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IT-Solutions for CAE

**17<sup>th</sup> German LS-DYNA Forum** Leinfelden, Germany October 16th, 2024

Facilitating Virtual Testing at an Industrial Level by Simulation Data Management

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- EuroNCAP Virtual Testing workflow
- Motivation
- Why SDM
- Setup in SDM
- Workflow summary
- Summary and outlook





## **EuroNCAP Virtual Testing workflow**

Why Virtual Testing? -> replace physical tests by simulation

- Virtual Testing (VT) workflow
  - OEM prepares simulation results (Step 2)
  - EuroNCAP checks data and accepts it
  - OEM performs sledtest
  - EuroNCAP validates simulation model
  - EuroNCAP rates VT load cases
- CAE Engineer needs and objectives
  - Data preparation and completeness
  - EuroNCAP quality criteria
  - Static model parts
  - rating values





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## Why SDM?

- Single point of access simulations, tests
- Collaboration teamwork, sharing of data, speedup of development
- Standardized data structure homogeneous visualization, evaluation, assessment
- Predictable & robust assessment automatic generation of hashes, extraction of key-results, reports
- Traceability and documentation each change by each user is captured and documented

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## **Setup in SDM: Requirements**

#### Project setup in SCALE.sdm

- Responsibilities
- Milestones
- Requirements

#### Quality criteria for EuroNCAP

- Energy of dummy and whole system
- Added mass
- Simulation run time
- Reasonable displacements

#### Rating criteria for EuroNCAP

- Accelerations
- Forces
- Displacements



✓ 6.3 Table 7.: EuroNCAP VTC	(10)		
	0	Head a3ms	$-\infty \le x < 80.00$ $80.00 \le x < \infty$
	0	Abdomen compression	$0.000 \le x < 65.00$ $65.00 \le x < 65.00$
	0	Chest compression	$0.000 \le x < 50.00$ $50.00 \le x < 50.00$
	0	Head excursion	$0.000 \le x < 80.00$ $80.00 \le x < 0.00$
	0	Head HIC (15 ms)	-∞ ≤ x < 700.0 700.0 ≤ x < ∞
	0	Lumbar Fy	$0.000 \le x < 2.000$ 2.000 $\le x < 0.000$
	0	Lumbar Fz	$0.000 \le x < 3.500$ $3.500 \le x < 0.000 \le $
	0	Lumbar Mx	$0.000 \le x < 120.0$ $120.0 \le x < 120.0$
	0	Pubic symphysis force	$0.000 \le x < 2.800$ $2.800 \le x < 0.000 \le $
	0	Neck moment y	$0.000 \le x < 50.00$ 50.00 $\le x < 50.00$

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## Setup in SDM: Model setup

- Modular structure imported, versioned, managed
- Shared data among load cases includes, parameters, ...
- Parameterization restraint system parameters

Outlook:

• Crash pulses from pre simulation automatically created from crash simulation

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	7	🖹 Body in White	sled_body_04			key

## **Setup in SDM: Traceability and documentation**

#### Documentation

any change can be documented in much detail ... description, images, documents, ...

#### Traceability

each change is automatically captured and can be tracked down later

#### Collaboration

anyone in the team can see and access every change of other team members





## Setup in SDM: Job submition and result data preparation

#### Job submition to HPC clusters

- Fast job submition with efficient data transfer
- Server component for specific HPC integration
- Live job feedback to the user
- Solver specific assembly
  - Solver independent SDM system
  - Python Assembly template as solver specific "API"
- Hashing process for static model parts
  - Crash pulses for acceleration of sled
  - Nodes of dummy & seat

SCALE :

- Automated result data storage and preparation
  - Extraction of result data in ISOMME format
  - Easy integration of third party software (Oasys)

Properties		<
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✓ □ Pool Version Changes	(1)	4
Merged optimizations for z-re	f and z-high load cases. Status for sumition to EuroNCAP	
$\checkmark$ $\triangleright$ Assembly	(4)	
Problematic entries	(0)	
✓ Scripts	(2)	
S extract_6vtc_videos		
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		Solving job: Solving: simulation time 0.053999 of 0.2 computed (Energy Info after 5) Job Folder Log	
2		Model assembly job	
		Scheduler-Information: Submitted Job 56462	
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		Solving job: Solving: simulation time 0.053999 of 0.2 computed (Energy Info after 5) Job Folder Log	

## Setup in SDM: static model parts



- Access to all simulations & testst
  - Search
  - Filter
  - ISOMME Export
- Interactive and custom web reports
  - Runs in any web browser
  - Access to all data of selected simulations
  - Compare on the fly in case of multi selection
  - Tables with key results
  - Colored assessments from defined requirements
  - Channel plotter

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Synchronous video playback

#### EuroNCAP VT web report

- Legend with overview and overall check
- Sections for each result category

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88		FS_AEMDB_75_x-ref_z-ref_50M_Sim_10013_V	Arthur Dent	2024-09-29, 9:38:3	Quality Criteria for EuroNCAP					
00	*	FS_Pole_90_x-ref_z-ref_50M_Sim_10013_VT	Arthur Dent	2024-09-28, 8:39:5						
ш	☆	FS_Pole_75_x-ref_z-ref_50M_Sim_10013_Vali	Arthur Dent	2024-09-27, 4:27:2	Result			Limit		
	☆	FS_AEMDB_90_x-ref_z-high_50M_Sim_10010	Arthur Dent	2024-09-24, 9:11:2						
	☆	FS_Pole_90_x-ref_z-ref_50M_Sim_10010_VT	Arthur Dent	2024-09-24, 9:11:2	Full Setup - Maximum Hourglass Energy < 10% of Maximum Internal En	iergy		≤ 0.1	0.01676	5
	☆	FS_Pole_75_x-ref_z-ref_50M_Sim_10010_Vali	Arthur Dent	2024-09-24, 9:11:2	WSID Dummy - Maximum Hourglass Energy < 10% of Maximum Internal E	Energy		≤ 0.1	0.02547	1
					Maximum Added Mass (%) < Total Model Mass at the beginning of the sim	nulation	≤	0.005	5.016e-4	4
					Z Displacement (mm) in the first 5 ms of the simulation			≤ 10	4.2	
					(Time of Maximum Head Y Displacement) + 20% < Simulation Time	3		≥ 1.2	1.5	
					Number of Mandatory Channels			115	115	
					Number of Mandatory Videos			6	6	
					Validation of Static Model Parts	3				
					Part			0		
					carpet part 1		3032	1		
					carpet part 2		1817	а		
					biw column (full)		de3e	b		
					biw hwac (full)		bc20	lf		
					biw ip03 (full)		1c29	f		
					biw pedals (full)		083d	7		
					sled part 1		51d7	1		
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(	+			>	contact_05 (full)		d86e	2		e
			Selected: 1	Total items: 11	control_02		36e3	e		9
										_

## Setup in SDM: Assessment of Results – Quality criteria of data

#### Quantity and Quality criteria for EuroNCAP

compare for each selected simulation

- Hourglass Energy of WSID Dummy & full Setup
- Added Mass
- Displacements of Dummy
- Number of required Channels and Videos

#### Summary of "static model parts"

compare to validation simulation and see instantly any unintended model changes

- 1<sup>st</sup> column is the reference simulation (from validation)
- Subsequent columns from other simulations of other load cases

#### **Quality Criteria for EuroNCAP** Result Limit Full Setup - Maximum Hourglass Energy < 10% of Maximum Internal Energy 0.001888 $\leq 0.1$ 0.01871 WSID Dummy - Maximum Hourglass Energy < 10% of Maximum Internal Energy ≤ 0.1 0.02882 0.02759 0.005757 Maximum Added Mass (%) < Total Model Mass at the beginning of the simulation ≤ 0.005 5.016e-4 5.016e-4 5.016e-4 4.2 4.2 Z Displacement (mm) in the first 5 ms of the simulation ≤10 (Time of Maximum Head Y Displacement) + 20% < Simulation Time ≥ 1.2 1.5 1.5 Number of Mandatory Channels 115 115 115 61 6 Number of Mandatory Videos 6 6 6

Validation of Static Model Parts						
Part						
carpet part 1	30321	30321	30321			
carpet part 2	1817a	1817a	1817a			
biw column (full)	de3eb	de3eb	de3eb			
biw hwac (full)	bc2df	bc2df	bc2df			
biw ip03 (full)	1c29f	1c29f	1c29f			
biw pedals (full)	083d7	083d7	083d7			
sled part 1	51d71	51d71	51d71			
sled part 2	88c9c	88c9c	88c9c			
contact_05 (full)	d86e2	d86e2	d86e2			
control_02	36e3e	36e3e	36e3e			
dummy content 1	1670a	9592a	1670a			
dummy content 2	5414c	5414c	5414c			
seat part 1	813c9	813c9	813c9			
seat part 2	3ca67	3ca67	3ca67			
seat belt content	61b01	61b01	61b01			
seat belt part 2	df543	467cf	df543			



## **Setup in SDM: Assessment of Results – Rating criteria**

#### Rating values for EuroNCAP

compare for each selected simulation see instantly which values don't match the requirements

- Accelerations
- Forces
- Displacements
- · ...

#### Channel plotter

inspect and compare all channel data from selected simulations

- Interactively select and deselect simulations
- Chouse location, parameter and axis to be displayed
- Easy to identify missing required channels

#### Video player

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inspect and compare all videos from selected simulations

- Synchronously play videos side by side to compare load cases
- Inspect videos frame by frame with common slider for all videos

	Assessment Criterion	Limit			
	HIC15	≤ 700	169	33.67	143.8
	A3ms	≤ 80	43.31 G	23.76 G	41.9 G
	Upper Neck Fz	≤ 3.74	0.296 kN	0.465 kN	0.192 kN
	Upper Neck MxOC	≤ 248	21.9608 N m	142.298 N m	24.4736 N m
	Upper Neck MyOC	≤ 50	22.7058 N m	46.3669 N m	14.2845 N m
	Lower Neck Fz	≤ 3.74	0.154 kN	0.054 kN	0.115 kN
	Lower Neck Mx(base of neck)	≤ 248	6.24678 N m	0.496497 N m	4.60146 N m
	Lower Neck My(base of neck)	≤ 700	11.7259 N m	7.50386 N m	5.74929 N m
	Chest compression	≤ 50	0.0	0.0	0.0
	Abdomen compression	≤ 65	0.0	0.0	0.0
	Pubic Symphysis force	≤ 2.8	0.0	0.0	0.0
	Lumbar Fy	≤ 2	0.423 kN	2.07 kN	0.404 kN
	Lumbar Fz	≤ 3.5	0.126 kN	1.01 kN	0.106 kN
	Lumbar Mx	≤ 120	5.95886 N m	120.588 N m	8.51914 N m
	Head excursion	≤ 80	44.3 mm	45.8 mm	45.6 mm
Location	Parameter	A	xis		

Head CoG acceleromete... - Accelerations [3] - y [3]



## **Workflow summary**





## **Workflow summary**





## Safeguarding against data manipulation

- Signing instead of hash
  - Would allow to proof that a given input was used to create a specific output (simulation result)
  - "static model parts" of OEMs would not need to be disclosed to testing authority



- Signatures can not proof that "static model parts" do not contain any model data that is somehow tampering the simulation results in the 1<sup>st</sup> place
  - e.g. how to proof that crash pulses are not tempered such that a certain rating is achieved?
- All output needs to be signed, and it would be probably best if the output complies to the requirements of EuroNCAP (e.g. channels and key-results already in ISO-MME)
- Need to be implemented by FEM solver developers

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## **Summary and Outlook**

#### Using an SDM-System to streamline the VTC process

- Automated result data preparation and checks
- Efficient integration of the iterative development process
- Traceability and documentation

#### Virtual Testing workflow at an industrial level

- High complexity in the CAE world (model, load cases, processes)
- Virtual testing adds to the complexity
- Tools for efficient data and process management required for a productive usage

#### • Challenges & Outlook:

- Safeguarding against manipulation has some open questions to be solved
- ····





# SO LONG, AND THANKS

FOR ALL THE FISH







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