DRIVING FORCES OF RESEARCH IN FUTURE SUSTAINABLE AUTOMOTIVE SYSTEMS

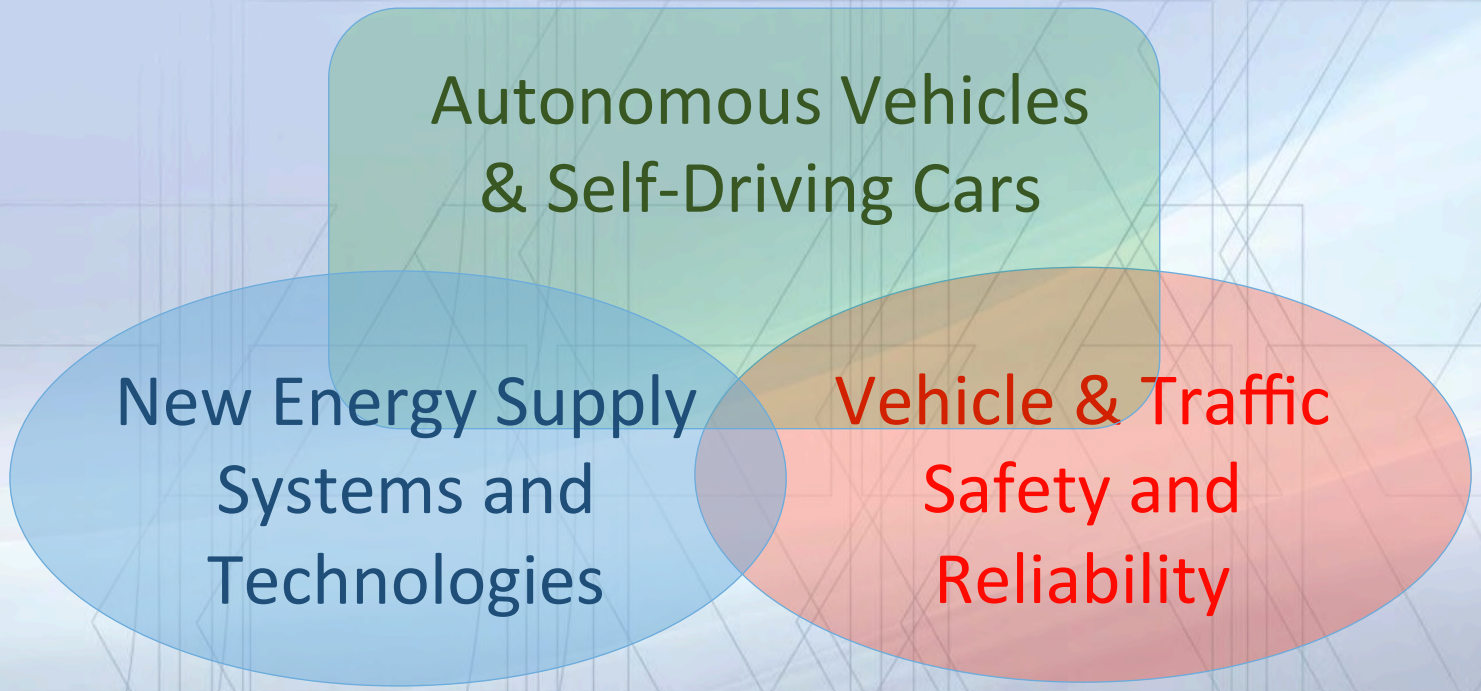
FROM A RESEARCHER'S POINT OF VIEW

Prof. József Bokor
member of the Hungarian Academy of Sciences

Cooperation between higher education, research institutes and automotive industry

Hungarian Academy of Sciences
Budapest, 31 January 2014

RESEARCH AND TECHNOLOGY AREAS



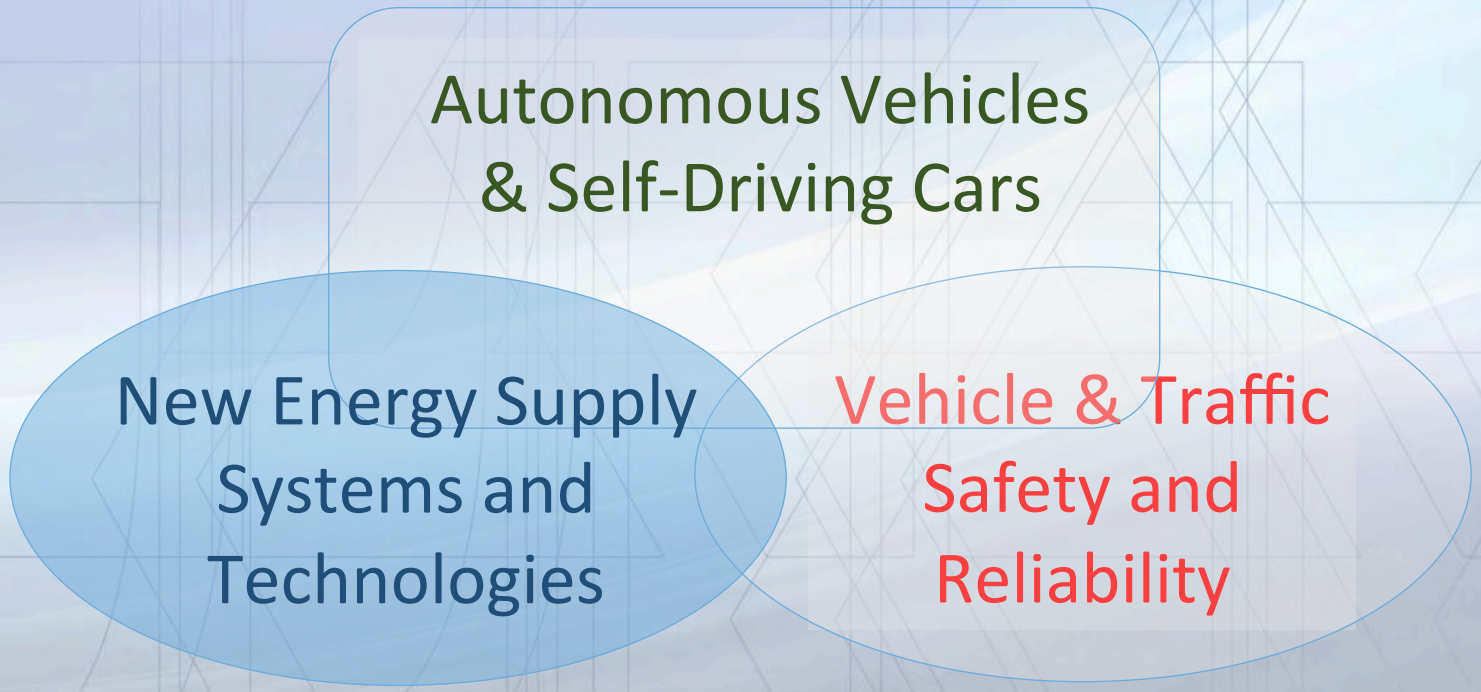
- Technology development for autonomous vehicles seems to be the main driving force of the future R&D in automotive
- More comprehensive autonomy could reduce traffic safety and efficiency further.

ROADMAP TO SELF-DRIVING CARS

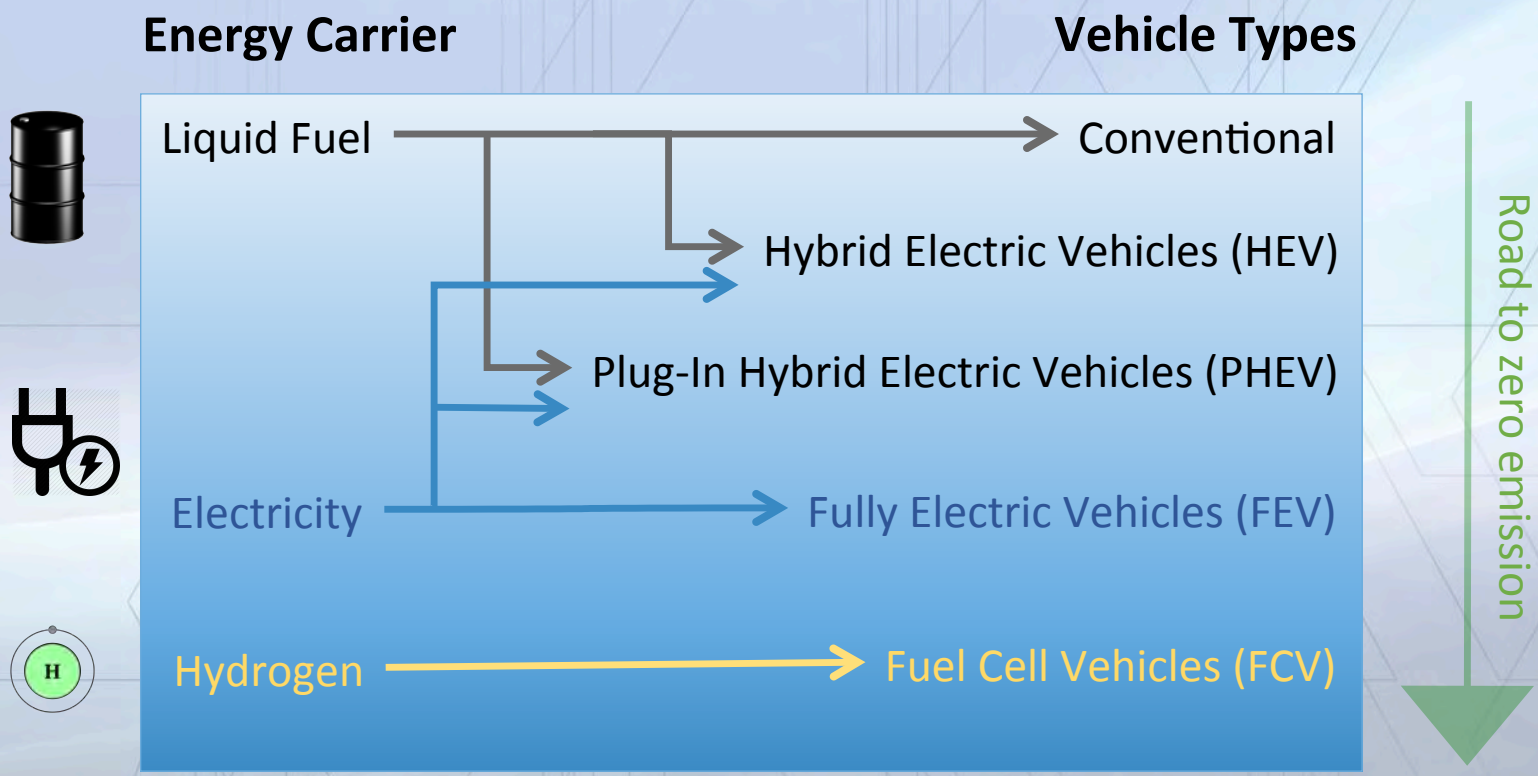
PREDICTIONS AND EXPECTATIONS

- 54 M self-driving cars by 2035 (in various levels of autonomy)
- Nearly all cars is self-driving by 2050

RESEARCH AND TECHNOLOGY AREAS



Energy Supply Systems



Hydrogen and electricity together represent the most promising ways to realize sustainable energy and fuel cells provide the most efficient way for converting hydrogen, and possibly other fuels, into electricity.

ENERGY SUPPLY SYSTEMS

ROADMARKS

1997: introduction of Toyota Prius in Japan. The world's automotive history turned to a new phase of development in 1997.

2000: Toyota and Honda HEVs are available in the US market.

There are more than 40 different models of HEV and PHEV vehicles available for sale these days.

The first Fully Electric Vehicle concept (EV-1) failed. The EV market collapsed around 1990, because of

- Limited range
- Long recharge time
- High cost
- Lack of infrastructure
- Lack of harmonized solutions and business plans
- Politics

ENERGY SUPPLY SYSTEMS

THE QUEST FOR RESOLUTION AND THE INEVITABLE ELECTRIC CAR

FEV and FCV are nascent technologies measured by the huge number of units which can be potentially sold worldwide.

EV-2 (with HEV, FEV and FCV included) is slowly making inroads into the transportation sector. Taking the idea to world-wide success the technology sector necessitates further research toward:

- New ideas for energy management and control.
- Novel electric drives, power train components and power electronics solutions with new temporary energy stores and battery types.
- Modeling and control of vehicle dynamics with regard to the electric drive concept.
- Integrated power train and battery management.
- Intensified joint efforts of electric, mechanical and control engineering.
- Reconsideration of societal challenges in a much wider perspective.
- To understand that EV-2 is a large-scale, system-wide concept, which would benefit from complex integrated solutions.

Energy Supply Systems

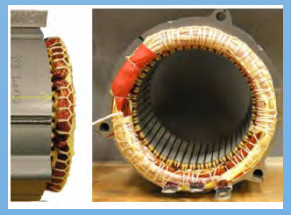
Research Projects at the JKK

- Motor drives modelling and identification
  - Building control oriented mathematical models by using both conceptual and empirical modelling methods.
  - distributed parameter (finite element) modelling of the magnetic, thermal and mechanical fields.
  - development of control oriented models using empirical parameter estimation and system identification methods.
- Motor drive electronics and controller implementations
  - microcontroller/microcomputer-based embedded electronics,
  - microcontroller/microcomputer software implementations,
  - building methodologies for high level (graphic, symbolic) programming and automatic low level code generation.
- Development of simulation platforms – HIL/SIL
- Validation of Electric Vehicle Drive implementations.

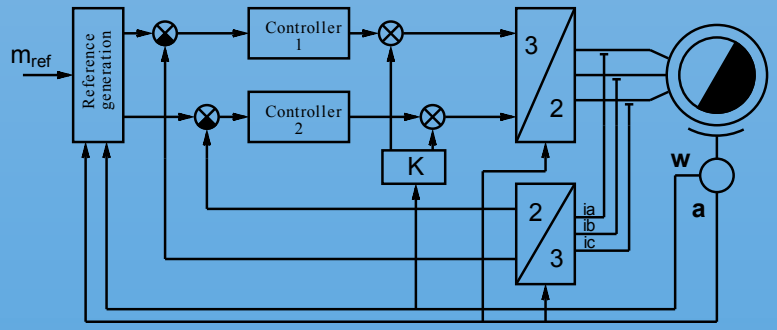
ENERGY SUPPLY SYSTEMS

RESEARCH PROJECTS AT THE JKK

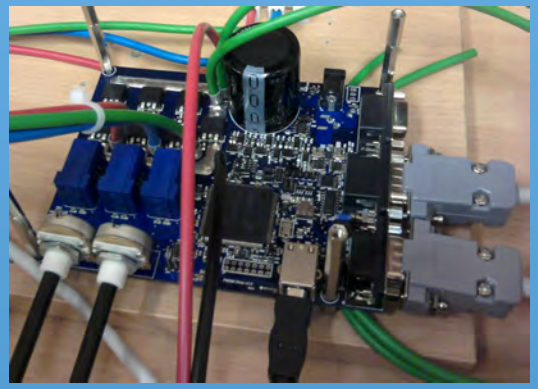
- Development of high torque and high efficiency Permanent Magnet Synchronous Motor (PMSM)



- Field Oriented Control (FOC) using Dynamic model of PMSM



- Embedded realization of the controller on a microcontroller platform



ENERGY SUPPLY SYSTEMS

THE QUEST FOR RESOLUTION AND THE INEVITABLE ELECTRIC CAR

Electric and Hydrogen fueled cars challenge new approaches to

- safety management
- distributed energy production
- fuel distribution (electricity grid, hydrogen refueling)
- ensure economic competitiveness

Safety regulations, codes and standards.

- A large barrier to the commercialization of electric and hydrogen energy technologies is the lack of safety measures on components and systems used by the technology onboard and in the refueling infrastructure (fire integrity, crashworthiness, material and component characteristics, hydrogen and battery leakage and unscheduled releases of chemicals in confined spaces).

Awareness and education

- to increase public acceptance of hydrogen and electric technologies
- produce human resources required by the operation of the large-scale systems

Research and Technology Areas

The question is not IF but WHEN

The self-driving car concept is a seamlessly integrated fusion of radar, cameras and other sensors, and advanced inter-vehicle communications

AUTONOMOUS (SELF-DRIVING) CARS

LEVELS OF AUTONOMY

① No autonomous driving features.

② Drivers initiated systems including lane keeping in cruise control, distance control, emergency braking, autonomous parking.

③ Computer control of vehicle functions ensuring autonomy in special situations.

④ Full autonomy in certain situations (highway driving). No drivers interaction is needed. OEM vendors target the feature on various horizon:

- Audi, BMW, Mercedes, Nissan - 2020
- Tesla - 2016
- Ford - 2017

⑤ Door-to-door autonomous driving.

⑥ Autonomous driving systems without allowing human control of any kind.

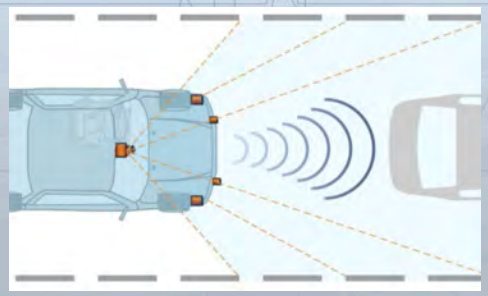
AUTONOMOUS (SELF-DRIVING) CARS

FROM STAND-ALONE TO NETWORKED SOLUTIONS

The stand-alone solution

The Google-car

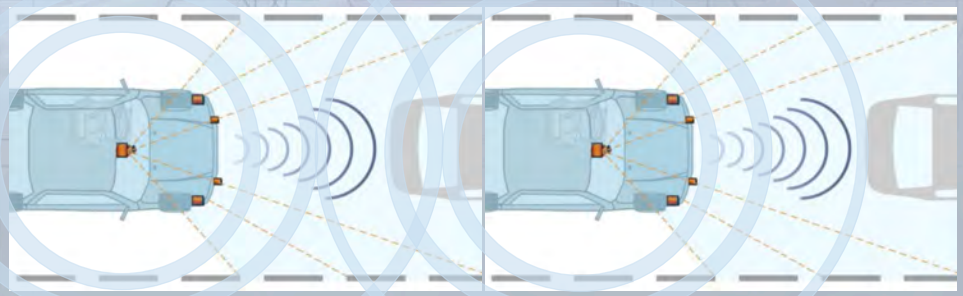
- Vehicle is under full control of on-board electronic systems (sensors/ actuators) and control solutions.
- Driving performance and traveling objectives are planned individually based on local available information.



The connected car solution

- Vehicle is under full control of on-board systems and solutions.

+ Interaction with the road and the immediate environment.
+ Driving performance and traveling objectives are cooperatively assigned.
+ Information fusion for higher control accuracy based on cooperative techniques.
+ Connection with traffic control systems, the Internet and the Cloud.

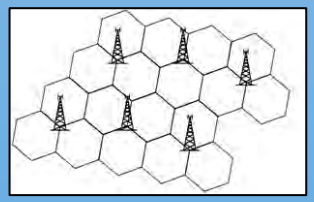


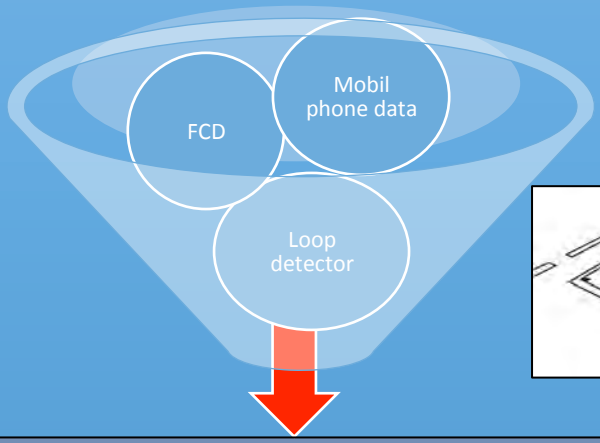
AUTONOMOUS (SELF-DRIVING) CARS

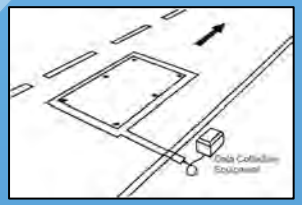
RESEARCH PROJECTS AT THE JKK

Floating Car Data-Based Sensor Fusion

- Improve applications accuracy
- Mobile and Vehicle data collection and fusion based on V2I communication methods







Data Fusion

For traffic forecasting, navigation, control

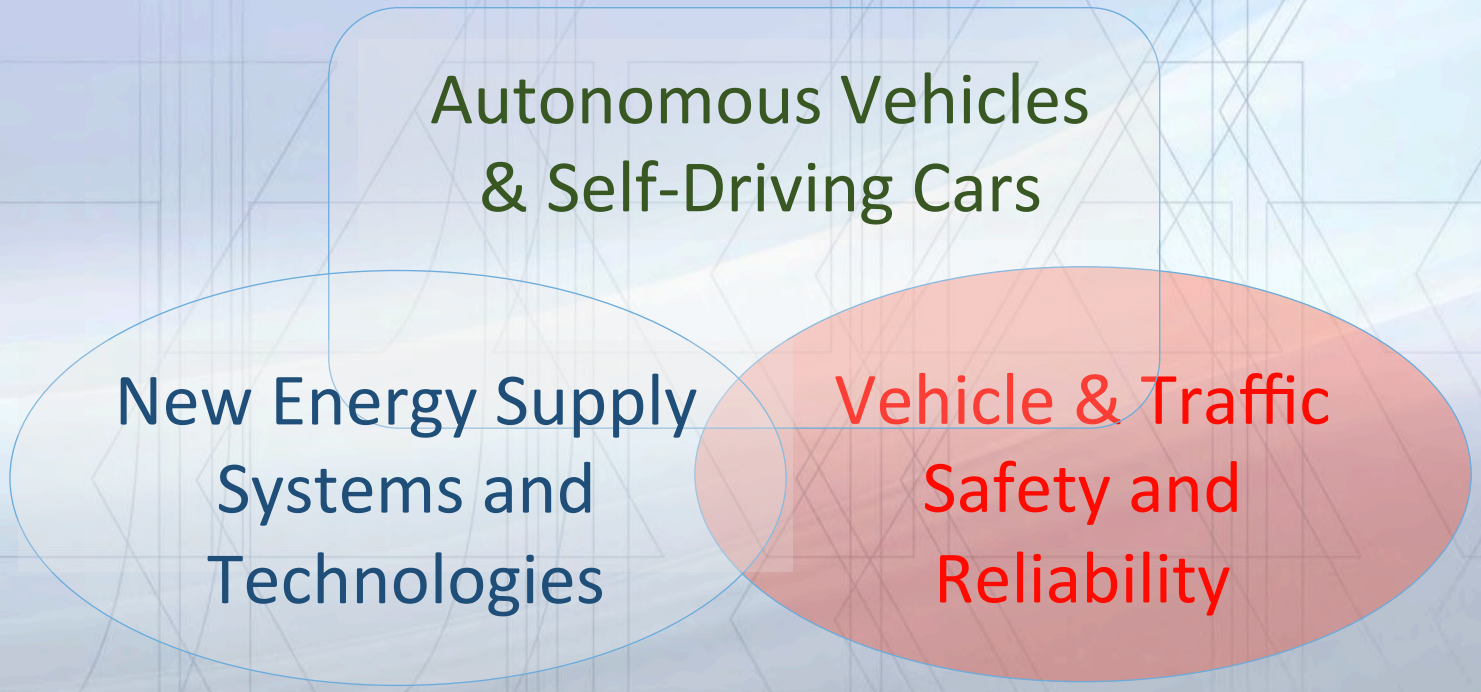
AUTONOMOUS (SELF-DRIVING) CARS

RESEARCH PROJECTS AT THE JKK

Platooning

A well-organized platoon control may have advantages in terms of increasing highway capacity and decreasing the travelling energy, fuel consumption and emissions.

RESEARCH AND TECHNOLOGY AREAS



VEHICLE & TRAFFIC SAFETY

RELIABILITY AND EFFICIENCY ENHANCEMENTS TECHNOLOGIES

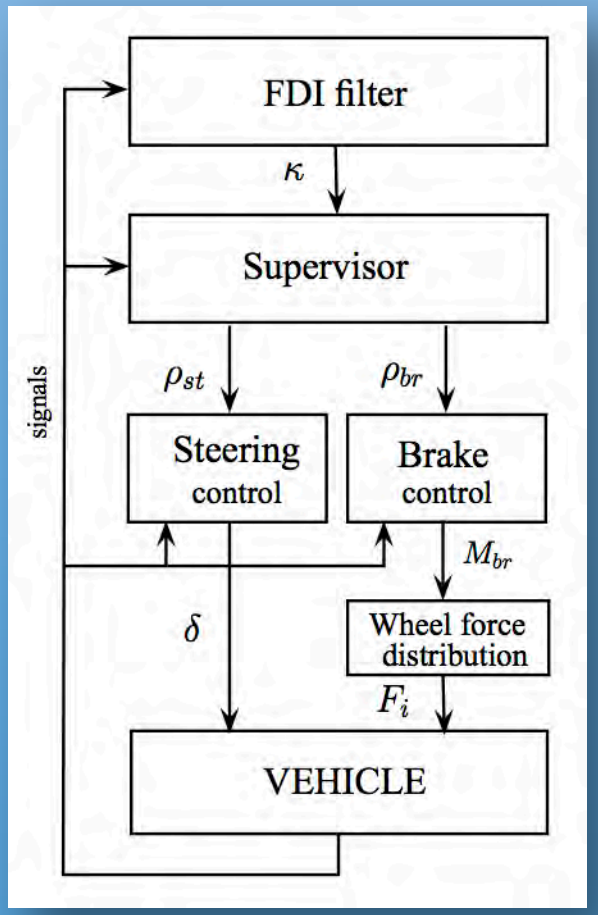
- An important challenge with a system that drives all by itself, even if only some of the time, is that it must be able to predict when it may be about to fail, to give the driver enough time to take over.
- This ability is limited by the range and accuracy of a car's sensors and detection capabilities and by the inherent difficulty of predicting the outcome of a complex situation.
- In case, from any reason, the onboard systems of the car fail, it may take five, six, seven … seconds to be able to come back to the driving task again, or hand over the task to the human driver—that means the car has to know [in advance] when its limitation (technical, physical or anything) is reached.
- The driving autonomy is fragile. The challenge is very big.

Fault tolerant design, failsafe behaviour

Control systems reconfiguration

A fault-tolerant control is able to change its operation in case of faults and adapt to the new faulty conditions.

- fault must be detected by an FDI filter,
- fault information must be taken into consideration in the control design.



AUTONOMOUS (SELF-DRIVING) CARS

SECURITY ISSUES

The self-driving car as complex cyber physical system

- Self-driving cars are irresistible to hackers and malicious actions
- Potential targets to hackers are onboard sensors (injection of deceptive information) and communication (interception and modification of messages),

CONCLUSIONS

COOPERATION BETWEEN HIGHER EDUCATION, RESEARCH INSTITUTES AND AUTOMOTIVE INDUSTRY

TÁMOP-4.1.1.C-12/1/KONV-2012-0002

BASIC RESEARCH FOR THE DEVELOPMENT OF HYBRID AND ELECTRIC VEHICLES

TÁMOP-4.2.2.A-11/1/KONV-2012-0012

"SMARTER TRANSPORT" - IT FOR CO-OPERATIVE TRANSPORT SYSTEM

TÁMOP-4.2.2.C-11/1/KONV-2012-0012

Nemzeti Fejlesztési Ügynökség
www.ujszechenyiterv.gov.hu
06 40 638 638

HUNGARY'S RENEWAL

The projects are supported by the European Union and co-financed by the European Social Fund.

THANK YOU FOR YOUR ATTENTION.