Contents of Work Package 2-WP11 Tools and Methods for Lifecycle Monitoring

2-WP11: Tools and Methods for Lifecycle Monitoring

Coordinator of the WP

University of West Bohemia, responsible person: Ing. Pavel Žlábek, Ph.D.

Participants of the WP

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VUT Brno_doc. Ing. Petr Porteš, Ph.D.
Vision Consulting Automotive, s.r.o._Ing. Petr Pavlata
Advanced Engineering s.r.o._Ing. Hynek Purš
VZÚ _ Ing. Jaroslav Václavík
UWB – RTI _ Ing. Pavel Žlábek, Ph.D.

Main Goal of the WP

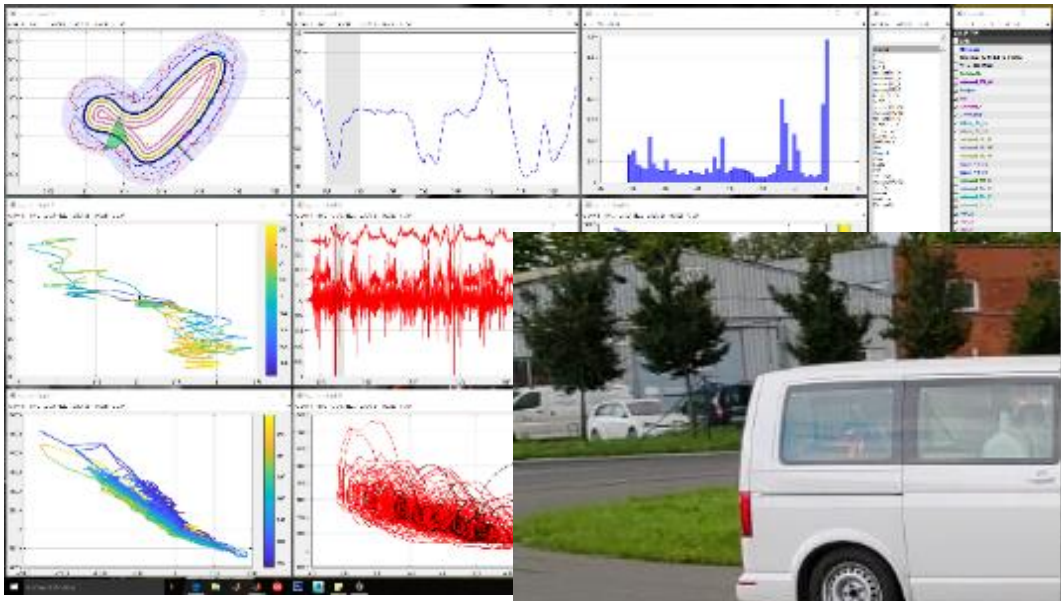
2-WP11-001 Integration of experimental data into multibody vehicle model.
2-WP11-002 Setup of the system for monitoring of lifecycle data.

Partial Goals for the Current Period

2-WP11-003 / 2-WP11-004 Technical report / papers supporting main goals - development of monitoring and process system used as source of lifecycle data and analysis in order to reduce time-to-market process of new products design.

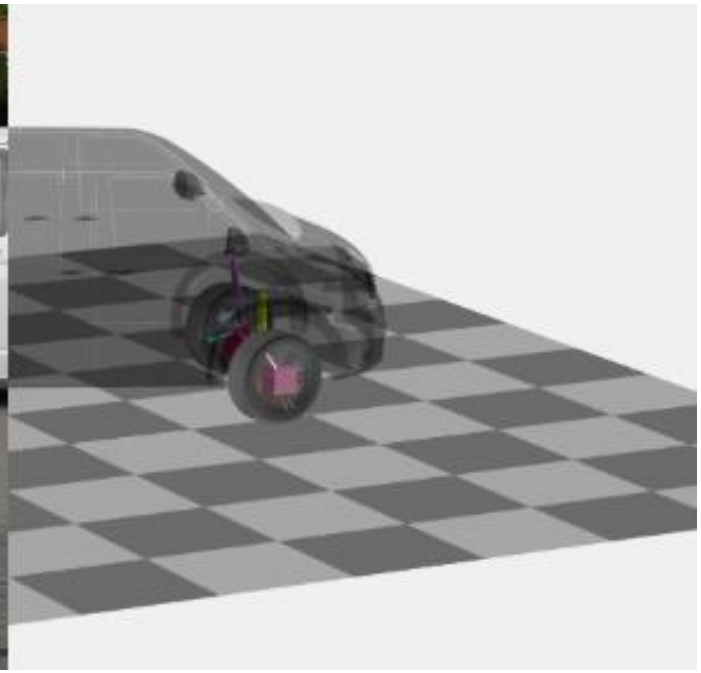
Activities in 2-WP11 Tools and Methods for Lifecycle Monitoring

2-WP11-001 Integration of Experimental Data into Multibody Vehicle Model



Development Method and Software together with Measuring System

Experimental Work and Verification Measurement

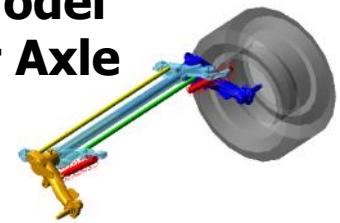


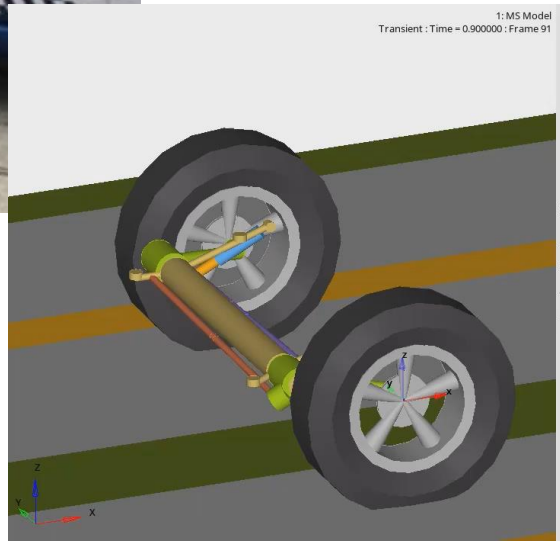
Activities in 2-WP11 Tools and Methods for Lifecycle Monitoring

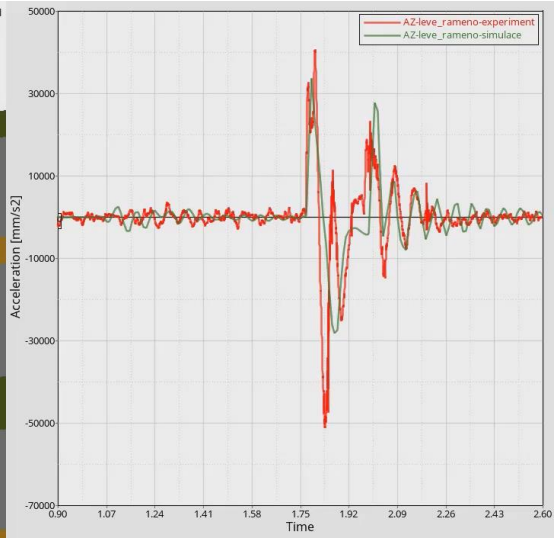
2-WP11-002 Setup of the System for Monitoring of Lifecycle Data.

Measuring System
Digital Twin
Comparison Experiment VS Simulation

MBS Model of Rear Axle







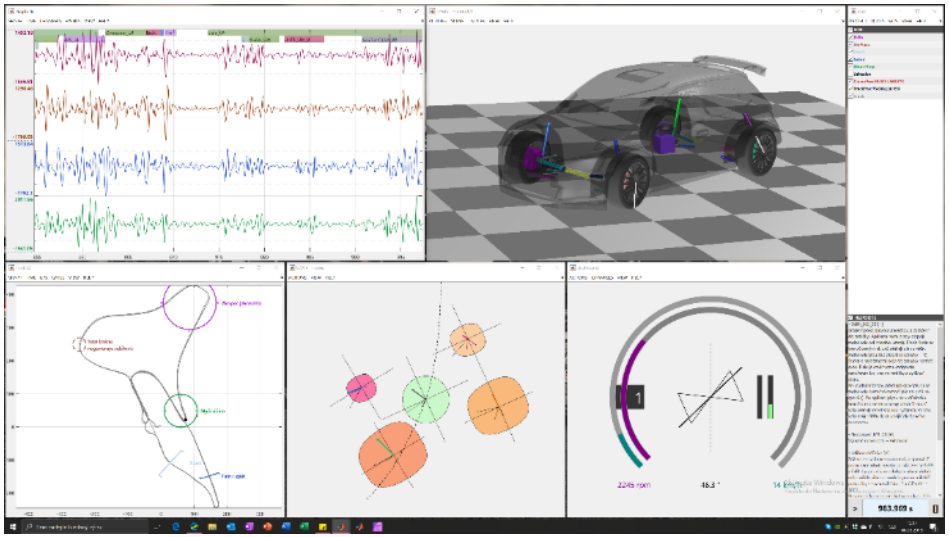
Activities in 2-WP11 Tools and Methods for Lifecycle Monitoring

2-WP11-001 Integration of Experimental Data into Multibody Vehicle Model

The software based on the link between the mathematical vehicle model and the measured vehicle drivetrain or suspension signals will allow to analyze more realistic dynamic behavior based on tests. The integrated mathematical model of a vehicle provides virtual sensor signals to help understanding dynamic processes. Information on critical handling condition can be used for the improvement of safety and comfort.

Integrated features

1. Data processing of measured data
2. Input to inverse MB model
3. Using of MB model to compute dynamic state
4. Output of modeled quantities (graphs + animations)
5. Compose measured and modeled data analysis
6. Interactive reports with live data

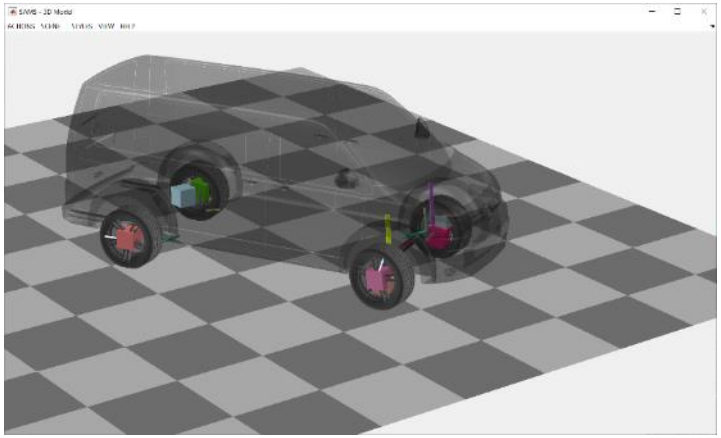


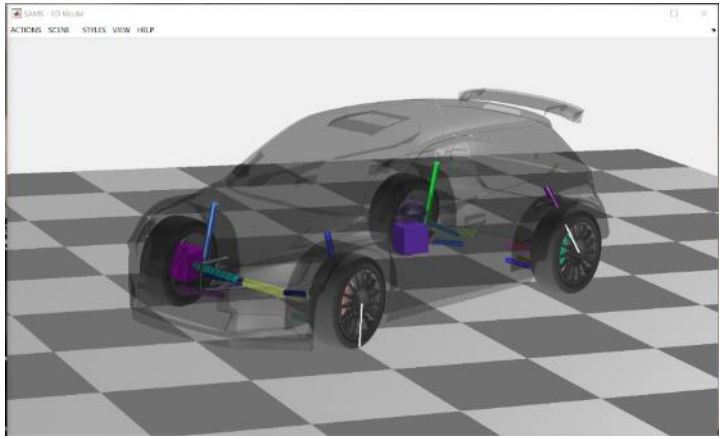
Activities in 2-WP11 Tools and Methods for Lifecycle Monitoring

2-WP11-001 Integration of Experimental Data into Multibody Vehicle Model

Method Development

- Different types of vehicles
- Optimized processing features
- Enhanced visualization
- Searching for optimal combination of measured and modeled subsystems



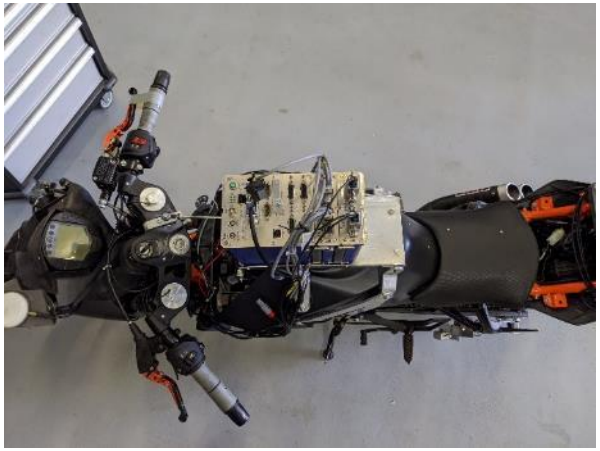


Activities in 2-WP11 Tools and Methods for Lifecycle Monitoring

2-WP11-001 Integration of Experimental Data into Multibody Vehicle Model

Experimental Work

- Simple tests (circular, acceleration, braking)
- Road tests
- Verification
- Calibration
- Parameter measurements



Activities in 2-WP11 Tools and methods for lifecycle monitoring

2-WP11-001 Integration of Experimental Data into Multibody Vehicle Model

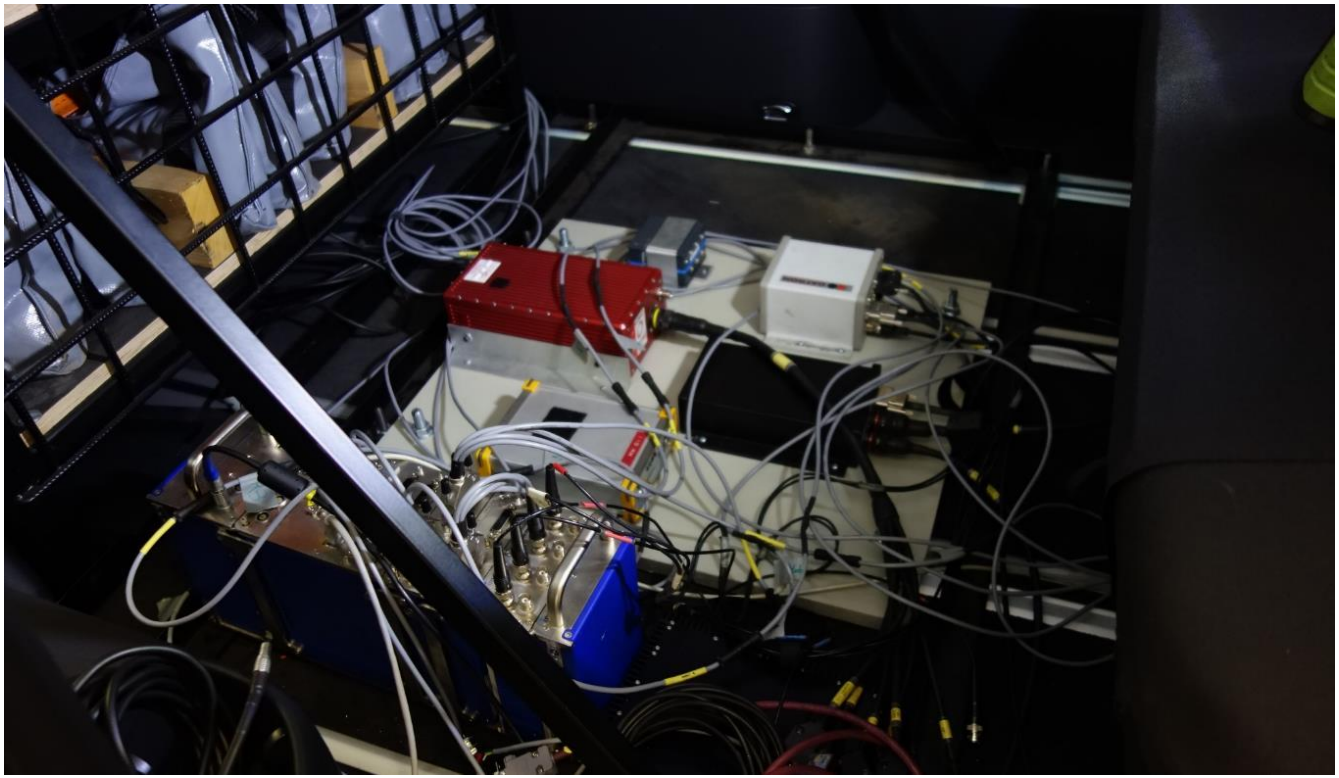
Development of a Measuring System Compatible with the Developed Method

- Driver (ECU or sensor)
  - Throttle
  - Brake pressure
  - Steering
- Body
  - Inertial and GPS system (OXTS RT3002 or alternatives)
  - Ride heights (LED or laser sensors)
- Suspension
  - Stroke
  - Damper force
  - Antirollbar torque
  - Suspension forces
- Driveline
  - Engine ECU
  - Revolution speeds
  - Driveshaft torques
- Tyres
  - Pressure
  - Inside temperatures
  - Outside temperatures
- Others
  - Correvit S400, Correvit V1
  - GoPRO cameras
- Data acquisition system
  - NI cDAQ-9139 CompactDAQ + Ni modules
  - imc CRONOSflex 400
  - or alternatives

Activities in 2-WP11 Tools and Methods for Lifecycle Monitoring

2-WP11-001 Integration of Experimental Data into Multibody Vehicle Model

Developed Measuring System Compatible with the Developed Method



Activities in 2-WP11 Tools and Methods for Lifecycle Monitoring

2-WP11-002 Setup of The System for Monitoring of Lifecycle Data

Measuring System - Detail Description

- measuring system is based on the NI cDAQ 9138
- controlled by a program created in LabVIEW
- data from sensors are recorded on the control panel disc
- control panel is powered by a UPS with battery - operation for several hours

- communication and supervision of the control panel provided via a WIFI router for connecting remote PCs.
- NI 9219 module was used to measure voltage from shock absorber extension sensors, NI 9234 for accelerometers, NI 9237 for strain gauges.

Activities in 2-WP11 Tools and Methods for Lifecycle Monitoring

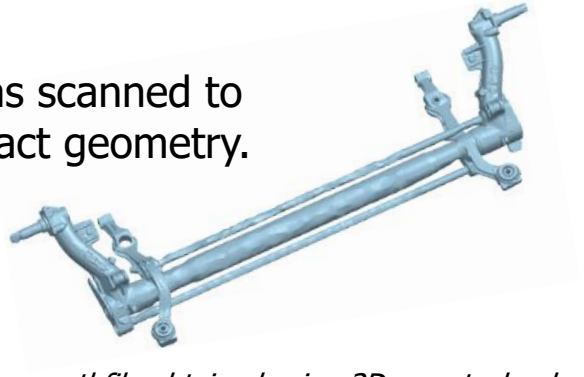
2-WP11-002 Setup of The System for Monitoring of Lifecycle Data

Building of the Dynamic Model of the Rear Suspension Mechanism

SW - ADAMS VIEW

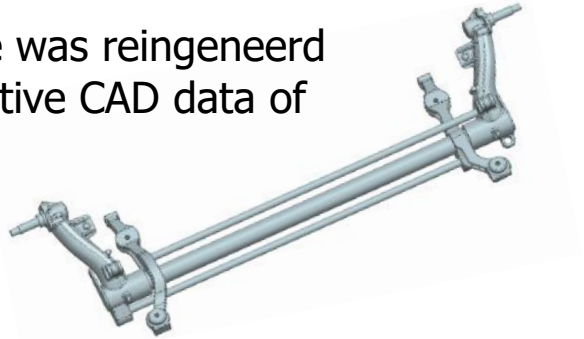
Physical rear suspension mechanism

STAGE 1
Rear axle was scanned to obtain its exact geometry.



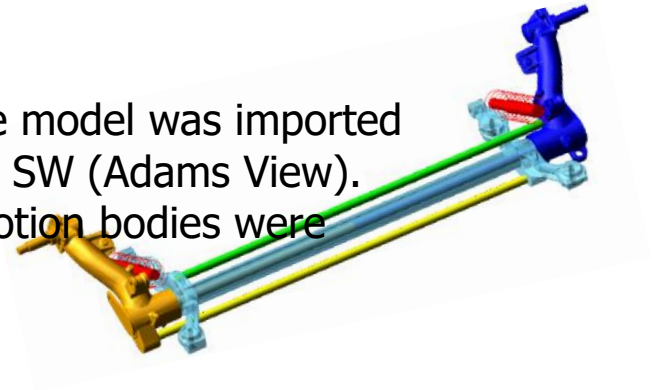
.stl file obtained using 3D scan technology

STAGE 2
Rear axle was reingeneerd to get native CAD data of it.



Native CAD data of the rear axle

STAGE 3
The rear axle model was imported into the MBS SW (Adams View). Individual motion bodies were defined.



Multibody model of the rear axle

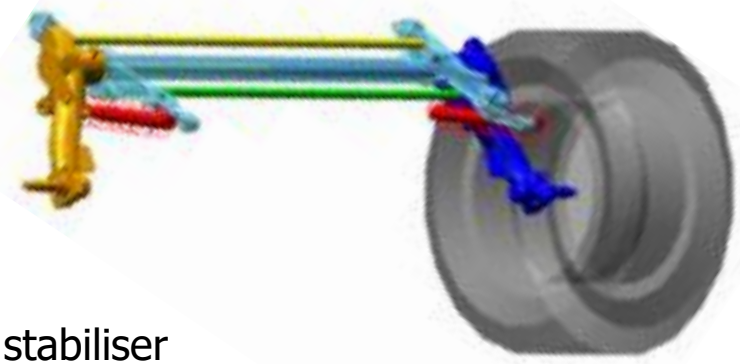
Activities in 2-WP11 Tools and Methods for Lifecycle Monitoring

2-WP11-002 Setup of The System for Monitoring of Lifecycle Data

Description of the MBS Model

SW - ADAMS VIEW

MBS model of the rear suspension mechanism consist of:



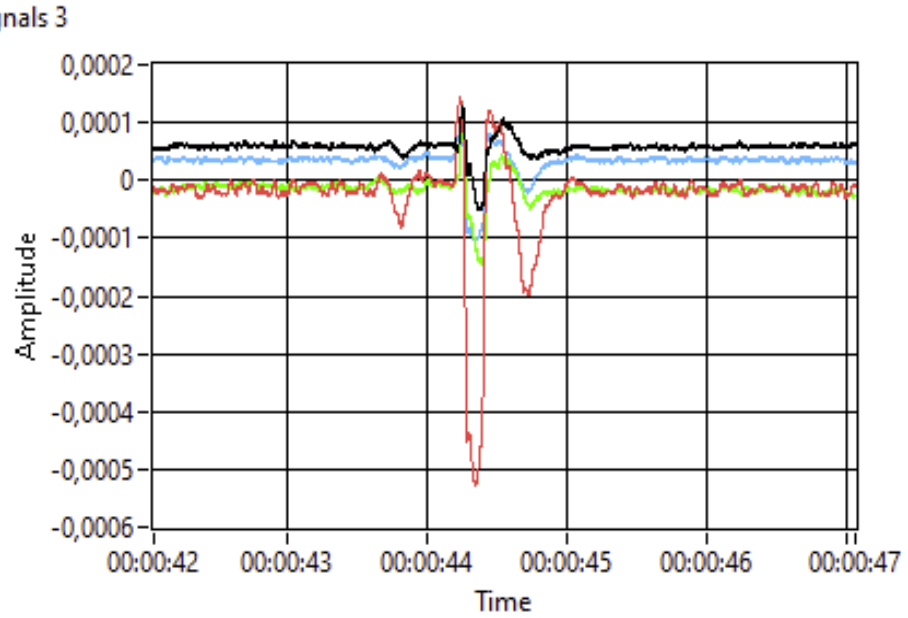
- Two flexible bodies:
  - Right torsional spring
  - Left torsional spring
- Five force elements:
  - Two dampers used.
  - Two tire elements representing a wheel
  - Rotational spring force element used as stabiliser
- A road model for the specific test scenario.
- Three rigid bodies:
  - Left and right arm
  - Stiff beam mount

Activities in 2-WP11 Tools and Methods for Lifecycle Monitoring

2-WP11-002 Setup of the system for monitoring of lifecycle data
Measuring System - on Track Measurement

Speed bumps passing the vehicle through speed bump at speeds of 30 and 50 km/h

- one wheel
- two wheels



Activities in 2-WP11 Tools and Methods for Lifecycle Monitoring

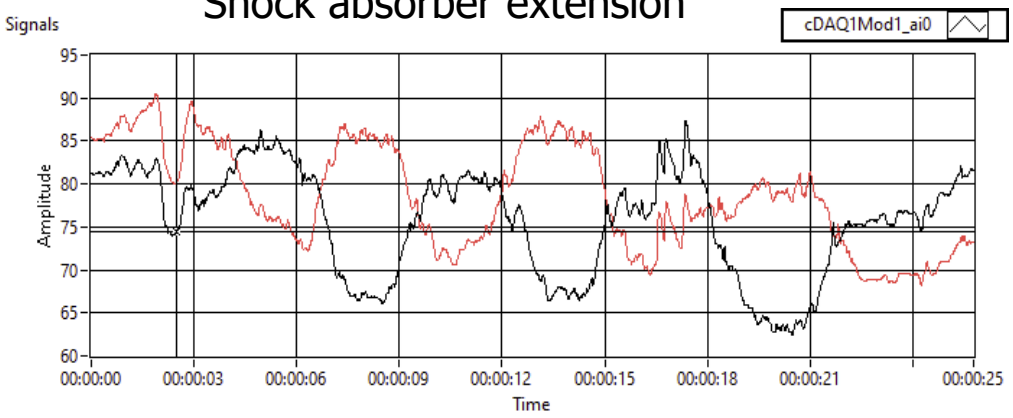
2-WP11-002 Setup of The System for Monitoring of Lifecycle Data
Measuring System - on Track Measurement

Long / Short turns

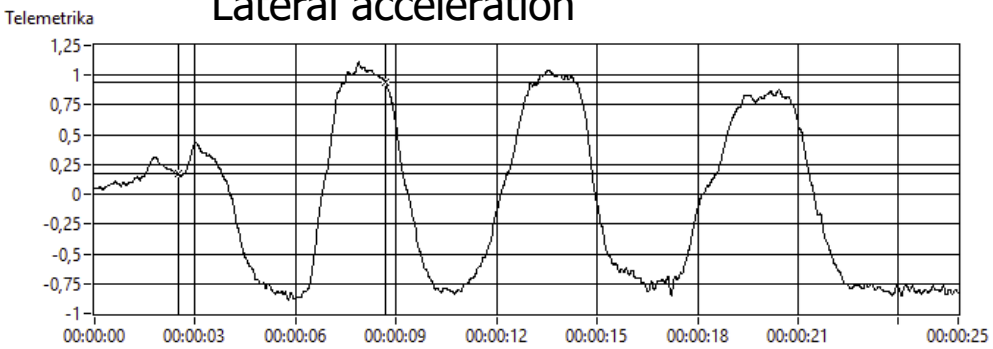
Steering changes at the chassis adhesion edge

Simulation of sudden changing of lanes

Shock absorber extension



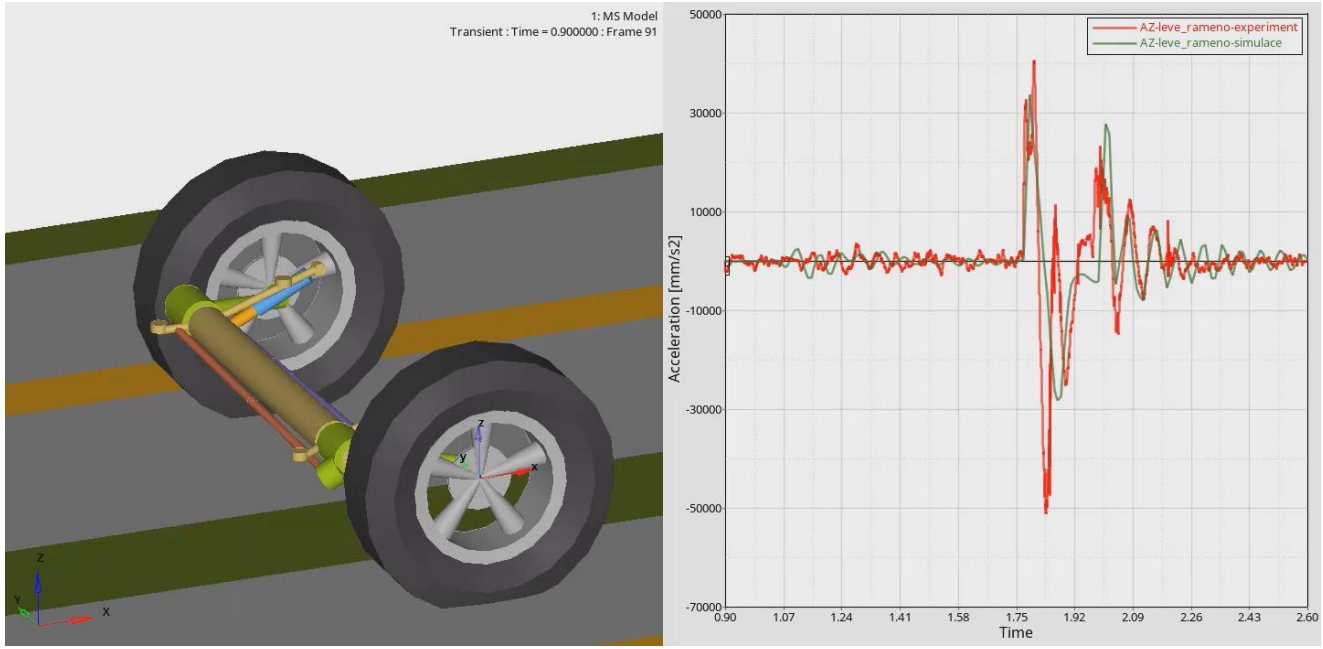
Lateral acceleration



Activities in 2-WP11 Tools and Methods for Lifecycle Monitoring

2-WP11-002 Setup of The System for Monitoring of Lifecycle Data
Comparison of the Experiment vs. Simulation Results

The animation shows realistic behavior. The first validation phase is based on the provided measurements on the real vehicle and it proves the principal content. The model validation process is supported and realized by the HyperStudy software.



Fulfillment of goals and deliverables of 2-WP11 Tools and Methods for Lifecycle Monitoring

Current State of Deliverables, Milestones and Fulfillment of Goals

Development of monitoring and process system used as source of lifecycle data and analysis in order to reduce time-to-market process of new products design. The process leads to digital twin of selected part of vehicle which can lead to more effective and accuracy design of newly developed parts with respect of lifetime fatigue analyses.

List of Due Deliverables and Their Added Value

2-WP11-001 Integration of experimental data into multibody vehicle model.

Development method and software together with measuring system and experimental work was done. Also the verification measurement was performed.

2-WP11-002 Setup of the system for monitoring of lifecycle data.

Functional sample of the system for monitoring of lifecycle data were done. The measurement was compared with digital twin of selected part – rear axle – dynamic response on passing the bump in defined speed.

2-WP11-003 / 2-WP11-004 Technical report / papers were done and partial results were presented to the public audience.

Current Contribution of 2-WP11 Tools and Methods for Lifecycle Monitoring

Assessment of the Contribution of Deliverables

The models of vehicle and the monitoring systems can be used in variable application – not only in automotive or in public transport vehicles. The same wide application have integration of measured data with multibody model. The obtained knowledge contribute to broadening usage of virtual vehicle design tools and methods and for testing of dynamic behaviour and vehicle reliability/durability together with comfort for passengers. It can be used in other WP and there are plans to continue with further development of virtual twins models in other projects or contract research.

Acknowledgement

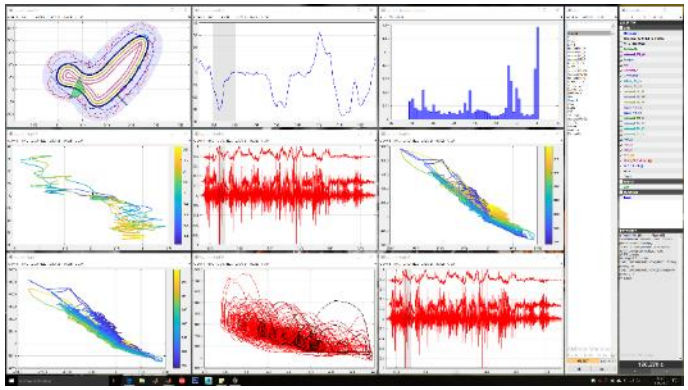
This research has been realized using the support of Technological Agency, Czech Republic, programme National Competence Centres, project #TN01000026 Josef Bozek National Center of Competence for Surface Transport Vehicles.

This support is gratefully acknowledged.

Výtah z prací 2019-2020 na 2-WP11 Nástroje a metody pro monitorování životního cyklu - VUT Brno_doc._Ing. Petr Porteš, Ph.D.

Integrace experimentálních dat do MBS modelu vozidla

Vývoj softwaru (dokončení prosinec 2020)



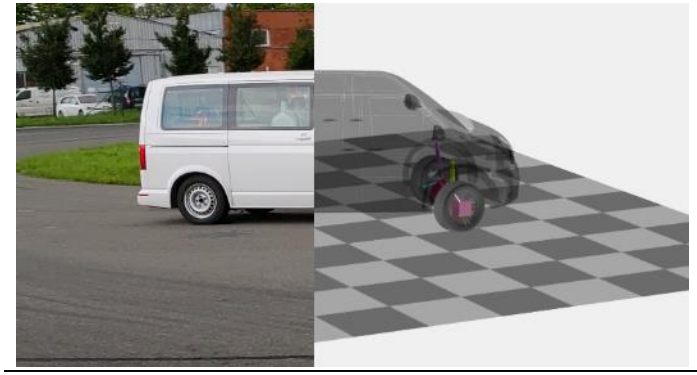
Vývoj metod

```
            sysMessage([num2str(n) ' inputs matched.'], true);
        end

    case 'compute'
        Time = Param;
        if Time ~= MODULES.Sams.ComputedTime
            InpCfg = MODULES.Sams.InputsID;
            InpVal = InpCfg(:, 2);
            ok = ~isnan(InpCfg(:, 1));
            InpVal(ok) = getValueIn(InpCfg(ok, 1), Time);
            InpVal = [Time; InpVal];

            Lib = calllib(MODULES.Sams.Name, 'computeData', InpVal);
            MODULES.Sams.ComputedTime = Time;
            MODULES.Sams.ComputedCheck = Lib;
        else
            Lib = MODULES.Sams.ComputedCheck;
        end
```

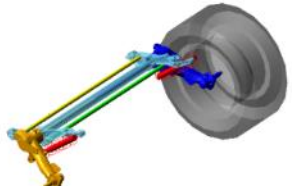
Experimentální práce a verifikace

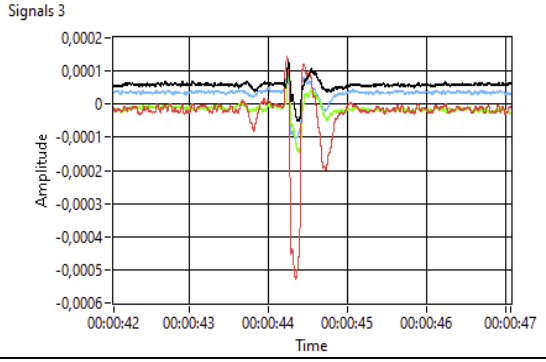


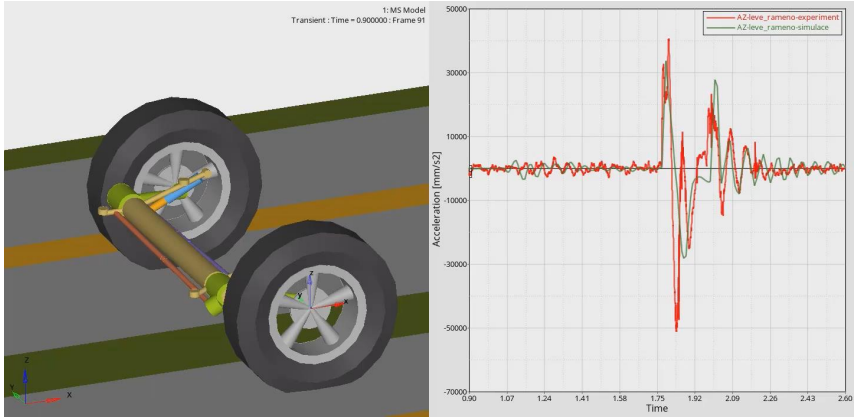
Vývoj měřícího systému kompatibilního s vyvíjenými metodami

Výtah z prací 2019-2020 na 2-WP11 Nástroje a metody pro monitorování životního cyklu - UWB – RTI _ Ing. Pavel Žlábek, Ph.D.

Měřící systém pro monitorování zatížení a deformací vybraného dílu osobního automobilu a digitální dvojče s možností vyhodnocení jeho životnostních parametrů



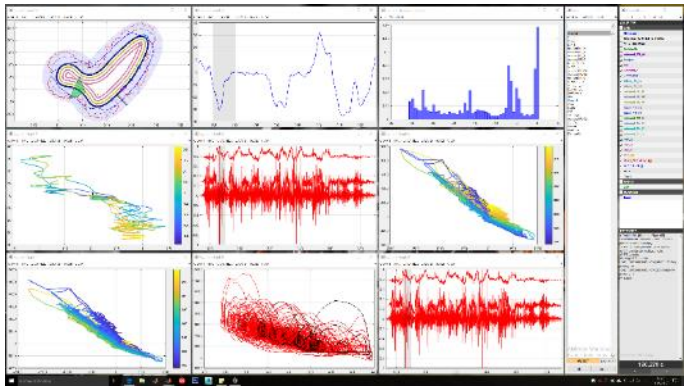




Results of 2-WP11 Tools and Methods for Lifecycle Monitoring
Achieved 2019-2020 - VUT Brno_doc. Ing. Petr Porteš, Ph.D.

Integration of Experimental Data into Multibody Vehicle Model

Development software (completion December 2020)



Method development

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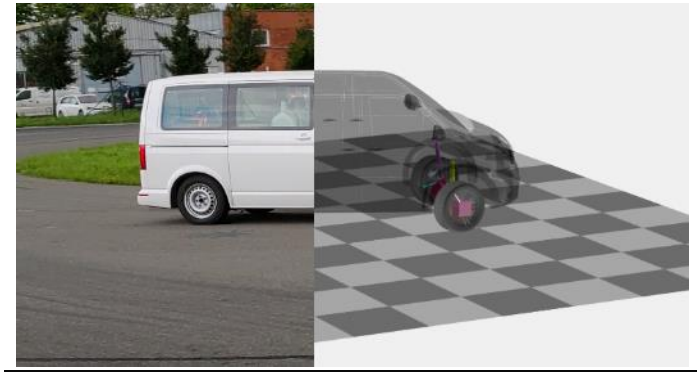
            MODULES.Sams.ComputedCheck = Lib;
        else
            Lib = MODULES.Sams.ComputedCheck;
        end
```

Experimental work and verification measurement



Development of a measuring system compatible with the developed method

Results of 2-WP11 Tools and Methods for Lifecycle Monitoring Achieved 2019-2020 - UWB – RTI _ Ing. Pavel Žlábek, Ph.D.

Measuring system for monitoring the load and deformation of a selected part of a car and a digital twin with the possibility of evaluating its lifecycle parameters.