

Evolution of new functionalities in vehicles,
enabled by the integration of microsystems:
a route towards European competitiveness!

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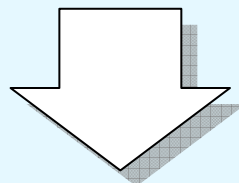
The EU-25 context from the automotive standpoint

Current Grand Challenges

- Growing dependence from primary energy (70% in 2030)
- Growing dependence from primary materials (Steel, Aluminium)
- Growing sensibility on Safety/Security/Environment
- Growing political-economic instability
- Growing mobility of people and goods
- Growing uncertainty to forecasting
- Growing system complexity (50-100: processors, actuators and sensors)

Possible Answers

- Radical changes on vehicle designs
- Innovation in functions, materials and technologies
- Stronger European partnerships and European visions



**Micro and Nano Technologies with specific
Focus on Smart Systems Integration to master new challenges**

Weight increase (B-segment)

Year 1980

Year 2000

Chassis:	150 kg	250 kg
Body:	200 kg	320 kg
Contents:	5 kg	60 kg
.....
Base Engine:	78 kg	87 kg
Add-on components:	9 kg	20 kg
TOTAL	750 kg	1100 kg



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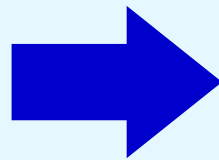
Contents & Components: increasing complexity and power consumption

Year 1980

Air conditioning (opt.)
Radio (opt.)

Year 2000

Air conditioning, Radio, ABS,
Power steering, Cam phaser,
Headrest, Fog-lights , Airbags,
Electronics/Management Systems,
More sophisticated suspensions,
Anti-intrusion bars, Pre-tensioners,
Adjustable steering wheel...



In a top-segment car

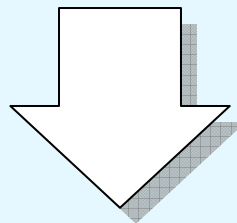
- **Over 2 km of wires**
- **80 - 100 sensors**
- **50 - 80 processors**
- **80 - 100 actuators**

For the last 15 years we have been facing an ever growing demand of electrical load with an average of **+100W/year (3000 W overall)**.

Requirements vs. Constraints

CHALLENGES DOWN THE ROAD

- **CO₂ Reduction** - 30% from 1990 to 2012
- **Alternative Fuels:** 14% of total in 2015
- **Noxious Emissions:** - 80% from 1997 to 2010
- **Safety:** - 50% fatalities from 2001 to 2010
- **Mobility:** **Dynamic Routing & Mobility Management**
- **Competition:** **The global market challenge**



The introduction of novel functions has contributed to increase EU Competitiveness, as well as to enhance Safety and Mobility. But, this trend is in contrast with the constraints of reducing Weight, Power Consumption, Emissions, Costs.

From Microsystems to Smart Systems integration

Micro-Systems Technology is already widespread in the automotive and is having a significant overall impact on safety, efficiency, security and comfort.

POWERTRAIN

(Power management)

- Pressure
- Manifold absolute pressure
- Mass air flow
- Knock
- Atmospheric pressure
- Fuel pressure
- Oxygen
- Angular position
- Rotational speed
- Tank level or pressure
- Pedals position ..
- ...

VEHICLE & CHASSIS

(Comfort)

- Humidity/Temperature
- Rain
- Fog
- Light
- Air quality
- Fingerprint
- Gyroscope (navigation)
- Force feedback pedal
- Driver seat vibration
- Steering wheel momentum

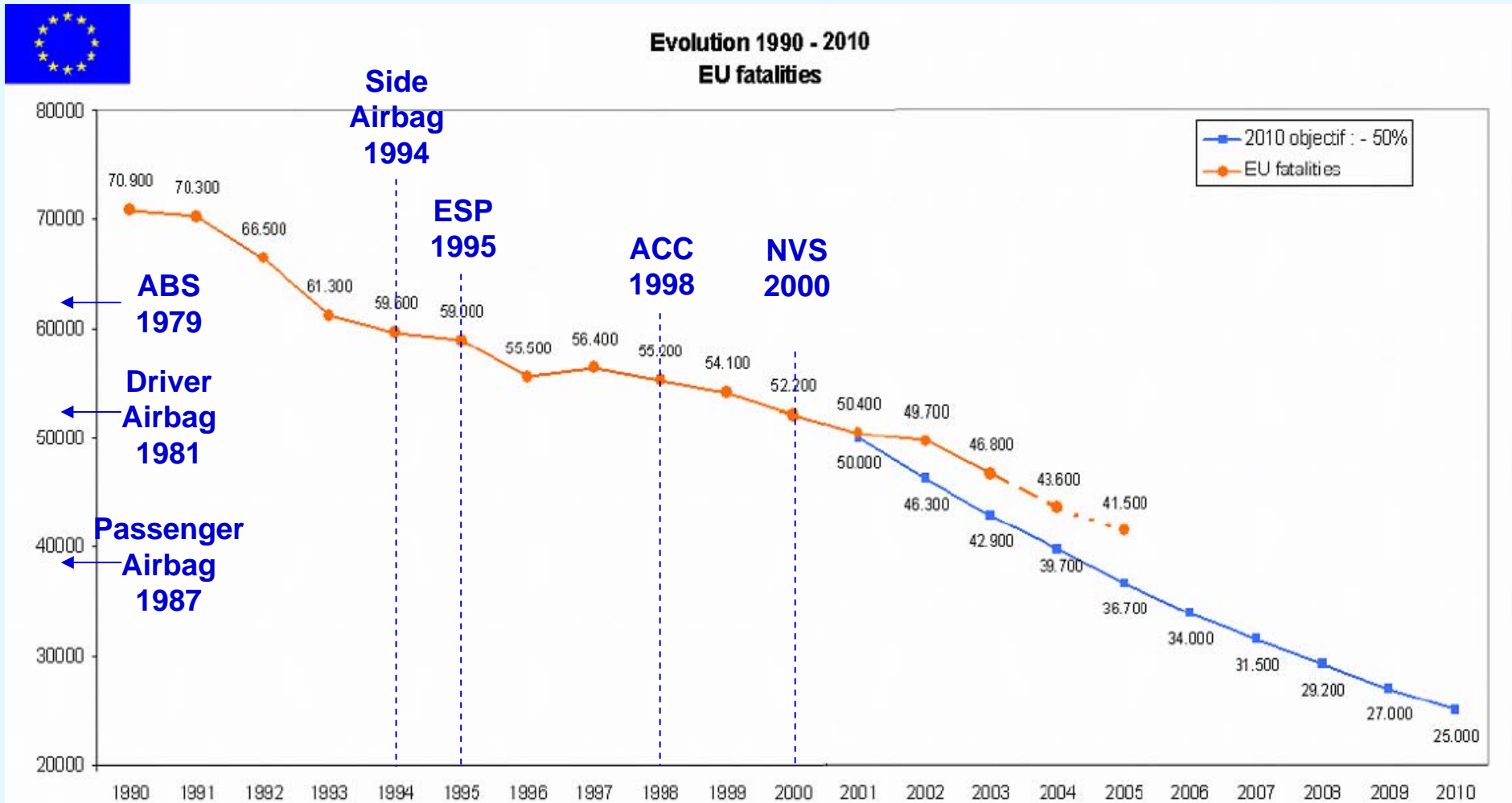
VEHICLE & CHASSIS

(Safety & Driver Assistance)

- Radar distance
- Accelerometers
- Gyroscopes
- Magnetometer
- Steering wheel
- Suspension stroke/acceler.
- Seat occupancy
- Yaw rate
- Rotational speed
- TPMS
- CMOS cameras
- IR systems

Entirely new functions can be enabled by MNT and the move from the add-on concept to **Smart Systems Integration** as the enabler to reduce **Weight, Power Consumption, Emissions, Costs.**

Achievements related to MST: reduction of fatalities



**From 70000 to 40000 fatalities in 15 years. From 600 to less than 200 fatalities per million vehicle.
The Smart Systems Integration will play a crucial role for next achievement!**

Example of Smart Systems Integration

Multifunctional Optical CMOS Sensor

7 FUNCTIONS :

- Crossing vehicle
- Tunnel/bridges detection
- Twilight
- Solar
- Mist, fog
- Rain
- Dimming (*int. / ext.*)

OTHER FUNCTIONS OF FRONTAL MONITORING THAT CAN BE INTEGRATED

- Lane Warning
- NIR night vision
- Pedestrian detection
- Road signs detection



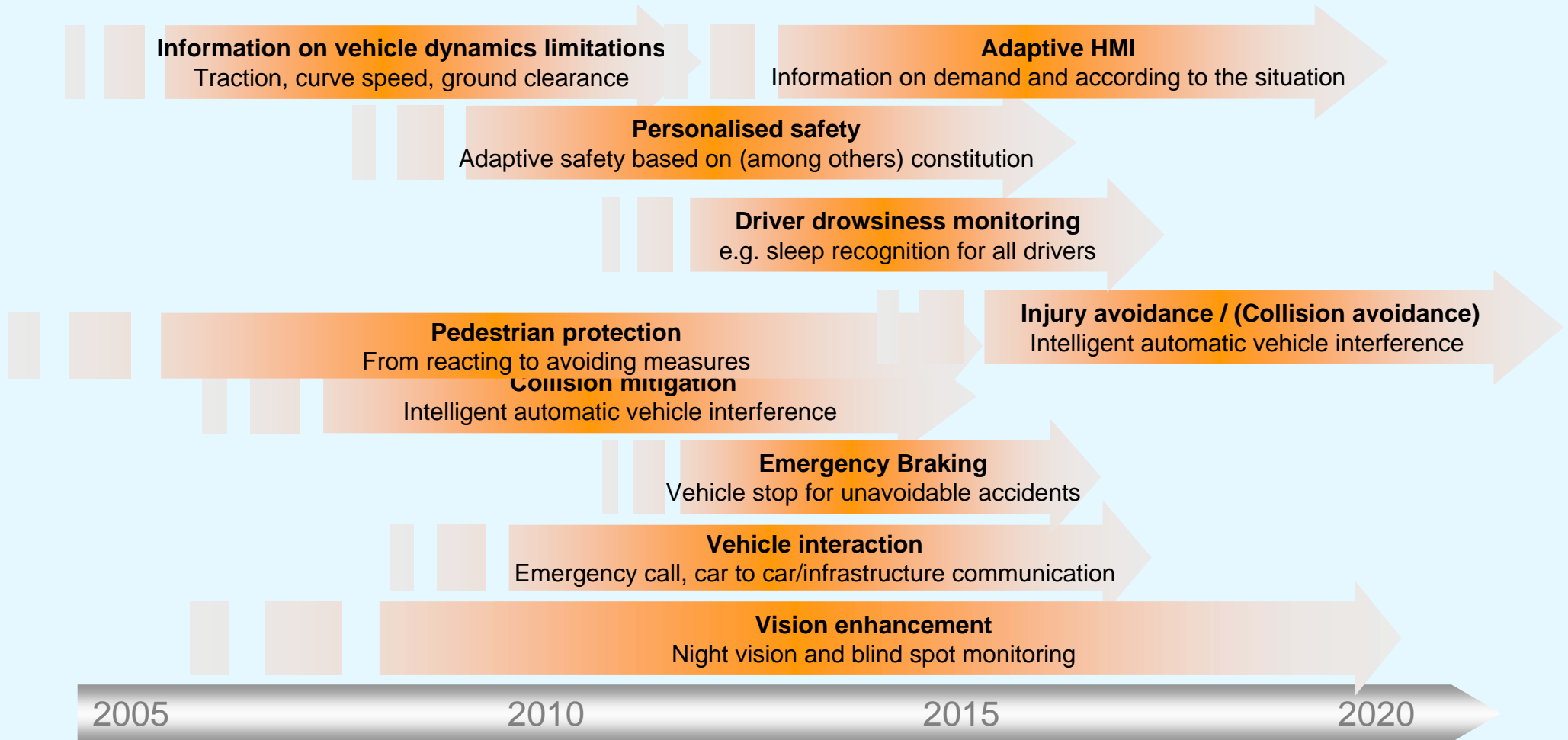
Vision

Integrate a single **CMOS sensor with planar micro optics** to operate as a **multifunctional smart system device** while additionally operating as controller of several actuators.

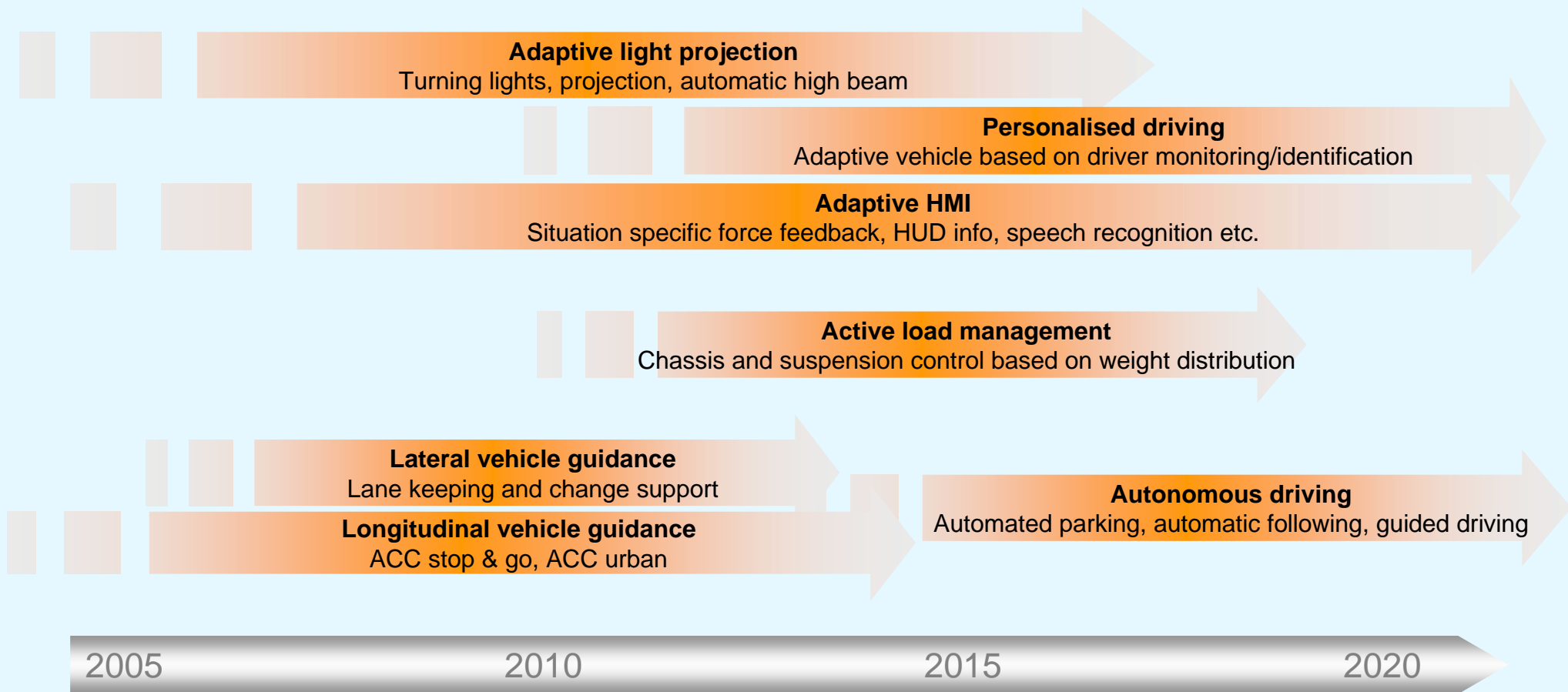
By the assistance of an integrated illuminator the single detector can perform at both visible and near IR wavelengths.

By networking architectures and advanced **data fusion** the device can provide the basic **input for novel safety, driver assistance** and convenience for low cost functions.

Safety functions roadmaps



Driver Assistance – Functions' Roadmap



Convenience – Functions' Roadmap

Safety support

Warnings and interference for safety critical situations

Automated secondary functions

e.g. anti fog windscreen, anti ice windscreen, anti dazzle system, automated light and wipers

Adaptive HMI

Situation specific force feedback, HUD info, free speech, personalised skins

User identification

Knowing about adjustments and habits

Adaptive control elements

Scalable, auto adjusting

Personalised environment

e.g. audio separation, personalised skins, adaptive climate, forming seats, redolence control

Complete Multimedia

Digital broadcast, wireless communication

Traffic management

Individual routing, overall traffic measures

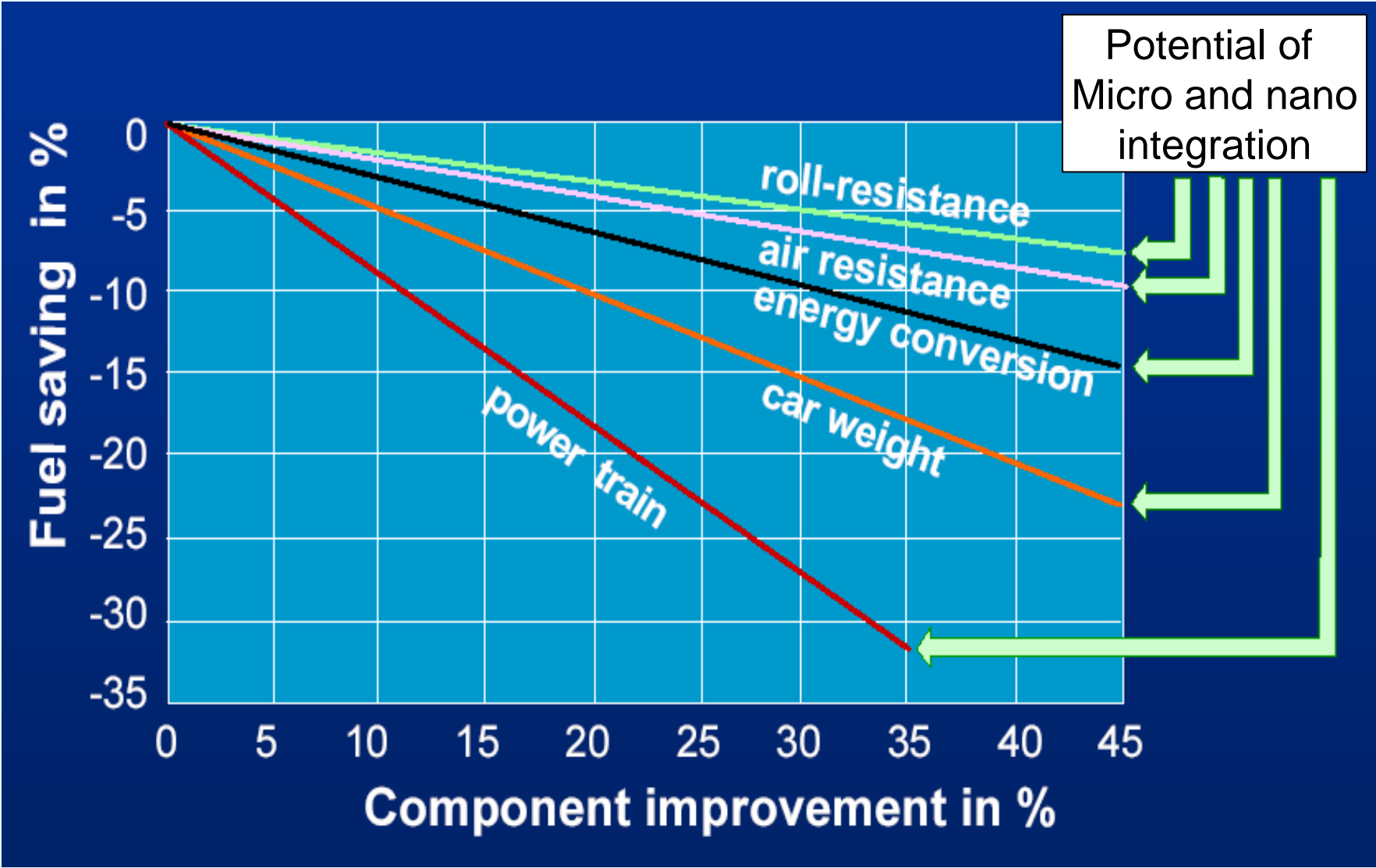
2005

2010

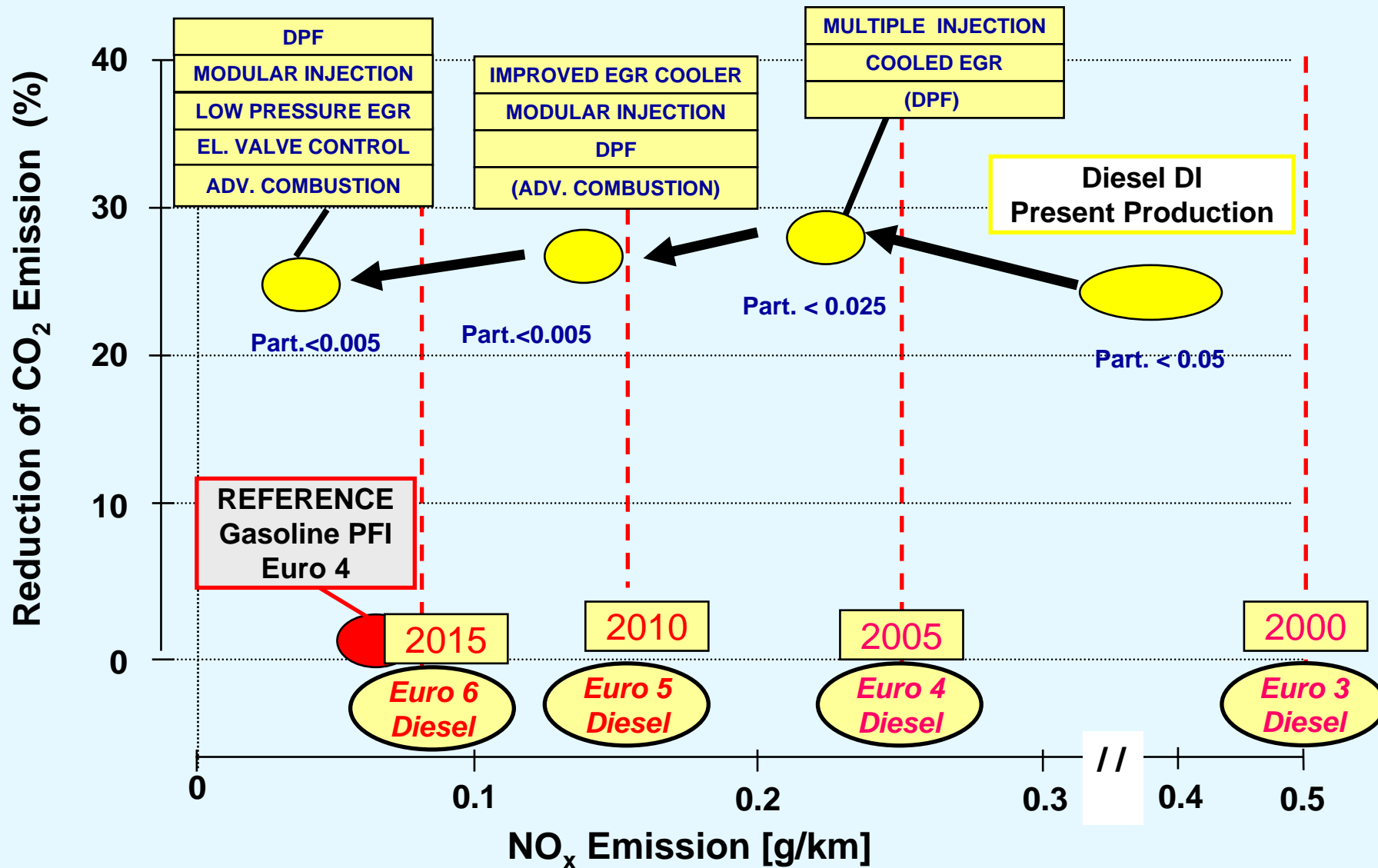
2015

2020

Energy saving in automotive



The diesel technology roadmap



Example: Sensors and Actuators in Internal Combustion Engines

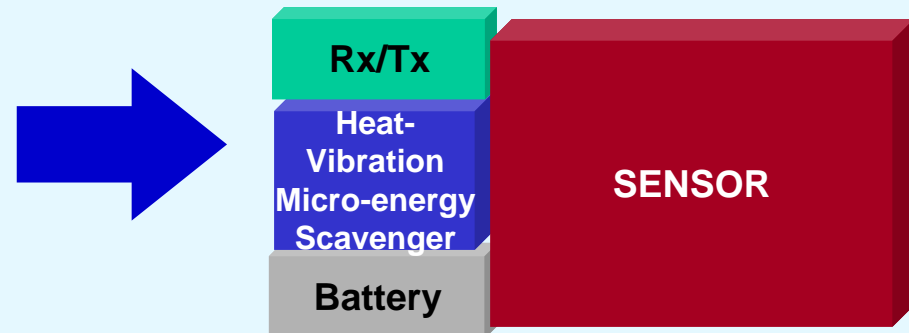
Most recently demonstrated fuel savings (~30%) come from the integration of the ICE and electrical motors in association with regenerative braking, integrated power-train management, comfortable stop and start (advanced hybrids).

Current and future fuel savings roadmaps will require more:

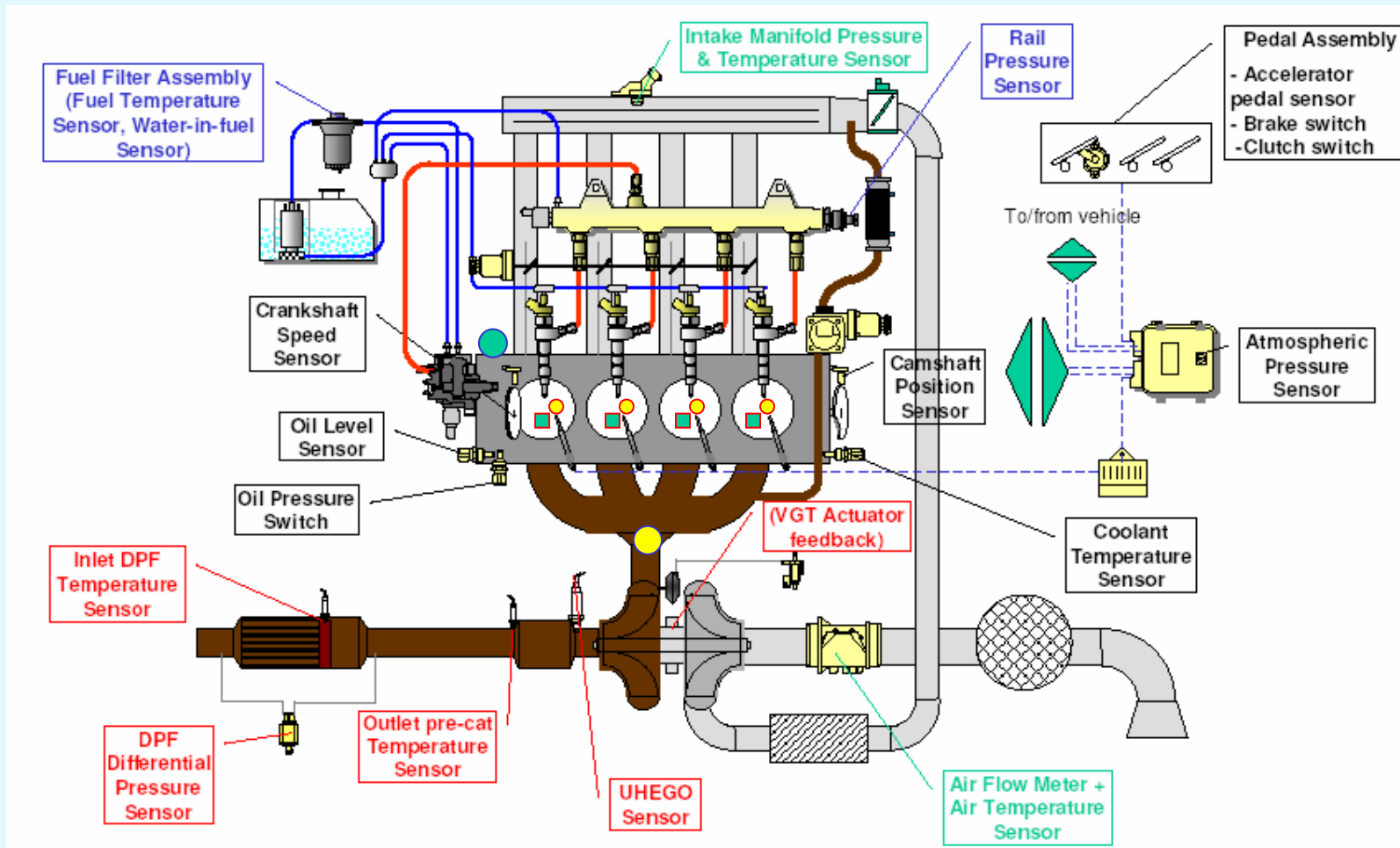
- **Sensing and Processing:** to couple the operation of the ICE to the electrical motors
- **Electrical motors and actuators**
- **Sensors:** to improve engine performance including efficiency, from today's 12-15 sensors to over 30 in few years. **Cylinder pressure, combustion temperature, combustion flame speed, engine output torque, oil viscosity, air to fuel mixture, air quality, valve position....still not in use.**

Wireless and autonomous sensors/actuators will be necessary to handle this complexity:

- energy generation by scavenging
- energy storing
- wireless communication



Present and future sensor needs in diesel multijet engines



- Combustion chamber pressure sensor
- Oil condition sensor
- Valve position sensors
- Exhaust gases composition sensor

Energy saving in automotive Involving further electronic developments

Hybrid propulsions...

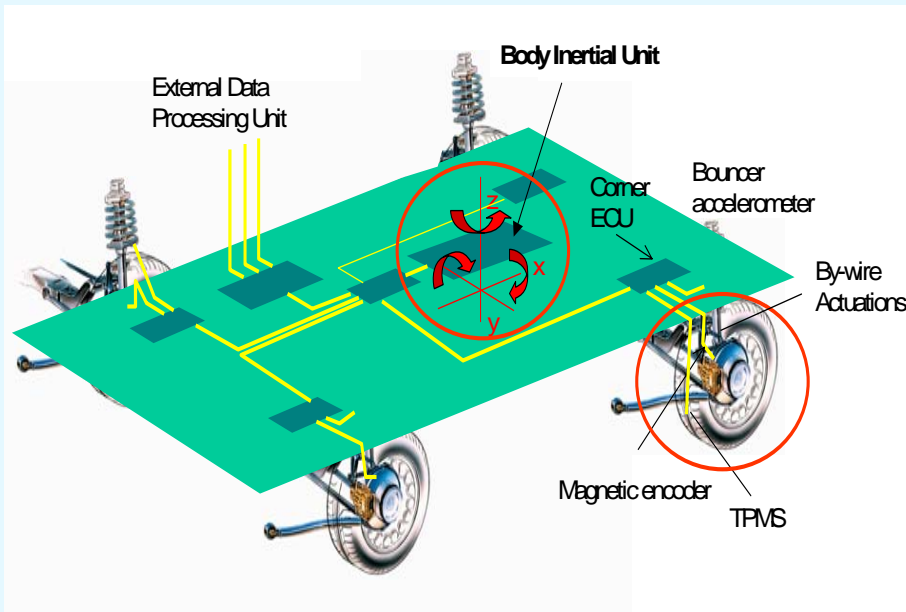
Average effective speed rather than maximum speed (via navigator)

Best route (via navigator)

Novel Electronic for energy saving in high speed computation (+ 100W/year of electrical energy in the last 15 Years)

Example: for Smart Systems Integration

Integrated smart actuators and sensors for comprehensive *quarter car* control



Sensors

- Braking force
- Vertical acceleration
- Wheel steer angle
- Wheel speed
- TPMS
- Inertial Clusters
- Suspension position

Actuators and drives

- Wheel steering (fault tolerant)
- Braking
- Suspension dumping
- Wheel electric motor (optional)

Local processing and control functions including:

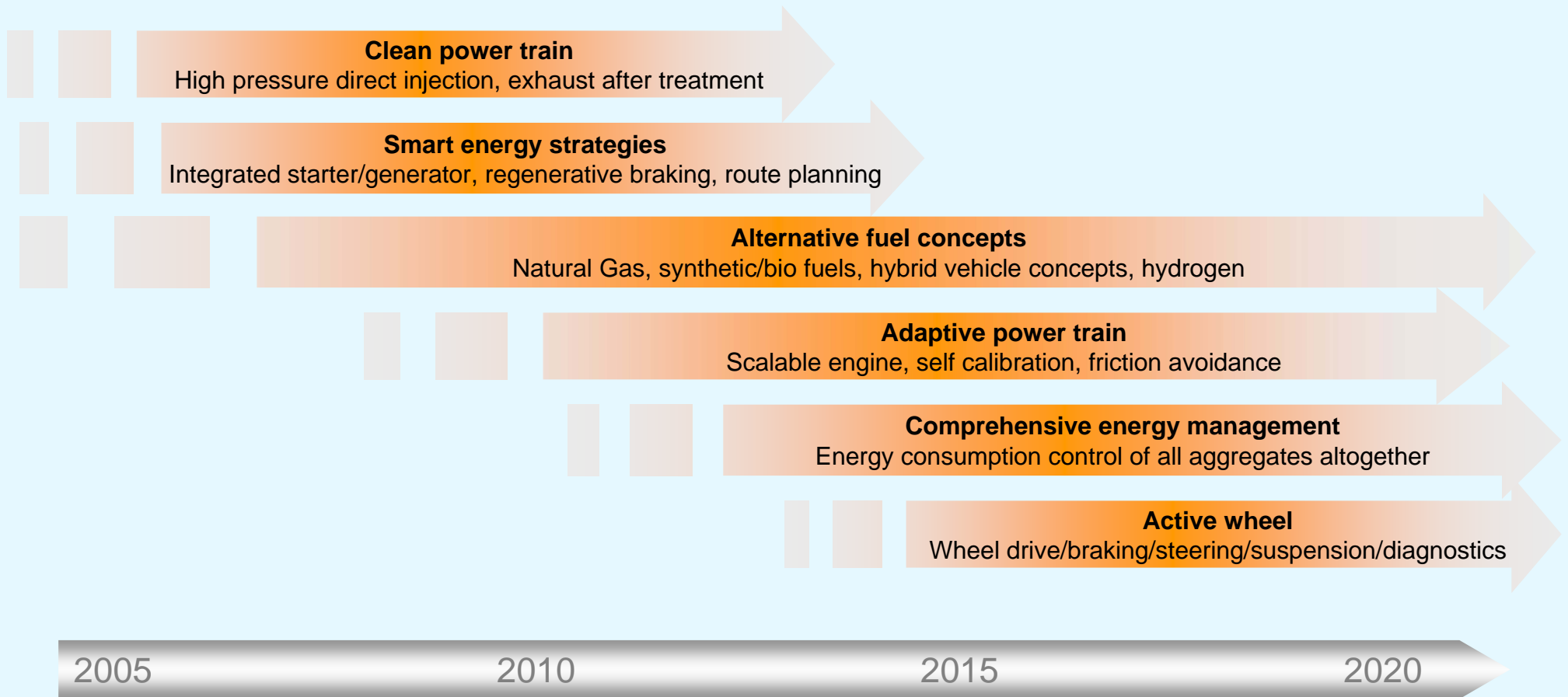
Wheel braking control (including ABS), Wheel steering control (fault tolerant), Dumping control, Tire monitoring, Communication (FlexRay and wireless), Diagnostics

Vision

The *quarter car* assembly, including suspension, tires, actuating systems for steering and braking functions with related networked sensors will allow the global control of the vehicle dynamic behavior.

Electric actuators integrated in the wheel/suspension system will provide efficient and clean traction, with regenerative braking capability (active wheel). The vehicle control system and the driver will have a real-time detailed awareness of the vehicle status in every driving condition, through the sensing distributed network. Thus enabling the capability of managing the vehicle interaction with the external world, including obstacles and pedestrians avoidance.

Smart Power Train- Functions' roadmap



Example of Smart Systems Integration

Integrated Lighting Systems based on chip-on-board LED technology



Industrial prototype of chip-LED taillight for Fiat IDEA (thickness 15mm)

TECHNOLOGIES

- LED light sources, integrated in die-form using chip-on-board technology
- LED sources integrated in micro-optics

Vision

Solid state emitting sources, novel nanoscaled high efficient phosphors, planar microoptics and sensors for light control in different conditions of visibility are **integrated directly on the external polymer cover**. By combining hybrid organic and inorganic technologies EPOSS envisions solutions with a **further integration of both solar energy converters and energy storage**.

System and Customer Benefits

- Thickness reduction (factor of 10)
- Increased efficiency/power reduction (-70%)
- Weight reduction (-50%)
- For-life operation
- Simplified installation
- Cost reduction (with respect to conventional LED technology)
- More stylistic options

Micro- nanotechnologies and Smart Systems Integration

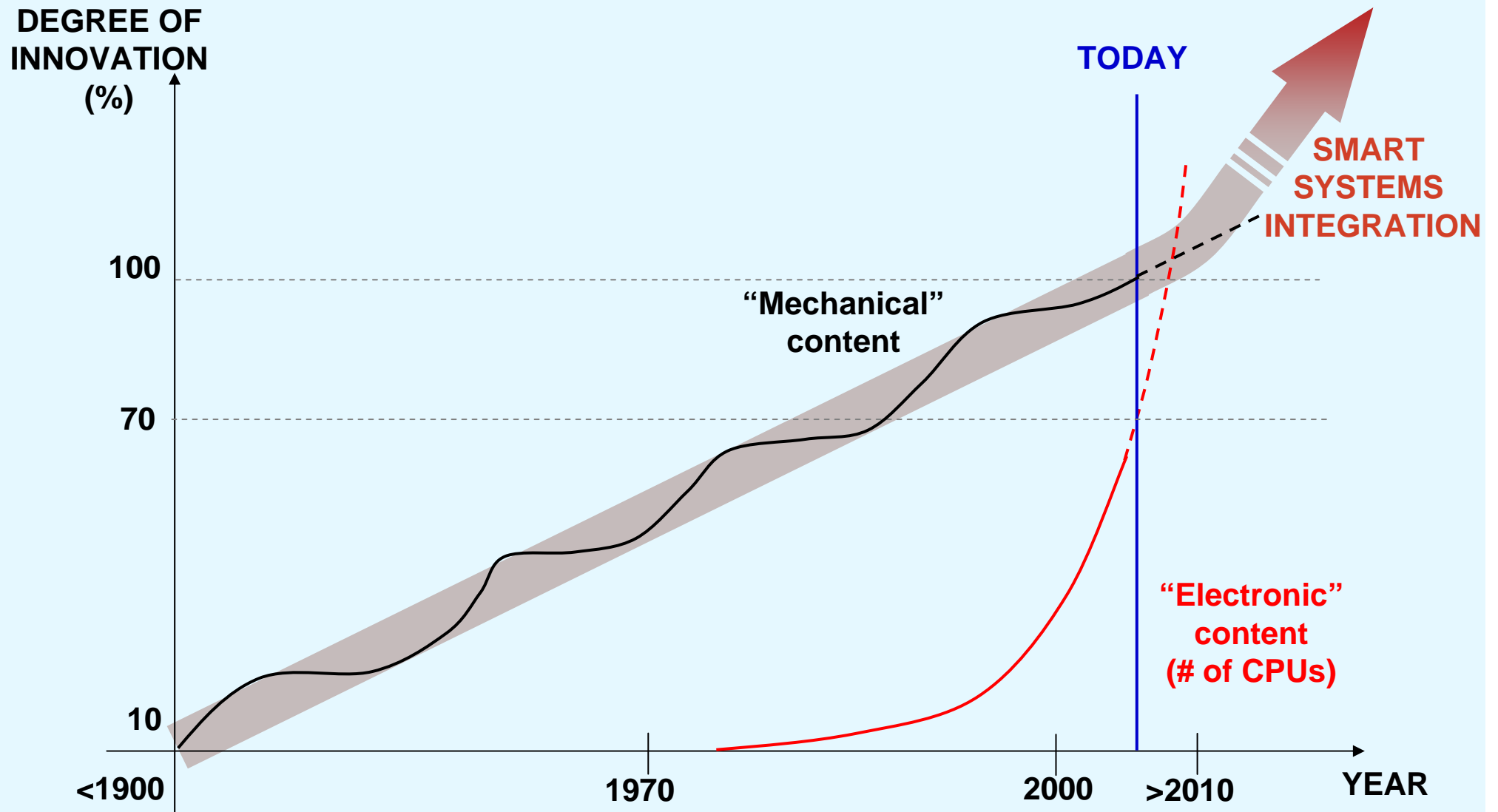
In many new technologies, it is common to overestimate what can be done in 5 years' time, and to underestimate what can be done in 50 years' time."

- Unknown

A CAR is a low cost complex assembly of more than 5000 pieces and a hundred of novel electronic based functionalities which can be in most cases conveniently re-engineered by micro-nanotechnologies and **Smart Systems Integration**

The Eposs Automotive Working Group

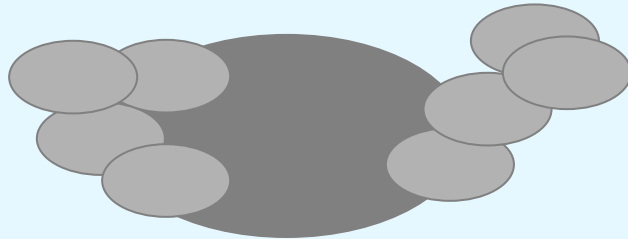
Micro-Nanosystem Integration to speed up innovation



Smart System Integration

A new paradigm towards sustainable complexity

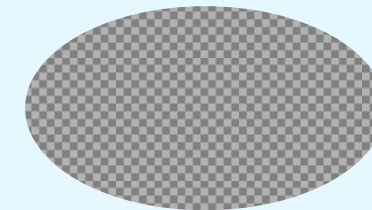
year 2000



Add-on Function

Complexity adds on top of Complexity
with the risk of losing the control

year 2010+

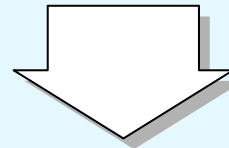


Distributed intelligence

Complexity is pervasive
and becomes manageable

Paradigm change

Increased smartness (and complexity) in **subsystems and components**
Higher complexity integrated in the material
Networking of subsystems

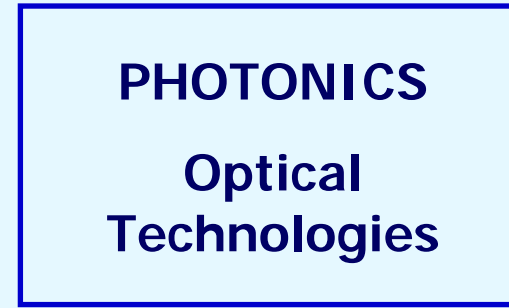
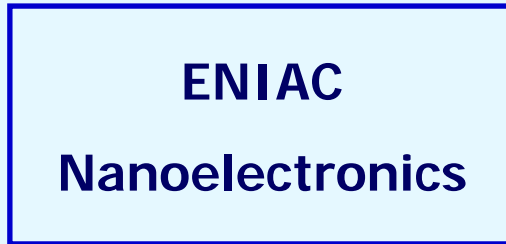


Reduced complexity at system level
Lower power consumption, weight, and cost
Higher robustness and reliability

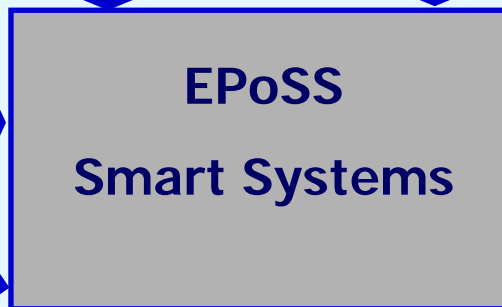
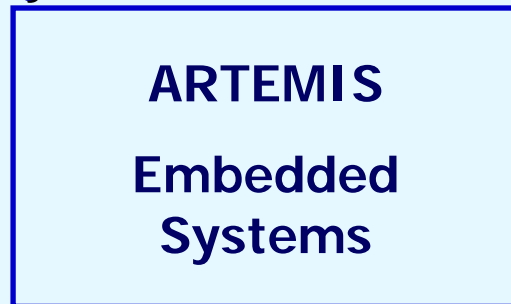
Growing complexity if properly managed, gives unique opportunities

NETWORKING BETWEEN THE FP7 TECHNOLOGY PLATFORMS

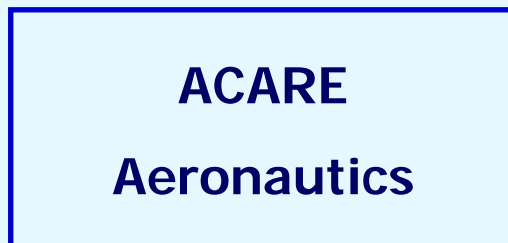
Component Level



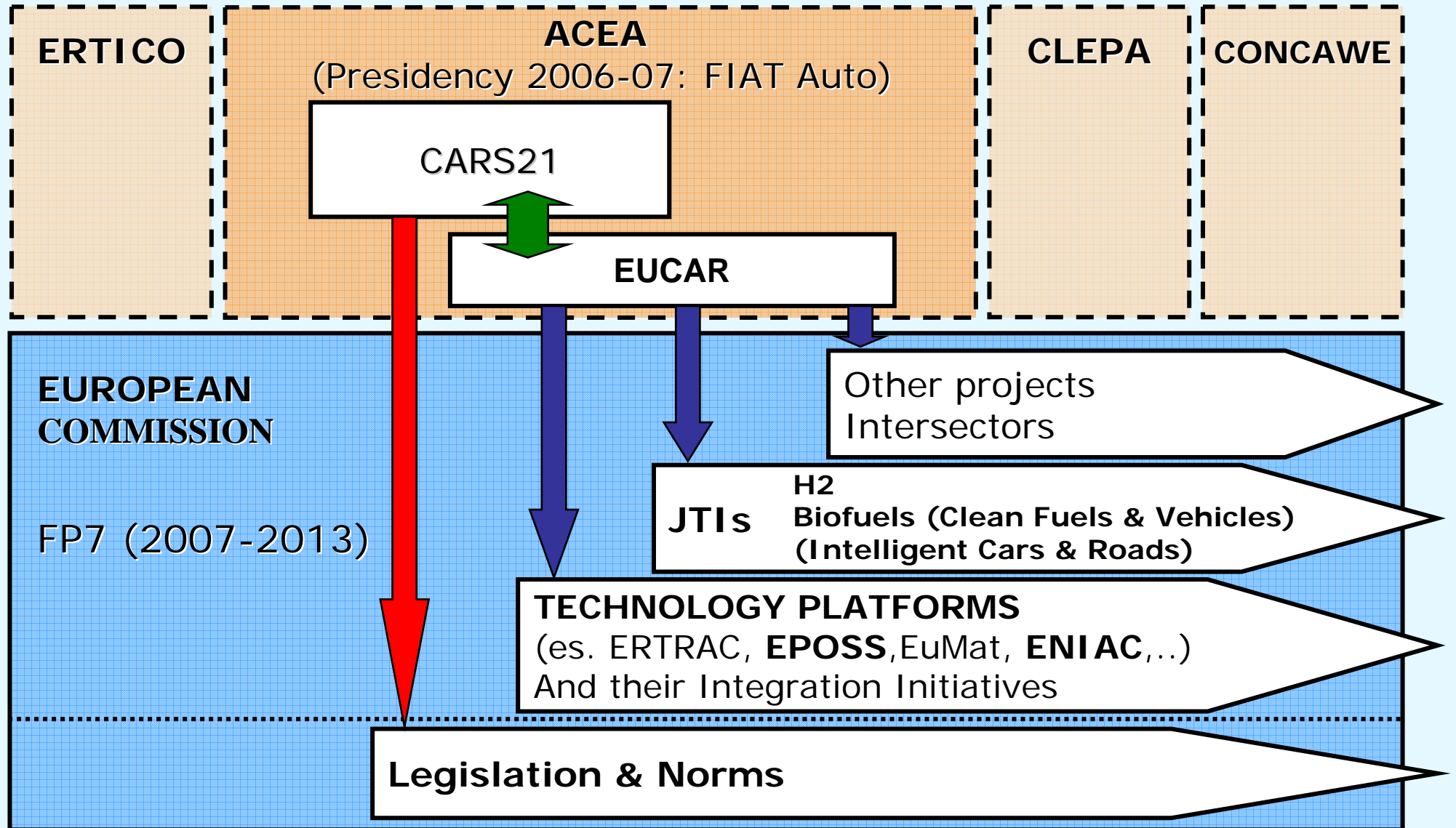
System Level



Application Level



EU PARTNERSHIP AND VISION



CONCLUSIONS

- **The fact that the Automotive represents both a challenge and a big opportunity for the EU Industry of Microsystems is widely acknowledged.**
- **Intelligent electronic-based systems already account for over 25% of the vehicle cost and penetration is expected to increase 15-20% a year in the next five years.**
- **Miniaturisation, wireless operation and networking** will be mandatory to mitigate the cost increase caused by the growing penetration of sensors, actuators and ICT.
- **“Only functions care”**: analysis of the functions as the starting point for the reengineering process.
- **“Complexity”** has to migrate from the systems to the subsystems/components all the way down to the materials; micro and nanotechnology will be key to this change.