EUROPEAN COMMISSION

HORIZON 2020 PROGRAMME - TOPIC H2020-GV-05-2017
Electric vehicle user-centric design for optimised energy efficiency

GRANT AGREEMENT No. 769902

Design Optimisation for efficient electric vehicles based on a User-centric approach

DOMUS – Deliverable Report

D5.5 - Regulation strategies for holistic comfort systems and logic control implementation in ECU

Deliverable No.	DOMUS D5.5	
Related WP	WP5	
Deliverable Title	Regulation strategies for holistic comfort systems and logic control implementation in ECU	
Deliverable Date	2021-06-04	
Deliverable Type	REPORT	
Dissemination level	Confidential – member only (CO)	
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Reviewed by (if applicable)	Filip Nielsen (Volvo)	2021-04-30 2021-06-04
Approved by	IDIADA	2021-06-04
Status	Final	2021-06-04

Change Log

Version	Modifications of document	Author	Date
Draft 1.0		IDI	2020-06-15
Draft 2.0	Expansion of chapters 6, 7 and 8	IDI	2021-04-13
Final	Incorporation of Volvo comments	IDI	2021-06-04

Disclaimer/ Acknowledgment

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 769902. The information and views set out in this publication does not necessarily reflect the official opinion of the European Commission. Neither the European Union institutions and bodies nor any person acting on their behalf, may be held responsible for the use which may be made of the information contained therein.

1 Publishable summary

Different comfort systems are integrated into the DOMUS prototype including heating panels, active seats and an HVAC unit with a smart outlet. Additionally, a set of sensors is also integrated in the cabin in order to monitor different parameters used for comfort and safety purposes, as shown in Figure 1.

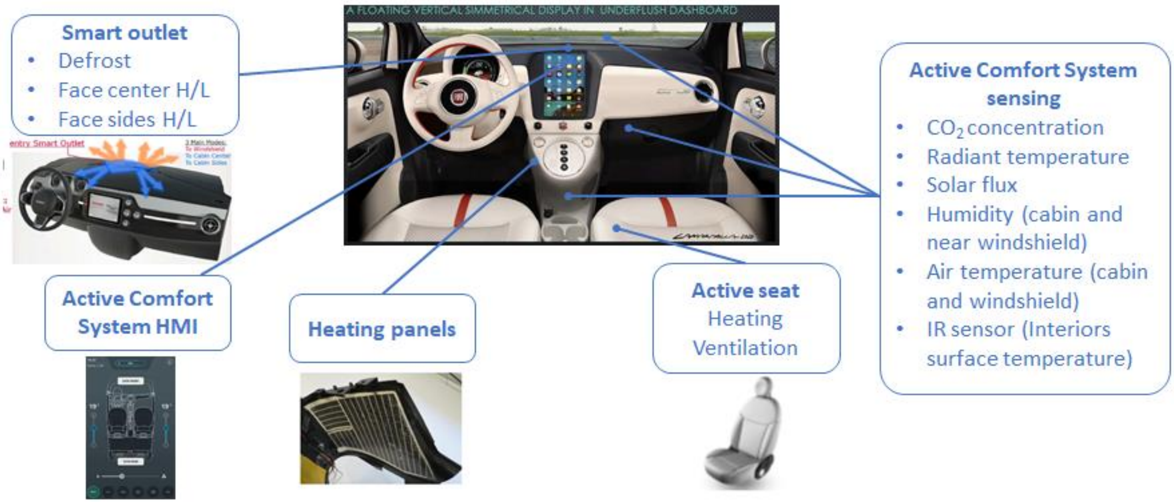

Figure 1 Comfort systems and sensor set integrated in the DOMUS prototype.

All these elements are integrated in an electronic architecture with one central climate ECU that contains the climate control software, which is the object of this deliverable.

The climate software was developed following a V-cycle process, as shown in Figure 2.

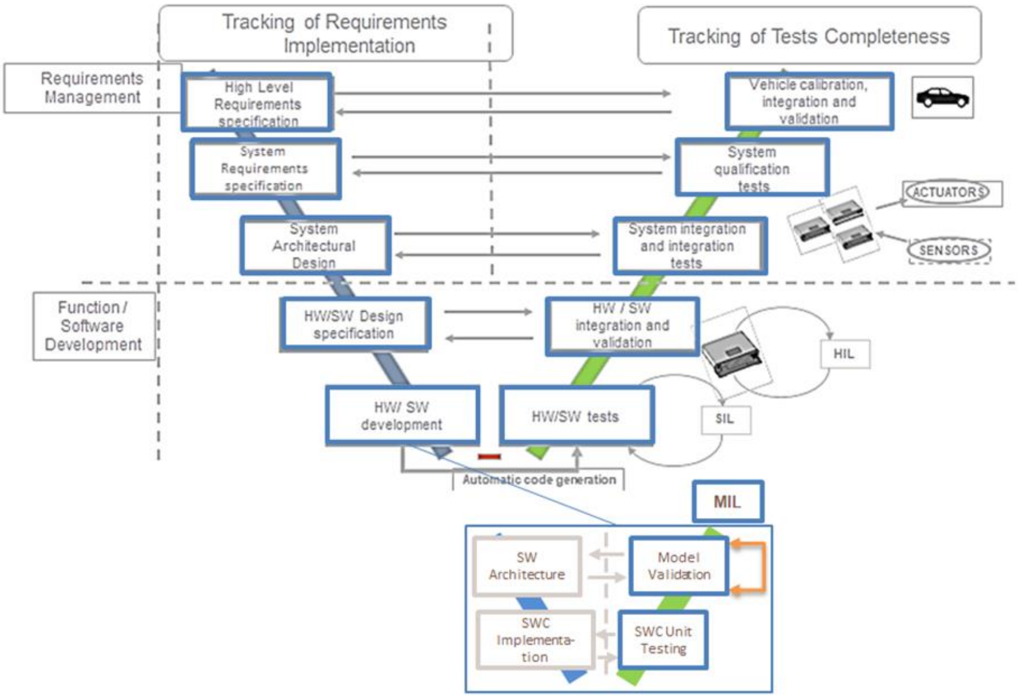

Figure 2 V-cycle process for developing software

Significant efforts were put in a MiL specifically built for debugging, optimizing, pre-calibrating and validating the software.

The proper design of the climate control software is a key factor for reaching the targets of the project.

Climate control software main characteristics

The software operates the different comfort systems in automatic mode mainly. This automatic mode can be altered by the user in case that an adjustment is required.

Architecture

In order to facilitate the integration to any vehicle, the SW is built in a modular structure. The main blocks are listed below:

- Target comfort block based on the user inputs on the HMI (weight, height, gender, and season).
- Actual comfort block based on air temperature, mean temperature and offline data.
- Winter block. This block calculates the cabin needs for proper comfort (air temperature, HVAC mode, airflow) in winter conditions.
- Summer block. This block calculates the cabin needs for proper comfort (air temperature, HVAC mode, airflow) in summer conditions.
- Active seats block. This block generates signals to the active seat ECUs based on the user inputs.
- Heating panels block. This block generates signals to the heating panels ECUs based on the user inputs.
- CO2 regulation block. This block generates signals to the blower and recirculation door in order to regulate the CO2 concentration.

Strategy

The CO2 concentration is monitored by using a CO2 concentration sensor. The strategy regulates the CO2 and maximizes the amount of time that the car is operating in full recirculation mode in order to avoid conditioning external air, which is typically high energy consuming.

The misting generation on the inner surfaces of the glasses is prevented by operating electrically heated windows based on glass humidity sensor outputs. The activation of the air conditioning, the fresh air mode, or the HVAC defrost outlet is no longer needed.

The preferred mode in winter is the bi-level, since no HVAC defrosting is needed for the demisting function.

Comfort systems combination

The active seats are automatically regulated due to the internal sensors and algorithm provided by FAURECIA. The heating function was observed in virtual models to be effective for local pelvis and back comfort.

The comfort provided by the heating panels has been observed in virtual models to be very low, and cannot be a replacement for an HVAC unit by itself.

MiL

A new Model in the Loop was built for debugging, optimizing, pre-calibrating and validating the climate control logic.

The plant model of the car cabin and cooling system was created and was run in co-simulation with the climate control logic as shown in Figure 3.

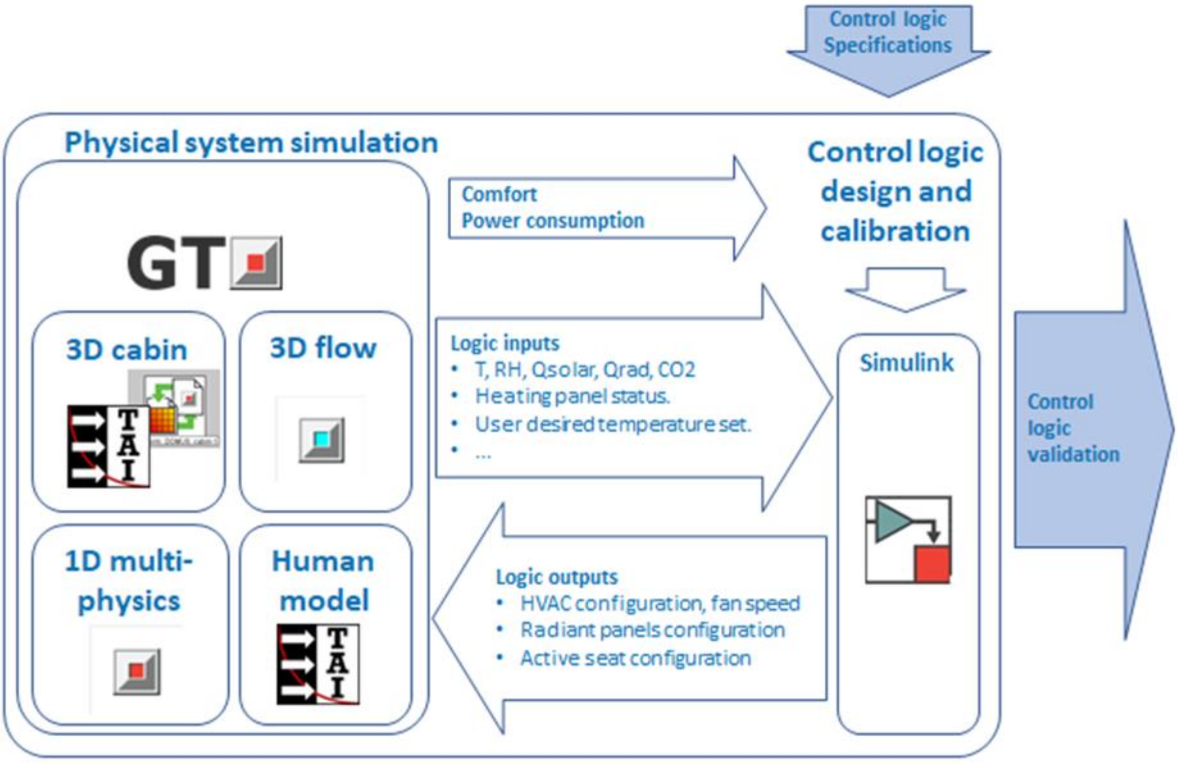

Figure 3 Co-simulation scheme.

This MiL offers the energy consumption of each of the comfort elements, and also provides the comfort metrics for a wide range of scenarios for the front occupants.

10 Acknowledgement

The author(s) would like to thank the partners in the project for their valuable comments on previous drafts and for performing the review.

Project partners:

#	Partner	Partner Full Name
1	IDIADA	IDIADA AUTOMOTIVE TECHNOLOGY SA
2	CRF	CENTRO RICERCHE FIAT SCPA
3	TME	TOYOTA MOTOR EUROPE
4	Volvo Cars	VOLVO PERSONVAGNAR AB
5	AGC	AGC GLASS EUROPE SA
6	DNTS	DENSO Thermal Systems S.p.A.
7	Faurecia	Faurecia Sièges d'Automobile
8	HUTCH	HUTCHINSON SA
9	IEE	IEE International Electronics & Engineering S.A.
10	LIST	LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY
11	COV	COVENTRY UNIVERSITY
12	Fraunhofer	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.
13	IKA	RHEINISCH-WESTFAELISCHE TECHNISCHE HOCHSCHULE AACHEN
14	TECNALIA	FUNDACION TECNALIA RESEARCH & INNOVATION
15	VIF	Kompetenzzentrum - Das Virtuelle Fahrzeug, Forschungsgesellschaft mbH
16	UNR	UNIRESEARCH BV

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement no. 769902

11 Appendix A – Quality Assurance

The following questions should be answered by all reviewers (WP Leader, peer reviewer 1, peer reviewer 2 and the technical coordinator) as part of the Quality Assurance Procedure. Questions answered with NO should be motivated. The author will then make an updated version of the Deliverable. When all reviewers have answered all questions with YES, only then the Deliverable can be submitted to the EC.
NOTE: For public documents this Quality Assurance part will be removed before publication.

Question	Peer reviewer 1
	Filip Nielsen (Volvo Cars)
1. Do you accept this deliverable as it is?	Yes The delivery includes control strategies for holistic comfort. Although unable to verify function in ECU
2. Is the deliverable completely ready (or are any changes required)?	Yes If the control works in a ECU this is ready
3. Does this deliverable correspond to the DoW?	Yes SubTask 5.2.1. Auto regulation strategy from application is done
4. Is the Deliverable in line with the DOMUS objectives?	Yes The deliverable decreases the energy use of the vehicle
a. WP Objectives?	Yes A control has been developed. *Develop and implement control logic strategies for both automatic regulation and manual assistance, using optimal energy levels in order to meet the users personalized needs adequately, capable of predicting the evolution of the conditions in the acclimated cabin.*
b. Task Objectives?	Yes The control has been developed (although is a bit unsure about the user-regulation assistance) *The purpose of this task is to design and implement a model-based unified control management software in order to manage the whole active comfort system in accordance with the data measured by the sensors: this will necessitate understanding the individual contribution of each component on the perceived comfort, evaluating cabin and users conditions individually and comparing them with the desired set points and, -according to the guidelines from the holistic comfort model (WP1)-, provide real-time actuation rules in order to achieve the optimal compromise between comfort perception and energy efficiency. This corresponds to the real tangible advantage of adopting the holistic approach from the very early design phases of the whole system.*
5. Is the technical quality sufficient?	YES