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DOMUS

Design OptiMisation for efficient electric vehicles based on a USer-centric approach

DOMUS – Deliverable Report

D1.4 – 3D Model for Simulating Thermal and Acoustic Behaviour of Car Cabins

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Change Log

Version	Modifications of document	Author	Date
1.0	Set up document incl. proposed table of contents.	Thomas Hirn	2019-04-08
1.1	Added descriptions and cues to sections	Thomas Hirn	2019-08-14
1.2	Including sections to Chapter "3.4 Relationship to other work packages" and "4.6 Fogging prediction for safety modelling"	James Brusey	2020-02-14
1.3	Including sections to chapter "4 Thermal Cabin Model" and chapter "6.2.1 DPIV at IDIADA"	Charalampos Tsimis	2020-03-03
1.4	Adopted version, including several sections. Distributed to partners for their input.	Niklas Drope	2020-03-17
1.5	Including sections to chapter "3.4 Relationship to other work packages"	Alberto Merlo	2020-03-16
1.6	Including chapter "6.2.2 CRF experimental campaign"	Fabrizio Mattiello (CRF)	2020-04-30
1.7	Draft Version, including partners input.	Niklas Drope, Thomas Hirn	2020-05-06
1.8	Feedback and additions on the validation chapters	Charalampos Tsimis	2020-05-12
1.09	Reviewed draft version	Jan Rejlek	2020-05-16
2.0	Additions on chapter "6.3.1 Flow Field Validation"	Charalampos Tsimis, Paul Marston	2020-05-18
2.1	Small Change in chapter 2.6	James Brusey	2020-05-25

2.2	Completed document, ready for final review and submission.	Niklas Drope	2020-05-29
2.3	Input ViF	Jan Rejlek	2020-05-31
2.4	Some minor changes after feedback from COV	Niklas Drope	2020-06-04
2.5	Some minor changes after feedback from COV	Jan Rejlek & Sebastian Möller	2020-06-05

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Publishable summary

This deliverable comprises the setup of different simulation models of the DOMUS passenger vehicle cabin. A high fidelity, three-dimensional (3D) thermal model of the cabin, including thermal manikins, is able to assess energy consumption and thermal comfort. An additional 3D model of the acoustics of the cabin allows for an evaluation of noise level in the vehicle cabin.

The 3D thermal model investigates the interior of the DOMUS vehicle cabin. Of course, this includes the possibility for an in-detail assessment of energetic aspects (i.e. energy consumption of various systems, like radiant panels). Furthermore, virtual thermal manikins are developed which on the one hand can record measurement data relevant for the determination of comfort and on the other hand are in thermal interaction with the vehicle cabin (heat and moisture emission) and allow for a comfort evaluation. Thanks to close coordination, the 3D thermal model generates parameter values that can directly serve as input to the DOMUS T1.2 *Holistic Comfort Model*.

The 3D acoustic model is developed in order to predict the effect of design modifications on NVH. This is in particular achieved by applying an inverse statistical energy analysis (SEA) combined with an operational transfer path analysis. Prior to the assembly of an actual SEA model, an extensive experimental campaign is conducted on a physical vehicle prototype. This allows to retrieve all the relevant data needed for model assembly at a later stage.

To better understand and validate the models, various practical experiments are carried out. These include a digital particle image velocimetry (DPIV) for an enhanced assessment of the flow field. Furthermore, climatic wind tunnel experiments are conducted to generate a transient database for the validation. In these wind tunnel experiments, the focus is on the acquisition of the different component surface temperatures in order to be able to compare them with the component temperatures of the simulations. Furthermore, air velocities are also measured during wind tunnel experiments, in order to validate the air velocities in the simulations.

The transient temperature curves of measurement and simulation show a very good agreement and the simulation predicts component and air temperatures with 5% accuracy against measured parameters. Also, the stationary temperatures reached after heat-up/cool-down show a good accordance with the measurements. During qualitative comparison of DPIV data, simulated and measured flow fields feature a similar trend. However, some deviations are observed and are addressed in this deliverable. The measured air velocities inside the cabin match with their simulated counterparts for all the sensor locations with an accuracy of 5 %.

By combining inverse SEA (PIM) with OTPA a very flexible prediction tool is obtained. The transmission of sound from all relevant sources to the panels enveloping the fluid domain can be obtained in a very broad frequency range and distinction can be made between airborne and structure-borne sound transfer. In the low frequency range, the methodology has predictable limitations associated with the basic assumptions of the underlying SEA theory.

All validation methods showed a good correlation of simulation and measurement. The objective to correctly predict air velocities and temperatures within an accuracy of 5% is achieved and described in the validation chapter. As described in the same chapter, also the acoustic modelling shows good accordance with test results, allowing for good predictability in the virtual assessment of DOMUS innovations. The validated simulation models are fully available and ready to use. They will be used to run different use cases to generate a data base, which helps to set up the 1D simulation models. Also, the investigation of DOMUS additional components and design interventions is possible with the 3D simulation models.