

# Prediction of Simulation Results with Integration of SDMZIP in SCALE SDM Solutions

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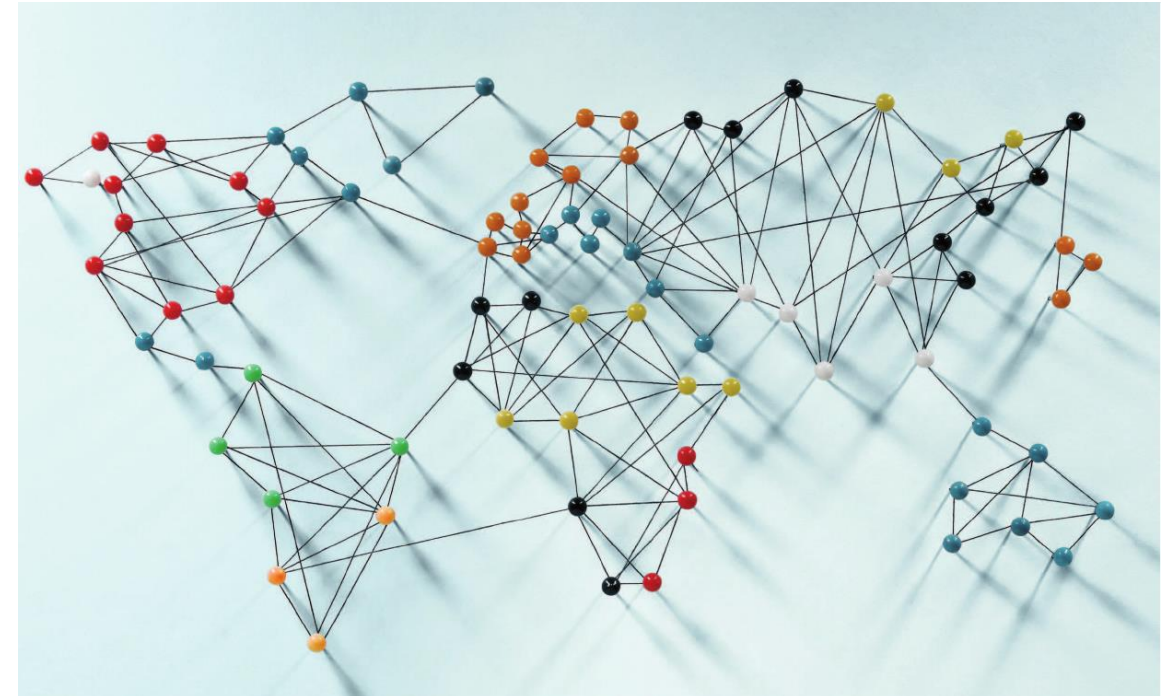
**automotive CAE Grand Challenge 2020**

**September 29 - 30, 2020**

**Hanau, Germany**

## Outline

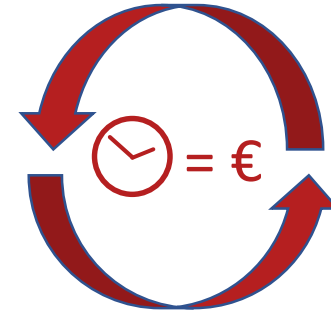
- Motivation & Aims
- Prediction tool
- Integration into SDM system
  - Requirements and workflow
  - Case study
- Conclusions & Outlook





## Motivation & Aims

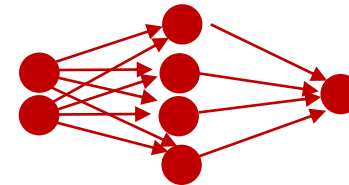
### ■ Motivation

- Virtual design driven by many iterations
- Each iteration costs computational time
- Fast prediction for overview and decision of important test cases



### ■ Aims

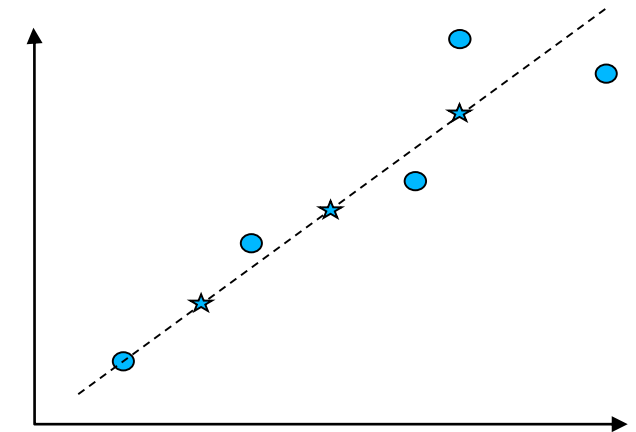
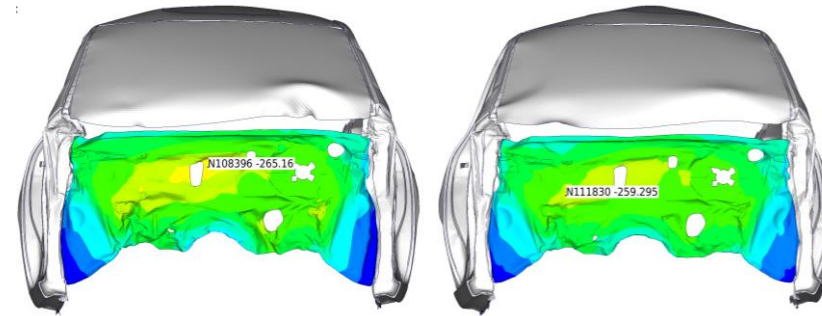
- saving time 
- reliable predictions 
- First step towards more complex ML methods
- All in one package: design, predict and visualize (SDM system integration)



## Prediction tool

- Full analysis results without solver
- PCA
- SDMZIP
  
- Limitations
  - Predictions within linear range
  - No extrapolation
  - More predicted entities -> more base simulations necessary
  
- Developed by SIDACT (*Stefan Mertler*)

Is-dyna | prediction



Known key values ●

New key values ★

# Integration into SDM System: SCALE.model

switch between model and results

## Required components

- SCALE SDM
- Solver:
  - LS-Dyna
  - prediction tool
- A4, Geco
- SDMZIP

The screenshot shows the SCALE software interface with several key components highlighted by callouts:

- product structure:** Points to the 'Komponenten' (Components) tree on the left, showing a hierarchy of libraries, barriers, and velocity formulas.
- model data:** Points to the central table listing simulation parameters and their values.
- version control for overall project:** Points to the 'Pool-Version' list at the top left, showing various project versions.
- version control for selected objects:** Points to the 'Attribute' table, which details specific parameters for selected objects.
- switch between model and results:** Points to the top navigation bar, which allows switching between the model and its results.
- Historie (History):** A panel on the right showing a timeline of simulation steps and results.

Barrier	Disziplin	Impac	Veloci	VELO_CAR
i	CRASH,PEDESTRIAN,OS_FRONT	=0		
o	CRASH,PEDESTRIAN,OS_FRONT	--get_attribute_float("Velocity")		
p	CRASH,PEDESTRIAN,OS_FRONT	s	--get_attribute_float("Velocity")	
w		f	10	--get_attribute_float("Velocity")+VELC
w		f	13	--get_attribute_float("Velocity")+VELC
w		f	15	--get_attribute_float("Velocity")+VELC
w		f	18	--get_attribute_float("Velocity")+VELC
w		f	20	--get_attribute_float("Velocity")+VELC
w		f	23	--get_attribute_float("Velocity")+VELC
w		f	25	--get_attribute_float("Velocity")+VELC
w		f	28	--get_attribute_float("Velocity")+VELC
w		f	30	--get_attribute_float("Velocity")+VELC
w		f	33	--get_attribute_float("Velocity")+VELC
w		f	35	--get_attribute_float("Velocity")+VELC
w		f	38	--get_attribute_float("Velocity")+VELC
w		f	40	--get_attribute_float("Velocity")+VELC
w		f	43	--get_attribute_float("Velocity")+VELC

product structure

model variants

model data

version control for selected objects

version control for overall project

switch between model and results

# Integration into SDM System: SCALE.result

switch between model and results

## Required components

- SCALE SDM
- Solver:
  - LS-Dyna
  - prediction tool
- A4, Geco
- SDMZIP

filtering

model variants

result data

The screenshot shows the CAVIT software interface. On the left, there are navigation panels for 'Projects and Collections', 'Scenarios', and 'Quickfilter...'. The main area is a 'Grid' table with columns for 'Name' and 'Date'. Below the grid, a 'Report' table shows test results.

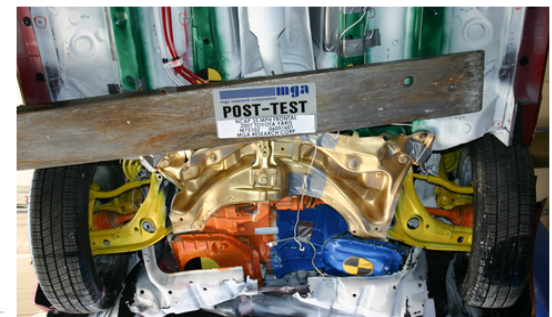
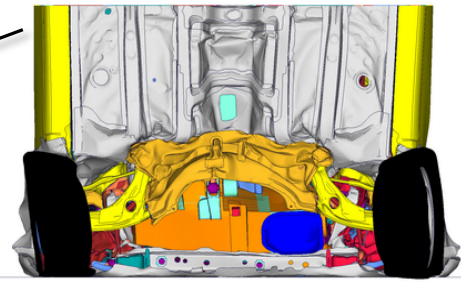
Name	Date
TEST OR 1243	
1243_YARIS_USNCAP_RW____f_56kmh____03_____l_sdyna_10.2_dp_MPP	2020-07-30T16:08:48
1243_YARIS_USNCAP_RW____f_56kmh____03_____l_sdyna_10.2_dp_MPP	2020-07-23T14:01:28
1243_YARIS_USNCAP_RW____f_56kmh____10_____l_sdyna_10.2_dp_MPP	2020-07-20T11:37:27
TEST_YARIS_USNCAP_RW____f_56kmh_lhd_-_T5677	2020-09-16T16:10:41
TEST_YARIS_USNCAP_RW____f_56kmh_lhd_-_T5677	2020-09-15T16:10:41
1243_YARIS_USNCAP_RW____f_56kmh____03_____l_sdyna_10.2_dp_MPP	2020-07-29T10:16:38

Test Name	Test P	Velocity
1243_YARIS_USNCAP_RW____f_56kmh____03_____l_sdyna_10.2_dp_MPP	USNCAP Front Impact	56.00 km/h
TEST_YARIS_USNCAP_RW____f_56kmh_lhd_-_T5677	USNCAP Front Impact	56.00 km/h

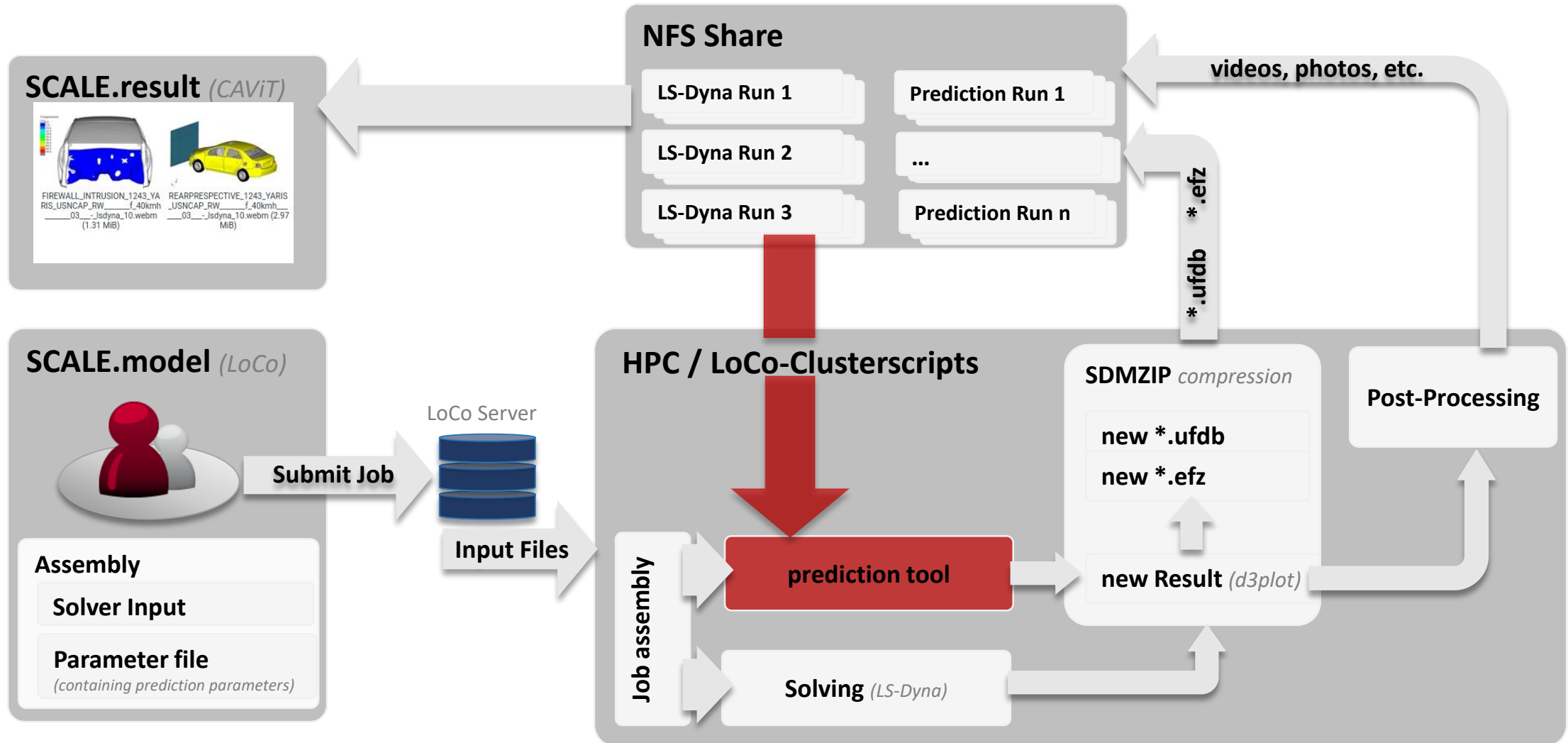
Bottom View Crash

Compare run and test data





# Integration into SDM System: Workflow



# Integration into SDM System: configuration

The screenshot shows the configuration for a project named 'Yaris'. On the left, there is a list of runs under the 'Assembled runs' category. The first four runs are highlighted in purple and represent '3 Is-dyna base runs'. The remaining 21 runs are highlighted in green and represent '21 prediction runs'. On the right, the 'Attribute' table shows various parameters for the runs. A red box highlights the 'Solver' attribute, which is set to 'prediction'. A callout box shows the configuration for the 'prediction' solver, with the 'prediction' option selected.

Project	ImpactLocation	Velocity	Multi	Solver	SolverVersion	SolverPrecision	Disziplin	Angle	Barrier	Hand Drive	Region	Overlap	Regulation	Impact_Art
YARIS	f	10	03	prediction	10.2	dp	CRASH	0	w	lhd	US	100	USNC	f

3 Is-dyna  
base runs

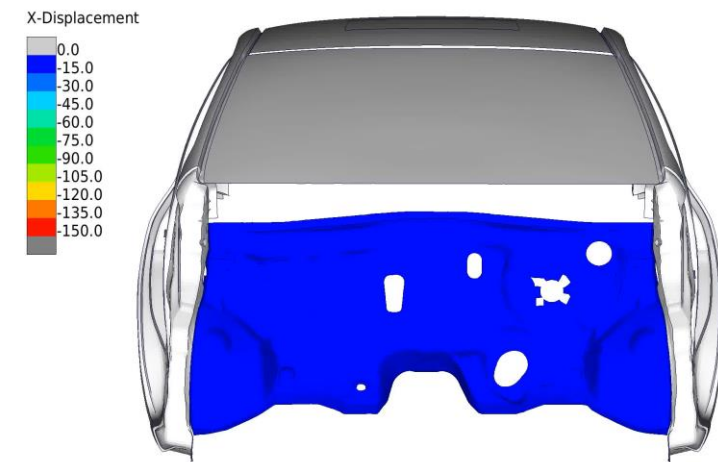
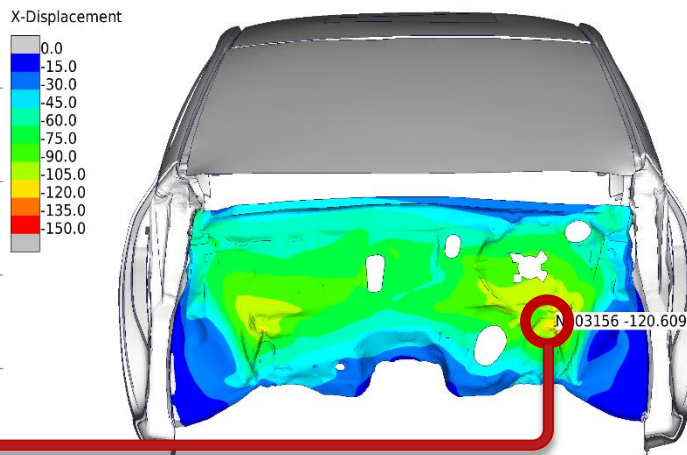
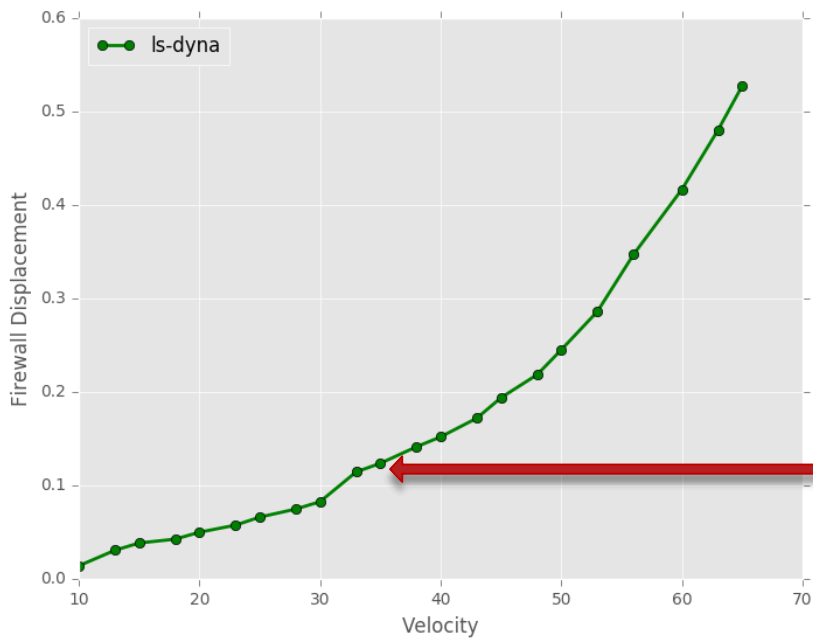
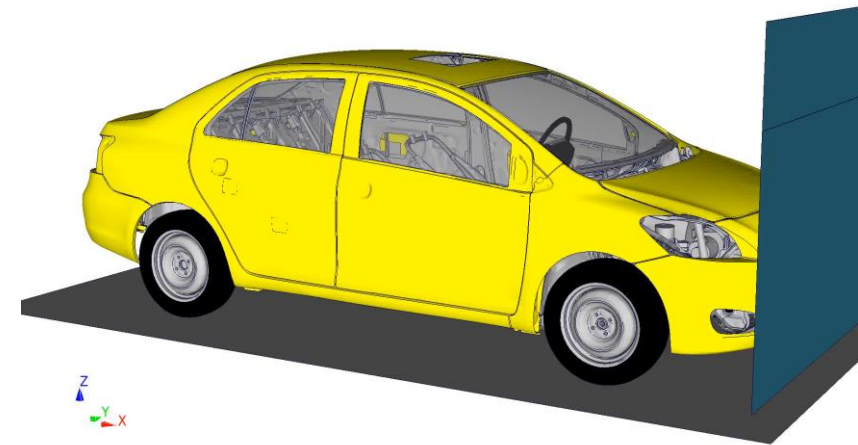
21 prediction  
runs

configuration:  
Solver = prediction tool



## Prediction: full factorial analysis

- Yaris
- Frontcrash with variable velocity (10 - 65kmh)
- Measure: Firewall displacement



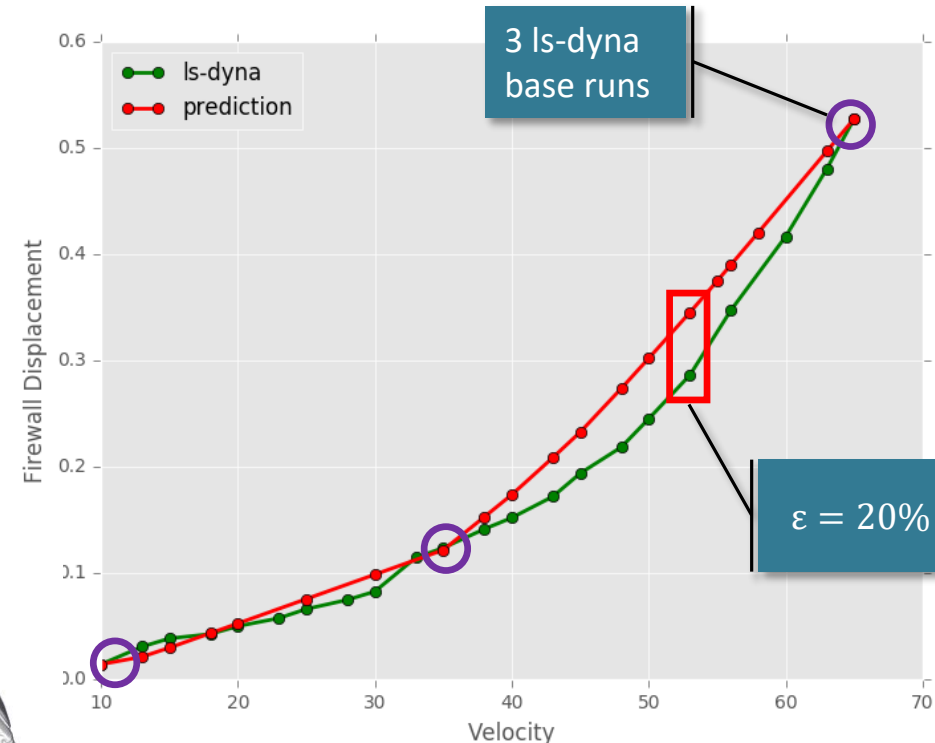
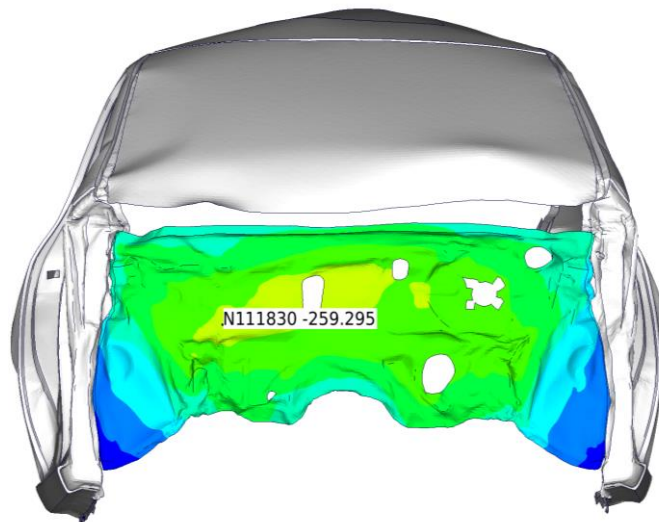
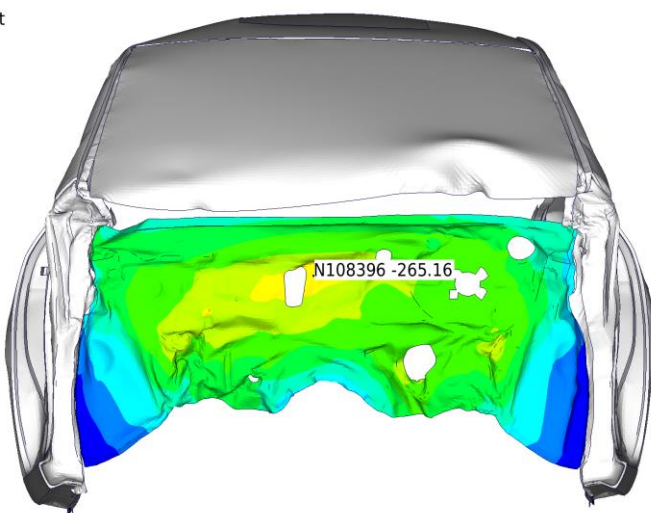
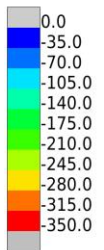
## Prediction: validation and error analysis

- All: 24 run / Is-dyna: 3 runs / predicted: 21 runs
- Mean error  $\bar{\epsilon} = 12\%$  (worst: 31%; best: 1.9%)

$\epsilon = 20\%$

Is-dyna | prediction


X-Displacement




## Prediction: benefits

- Getting a d3plot file without having to use a solver

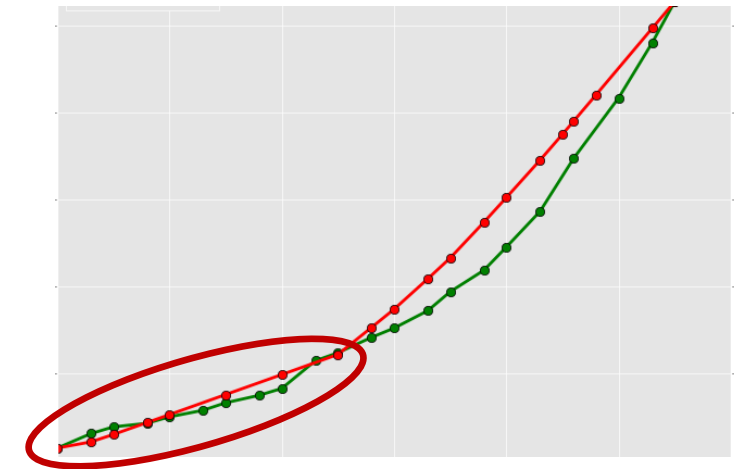
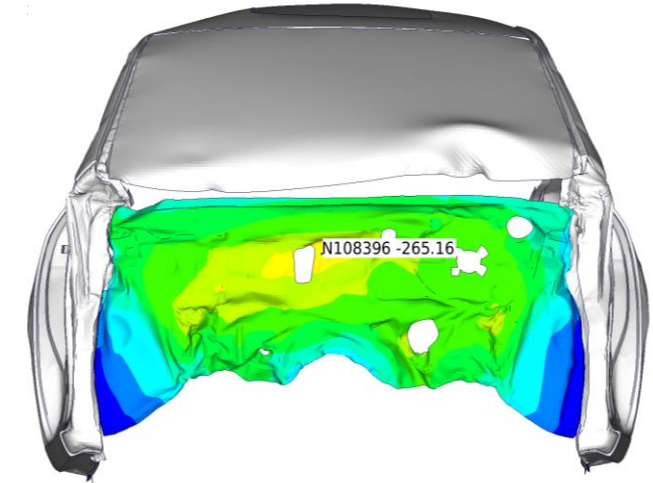
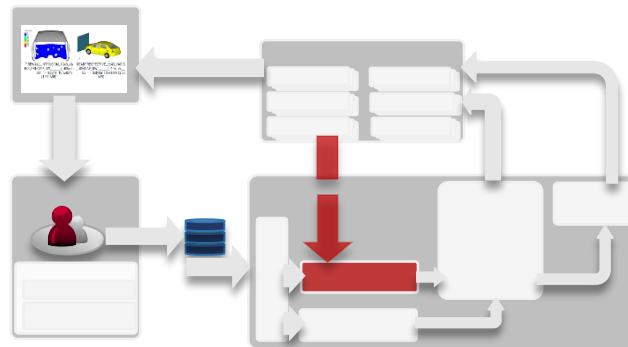
- Run-Time 

- LS-Dyna (12CPU): 8h10min 

- Prediction (1CPU): 0h02min 

- Good accuracy for linear correlation

- Integration into Tool-Chain



# Reference solution using meta modell (quadratic polynomial)

- SCALE.result AdOn (under development)

The screenshot shows the CAVIT software interface. On the left, there are panels for 'Projects and Collections', 'Scenarios', and 'Quickfilter'. The main area displays a table of test results. A red box highlights the 'Data Analysis (0.0.0)' option in the top right menu. A blue callout box with an arrow points to this option, containing the text 'start data analysis tool'.

Name	Date
TEST OR 1243	
1243_YARIS_USNCAP_RW_____f_56kmh_____03_-_l_sdyna_10.2_dp_MPP	2020-07-30T16:08:48
1243_YARIS_USNCAP_RW_____f_56kmh_____03_-_l_sdyna_10.2_dp_MPP	2020-07-23T14:01:28
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1243_YARIS_USNCAP_RW_____f_56kmh_____03_-_l_sdyna_10.2_dp_MPP	2020-07-29T10:16:38

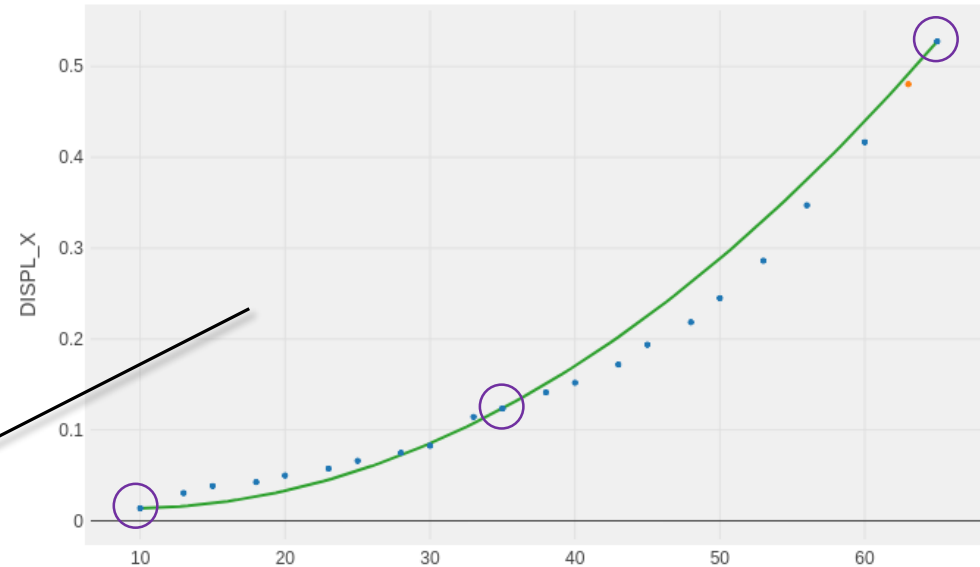
Test Name	Test Protocol	Test Style	Velocity
1243_YARIS_USNCAP_RW_____f_56kmh_____03_-_l_sdyna_10.2_dp_MPP	USNCAP	Front Impact	56.00 km/h
TEST_YARIS_USNCAP_RW_____f_56kmh_lhd_-_T5677	USNCAP	Front Impact	56.00 km/h

Bottom View Crash



# Reference solution using meta modell (quadratic polynomial)

Active	Outlier	Input	Output
<input checked="" type="checkbox"/>	<input type="checkbox"/>	V_MAX Input	DISPL_X Output
<input checked="" type="checkbox"/>	<input type="checkbox"/>	10	0.01397
<input type="checkbox"/>	<input type="checkbox"/>	13	
<input type="checkbox"/>	<input type="checkbox"/>	15	
<input type="checkbox"/>	<input type="checkbox"/>	18	0.04254



### Create New Model

Name \*

Use Cross Validation

Keep Random Seed

Polynomial Regression

Tensorflow (Neural Networks)

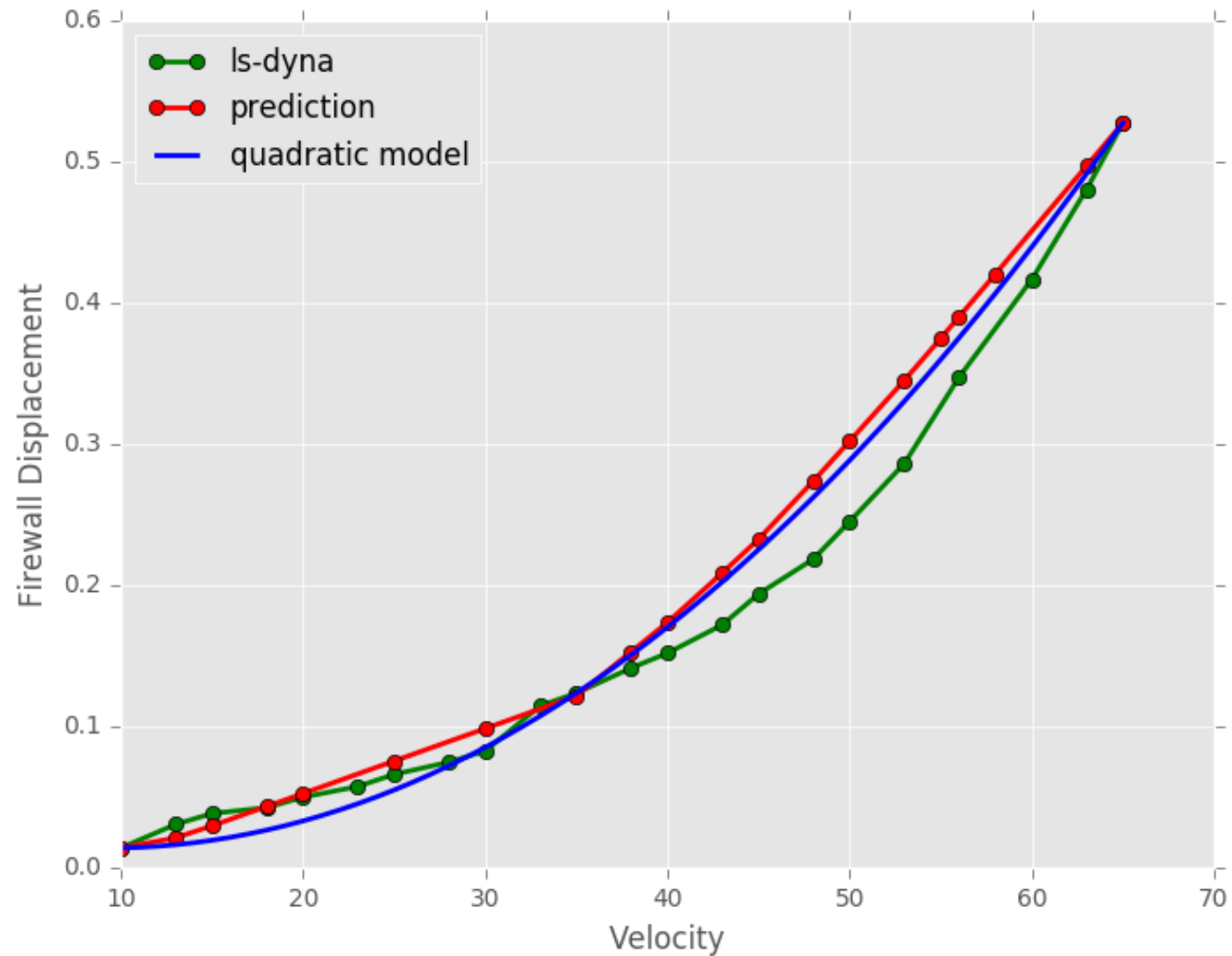
Generate Model

- Polynomial regression
- Mean error = 15% (worst: 4)
- No full solver output (d3pl)



## Comparison prediction <-> quadratic metamodel

- prediction —
  - linear
  - d3plot included
  
- metamodel —
  - quadratic
  - cheap, fast, easy





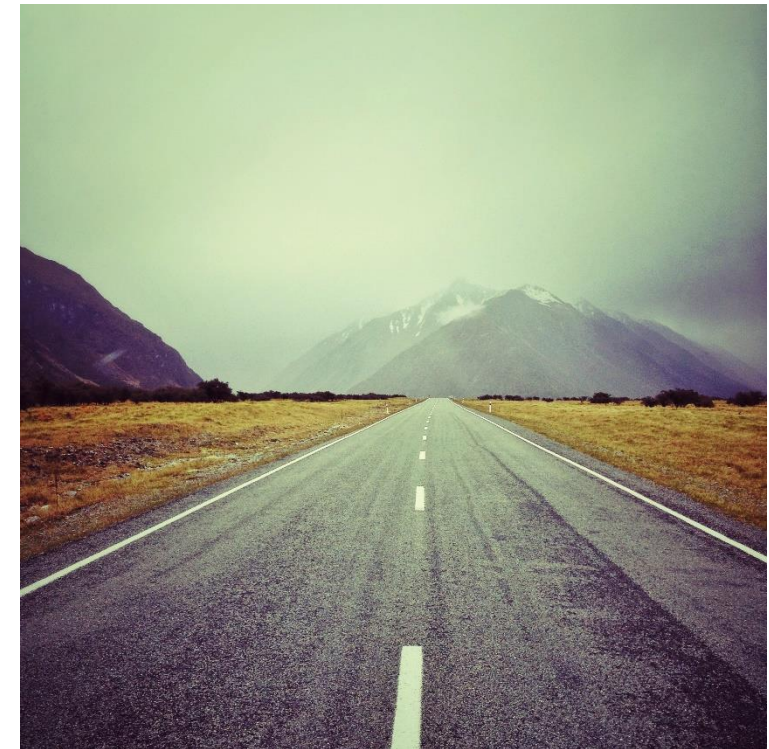
## Conclusions & Outlook

### ■ Conclusions

- Integration into CAE-Workflow
- Results for given example quite accurate
- Less simulations and computational time necessary

### ■ Outlook

- Prediction tool has to be investigated further
  - E.g. more dimensional predictions
- Integration of other (ML) methods into SDM system



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