runs, including '0070_lsdyna_CRASH', '0070_lsdyna_NVH', and '0070_pamcrash_CRASH'.
- Table:** A table with columns for Name, Version, Eigentümer, Änderungsda..., and FileType. A row is highlighted with a blue box and labeled 'Meshed component'.
- Historie:** A list of actions, including '5 Change discipline', '4 Disziplinen anpassen', '3 1.849', '2 Removed SolverType', and '1 live'. A blue box labeled 'CAD data' points to this panel.
- Database:** A table showing the database structure, including 'ANSAPART', 'EDGE', 'ELEMENT', 'GEOMETRY', 'GRID', 'MATERIAL', 'PROPERTY', and 'SET'.
- 3D View:** A 3D view of the car body model with a yellow meshed component. The current part is 'Slave tied'.
- Modules Buttons:** A panel with buttons for 'Hot Points', 'CONs', 'Faces', and 'Surfaces'.

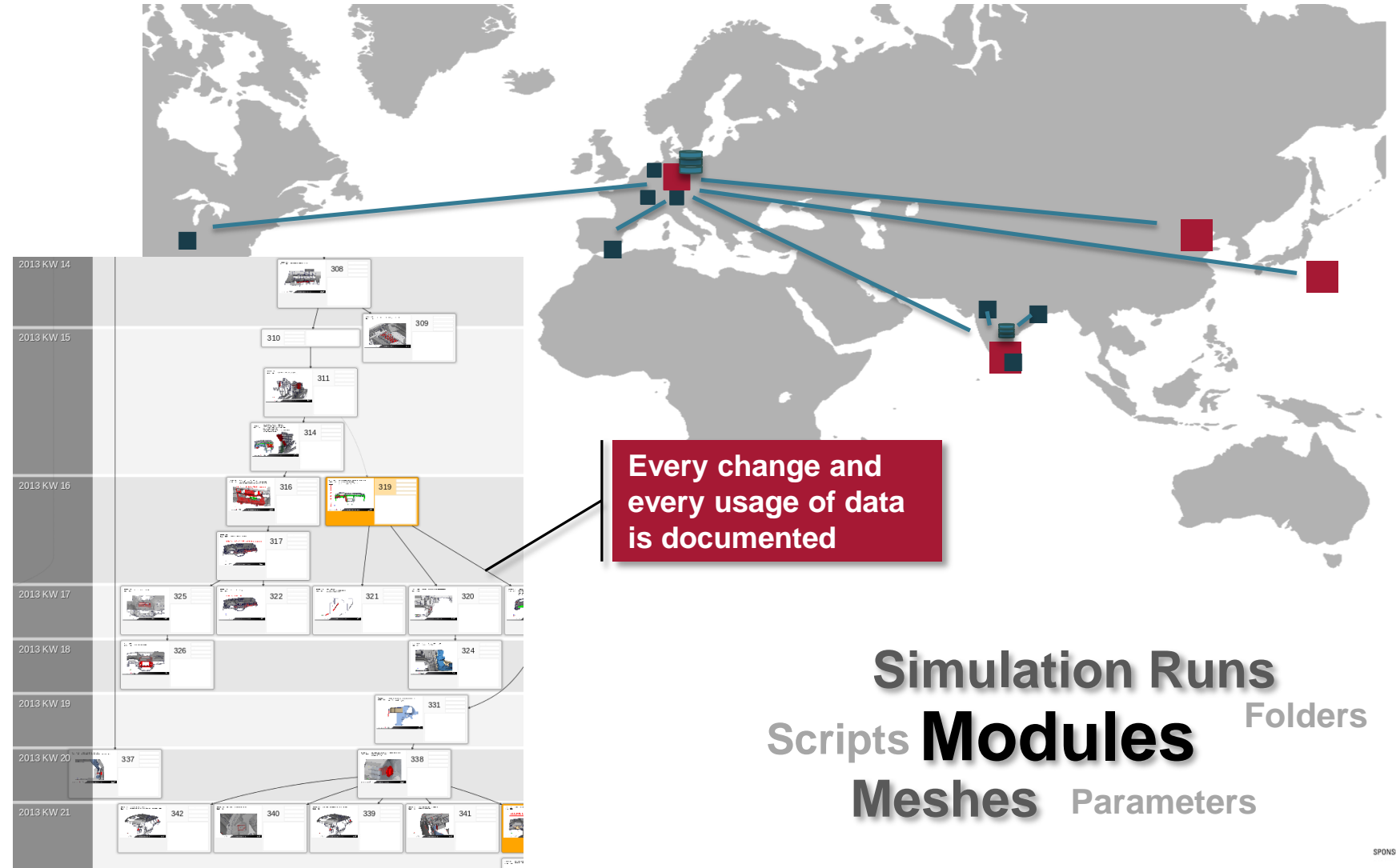
product structure from PDM / CAD-System

create multiple solver representations

open data directly for meshing

collaborate and track changes

- Multitude of
 - Product variants
 - Users and sites
 - Projects sharing data
 - **Simulation results!**
- Version control is the key!
 - Each **object** is versioned
 - Every **change** is tracked and documented
 - The complete audit trail of all data is preserved
- Synchronization
 - Data is automatically synchronized between all users
 - No file handling



document changes

Documentation

- Users describe each change
- Pictures and other documents can be attached

What is missing for Machine Learning?

- Classification of the change
- Intention and reason of the change
- Rating of the effectiveness of the change

mesh data

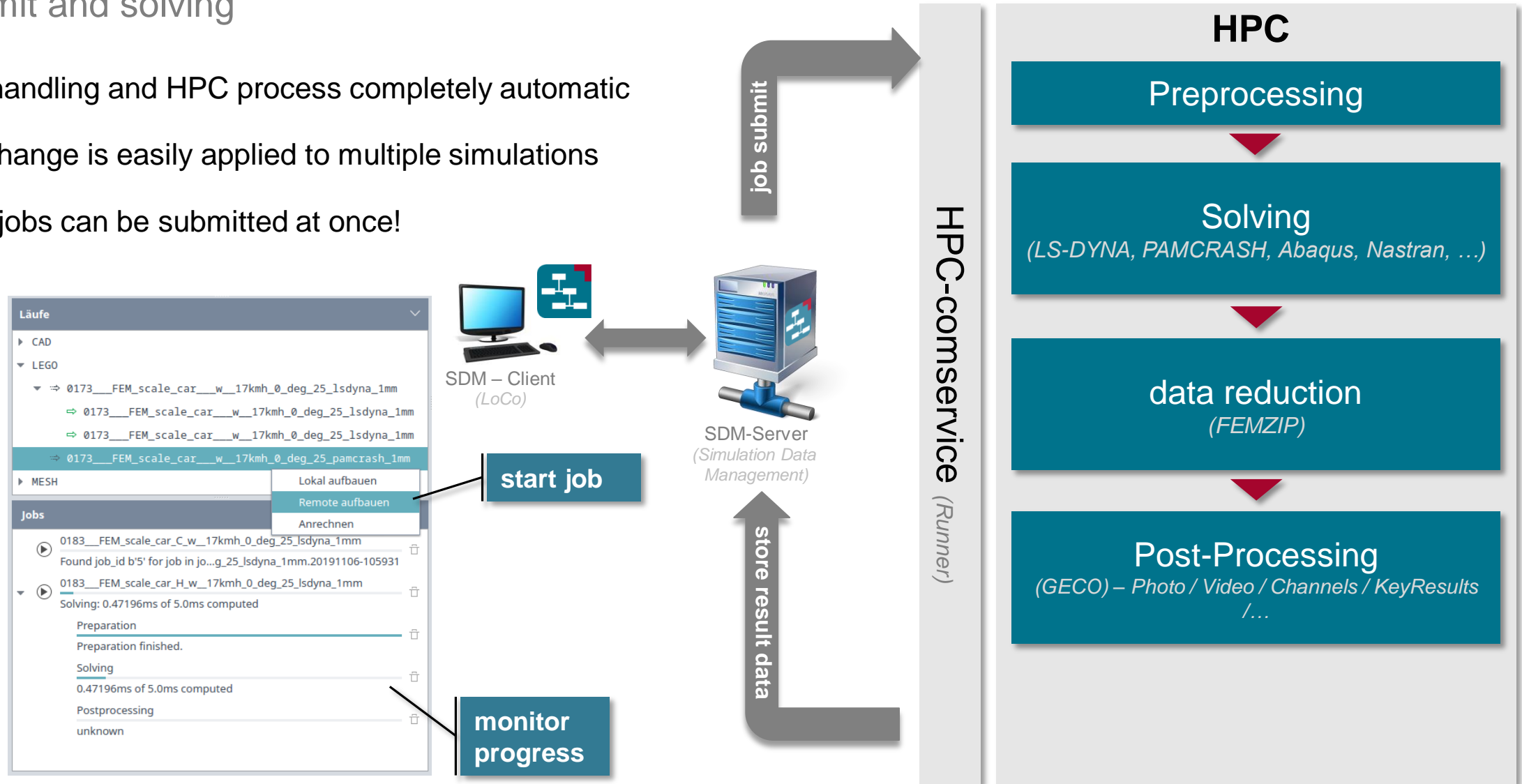
Name	Por-Version	Agentürmer	Änderungsda...	FileType	
trunk_floor_side_right	PID-127	66	peter	18.09.18	ansa
trunk_floor_side_right	PID-127	66	peter	18.09.18	step
trunk_floor_side_right	PID-127	66	peter	18.09.18	fcstd

document every change in a version history

compare CAD and mesh data

job submit and solving

- Data handling and HPC process completely automatic
- One change is easily applied to multiple simulations
- Many jobs can be submitted at once!



result assessment

- Browse results of large amounts of simulation and test data
- Search, group and filter
- Highlighting of critical KPIs
- Access all related simulation data
(reports, movies, pictures, channels, solver result files)
- What is missing for Machine Learning (ML)?
 - Autom. detection of unexpected behavior
 - Tracking of certain behavior
 - Link between certain behavior and applied changes

KPI (key performance indices) that violate limits are highlighted

Test Nummer	Datum	Wall Intrusion	OLC	ADPI
87C70FHQDFYDBB52	DM3F6DWK0KSA846L	11	21.5	76
GjZGM030UVDF386H	Y7ZCMQ2NBLLK0YBH	21	22	39
T1R6WJ82WRWP2IK1	6UGU9CFW2FT13MY7	11	30	55
ZMM30ONB06L24MKR	3GOZO84W5X6TNEJY	19	20	47
EXI5PJQK1SPU1R5L	50FFJM5B5GSL7Z2J	21	21	41
A2LWG511S0O8OT2M	STYB3IUHPEQLDJOB	11	20	82
P4QFLZB5GHR4OMC8	TUSGHSX7FXWN5MXY	12	20	75
GC942QHGXNLQN9FT	OQAEAPVYFZLJ8EKI	11	20	82
VBPY4L71NXN08AT3	DL7S3MVMPQQSN0LF	10	24.1	75
5BRIL76LBX0QYEZR	R6393OD40Z2YR4XM	9	20	100
2I2SVBK0KP5BIR8R	287JXR92I6ADMT4G	19	20	47

Overview Key Results

Table 1: Structural Key Results

Simulation #	OLC Middle
Simulation #1	50.2
Simulation #2	50.2
Simulation #3	51.2
Versuch #1	50.2

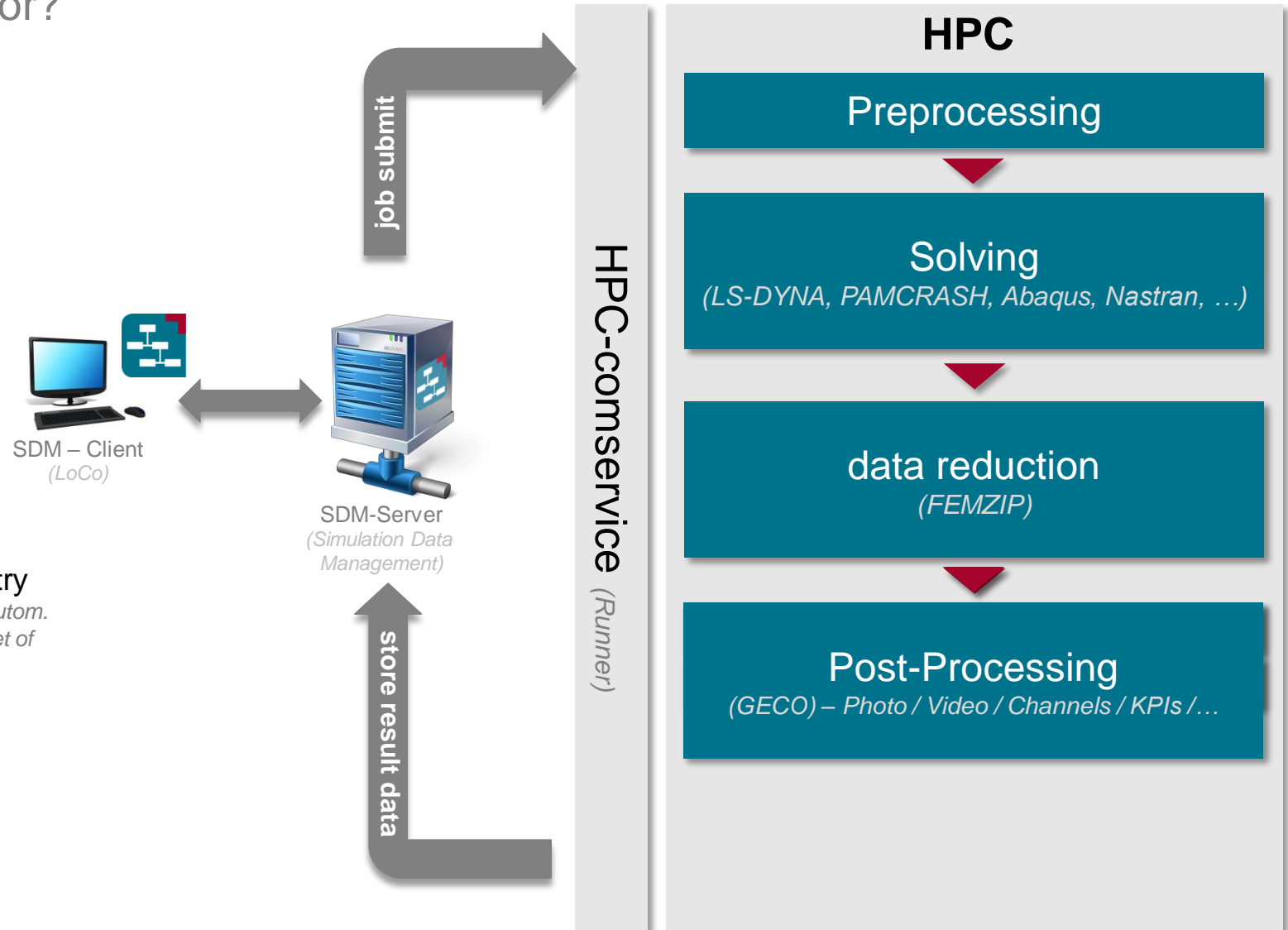
Table 2: Occupant Safety Co Driver Dummy

S2_0629

	Wert	Ratin
KOPF		
- hic15 [1]	325	4.0
- a3ms [g]	59.2 g	4.0
- a res [g]	62.8 g	4.0
THORAX		
- shld [kN]	2.72 kN	0.0
- trri1 [mm]	-22.3 mm	4.0
- trri2 [mm]	-24.8 mm	4.0
- trri3 [mm]	-31.7 mm	3.33

but what about unexpected behavior?

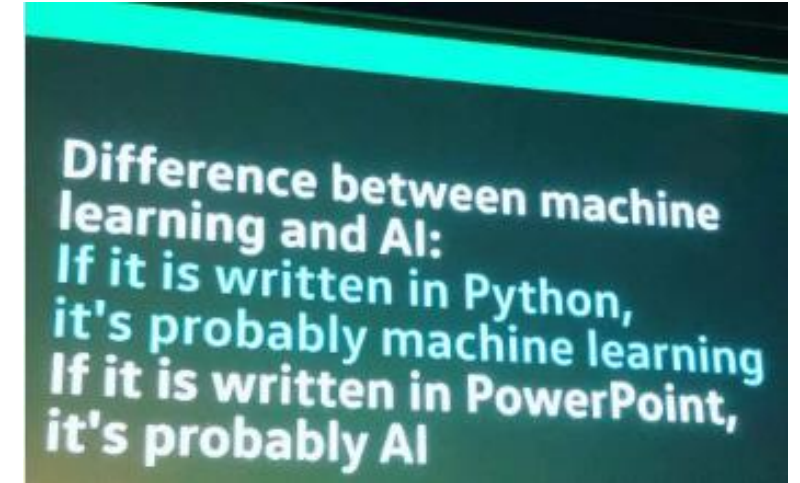
- Only previously defined KPIs are automatically monitored
 - Data is extracted during postprocessing on HPC
 - Only fixed limits are used for monitoring
- What would be needed to detect unexpected behavior?
 - Outlier analysis for KPIs
 - Detection of unseen behavior on geometry
(needs a database of result data that can be used for autom. searching and analyzing of similar behavior on a large set of simulations)
- How to integrate in process?



differences between AI and machine learning

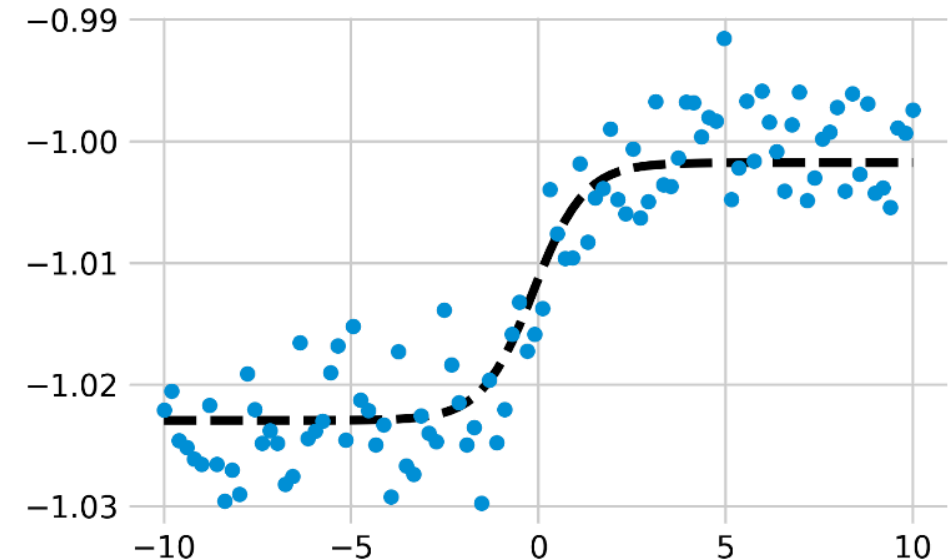
■ AI: Artificial Intelligence

- „... the term "artificial intelligence" is often used to describe machines (or computers) that mimic "cognitive" functions that humans associate with the human mind ...". [Wikipedia](#)
- Strong AI vs. weak AI [de.wikipedia.org](#)
 - **Strong AI:** attainment of cognitive abilities
 - **Weak AI:** focused on narrow tasks

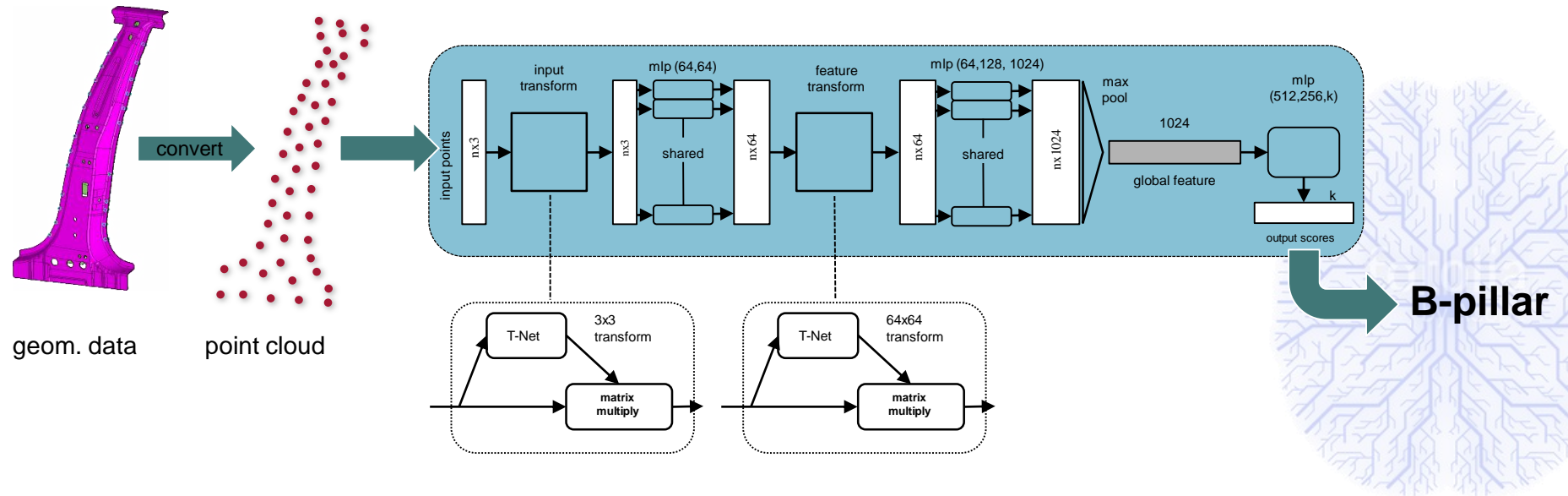


so what is machine learning?

- Different mathematical methods to solve weak AI problems
- Learning from collected/existing data
- Supervised learning: (*supervised, semi-supervised, reinforcement, active*)
 - Pairs of input data and their results are provided
 - Algorithm can deliver prognoses based on that
- Unsupervised learning:
 - Autonomous data arrangement and clustering
 - Data simplification before learning
(*e.g. Main components analysis*)



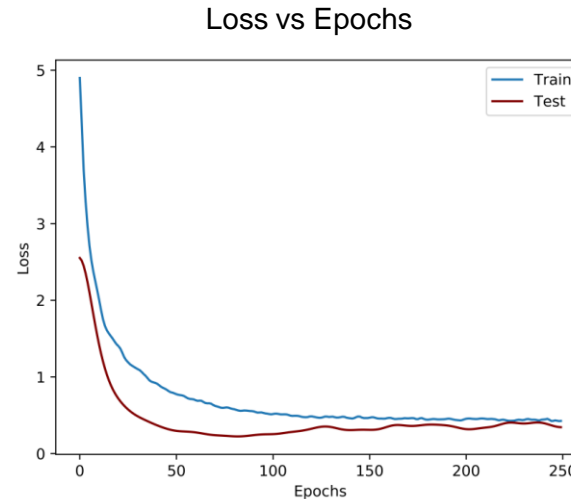
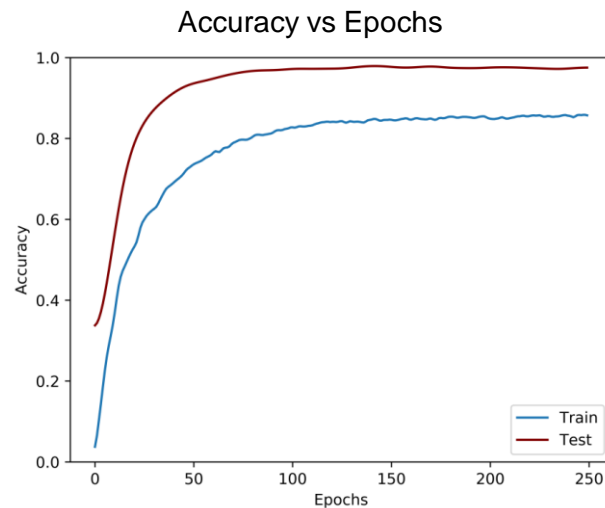
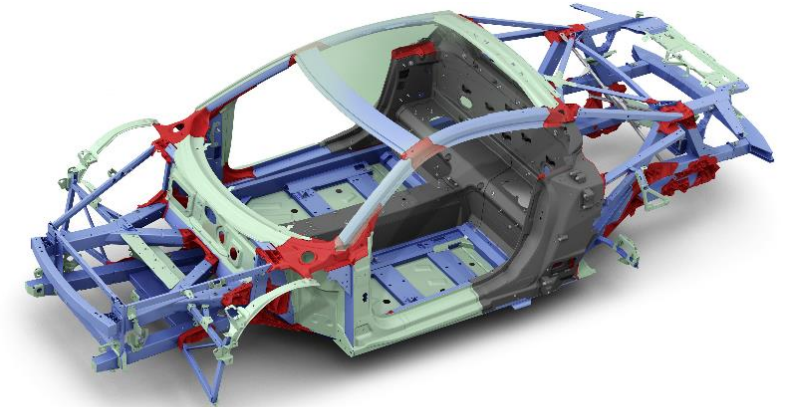
example: geometry recognition



- **Big Data:** Provision, conversion and evaluation of countless components from SDM-System
- **Deep Learning:** Different neural networks with many „hidden“ layers are combined and trained
- **Artificial Intelligence:** ability to detect components was reproduced (*weak AI*)

example: geometry recognition

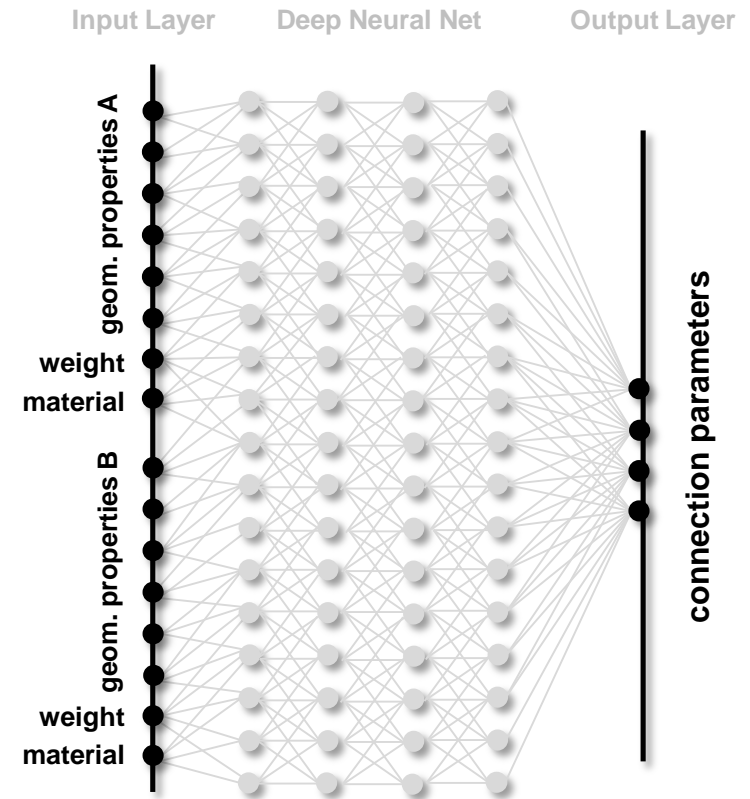
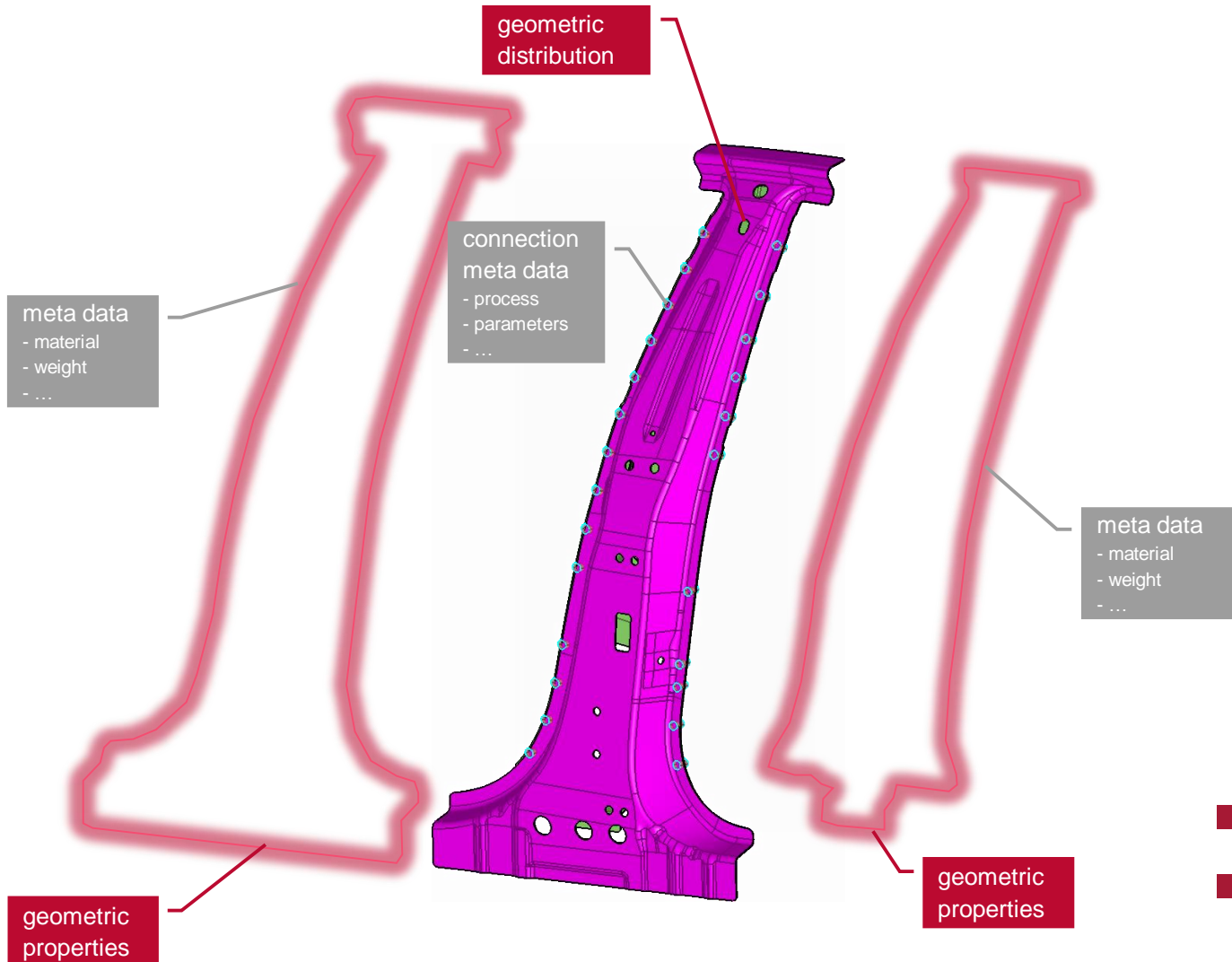
- 5367 versions of body in white includes (2011-2018 extracted from LoCo)
- ~1TB PAM-CRASH includes of the same body in white
- ~580 individual parts in total ~5000 different versions



- Next Steps
 - Identify parts across multiple different vehicles
 - Identify a part group structure

- ~561 von 580 Parts were identified correctly

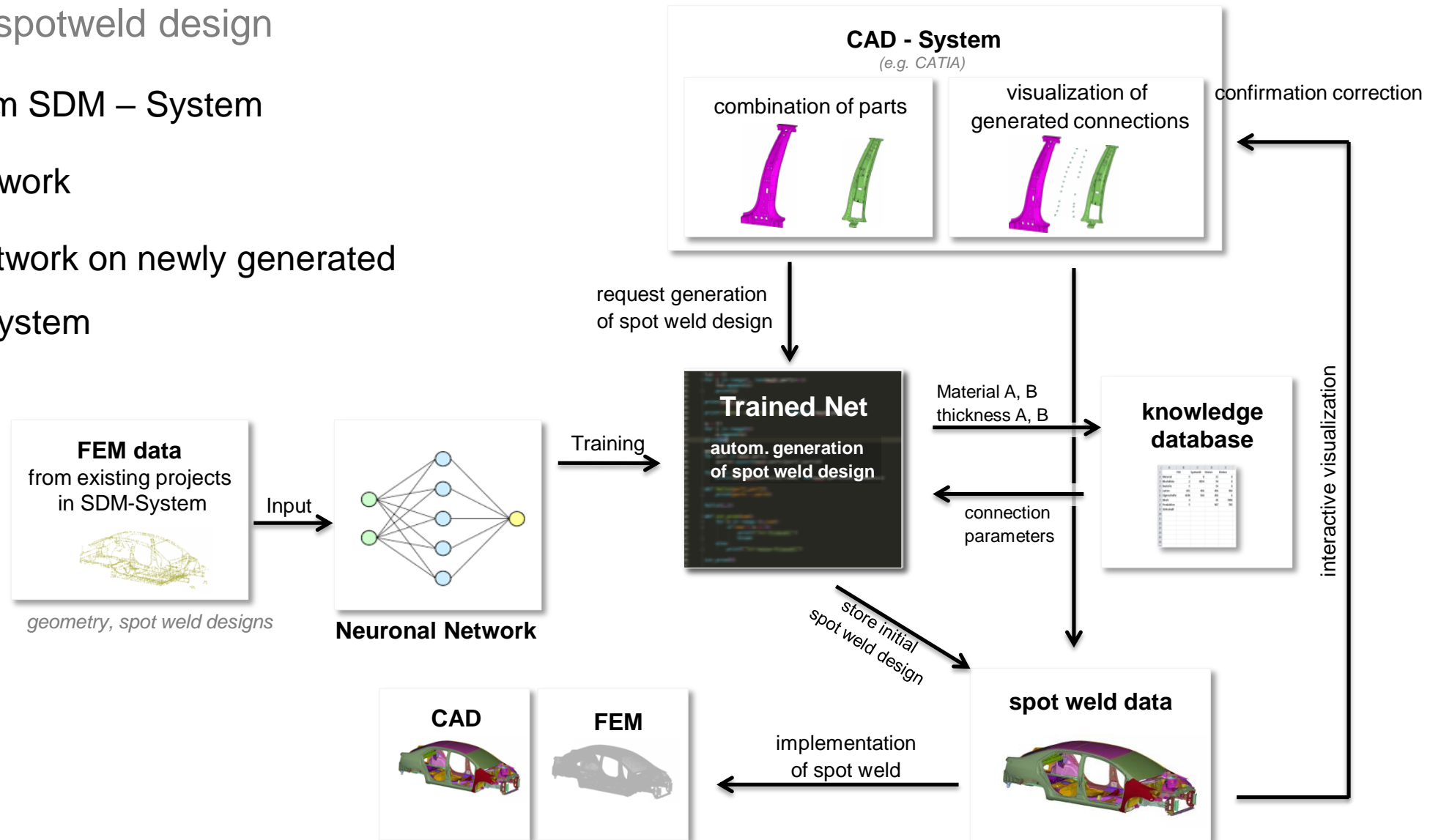
example: autom. spotweld design



- Extract training data from existing FEM data
- Estimation for initial spot weld layout with NeuralNet

example: autom. spotweld design

- Extract data from SDM – System
- Train neural network
- Apply neural network on newly generated data in SDM –System



how to access data of many, many, many simulations

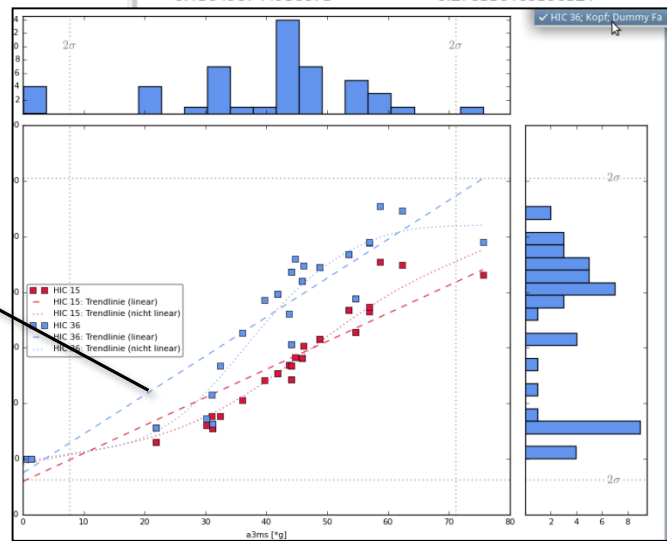
■ All simulation results are accessible in SDM-System

- KPIs of all simulations can be browsed, filtered, searched, grouped, ...
- Statistics can be performed on existing simulation results
- Big amounts of data can be analyzed

browse, sort, filter
KPIs of all simulations and tests

create models
analyze trends

Input		Output
DUMMY_NECK_UPPER_FORCE	GKN	DUMMY_CHEST_DEFLEC
Input	Input	Output
0.512075129199124	0.503098380003094	0.083201521751117
0.385688314526716	0.44250052231538	0.424381099410046
0.471452866237825	0.413690227031111	0.530159342779953
0.469067153101191	0.477384433145722	0.370981970557424
0.165657154139583	0.083189755056854	0.487842531840988
0.190391682523203	0.317582336700658	0.623835253900866
0.907476130623244	0.689741487202134	0.360009924463803
1	0.726490107154115	0.278050394221757
0.213617275727091	0.114595725410726	0.540166510448255
0.363016433602833	0.370875460664871	0.431410927937366
0.750007284019958	0	1
0.399046172568327	0.289030878291524	0.577162706070464
0.130496744956075	0.270530109390521	0.423664332579809
		0.531592876440426
		0.581187627501792
		0.508987153332966
		0.469509841759938
		0.645283122897943
		0.525693334068479
		0.43518773773612



- SDM Systems are the basis for ML because...
 - many CAE tasks can be automated
 - data from different users, disciplines, product variants are centrally located and stored
 - dataset can be related to each other

- Challenges to implement ML based assistants in SDM systems
 - Capturing the relationship between data
 - Gathering the relevant data from the user

- Prospects
 - ML (weak AI) will help to further automate tasks in SDM systems
 - Discovery of relevant data and trends

- Without structured and related data there will be no ML

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