



Compact, smart and reliable drive unit for  
commercial electric vehicles



**-COSIVU-**

**Clustering event Brussels  
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**Proposal :** 313980

**Acronym :** COSIVU

**Program :** GC.ICT.2012.6-8: - PPP GC: ICT for fully electric vehicles

**Call :** FP7-2012-ICT-GC

**Funding scheme :** Small or medium-scale focused research project –STREP – CP-FP-INFOS

**Duration :** 36 months

# Outline

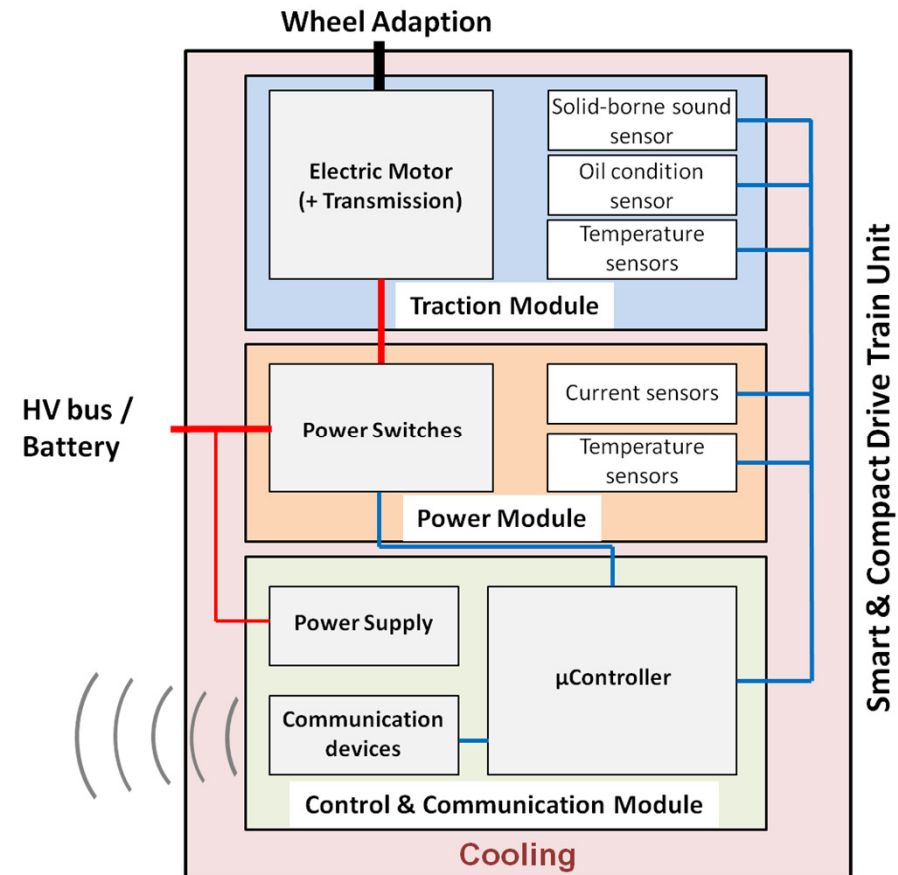
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- I. Project Objectives
- II. Project partners & their main roles
- III. Major technological challenges and technological approach,
- IV. Expected Impact and Exploitation potential
- V. Topics that may benefit from cooperation within the cluster










# I. Project Objectives

## Development of a Compact & Smart Drive for Commercial Electric Vehicles:

- Substitution of the central drive train by **compact and smart drives attached to the individual wheels** coordinated and controlled by a central computer and wireless communication
- **One system package** for the wheel motor, its simple transmission, and the inverter modules
- Sensors, signal conditioning, microcontroller, and software for **Functional and Health Monitoring** of the motor/transmission and the inverters
- **Closed loop control** based on the sensor signals - at three stages: local (= within the smart drive unit), global short-time and long term (employing the central computer and wireless bi-directional communication)

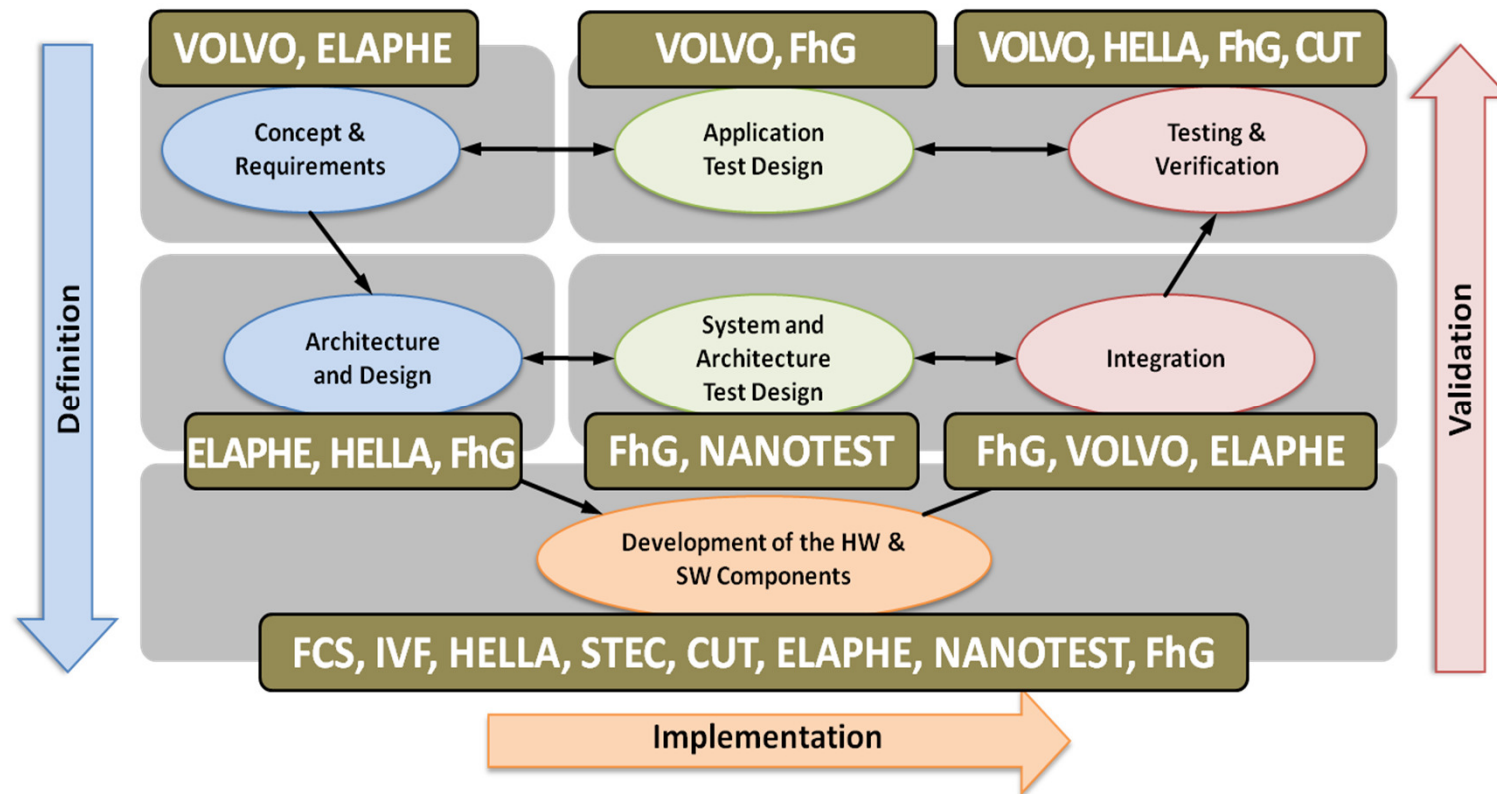


## II. Overview project partners & their main roles

|   |   |
|---|---|
|    | Project coordination. Novel heat removal solutions – technology and material development,   |
|    | Definition of Requirements, providing of In-Wheel motor, functional testing of developed demonstrator   |
|    | 1200 V SiC bipolar junction transistors and SiC-based Power modules   |
|    | Health monitoring (solid-borne sound sensor, oil condition sensor), $\mu$ Controller programming  |
|    | Current sensors (anisotropic magnetoresistive - AMR effect)   |
|    | Overall system integration & optimization (design, prototyping, testing, ...), transfer of COSIVU architecture to an alternative direct drive electric motor version for other vehicle platforms                      |
|   | Material characterization (for FE-Simulations), thermal characterization, failure analyses  |
|  | <u>ENAS</u> : Electrical & thermo-mechanical reliability assessment, in co-operation with Chemnitz University (e.g. power cycling)<br><u>IISB</u> : Power module system integration, development of gate driver stage |
|  | Functional & health monitoring based on thermal impedance spectroscopy and current sensing + $dv/dt$ flank control  |

## II. Overview project partners & their main roles

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# III. Major technological challenges and technological approach,

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**The Project COSIVU aims to develop a new architecture of smart drive units for commercial vehicles, which will be based on the following building blocks:**

- Next generation type of VOLVO traction system. Not one central but individual wheel motors: heavy duty / yet light weight solution due to integrating a low volume (= low mass) motor with a single transmission stage
- Near wheel version of ELAPHE high torque direct drive motor technology without any transmission and its application in passenger car with the COSIVU sensor system
- Sensor systems, for functional and health monitoring of the
  - mechatronic unit based on structure-borne sound analysis and oil conditioning analysis,
  - smart system based on thermal impedance spectroscopy
- Motor control by a novel, very compact smart system consisting of the following hardware components:
  - Power stage (1200V / 500 A) based on SiC devices (<- first known system in this power range worldwide / new control architecture needed)
  - Control module (for motor control, sensors, ...)
  - Sensor, signal operation, and redundant wired/wireless communication modules all directly integrated into the mechatronic unit
- Novel cooling concept for the smart system (its power stage) and for the direct drive motor solution for passenger cars

# III. Major technological challenges and technological approach,

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The new architecture provides the following extended functionalities:

- **Fast and very flexible response of the traction system** to any service condition – much more flexible than with one central motor unit
- **Motor control features** implemented in the smart system:
  - local stage:
    - Short term response for efficiency improvements
    - Fast response to avoid critical situations
    - Optimization of the recuperative braking
  - global stage
    - Balancing between the individual drives (increasing energy efficiency and safety),
    - (Prognostic) risk factor exclusion or minimization,
    - Fatigue and failure avoidance
- **Fail safe system** approach by e.g. enabling fast response torque coupling due to a redundant and direct communication link (in addition to the main communication link between the smart system and the central unit)
- **A wireless communication** will be considered as first choice,
- The architecture is demonstrated by implementing new product design and test strategies (DfX)

## IV. Expected impacts and Exploitation Potential

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### **Improved energy efficiency and extended driving range of the FEV:**

- **Weight reduction due to advanced drive-train topology:**

⇒ by replacing one central motor, the large & heavy transmission, and the extensive engine cooling system by low weight & compact smart drives at each individual wheel of the vehicle with no mechanical (differential) transmissions between the wheels

- **Weight reduction due to compact design of drive-train unit:**

⇒ by the mechatronic integration of the electric motor, the transmission and the power electronics into one system package

- **Weight reduction and increased efficiency due to the usage of novel SiC components:**

⇒ reduced switching losses in the transistors, freewheeling diodes, electric machine (higher switching frequencies) ⇒ reduced cooling effort! (weight, costs, ...)

- **Weight reduction and increased efficiency due to improved switching control and advanced functional monitoring:**

⇒ optimized and energy efficient inverter usage for all operation conditions and modes at all time; reduced EMC emission due to dv/dt flank control ⇒ possible downsizing of EMC filters (and thus costs)



## IV. Expected impacts and Exploitation Potential

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### Reduced costs of the electronic components and the overall FEV at increased performance:

- Replacement of complex and expensive mechanical transmission parts by ICT solutions
- Mechatronic integration => less cable, connectors, housings etc.
- SiC components offers much saving potential (cooling, chip area..)
- Reduction of repairing and maintenance costs due to the health monitoring of critical components (increase of uptime)
  - ⇒ Reduction of the **cost-of-ownership** can be realized by lifetime and reliability improvements
  - ⇒ **Extended driving range** due to increased energy efficiency

## IV. Expected impacts and Exploitation Potential

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### **Significant improvement of FEV's safety, comfort and new information and comfort services for FEV users:**

- Safety improvements by real-time closed loop control based on functional and health monitoring:
  - Solid-borne sound sensor: (functional + health status of traction module)
    - Functional Monitoring: determine status of the motor(& gear) such as cold/hot, high/low speed, full-load/no-load → in order to be able to keep the motor in optimal operational conditions in all modes of operation / under all circumstances
      - ⇒ increased energy efficiency, increased lifetime
    - Health Monitoring: long term state of health
      - ⇒ risk detection and failure avoidance → maximum 'up-time'
  - Oil condition sensor (supplementary option): (functional + health status of traction module)
    - ⇒ measurement of critical oil parameters like of viscosity, temperature
    - ⇒ e.g. to get knowledge about next date for service/oil change

## IV. Expected impacts and Exploitation Potential

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### **Significant improvement of FEV's safety, comfort and new information and comfort services for FEV users:**

- Current Sensor: functional status of the power electronics by using of highly advanced anisotropic magnetoresistive (AMR) sensors
- Thermal impedance spectroscopy during operation: health status of the power electronics
- Compact wheel drive train system of very small volume  $\Rightarrow$  more space available without changing the vehicle type  $\Rightarrow$  increase in passenger space (comfort) and/or safety zone of the vehicle
- The occurrence of dangerous situations can be eliminated by electronics (instead of mechanical safety features)  $\Rightarrow$  Total weight and thus emission of GHG will be reduced

## IV. Expected impacts and Exploitation Potential

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### **Strengthened global competitiveness of the European automobile, ICT and battery sectors. Market penetration of key components of FEVs:**

- Besides the energy storage system, the drive-train unit is the main part of an EV, whereby costs, durability, cooling architecture, energy efficiency, and safety are still key issues to be improved
  - ⇒ COSIVU will address these issues by combining new drive-train architecture with advanced information and communication technologies
- Application of COSIVU concept & architecture on fully electrical commercial vehicle (Volvo) as well as on passenger cars (Elaphe)
  - ⇒ Enabling of higher market penetration
- High re-use potential of COSIVU key parts like 1200V SoC power stage or the functional and health monitoring models, e.g. for V2G concepts

## **V. Topics that may benefit from cooperation within the cluster**

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- SiC power electronics
- Smart System Integration
- Commercial vehicle electrification
- Transfer of technology from commercial to passenger vehicles
- IPR issues, lessons learned,
  - Transfer of Ownership?
- The project will start 1 October 2012. More will follow at the next clustering event.

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**Thank you for your attention!**