Optimization of scalaBle rEaltime modeLs and functIonal testing for e-drive ConceptS

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No	Who	Description	Date
1	Willem van Dorp	First draft set up	09-11-2020
2	Jacqueline Heintz	Texts from newsletters added	10-11-2020

Contents

Tables

1 Introduction

Within the OBELICS project, many dissemination activities have been undertaken. Among them are the newsletters. In this deliverable the newsletters are collected that have been sent out during the OBELICS project.

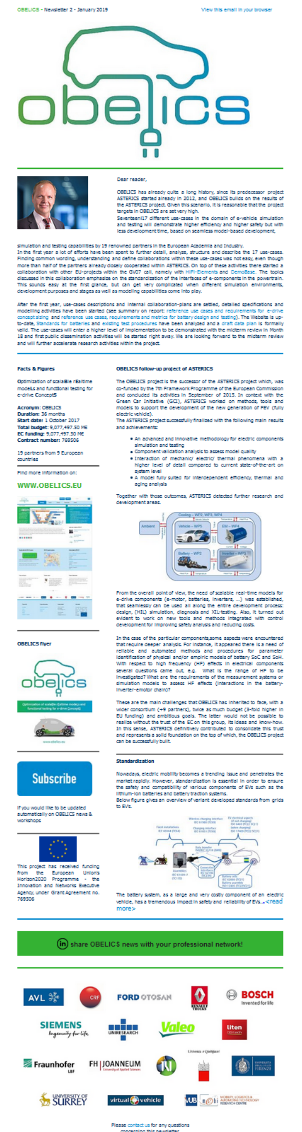
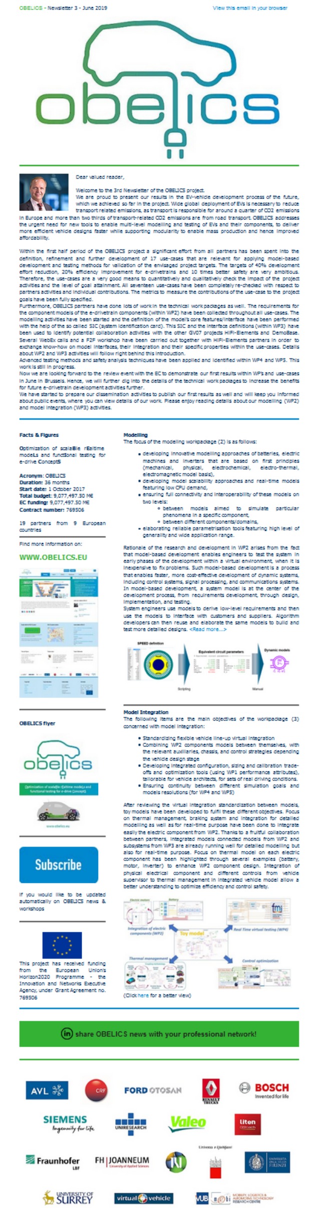
Role of the partners: UNR has created the newsletters including a target group database of contact details. The information for the database was collected with the support of all partners, implemented in the database by UNR and updated regularly, further, there was a possibility to register on the website for the newsletters. The OBELICS partners has contributed to the newsletters by providing detailed descriptions of the past/ongoing activities supported with photos and images.

2 Newsletters

In total four newsletters were sent to the recipients in our contact database.

Table 1 shows the newsletters that were sent (the contents are given below) during the development phase of the project. The newsletters where also used to announce the midterm conference and the final event, and to enable the registration for these events. See chapter 3 and 4 for more details.

Table 1. The newsletters sent during the OBELICS project.

1	2	3	4
Newsletter 1 July 2018 114 recipients Opened by 35	Newsletter 2 January 2019, and 128 recipients Opened by 48	Newsletter 3 June 2019 148 recipients Opened by 47	Newsletter 1 January 2020 153 recipients Opened by 57
			

2.1 Text Newsletter 1

Introduction by the coordinator:

Dear reader,

In the OBELICS project, 19 renowned partners from industry and science develop new methods, tools and standards for the efficient development of next-generation electric vehicles, demonstrated via industrial relevant use cases. The ultimate goal of the project is the development of a systematic and comprehensive framework for the design, development and testing of advanced e-powertrains and EV's line-ups.

This framework will allow the reduction of development efforts by 40%, while improving efficiency of the e-drivetrain by 20% and increase safety by a factor of 10.

AVL is the Coordinator of this innovative research project and gets administrative and project management support from Uniresearch, which is also partner in this consortium. The project consortium consists of partners from automotive industry (CRF, Ford, Volvo, Renault, Bosch, AVL, Siemens and VALEO) and technically competent and very well-known scientific partners (FHJ, VIF, VUB, FhG, CEA, ULJ, UNIFI, US, NIC).

There is a close collaboration planned with other EU-projects that deal with similar or related research topics (e.g. with HiFi-Elements).

Within OBELIC the activities are clustered. E-motor, control as well as inverter design & testing activities are summarized in cluster 4, which will demonstrate more efficient development and testing activities for e-vehicles.

15 Exemplary use cases are divided up into 4 use case clusters, which introduce industrial and prospective, relevant engineering activities, to develop, proof and demonstrate new methods and tools along the entire e-vehicle development process.

Battery design and testing methods and tools are part of use-case cluster 3 that will contribute significantly to increased safety and efficiency of batteries, respectively e-vehicles.

In Cluster 2, there are 5 use cases working on e-vehicle system integration and optimization technologies, in order to enable more efficient electric vehicles and reduced testing efforts simultaneously.

Use-case cluster 1 deals with new e-drive concepts & components sizing in earlier design phase for 3 different vehicles and will contribute to the efficiency improvement as well as reduction of development efforts for electric drivetrains.

The main ingredients for reaching these improvements are the OBELICS advanced heterogeneous model-based testing methods and tools as well as scalable and easy to parameterize real-time models, combined with frontloading of activities in early development phases.

Horst Pfluegl

Future EV design

CRF, the research and innovation centre of FCA, will exploit the output of OBELICS in future EV design when it comes to the implementation of a holistic energy management through detailed and validated modelling, testing at component and sub-component level or experimenting new and advanced HiL/XiL approaches. By improving the understanding of design capabilities and testing component of EVs, the aim is on the one hand to achieve higher performance levels at lower cost, and on the other hand customer satisfaction by maintaining or improving the actual standard, hence enabling greater market penetration of electrified vehicles developed primarily for use in the urban context. In turn this will facilitate the drive towards technological leadership in Europe in this key sector for future mobility. One of the expected OBELICS result is to include new vehicle metrics close to the real use of the vehicle in the early design phase of a new EV, to bring the project phase and the customer closer together right from the beginning. FCAs primary aim is to introduce technical solutions that reduce the environmental impact of road transport to the market as fast as possible.

CRF intends to exploit the detailed modelling and testing tools developed in OBELICS to rapidly validate and prototype different design options and configurations. By bringing together the key stakeholders in the value chain, OBELICS aims to adopt an integrated, unified approach in order to increase the efficiency of the EVs, to reduce the development and validation time of the tools to a minimum, to maintain the reliability of the systems and all subsystem components. The new metrics introduced in OBELICS are not just related to the vehicle but can be also extended to the component to increase the design efficiency of all the stakeholders with a consistent reduction in development time also of the single component. The new Hil methods and the ability to use the advanced novel tools that are going to be implemented in OBELICS will help to ensure safety and improve efficiency of EVs to be developed and produced by FCA in the coming years, helping to reduce development and testing efforts significantly, and hence contributing to the minimization of development lead times and costs.

Reliability and functional safety

The Fraunhofer Institute for structural durability and system reliability (LBF) is involved in the OBELICS project mainly in reliability and functional safety assessment of the power train and power train components. At LBF, several multiphysical test stands are available, especially for testing of HV batteries (Fig.1) and power electronics (Fig. 2). In both cases, the unique feature of these test stands is the simultaneous instead of the sequential application of all operational loads like mechanical vibrations, electrical operation and resulting thermomechanical stress, and climatic conditions. Qualitative evaluation methods like Failure Modes and Effects Analysis are available standard procedures allowing for the combination of different failure scenarios throughout the hierarchical stages of the system topology up to vehicle level.

In OBELICS, there is a unique chance to merge these different competencies by applying them to different real hardware use cases of the power train like batteries, inverters, and a complete real vehicle furnished by the project partners. By doing so, LBF will, on the one hand, gain experience in real word application of the methods and, on the other hand, will be enabled to broaden the portfolio for bilateral industry projects as a "all in all" solution from experimental, numerical, and qualitative evaluation methods

One focus of LBF is on the further development of a new tool, called the probabilistic FMEA (probFMEA). In contrast to classical FMEA, with this tool it is possible to handle quantitative probabilities for failures on component level to occur. Consequently, the tool is capable of calculating system failure probabilities which are necessary in order to create metrics allowing for reliability as well as safety assessment.

In OBELICS, this tool is therefore important for supporting the development process of power train subsystems in order to reach and to monitor the defined safety and efficiency goals.

First results have been achieved in order to adapt the tools to the demands and specific system structures of OBELICS and were presented on the workshop "Reliability of mechatronic and adaptronic systems", organised by the German association on Materials research and - testing (DVM) on 27-28 February in Munich (Fig.3)

Next steps will be the collection of input data from the Use cases as well as expert knowledge in order to set up a first system structure and to derive a failure net.

Website: Find more information on: **WWW.OBELICS.EU**

OBELICS flyer

OBELICS Consortium at the second General Assembly in Paris on 24 and 25 April 2018

This project has received funding from the European Union's Horizon2020 Programme - the Innovation and Networks Executive Agency, under Grant Agreement no. 769506

2.2 Text Newsletter 2

Introduction by the coordinator:

Dear reader,
OBELICS has already quite a long history, since its predecessor project ASTERICS started already in 2012, and OBELICS builds on the results of the ASTERICS project. Given this scenario, it is reasonable that the project targets in OBELICS are set very high.
Seventeen!17 different use-cases in the domain of e-vehicle simulation and testing will demonstrate higher efficiency and higher safety but with less development time, based on seamless model-based development, simulation and testing capabilities by 19 renowned partners in the European Academia and Industry.
In the first year a lot of efforts have been spent to further detail, analyze, structure and describe the 17 use-cases. Finding common wording, understanding and define collaborations within these use-cases was not easy, even though more than half of the partners already closely cooperated within ASTERICS. On top of these activities there started a collaboration with other EU-projects within the GV07 call, namely with HiFi-Elements and DemoBase. The topics discussed in this collaboration emphasize on the standardization of the interfaces of e-components in the powertrain. This sounds easy at the first glance, but can get very complicated when different simulation environments, development purposes and stages as well as modeling capabilities come into play.

After the first year, use-cases descriptions and internal collaboration-plans are settled, detailed specifications and modelling activities have been started (see summary on report: reference use cases and requirements for e-drive concept sizing and reference use cases, requirements and metrics for battery design and testing). The Website is up-to-date, Standards for batteries and existing test procedures have been analyzed and a draft data plan is formally valid. The use-cases will enter a higher level of implementation to be demonstrated with the midterm review in Month 18 and first public dissemination activities will be started right away. We are looking forward to the midterm review and will further accelerate research activities within the project.

<u>OBELICS follow-up project of ASTERICS</u>
The OBELICS project is the successor of the ASTERICS project which, was co-funded by the 7th Framework Programme of the European Commission and concluded its activities in September of 2015. In context with the Green Car Initiative (GCI), ASTERICS worked on methods, tools and models to support the development of the new generation of FEV (fully electric vehicle).
The ASTERICS project successfully finalized with the following main results and achievements:

An advanced and innovative methodology for electric components simulation and testing
Component validation analysis to assess model quality
Interaction of mechanic/ electric/ thermal phenomena with a higher level of detail compared to current state-of-the-art on system level A model fully suited for interdependent efficiency, thermal and aging analysis

Together with those outcomes, ASTERICS detected further research and development areas.

From the overall point of view, the need of scalable real-time models for e-drive components (e-motor, batteries, inverters, …) was established, that seamlessly can be used all along the entire development process: design, (HIL) simulation, diagnosis and XIL-testing. Also, it turned out evident to work on new tools and methods integrated with control development for improving safety analysis and reducing costs.

In the case of the particular components,some aspects were encountered that require deeper analysis. For instance, it appeared there is a need of reliable and automated methods and procedures for parameter identification of physical and/or empiric models of battery SoC and SoH. With respect to high frequency (HF) effects in electrical components several questions came out, e.g. What is the range of HF to be investigated? What are the requirements of the measurement systems or simulation models to assess HF effects (interactions in the battery-inverter-emotor chain)?

These are the main challenges that OBELICS has inherited to face, with a wider consortium (+9 partners), twice as much budget (3-fold higher in EU funding) and ambitious goals. The latter would not be possible to realize without the trust of the EC on this group, its ideas and know-how. In this sense, ASTERICS definitively contributed to consolidate this trust and represents a solid foundation on the top of which, the OBELICS project can be successfully built.

Standardization

Nowadays, electric mobility becomes a trending issue and penetrates the market rapidly. However, standardization is essential in order to ensure the safety and compatibility of various components of EVs such as the lithium-ion batteries and battery traction systems.
Below figure gives an overview of variant developed standards from grids to EV's.
The battery system, as a large and very costly component of an electric vehicle, has a tremendous impact in safety and reliability of EVs...**<link to website>**

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2.3 Text Newsletter 3

Introduction by the coordinator:

Dear valued reader,

Welcome to the 3rd Newsletter of the OBELICS project.

We are proud to present our results in the EV-vehicle development process of the future, which we achieved so far in the project. Wide global deployment of EVs is necessary to reduce transport related emissions, as transport is responsible for around a quarter of CO2 emissions in Europe and more than two thirds of transport-related CO2 emissions are from road transport. OBELICS addresses the urgent need for new tools to enable multi-level modelling and testing of EVs and their components, to deliver more efficient vehicle designs faster while supporting modularity to enable mass production and hence improved affordability.

Within the first half period of the OBELICS project a significant effort from all partners has been spent into the definition, refinement and further development of 17 use-cases that are relevant for applying model-based development and testing methods for validation of the envisaged project targets. The targets of 40% development effort reduction, 20% efficiency improvement for e-drivetrains and 10 times better safety are very ambitious. Therefore, the use-cases are a very good means to quantitatively and qualitatively check the impact of the project activities and the level of goal attainment. All seventeen use-cases have been completely re-checked with respect to partners activities and individual contributions. The metrics to measure the contributions of the use-case to the project goals have been fully specified.

Furthermore, OBELICS partners have done lots of work in the technical work packages as well. The requirements for the component models of the e-drivetrain components (within WP2) have been collected throughout all use-cases. The modelling activities have been started and the definition of the model's core features/interface have been performed with the help of the so called SIC (system identification card). This SIC and the interface definitions (within WP3) have been used to identify potential collaboration activities with the other GV07 projects HiFi-Elements and DemoBase. Several WebEx calls and a F2F workshop have been carried out together with HiFi-Elements partners in order to exchange know-how on model interfaces, their integration and their specific properties within the use-cases. Details about WP2 and WP3 activities will follow right behind this introduction.

Advanced testing methods and safety analysis techniques have been applied and identified within WP4 and WP5. This work is still in progress.

Now we are looking forward to the review event with the EC to demonstrate our first results within WP's and use-cases in June in Brussels. Hence, we will further dig into the details of the technical work packages to increase the benefits for future e-drivetrain development activities further.

We have started to prepare our dissemination activities to publish our first results as well and will keep you informed about public events, where you can view details of our work. Please enjoy reading details about our modelling (WP2) and model integration (WP3) activities.

Modelling

The focus of the modeling workpackage (2) is as follows:

- developing innovative modelling approaches of batteries, electric machines and inverters that are based on first principles (mechanical, physical, electrochemical, electro-thermal, electromagnetic model basis),
- developing model scalability approaches and real-time models featuring low CPU demand,
- ensuring full connectivity and interoperability of these models on two levels:
    - between models aimed to simulate particular phenomena in a specific component,
    - between different components/domains,

- elaborating reliable parametrisation tools featuring high level of generality and wide application range.

Rationale of the research and development in WP2 arises from the fact that model-based development enables engineers to test the system in early phases of the development within a virtual environment, when it is inexpensive to fix problems. Such model-based development is a process that enables faster, more cost-effective development of dynamic systems, including control systems, signal processing, and communications systems. In model-based development, a system model is at the center of the development process, from requirements development, through design, implementation, and testing. System engineers use models to derive low-level requirements and then use the models to interface with customers and suppliers. Algorithm developers can then reuse and elaborate the same models to build and test more detailed designs.

Model Integration

The following items are the main objectives of the workpackage (3) concerned with model integration:

- Standardizing flexible vehicle line-up virtual integration
- Combining WP2 components models between themselves, with the relevant auxiliaries, chassis, and control strategies depending the vehicle design stage
- Developing integrated configuration, sizing and calibration trade-offs and optimization tools (using WP1 performance attributes), tailorable for vehicle architects, for sets of real driving conditions.
- Ensuring continuity between different simulation goals and models resolutions (for WP4 and WP5)

After reviewing the virtual integration standardization between models, toy models have been developed to fulfil these different objectives. Focus on thermal management, braking system and integration for detailed modelling as well as for real-time purpose have been done to integrate easily the electric component from WP2. Thanks to a fruitful collaboration between partners, integrated models connected models from WP2 and subsystems from WP3 are already running well for detailed modelling but also for real-time purpose. Focus on thermal model on each electric component has been highlighted through several examples (battery, motor, inverter) to enhance WP2 component design. Integration of physical electrical component and different controls from vehicle supervisor to thermal management in integrated vehicle model allow a better understanding to optimize efficiency and control safety.

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2.4 Text Newsletter 4

Introduction by the coordinator:

Dear valued reader!

Electric vehicles are still on the rising edge and will achieve worldwide vehicles sales of between EUR 2.4 and 2.9 million, compared with around EUR 2 million in 2018. Even though there was a slowdown in the third quarter of 2019, especially in China due to the reduced number of subsidiaries, market growth is continuing. Volkswagen is driving this transformation forward on a massive scale, now again supported by the announcement to discontinue the production of combustion engines for the Motorsport Division as well .

The OBELICS project is thus fully in line with current trends in the automotive market. It will contribute to making future electric vehicles cheaper, safer and with longer ranges.

By supporting vehicle design, development and testing with advanced modeling tools, test methods and devices, OBELICS will contribute significantly to the success of electric and electrified vehicles.

The community of experts around the powertrain components of electric vehicles is growing and growing. Batteries, power electronics, electric motors, controls – all areas are covered within OBELICS and therefore the possibilities to create synergies with other research projects are great.

The OBELICS team members met with iModBatt/Ghost/HiFiElements and other partners for a joint workshop. In addition, there were many opportunities at EUCAR, EARPA, EGVIA workshops, meetings and conferences (e.g. RTR2019, a collaborative approach among all 3 organizations) to collaborate with the growing community.

Please inform yourself about the iModBatt workshop and the methods for safety assessment methods of batteries. I look forward to seeing you again in future synergetic workshops and conferences.

Horst Pfluegl, AVL (Coordinator OBELICS)

Mechanical reliability and safety of the HV Battery

The evaluation of mechanical reliability and safety of HV batteries was mainly done by the OBELICS partners Bosch und Fraunhofer LBF. Primary goal is the deeper understanding of the battery behavior during field relevant vibration loads, while the secondary goal is a tailor-made implementation of a novel probabilistic FMEA for battery systems. Therefore, a measurement campaign was initialized with a Fiat 500e battery system supplied by Bosch. The battery contains 97 electrically connected battery cells arranged in five and six cell modules. The total mass of the battery system is about 270 kg. The scalable tests were performed in a multi-axial test rig with climatic chamber available at the LBF Fraunhofer Darmstadt.

The motivation for this research is to determine the transfer function between the fixture points of the battery and several areas in the interior, especially the housings of the cell packs. For this purpose, a total of 8 tri-axial MEMS accelerometers, which are built inhouse at Fraunhofer LBF, and 10 strain gauges have been positioned inside the battery. The battery is then attached to the testing fixture developed to hold it in position during measurement tests. In addition to these sensors, there are reference accelerometers (accelerometers used to monitor tests) placed adjacent to mounting positions (outside) of the battery, and at positions similar to measurement drives to gather data. The tests are performed at the multi-physical testing environment in Fraunhofer LBF, which consists of a multi-axis shaker table (MAST), a vehicle energy system (VES) and a climatic chamber (CC), as shown in below figure.

OBELICS at the iModBatt battery modelling workshop

On the 18th October 2019 there was a very well-organized **workshop on battery modelling** and testing in San Sebastian near CIDETEC facilities. Researchers from battery related research projects like iModBatt, GHOST, ADVICE, EVOLVE, HiFi-Elements, QUIET and others were invited. The workshop was opened by Mr. Luca Feola, Project Officer of both iModBatt and GHOST. Each project was presented by the coordinator or a partner of the project. In the further sequel, the presentations were discussed with the available high-level expertise forum to spread knowledge within the community and to review the results achieved so far.

After the presentation of the highlights of the invited H2020 projects, a round table was organized that focused on aspects related to customization of the battery design versus modularity and use of batteries after their first life. During the breaks and after the presentations there was a poster session to further intensify discussions and collaborations between the different projects. The interactive discussion was very lively, and the visions of how future mobility was likely to evolve or should evolve were sometimes quite different despite many similarities.

Among the 12 very interestingly presented project, surprisingly there were only 2 projects, namely OBELICS and HIFI-Elements, that researches on tools, methods and development processes itself, which form the basis for further investigations of new battery and vehicle concepts and therefore also for the other projects.

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3 Deviations from Annex 1

There are no deviations from Annex 1.

4 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 no.	Partner organisation name	Short Name
1	AVL List GmbH	AVL
2	Centro Richerche Fiat SCpA	CRF
3	FORD Otomotiv Sanayi Anonim sirketi	FO
4	Renault Trucks SAS	RT-SAS
5	AVL Software and Functions GmbH	AVL-SFR
6	Robert Bosch GmbH	Bosch
7	SIEMENS INDUSTRY SOFTWARE NV	SIE-NV
8	SIEMENS Industry Software SAS	SIE-SAS
9	Uniresearch BV	UNR
10	Valeo Equipements Electroniques Moteurs	Valeo
11	Commissariat à l'Energie Atomique et aux Energies Alternatives	CEA
12	LBF Fraunhofer	FhG-LBF
13	FH Joanneum Gesellschaft M.B.H.	FHJ
14	National Institute of Chemistry	NIC
15	University Ljubljana	UL
16	University Florence	UNIFI
17	University of Surrey	US
18	Das Virtuelle Fahrzeug Forschungsgesellschaft mbH	VIF
19	Vrije Universiteit Brussel	VUB

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