Optimal Energy Consumption and Recovery Based on a system network

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Project fact sheet

- **Duration:** 36 months, from May 2011 to April 2014

- **Total Budget:** 7.74 million Euros
- **Project funding:** 4.40 million Euros

- **Contract type:** Small or medium scale focused research project (STREP)
- **Funding scheme:** Collaborative project

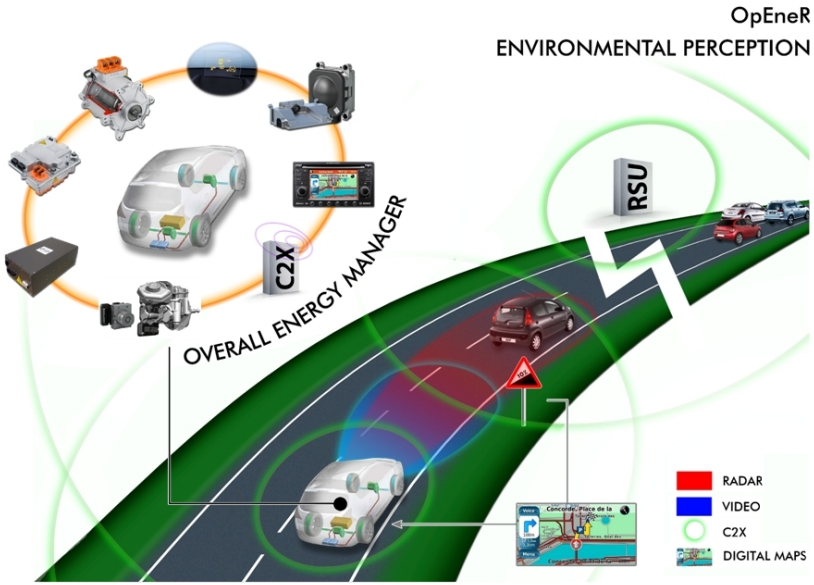
- **Project officer:** Marc Boukerche, Research Programme Officer, EC - CONNECT/A4

- **OpEneR Website:** www.fp7-opener.eu

Project summary in a nutshell

Target: significantly increase the efficiency, driving range, and safety of electric vehicles

Energy Manager: merging data from on-board and off-board sources



optimal cooperation between electric drivetrain and regenerative braking system

new driving strategies and driver assistance systems

supporting external information from radar, video, satellite navigation, car-to-infrastructure and car-to-car systems

Project partners

Partner	Contact	
Robert Bosch GmbH (Germany, Project Coordinator)	Kosmas Knödler	BOSCH Invented for life
Peugeot Citroën Automobiles S.A. (France)	Sylvain Laversanne	PSA PEUGEOT CITROËN
Robert Bosch Car Multimedia GmbH (Germany)	Andreas Engelsberg	BOSCH Invented for life
AVL List GmbH (Austria)	Stephen Jones	AVL
Centro Tecnológico de Automoción de Galicia (Spain)	David Sanchez	CTAG Centro Tecnológico de Automoción de Galicia
FZI Forschungszentrum Informatik (Germany)	Alexander Viehl	FZI

- Coordinator, regenerative and vacuum free braking system, radar and video systems for surround sensing
- Two fully electric vehicles Peugeot 3008 with one e-machine per axle
- Satellite navigation system with 3D map information and eco routing
- Powertrain and overall vehicle simulation
- HMI, car-to-infrastructure and car-to-car communication
- Virtual HW-simulation, use cases and requirement management, and energy management system

Project objectives

Hypothesis: vehicle electrification will contribute significantly to the further reduction of vehicle fleet CO2 emissions

Challenge: limited electric driving range, high battery price, and long charging times are major impediments to market acceptance

OpEneR objectives

- unlock market for FEV by **significantly increasing driving range** without higher battery size, and by limiting battery price and charging time
- reduce "range anxiety" of drivers through **realization of longer, more consistent, predictable and clearly displayed remaining driving range**
- merge data from diverse range of on-board and off-board sources to **provide timely and effective driver guidance through enhanced vehicle dashboard displays**
- **develop advanced support system** that allow drivers to consistently adapt their route and driving style in order to achieve best energy efficiency and thus driving range
- provide **advanced and fully integrated driver support**, based on a networked architecture
- **improve safety** by sophisticated and integrated vehicle stability controller with enhanced environmental sensing

Project results: demonstration in two fully operational FEV under real world conditions

Exploitation potential

innovative and highly efficient overall energy manager as coordinator of subsystems that provide additional information and functionalities

high level regenerative braking system with vacuum free brake booster

optimised deceleration profiles for best energy recuperation

advanced/intuitive HMI display supports/ encourages drivers to control the vehicle energy optimized, comfortable and safe

map based range estimation for FEV

active safety systems and Eco-Driving

functional safety concepts for system network architecture

advanced simulation tools for virtual development and validation of energy management, safety and HMI

coupling of **ADAS & FEV**

usage of radar sensor technology for **monitoring vehicle surroundings** and definition of smooth driving strategies

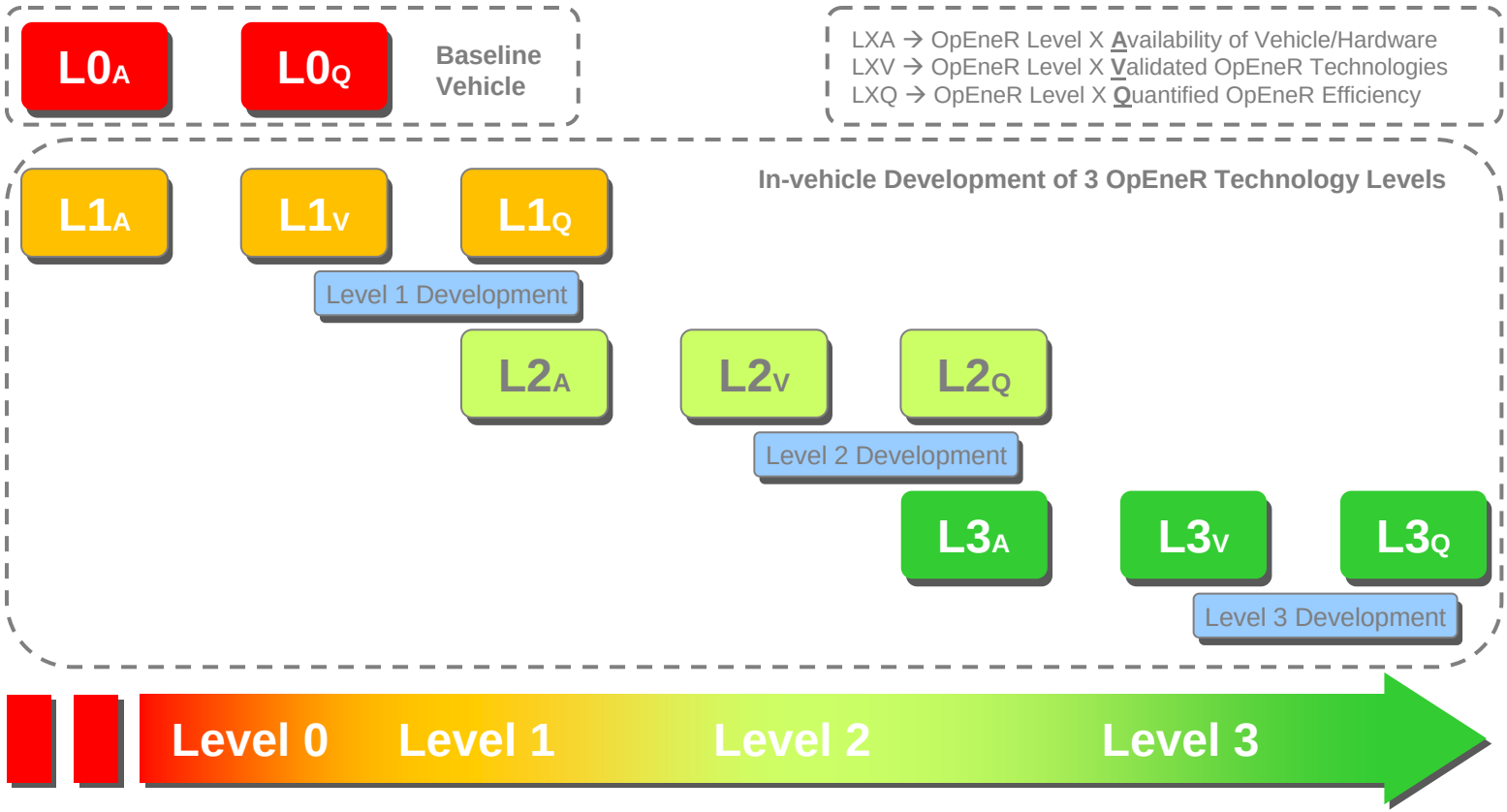
video camera based corridor planning, lane keeping support, **road sign recognition and object detection**

Major technological challenges: high level integrated approach with many communication lines and high data traffic, sophisticated operation strategies, driver acceptance

OpEneR Technology Levels

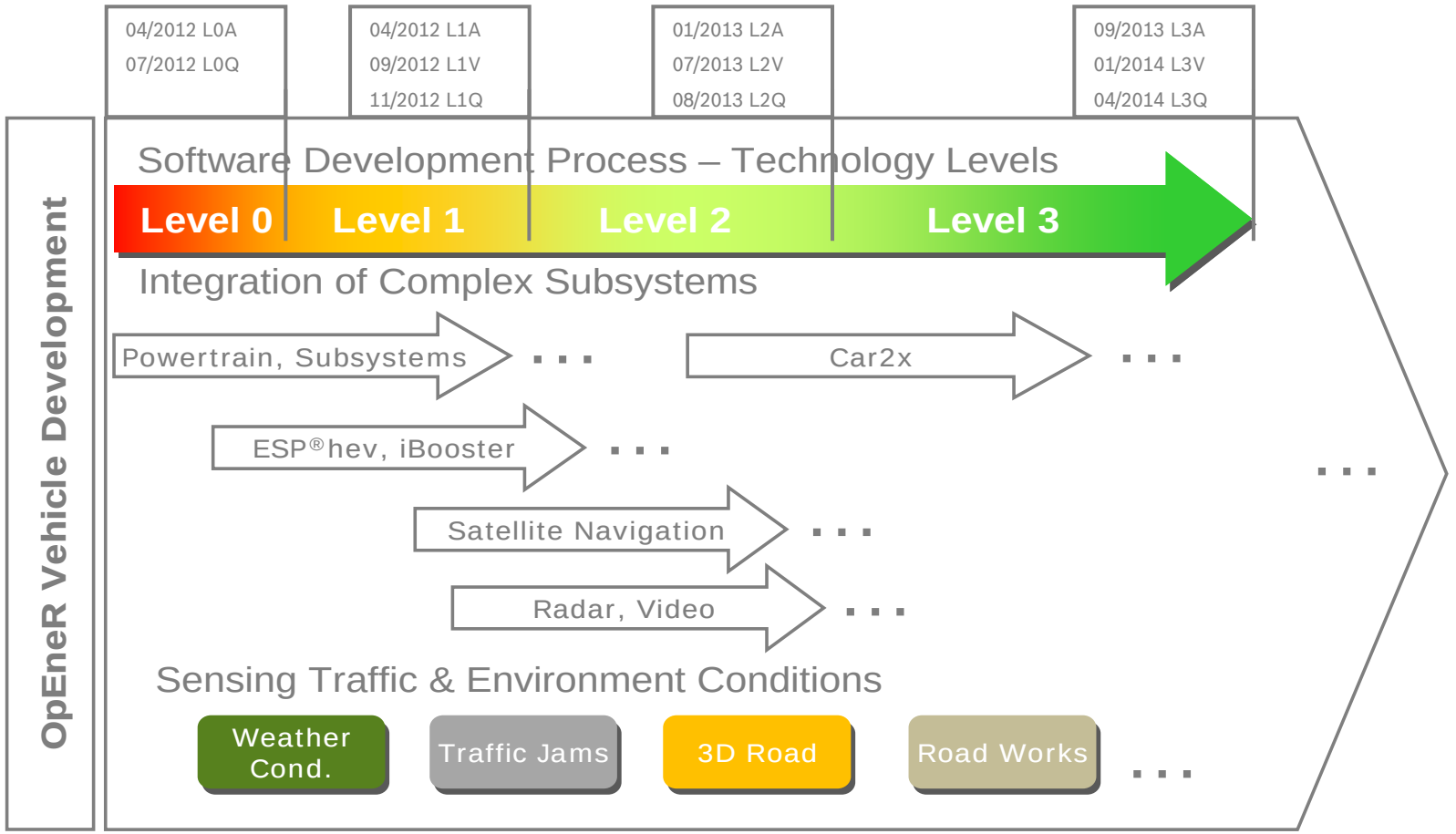
Project challenge: highly complex network of on-board and off-board systems

Approach: assure success by three-stage system integration



Project timeline

LXA → OpEneR Level X **A**vailability of Vehicle/Hardware
LXV → OpEneR Level X **V**alidated OpEneR Technologies
LXQ → OpEneR Level X **Q**uantified OpEneR Efficiency

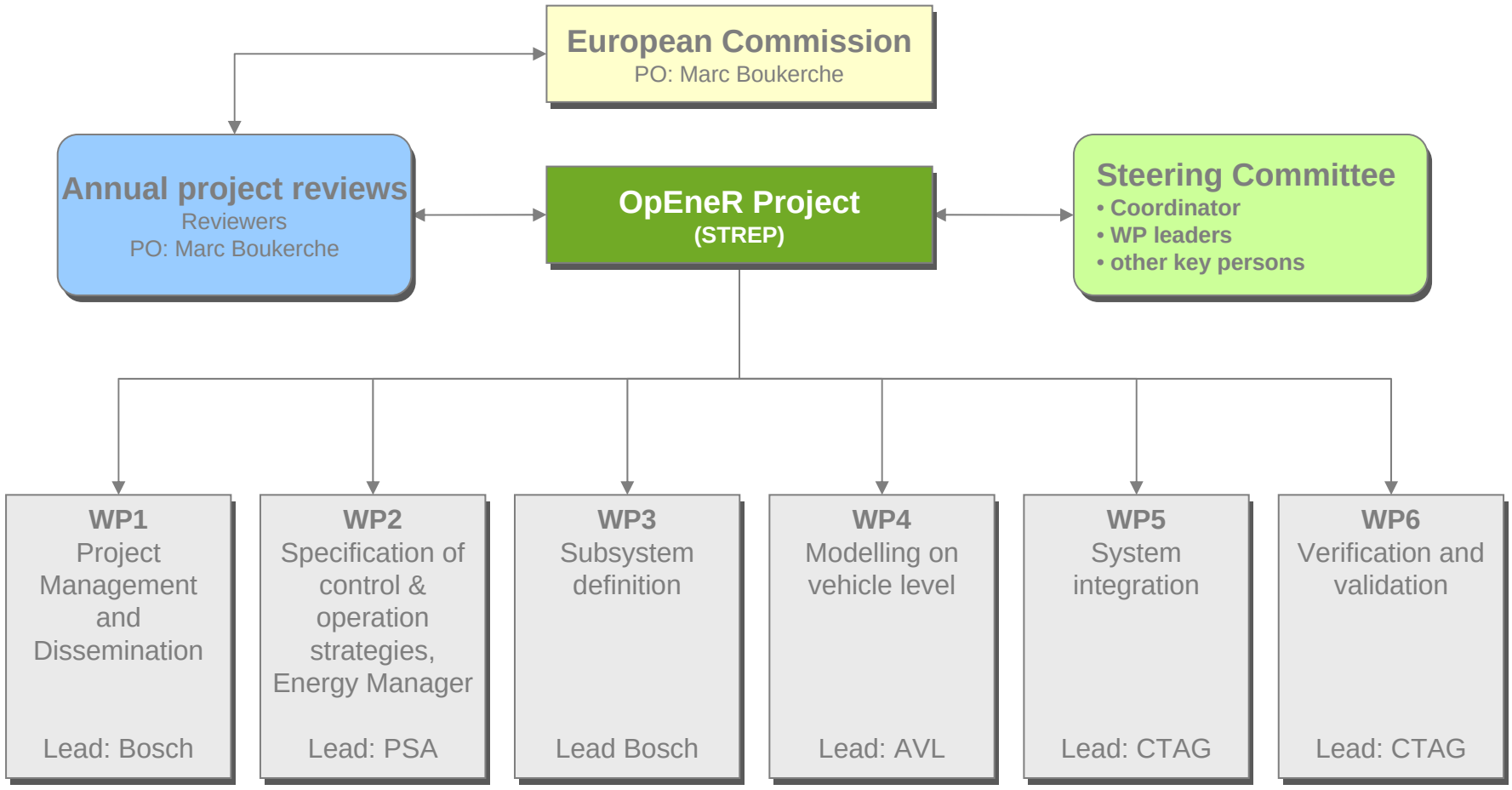


Workpackage structure

STREP OpEneR

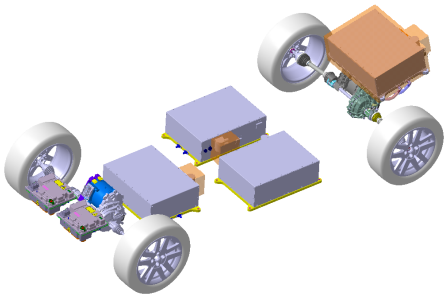
WP1 - Project Management and Dissemination	WP2 - Specification of control & operation strategies, Energy Manager	WP3 - Subsystem definition	WP4 - Modelling on vehicle level	WP5 - System integration	WP6 - Verification and validation
1.1 - Overall management	2.1 - Vehicle specification and base prototype delivery	3.1 - Definition of E/E-architecture and subsystems network topology	4.1 - Evaluation of existing vehicle simulation environments	5.1 - HMI definition and development	6,1 - C2I corridor preparation and adaptation
1.2 - Financial management	2.2 - Concept of system topology on vehicle level including all new subsystems	3.2 - Specification and adaptation of subsystems	4.2 - Simulation environment development	5.2 - OpEneR systems in vehicle integration	6.2 - Test methodology and test plan definition
1.3 - Steering Committee	2.3 - Design, dimensioning, and simulation of vehicle concept	3.3 - Specification of communication lines and communication data identification	4.3 - Definition and assessment of a metrics	5.3 - Subsystem assessment	6.3 - OpEneR pilot testing and final testing
1.4 - Dissemination and exploitation	2.4 - Control and operation strategies with respect to safety, comfort and efficiency	3.4 - Definition of individual subsystem release test	4.4 - Setup/ calibration/validation of the FEV simulation model		6.4 - Analysis and verification of test results
1.5 - Link to other projects (liaison)		3.5 - Base calibration of subsystems and network			
1.6 - Legal issues					

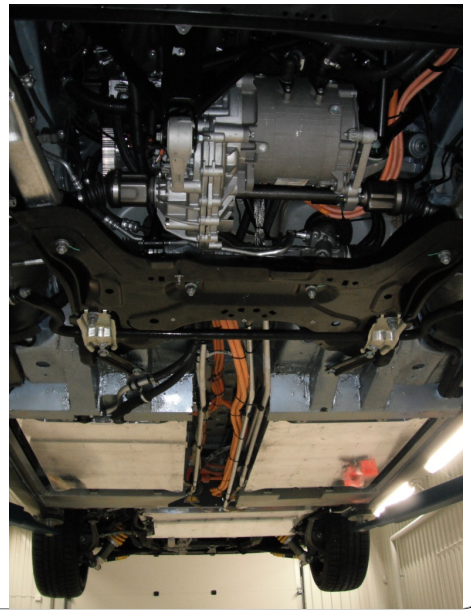
Organization and steering instruments

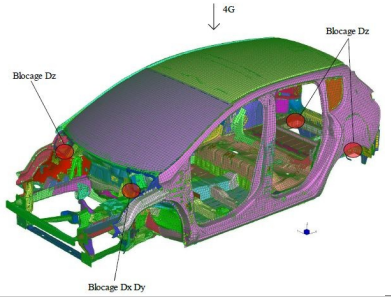


Integration of OpEneR Level 0/1

- **In common for both prototypes**
  - 2 e-machines + 2 double inverters integrated
  - 4 battery packs integrated
  - Electric Heating and A/C integrated
  - Thermal management for all drivetrain components integrated
  - dSpace MicroAutobox integrated as VCU
  - First torque controller (early energy manager) software running

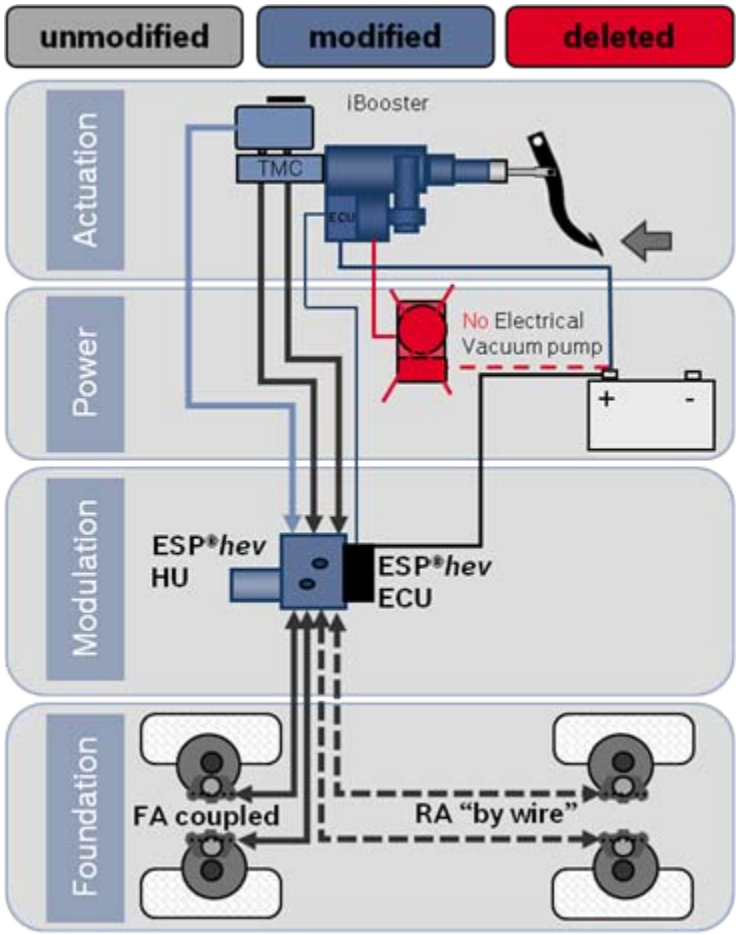






Integration of OpEneR Level 0/1

- **OpEneR Prototype n°1**
  - II brake circuit distribution (black-and-white)
  - Electromechanical brake force amplifier *iBooster* integrated
  - Regenerative braking System *ESP®hev* integrated
  - no surround sensing sensors integrated (E/E-architecture prepared)
  - no SatNav system integrated (E/E-architecture prepared)
  - original HMI still exists



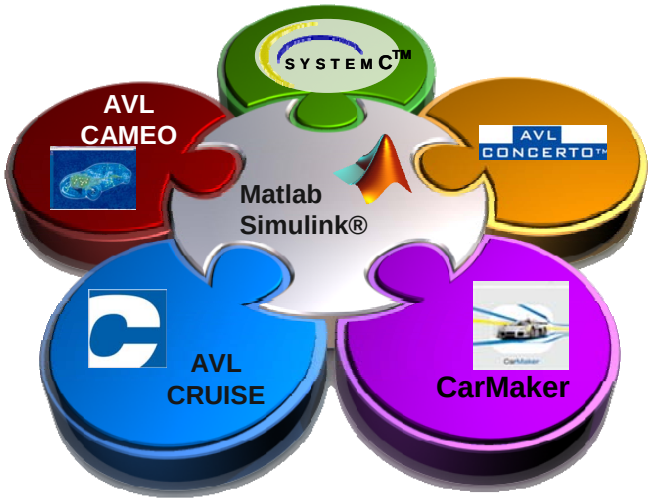
Integration of OpEneR Level 0/1

- **OpEneR Prototype n°2**
  - X brake circuit distribution still exists
  - vacuum pump and pneumatic brake force amplifier still exists
  - ESP8.1 without torque blending still exists
  - no surround sensing sensors integrated
  - no SatNav system integrated
  - New OpEneR HMI integrated

Integration of OpEneR Level 0/1

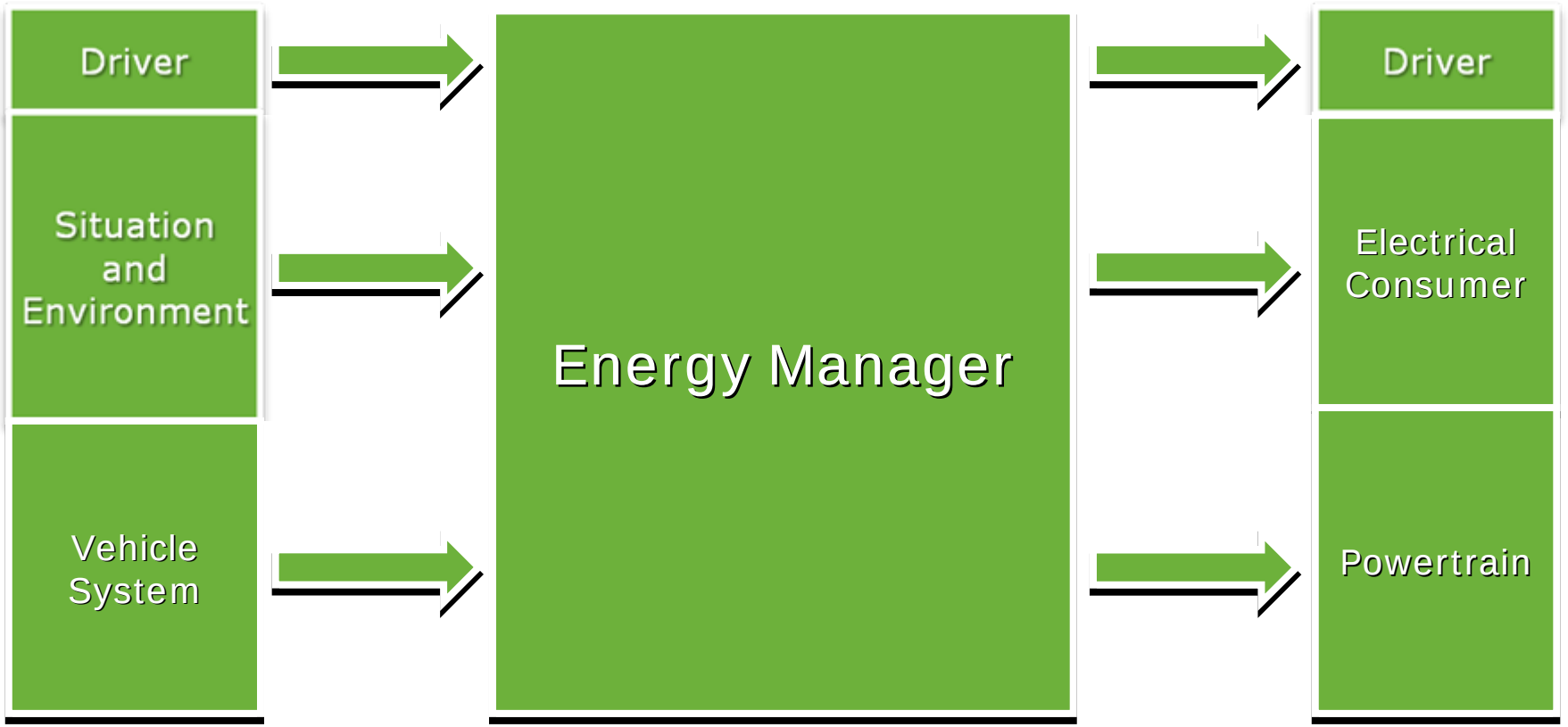
- **Scenarios, use case, requirements**

- **Simulation Toolchain**
  - Setting up toolchain for supporting OpEneR development process
  - Development of appropriate simulation tools
  - Integration of tools through correct interfaces
  - Enhanced MiL / SiL platform
  - Parallelization of testing & software validation processes



Integration of OpEneR Level 0/1

- **Energy Manager**



Integration of OpEneR Level 0/1

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Thanks for your attention