

## MODA

### Modelling data documenting one simulation

#### ALLIANCE, Design and Optimization

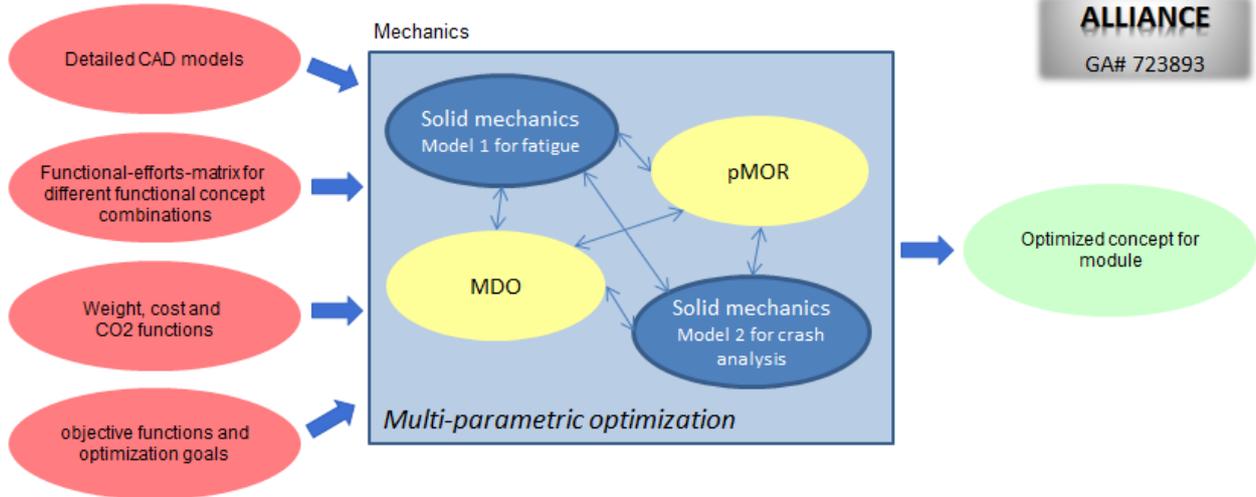
*Metadata for these elements are to be elaborated over time*

#### Purpose of this document:

Definition of a data organisation that is applicable to ALL materials modelling simulations. The fiche should contain all elements that are needed to describe a simulation. This information spans from the end-user (manufacturer) information to the computational modelling details.

#### OVERVIEW of the simulation

1	<b>USER CASE</b>	<i>Crash worthiness of a joint, lightweight optimised wheel house with strut tower and rails (one component) of a passenger car (C-segment) according current Euro NCAP standards Properties to be simulated are fatigue, noise, vibration and harshness (NVH) properties and crash performance.</i>	
2	<b>CHAIN OF MODELS</b>	<b>MODEL 1</b>	<i>Continuum macro-mechanic: solid mechanics (conservation eqs) to calculate fatigue/damage, plasticity, structural dynamics (eigenfrequencies, mode shapes)</i>
2	<b>CHAIN OF MODELS</b>	<b>MODEL 2</b>	<i>Continuum macro-mechanic: solid mechanics (conservation equations and eqs of motion) to calculate crash behaviour</i>
3	<b>PUBLICATION ON THIS ONE SIMULATION</b>	<i>None available so far</i>	
4	<b>ACCESS CONDITIONS</b>	<i>Input data: proprietary CAD/FE-models from the modules (OPEL) Model 1: Multi-parametric optimization (commercial code (IPEK, IKA, LBF); implementation using commercial software Matlab/Simulink (<a href="http://mathworks.com">mathworks.com</a>) and commercial FE-software ANSYS (<a href="http://ansys.com">ansys.com</a>), Abaqus (<a href="http://3ds.com">3ds.com</a>))</i>	
5	<b>WORKFLOW AND ITS RATIONALE</b>	<p>The refinement and multi-parametric optimization of functional concepts is performed. The optimization is an iterative process, consisting of the following subtasks</p> <ul style="list-style-type: none"> <li>• Detailing of CAD models</li> <li>• Structural optimization (model 1) to optimize fatigue and NVH properties</li> <li>• Multidisciplinary design optimization (MDO) using parametric model order reduction (pMOR) methods</li> <li>• Crash behavior (model 2) and consequent optimization.</li> <li>•</li> </ul>	



**Workflow**

**Each model** used in this simulation can be documented in four chapters:

1. Aspect of the User Case or System simulated with this model
2. Model
3. Computational aspects
4. Post processing

**MULTI-PARAMETRIC OPTIMIZATION OF FUNCTIONAL CONCEPTS**

Model 1 for Structural Optimisation

1 ASPECT OF THE USER CASE/SYSTEM TO BE SIMULATED		
1.1	<b>ASPECT OF THE USER CASE TO BE SIMULATED</b>	Simulation of the fatigue and NVH behavior of a joint, lightweight optimized wheel house with strut tower and rails (one component) of a passenger car (C-segment) according allowable stresses and requirements for NVH defined by OPEL
1.2	<b>MATERIAL</b>	<i>SotA material data for steel and aluminum will be used; once material data measured within ALLIANCE become available those will be implemented</i>
1.3	<b>GEOMETRY</b>	<i>joint wheel house with strut tower and rails (one component) of a C-segment vehicle Inputs are the CAD data provided by OPEL and/or derived within the project</i>
1.4	<b>TIME LAPSE</b>	<i>Unknown</i>
1.5	<b>MANUFACTURING PROCESS OR IN-SERVICE CONDITIONS</b>	<i>Operational loads defined by OPEL (accelerations, forces, displacements)</i>
1.6	<b>PUBLICATION ON THIS ONE SIMULATION</b>	<i>None available so far</i>

2 GENERIC PHYSICS OF THE MODEL EQUATION		
2.0	<b>MODEL TYPE AND NAME</b>	<i>Solid mechanics (macro-mechanics) (Ch. 4.2)</i>

2.1	MODEL ENTITY	<i>finite volumes</i>	
2.2	MODEL PHYSICS/ CHEMISTRY EQUATION PE	Equation	<i>conservation of energy</i>
		Physical quantities	<i>Masses and mass moments of inertia, damping, stiffness, displacement, internal and external forces</i>
2.3	MATERIALS RELATIONS	Relation	<i>Only constant values are entered, no constitutive equations are used</i>
		Physical quantities/ descriptors for each MR	<ol style="list-style-type: none"> <li>1. <i>Masses and mass moments of inertia (M; matrix)</i></li> <li>2. <i>Damping (B; matrix)</i></li> <li>3. <i>Stiffness (C; matrix)</i></li> <li>4. <i>Displacement</i></li> <li>5. <i>Stresses</i></li> <li>6. <i>Internal and external forces (F; matrix)</i></li> </ol>
2.4	SIMULATED INPUT	<ul style="list-style-type: none"> <li>• <i>none</i></li> </ul>	

<b>3</b>	<b>SOLVER AND COMPUTATIONAL TRANSLATION OF THE SPECIFICATIONS</b>		
3.1	NUMERICAL SOLVER	<i>Implicit finite element solvers</i>	
3.2	SOFTWARE TOOL	<i>ANSYS, Abaqus</i>	
3.3	TIME STEP	<i>variable</i>	
3.4	COMPUTATIONAL REPRESENTATION	PHYSICS EQUATION, MATERIAL RELATIONS, MATERIAL	<i>Written up for the entity in the model</i>
3.5	COMPUTATIONAL BOUNDARY CONDITIONS	<ul style="list-style-type: none"> <li>• <i>Degrees of Freedom of the entire model</i></li> <li>• <i>run-time of simulation</i></li> </ul>	
3.6	ADDITIONAL SOLVER PARAMETERS		

<b>4</b>	<b>POST PROCESSING</b>		
4.1	THE PROCESSED OUTPUT	<i>Allowable stresses and required eigenfrequencies which are used to optimize the concept for a module. For this concept a crash test is done with model 2.</i>	
4.2	METHODOLOGIES	<i>n/a</i>	
4.3	MARGIN OF ERROR	<i>within 10% of measured mechanical properties</i>	

## Model 2 for crash analysis

1 ASPECT OF THE USER CASE/SYSTEM TO BE SIMULATED		
1.1	ASPECT OF THE USER CASE TO BE SIMULATED	Simulation of the crash worthiness of a joint, lightweight optimised wheel house with strut tower and rails (one component) of a passenger car (C-segment) according current Euro NCAP standards; accelerations, displacements, forces and stresses will be iteratively optimized to meet weight targets and Euro NCAP standards
1.2	MATERIAL	SoTA material data for steel and aluminum will be used; once material data measured within ALLIANCE become available those will be implemented
1.3	GEOMETRY	Optimised (with model 1) joint wheel house with strut tower and rails (one component) of a C-segment vehicle
1.4	TIME LAPSE	about 100 milliseconds
1.5	MANUFACTURING PROCESS OR IN-SERVICE CONDITIONS	crash conditions according current EURO NCAP standards; external forces and displacements (crash analysis)
1.6	PUBLICATION ON THIS ONE SIMULATION	None available so far

2 GENERIC PHYSICS OF THE MODEL EQUATION			
2.0	MODEL TYPE AND NAME	Solid mechanics (macro-mechanics)(Ch. 4.2)	
2.1	MODEL ENTITY	finite volumes	
2.2	MODEL PHYSICS/CHEMISTRY EQUATION PE	Equation	Tightly coupled time dependent equations of motion and conservation of energy
		Physical quantities	Masses and mass moments of inertia, damping, stiffness, displacement, velocity, and acceleration, internal and external forces, time
2.3	MATERIALS RELATIONS	Relation	Only constant values are entered, no constitutive equations are used
		Physical quantities/descriptors for each MR	<ol style="list-style-type: none"> <li>1. Masses and mass moments of inertia (<math>M</math>; matrix)</li> <li>2. Damping (<math>B</math>; matrix)</li> <li>3. Stiffness (<math>C</math>; matrix)</li> <li>4. Displacement, velocity, and acceleration (<math>u, v, a</math>; vectors)</li> <li>5. Internal and external forces (<math>F</math>; matrix)</li> <li>6. Stresses</li> <li>7. Time (<math>t</math>; vector)</li> </ol>
2.4	SIMULATED INPUT	<ul style="list-style-type: none"> <li>• none</li> </ul>	

3 SOLVER AND COMPUTATIONAL TRANSLATION OF THE SPECIFICATIONS		
3.1	NUMERICAL SOLVER	Implicit finite element solvers and explicit finite difference solver
3.2	SOFTWARE TOOL	ANSYS, Abaqus
3.3	TIME STEP	variable
3.4	COMPUTATIONAL REPRESENTATION	PHYSICS EQUATION, Written up for the entity in the model

		<b>MATERIAL RELATIONS, MATERIAL</b>	
<b>3.5</b>	<b>COMPUTATIONAL BOUNDARY CONDITIONS</b>	<ul style="list-style-type: none"> <li>• <i>Degrees of Freedom of the entire model</i></li> <li>• <i>run-time of simulation</i></li> </ul>	
<b>3.6</b>	<b>ADDITIONAL SOLVER PARAMETERS</b>		

## Post processing

*The “raw output” calculated by the model is per definition the physics variable in the PE(s). This is already specified in the entry 2.2 and will appear in your dark green circle in the workflow picture.*

*This output is often processed by a post processor in order to calculate values for physics variables for different entities that can be input to the next model. Or the output is homogenised for larger volumes in the form of a MR or Descriptor Rule that are the final output of the total simulation.*

*This will appear in your light green circle in the workflow picture and also in 2.4 of the next model.*

*The methodology (often including new physics) used to do this calculation is to be documented.*

<b>4</b>	<b>POST PROCESSING</b>	
<b>4.1</b>	<b>THE PROCESSED OUTPUT</b>	<i>Crash worthiness is used to further optimize the concept for a module.</i>
<b>4.2</b>	<b>METHODOLOGIES</b>	<i>n/a</i>
<b>4.3</b>	<b>MARGIN OF ERROR</b>	<i>within 10% of measured mechanical properties</i>