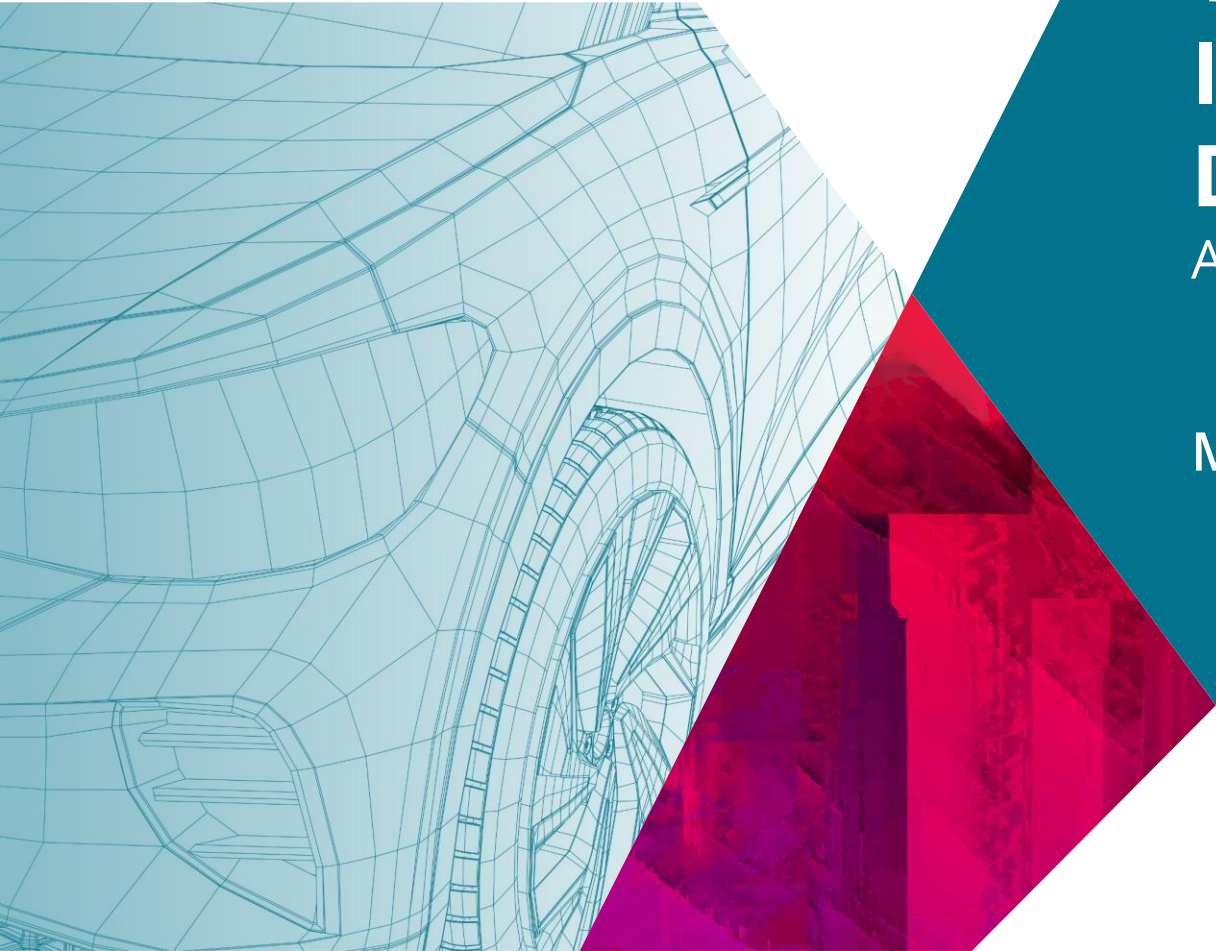


The logo for SCALE, featuring the word "SCALE" in a bold, blue, sans-serif font. The letter "E" is stylized with a red square at its top right corner.

SCALE

IT-Solutions for CAE

A blue wireframe model of a car, showing the front end including the headlight, grille, and wheel. It is positioned on the left side of the slide, partially overlapping the white background and the blue geometric shapes.

Target Evaluation and Interactive Reporting in a Post- Data Management Platform

An Integrated Approach in Systems Engineering

Martin Liebscher, Gordon Geissler, Henrik Heise

1 **Introduction of Joint Test and Simulation Data Management**

Challenges, Solutions, Use of AI

2

Reporting

Interactive Reports and Analyses

Integration in the Systems Engineering Process

3

ML/AI

Current Status and Outlook

4

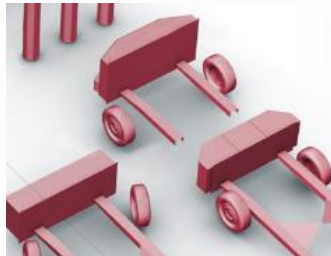
Summary

Initial Situation

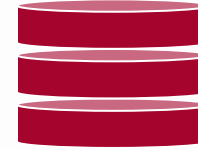
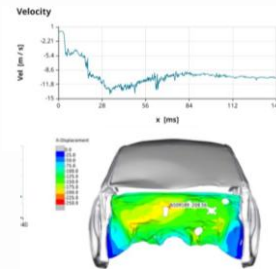


Test results

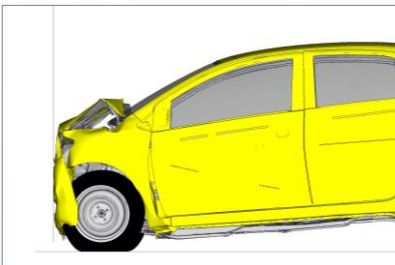
Meta
Information



Data Preparation



Evaluation /
Analysis /
Reporting



Simulation results

Meta
information

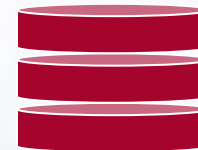
Different terms for
meta information:
Test case, KPI, curve ...

No integrated
presentation later

Data Preparation

Different data formats

Different analysis
procedures / tools



Storage in different
databases

Evaluation /
Analysis /
Reporting

Joint evaluation or
comparison requires a
great deal of manual
effort



Digital Twin

No digital twin without a consistent data structure and linking of meta data.



Economic Efficiency / Compliance

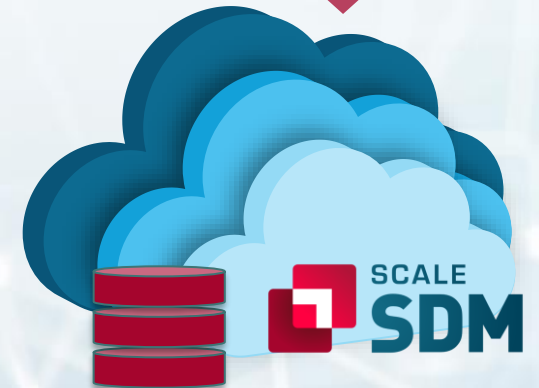
Manual processes / comparisons / reports are expensive
Regulatory pressure



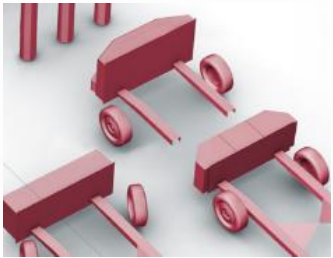
Challenges of AI Integration

AI can only work if data is structured, clean and contextualized. Data becomes very valuable

DIGITAL TWIN



Meta Information



Meta Information

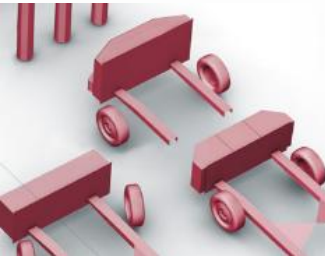
Introduction of Standardization / Master Data Management (MDM)

- Same terms / IDs for (context) information
Test cases, Parameters, KPIs, Properties, ...

Why?

- Basis for joint presentation and reporting
Due to the identical description, a uniform presentation/navigation is possible.
- Reduces data conflicts and inconsistencies
MDM ensures a “Single Source of Truth” – a central, reliable source of data. Test and simulation use the same identifier.
- Lower error rate with automated workflows
Automation is becoming more reliable, and less reworking is needed.

Meta
Information



Meta
Information

Master Data Management in



Configuration

Confidential information

2

MDM

Attributes

Requirements

Test cases

Attribute components

Attribute value lists

Attribute values

Calculation rules

Disciplines

Data classifications

Result

Project

Add-ons

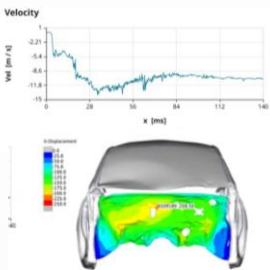
MDM attributes

Drag here to set row groups

State	Identifier	Name	Compone...	Source	Data type	Display unit
				External / Intern:		
✓	Main_Location_ID	Main Location	Requirements attri...	External	TEXT	
✓	Customer test engineer name	Customer test engineer name	GRID attributes	External	TEXT	
✗	test111	test111	General	Internal	DATETIME	
✓	1.0.00.D.O.PROJECT_TYPE	Project type	General	Internal	TEXT	
✓	0.0.00.R.O.GENERAL_INFORMATI...	Simulation Walltime	General	Internal	NUMBER	h
✓	1.0.00.D.O.LOCO_PARAM_OVERLAP	Barrier overlap	General	Internal	NUMBER	
✓	1.0.00.D.O.LOCO_PARAM_RUN_AT...	CFD Velocity	General	Internal	NUMBER	
✓	test.loadcase_abbreviation	test.loadcase_abbreviation	General	Internal	TEXT	
✓	YES_NO	Yes No	General	Internal	TEXT	
✓	PRIORITY	PRIORITY	General	Internal	TEXT	
✓	1.0.00.D.O.PROJECT	Project	General	Internal	TEXT	
✓	1.0.00.D.O.LOCO_PARAM_RUN_LA...	Label	General	Internal	TEXT	
✓	SUUID	SUUID	General	Internal	TEXT	
✓	1.0.LE.R.O.VEHICLE_OLC_BPILLAR...	OLC B-Pillar lower left optical	General	Internal	NUMBER	G
✓	1.0.00.D.O.VEHICLE_SPEED	Vehicle Speed	General	Internal	NUMBER	km/h
✓	1.0.00.D.O.BARRIER_OVERLAP_PE...	Barrier overlap	General	Internal	TEXT	
✓	1.0.00.D.O.LOCO_PARAM_RUN_AT...	Discipline	General	Internal	TEXT	
✓	STYPE	STYPE	General	Internal	TEXT	
✓	1.0.00.D.O.LOCO_PARAM_1.0.00.D...	Vehicle speed	General	Internal	NUMBER	km/h



Data Preparation



Data Preparation

Same Evaluation Routines Wherever Possible
primarily KPIs, reworking of curves, images, ...

Tools / scripts can be managed and versioned in SCALE.sdm

Configuration

Confidential Information

Calculation rules

Python code: -CNCAP AOP Seite S2 Bauch Ergebnis 001

```
12 max_df = max(abs(float(args[0])),abs(float(args[1])))
13
14 # Left side crashes
15 if args[4]=="RI":
16 # check if data is missing
17 if args[2] is None or args[3] is None :
18 raise Exception("Daten fehlen")
19 #return max value
20 else:
21 max_df = max(abs(float(args[2])),abs(float(args[3])))
22
23
24 if max_df >= 0.048: result= "capping"
25
26 else:
27 res_rib = 1.0+(max_df-0.038)*(1.0/(0.038-0.048))
28 result = round(max(0.0,(min(1.0,res_rib)+modvc)),3)
29 return result
```

Details

Name:

-CNCAP AOP Site WS Dummy Result 001

Description:

1.3 1.3.2.9 Overall rating for the side impact test against the mobile deformation barrier test against the mobile for set on later AL hte 2.1.3.

Input test attributes:

- 1 {{x1}} S{x12} S{x.3} R.O.CNCAP_SID_HEAD_RESULT_001
- 2 {{x1}} S{x12} S{x.3} R.O.CNCAP_SID_CHEST_RESULT_001
- 3 {{x1}} S{x12} S{x.3} R.O.CNCAP_SID_ABDOMEN_RESULT_001
- 4 {{x1}} S{x12} S{x.3} R.O.CNCAP_SID_DUMMYFICS_RESULT_001
- 5 {{x1}} S{x12} S{x.3} R.O.CNCAP_SID_DEPLOYMENT_001
- 6 Versuchsart

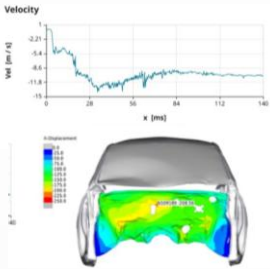
Result test attribute:

-CNCAP_21J3. S{x12} S{x.3} D.MBYRROD SET_MY_RESULT_BEET_SYSTEM_FAILURE_EISD1

Versuchsart

Close

Data Preparation



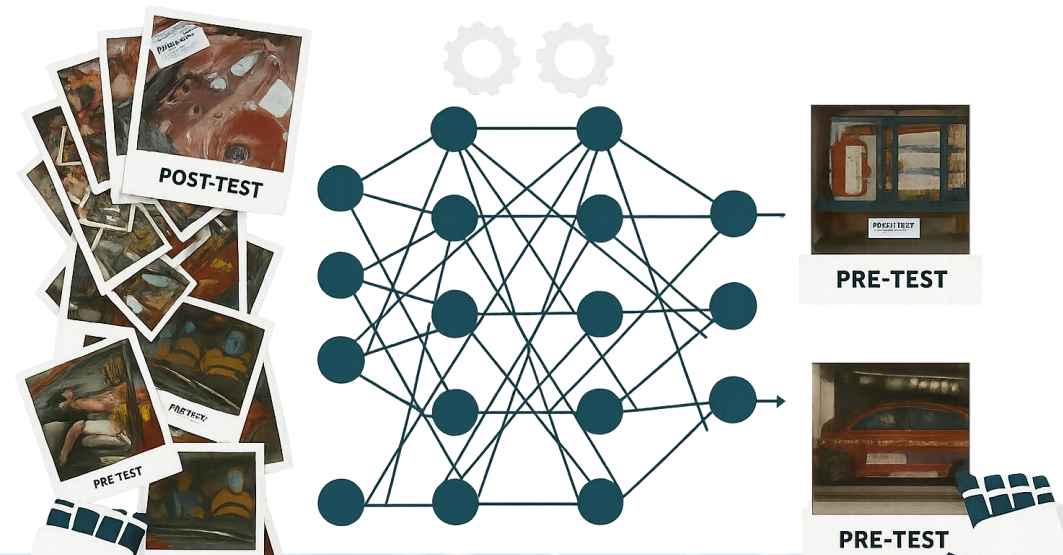
Data Preparation

Use of AI: Image Labeling / Automatic Checking

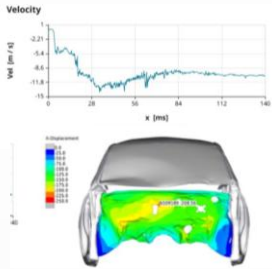
- Reduces manual effort / scalable
Automatic labeling recognizes and assigns images directly during import – no manual maintenance required.
- Ensures consistent data quality / Reliability and data quality
Pre-defined rules and AI models ensure uniform terminology and classifications.
- Basis for further automation and analyses / reporting
Standardized labels can be used in additional processes such as quality checks or data analyses.

Additionally

- Evaluation of content
- Anomaly detection, ...



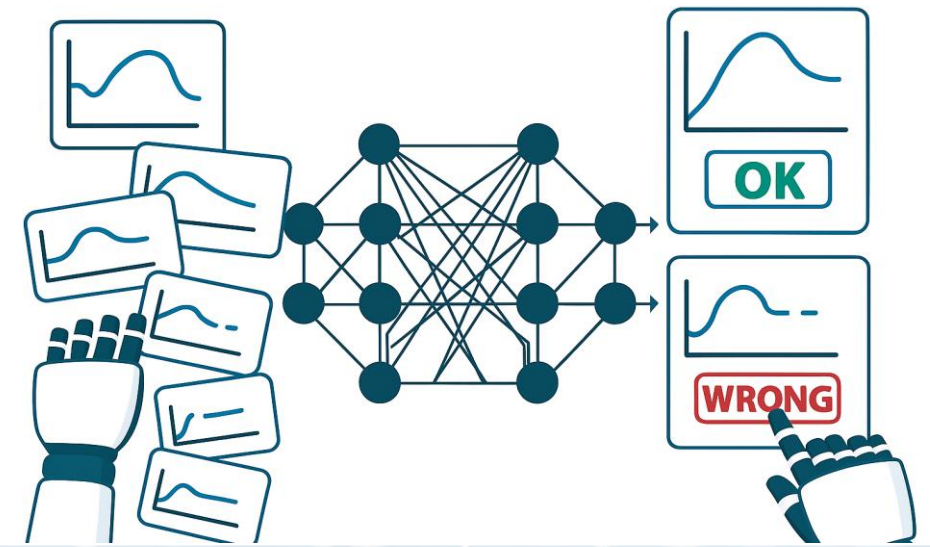
Data Preparation



Data Preparation

Use of AI: Checking Curves / Time Series

- Some advantages as image classification
Adding channel numbers
- Automatic recognition of measurement errors and outliers
The AI checks curves for gabs, jumps or implausible values due to faulty or missing measurement data.
- Validates curves against expected patterns
Deviations from the typical pattern are recognized – for example inverted or distorted curves.
- Evaluates the quality of the curve rather than just the content
Along with classification, the formal quality of the measurement data is also checked to filter out incorrect data records.

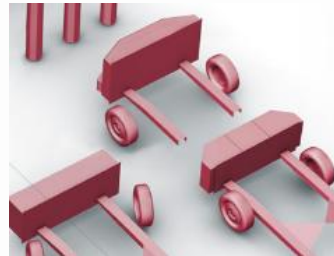


Introduction of Joint Data Management

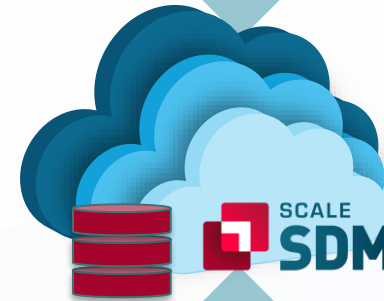
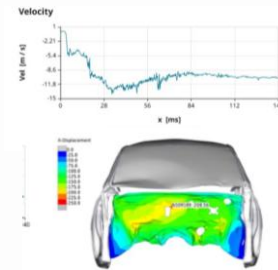


Test Results

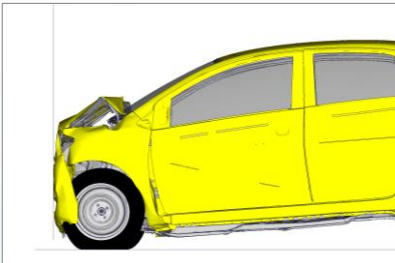
Meta
Information



Data Preparation



Evaluation
Analysis
Reporting



Simulation Results

Meta
Information

Different terms for
meta information.

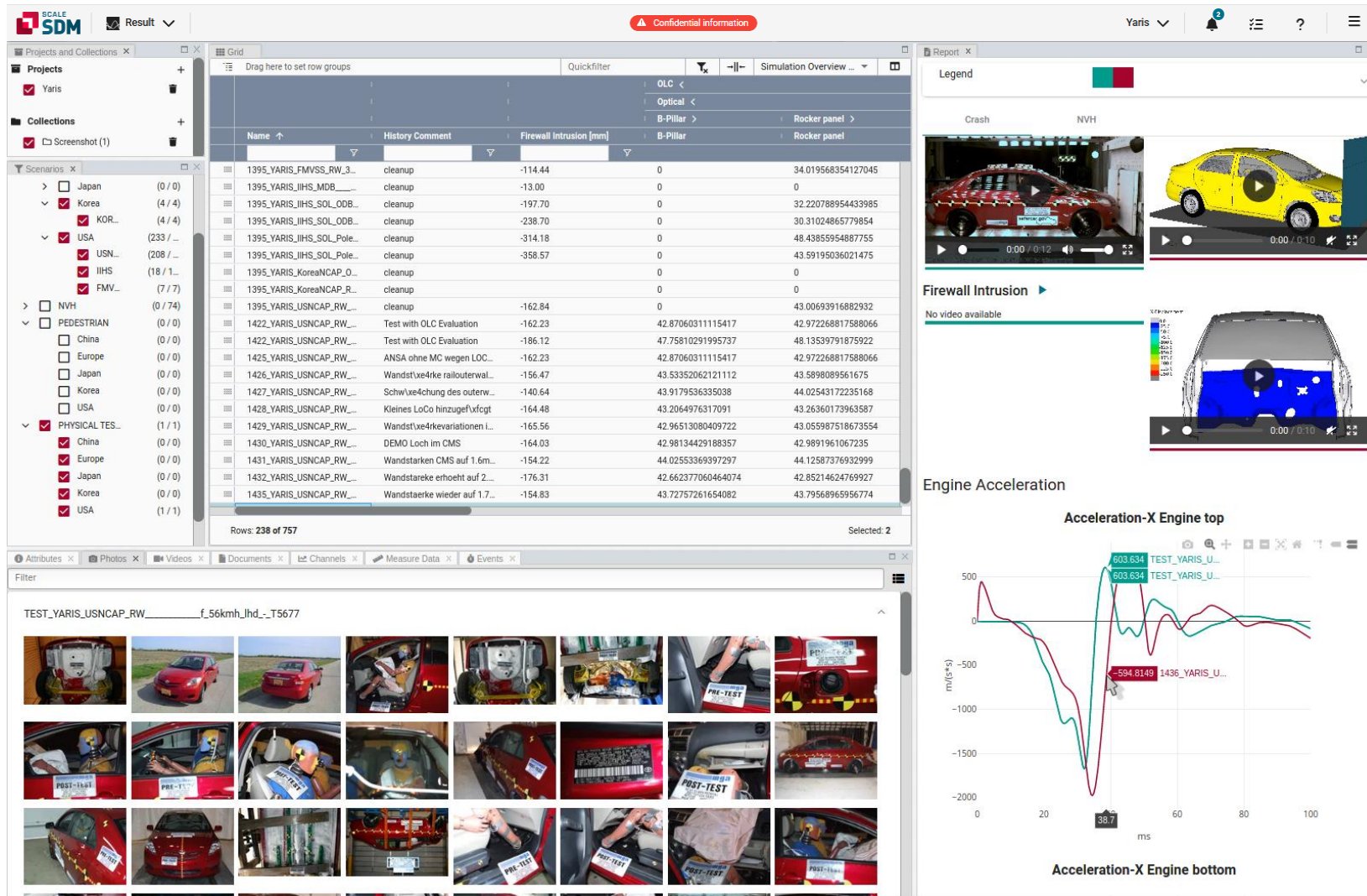
No integrated
presentation later

Data Preparation

No uniform terminology
for result KPIs

Different analysis
procedures

Introduction of Joint Data Management



- Integrated presentation of tests and simulations
- Easier identification of relevant tests and simulations
- Comparison and evaluation are made possible

1 Introduction of Test and Simulation Data Management

Challenges, Solutions, Use of AI

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Outlook

The screenshot displays the SAFECAR-ML software interface, which is used for structural analysis and reporting of vehicle crash tests. The interface is divided into several main sections:

- Left Panel (Navigation):** Contains a 'Projects and collections' sidebar with a tree view showing the project hierarchy. The 'CRASH' collection is selected, and the 'SAFECAR-ML' project is active. Below this, there are checkboxes for various standards and regions (China, Europe, Japan, Korea, USA, USNCAP, IIHS, FMVSS, NVH, SIMPACK, PEDESTRIAN, PHYSICAL TESTS).
- Top Panel (Overview):** Displays the 'Structural Ratings' overview for the 'CRASH side' test. It shows a table of results for various structural components.
- Table of Structural Ratings:** The table lists the following components and their corresponding ratings (values are in parentheses):
 - B-Pillar Lower Outer: 52.00
 - B-Pillar Inner Part: 23.00
 - B-Pillar Lower Bracket: 4.00
 - B-Pillar Upper Outer: 0.00
 - B-Pillar Internal Support: 0.00
 - Roof Cross Member: 0.00
- Right Panel (3D Visualization):** Shows a 3D model of a car chassis with a yellow car body. The model is overlaid with a color-coded structural rating map, where red indicates high stress/strain and blue indicates low stress/strain. The car is shown from a side profile, with the chassis and engine compartment visible.
- Bottom Panel (Reporting):** Contains a 'Report' section with a 'Select a report' dropdown menu. The 'SAFECAR-ML Side Crash' report is selected. Below this, there is a 'Legend' section with a color scale from 0.00 (blue) to 1.00 (red). The 'Presentation mode' is set to 'Side Crash - Structural Rating'.

Projects and collections

Projects

☒ SAFECAR-ML

Collections

Scenarios

Quickfilter...

CRASH

- ☒ China
- ☒ Europe
- ☒ Japan
 - ☒ TRIAS 18/47
 - ☒ JAPAN-NCAP
 - ☒ Other
- ☒ Korea
- ☒ USA
 - ☒ USNCAP
 - ☒ IIHS
 - ☒ FMVSS
 - ☒ Other
- ☐ NVH
- ☐ SIMPACK
- ☐ PEDESTRIAN
- ☐ PHYSICAL TESTS
- ☐ Other

Grid

Drag here to set row groups

CRASH side

Star	Name	Base	History Comment	Date
★	TEST_YARIS_USNCAP_RW_____f_56kmh_lhd_..._T5677			11/11/20, 12:11
★	0173_YARIS_USNCAP_RW_____f_56kmh_lhd_NR_..._Isdyna_6...	0155...	Sheet contour changed in the radiator frame brac...	10/28/25, 4:01
★	0173_YARIS_IIHS_MDB_____s_60kmh_lhd_NR_..._Isdyna_c8...	0155...	Sheet contour changed in the radiator frame brac...	10/28/25, 4:49
★	0172_YARIS_USNCAP_RW_____f_56kmh_lhd_NR_..._Isdyna_d...	0164...	sheet deleted in upper right support frame. - A sh...	10/18/25, 9:06
★	0172_YARIS_IIHS_MDB_____s_60kmh_lhd_NR_..._Isdyna_ef3c	0164...	sheet deleted in upper right support frame. - A sh...	10/18/25, 9:06
★	0171_YARIS_USNCAP_RW_____f_56kmh_lhd_NR_..._Isdyna_f...	0163...	sheet shortened right rear suspension connector...	10/18/25, 8:32
★	0171_YARIS_IIHS_MDB_____s_60kmh_lhd_NR_..._Isdyna_5a...	0163...	sheet shortened right rear suspension connector...	10/17/25, 4:05
★	0170_YARIS_USNCAP_RW_____f_56kmh_lhd_NR_..._Isdyna_1...	0165...	sheet extended in a left floor support. - sheet ext...	10/17/25, 2:27
★	0170_YARIS_IIHS_MDB_____s_60kmh_lhd_NR_..._Isdyna_45...	0165...	sheet extended in a left floor support. - sheet ext...	10/18/25, 8:31
★	0169_YARIS_USNCAP_RW_____f_56kmh_lhd_NR_..._Isdyna_f...	0161...	bead deleted in trunk floor side. - A bead located ...	10/10/25, 3:57
★	0169_YARIS_IIHS_MDB_____s_60kmh_lhd_NR_..._Isdyna_73...	0161...	bead deleted in trunk floor side. - A bead located ...	10/10/25, 3:57
★	0168_YARIS_USNCAP_RW_____f_56kmh_lhd_NR_..._Isdyna_0...	0162...	bead created in firewall. - A bead was created in t...	10/10/25, 11:37
★	0168_YARIS_IIHS_MDB_____s_60kmh_lhd_NR_..._Isdyna_fa01	0162...	bead created in firewall. - A bead was created in t...	10/10/25, 11:37
★	0167_YARIS_USNCAP_RW_____f_56kmh_lhd_NR_..._Isdyna_8...	0160...	bead depth increased in right floor. - The bead on ...	10/9/25, 2:28 P
★	0167_YARIS_IIHS_MDB_____s_60kmh_lhd_NR_..._Isdyna_9b...	0160...	bead depth increased in right floor. - The bead on ...	10/10/25, 2:31
★	0166_YARIS_USNCAP_RW_____f_56kmh_lhd_NR_..._Isdyna_0...	0157...	hole length shortened in Rear Wheel Well Router. ...	10/16/25, 3:07
★	0166_YARIS_IIHS_MDB_____s_60kmh_lhd_NR_..._Isdyna_25...	0157...	hole length shortened in Rear Wheel Well Router. ...	10/10/25, 10:05
★	0165_YARIS_USNCAP_RW_____f_56kmh_lhd_NR_..._Isdyna_1...	0152...	hole shortened in front radiator frame. - A hole lo...	10/8/25, 4:05 P
★	0165_YARIS_IIHS_MDB_____s_60kmh_lhd_NR_..._Isdyna_80...	0152...	hole shortened in front radiator frame. - A hole lo...	10/8/25, 4:05 P
★	0164_YARIS_USNCAP_RW_____f_56kmh_lhd_NR_..._Isdyna_d...	0158...	hole diameter increased in upper frame. - A hole l...	10/8/25, 3:08 P
★	0164_YARIS_IIHS_MDB_____s_60kmh_lhd_NR_..._Isdyna_efd4	0158...	hole diameter increased in upper frame. - A hole l...	10/8/25, 3:08 P
★	0163_YARIS_USNCAP_RW_____f_56kmh_lhd_NR_..._Isdyna_4...	0159...	hole created in right front floor member. - A circul...	10/7/25, 11:58
★	0163_YARIS_IIHS_MDB_____s_60kmh_lhd_NR_..._Isdyna_0d...	0159...	hole created in right front floor member. - A circul...	10/7/25, 11:58
★	0162_YARIS_USNCAP_RW_____f_56kmh_lhd_NR_..._Isdyna_f...	0151...	circular hole deleted in rear floor. - PID: 2175, part...	10/7/25, 11:32
★	0162_YARIS_IIHS_MDB_____s_60kmh_lhd_NR_..._Isdyna_49...	0151...	circular hole deleted in rear floor. - PID: 2175, part...	10/7/25, 11:32
★	0161_YARIS_USNCAP_RW_____f_56kmh_lhd_NR_..._Isdyna_f...	0148...	bead depth decreased in right outer rail. - A previ...	9/25/25, 10:56
★	0161_YARIS_IIHS_MDB_____s_60kmh_lhd_NR_..._Isdyna_04...	0148...	bead depth decreased in right outer rail. - A previ...	10/7/25, 9:19 A
★	0160_YARIS_USNCAP_RW_____f_56kmh_lhd_NR_..._Isdyna_5...	0156...	bead width extended in trunk floor. - bead on the r...	9/25/25, 10:02
★	0160_YARIS_IIHS_MDB_____s_60kmh_lhd_NR_..._Isdyna_40...	0156...	bead width extended in trunk floor. - bead on the r...	9/25/25, 10:02

Total items: 342

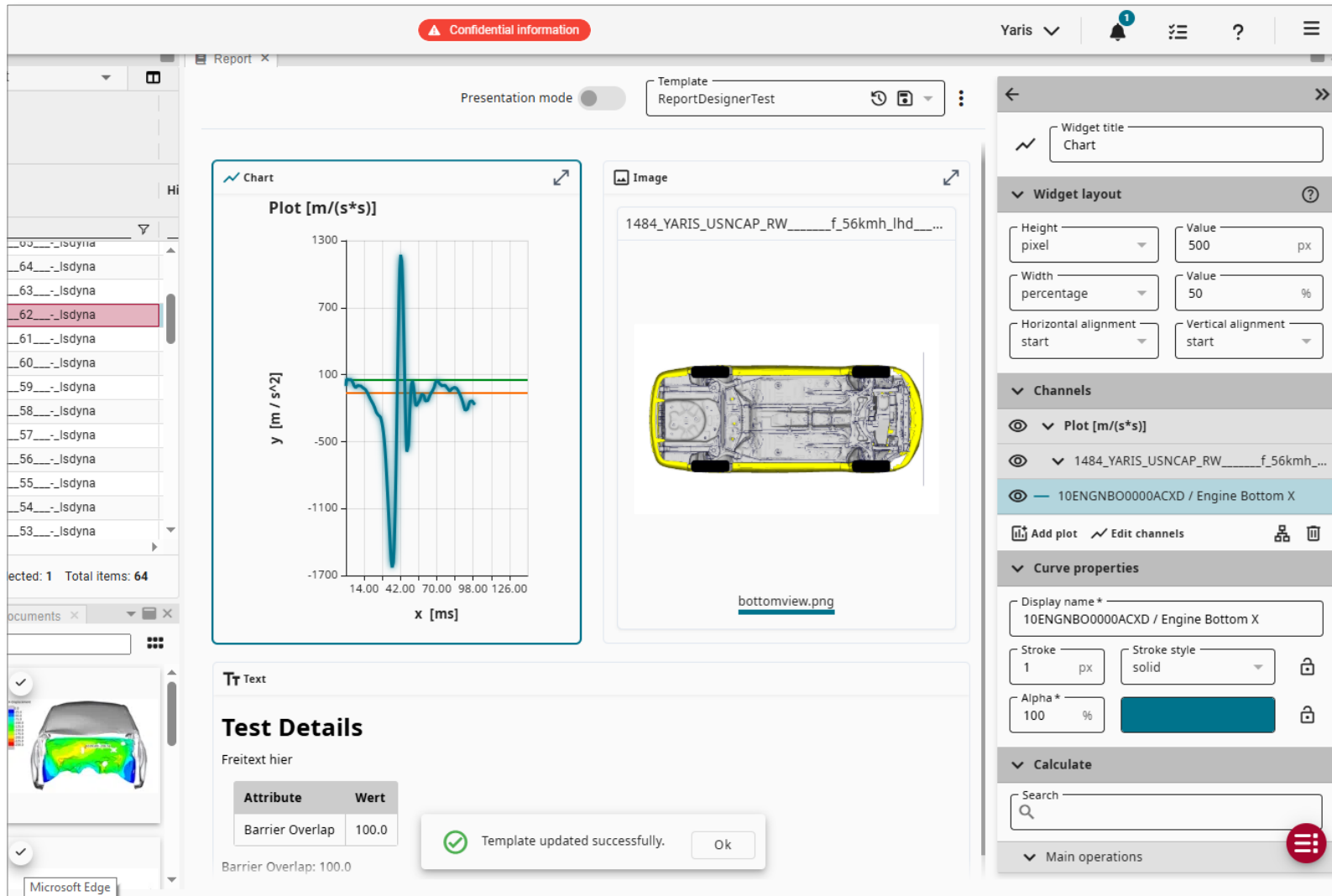
Report

Select a report

SAFECAR-ML Side Crash

Automatic
Selection

No test selected.



- Inline editing with the Report Designer
- Privately or publicly available reports

Alternative

- Own JS-based reports, flexible, very few limitations
- Integration of reports based on e.g. Animator, Metapost, ...

17 Systems Engineering im Bereich Fahrzeugsicherheit der AUDI AG: Von digitaler Zettelwirtschaft zu digitaler Transparenz 19.11.2024

Motivation für Systems-Engineering in Kombination mit digitaler Datenverarbeitung



› Richtlinienkonforme Datenaufbewahrung und Nachweispflicht über mehrere Jahrzehnte erforderlich

Produktsetup: SCALE.sdm





normierte
Daten aus
Stammdatensystem



Produktausstattung



SCALE.sdm Confidential information

Requirements

Milestones

Region Richtlinien-Test-Protokoll-Versionen Test case Quickfilter

Group	Name	Description	Threshold	Status	Value	Assessm...	Referenc...	Con
> USA	(385)							
> Korea	(38)							
> Japan	(114)							
> Indien	(80)							
▼ ECE RL	(128)							
> None	(76)							
▼ ECE-R_94_2016(Final-2016-06)	(76)							
> FrontalECE-R_094_56km/h_O...	(18)							
▼ FrontalECE-R_094_56km/h_OD...	(18)							
	1.0.00.R.O.VEHICLE_Y_DEVIATIO...	Annex 3 "1.3.1. Alignment...	$-\infty \leq x < -20.00$	$-20.00 \leq x \leq 20.00$	+1			
	Dummy POS1 geborgen ohne Sit...	5.2.5. After the impact, it ...	x = YES	x = NO				
	Dummy POS1 geborgen ohne W...	5.2.5. After the impact, it ...	x = YES	x = NO				
	Dummy POS3 geborgen ohne Sit...	5.2.5. After the impact, it ...	x = YES	x = NO				
	Dummy POS3 geborgen ohne W...	5.2.5. After the impact, it ...	x = YES	x = NO				
	Eine oder mehrere Tür(en) verrie...	5.2.4. After the impact, th...	x = NO	x = YES	x = UNRATEABLE			
	Eine oder merhere Tür(en) wahre...	5.2.3. During the test no d...	x = NO	x = NEIN	+3			
	Elektrolyt in Innenraum	5.2.8.2. Electrolyte spillag...	x = NEIN	x = JA				
	Geschwindigkeit ECE-R_094 (Beh...	Annex 3 "4. Test speed" Ve...	$-\infty \leq x < 56.00$	$56.00 \leq x \leq 57.00$	+1			
	Gurtschlossöffnungskraft	5.2.5.2. To release the du...	$-\infty \leq x \leq 60.0$	$60.00 \leq x < \infty$	+1			
	Gurtschlossöffnungskraft	5.2.5.2. To release the du...	$-\infty \leq x \leq 60.0$	$60.00 \leq x < \infty$	+1			

Konfiguration der Projektanforderungen auf Basis der projektunabhängigen Stammdaten in Kombination mit der Produktausstattung

Integration in Systems Engineering: Automatic Evaluation

The screenshot displays the SCALE SDM software interface, which is used for automatic evaluation in systems engineering. The interface is divided into several sections:

- Left Panel:** Contains a tree view of projects and collections. The 'CRASH' collection is expanded, showing sub-collections for 'China', 'Europe', 'Japan', 'Korea', and 'USA'. Under 'USA', 'USNCAP' and 'IIHS' are selected.
- Center Panel:** A table listing items. The table has columns for 'Star', 'Name', 'Base', 'History Comment', and 'Date'. The 'Name' column shows item IDs and descriptions, such as '0145_YARIS_IIHS_MDB_s_60kmh_lhd_NR_..._lsdyna_aeae'. The 'History Comment' column provides details about the item's history, such as 'bead depth increased in outer right rail. - A bead l...'. The 'Date' column shows the date and time of the last update.
- Right Panel:** Displays detailed evaluation results for a selected report, 'SAFECAR-ML Side Crash'. The results are organized into three sections: 'Max. Intrusion B Pillar', 'Velocity Limit Exceedance B Pillar', and 'Overview Element Failure'. Each section contains a table with 'Pool Version', 'Head', 'Thorax', 'Abdomen', and 'Pelvis' scores.

The 'Max. Intrusion B Pillar' section shows scores for Pool Version (145), Head (0.27), Thorax (0.33), Abdomen (0.34), and Pelvis (0.33). The 'Velocity Limit Exceedance B Pillar' section shows scores for Pool Version (145), Head (12.42), Thorax (13.12), Abdomen (13.64), and Pelvis (12.92). The 'Overview Element Failure' section shows scores for Pool Version (145), B-Pillar Lower Outer (42), B-Pillar Inner Part (27), B-Pillar Lower Bracket (4), B-Pillar Upper Outer (0), B-Pillar Internal Support (0), and Roof Cross Member (44).

1 Introduction of Test and Simulation Data Management

Challenges, Solutions, Use of AI

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Summary

Grid

Drag here to set row groups

⌂

⌂

⌂

⌂

⌂

⌂

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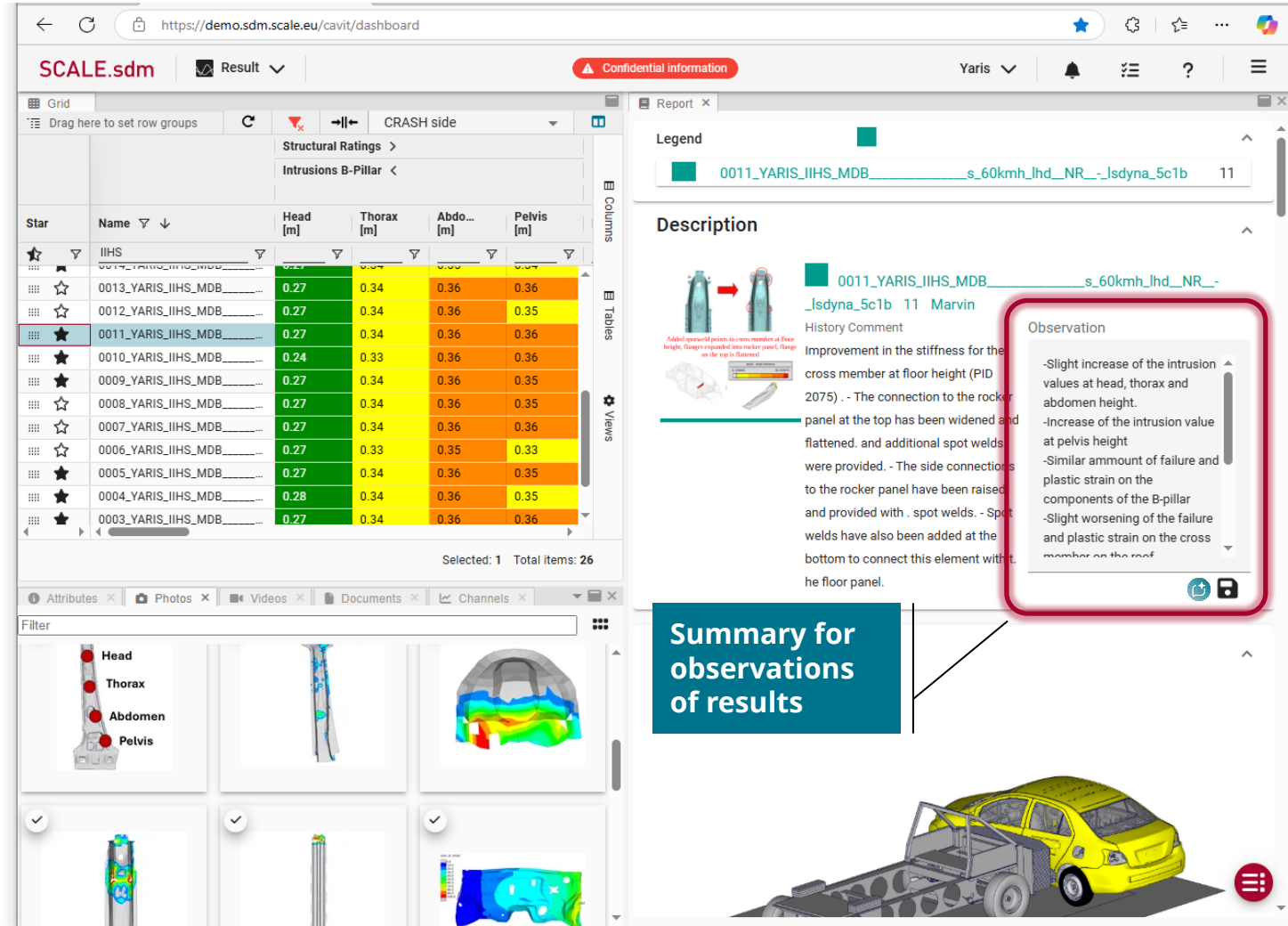
ML-based Data Analysis

Report/Comparison Summary

- Reports can be very long, sometimes hundreds of pages.
- Checking all results is time-consuming, comparison even more so important changes can be overlooked.

Implementation

- Automatic creation of a concise summary short and to the point.
 - Retrieval of data for important results of the relevant simulations/tests
 - Creation of a prompt for the LLM
 - Appearance of the answer
- Focus on the most relevant changes, e.g. changed KPI evaluations.



The screenshot displays the SCALE.sdm web application interface. The top navigation bar includes the URL <https://demo.sdm.scale.eu/cavit/dashboard>, the SCALE.sdm logo, and a 'Result' dropdown menu. A 'Confidential information' warning is visible. The main content area is divided into two panels. The left panel, titled 'Grid', shows a table of structural ratings for various components. The right panel, titled 'Report', displays a detailed view of a specific component, including a legend, description, and observation section.

Star	Name	Head [m]	Thorax [m]	Abdo... [m]	Pelvis [m]
☆	0013_YARIS_IHS_MDB	0.27	0.34	0.36	0.36
☆	0012_YARIS_IHS_MDB	0.27	0.34	0.36	0.35
☆	0011_YARIS_IHS_MDB	0.27	0.34	0.36	0.36
☆	0010_YARIS_IHS_MDB	0.24	0.33	0.36	0.36
☆	0009_YARIS_IHS_MDB	0.27	0.34	0.36	0.35
☆	0008_YARIS_IHS_MDB	0.27	0.34	0.36	0.35
☆	0007_YARIS_IHS_MDB	0.27	0.34	0.36	0.36
☆	0006_YARIS_IHS_MDB	0.27	0.33	0.35	0.33
☆	0005_YARIS_IHS_MDB	0.27	0.34	0.36	0.35
☆	0004_YARIS_IHS_MDB	0.28	0.34	0.36	0.35
☆	0003_YARIS_IHS_MDB	0.27	0.34	0.36	0.36

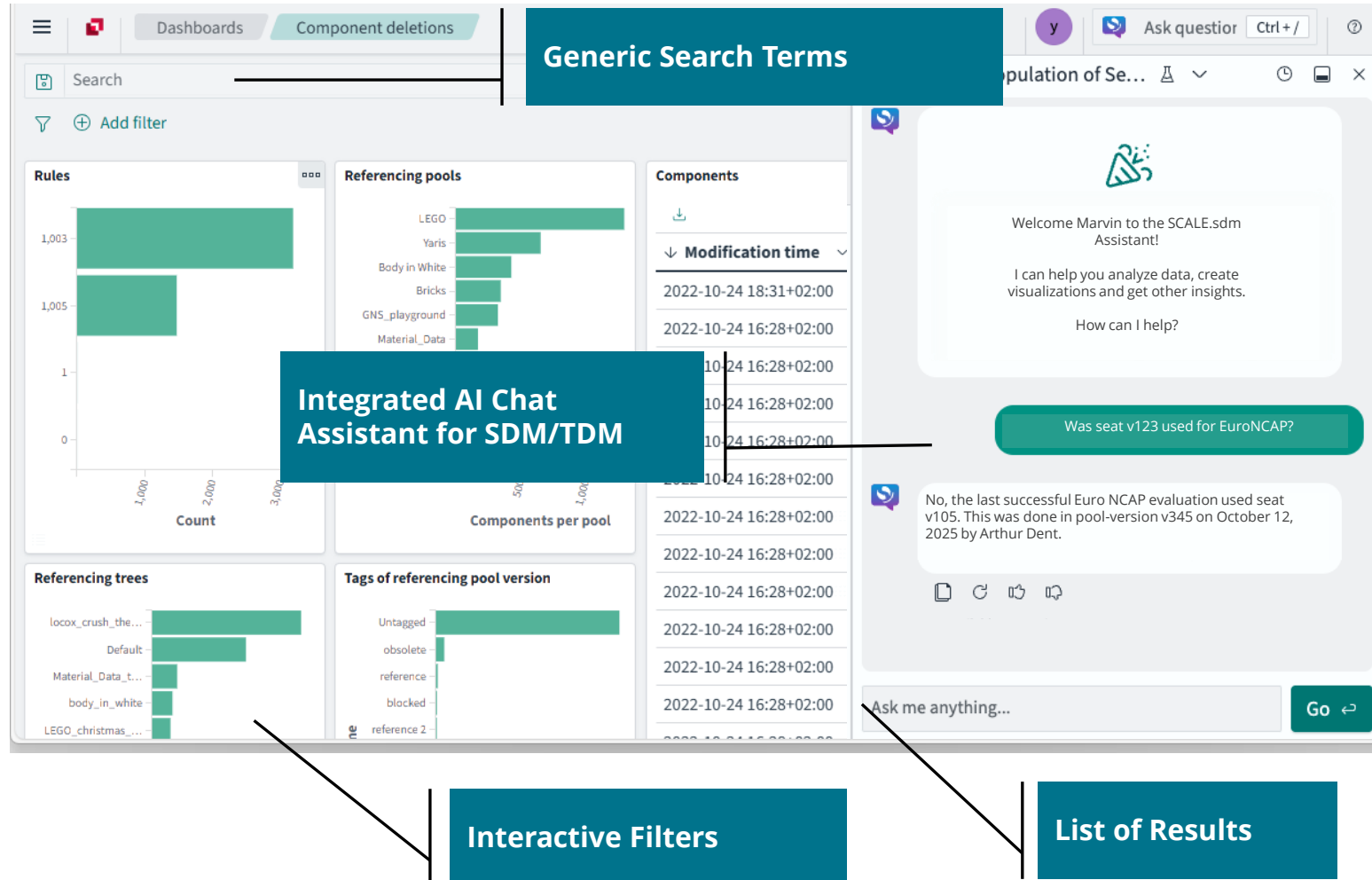
The right panel shows a detailed report for component 0011_YARIS_IHS_MDB. It includes a legend, a description of the component, and an observation section. The observation section is highlighted with a red box and contains the following text:

Observation

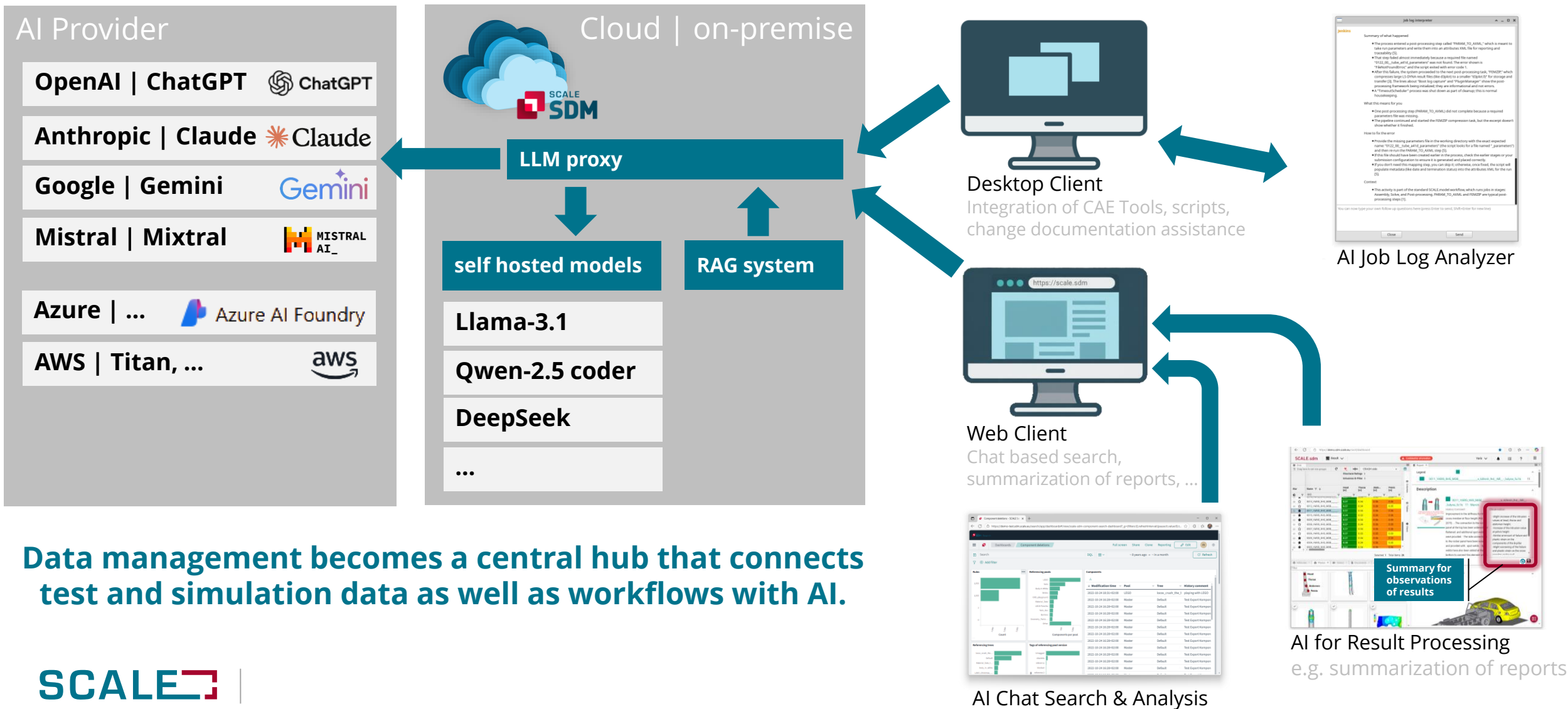
- Slight increase of the intrusion values at head, thorax and abdomen height.
- Increase of the intrusion value at pelvis height
- Similar amount of failure and plastic strain on the components of the B-pillar
- Slight worsening of the failure and plastic strain on the cross member on the roof

A blue box labeled 'Summary for observations of results' is positioned below the observation section. At the bottom of the interface, there is a 3D model of a yellow car and a red button with a menu icon.

- SDM/TDM data in search index and vectorized in RAG
very short and concise
- The access rights of users are respected
Answers only include information that the user is allowed to access.
- Knowledge from existing simulations/tests and observations are used
all change documentation and observations are saved in the RAG of the SDM system.



Integrating AI Services in CAx Workflows



1 Introduction of Test and Simulation Data Management

Challenges, Solutions, Use of AI

2

Reporting

Interactive Reports and Analyses

Integration in the Systems Engineering Process

3

AI

Approach, Current Status and Outlook

4

Summary



Digital Twin

No digital twin without a consistent data structure and linking of meta data. Standardization of data structures.



Challenges of AI Integration

AI can only work if data is structured, clean and contextualized.



Open System for Integrating AI / Third-party Systems

Focus on data management platform – Integration of third-parties

