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

Deliverable 2.2 Approach and Results of User Centred Design of Novel Cabin Design Models through Disruptive Approaches

Deliverable No.	DOMUS D2.2	
Related WP	Work package 2: Advanced Cabin Design and Virtual Assessment Implementation and testing of the different solutions at the full vehicle level	
Deliverable Title	Approach and Results of User Centred Design of Novel Cabin Design Models through Disruptive Approaches	
Deliverable Date	2020-04-30	
Deliverable Type	REPORT	
Dissemination level	Confidential – member only (CO)	
Written By	Peter Moertl (ViF) Sebastian Möller (ViF) Alberto Merlo (CRF)	2020-02-29 2020-03-31
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Approved by	IDIADA	2020-05-05
Status	Final	2020-04-26

Change Log

Version	Modifications of document	Author	Date

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.

Publishable summary

In the endeavor to fight the effects of the climate change, the automotive industry is struggling to develop new technologies to curb the amount of greenhouse effect emissions from the ICE powered vehicles. Electric vehicles are emerging thereby as the most sustainable option for both satisfying the future mobility needs and reducing the impact on the environment. The challenge within the DOMUS project is how novel cabin designs could achieve such sustainability goals while achieving effective, safe, and comfortable experiences by vehicle occupants. To investigate how radical innovative redesigns of vehicle cabins could be methodologically achieved and then virtually assessed, the DOMUS project develops and tests methodologies to meet these goals. The overall project objective is to increase the range of electric vehicles by 25 % while maintaining driver and passenger comfort and safety. For this purpose, the DOMUS project utilizes and adapts innovation principles along with human-centered design approaches to collaboratively expand existing knowledge toward future projections of mobility need landscapes and expected user needs. In this deliverable the user-centered design principles and innovative cabin designs are described as well as virtual assessment methods and results are presented to estimate the efficiency impact of these innovations.

A three-fold strategy was used to identify novel solutions and design ideas to meet the DOMUS efficiency goals. The Concept-Knowledge design framework [1] was used as innovation management process to work as team toward achieving innovative solutions. The framework was administered in a series of three in-person workshops with the contributing project partners. In these workshops initial design solutions were identified that were simulated and evaluated for their impact on efficiency. A critical innovation starting point were an analysis of future European mobility situations and constraints that were investigated based on ongoing national and international planning activities such as the EU Horizon 2020 project Mobility4EU ([6]). In these process, DOMUS consortium partners contributed their expertise in designing novel EV cabins in the context of future mobility as well as critical market relevant constraints and environments were investigated.

During these workshops four discrete mobility use cases were created in which different personas exhibit their mobility needs within different environments to reflect mobility in the near to mid-term future. These use cases describe how car-sharing vehicles could be utilized and reflect specific vehicle usage personas that are consistent with the reviewed EU mobility visions. They reflect different gender, cultural, geographic, economic, and professional diversity.

Based on the use cases, several possible cabin design variants were developed to meet the mobility needs. The baseline design variant (DV 0) is the current Fiat 500E design. Three additional design variants were created. DV 1a consists of the baseline Fiat 500e with enhancements based on the DOMUS project innovations such as novel insulation materials, windshields, heat-radiation panels, and a novel dashboard. In addition, DV 1b and DV 2 consist of more radical design modifications that reduce the weight of the vehicle by tailoring the cabin to specific use cases that would be facilitated by wide availability of car-sharing services in the future. Whereas DV 1b is still based on a Fiat 500E baseline design, DV2 was especially designed for the DOMUS project and thereby deviates considerably from the baseline design for improved efficiency. Specifically, DV 1b and DV 2 should allow for vehicle tailoring where efficiency improvements are achieved by reducing the unused and unnecessary components and materials for lower occupancy situations. As an important modular aspect were Dual Zone Separations introduced that allow for thermally insulating the unused space of the cabin. Thereby, less space of the cabin needs to be cooled or warmed. Also, automated driving was introduced to achieve optimally efficient driving styles, thereby avoiding unnecessary accelerations and decelerations while driving.

An initial assessment of the fundamental cabin characteristics was performed to determine whether the design changes were coming close to achieve the DOMUS project objective. This initial assessment was based on simplifying assumptions about the basic physical mechanisms underlying the efficiency gains for realistic driving cycles. This initial assessment was conceived to be completed by more detailed assessments later on in the DOMUS project.

The results of this initial assessment show that the target of a range increase of 25% remains ambitious in especially in the case of design variant 1a and 1b where bigger conceptual changes to the base vehicle are not possible. To be able to reach the target, additional efforts during the project are needed to combine the effects of the technological innovations and an adapted driving style in an optimal way.
The disruptive design changes of DV 2 allow for a significant weight reduction. Depending on the driving task it has been shown that this factor alone makes a range increase of 30 % and more possible. Considering the reduced power demand of the active comfort system resulting from the redesign of the cabin, also for less demanding driving tasks like the NEDC cycle a range increase of more than 25 % is possible.