

DAIMLER

Fully automated simulation and optimization process for CAE applications

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Agenda

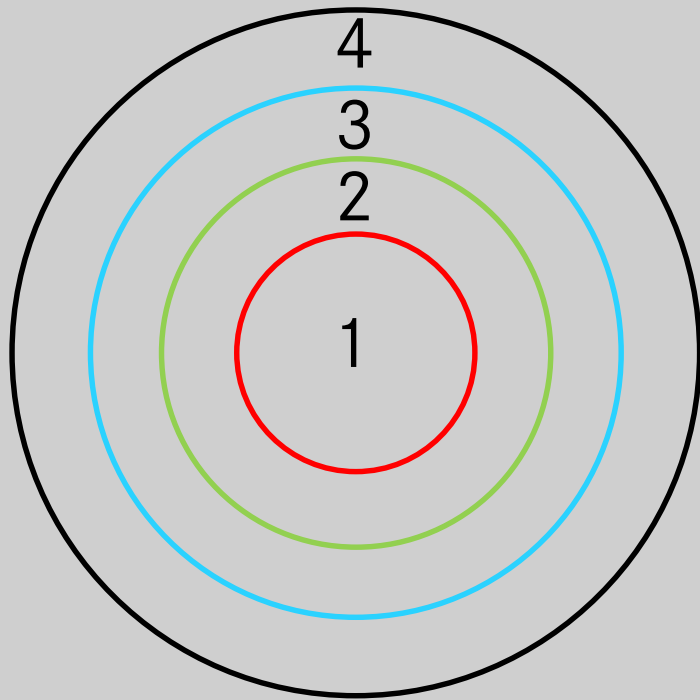
1. Motivation
2. Optimization – Basic Needs
3. Optimization – Challenges
4. CAE-AutoWorkflow
5. Example: Truck Aerodynamics
6. Example: Passenger Car Aerodynamics
7. Conclusions and Future Work

Motivation

- Reduction of prototypes in development process
- Hardware in early phases of development process not available
- Reduction of measurement time in costly measurement devices (e.g. wind tunnels)
- Deeper insight in physical phenomena



Optimization – Basic Needs



Main Steps of the Optimization Process

1. Fully automated simulation process for every application
2. Parameterized input data
(numerical values or parameterized geometry)
3. Optimizer or DOE (Design of Experiments)
(control of parameter variations)
4. Post-processing of Results

The importance of the different steps is decreasing from 1 to 4. For example it is not necessary to define a DOE when the simulation process at hand is not fully automated.

The most important and most time consuming step is the definition of the parameters including their variation range as well as the target value.

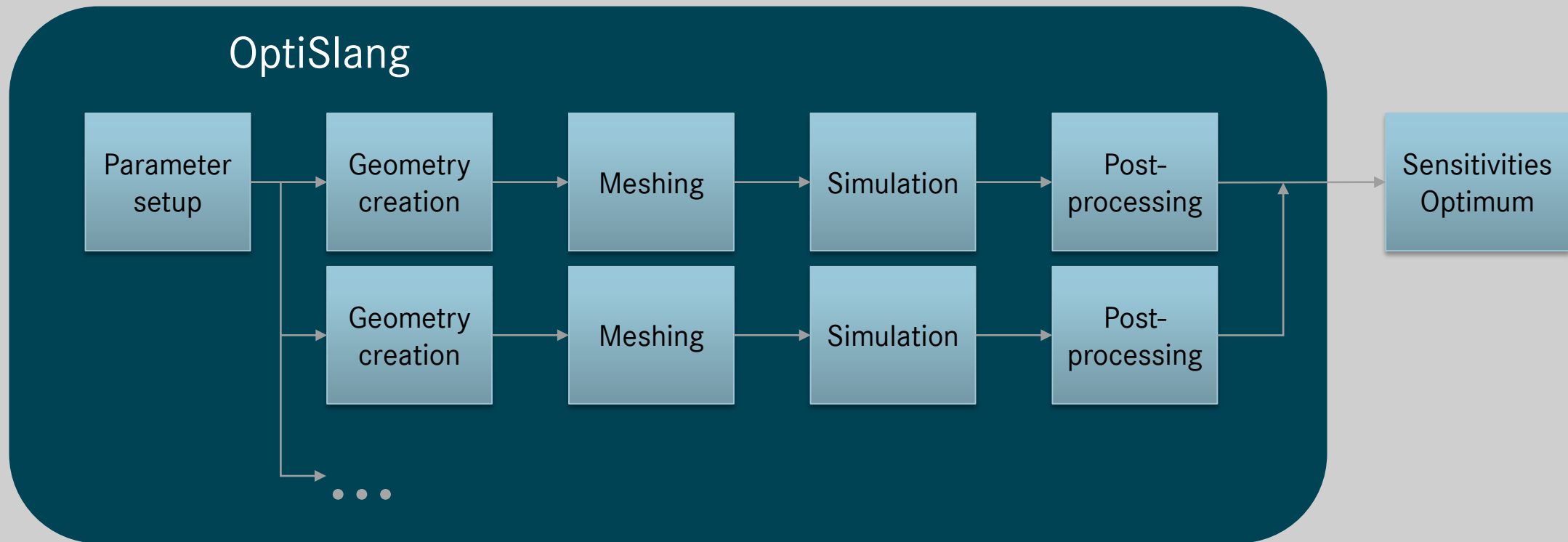
Optimization - Challenges

- Definition of parameter range
- Fully automated simulation process
- Control of input parameters
- Automated post-processing of target values
- High robustness of simulation process
- Huge amount of data (memory requirements, data transfer)
- Huge amount of simulations (availability of CPUs)



CAE-AutoWorkflow

Application: Aerodynamics



Software-Tools:



.....

CAE-AutoWorkflow

```

workflow = ansa_combine,GenerMesh,sim
casename = Aero_Test
starccm_version = 9.04.009

...

[sim]
type = starccm_generic
input = VolMesh.sim
result_file = VolMesh_Result.sim
    
```

Input-File

The screenshot shows the CAE-AutoWorkflow interface. The 'Project tree' on the left lists the workflow steps: Parameter..., blend_shape..., ansa_combine, GenerMesh, and sim. The 'Selected item' is 'sim', with 'optiSLang type: SensitivitySystem' and 'Autosim type: None'. The 'Autosim properties' tab is active, showing settings for 'DYNAMIC_SAMPLING' (ADVANCED_LATIN_HYPERCUBE_SAMPLING) and 'NUM_DISCRETIZATION' (5). The 'Parametrization' tab shows a table of 10 parameters (D_H to D_D) with their respective ranges and resolution settings.

Name	parameter	ty	ference	val	Constant	Value type	Resolution	Range	Range plot
1	D_H	Optimiz...	0			REAL	Continu...	0 0.33	
2	D_R1	Optimiz...	0.9			REAL	Continu...	0 1	
3	D_A	Optimiz...	0.4			REAL	Continu...	0 0.43	
4	D_R2	Optimiz...	0			REAL	Continu...	0 3.24	
5	D_B	Optimiz...	0.9			REAL	Continu...	0 0....	
6	D_B_Re...	Optimiz...	0.6			REAL	Continu...	0 0.6	
7	D_B_Up	Optimiz...	0			REAL	Continu...	0 0....	
8	D_C	Optimiz...	0			REAL	Continu...	-0.... 0....	
9	D_R3	Optimiz...	0			REAL	Continu...	0 0.39	
10	D_D	Optimiz...	-0.25			REAL	Continu...	-0.... 0	

The screenshot shows the CAE-AutoWorkflow interface with simulation results. The 'Project tree' on the left lists the workflow steps: _ParameterUpdate, blend_shape_control, ansa_combine, GenerMesh, and sim. The 'Selected item' is 'sim', with 'optiSLang type: SensitivitySystem' and 'Autosim type: None'. The 'Autosim properties' tab is active, showing settings for 'DYNAMIC_SAMPLING' (ADVANCED_LATIN_HYPERCUBE_SAMPLING) and 'NUM_DISCRETIZATION' (5). The 'Parametrization' tab shows a table of 10 parameters (D_H to D_D) with their respective ranges and resolution settings.

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Example: Truck Aerodynamics

➤ **Computing Mesh:**

100 million computational cells

Computational domain : l : b : h = 115 : 90 : 36 m

Size of result files : 60 GB

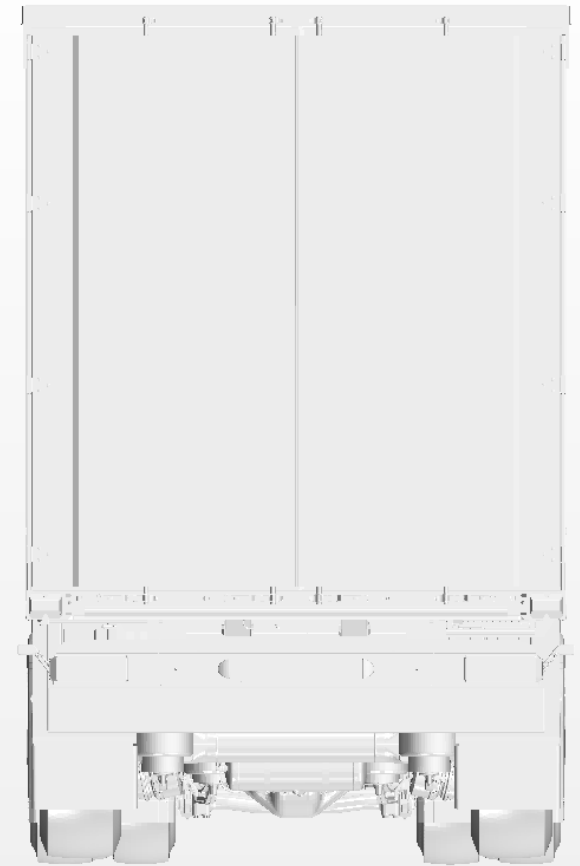
➤ **Resources:**

Pre- / Post Processing : min. 200 GB memory

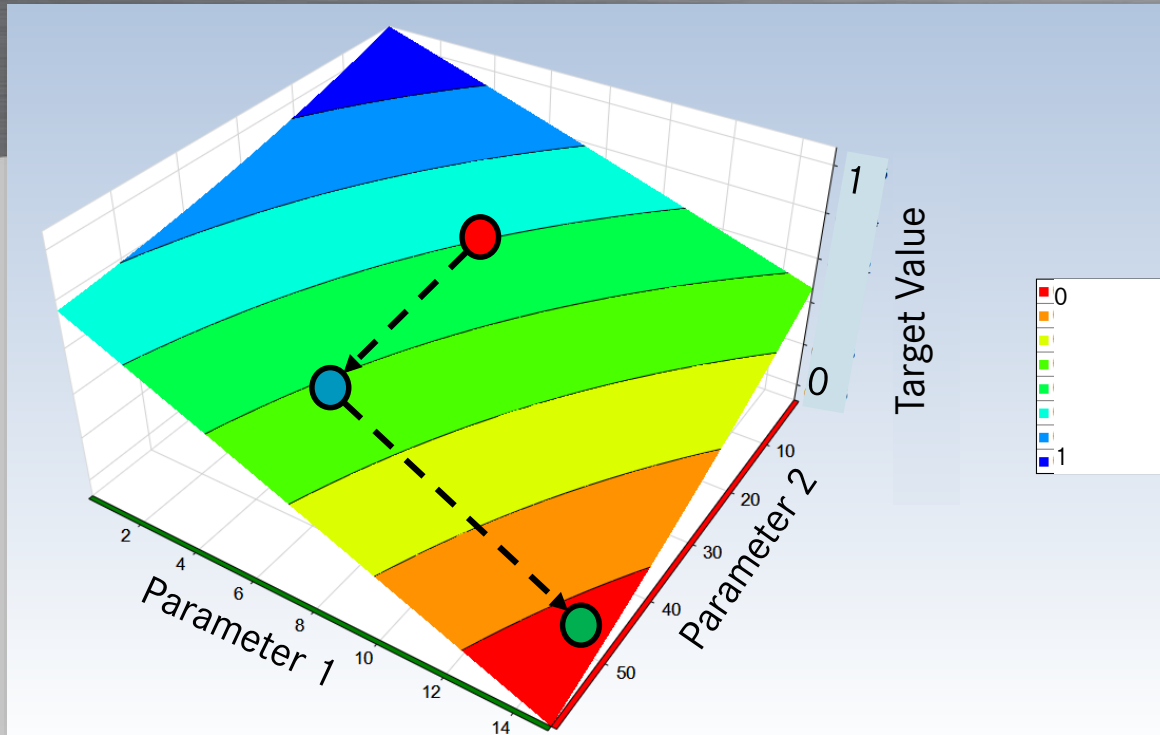
Per simulation about 2 days on 400 cores

9 parameters: 200 CFD runs

**Total amount of data per sensitivity analysis :
approximately 8TB**

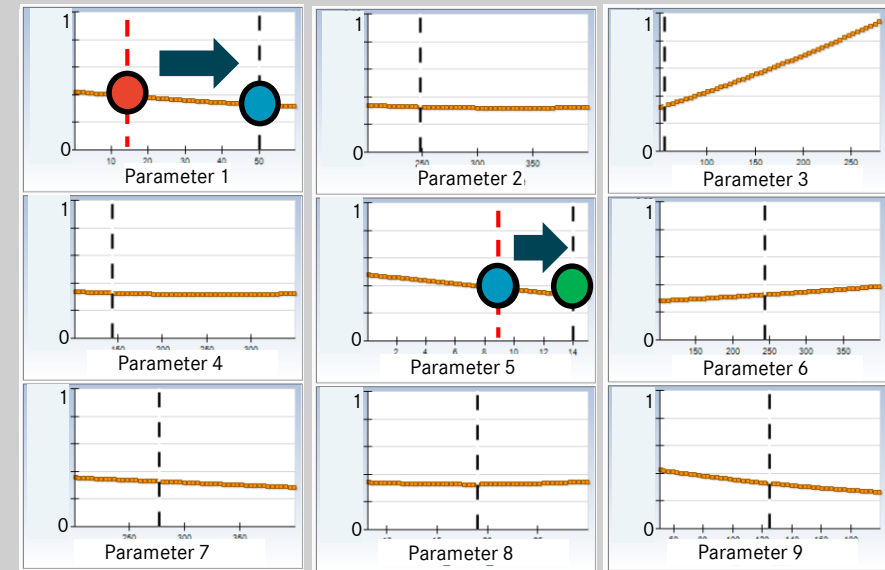


Analysis in Meta-Model



- In the meta - model relationships can be analyzed in real time and discussed in the development team
- Determining optimum

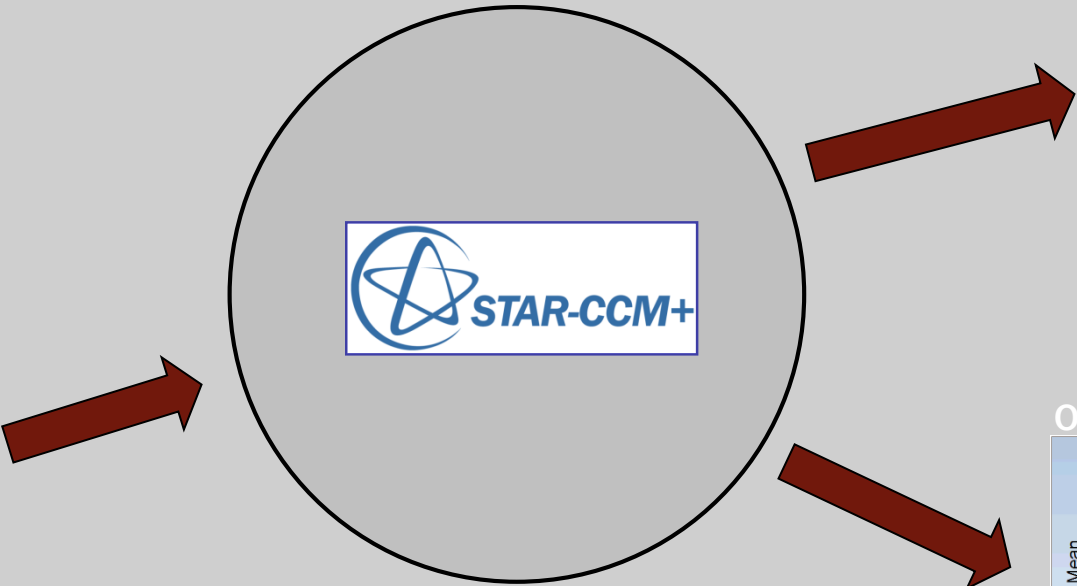
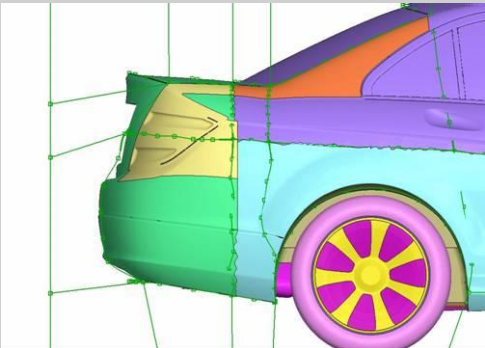
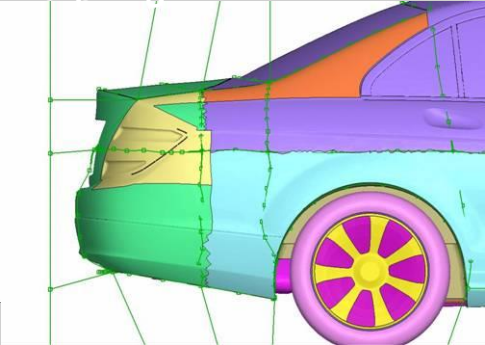
9-dimensional parameter space



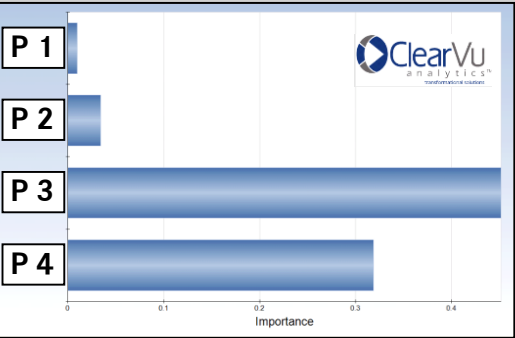
- The above sensitivities are only valid for exactly one parameter combination
- With the postponement of a parameter , all other functional relationships change

Example: Passenger Car Aerodynamics

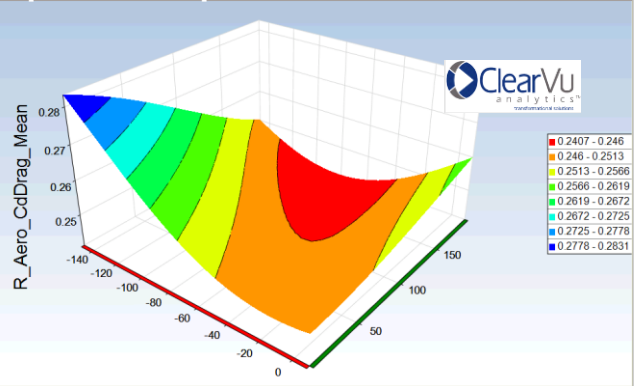
ANSA
Morphing



Sensitivities



Optimal Shapes



Conclusions and Future Work



- CAE-AutoWorkflow successfully implemented
- High robustness of simulation process
- Highly appreciated insight in parameter sensitivities
- Extension to more applications ongoing