Contents of Work Package 3-WP11: Vehicle Instrumentation, Testing and Life Cycle Monitoring

3-WP11: Vehicle Instrumentation, Testing and Life Cycle Monitoring

Coordinator of the WP

Brno University of Technology - Ing. Kamil Řehák, Ph.D.

Participants of the WP

Brno University of Technology – Ing. Kamil Řehák, Ph.D., Ing. Aleš Prokop, Ph.D., prof. Ing. Václav Píštěk, DrSc., doc. Ing. Pavel Kučera, Ph.D.; Zetor Tractors a.s. – Ing. Stanislav Mitáš, Ph.D; Tatra Trucks a.s – Ing. Martin Frait; West Bohemia University – Ing. Pavel Žlábek, Ph.D., Technical university Ostrava – Ing. Miroslav Trochta, Ph.D.

Main Goal of the WP

Development of approach to increase repeatability of measurement which significantly affect results of technical experiments.

Partial Goals for the Current Period

Finalisation of concept study, perform initial measurement, perform multiphysics simulation, compare the results between experimental and numerical approach, detect area for accuracy increasing.

Contents of Work Package 3-WP11 Vehicle Instrumentation, Testing and Life Cycle Monitoring

3-WP11: Vehcile Instrumentation, Testing and Life Cycle Monitoring

Official 3-WP11 Deliverables:

- 3-WP11-001 | **Instrumented tractor for monitoring**, G-funk, ZETOR 0.7; BUT 0.2; TUO 0.05; WBU 0.05
- 3-WP11-002 | **Knowledge database of operation conditions and their influencing of tractor components lifecycle**, O-Ostatní, ZETOR 0.3; BUT 0.3; TUO 0.2; WBU 0.2
- 3-WP11-003 | **Virtual driver for exact experiment repeatability**, G-funk, BUT 0.85; TATRA 0.10; WBU 0.05

Activities in 3-WP11 Vehicle Instrumentation, Testing and Life Cycle Monitoring

3-WP11-001: Instrumented tractor for monitoring

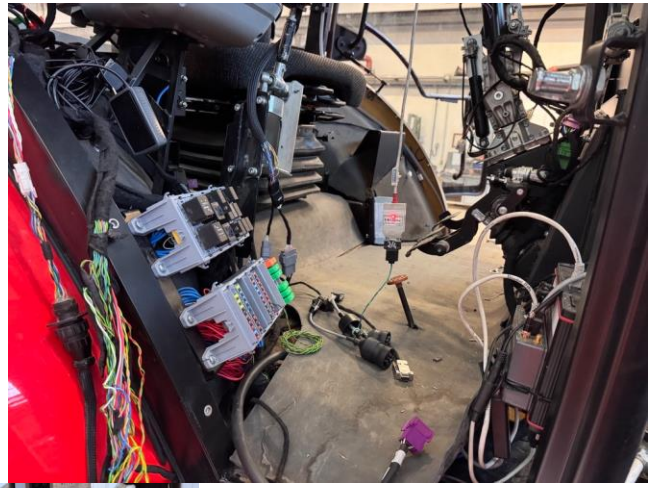
- *Modify tractor - sensors and control unit for serial production*
- *Add sensors to the tractor for validation of numerical model and evaluation of added sensors*
- *Perform measurement on ISO test rig*
- *Perform measurement on lifetime test rig*
- *Perform measurement in the filed with different accessories*
- *Evaluate data from technical experiment*

Activities in 3-WP11 Vehicle Instrumentation, Testing and Life Cycle Monitoring

3-WP11-001: Instrumented tractor for monitoring

Sensors and control unit for serial production

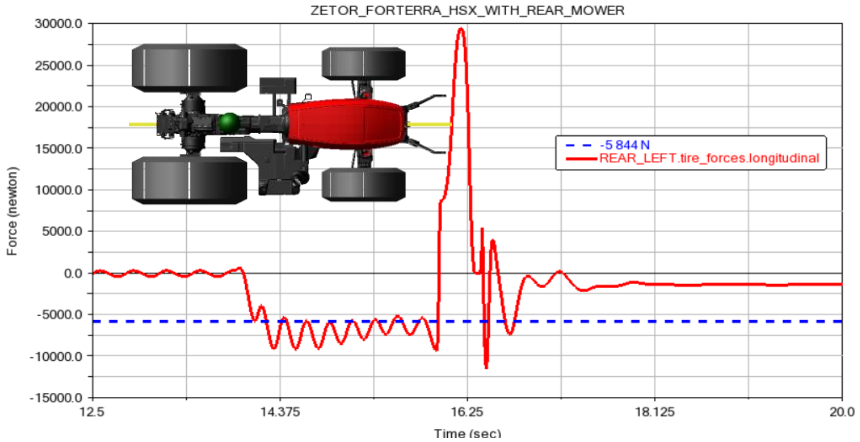
– New architecture of control unit which enables remote full control (future work)
  - Travel speed
  - Power shift gear
  - Engaged gear
  - Engine RPM
  - Engine load
  - GPS
  - Steering angle
  - Hydraulic pressure
  - Receiver for remote control (autonomous driving)

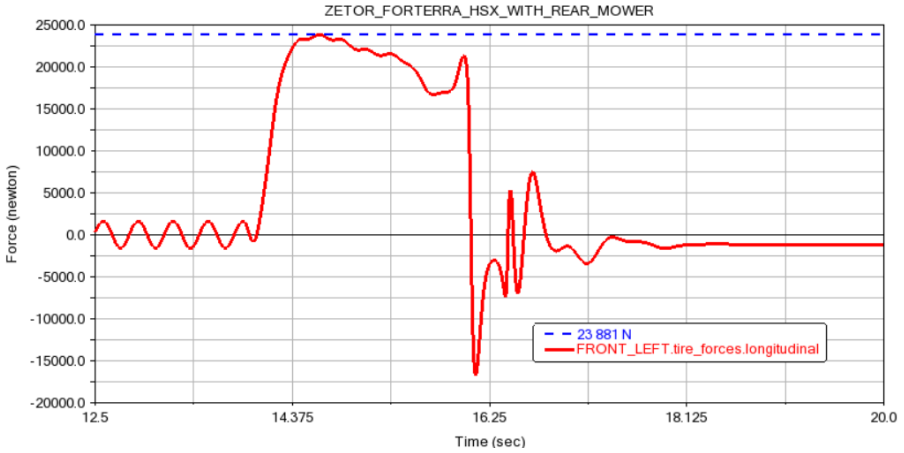


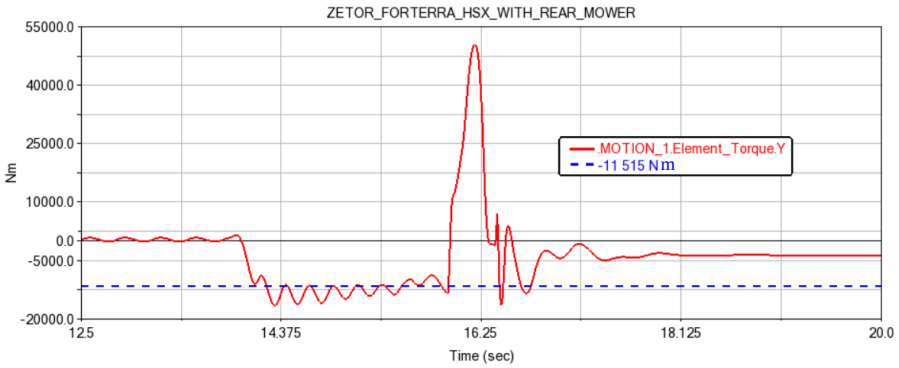
Activities in 3-WP11 Vehicle Instrumentation, Testing and Life Cycle Monitoring

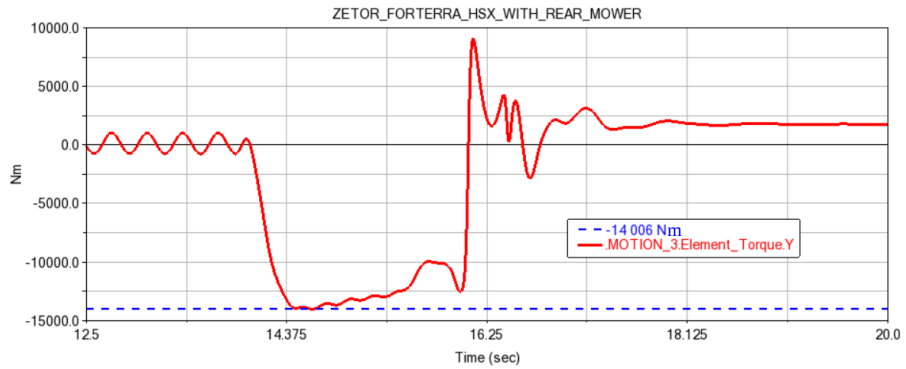
3-WP11-001: Instrumented tractor for monitoring

Add sensors to the tractor for validation of numerical model and evaluation of added sensors







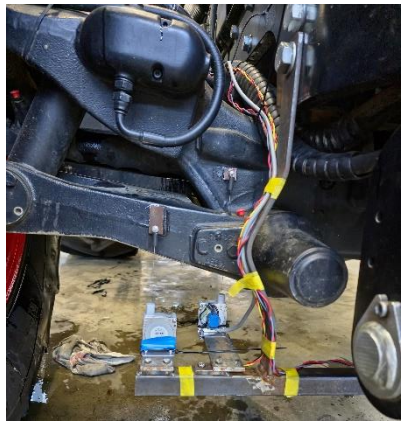


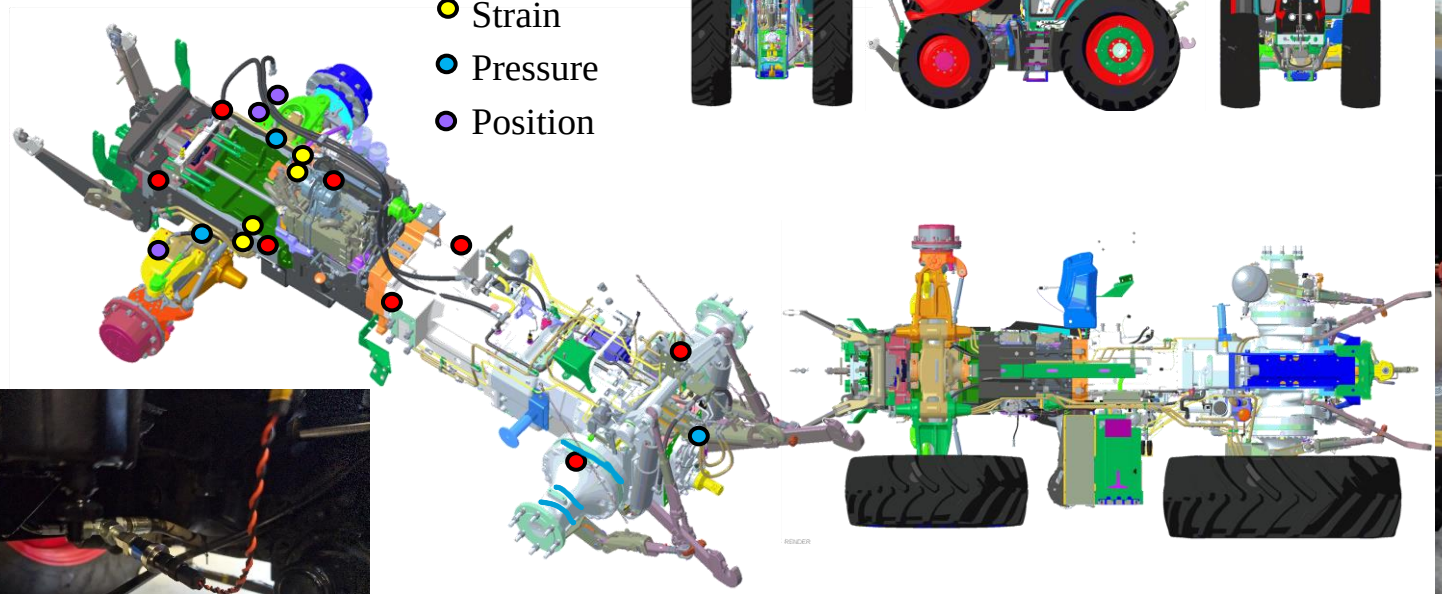
Activities in 3-WP11 Vehicle Instrumentation, Testing and Life Cycle Monitoring

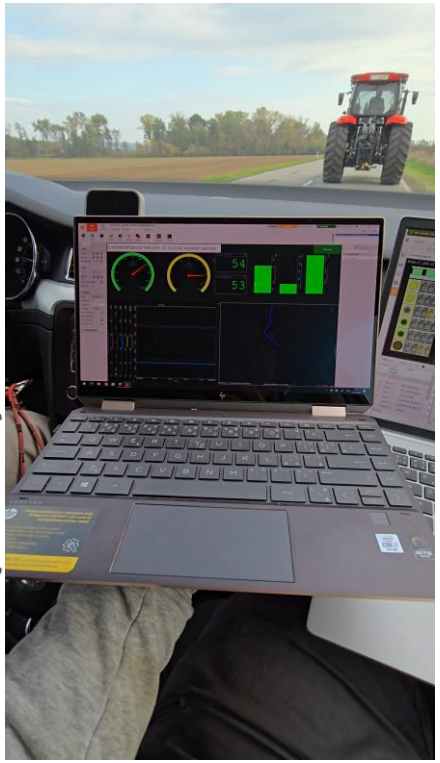
3-WP11-001: Instrumented tractor for monitoring

Add sensors to the tractor for validation of numerical model and evaluation of added sensors

- **Description of dynamic behaviour of tractor body**
- **Online monitoring**





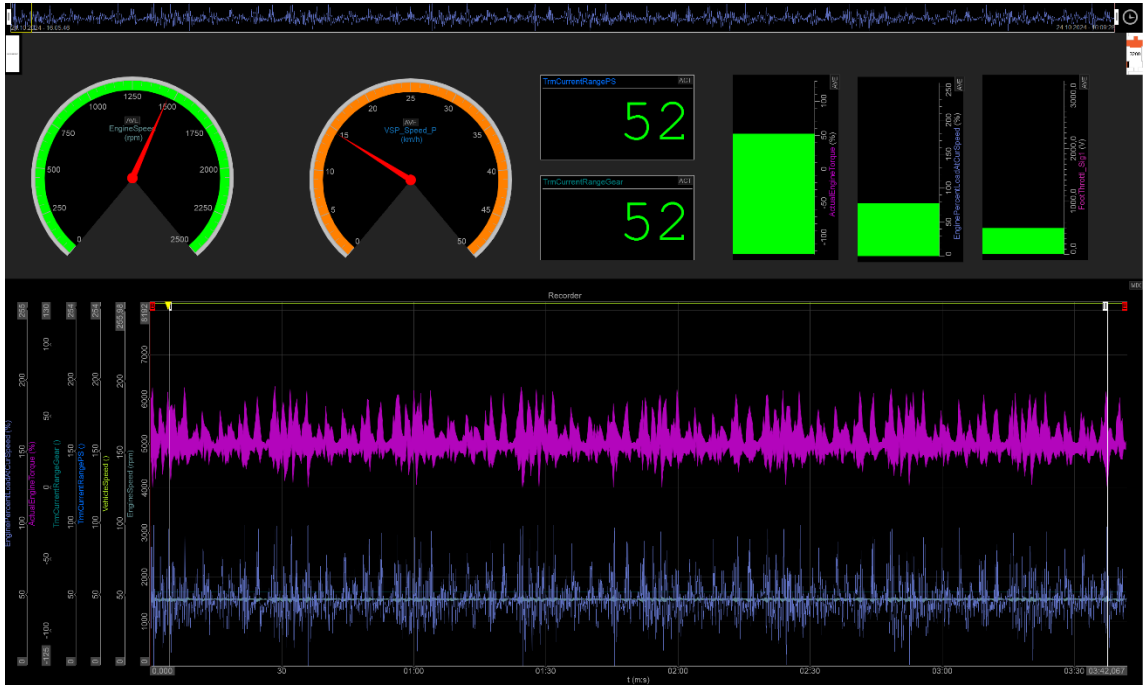


Activities in 3-WP11 Vehicle Instrumentation, Testing and Life Cycle Monitoring

3-WP11-001: Instrumented tractor for monitoring

Perform measurement on ISO test rig

- Weight in front and rear three-point hitch
- **Travel speed 3, 6 km/hod**

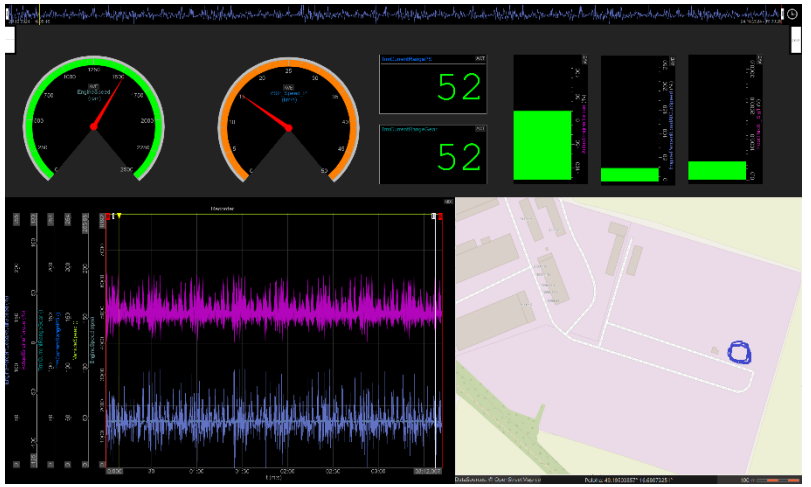


Activities in 3-WP11 Vehicle Instrumentation, Testing and Life Cycle Monitoring

3-WP11-001: Instrumented tractor for monitoring

Perform measurement on lifetime test rig

- Travel speed 9, 12, 15, 20 km/hod



Activities in 3-WP11 Vehicle Instrumentation, Testing and Life Cycle Monitoring

3-WP11-002: Knowledge database of operation conditions and their influencing of tractor components lifecycle

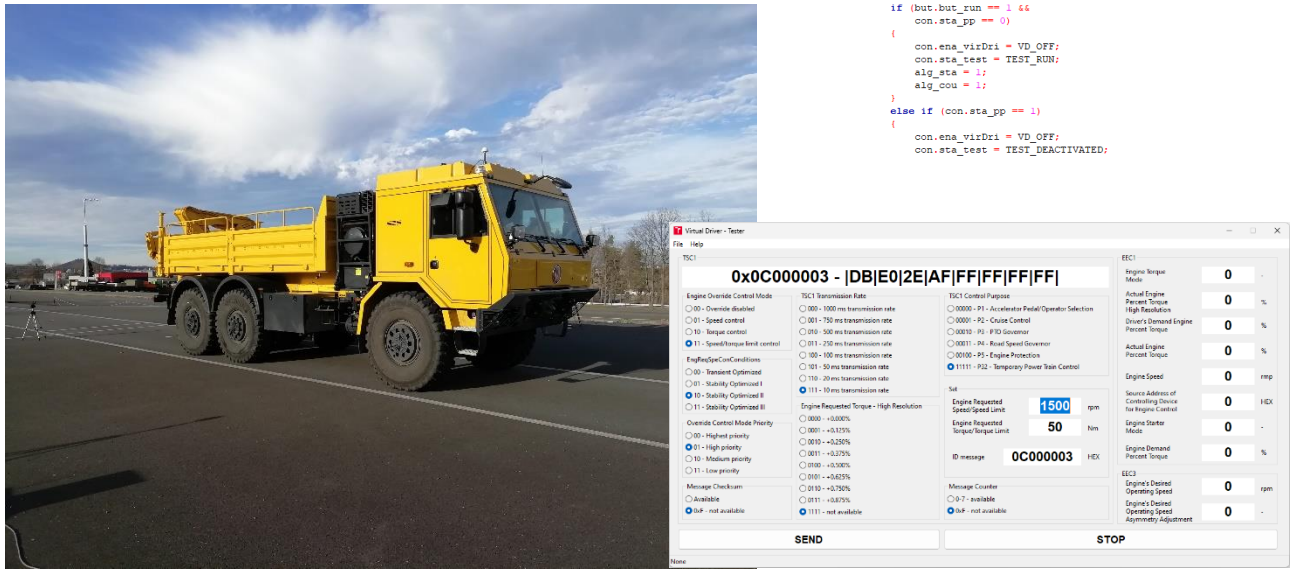
- Performing measurement on different background
  - Transportation on the road
  - Transportation on the cobblestone
  - Transportation on the concrete panels
  - ISO test rig
  - Life time test rig
- Performing measurement (separetely and combination)
  - Weight in front and rear three-point hitch
  - Basic operations with carried machine
  - Basic operations with semi-mounted machine
  - Basic operations with towed machine
- Data processing – own software

Activities in 3-WP11 Vehicle Instrumentation, Testing and Life Cycle Monitoring

3-WP11-003: Virtual driver for exact experiment repeatability

- Objectives and benefits
  - Ease of implementation on different vehicles
  - Repeatability of measurements
  - Better comparison of measured noise data - separation of driver influence
  - Automation/Autonomy to reduce personnel demands
- VD algorithm programming
  - Basic structure
  - The main algorithm
  - Periphery
  - Diagnostics
- Software interface programming
  - For programming
  - To set the parameter
- Software programming for testing
  - VD requirements for the vehicle
  - Verification of vehicle response functionality

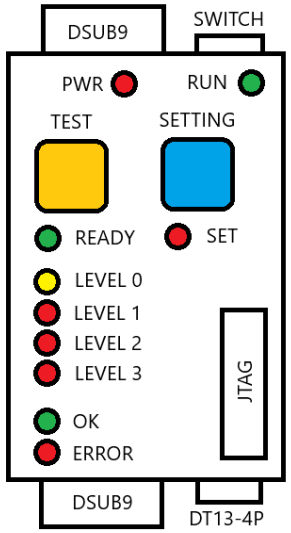
```
/* Includes ------------------------------------------------------------------*/
#include "VDFEER_algorithm.h"

uint8_t MyState = 0;

/* VDFEER ALGORITHM ----------------------------------------------------------*/
/**
* @brief  Control algorithm.
* @param
* @retval
* @note   -.
* Example usage:
<pre> Algorithm () </pre>
*/
uint8_t Algorithm(void)
{
/* COUNTER TIME --------------------------------------------------------------*/
    static uint32_t alg_cou;     // Vynoser casova pomlcky
/* STATE ---------------------------------------------------------------------*/
    static uint8_t alg_sta;      // Faloha v diagramu algoritmu

/* Control-Key ---------------------------------------------------------------*/

/* Control-Error -------------------------------------------------------------*/
    if (Error.ErrComplete[0] < 10)
    {
        switch(alg_sta)
        {
/* DEATIVATE TEST ------------------------------------------------------------*/
            default:
                if (but.but_run == 1 &&
                    con.sta_pp == 0)
                {
                    con.ena_virDri = VD_OFF;
                    con.sta_test = TEST_RUN;
                    alg_sta = 1;
                    alg_cou = 1;
                }
                else if (con.sta_pp == 1)
                {
                    con.ena_virDri = VD_OFF;
                    con.sta_test = TEST_DEACTIVATED;
```

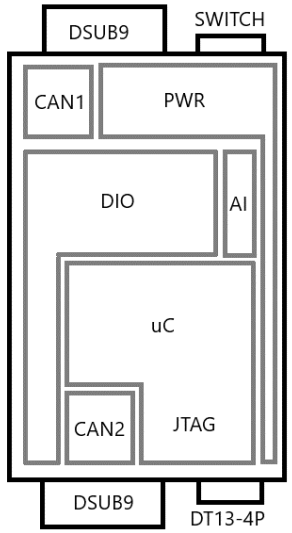


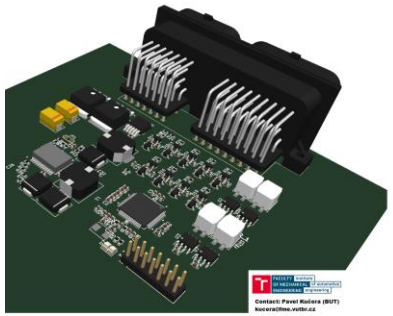
Activities in 3-WP11 Vehicle Instrumentation, Testing and Life Cycle Monitoring

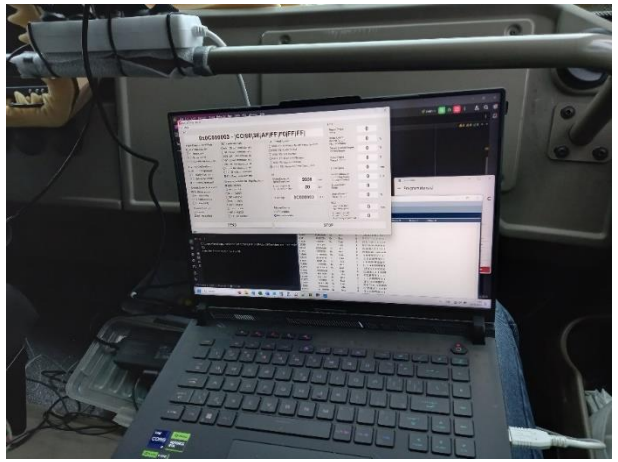
3-WP11-003: Virtual driver for exact experiment repeatability

- Hardware VD
  - IO interface
  - Control interface
  - Signaling interface
  - Modification of the first HW version
  - Setup and programming software
- Testing on the vehicle
  - VD drive train control test
  - Requirements for revolutions
  - Monitored vehicle response
- Next step
  - Determination of approach speed
  - VD hardware development
  - Completion of VD programming
  - Testing
  - Alternatively, expansion with AI elements









Current contribution of 3-WP11 Vehicle Instrumentation, Testing and Life Cycle Monitoring

Acknowledgment

This research has been realized using the support of Technological Agency, Czech Republic, programme National Competence Centres II, project # TN02000054 Božek Vehicle Engineering National Center of Competence (BOVENAC).

Fulfillment of goals and deliverables of 3-WP11 Vehcile Instrumentation, Testing and Life Cycle Monitoring

Current State of Deliverables, Milestones and Fulfillment of Goals

- 3-WP11-001 | Instrumented tractor for monitoring, ZETOR 0.7; BUT 0.2; TUO 0.05; WBU 0.05 **in progress & no major delays:**
  - Technical experiment were performed, perform multiphysics simulation, compare the results between experimental and numerical approach.
- 3-WP11-002 | Knowledge database of operation conditions and their influencing of tractor components lifecycle, ZETOR 0.3; BUT 0.3; TUO 0.2; WBU 0.2 **in progress & no major delays:**
  - results from technical experiment were evaluated.
- 3-WP11-003 | Virtual driver for exact experiment repeatability, G-funk, BUT 0.85; TATRA 0.10; WBU 0.05 **in progress & no major delays:**
  - VD hardware development
  - VD algorithm programming
  - Tested on a vehicle

Fulfillment of goals and deliverables of 3-WP11 Vehcile Instrumentation, Testing and Life Cycle Monitoring

List of Due Deliverables and Their Added Value

- **3-WP11-001 - Instrumented tractor for monitoring** enables to monitor behaviour of tractor during whole spectrum of operation conditions and based on this set appropriate servis interval and decrease servise costs.
- **3-WP11-002 - Knowledge database of operation conditions and their influencing of tractor components lifecycle** extends knowledge of current tractor operations conditions including effect on the lifetime. It enables to set appropriate servis interval and decrease servise costs.
- **3-WP11-003 - Virtual driver for exact experiment repeatability** enables the reduction of costs and the increase of competitiveness of capabilities.

Current contribution of 3-WP11 Vehcile Instrumentation, Testing and Life Cycle Monitoring

Assessment of the Contribution of Deliverables

Financial resources are used according the project plan and the share of commercialization is also met.
Based on the cooperation the proposal for new project are prepared or under assesment.

Current contribution of 3-WP11 Vehcile Instrumentation, Testing and Life Cycle Monitoring

Assessment of the Formal/Administrative Goals of the Work Package

	BUT	ZETOR TRACTORS	TATRA TRUCKS	TUO	WBU
Finances (reporting/spending)	OK	OK	OK	OK	OK
Commercialization (the whole organisation)	OK	OK	OK	OK	OK
Deliverables	OK	OK	OK	OK	OK

Current contribution of 3-WP11 Vehcile Instrumentation, Testing and Life Cycle Monitoring

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Výtah z prací 2023-2025 na 3-WP11 Vehcile Instrumentation, Testing and Life Cycle Monitoring

3-WP11-003 Virtuální řidič pro přesnou opakovatelnost experimentu

(Pavel Kučera – kucera@fme.vutbr.cz)

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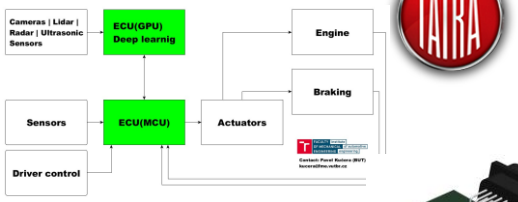
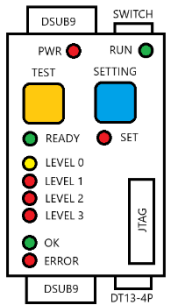
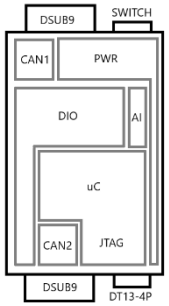
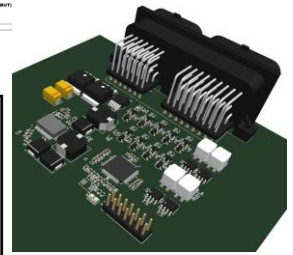


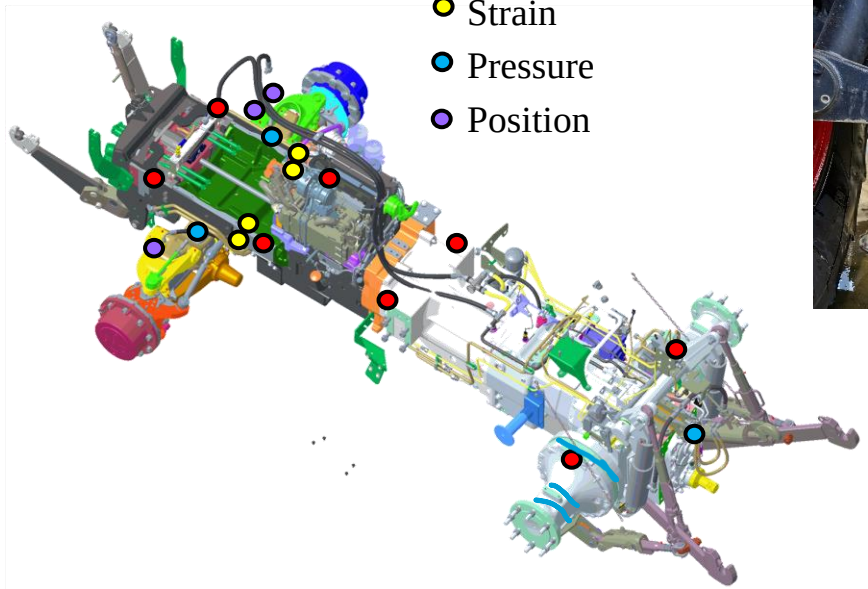


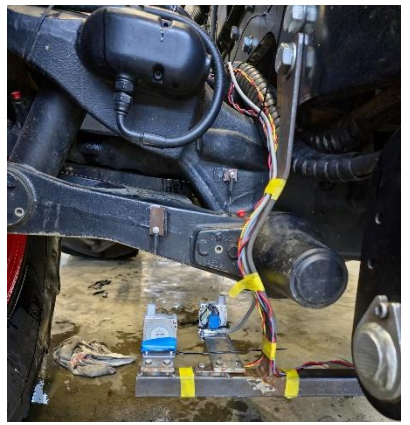




3-WP11-001 Instrumentovaný traktor pro monitorování

3-WP11-002 Znalostní databáze provozních podmínek a jejich vliv na životnost komponent traktoru





Results of 3-WP11 Vehcile Instrumentation, Testing and Life Cycle Monitoring–Achieved 2023-2025

3-WP11-003 Virtual driver for exact experiment repeatability

(Pavel Kučera – kucera@fme.vutbr.cz)

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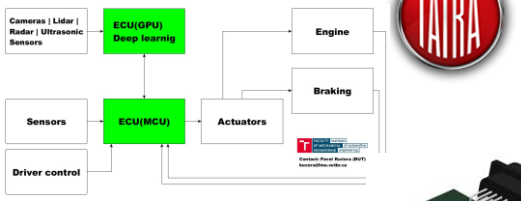
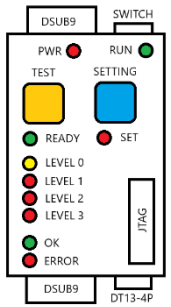
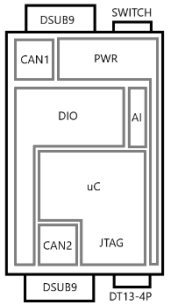
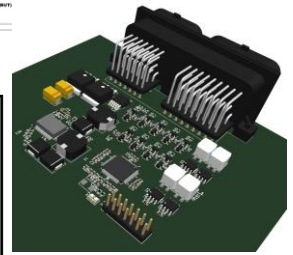




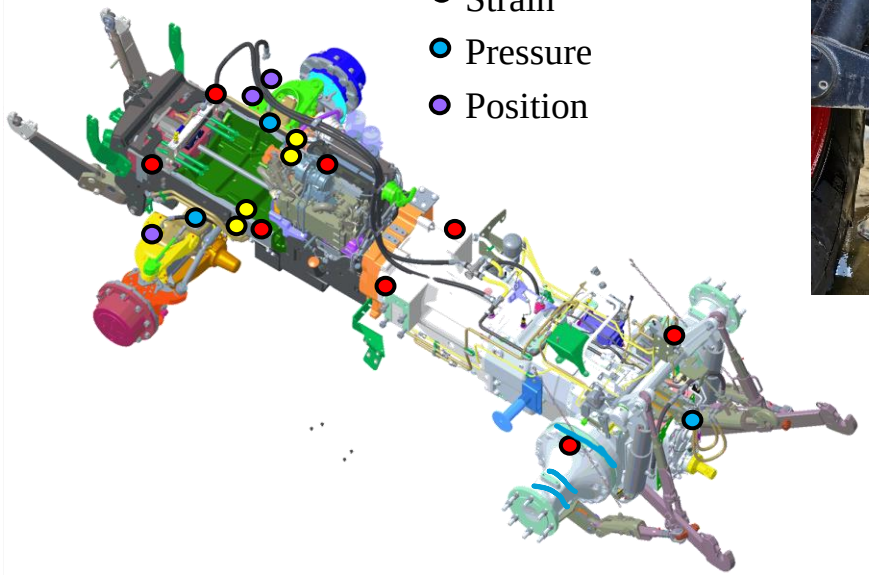


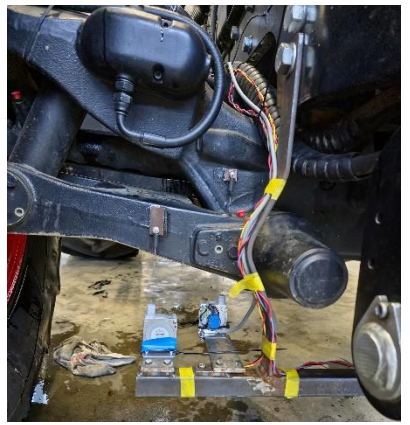


3-WP11-001 Instrumented tractor for monitoring

3-WP11-002 Knowledge database of operation conditions and their influencing of tractor components lifecycle

- Acceleration
- Strain
- Pressure
- Position





Výtah z prací 2024 na 3-WP11 Vehcile Instrumentation, Testing and Life Cycle Monitoring

3-WP11-003 Virtuální řidič pro přesnou opakovatelnost experimentu

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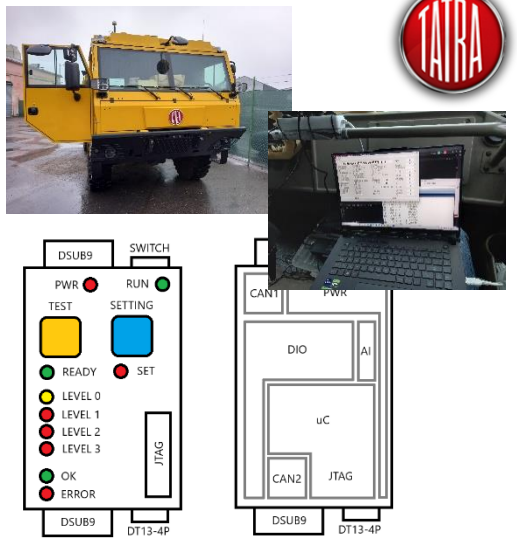

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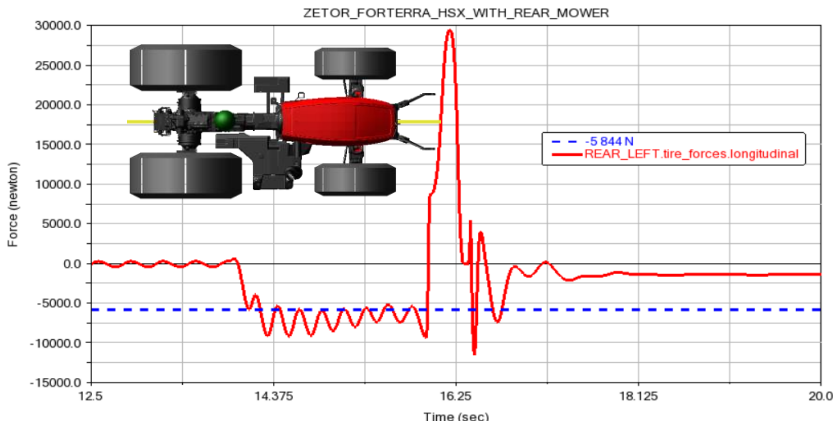

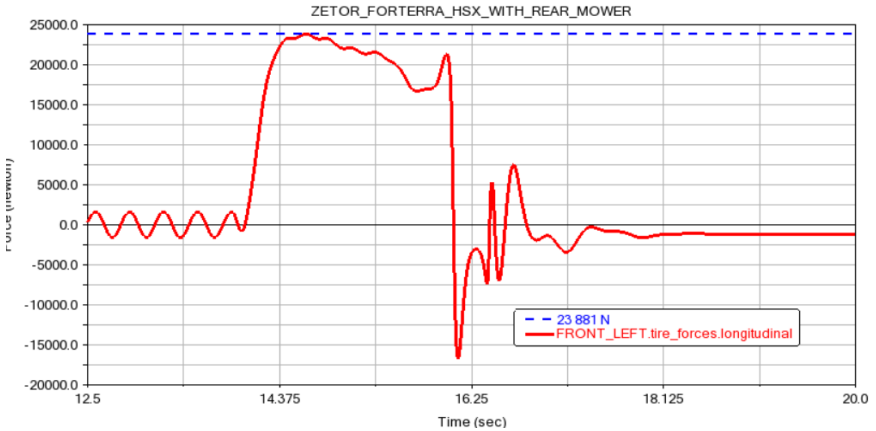

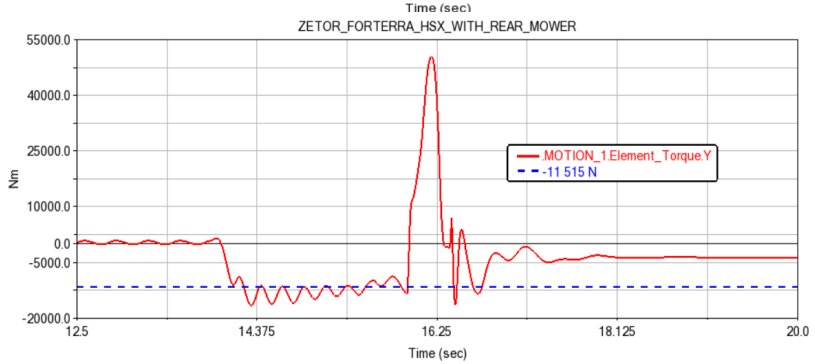

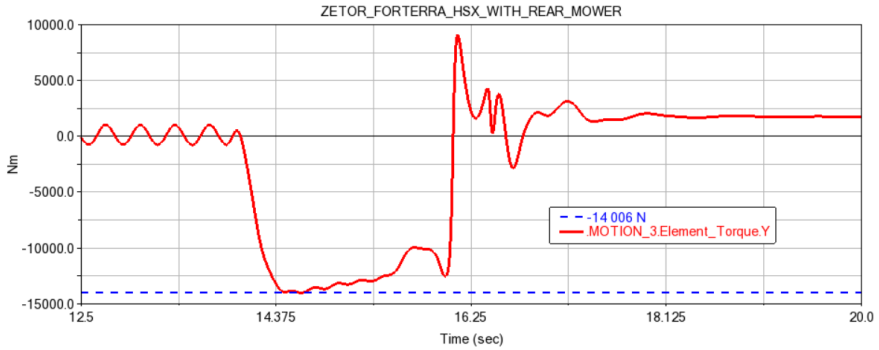

Results of 3-WP11 Vehcile Instrumentation, Testing and Life Cycle Monitoring–Achieved 2024

3-WP11-003 Virtual driver for exact experiment repeatability

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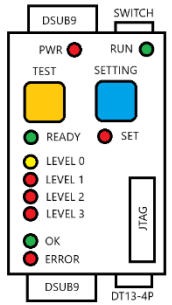

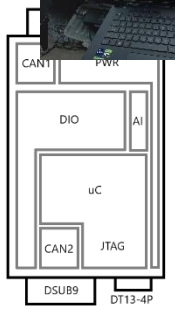

3-WP11-001 Instrumented tractor for monitoring

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