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Central European Institute of Technology
BRNO | CZECH REPUBLIC

CEITEC activities towards Mobility 4.0, automated driving and robotics

Prof. Pavel Václavek, Research group leader
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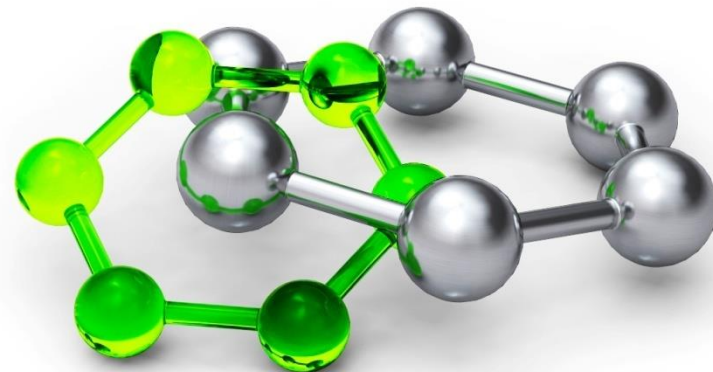**Prof. Luděk Žalud, robotics lab. leader**
ludek.zalud@ceitec.vutbr.cz

Aim and Vision

" *CEITEC is a scientific centre in the **fields of life sciences, advanced materials and technologies** whose aim is to establish itself as a recognized European centre of science.* "

CEITEC is leading a path to

global scientific recognition

through synergy and collaboration,

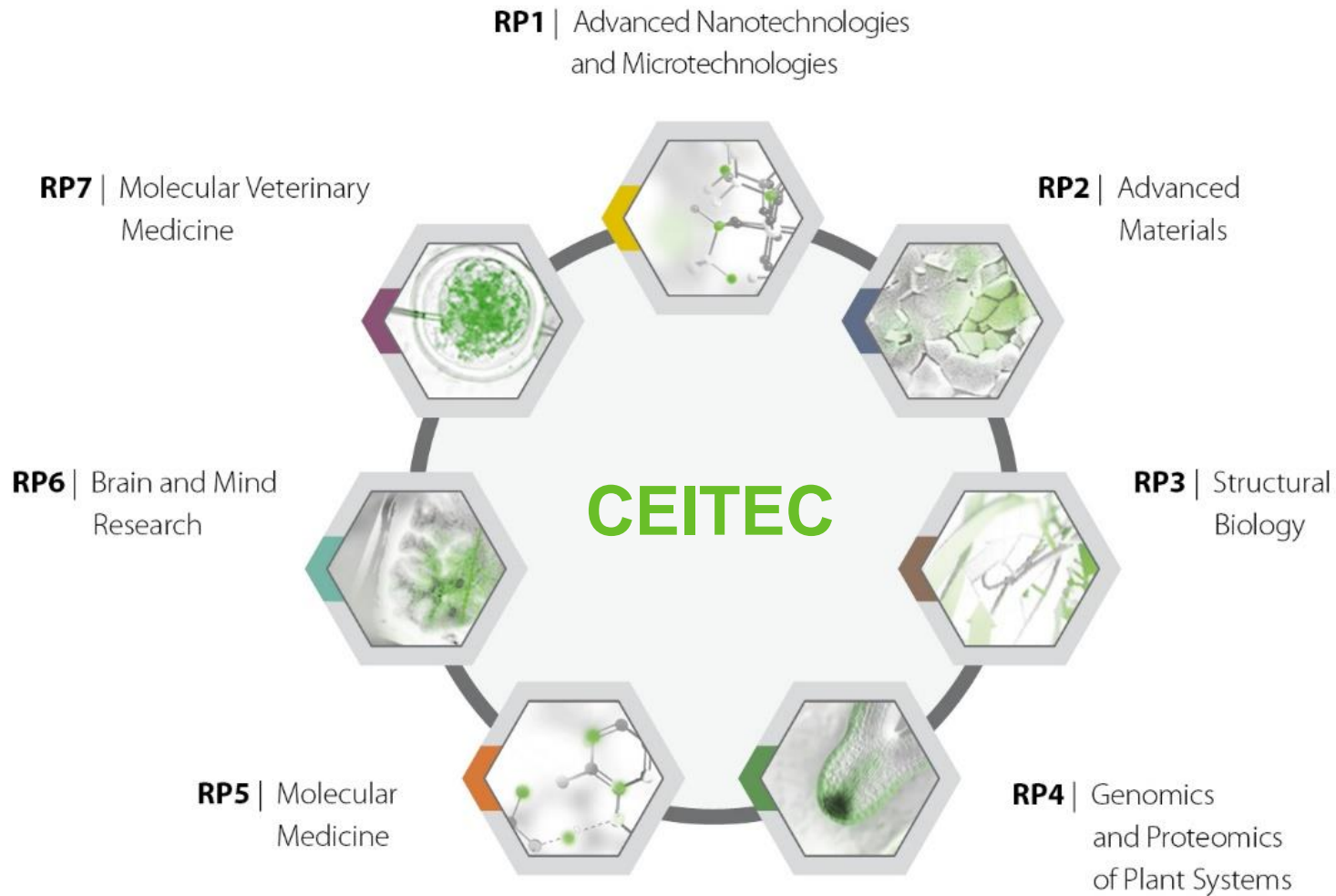*in order to achieve a regional knowledge-based economy.*

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CEITEC - overview

- **6** partners
- **600** researchers
- **7** research programmes
- **63** research groups
- **25,000 m^2** of new laboratories
- **10** core facilities
- Budget (eligible cost): **EUR 208/ USD 275 mil.**
- Start of research activities: **Q1 2011**
- Startup phase completed: **Q4 2015**
- Now in full operation
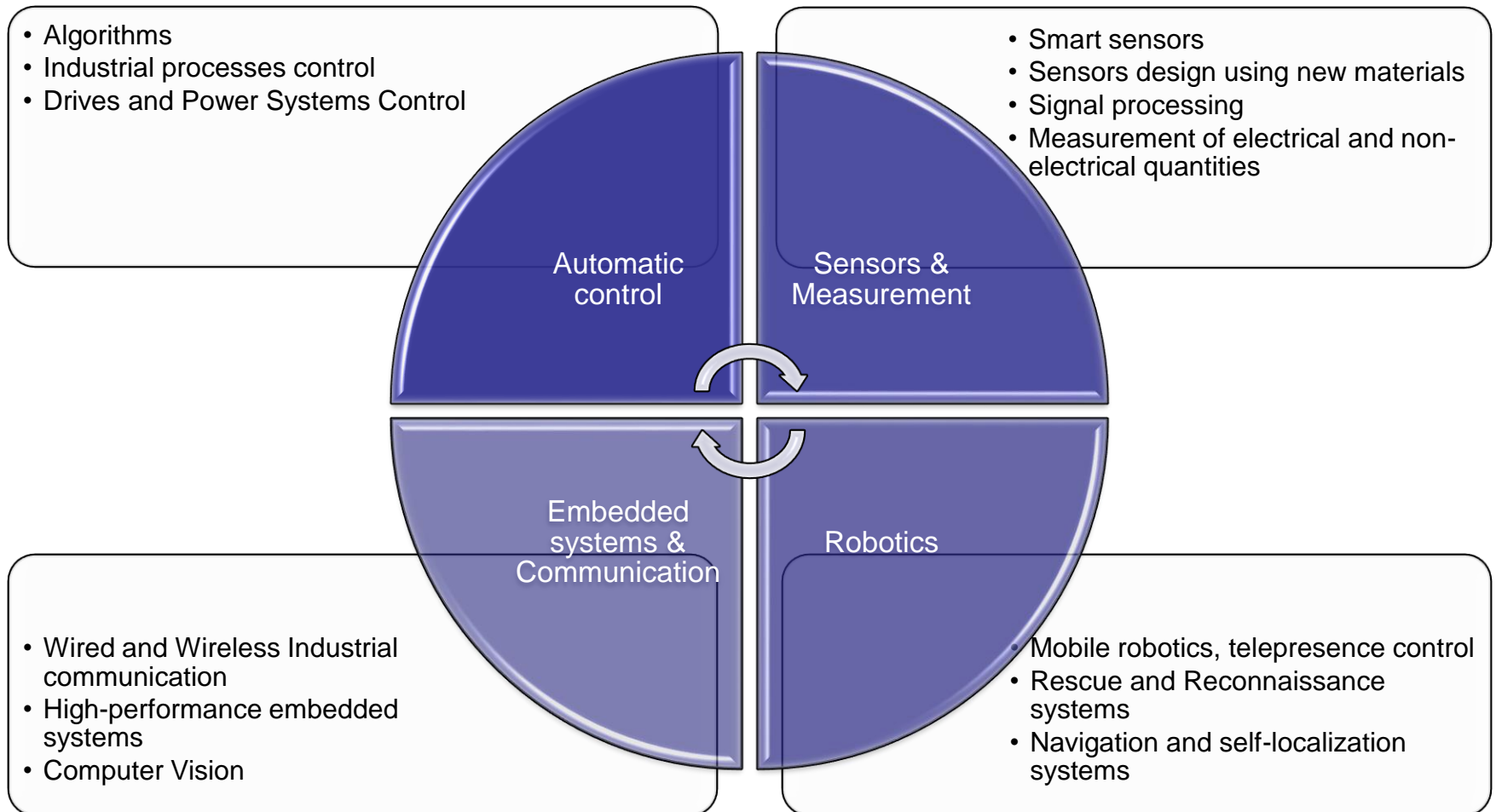
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Brno/Czech Republic/Europe

Research Programmes

RP1 | Advanced Nanotechnologies and Microtechnologies

RP2 | Advanced Materials

RP3 | Structural Biology

RP4 | Genomics and Proteomics of Plant Systems

RP5 | Molecular Medicine

RP6 | Brain and Mind Research

RP7 | Molecular Veterinary Medicine

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Research Group
# Cybernetics in Material Science

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Research topics
Cybernetics in Material Science

50 researchers

Automatic control
- Algorithms
- Industrial processes control
- Drives and Power Systems Control

Sensors & Measurement
- Smart sensors
- Sensors design using new materials
- Signal processing
- Measurement of electrical and non-electrical quantities

Embedded systems & Communication
- Wired and Wireless Industrial communication
- High-performance embedded systems
- Computer Vision

Robotics
- Mobile robotics, telepresence control
- Rescue and Reconnaissance systems
- Navigation and self-localization systems

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Automatic Control

- Modern control theory applications – robust and predictive control, control performance assessment, state observers
- Advanced control systems for AC drives control
- Sensorless drives
- Drives modeling and parameters estimation
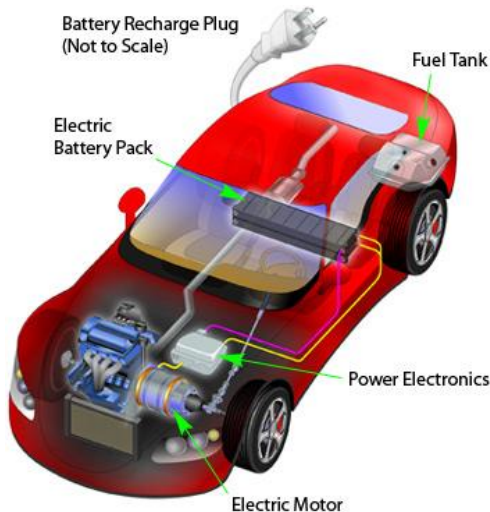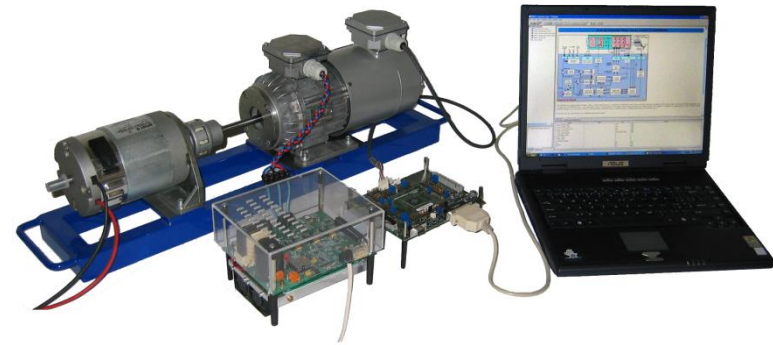
- "Green" cars powertrain control – multiphase and high-speed machines
- Fail-safe and Fail-operational control
- Drive, electronics and sensors self-diagnostics
- Implementation and verification of control algorithms in embedded systems

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Sensors and Measurement

- Methods of electrical and non-electrical quantities measurement
- Signal processing
- Smart sensors, wireless sensors
- Sensors calibration and diagnostics
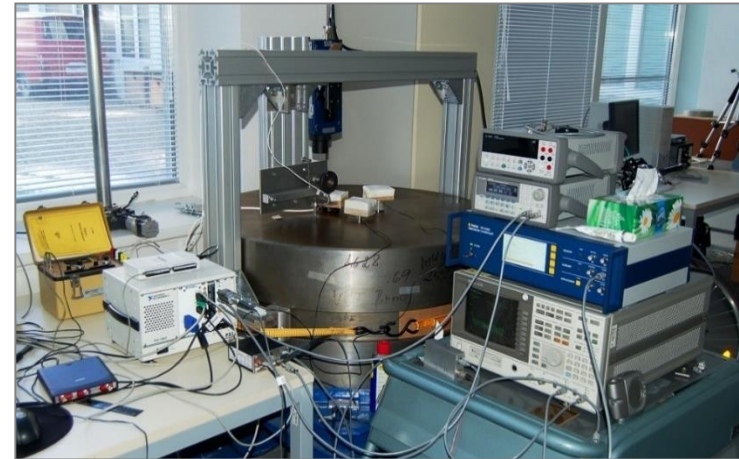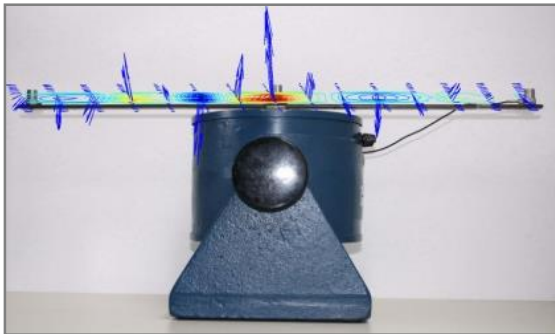
- Specialization on vibration and noise measurement
- Non-contact vibration measurement, Laser Doppler vibrometry
- Development and applications of Near-field acoustic holography methods, sensor arrays
- Acoustic Emission measurement
  - sensors calibration
  - non-destructive diagnostics of materials and systems

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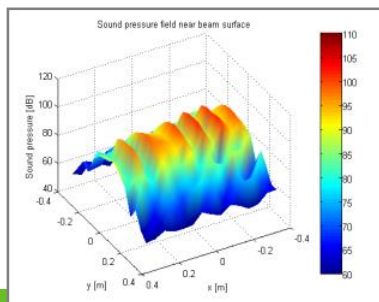
# Embedded systems, communications and image processing

o Embedded systems design: MCU, FPGA, DSP, …;

o Security, reliability and safety related applications

o Real-time OS based applications

o Wired and Wireless industrial communication
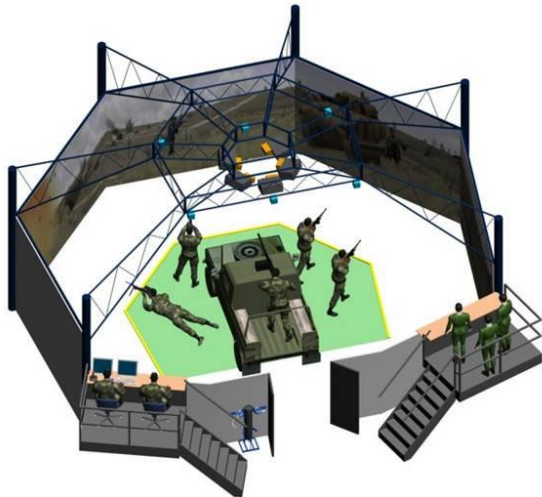
o Design of High-Frequecy (GHz) solutions, RF design, VHDL design

o Image Processing - High Speed, Smart Camera, 500 frames/s, 1280x1024 pix

o Image processing for industrial and transportation application, visual simulators applications (eg. military simulators, laser beam tracking,..)

o Human-machine interfaces for industrial and transportation systems

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Mobile Robotics and Telepresence

- reconnaissance of dangerous areas
  - chemical/nuclear contamination measurement
  - victim search&identification

- user interfaces
  - visual telepresence
  - augmented reality

- spatial technologies for medical rehabilitation
  - motion capture
  - optical scanning – 3D spatial, thermo
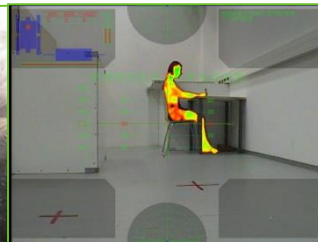
ATEROS
Autonomous Telepresence Robotic System

- single-operator robotic system with heterogeneous robots
- unified system approach – communication, user interface
- wide variety of missions: CBRN, area/facility guarding, environmental mapping, US&R

BIG UGV

MAPPING

SMALL UGV

UAV

OPERATOR

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ORPHEUS-AC2 – CBRN Robot

- military reconnaissance robot
- measurement in environments with radiation/chemical/biological contamination
- 2 chemical, 2 radiation sensors
- communication: wireless/by wire

- prepared for hard outdoor terrain
- extreme working conditions – temperatures, vibrations, EMC
- military-grade tests NATO – STANAG
- from 2014 in active armament of Czech Army
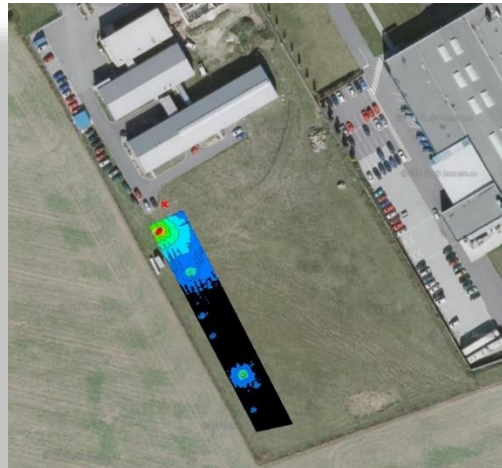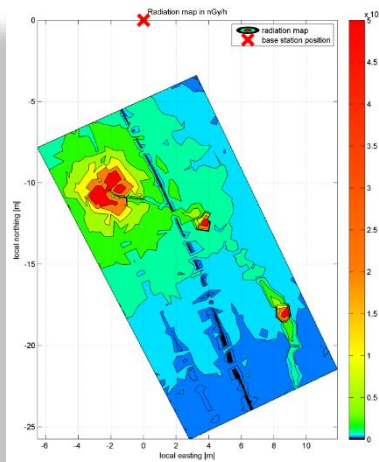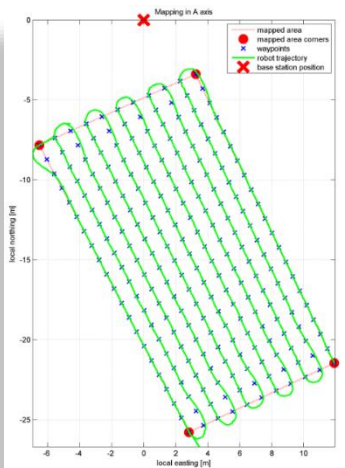

ORPHEUS AC

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MORPHEUS

- outdoor robot for environmental measurement
- maximum space for sensors
- custom – made motors inside the wheels
- high speed – up to 15 km/h
- maximum payload – 30 kg

- appropriate for:
    - gamma radiation measurement,
    - autonomous 3D map building,
    - victim search, etc.
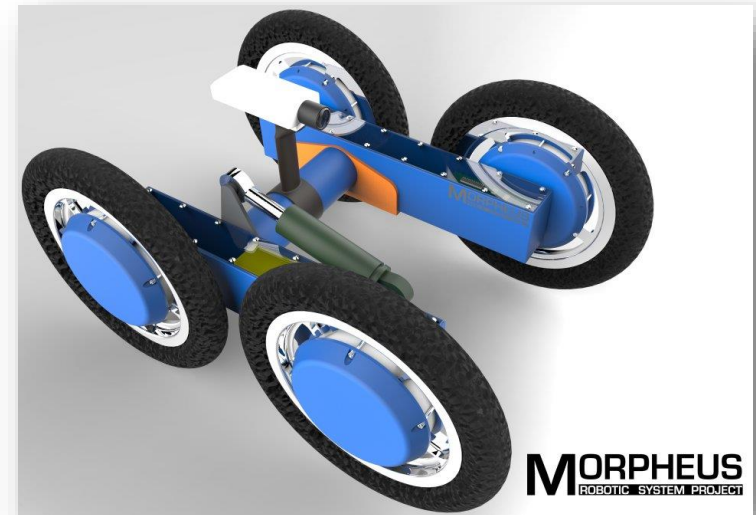
Radiation Field Measurement

- precise self-localization and navigation – fusion RTK-GNSS, INS, odometry
- autonomous path-planning

Activities towards Mobility 4.0
e-cars, automated driving

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Technology evolution
in the automotive business

Future vehicle requirements
Autonomous electrified connected

Affordability, Efficiency,
Safety, Availability

Advanced mobility solution
Co-Modality , Smart Mobility

Car2me

Robot taxi

Transportation / Infrastructure

Todays vehicle concerns

Low Emission ZONE

Sharing & mobility on Demand
Shared car, fleet concepts

The car of the future

With more people moving to
cities and using smart phones,
car sharing will become easier

Connect to the web to
preheat your oven
from the car

Your car might even drive you to
work then drive itself home
so you won't have to park

www.pwc.co.uk/megatrends   #megatrends   #sharingeconomy

Novel

Product innovation

Optimizing

Traditional

Business Model innovation

Revolutionary

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AutoDrive
EU light-house project in automated driving

- AutoDrive – project aimed at **highly and fully automated** vehicles, covering sensing, perception, communication, decision/control and actuation subsystems.

- Key industrial partners – Infineon Technologies, Daimler, BOSCH, NXP, ZF Friedrichshafen (60 leading companies and institutes from Europe + ITRI Taiwan)

- selected by EU to be **Mobility 4.0 light-house initiative**

  - we will play light-house role on EU automated driving road-map for years 2017 – 2020

  - clustering of EU automated driving research projects, standardization and commercial activities

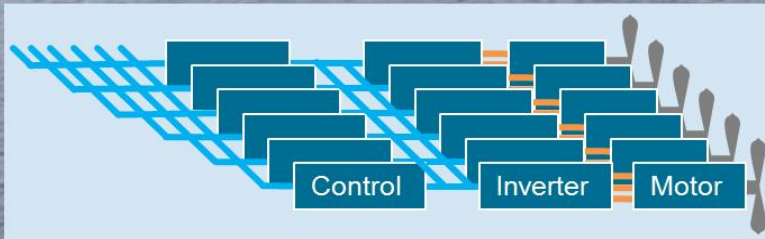# AutoDrive - CEITEC contribution to Mobility 4.0

- Fail-safe systems are not sufficient, automated driving will rely on fail-aware and fail-operational systems.

- Making links between automotive and airspace industry to make driving as safe as flying.

- CEITEC is key partner in AutoDrive project and Mobility 4.0 initiative for

    - Control, monitoring and diagnostics of fail-operational powertrains (automotive / aviation electrical powertrains)

    - 3D surround sensing – 3D map building algorithms, navigation data fusion, SLAM techniques, moving obstacles detection
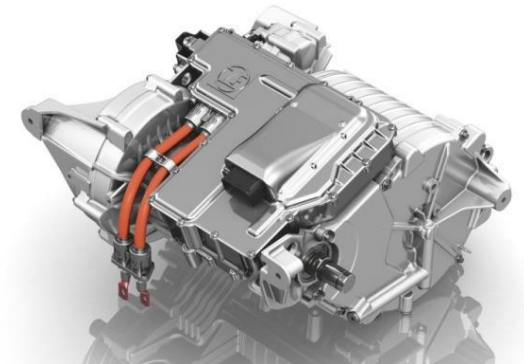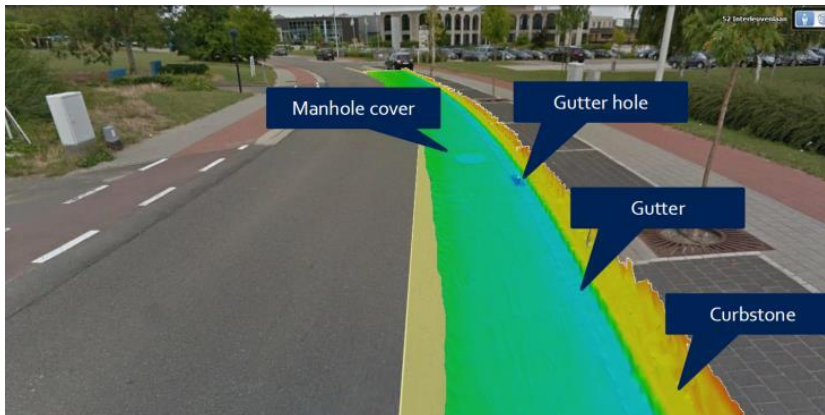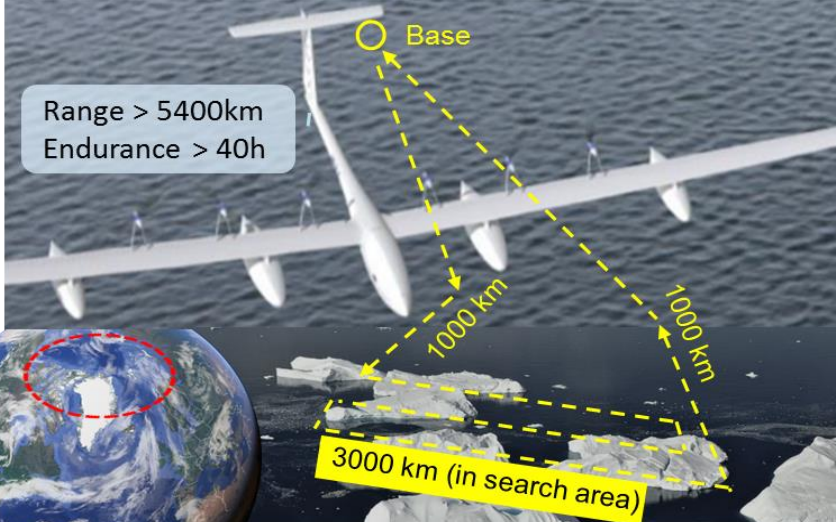
AutoDrive: when fail-safe is not sufficient, rely on **fail-aware and fail-operational components**

Fail-operational aviation powertrain
6 time redundant: motors, inverters, fuel cells

Control   Inverter   Motor

Base
Range > 5400km
Endurance > 40h
1000 km
1000 km
3000 km (in search area)

Fail-operational automotive powertrain
6 phase motor and inverter

Power net   DC/DC
Battery   Charger
Motor   Inverter

Research projects

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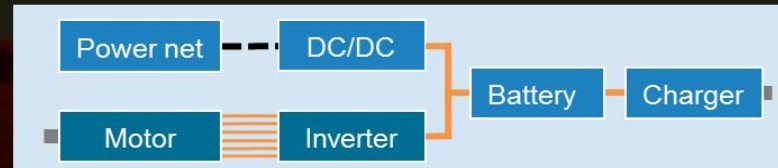
Recent projects

MotorBrain - Nanoelectronics for Electric Vehicle Intelligent Failsafe Power Train - www.motorbrain.de

○ EU FP7 ENIAC initiative project, 2011-2014 - 30 partners from Austria, Czech Republic, Germany, Spain, Italy, Netherlands, Romania, Sweden, United Kingdom – Infineon, Siemens, ZF Friedrichshafen, Fraunhofer, TU Dresden, NXP, ST Microelectronics, Fiat,…

○ Development of a new powertrain for electrical car, CEITEC involved in the drive control system design and implementation

○ RG involved in electrical drive advanced fault tolerant control, energy efficient control, drive and electronics diagnostics

○ Prototype presented at the Hannover Messe "MobiliTec" in 2014
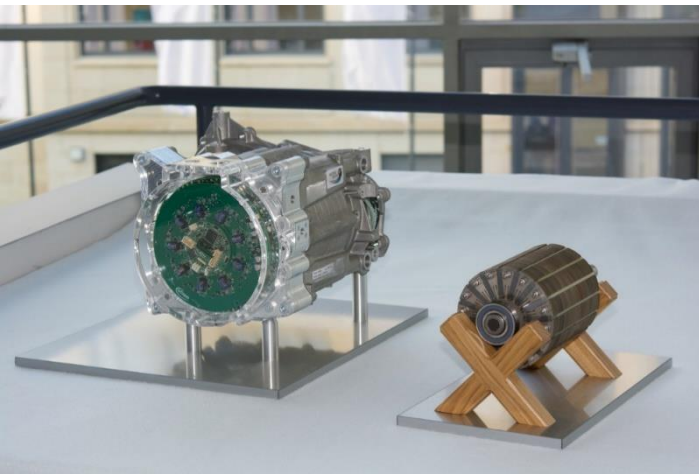
Recent projects

CREDO – EU project within 6th FP Aeronautics and Space, 2006-09

Cabin noise Reduction by Experimental and numerical Design Optimization

- Main objective
  - Determination of sound power entering aircraft cabin - Analytical tools, experim. procedures **=> For fast and cost-effective design of low-noise cabins**

- Developed technologies
  - Local interior field measurement/processing algorithms
    - microphone array methods, **NAH, beamforming**
    - **scanning laser Doppler vibrometry**

- Project consortium
  - EU universities and research centers (Italy, France, CR)
 - Industrial and end users (B&K, DLR, EADS, Alenia, Dassault)
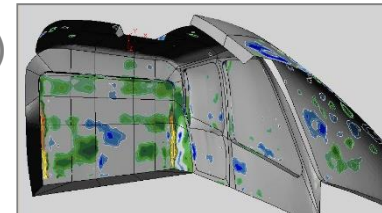
    Project successfully finished 2009

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Current projects

EMC2 - Embedded multi-core systems for mixed criticality applications in dynamic and changeable real-time environments - www.artemis-emc2.eu

- large EU FP7 JTI ARTEMIS project (2014 – 2017) – 100 partners, 100 mil. EUR (Infineon, BMW, AUDI, Volvo, ABB, Fraunhofer, NXP, Siemens, AIT, Thales, Rockwell, TU/e, Technion)

- CEITEC responsible for development of control algorithms for industrial drives, e-car powertrain control, computer vision
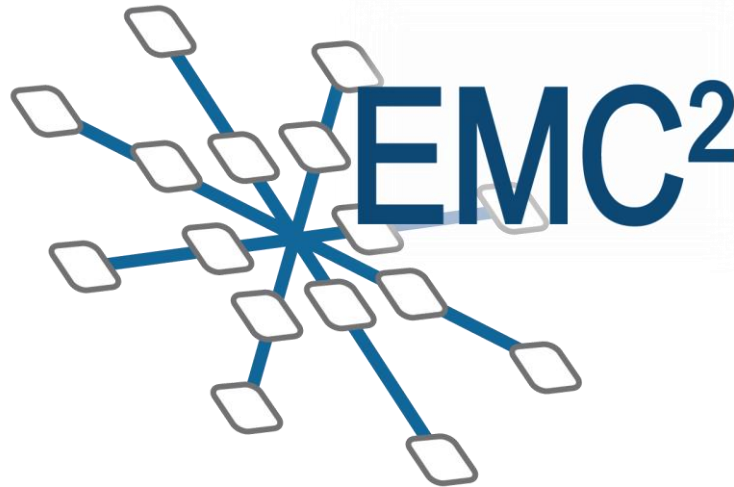
Current projects

3Ccar - Integrated Components for Complexity Control in affordable electrified cars – www.3ccar.eu

- large EU H2020 JTI ECSEL project (2015 – 2018) – 50 partners, over 50 mil. EUR (Infineon, BMW, Daimler, Fraunhofer, Siemens, OTH-AW, TU Dresden, AVL, AIT, ITRI Taiwan…..)

- CEITEC responsible for development of control algorithms for powertrain and smart servos, electrified car energy management.

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Current projects
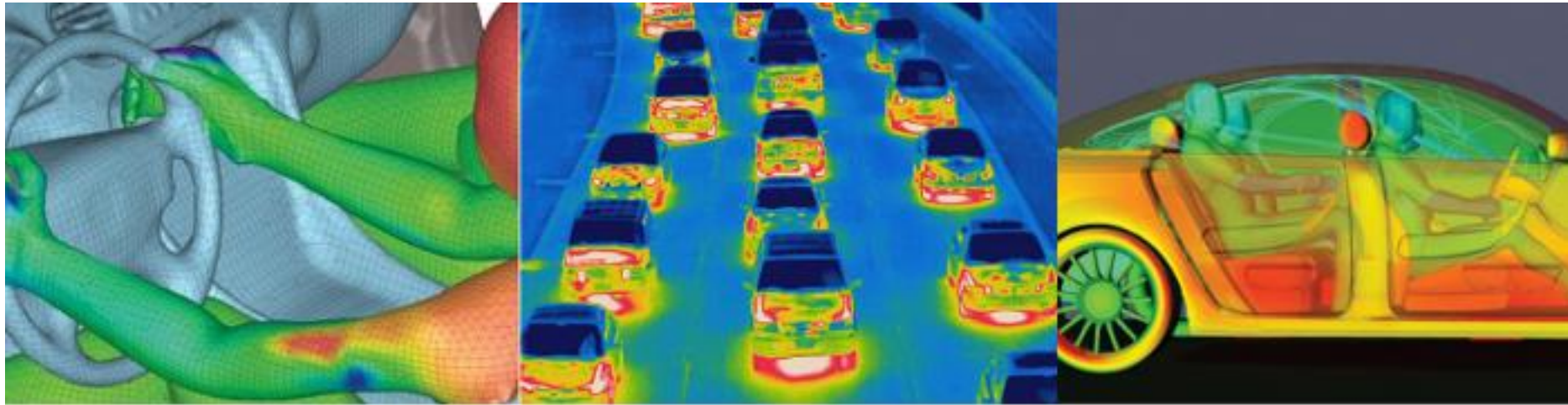
H2020 – OSEM-EV - Optimised and Systematic Energy Management in Electric Vehicles – www.osem-ev.eu

• large EU H2020 project (2015 – 2018) – 12 partners, over 8 mil. EUR (Infineon, Daimler, Fraunhofer, Siemens, TU Dresden, AVL, Valeo….)

• CEITEC responsible for development of control algorithms for energy flow management.

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Current projects

Precise monitoring of diabetic nectrotic tissue and inflammation

RoScan – robotic multispectral/hyperspectral scanner

- Industrial manipulator + set of optical sensors
  - 2D triangulation proximity scanner
  - thermal imager
  - color CCD camera

- cheap
- fast
- no radiation to the patient body
- 3D data may be analyzed and stored for comparison

ASTON!SH
Advancing Smart Optical Imaging and Sensing for Health

http://roscan.ceitec.cz/

- resolution: **0,01 mm**
- precision: **< 0,05 mm**
- reach: **1000 mm**
- acquisition time: **30s**
- patient restrictions: **none**
- scanning cost: less than 1 EUR

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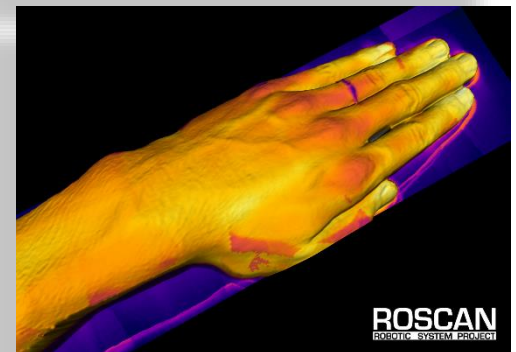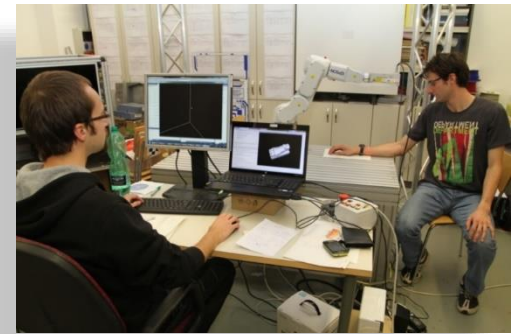
Cooperating institutions (international projects and contract research)

- Key cooperation partners
    - Infineon Technologies
    - Daimler
    - Siemens
    - Fraunhofer
    - ZF Friedrichshafen
    - TU Dresden
    - Ostbayerische Technische Hochschule Amberg-Weiden
    - NXP Semiconductors
    - Honeywell
    - National Instruments
    - ABB
    - Rockwell Automation
    - Brüel & Kjær
    - DIGNIO
    - Saab

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