ARTEMIS JOINT UNDERTAKING
The public private partnership for R&D in the field of ARTEMIS

POLLUX

EPoSS
European Technology Platform on Smart Systems Integration

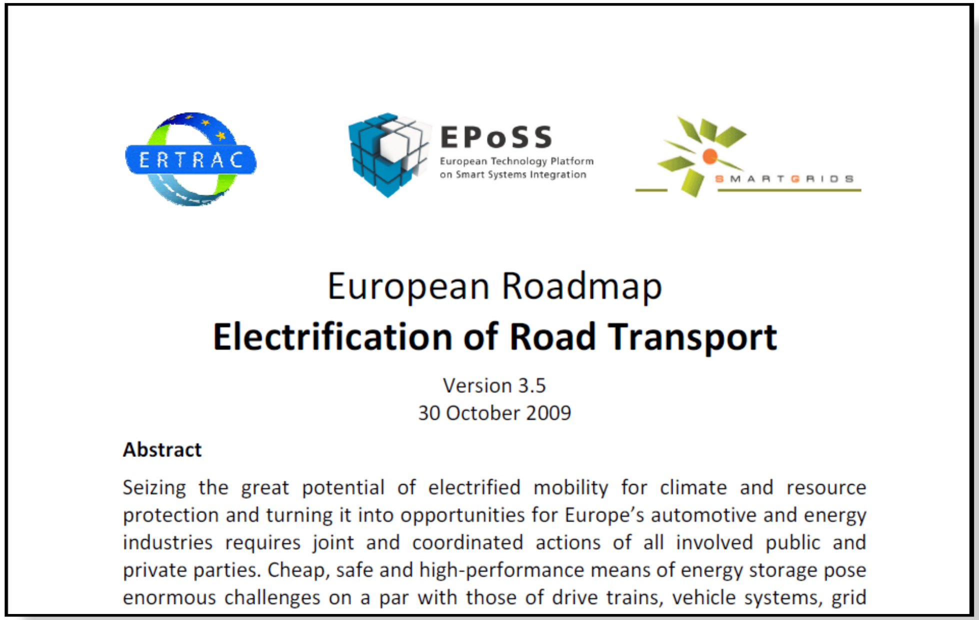
CRF CENTRO RICERCHE FIAT

EV Architectures from level 0 to level 1 and beyond

Marco Ottella
Project Coordinator

Process Oriented eLectronic controL Units for Electric Vehicles Developed on a Multi-System Real-Time Embedded Platform

Motivations


European Roadmap

Electrification of Road Transport

Version 3.5

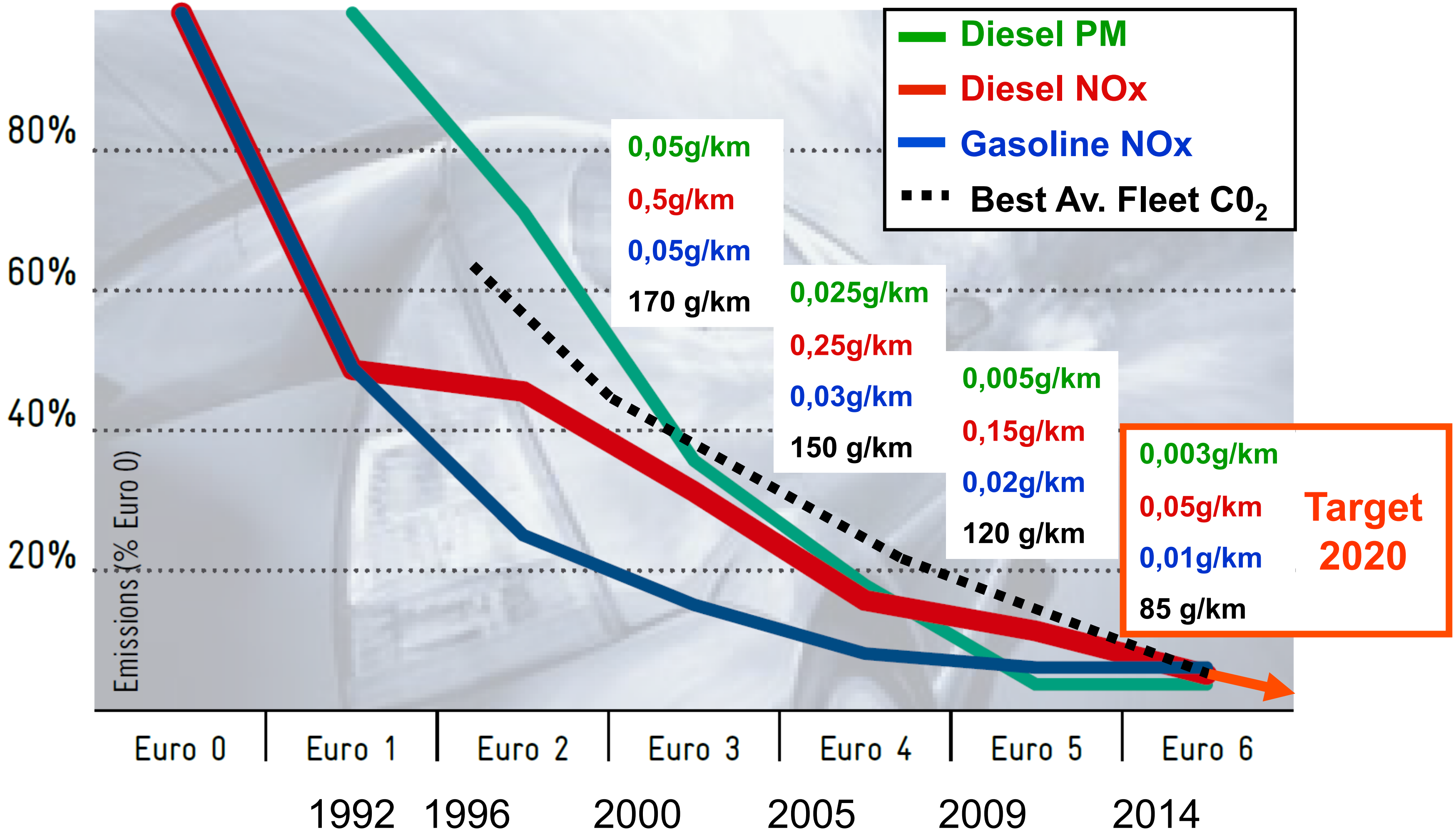
30 October 2009

Abstract

Seizing the great potential of electrified mobility for climate and resource protection and turning it into opportunities for Europe's automotive and energy industries requires joint and coordinated actions of all involved public and private parties. Cheap, safe and high-performance means of energy storage pose enormous challenges on a par with those of drive trains, vehicle systems, grid

- **Primary energy savings** (aiming at energy security)
- **Cut of GHG Emissions** (preventing climante change)
- **Reduction of noxious** emissions (raising public health)
- **Range and speed** (freedom of mobility and the need of fuels)
- **Cost of technology and constraints on raw materials** (EU security)

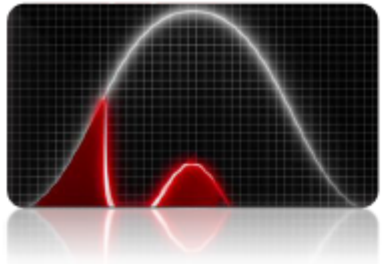
Evolution of powertrain Technologies



Source ACEA " Car, Trucks & the environment", dec 2009

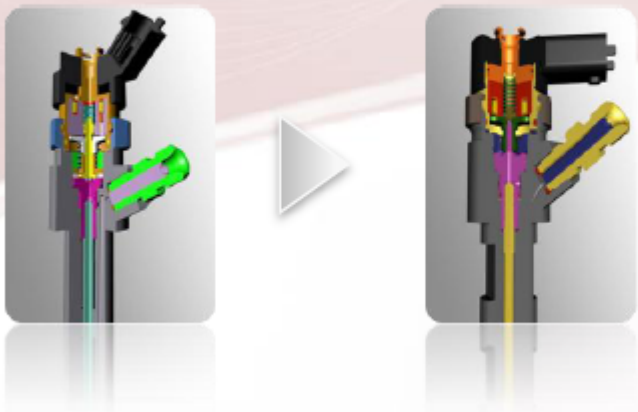
Technologies for the CO^2 reduction of ICE
Gasoline and Diesel

- **New breed of technologies to achieve CO_2 reduction in combustion engines**
  - 2nd generation MultiAir technology
  - In-house development of advanced turbo-charging systems
  - MultiAir coupled with GDI technology



- **Extension of MultiAir technology to diesel engines** combined with new IP in EGR control functionality

Innovative MultiJet II servo-valve



Multijet | **Multijet II**

Full deployment of MultiJet II

- Digital injection rate shaping bringing
  - Up to 3% lower CO_2 emissions
  - Up to 20% lower NO_x emissions
- Greater accuracy in fuel injection quantity control
  - Noise and driveability improvement

Source: Alfredo Altavilla – Fiat Powertrain Technologies

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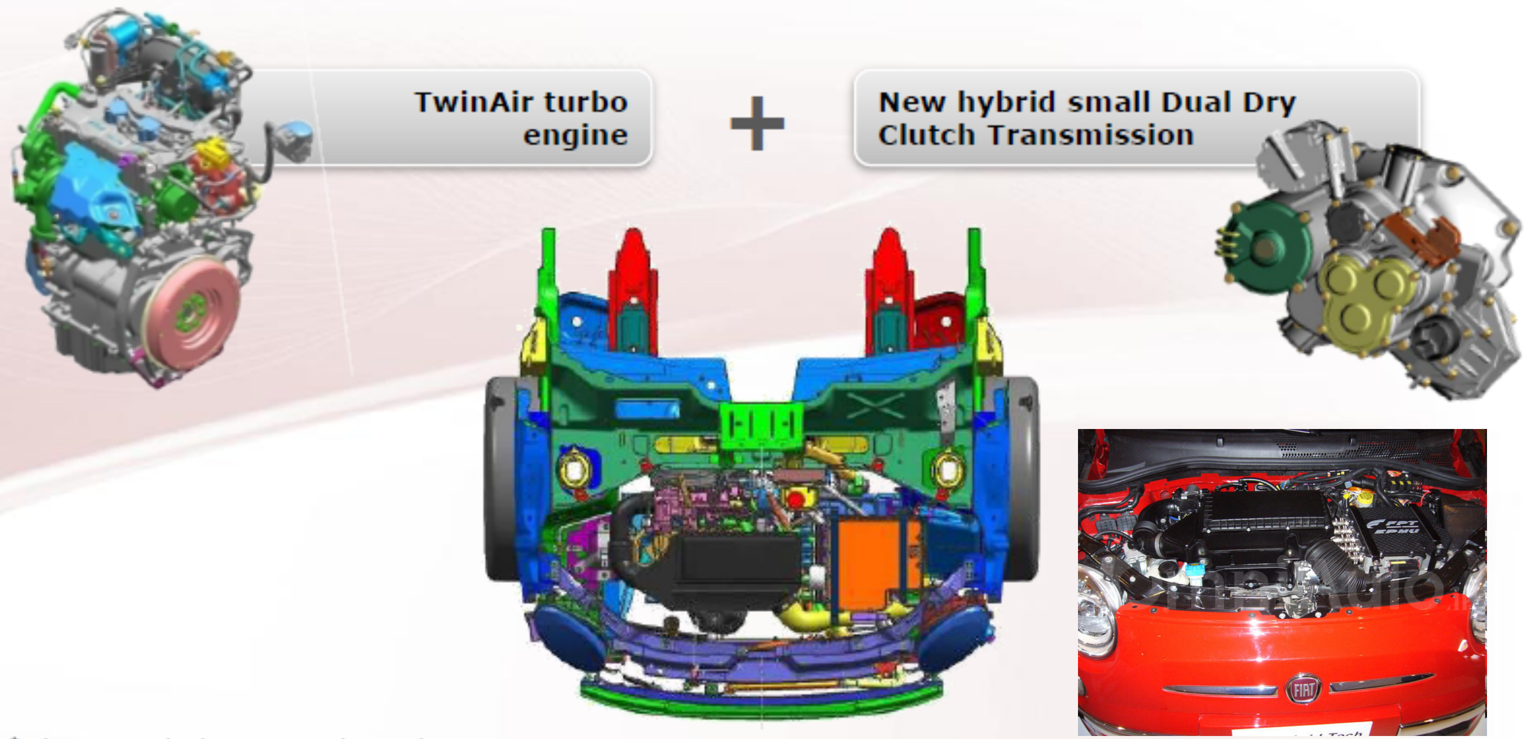
Energy savings and CO^2 reduction
Hybrid powertrain for city cars

24% reduction* of CO_2 emissions in urban driving cycle

~80 g/km CO_2 in NEDC cycle

~ 69 g/km CO_2 combined with CNG



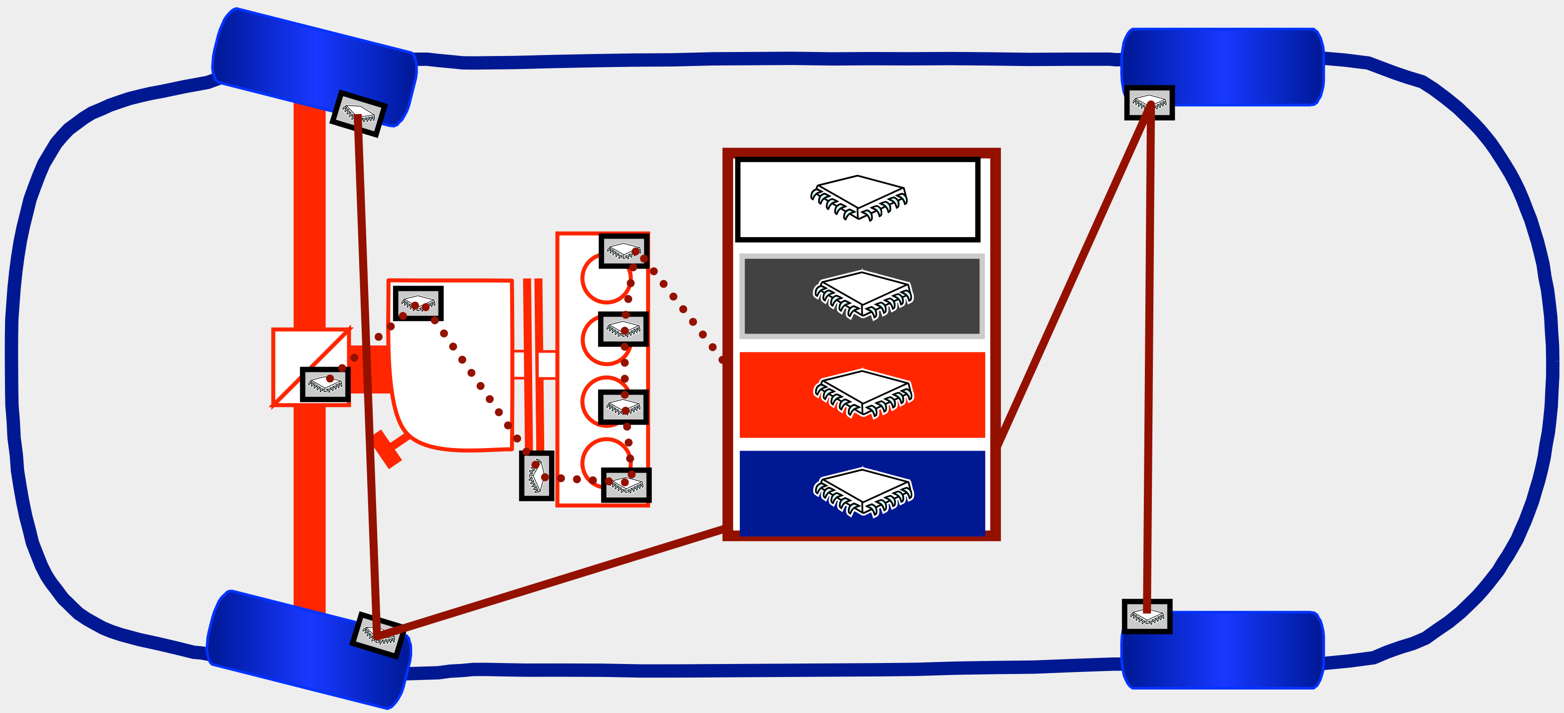
* When compared to base engine with manual transmission

Source: Alfredo Altavilla – Fiat Powertrain Technologies

EV and HEV facts

- Radically downsized Gasoline Engine would ask for high torque at low-speed for enhanced fun-to-drive. Hybridization helps in this direction also enabling PHEV functions
- In urban mobility and for ranges of around 150 km (NEDC cycle) the 2010 state-of-the-art technology allows simple, efficient and economical FEV car solutions
- The rapid advancement in performance and cost of battery systems in few years will extend this consideration for ranges up to 250km
- **Renewable Energy (40% CAGR 2003-2009) and e-mobility (70 million vehicles in 2010) are indeed converging technologies**

Conventional car architecture



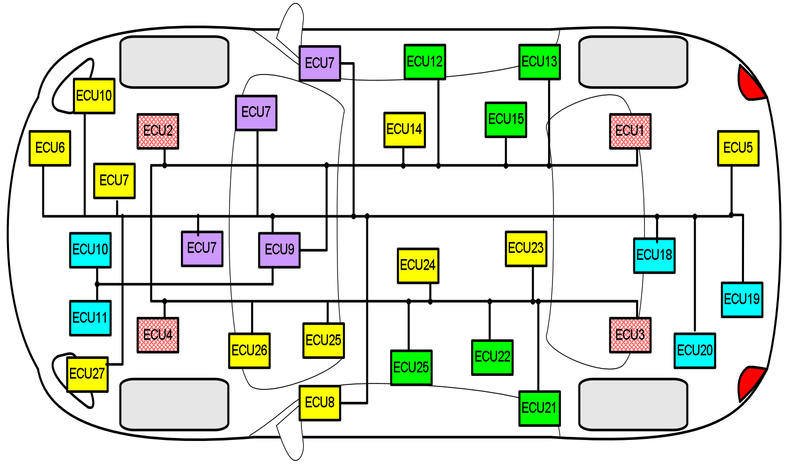
FlexRay™ bus

Can bus

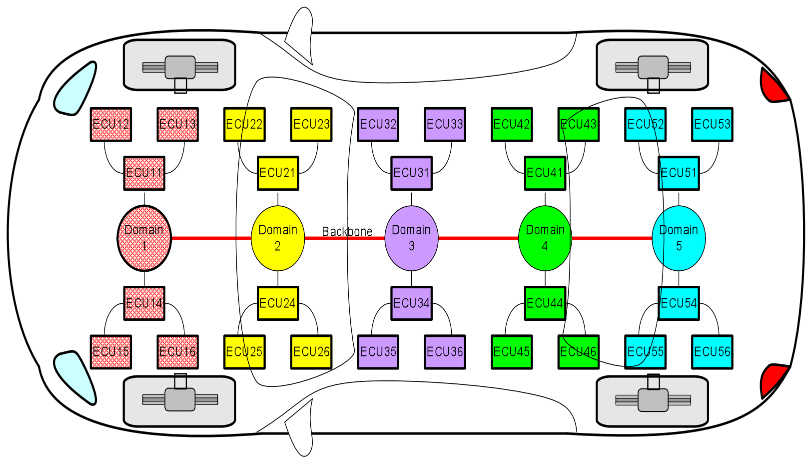
Power & signal distribution	Infotainment
	Body
	Chassis
	Powertrain

Generic E/E Architecture and trends

- **Powertrain domain**: High computation power, Multi-tasks, **Time constraints ~ 100us – 1ms**)
- **Chassis domain:** High computation power, Multi-task, distributed, **time constraints ~ 1ms, Time triggering**, **safety critical functions (X-by-wire)**
- **Body domain**: Highly distributed, hierarchical, optimal scheduling of task and messages, **time contraints ~ 1s, some safety critical entities**

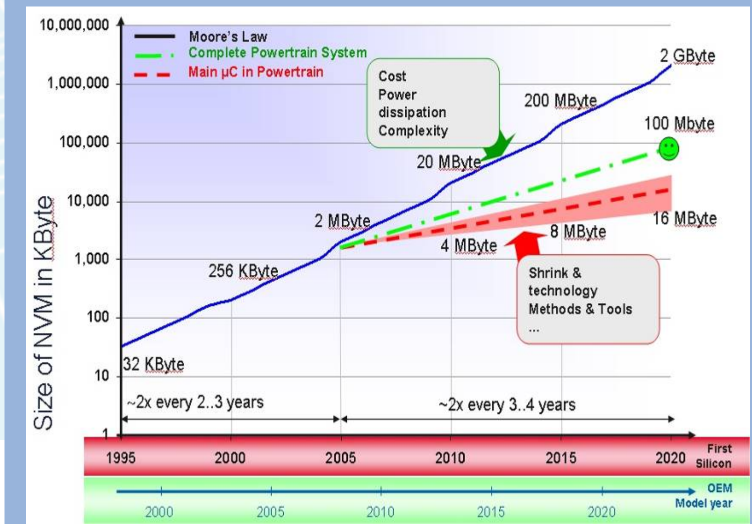


- Improved In-vehicle network with increased bandwidth and higher determinism (backbone)
- Increase Car Electrification: High Voltage, High Power
- Convergence of Systems
  - Partitioning by application “Domain” abd by location
  - Grouping of functions



Elaboration from Infineon source

Software-Enabled Functionality by increased Microcontroller Performance



Semiconductor Industry provides a 30% to 60% annual performance increase at same cost

- Software platform, reuse of software modules across application and customers
- Migration of functions from hardware to software
- Hardware independent Software
- Wider use of automatic code generation
- Software standardization e.g. Operating system, Drivers with application level interfaces (OSEK, AutoSar, IEC61508, ISO26262…)
- Robust, transparent software e.g. encapsulation, software self test
- µC family concept with performance increase and easy migration path

Elaboration from Infineon source

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Safety as a first concern
The ISO 26262 standard definition

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Risk parameter: severity

Class	S0	S1	S2	S3
Description	No injuries	Light and moderate injuries	Severe and life-threatening injuries (survival probable)	Life-threatening injuries (survival uncertain), fatal injuries
Reference for single injures	MAIS 0 Damage that cannot be classified safety related, e.g. bumps with the infrastructure	MAIS 1 and 2	MAIS 3 and 4	MAIS 5 and 6

Risk parameter: exposure

Class	E1	E2	E3	E4
Description	Extremely low probability	Low probability	Medium probability	High probability
Definition of duration/ probability of exposure	Not specified	< 1% of average operating time	1% - 10% of average operating time	> 10% of average operating time
Informative examples	–	Pulling a trailer Driving with roof rack Driving on a mountain pass with unsecured steep slope Snow and ice Driving backwards Fuelling Overtaking Car wash	Tunnels Hill hold Night driving on roads without streetlights Wet roads Congestion	Accelerating Braking Steering Parking Driving on highways Driving on secondary roads City driving
Magnitude of class E	0.001	0.01	0.1	1

Risk parameter: controllability

Class	C1	C2	C3
Description	Simply controllable	Normally controllable	Difficult to control or uncontrollable
Informative examples	When starting the vehicle with blocked steering column, the car can be brought to stop by almost all drivers early enough to avoid harm to persons nearby. Faulty adjustment of seats while driving can be controlled by almost all drivers through adjustment of seats and bringing the vehicle to a stop.	Driver can normally avoid departing from the lane in case of a failure of ABS during emergency braking. Driver is normally able to avoid departing from the lane in case of a motor failure at high lateral acceleration (motorway exit). Driver is normally able to bring the vehicle to a stop in case of a total light failure at medium or high speed on an unlighted country road without departing from the lane in an uncontrolled manner. Driver to hit an unlighted vehicle on an unlighted country road.	Self-steering with high angular speed at medium or high vehicle speed can hardly be controlled by the driver. Driver can normally avoid departing from the lane on snow or ice in a curve in case of a failure of ABS during emergency braking. Driver cannot bring the vehicle to a stop if a total loss of braking performance occurs. In case of faulty airbag release at high or moderate vehicle speed, driver usually cannot prevent vehicle from departing from the lane.
Magnitude of class C	0.01	0.1	1

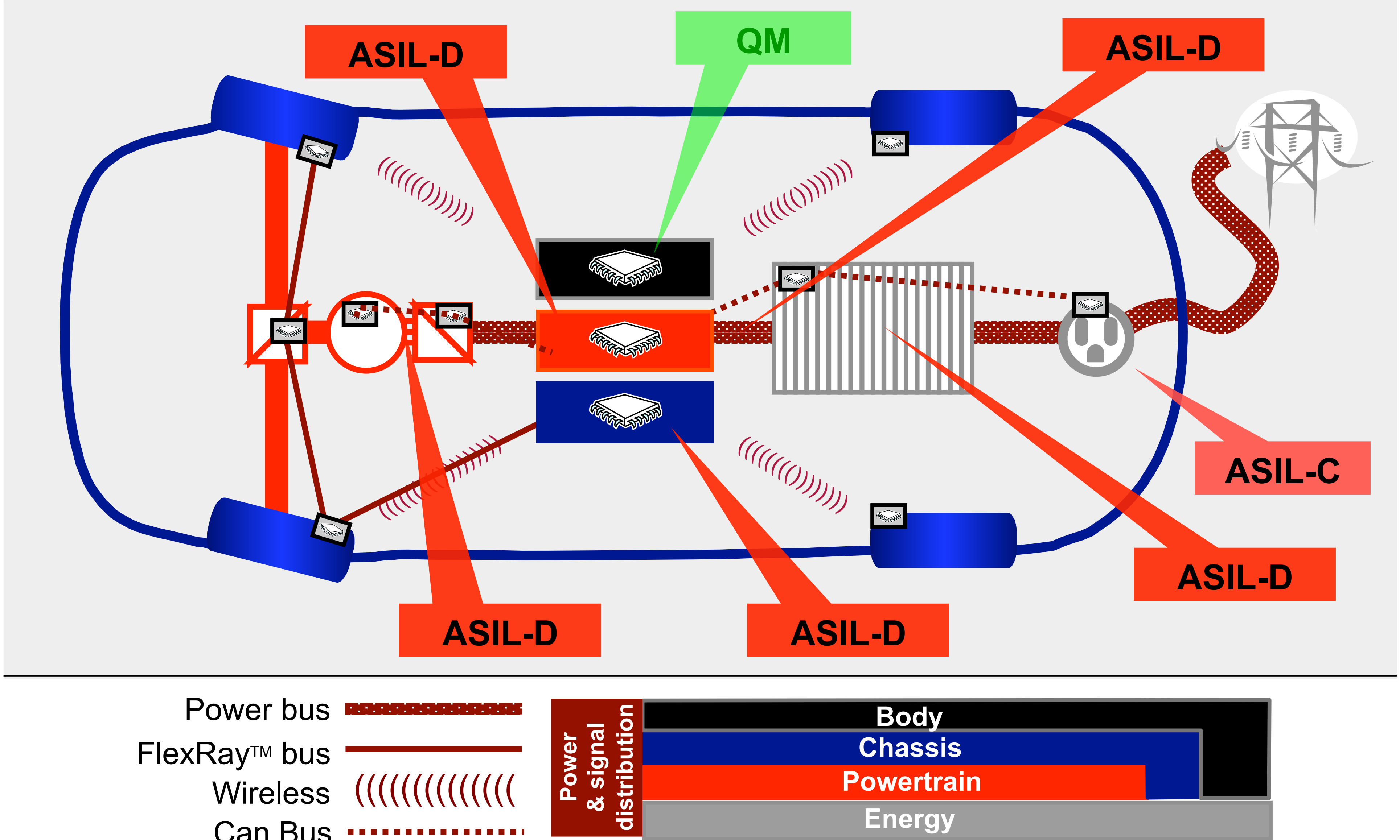
Severity	Probability: E x C				
	0,0001	0,001	0,01	0,1	1
S0 (no injuries)	QM	QM	QM	QM	QM
S1 (light and moderate injuries)	QM	QM	QM	ASIL A (SIL 1)	ASIL B (SIL 2)
S2 (severe and life-threatening injuries)	QM	QM	ASIL A (SIL 1)	ASIL B (SIL 2)	ASIL C (SIL3 (2))
S3 (fatal injuries)	QM	ASIL A (SIL 1)	ASIL B (SIL 2)	ASIL C (SIL3 (2))	ASIL D (SIL 3)

Risk matrix ISO-DIS 26262

E = probability of exposure
C = controllability

Source: STMicroelectronics

EV architecture level 0
Risk assessment analysis



Electric Powertrain safety issues

- Centralised powertrain leads to:
  - High power
  - High current/voltages
  - Big and concentrated energy storage

- Issues arise from:
  - Drive failure can result in sudden stop or loss of traction
  - Potential electrical hazards from concentrated energy storage
  - High voltages/currents leads to potentially hazardous magnetic fields
  - Overall decreased efficiency and realiability
  - Redundancy: howto?

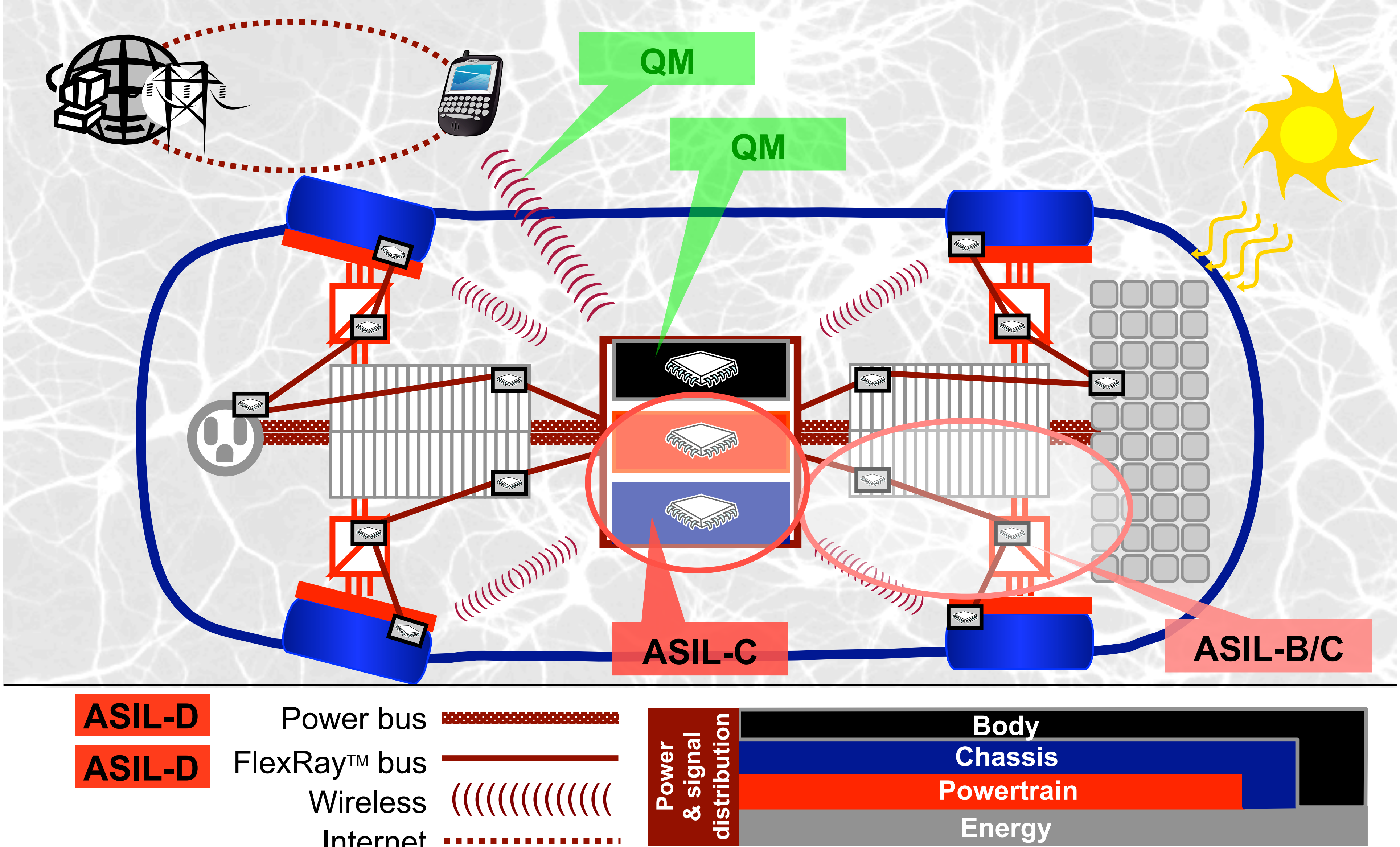
Distributed electric powertrain features

- Inherently fault-tolerant: failure in one drive will not significantly affect the vehicle as a whole
- Fail-safe: no complete loss of power will take place
- Improved traction control on low friction road and overall active safety enhancement

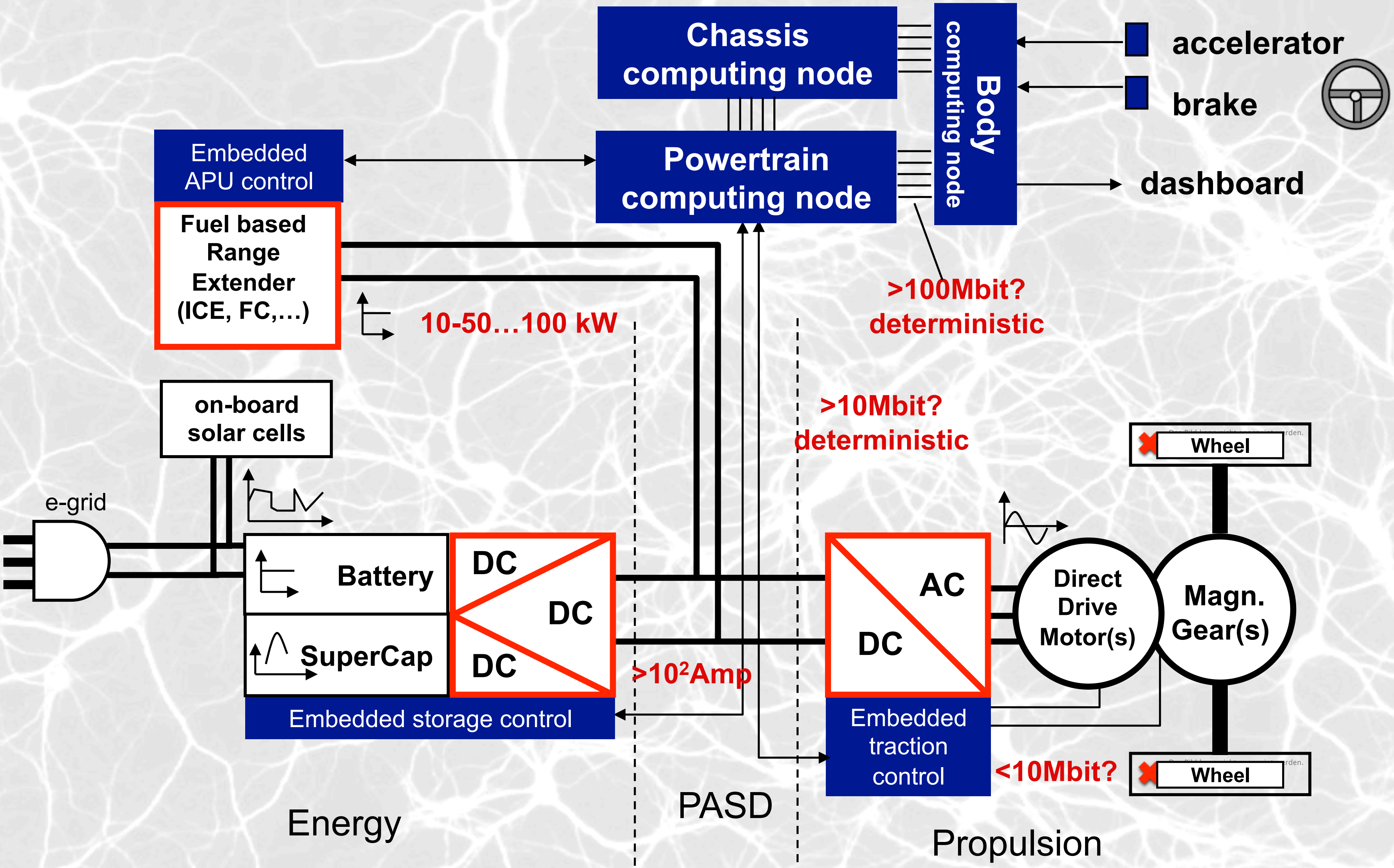
+

- The safety of electric drives can be enhanced with innovative fail safe electric machines and drives
- Active differential features can be implemented for fun-to-drive and fail safety
- In case of failure, a fast and effective fault detection can prevent car loss of track, while the traction power can be re-distributed to other remaining active wheels

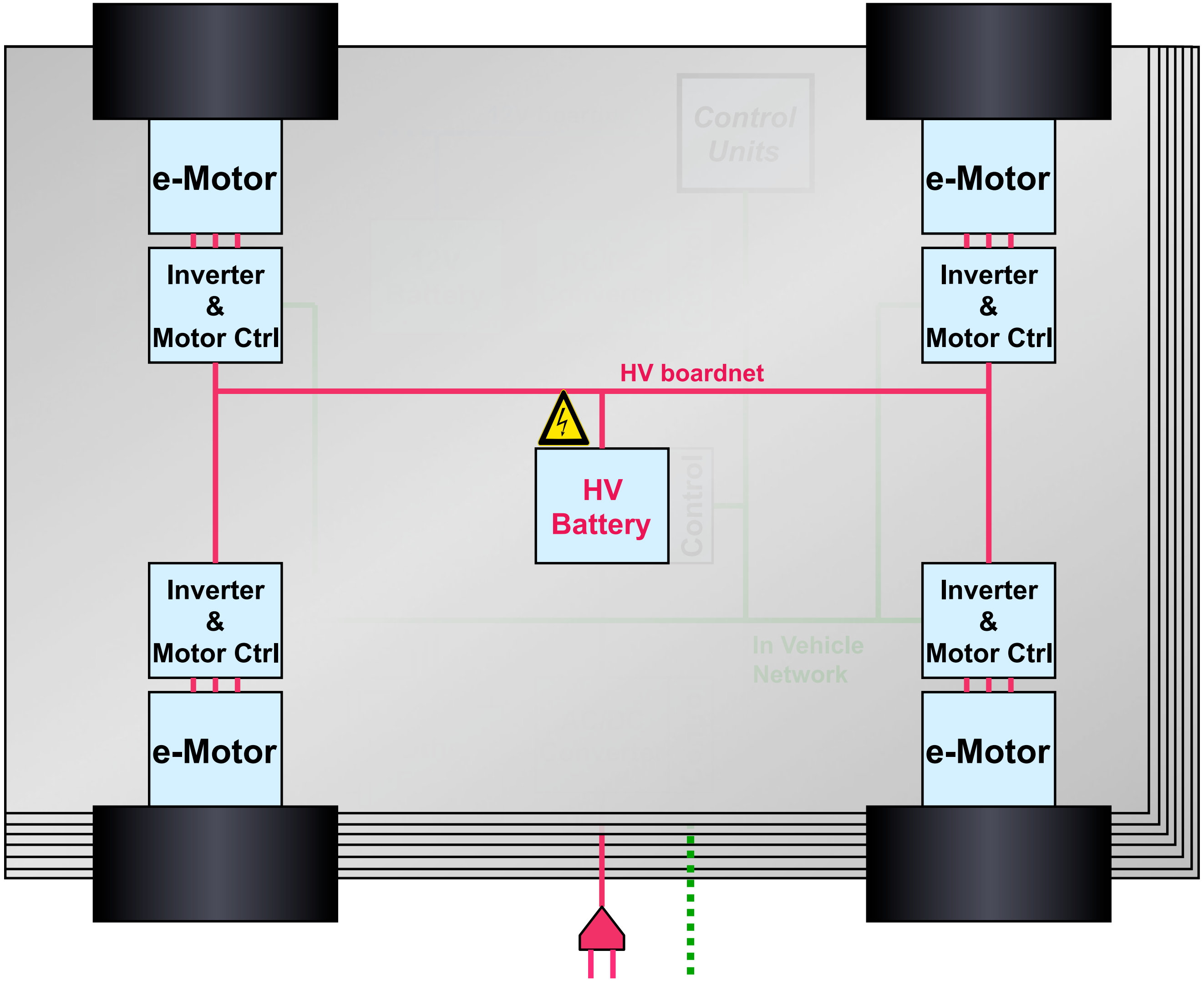
EV architecture level 2
Enabling risk mitigation features



Safe communication media and protocols



Layered power and signal distribution systems



Elaboration from NXP Semiconductors source

- Distributed propulsion
  - Simplicity
  - Efficiency
- Computing node (s)
  - Reduced effort
  - Redundancy
- in-vehicle network
  - Reliability
  - Bandwidth
  - Determinism
- V2G+I
  - Energy
  - Internet
- Partial networking

Examples of recent media alarms on EV and HEV hazard

- **The New York Times: “Fear, but Few Facts on Hybrid Risk”**

  By Dr. Jim Motavilli, April 27, 2008

  - “The flow of electrical current to the motor produces magnetic fields, which some studies have associated with serious health matters, including a possible risk of leukemia among children. With the batteries and power cables in hybrids often placed close to the driver and passengers, some exposure to EMF is unavoidable. Moreover, the exposure will be prolonged — unlike, say, using a hair dryer or electric shaver — for drivers who spend hours each day at the wheel”.
  - “Lawrence Gust of Ventura, Calif., a consultant with a specialty in EMF’s and electrical sensitivity, agreed that the readings in hybrid cars were high but did not want to speculate on whether they were harmful. “There are big blocks of high-amp power being moved around in a hybrid” he said. “I get a lot of clients who ask if they should buy hybrid electric cars, and I say the jury is still out.”

- **The Consumerist : Hidden Hybrid Automobile Dangers. What you should know about EMFs**

  By Jay Slatkin, May 9, 2008, 13,153 views

  - Typical Internet Comments "Did it occur to anyone that driving a car is possibly the most dangerous thing anyone can do? “

POLLUX Identity card

- 35 partners
- 10 EU countries
- 33M€ budget
- 21 supply chains
- 87 deliverables
  - Reports
  - Demonstrators
  - Public releases

Pollux in a nutshell
the consortium

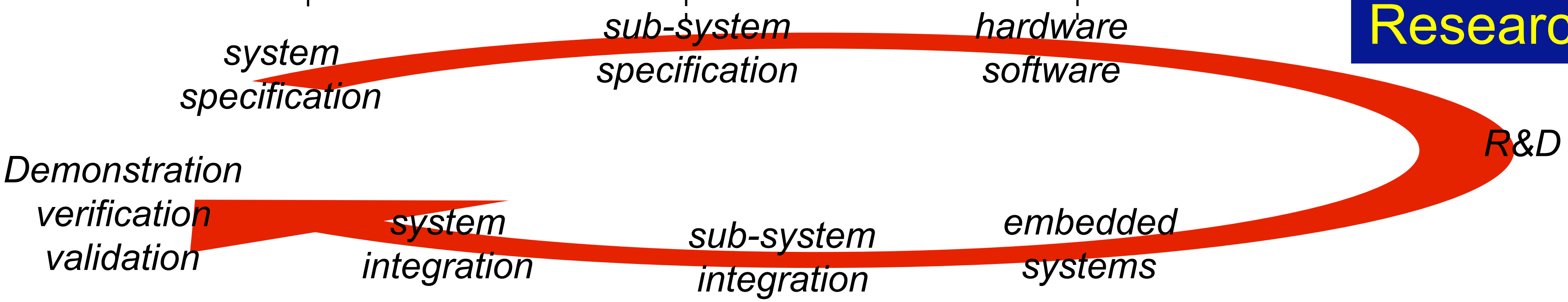
OEM

Tier1, Engineering

Tier2, Embedded systems

SME

Research



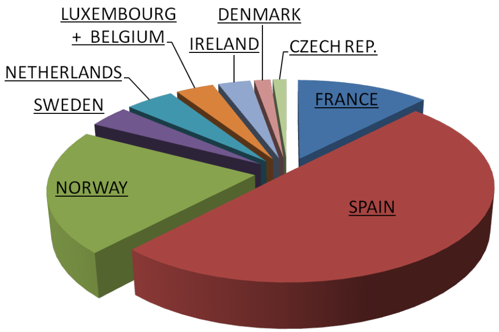
Pollux in a nutshell
objectives

- Define the reference platform(s) (Hard and Soft) for the next generation of electric vehicles
- Develop the underlying embedded systems to perform the platform composition (distributed and centralised control units)
- Investigate the functional safety, security and health constraints
- Make the developments functional on vehicle demonstrator in synergy with the other projects

Standardisation

Pollux results exploitation

e-vehicles currently commercialised…



Largest fleet of EV in europe
mostly outside italy

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Pollux results exploitation

…e-vehicles coming soon

EPoSS European Technology Platform on Smart Systems Integration

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e500

iOn

c-zero

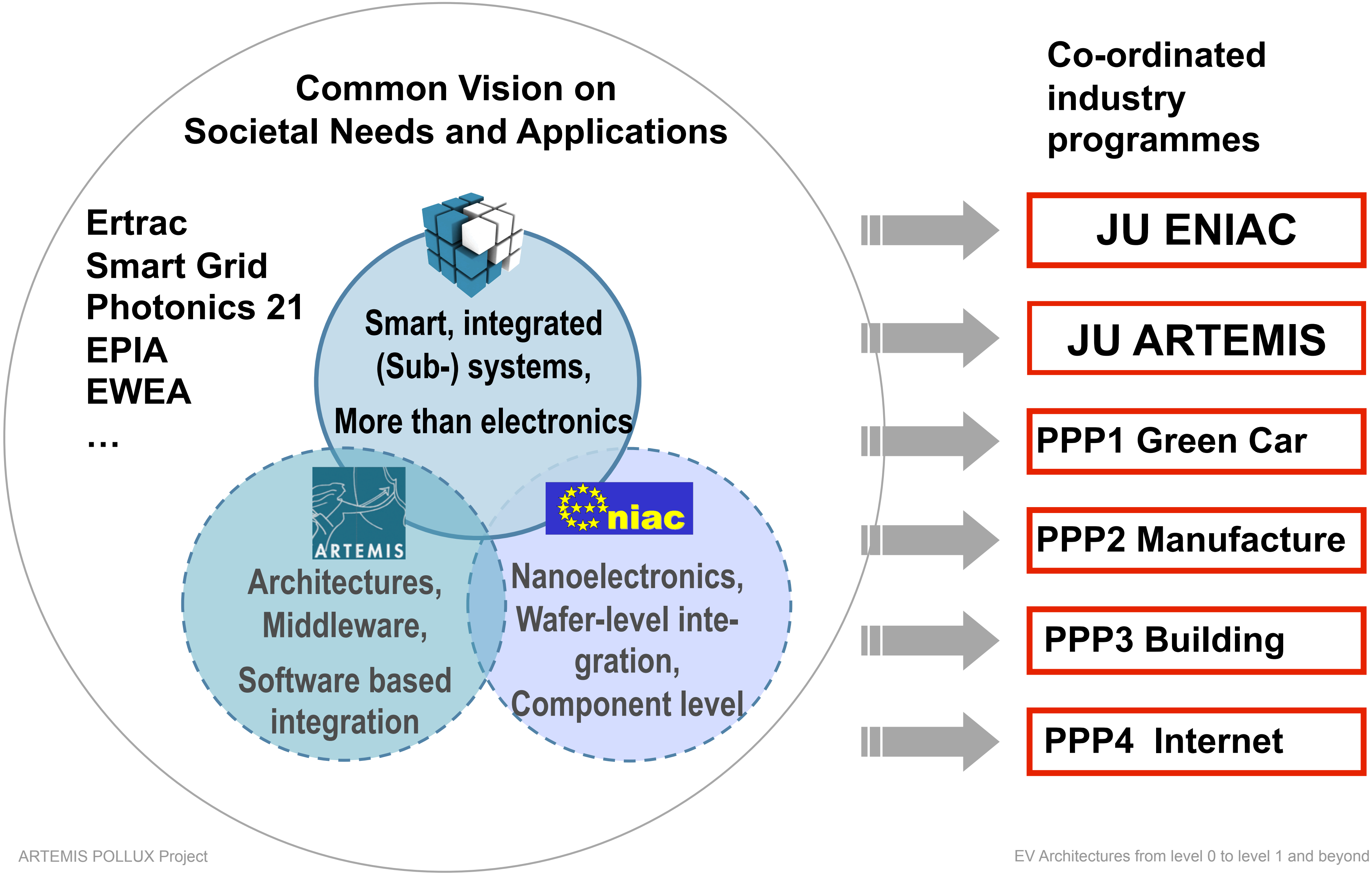
FIAT

MICRO-VETT electric

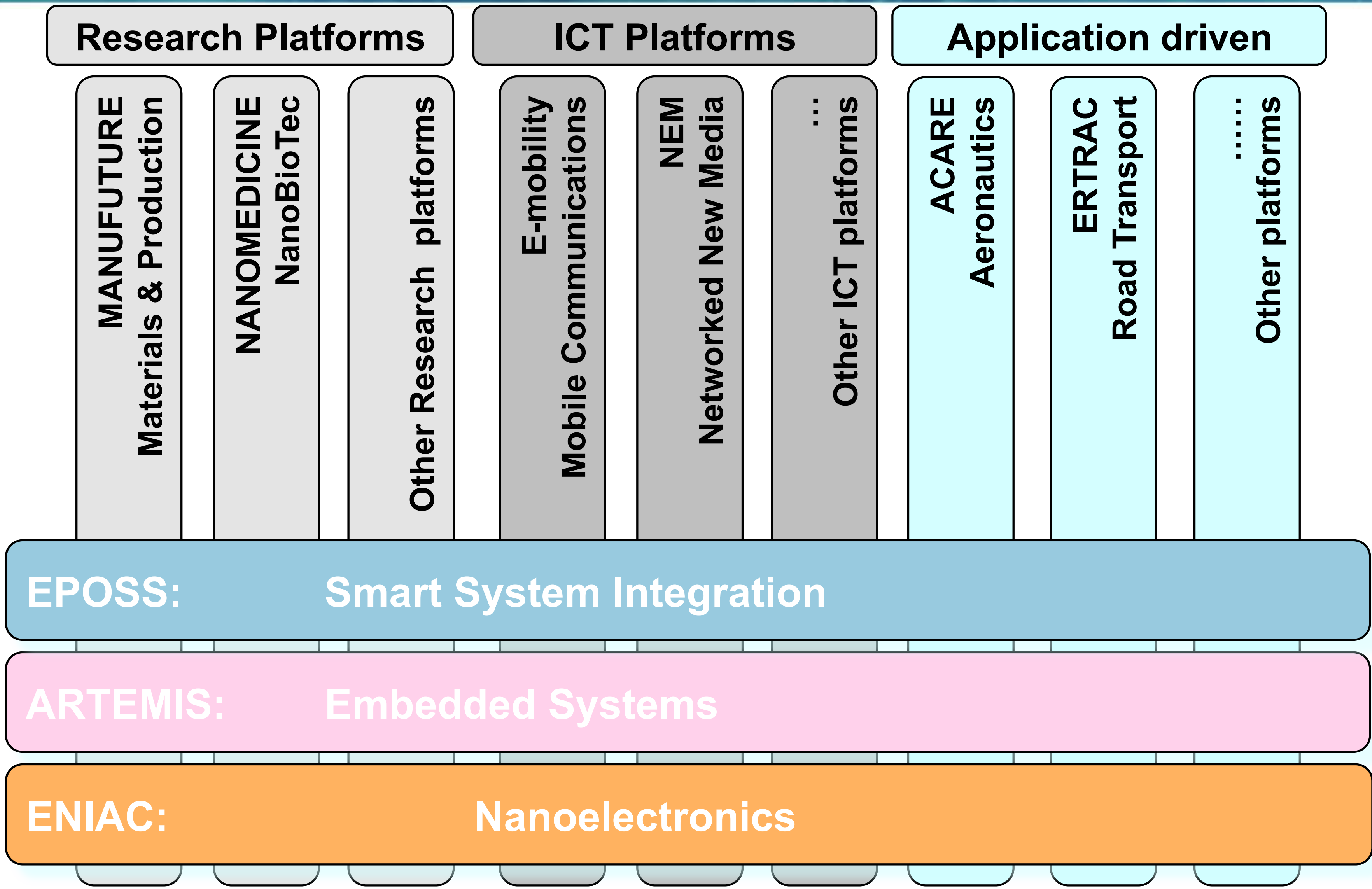
PSA PEUGEOT CITROËN

QUICC!

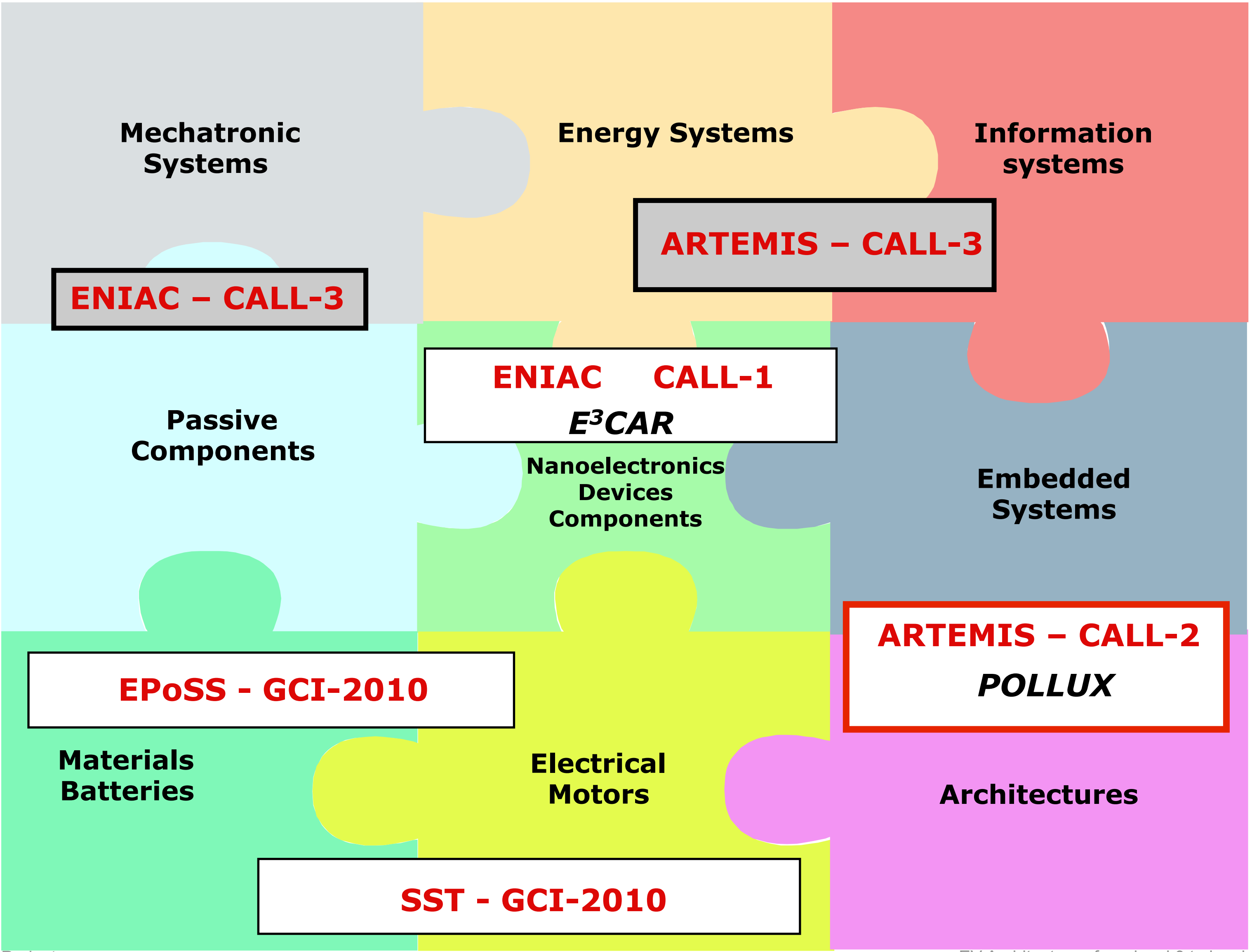
European vision on EV



Cooperation between TPs



Pollux and the others



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A STEP BY STEP approach

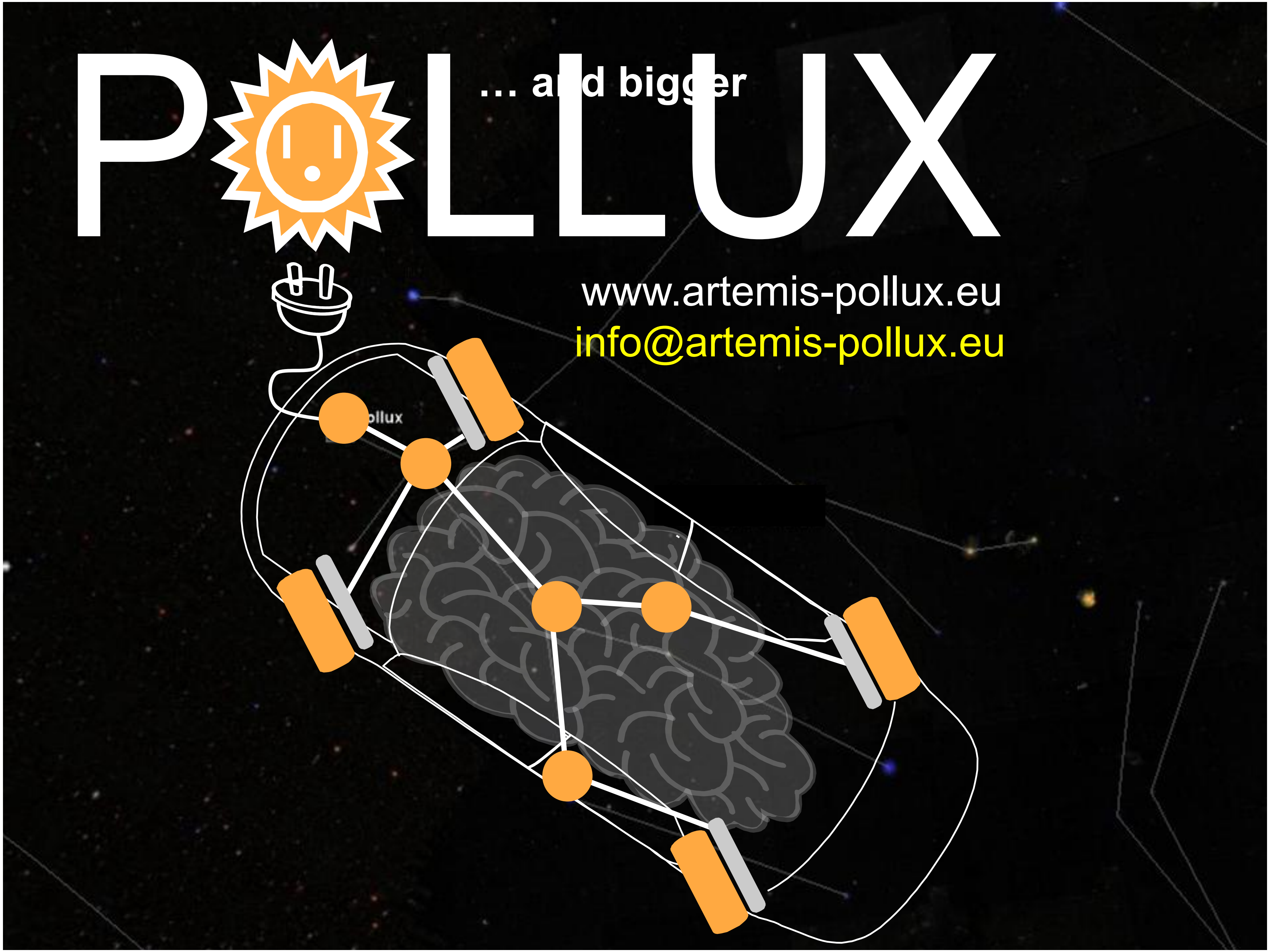
Components level 1	**ENIAC call 1**	**E^{3}CAR 01.03.2009**
In-vehicle Architecture level 1	**ARTEMIS call 2**	**POLLUX 01.03.2010**
Out-vehicle architectures	**ARTEMIS call 3**	FPP in preparation
Components level 2	**ENIAC call 3**	FPP in preparation
In-vehicle Architecture level 2	ARTEMIS call 4	AWP 2011
Components level 3	ENIAC call 4	AWP 2011..?

Projects addressing the challenges at the largest possible level. That is spread knowledge and technologies in such a way that all participating Nations understand the importance of the topic and could envision a direct benefit for the society and their Industries.

We all have done an excellent job until now…

…let's go on faster!


Never stop thinking bigger…
Pollux
Castor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www.artemis-pollux.eu
info@artemis-pollux.eu