INCOBAT: 1st Periodic Report

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Project	INCOBAT	**Project Number**	608988

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Publishable Summary

In recent years, electric mobility has been promoted as the clean and cost-efficient alternative to combustion engines. Although there are already solutions on the market, mass take-up did not yet take place. There are different challenges that hinder this process from an end user point of view such as costs of the vehicle, driving range, or infrastructure support. Several of these challenges are directly connected to the battery, the central element of the full electric vehicle (FEV). The costs of the battery sum up to 40% of the total costs of a FEV, and the range of a FEV is strongly reduced in comparison to the combustion engine.

On 1st of October 2013, the research project INCOBAT started under the coordination of AVL List GmbH (Austria). The aim of INCOBAT is to provide innovative and cost efficient battery management systems for next generation HV-batteries. To that end, INCOBAT will propose a platform concept in order to achieve cost reduction, reduced complexity, increased reliability as well as flexibility and higher energy efficiency.

The consortium joins the partners AVL List GmbH, Ideas&Motion, Fraunhofer ENAS, Infineon Technologies AG and Austria AG, Impact Clean Power Technology S.A., Manz Italy Srl and Chemnitzer Werkstoffmechanik GmbH and is in the position to provide a 100% European value chain for the development of next generation HV battery management systems.

Objectives

The main objectives of the INCOBAT project are:

- Very tight control of the cell function leading to an increase of the driving range of the FEV by 30% for current chemistry and by a factor of 10 and more by enabling the use of new cell chemistries such as LiS or even Li-air
- Radical cost reduction of battery management system – factor of 10 (at least) with respect to current solutions
- Development of modular concepts for system architecture and partitioning, safety, security, reliability as well as verification and validation, thus enabling efficient integration into different vehicle platforms.

Approach

The INCOBAT project focuses on the following 12 technical innovations (TI) regrouped into four innovation groups (see **Figure 1**):

- Customer needs and integration aspects: ensures a correct identification of customer needs and enables an efficient integration into different platforms. This is supported by the use of mission profiles (TI-01) – in order to take into account the different driving styles of the customers, the

different traffic conditions in the same scenarios and the different tracks – and by the integration into a demonstrator vehicle (TI-12)

- Transversal innovation: consistent concept and specification: This second group targets the optimisation of the system architecture and its consistent description over the technologies and over the system hierarchies. This aspect aims at providing a consolidated basis in order to simplify later industrialization of the proposed technologies. This includes the TI-02 “Model-based systems engineering” to improve correctness / completeness / consistency of system specification, the TI-03 “System architecture - efficient partitioning of the functionalities” for system optimization at BMS or even vehicle level and the TI-04 “Integration of multiple functionalities” to reduce the number of electronic control units (and thus related costs) in the vehicle.
- Technology innovation: E/E control system: This third group aims at improving the components of the E/E control system. Regarding the electronic parts, it regroups TI-05 “TriCore AURIX Platform for additional computing resources” and the TI-06 “Smart and integrated module management unit”. From the software part, this is achieved by the TI-07 “Modular SW platform” and by TI-08 “Improved BMS control algorithms”
- Transversal innovation: improving system maturity: This last group targets the evidences related to the trust on the technical solutions with respect to correct operation (TI-10 Design and validation plan including reliability consideration), functional safety and security (TI-09 Definition and integration of safety and security concept) as well as reliability (TI-11 Reliability and robustness validation). This group of technical innovations is an indicator for the maturity of the proposed technology and further provides information on the efforts required for proper integration and validation of the system.

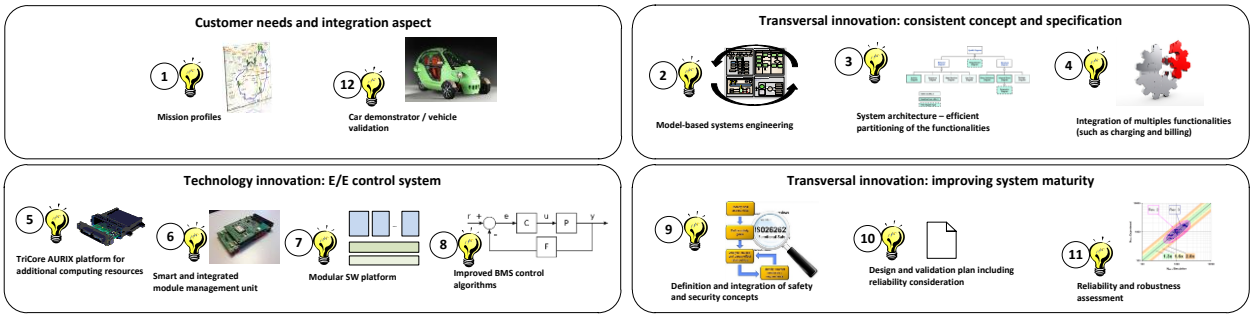

Figure 1: INCOBAT technical innovations

Achievements to date

The first project period (year 1) was focused on the milestone MS2: Architecture definition supported by simulation. Main efforts were allocated to WP1 System Design for Energy Efficiency, WP2 Control Strategy and SW as well as WP3 Battery Management Technology and Hardware in order to perform a systematic definition of the system and start component development where appropriate.

Following outcomes directly related to MS2 have been achieved during the first project year

- Identification of BMS targets and systematic refinement into functional and technical requirements by means of state of the art requirement engineering method. The requirements cover the BMS control system, the related control software and the electronic hardware. This work therefore strongly supports the harmonization and consolidation over the expertise boundaries.
- Definition of preliminary system architecture using a component-based approach based on SysML. This enables the partitioning of the system into different abstraction layers and the integration of different viewpoints such as structure, technical dependencies, safety & security aspects.
- Setup of a security-aware hazard analysis and risk assessment framework for the conjoint analysis of safety risk and safety threats.
- Definition of preliminary design and validation plan (DVP) consistent to the proposed system architecture. This consistency provides higher confidence of completeness of the test program with respect to the proposed architecture.
- Definition of methods for gathering mission profiles by tailoring the industry standard NEDC, FTP-75 and WLTP according to the three INCOBAT targets: benchmark of INCOBAT technology, tailoring and calibration of INCOBAT SoX algorithms, and robustness evaluation.
- Development of a simulation framework for the evaluation of battery state estimation algorithms based either on Electrochemical Impedance Spectroscopy (EIS) or on model-based estimation for SoC, SoF and SoH.
- Cell measurement campaign as input for the simulation framework and for the calibration of the battery state estimation.

Furthermore, following important achievements as preparation for MS3 (Lab Demonstration with beta sample) have been worked out during the first project period

- Introduction of multicore platform OIKOS implementing the AURIX CPU within the INCOBAT consortium: this deployment (including training workshop) strongly supported the training of the partners toward this new generation of computing platforms
- Enhancement of OIKOS platform for INCOBAT purposes: a new board generation has been developed according to the requirements from WP1 as input for the second project period
- First version of satellite boards was designed. This satellite boards have been reworked to improve the robustness against EMC.

Impact/expected impact

Over the years the E/E systems have steadily increased their value on the vehicle: the current estimate accounts for almost 30% of the entire vehicle costs. A foresight of the market in the next years shows the x-EV will exceed 10% of the total market share in 2020, leading the value of the semiconductor per car around 700 USD in 2020 (it was ~320 in 2008) with more than 5 million electrical vehicles. INCOBAT project targets to strengthen the European position in the worldwide market helping Europe in keeping the necessary know -how and in seizing the opportunities of the market by providing new and innovative platforms and solutions for the industrializations of the electrical vehicles, while curtailing the costs and improving the performances. Impacts of the INCOBAT project on the market position of Europe and on the objectives of the work program are the following:

- Improved energy efficiency and extended driving range of the FEV
- Increased performance and reduced costs of the electronic components and the overall FEV produced in Europe.
- Significant improvement of FEVs' safety and comfort
- Strengthened global competitiveness of the European automobile, ICT and battery sectors; market penetration of key components of FEVs.

Project Consortium:

Partner	**Country**
AVL List GmbH	Austria
Ideas&Motion	Italy
Fraunhofergesellschaft zur Förderung der angewandten Forschung E.V.	Germany
Infineon Technologies Austria AG	Austria
Infineon Technologies AG	Germany
Impact Clean Power Technology S.A.	PL
MANZ Italy SRL	Italy
Chemnitzer Werkstoffmechanik GmbH	Germany

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