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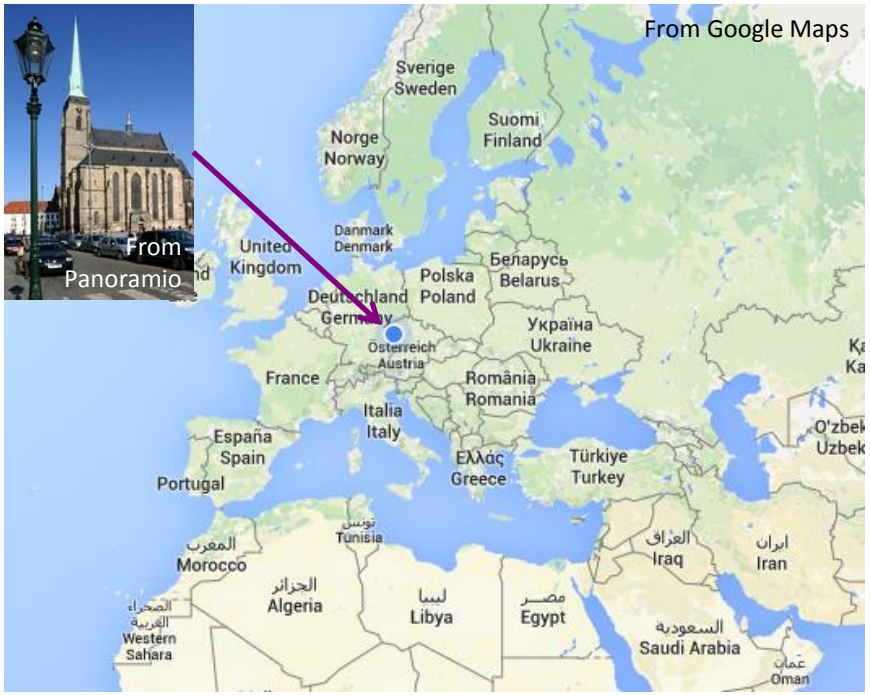
VIRTUAL HUMAN BODY MODELS FOR SAFETY ASSESSMENT AND MEDICAL APPLICATIONS



J. Vychytil, Plzeň, 12.11.2018

MLT & MMI DEPARTMENTS

NEW TECHNOLOGIES
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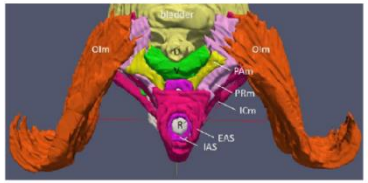
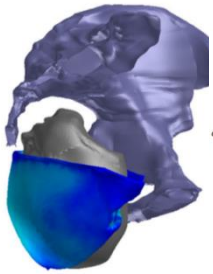
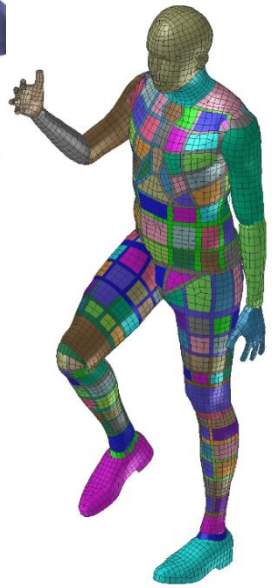
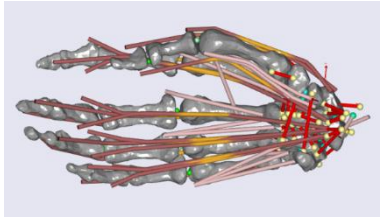
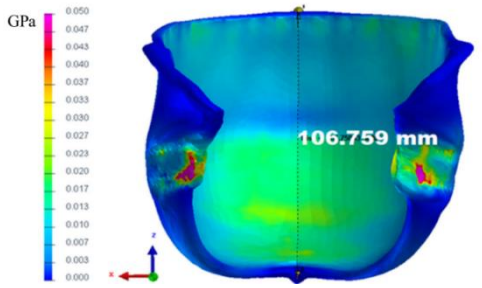
- **Departments**
  - Human Body Modelling
  - Man-Machine Interaction
- **Our team counts 10 + 2**
  - 1 Associated professor, 6 PostDocs,
    1 PhD student, 1 Master degree,
    1 Undergraduated student,
    2 Administrators
- **Our focus**
  - Development of
    human body models
  - Applications (safety, medicine)







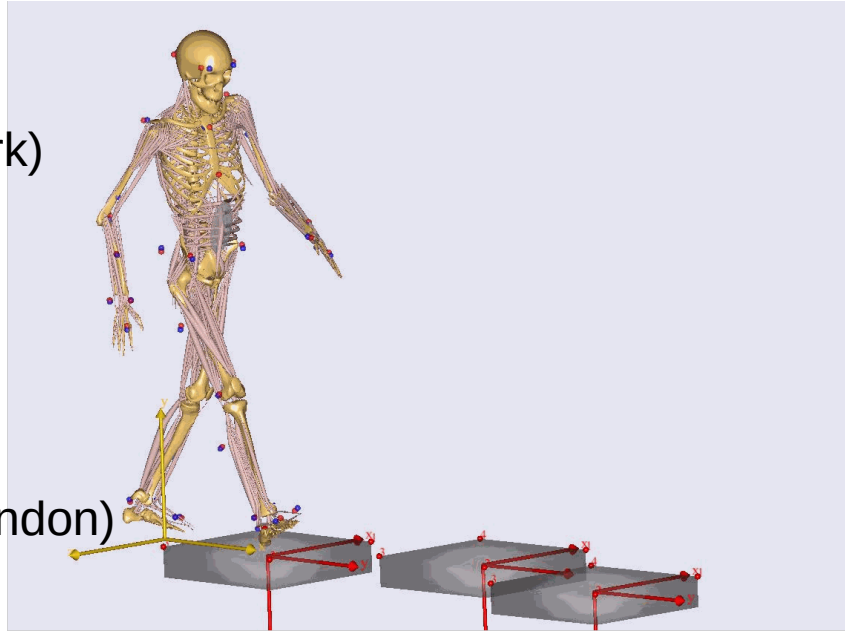




ANYBODY

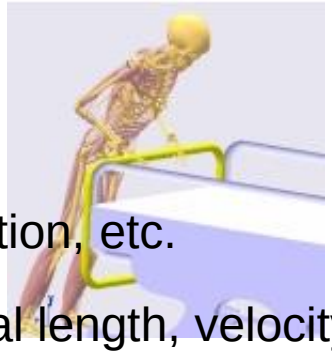
- Musculoskeletal human body model
- AnyBody Modeling System (Aalborg, Denmark)
- **Bones**: rigid body, real shapes (MRI, CT)
- **Joints**: real anatomy and physiology
- **Muscles**: real attachments and trajectory,

  active model (Hill - three elements, muscle-tendon)

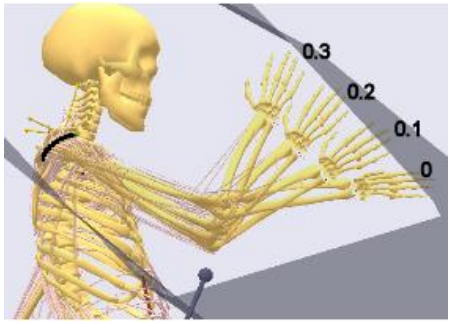


- Interaction with arbitrary environment, simulation of real movements, simple modification respecting given requirements, scaling, personalization, pathologies simulation, joint replacement implementation, etc.

ANYBODY



- **Outputs**:
- **Bones**: trajectory, velocity, acceleration, etc.
- **Joints**: reaction force, rotation, angular velocity and acceleration, etc.
- **Muscles**: force distribution, stress, activity, overloading, actual length, velocity and acceleration of shortening/elongation, etc.
- **Applications**: Ergonomy, sport, Clinical practice – orthopedics, rehabilitation
- **Software**: AnyBody Modelling System
- **Licensing**: MMI - Available in projects only, without any commercial applications AnyBody Technology - owner



FE MODEL OF PELVIC FLOOR

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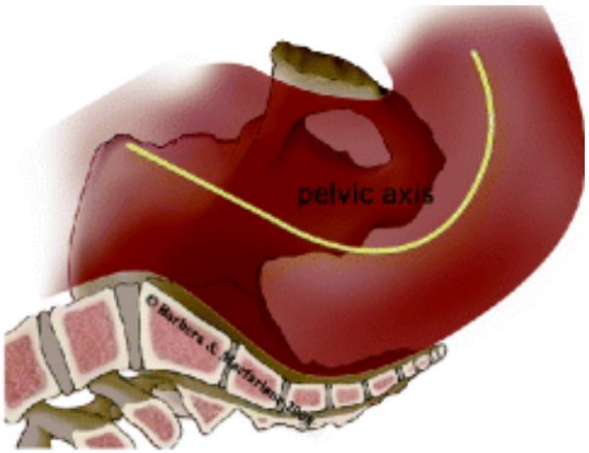
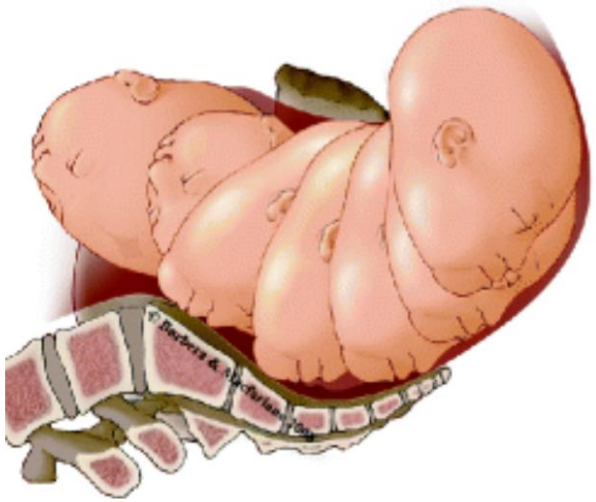
- Motivation
  - Prediction of injury during child delivery
  - Influence of forceps, vacuum device
  - Manual perineal protection

- Assessment via numerical simulations





FE MODEL OF PELVIC FLOOR

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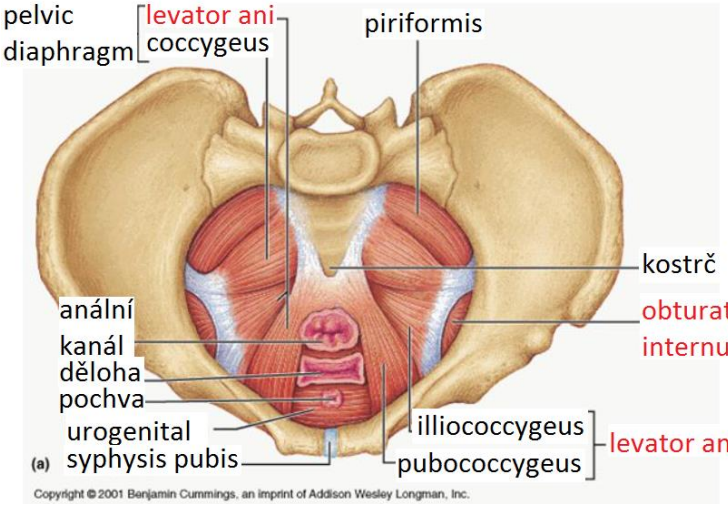
- Model structure
  - Bones
    - Pelvis of mother, head of the child
    - Rigid bodies
  - Muscles
    - Levator ani, obturator, sphincter
    - Hyperelactic material (Ogden)
    - Passive model
    - **Material parametres**

determined from traction test – porcine samples



FE MODEL OF PELVIC FLOOR

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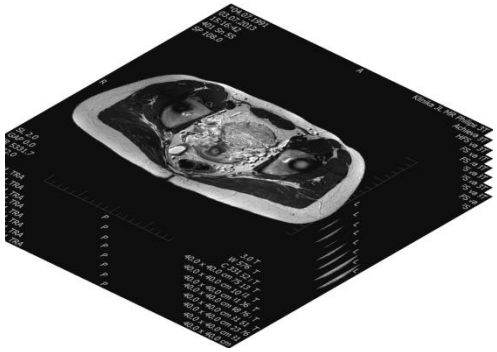
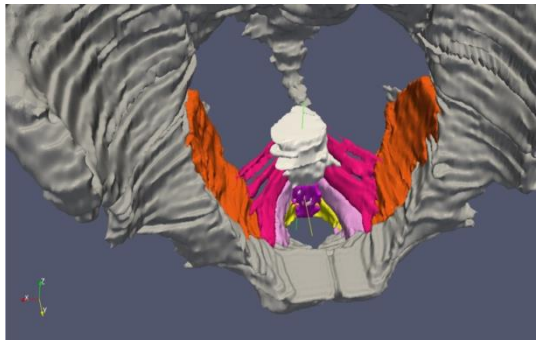
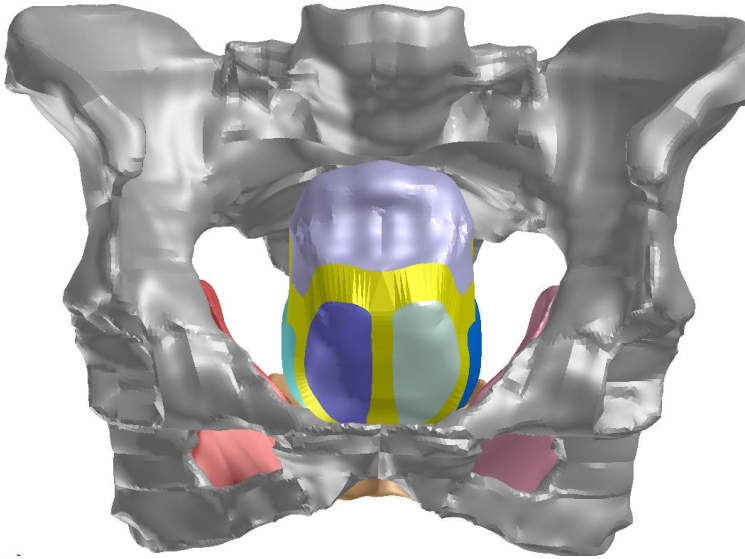
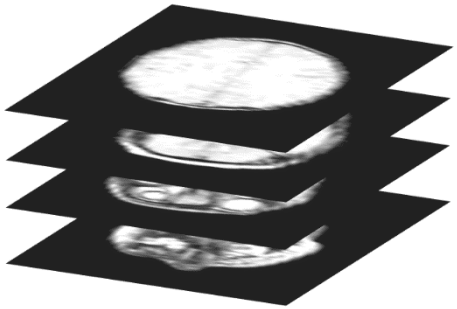
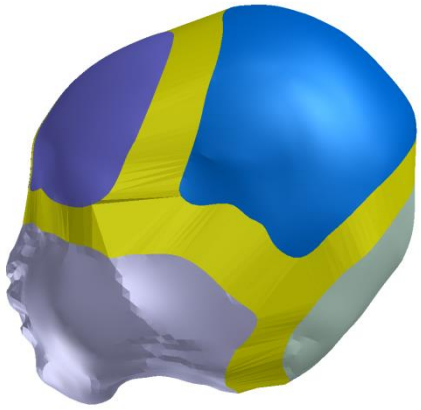
- MRI data

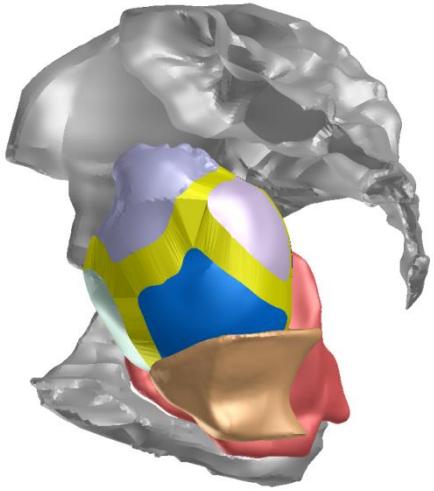












FE MODEL OF PELVIC FLOOR

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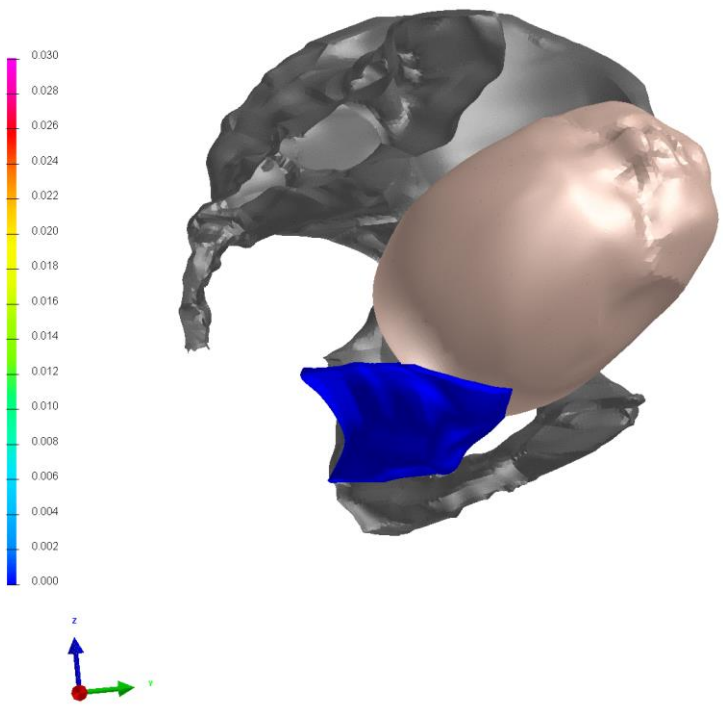
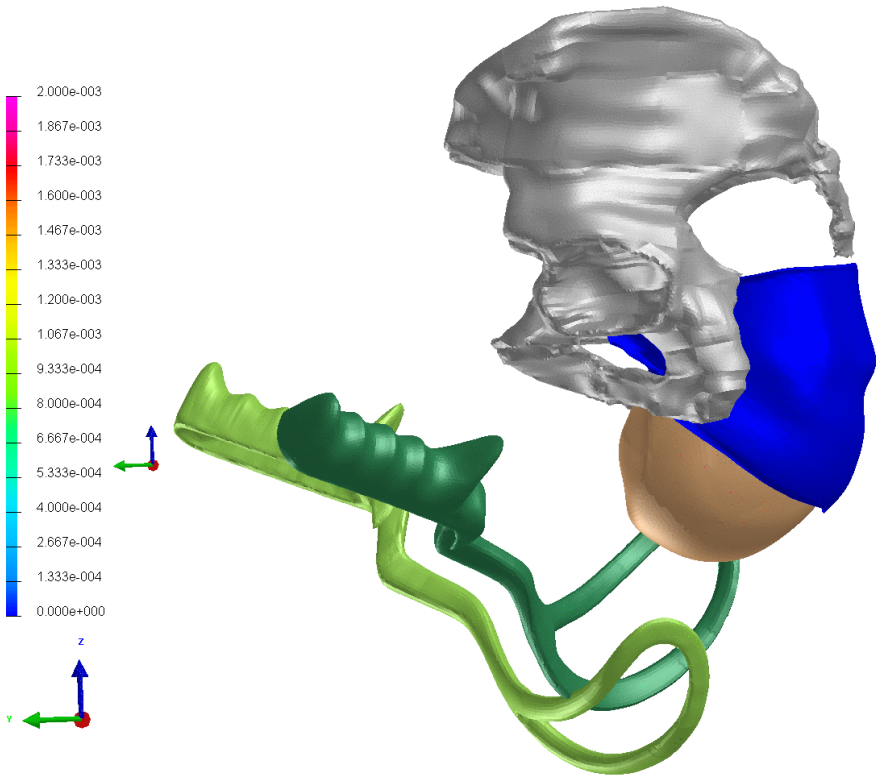
- Childbirth with the help of forceps





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esi get it right™
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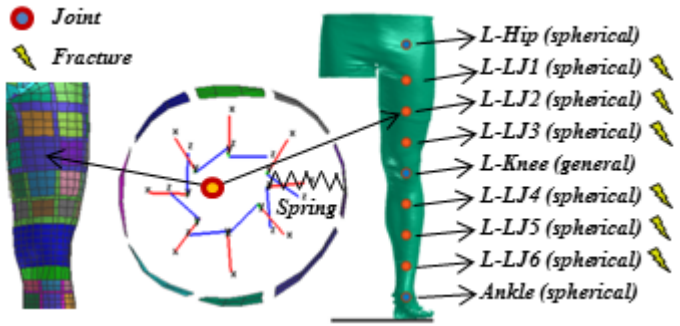
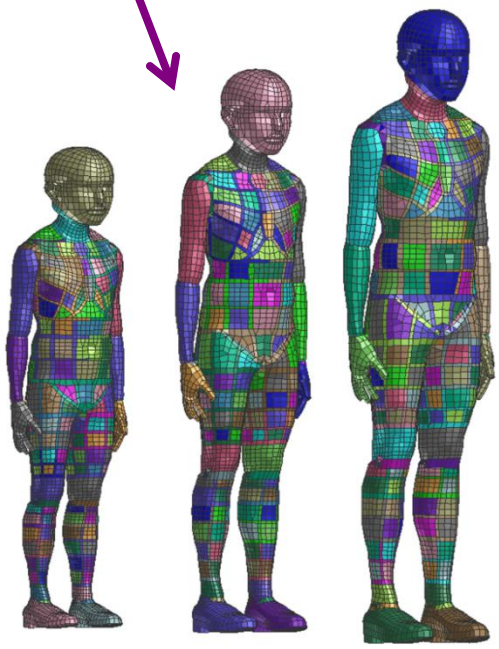
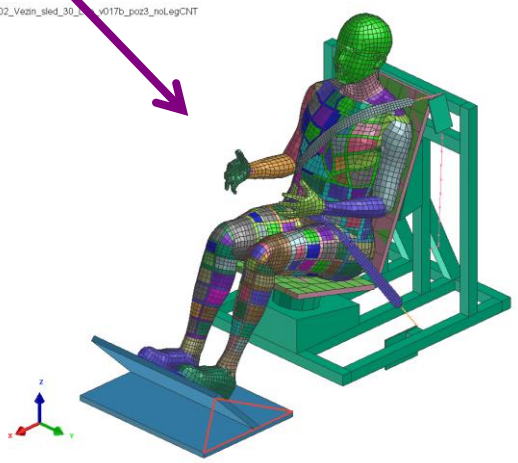
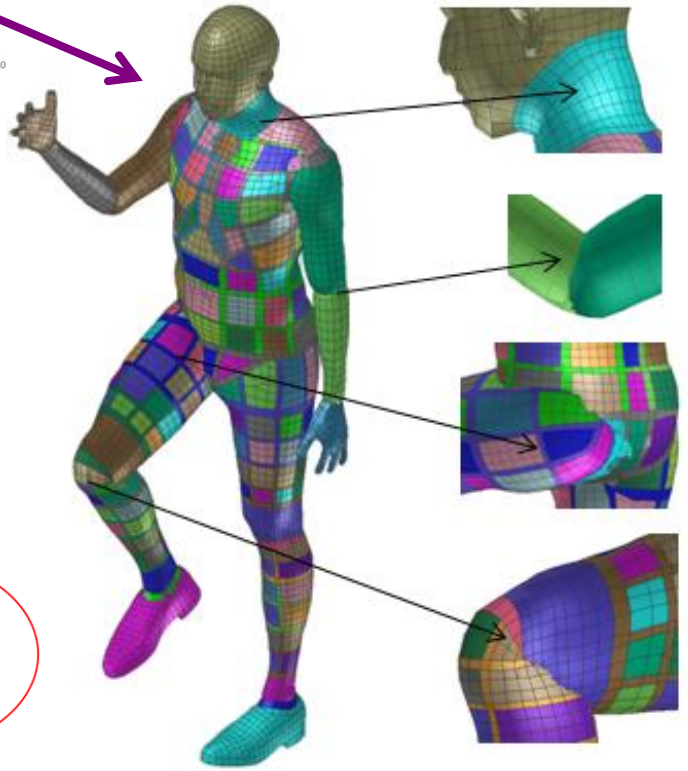
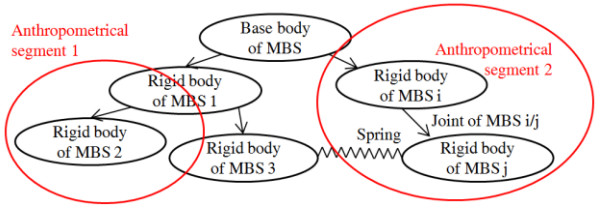
- MBS with compressible segments
- Simple positioning
- Multi-purpose validation
- Age scaling











DEVELOPMENT

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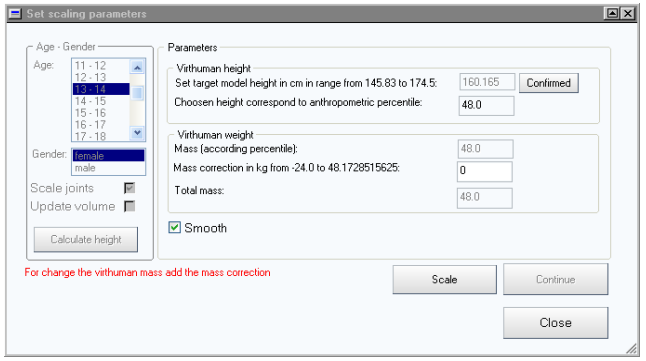
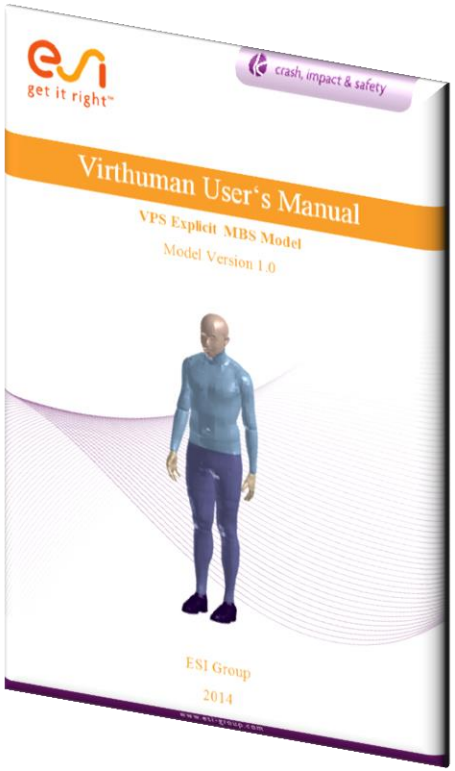
- Reference model Virthuman
- European database CAESAR

  (close to Hybrid III a Eurosid II)
- Fully validated (SAE Technical Papers)
  - 2014-01-0534, DOI:10.4271/2014-01-0534
  - 2016-01-1511, DOI:10.4271/2016-01-1511
  - 2017-01-1451, DOI:10.4271/2017-01-1451
- Injury prediction based on EuroNCAP

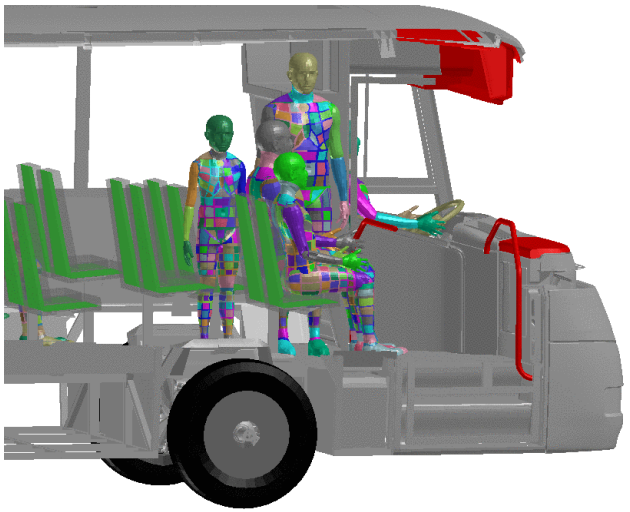
  GOOD ACCEPTABLE MARGINAL POOR
- Scaling for age, gender, height and mass
- Personalization in preparation

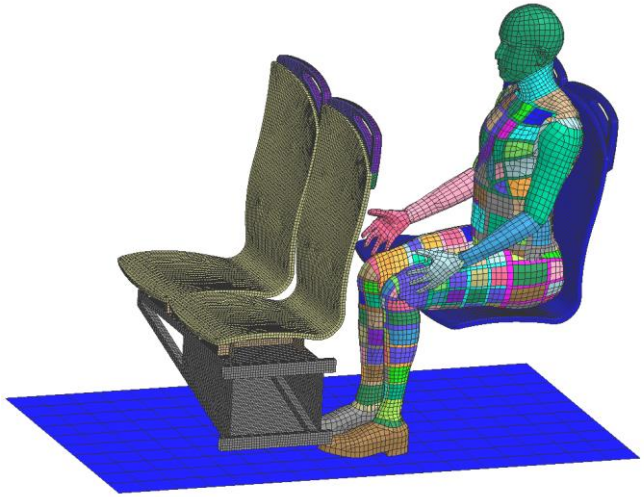


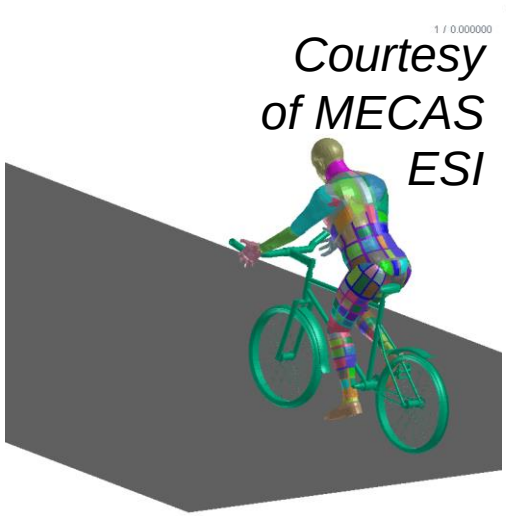


APPLICATION

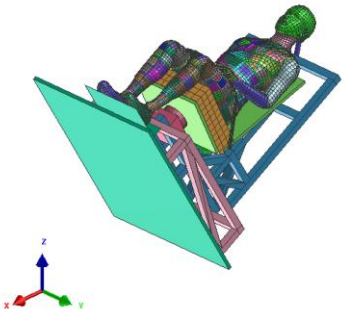
- Road and rail transport
- Vulnerable road user (VRU)
  - Pedestrian, two-wheelers
- Public transport
- Air transport







Courtesy of MECAS ESI



Cooperation with WUT (Poland)

CASE STUDY: MOTORCYCLIST

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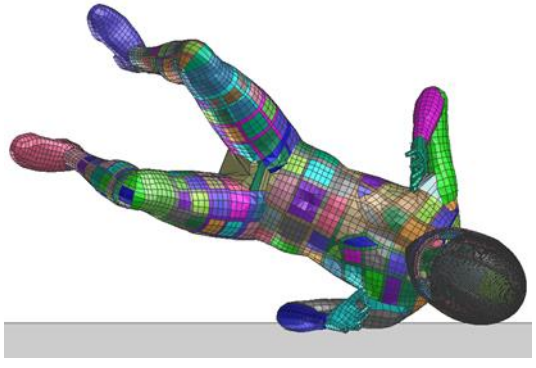
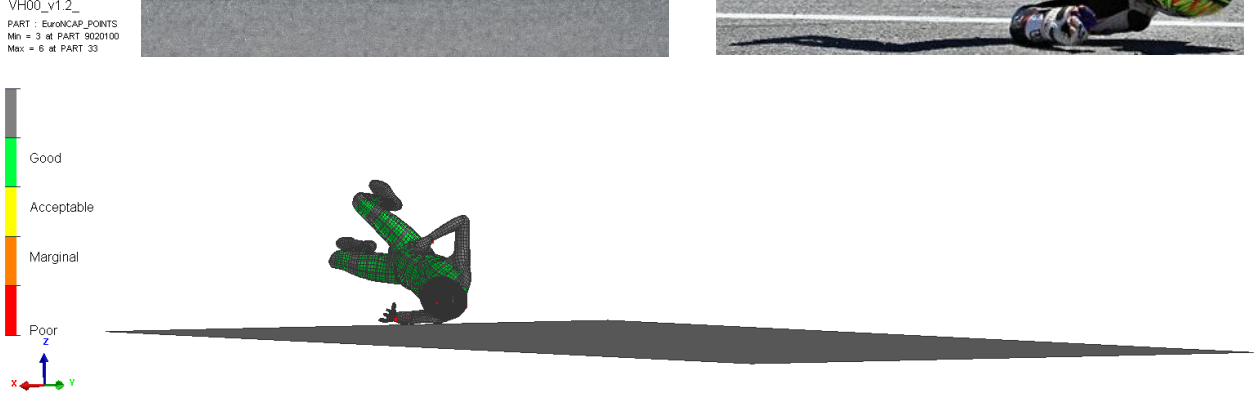
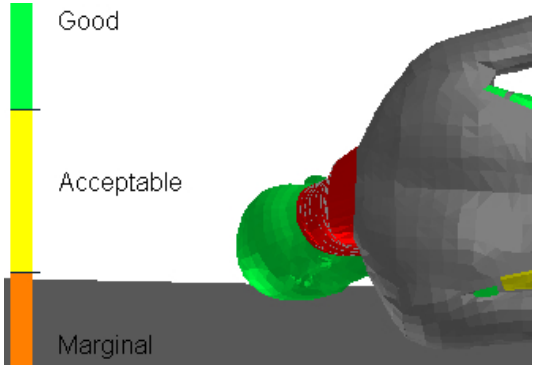
- Based on Moto GP accident in Jerez, Spain (2014), 86 km/h
- Karel Abraham, 24 years, 182 cm, 75 kg
- Personal protective equipment (PPE)
  - Helmet, added mass representing gloves and boots







CASE STUDY: RAILWAY PASSENGERS

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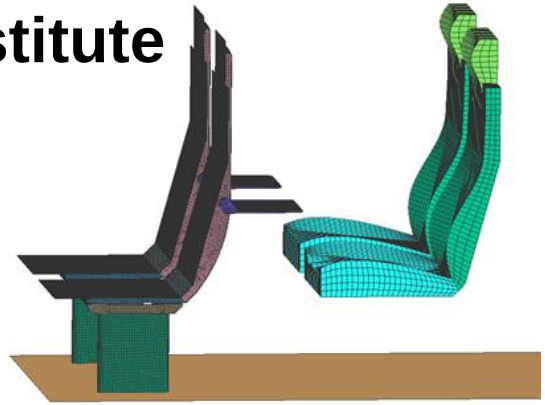
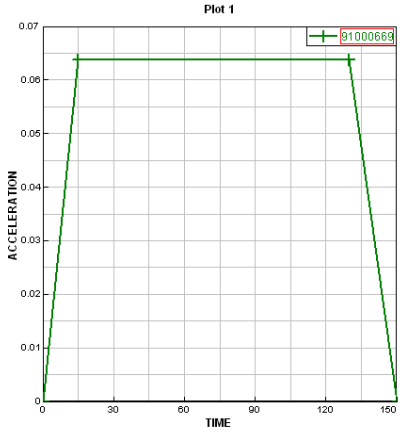
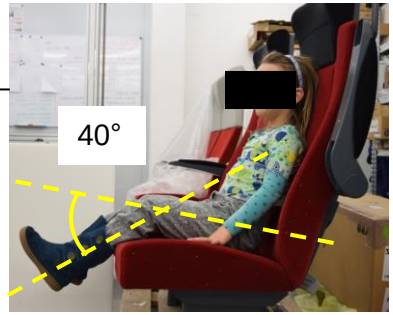
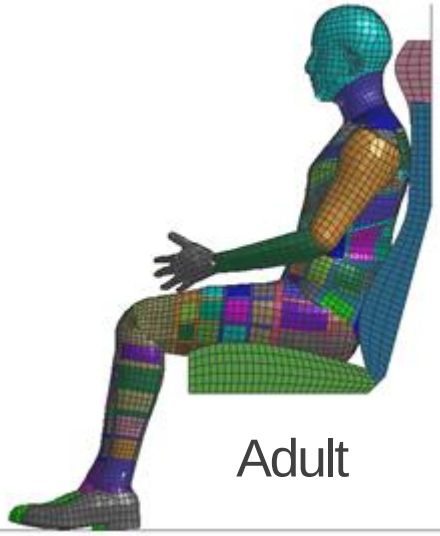
- **Regional Technological Institute**
- Influence of table position
  - Prescribed acceleration
  - Folded/unfolded table



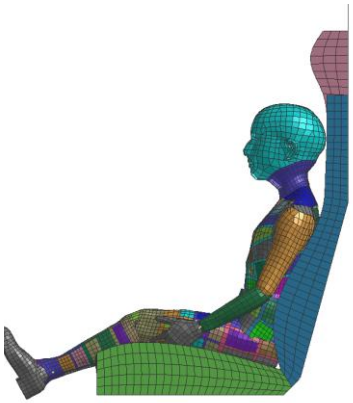


- Adult – upright position (norm GMRT2100)
- Child – 2 variants based on real seating

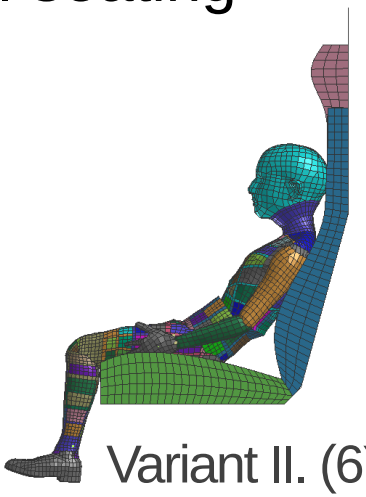




Adult



Variant I. (6YO)



Variant II. (6YO)

CASE STUDY: RAILWAY PASSENGERS

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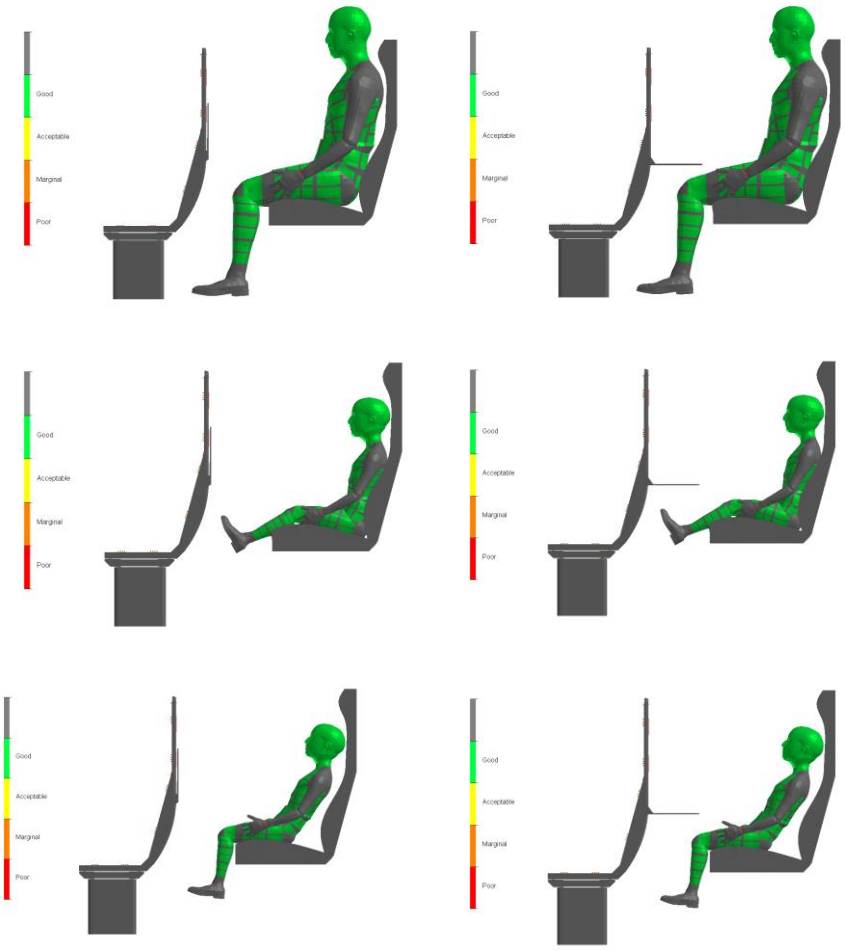
- Folded table
  - Increases risk of abdominal and chest injuries (6YO)
  - Does not have significant impact on an adult
  - Some GMRT2100 limits are exceeded
- High risk of head injury (6YO)



ACCIDENT INVESTIGATION: PUBLIC BUS

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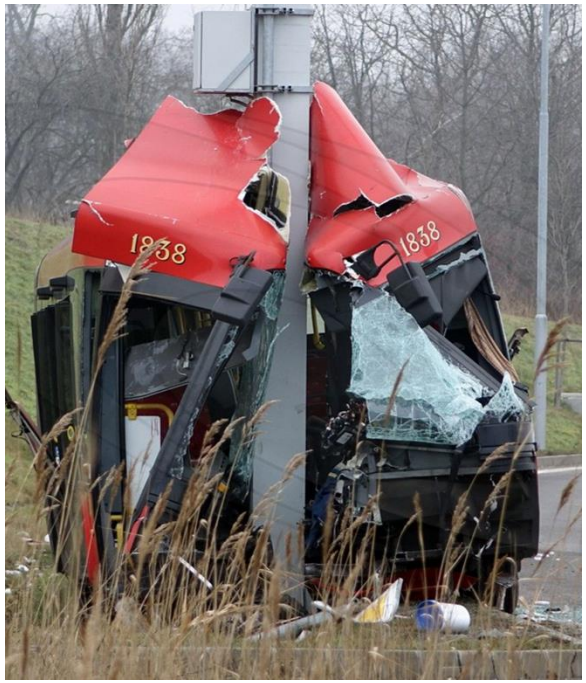
- Accident reconstruction by VCA (**Vision Consulting Automotive**)
- Public NB18 city bus accident in Bratislava (Slovakia, 2016)
- Driver got a heart attack
- 16 people injured (including driver)



ACCIDENT INVESTIGATION: PUBLIC BUS

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- 16 people injured in total
  - 8 people in hospital complicated fractures of tibia and head injuries
  - 1 woman serious abdominal injury
  - Other injuries with abrasions and bruises were treated ambulant

ACCIDENT INVESTIGATION: PUBLIC BUS

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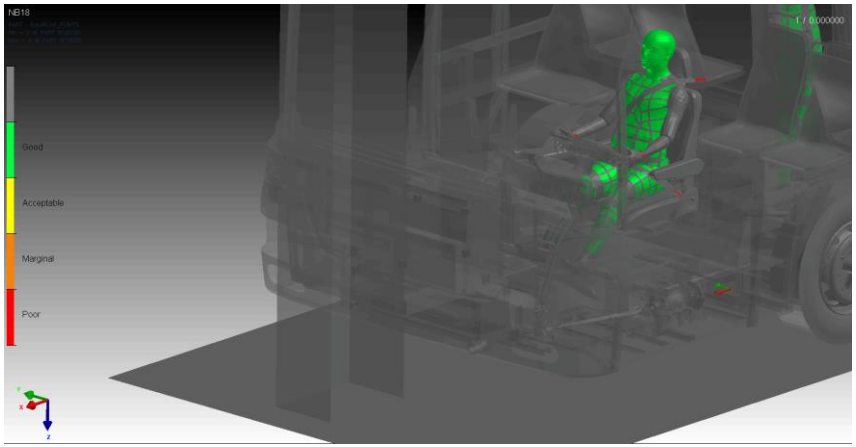
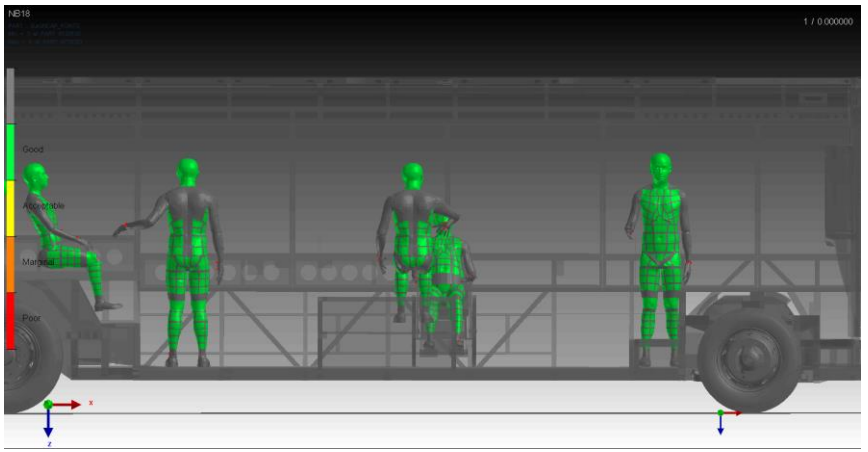
- Public transport safety assessment and optimization
- Multi-directional impact, more than 1 passenger

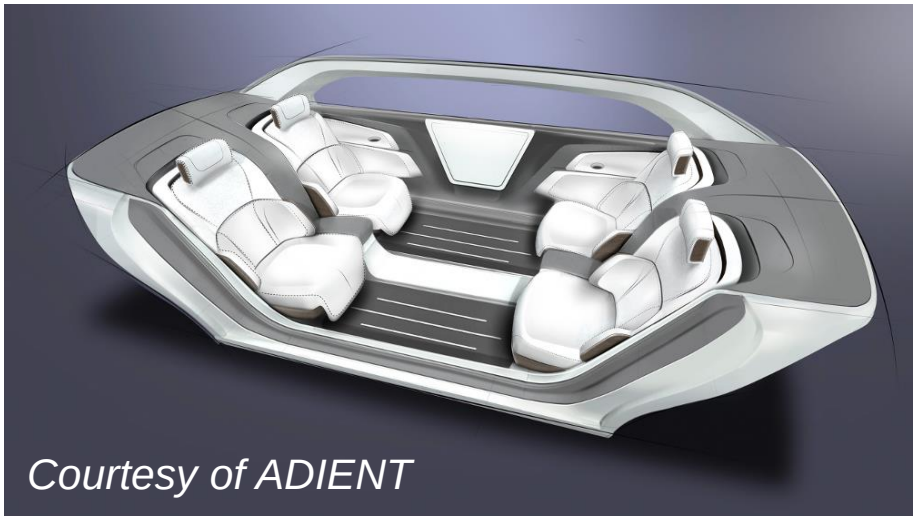




FUTURE CHALLENGES

- Multi-modal transport (autonomous cars, two-wheelers)
- Complex passenger configurations

  („non-standardized“ seating)
- Multi-directional impacts
- Diverse population
- Virtual prototyping
- Design optimization
- Human protection
- Virtual approach to be addressed



REFERENCES / INTERNATIONAL PROJECTS

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- **APSN** Advanced Passive Safety Network (6. RP)
- **APROSYS** Advanced Protective Systems (6. RP)
- **MYMOSA** Motorcycle and Motorcyclist Safety (6. RP)
- **SIM** Safety In Motion (6. RP)
- **MOTORIST** Motorcycle Rider Integrated Safety (7. RP)
- **COST TU1407** Scientific and technical innovations for safer Powered Two Wheelers (COST)
- **CZ-BY No. 38** Virtual human models for the prevention, therapy and rehabilitation of shoulder pathologies (CZ-BY)
- **CZ-BY No. 182** Obstetrics 2.0 – Virtual models for the prevention of injuries during childbirth (CZ-BY)

REFERENCES / COOPERATION

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- **Aalborg University** (Denmark)
- **AMSAFE** (USA)
- **Charles University** (Czech Republic)
- **Criminalistic Institute** (Czech Republic)
- **ESI Group** (Czech Republic, France, Korea)
- **Institute for the Care of Mother and Child** (Czech Republic)
- **OTH Regensburg** (Germany)
- **Tianjin University of Science and Technology** (China)
- **TRW** (Germany)
- **Vision Consulting Technology** (Czech Republic)
- **Warsaw University of Technology** (Poland)

EXPECTATIONS

NEW TECHNOLOGIES
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- **Offers**
  - Bilateral cooperation
  - Leading students (bachelor, master and Ph.D. thesis, study stays, trainings)
- **Expectations**
  - To find partnerships for further development in order to bring new solutions to market
  - To exchange students and staff for sharing and improving knowledge
  - To address industrial partners for contract research

Assoc. Prof. Luděk Hynčík, Ph.D.
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