iCOMPOSE Consortium – 9 partners from 6 countries

iCOMPOSE Hard Facts

PROJECT COORDINATION: VIRTUAL VEHICLE Research Center (Austria)
START: 1 October 2013
WEBSITE: www.i-compose.eu
DURATION: 38 months
NUMBER OF PARTICIPATING ORGANIZATIONS: 9
NUMBER OF PARTICIPATING COUNTRIES: 6

Successful final iCompose Meeting in Lommel

On the 30th of November 2016, the iCOMPOSE project closed the final project period successfully. Again, the review meeting took place in Lommel (Belgium) at Flanders MAKE facilities on the 13th of December. All active partners (Virtual Vehicle, University of Surrey, SKODA Auto, Flanders Make, Hutchinson, AVL List, Infineon Technologies, and Fraunhofer IVI) presented their contributions as well as the next steps towards exploitation and dissemination of all innovations developed throughout the project.

After a very heavy agenda packed with technical details in the morning, a short test drive around the Flanders Make building was scheduled showcasing the semi-autonomous driving of the Range Rover Evoque demonstrator vehicle featuring the novel control and processing algorithms implemented on the novel multi-core platform (iCEMCCU).

After a short transfer to Kristalpark, the Skoda Rapid demonstrator vehicle was presented demonstrating the modern HMI, as well as the 7 speed gear box.

Finally, the Range Rover Evoque demonstrated the progress made with respect to the vehicle dynamics controllers developed throughout Work Package 5 by University of Surrey together with Flanders Make in a series of tests:
* Obstacle avoidance with and without the vehicle slip control
* Obstacle avoidance with and without the novel hitch angle control
* Swaying test with and without the hitch angle control

After a short closed discussion, the Project Officer announced the results and congratulated all participants to the successful project.

Main S&T results/foreground of the project

The S&T results of iCOMPOSE can be analysed according to the main areas of potential technological impact and innovation:

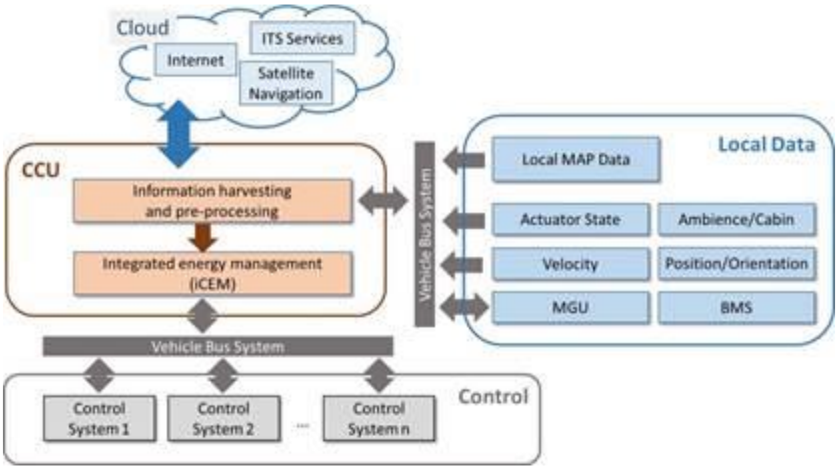
a) **Control system architecture** for (fully) electric vehicles on the AURIX hardware platform of Infineon;
b) **Comprehensive management of energy and thermal systems** to increase safety and fun-to-drive with decreased energy consumption;
c) Adoption of **cloud-sourced information for enhanced vehicle efficiency** for semi-autonomous driving;
d) Enhanced **energy storage unit management** by deploying a model-predictive controller for the DMES system.

The **technological impacts were experimentally demonstrated on the vehicle demonstrators** which were equipped with the multi-**core computing platform AURIX.**

The main output is:

iCEM CCU Design and Hardware – INFINEON TECHNOLOGIES AG (HOLGER SCHMIDT)

In the scope of the iCOMPOSE project the integrated control system architecture has been introduced for comprehensive energy management and vehicle dynamics control. It demands for a CCU as an extension to the established concept of single domain controllers such as motor control, battery management or HVAC control.



Model-based functional safety engineering – FLANDERS MAKE VZW (WOUTER DE NIJS)

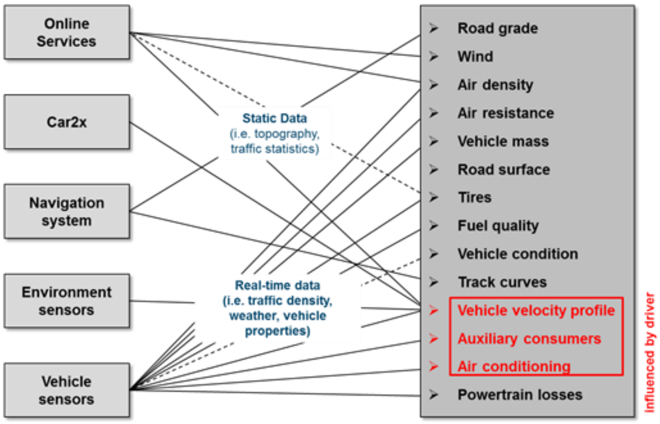
Functional, operational and environmental requirements were collected and the boundaries of iCEM system together with its preliminary architecture were determined. Safety Goals (SG) were identified with the help of HARA and they were captured in the SysML model with the help of dedicated extension.

The Software implementation on the iCEM CCU – VIRTUAL VEHICLE (MATTHIAS K. SCHARRER)

Meeting cost and integration requirements, the development environment is required to be a low-cost solution with the possibilities to integrate software components from other partners. The fundamental configuration of the software development comprises a set of Makefile generation rules, optimised GNU C libraries and settings embedded into the HighTec compiler toolchain

Cloud-sourced information – VIRTUAL VEHICLE ([MATTHIAS K. SCHARRER])

Cloud-sourced information directly affects the comprehensive energy management of the FEV (i.e., the control reference for the actuators) and is also adopted for the generation of the speed profile for vehicle semi-autonomous driving.



Comprehensive energy management HMI – SKODA AUTO ([PAVEL NEDOMA])

The HMI proposed by SKODA development platform is based on industrial embedded system with interface for Controller Area Network (CAN), external visualization unit and inertial sensors (three axis acceleration sensor, single wheel velocity sensor, steering wheel angle sensor etc.) Recorded data can be on-line visualized or post-processed analysed.
The system is designed to minimize the user's manipulation and to enable permanent connection to the vehicle network. The semi-automatic driving style is used to compare different HMI concepts and vehicle assistant systems with minimum influence of driver inputs.

Optimal gear box shifting – SKODA AUTO ([PAVEL NEDOMA])

For an electric engine it is not possible to design a shifting map the same as for a combustion engine, because of its behaviour. But it is necessary to consider engine efficiency and power for various engine speeds and loads.
Consider the engine load only affected by a throttle position (driver command) and the engine speed as a function of the vehicle speed and selected gear ratio. With these conditions it is possible to calculate the shifting points to keep a higher engine efficiency or vehicle dynamics.

Energy-Efficient Vehicle Control – UNIVERSITY OF SURREY (ALDO SORNIOTTI)

The theoretical and experimental analysis of iCOMPOSE has led to the following conclusions:

- The energy-efficient CA algorithms bring energy savings typically between 2% and 3% along driving cycles with respect to fixed torque distribution strategies.
- In the measured cornering conditions, the energy-efficient CA allows energy consumption reductions of ~4% with respect to the ED mode.
- With a proper tuning of the reference cornering response, it is possible to obtain significant energy savings (higher than the savings obtainable with the CA) with respect to the passive vehicle. In particular, the optimal understeer characteristic brings measured input power reductions of up to ~11% for the case study vehicle demonstrator.
- The optimal understeer characteristic in terms of energy efficiency is close to the condition of neutral steering for the specific electric vehicle.
- For a given value of lateral acceleration, the pattern of the power loss variation as a function of the reference yaw moment is characterized by a relatively symmetric behavior, even if the absolute minimum is always achieved for destabilizing yaw moments.

Torque-vectoring controllers for variable tyre-road friction conditions – UNIV. OF SURREY (ALDO SORNIOTTI)

In the context of concurrent yaw rate and sideslip control through torque-vectoring, the main points of novelty of the iCOMPOSE study are:

- A SISO (single-input single-output) formulation, based on continuous control of the only yaw rate, and the variation of the reference yaw rate when sideslip angle exceeds pre-defined thresholds. This set-up ensures very simple control system design, and can be associated with any SISO control structure, e.g., based on proportional integral control, sliding mode control, or $H\infty$ control.
- The analysis of the effect of different locations of the control point used for the computation of the sideslip contribution.
- The experimental demonstration of the proposed controllers along manoeuvres with quickly variable tire-road friction coefficient.
- The analysis of the performance benefit achievable by continuous torque-vectoring through the electric drivetrains, rather than direct yaw moment control exclusively actuated in emergency conditions through the friction brakes.
- The development and experimental testing of a torque-vectoring control function for the case study electric vehicle towing a trailer, in order to reduce the hitch angle oscillations.

State estimators – VIRTUAL VEHICLE (MATTHIAS K. SCHARRER)

Because of several error sources and other influences, the accuracy of GPS only based position estimation is limited or the signal may be blocked completely. Sensor fusion techniques are used to achieve better accuracy and to increase reliability. Two variants were implemented: i) A strapdown algorithm using 3 gyroscopes, 3 accelerometers (6 DOF-Sensor) and one wheel-speed sensor and ii) A reduced inertial sensor system using 1 gyroscope, 2 accelerometers and one wheel-speed sensor.

Semi-autonomous driving: – FLANDERS MAKE VZW (WOUTER DE NIJS)

Semi-autonomous driving is implemented as a speed reference tracking algorithm. The speed reference is computed offline using an optimization approach to minimize energy consumption. Various model-based control methods for tracking the speed reference were designed and implemented on hardware: a novel exponentially stabilizing gain scheduling proportional-integral controller (gs-PI), a state-of-the-art offset-free explicit model predictive controller with preview (e-MPC) and a non-linear MPC approach. The first two controllers were validated experimentally with an electric vehicle demonstrator on a 4-wheel-drive rolling road and on the test track at the Ford Lommel Proving Ground.

Holistic thermal management – AVL LIST GMBH (DAMIR HORVAT)

The thermal management is implemented on the centralized multicore computing unit.
The obvious aim, therefore, is the development and implementation of a resource-friendly model predictive controller for all thermal functionalities. On the basis of a specially developed library of cooling and air-conditioning components, a simulation environment which includes the DMES for the development and testing of the controller was built. In the process, three different system configurations were explicitly analysed using the LOTUS Evora 414E in order to reference the controller in compliance with current development trends.

Supercapacitor pack – HUTCHINSON SA (MARC ZIMMERMANN)

Hutchinson is developing innovative supercapacitors based on aqueous electrolytes. Those systems allies high power performances together with overall enhanced safety behaviour as compared to classical supercapacitors, which are of very high interest for applications as energy storage systems for transportation. In order to demonstrate the interest for a dual energy storage system, a 72 cells supercapacitor pack has been developed using commercial cells.

Energy storage unit management – FRAUNHOFER IVI (RICHARD KRATZING)

Combining lithium-ion batteries with supercapacitors within the storage systems of electric and hybrid vehicles is a way to fulfil the demand for both a high energy content and a high power level. In addition, it is possible to avoid power peaks within the lithium-ion batteries, which leads to a significantly increased lifetime. In order to fully exploit this potential, it is necessary to achieve optimal control of the power distribution between the two storage components.
For this purpose, a predictive control strategy is developed that uses a short-term prediction of the vehicle’s expected power demand to calculate the current setpoint for the supercapacitors in real-time. In order to accurately follow that setpoint a highly dynamic DC/DC converter is developed.

Thank you to the Consortium!

Dear **iCOMPOSE partners**,
our project finished successfully. Therefore, we want thank you for your great work, efforts and cooperation. We hope to work with you again in future projects!
Your iCOMPOSE Coordination Team

iCOMPOSE is a project under the Seventh Framework Programme of the European Commission