Contents of Work Package **4-WP05** Tools of Design and Components for Advanced Vehicles - Safety, Design, Active Control and Lubrication of Future Rail Vehicles

FEFEFOF_4-WP05: Safety, Design, Active Control and Lubrication of Future Rail Vehicles

Coordinator of the WP 05

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Siemens Mobility spol. s r.o., Ing. Tomáš Ondra
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Tribotec spol. s r.o., Ing. Pavel Rosendorf

Contents of Work Package **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

Main Goal of the WP

- Design of a working sample of a new two-axle bogie for freight wagon. Testing main components of bogie, suspension elements, dampers. Performance of strength calculations and life-time test of materials. Processing of the production documentation of the main components of the new bogie.

- Development of MBS models of a virtual low-floor articulated tram with active elements in bogies.

- Methodology of design of parameters of elements passive safety of railway vehicles.

- Development of a functional sample of a new on-board application unit for liquid and semi-liquid lubrication to control the coefficient of friction between wheels and rails, development of an advanced system to control the coefficient of friction of a roundabout in sharp curves of railway and tram tracks.

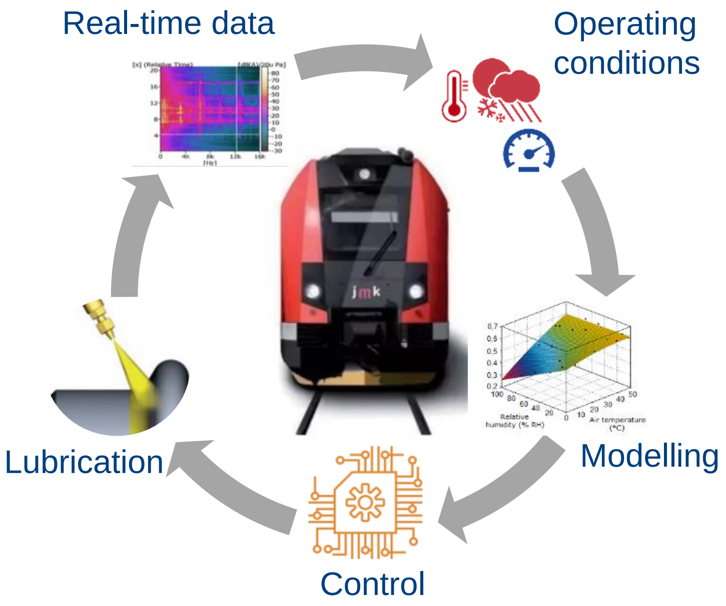
All these R&D activities will contribute to shortening the time between conceptual research and the application of an innovative product to the market (time-to-market, TTM) by about 20%, primarily by using the accumulated experience from previous solutions and timely removal of development dead ends in its initial phase.

Contents of Work Package **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

Partial Goals for the Current Period

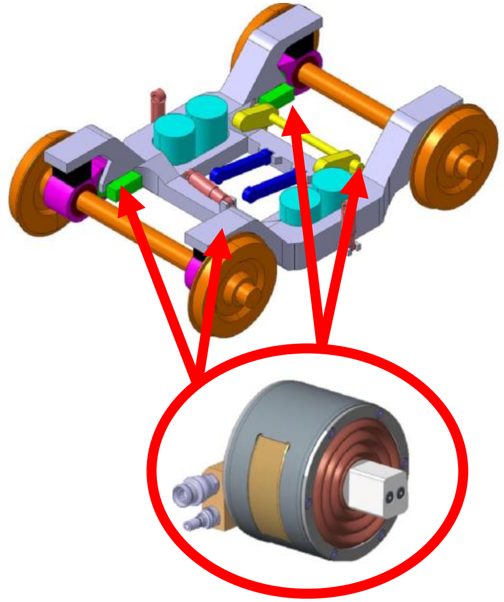
- Development and implementation of friction management technique through the application of a digital twin approach.
- Control system for the wheel-flange/top-of-rail lubrication based on the combination of:
  - automatic prediction of load, slip and contact area of the wheel-rail contact (based on models, GNSS + map data and operating conditions);
  - prediction of changing properties of the friction layer between the rail and the wheel (based on experimental results and models)
  - feedback from the on-board condition monitoring (noise and vibration);
  - real-time evaluation and optimization of the lubrication control.

The system will be implemented, tested and optimized on a real railway system (Brno-Blansko).

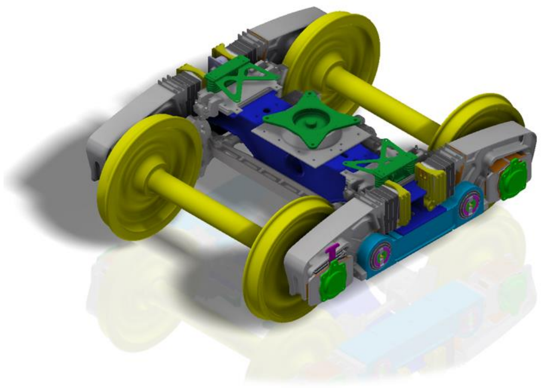


Contents of Work Package **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

Partial Goals for the Current Period



- concept design of a low-floor articulated tram with active elements in the tram bogies, development of more accurate MBS models of bogies and trams with actuators, development of actuator control algorithms, simulation of actuator failure states, evaluation of safety risks
- creation of a model of a rail vehicle accident with a car, analysis of the parameters of deformation elements for the consequences of accidents, conceptual design of new crash elements of trams and regional rail vehicles



- selection of suitable sensors for application in the system of measuring the position of wheelset in the track, design of the layout of the sensor system and processing of signals from individual sensors
- design of partial parts, production of functional samples, production and assembly of a functional sample of a new bogie for freight wagons, performance of quasi-static and dynamic tests of bogie and their evaluation

Contents of Work Package **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

4-WP05: Safety, Design, Active Control and Lubrication of Future Rail Vehicles

Official 4-WP05 Deliverables:

Main Goal

- 4-WP05-005 | **Test sample of a key part of the railway bogie**, G_{funk}, (VÚKV 0.2 , TatraVagonka 0.8)
  TN 02000054/004-V19

- 4-WP05-007 | **Onboard lubrication unit for advanced friction management**, G_{funk},
  TN 02000054/004-V21 (FME VUT 0.3 , Tribotec 0.7)

Contents of Work Package **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

4-WP05: Safety, Design, Active Control and Lubrication of Future Rail Vehicles

Official 4-WP05 Deliverables:

Another goal

- 4-WP05-001 | **MBS model of a virtual low-floor articulated tram with active elements** ,O, (FME CTU 0.75 + STRN 0.2 + VÚKV 0.05)

TN 02000054/004-V15

- 4-WP05-002 | **Methodology of design of parameters of elements passive safety of railway vehicles** ,O, (FME CTU 0.9 + SIEMENS Mobility 0.1)

TN 02000054/004-V16

- 4-WP05-003 | **Methodology of design of shape solution of passive protective elements of given parameters for railway vehicles**,O, (FME CTU 0.9 + SIEMENS Mobility 0.1)

TN 02000054/004-V17

Contents of Work Package **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

4-WP05: Safety, Design, Active Control and Lubrication of Future Rail Vehicles

Official 4-WP05 Deliverables:

Another goal

- 4-WP05-004 | **Analysis of the possibilities of the conceptual solution of sensors for determining the current position of the wheelset in the track**,O, (FME CTU 0.9 + STRN 0.1)

TN 02000054/004-V18

- 4-WP05-006 | **Report on Milestones - New bogie for freight wagons**,O, (VÚKV 0.8 + Tatravagonka 0.2)

TN 02000054/004-V20

- 4-WP05-008 | **Prediction of friction in the wheel-rail interface**,O, (FME BTU 0.4 + STRN 0.3 + UPa 0.3)

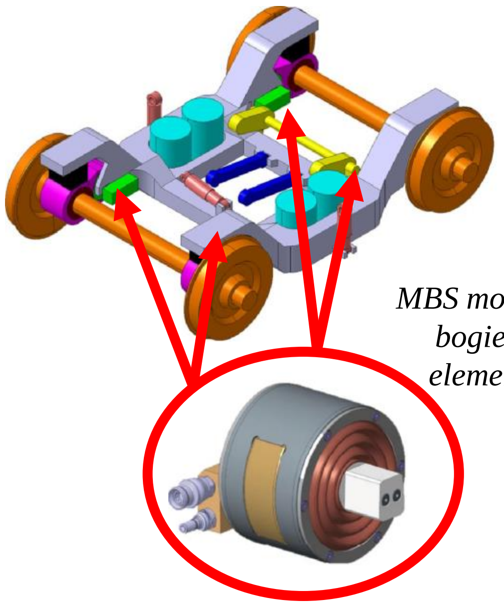
TN 02000054/004-V22

Activities in **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

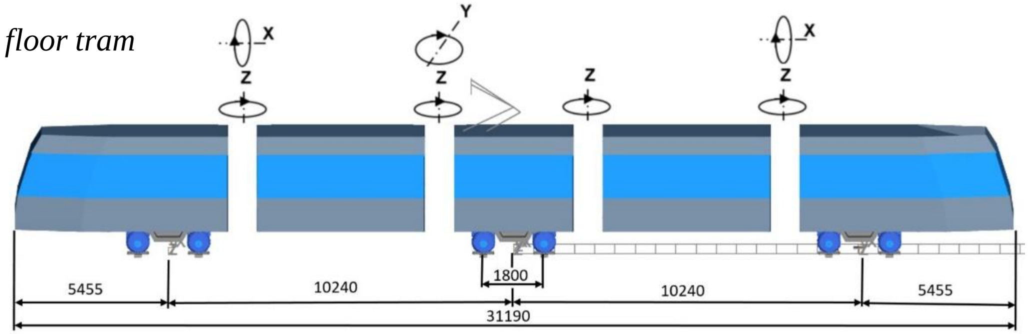
4-WP05-001: **MBS model of a virtual low-floor articulated tram with active elements**

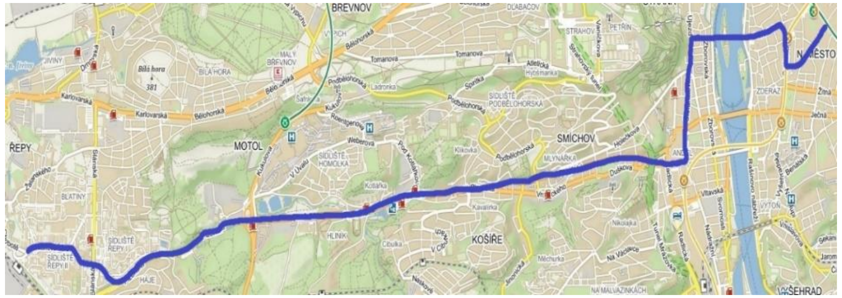
- Concept design of low floor tram with active elements in the tram bogies
- Creation of an MBS model of an articulated tram with active elements in the tram bogies
- Creation of a test track model according to the Václavské náměstí – Sídliště Řepy

MBS model of articulated low floor tram



MBS model of the tram bogie with active elements Liebherr





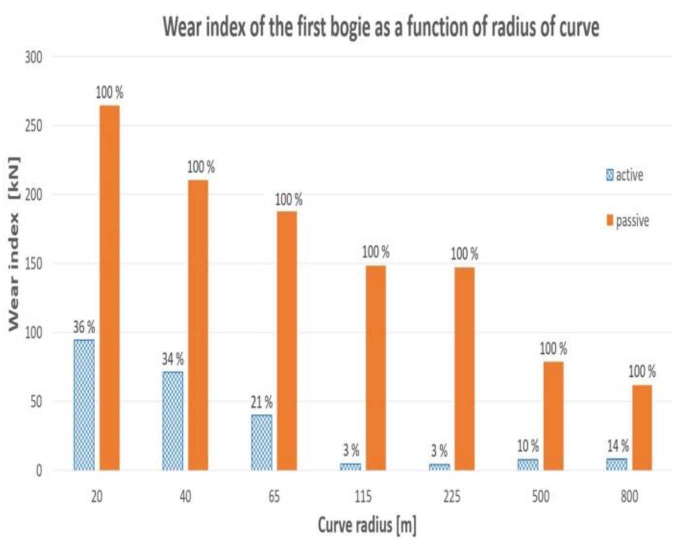
Interval radius [m]	Number of curves	Length of the curves [m]	Length of the transitions [m]
R20 – R30	4	103	0
R30 – R50	9	67	30
R50 – R80	4	183	53
R80 – R150	8	318	188
R150 – R300	12	798	363
R300 - R600	13	1227	252
R600 - R1000	6	331	92
> R1000	12	590	11
Straight line	58	6 035 m	
Total line length		10 641 m	

Analysis of directional curves and gradients of the tram line Václavské náměstí – Sídliště Řepy

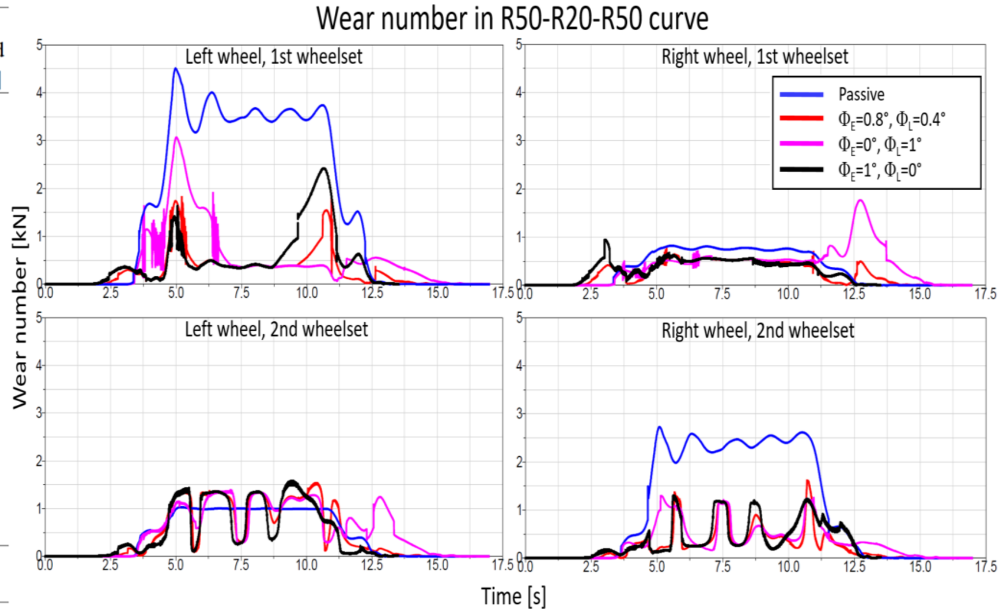
Activities in **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

4-WP05-001: **MBS model of a virtual low-floor articulated tram with active elements**

- Created the first version of the actuator control algorithm
- Simulations of driving a vehicle with active and passive suspension on a test track under various boundary conditions were carried out - reduction in the wear index around 75% was achieved
- Publication of the results achieved at the ProRail 2023 conference in Žilina - Slovakia



Wheelset guidance	Speed [kph]	Loading	Friction coeficient	Wear index [N]	Reduction of wear index [%]	Disipated energy [J]	Reduction of disipated energy [%]
passive	max	EL4	0.4	1 124 368		7 460 732	
passive	max	EL4	0.15	342 539		2 517 519	
passive	max	ELE	0.4	886 817		5 922 422	
passive	max	ELE	0.15	266 268		1 937 006	
passive	15	EL4	0.4	1 512 409		6 301 704	
passive	15	EL4	0.15	617 168		2 571 533	
passive	15	ELE	0.4	1 525 949		6 358 121	
passive	15	ELE	0.15	496 158		2 067 325	
active	max	EL4	0.4	338 534	70	1 601 659	79
active	max	EL4	0.15	141 621	59	1 055 892	58
active	max	ELE	0.4	270 397	70	1 055 203	82
active	max	ELE	0.15	111 156	58	812 322	58
active	15	EL4	0.4	381 586	75	1 589 942	75
active	15	EL4	0.15	167 917	73	699 654	73
active	15	ELE	0.4	304 153	80	1 267 304	80
active	15	ELE	0.15	134 726	73	561 358	73
passive wheelset guidance in total				6 771 676		35 136 362	
active wheelset guidance in total				1 850 090	73	8 643 334	75



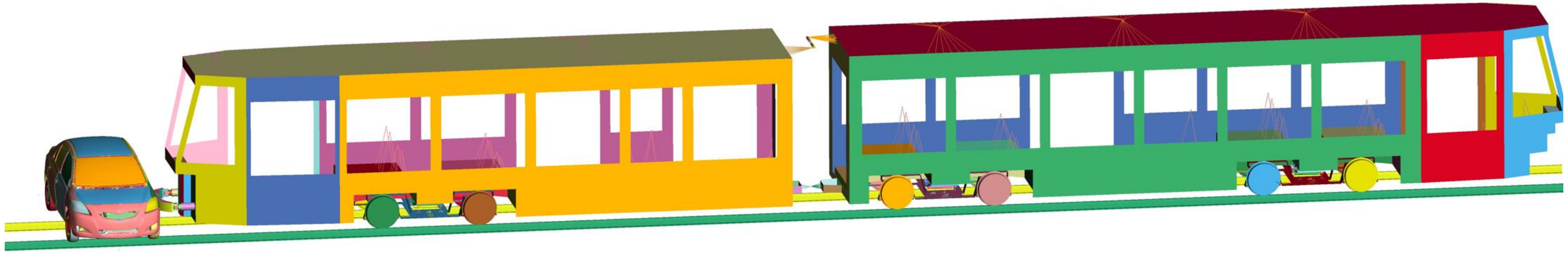
Activities in **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

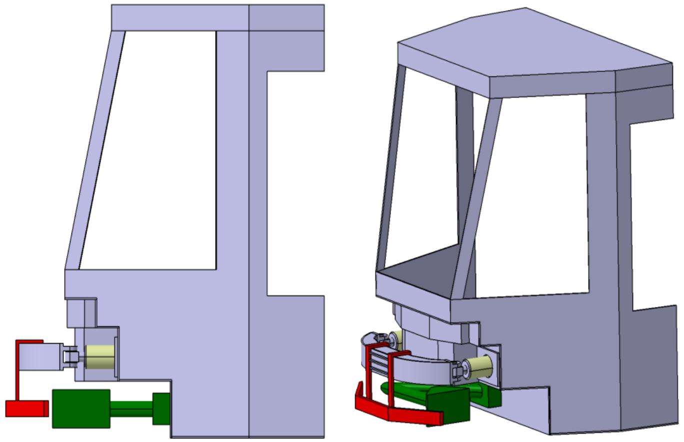
4-WP05-002: **Methodology of design of parameters of elements passive safety of railway vehicles**

4-WP05-003: **Methodology of design of shape solution of passive protective elements of given parameters for railway vehicles**

- Creation of a simulation model of an articulated low-floor tram
- Application of knowledge from the fields of stiffness compatibility body cars and geometry of road vehicles.

Models of personal car and articulated low-floor tram





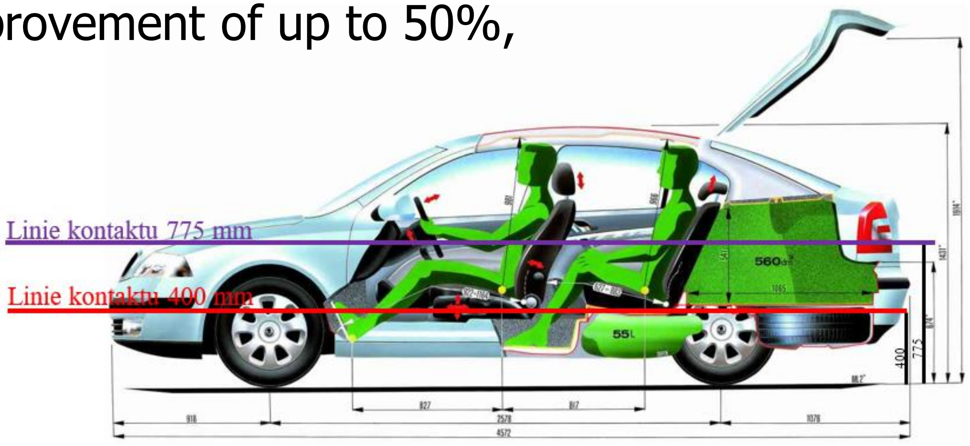
A model of the driver's cabin of an articulated low-floor tram with a new crash element

Activities in **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

4-WP05-002: **Methodology of design of parameters of elements passive safety of railway vehicles**

4-WP05-003: **Methodology of design of shape solution of passive protective elements of given parameters for railway vehicles**

- Determination of the influence of individual parameters on the consequences of accidents:
  - characteristics of deformation elements => improvement of up to 25%,
  - height position of deformation elements above the TK plane => improvement of up to 60%,
  - width of contact area of deformation elements => improvement of up to 50%,
  - contact surface height => negligible improvement.

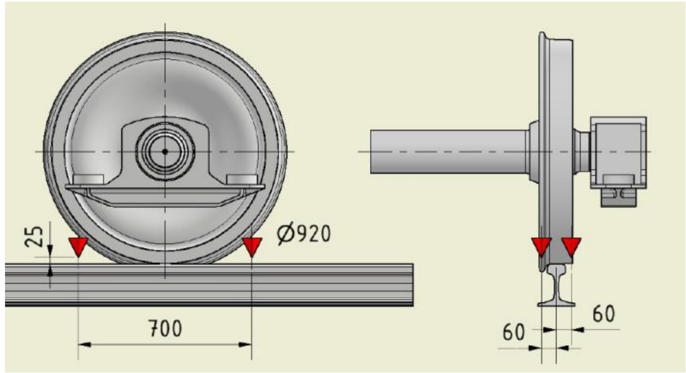


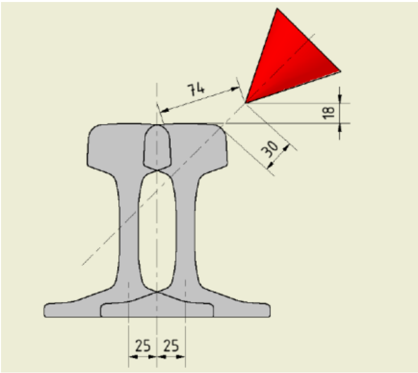
The area of the height line of the crash side contact

Activities in **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

4-WP05-004: **Analysis of the possibilities of the conceptual solution of sensors for determining the current position of the wheelset in the track**

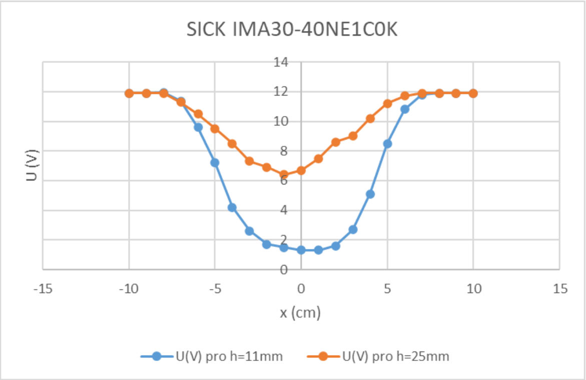
- study of possible locations of the sensor system on the vehicle,
- defining the basic parameters of the sensors,
- research of sensors available on the market,
- purchase of suitable sensors in terms of technical parameters, availability and price, first sensitivity testing,
- development of a preparation for detailed testing of sensor sensitivity.

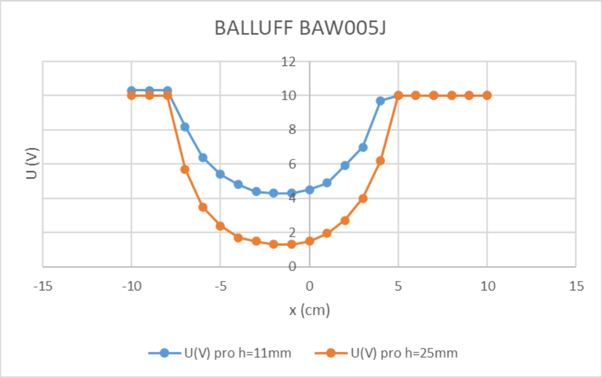




Principle – locations of sensor in bogie

Inductive Analog Sensor MXN 080.19 S4



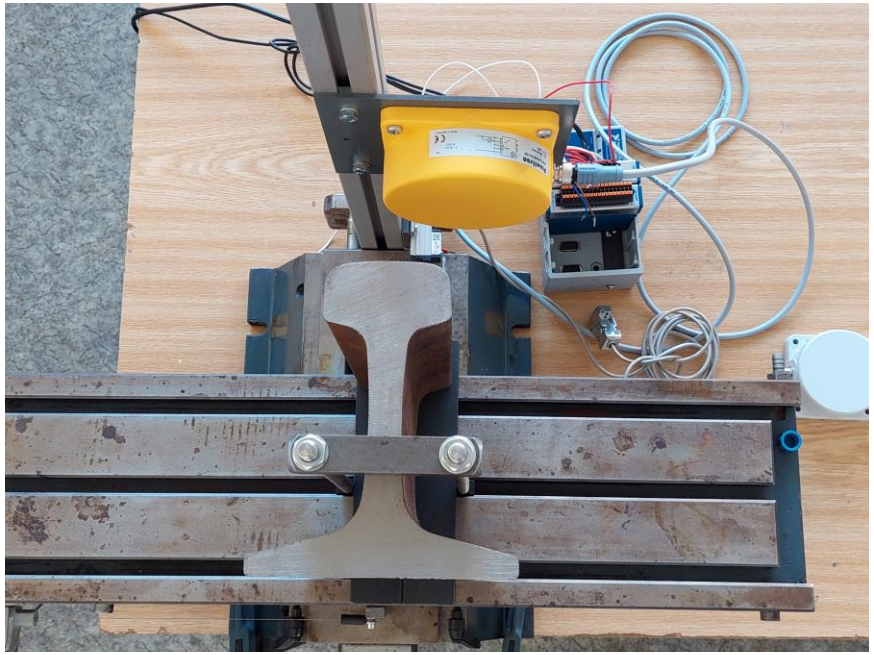


The inductive sensor and basic test of its sensitivity

Activities in **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

4-WP05-004: **Analysis of the possibilities of the conceptual solution of sensors for determining the current position of the wheelset in the track**

- development of a preparation for detailed testing of sensor sensitivity.



A test fixture for a basic test of its sensor sensitivity

Activities in **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

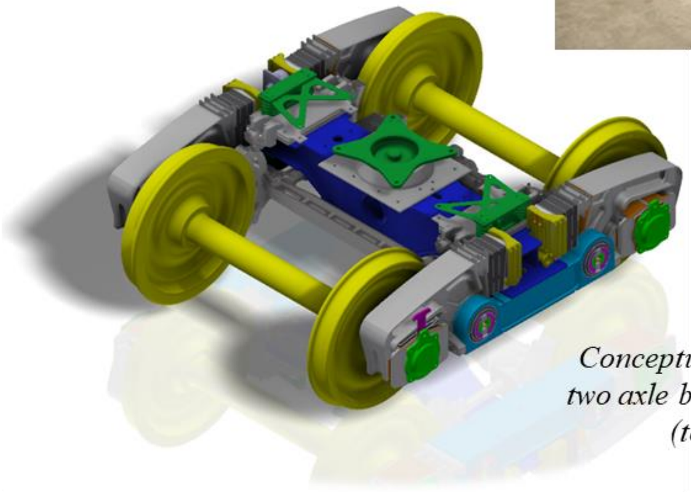
4-WP05-005: **Test sample of a key part of the railway bogie**

4-WP05-006: **Report on Milestones - New bogie for freight wagons**

Proposal of new freight bogie – motivation and goal

- Current standard – freight bogie Y25 (since 1967 as UIC Standard)
- Freight bogie Y25 is not able to be fully comply with actual standards
- Main problematic areas:
  - Noise level
  - Interaction between wheel and rail
- Conceptual characteristics of new rail freight bogie NP-X:
  - Identical interfaces and lower or same space requirements as Y25
  - Family of 3 concepts – NP-S, NP-R, NP-VR
  - Using of rubber suspension oriented horizontal
  - Riveted connections in structural areas (bogie frame)
- International cooperation with strategic partner from industry
- Patented solution with high potential on railway market

Freight bogie Y25



Conceptual proposal of the new two axle bogie for freight wagons (test device FV2)

Activities in **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

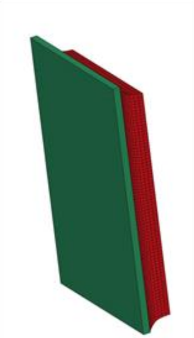
4-WP05-005: **Test sample of a key part of the railway bogie**

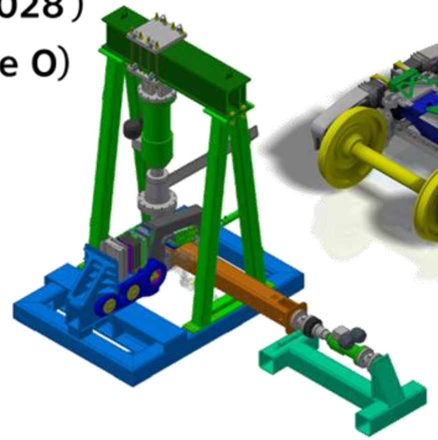
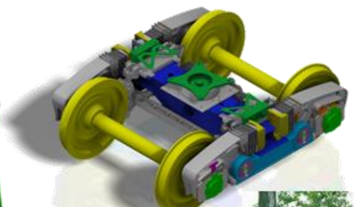
4-WP05-006: **Report on Milestones - New bogie for freight wagons**

VÚKV TATRAVAGÓNKA POPRAD

Proposal of new freight bogie – activities

- Activities in current project FEFEFOV extend results received in earlier project CKDV.
- Overview over planned activities and results in project FEFEFOV (2023 - 2028):
  - Development and testing of key part of the bogie (1. result: test sample G_{funk} in 12/2025)
  - Development of bogie concept, production of test samples (bogies) and testing under railway vehicle on test ring and real track (2. result: test sample G_{funk} in 12/2028)
  - Detailed documentation of all activities (other results: reports of type O)


Testing on existing devices => Calculations => Choice of measuring devices => Proposal of rubber springs => Construction of new test devices (FV1, FV2 and FV3) and testing

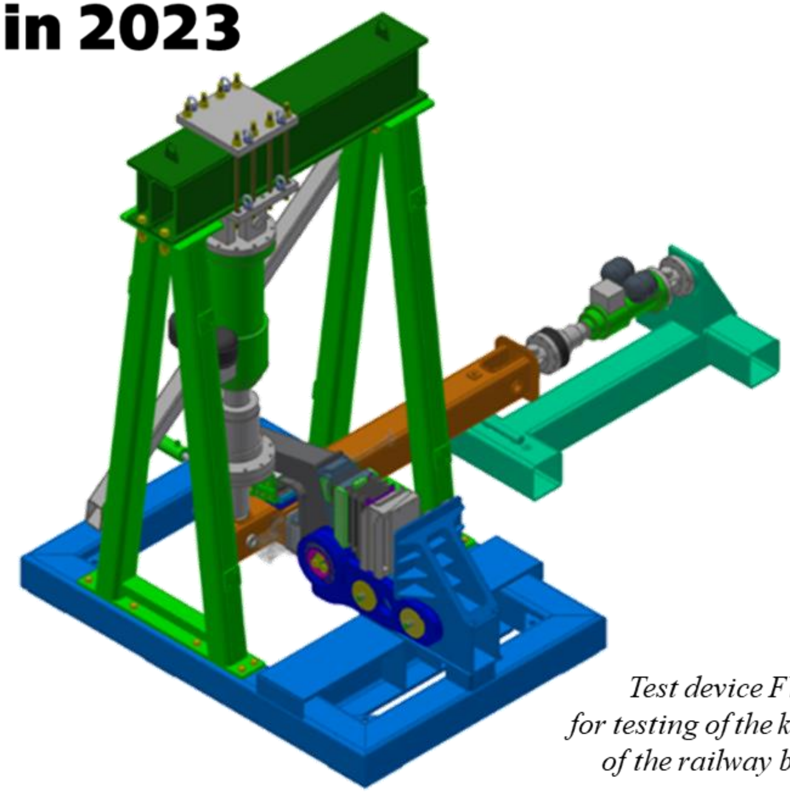
Activities in **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

4-WP05-005: **Test sample of a key part of the railway bogie**

4-WP05-006: **Report on Milestones - New bogie for freight wagons**

Proposal of new freight bogie – activities in 2023

- Introducing of project teams VÚKV a TVP.
- Discuss and agreement about intentions, goals and time schedule.
- Proposal of test device FV1 (relating to key part of the bogie).
- Conceptual proposal of test device FV2 (represents whole bogie).
- Making of necessary set of calculations and simulations (FV1, FV2).
- Making of product documentation (FV1).
- Start of production FV1 – part in TVP, part organized by VÚKV.
- Next activities:
  - finishing of production FV1,
  - start of testing (quasi static, dynamic).



Test device FV1 for testing of the key part of the railway bogie

Activities in **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

4-WP05-007: **Onboard lubrication unit for advanced friction management**

4-WP05-008: **Prediction of friction in the wheel-rail interface**

Motivation

- Lack of an effective solution for wheel-flange and top-of-rail lubrication in curves with small radii (< 300 m).
- Railway corridor between Brno and Blansko with a large number of curves, open after reconstruction in 2023.
- 30y full-service of train units for the South Moravian region operated in the corridor (Skoda Group).

The electrical unit Regio Panter for the South Moravian

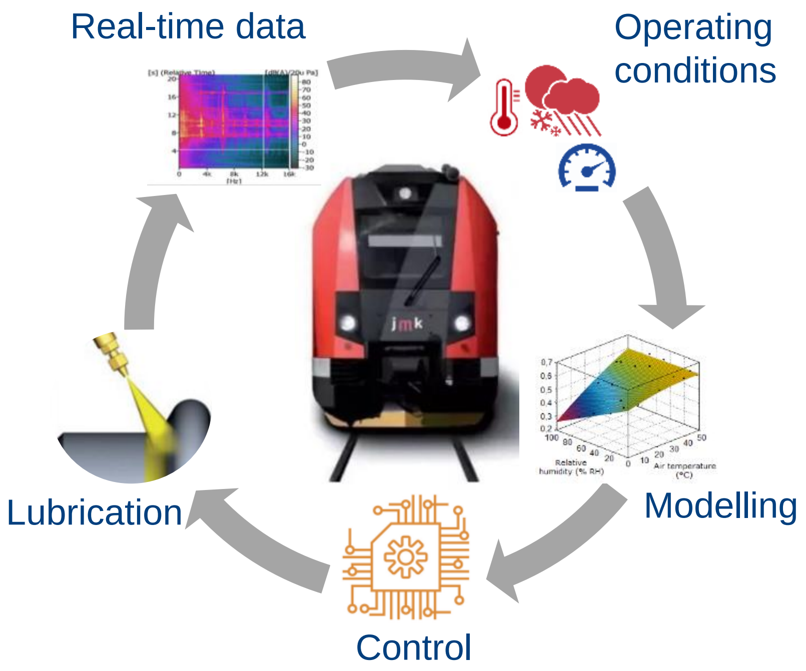
View of part of the curved railway track Brno - Blansko

Activities in **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

4-WP05-007: **Onboard lubrication unit for advanced friction management**

4-WP05-008: **Prediction of friction in the wheel-rail interface**

- Development and implementation of friction management technique through the application of **a digital twin** approach.
- Control system for the wheel-flange/top-of-rail lubrication based on the combination of:
  - automatic prediction of load, slip and contact area of the wheel-rail contact *(based on models, GNSS + map data and operating conditions);*
  - prediction of changing properties of the friction layer between the rail and the wheel (based on experimental results and models);
  - feedback from the on-board condition monitoring (noise and vibration;
  - real-time evaluation and optimization of the lubrication control.

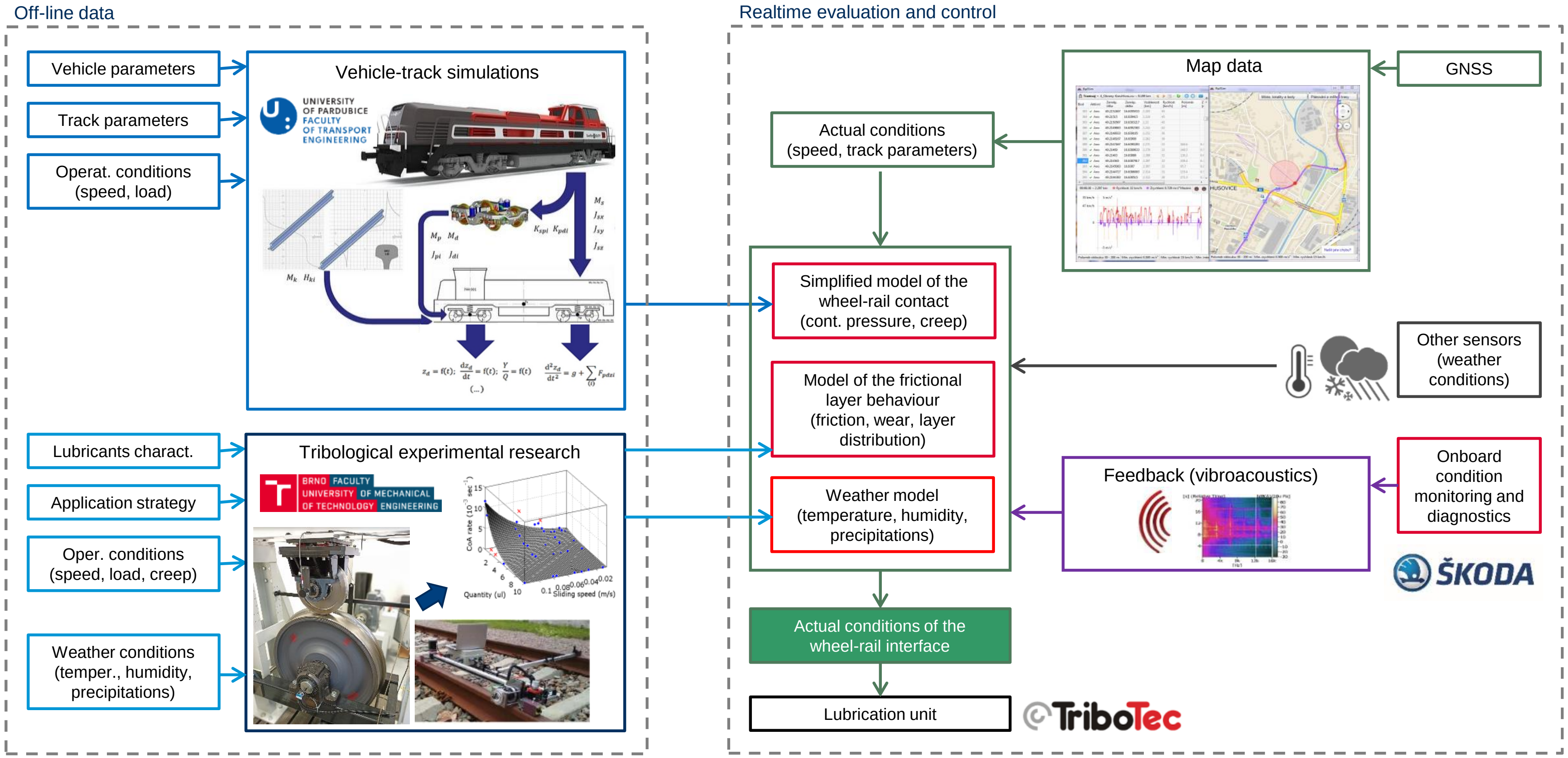


Concept solution of a digital twin electric unit.

Activities in **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

4-WP05-007: **Onboard lubrication unit for advanced friction management**

4-WP05-008: **Prediction of friction in the wheel-rail interface**

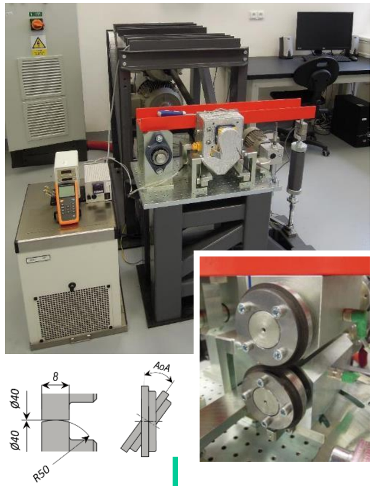


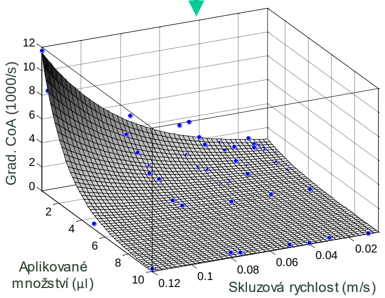
Activities in **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

4-WP05-007: **Onboard lubrication unit for advanced friction management**

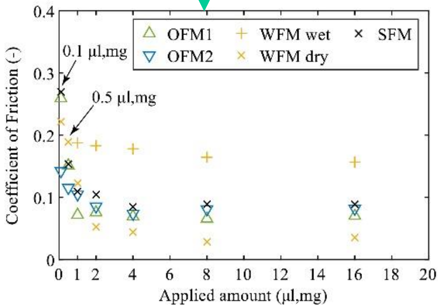
4-WP05-008: **Prediction of friction in the wheel-rail interface**

Small-scale twin-disc

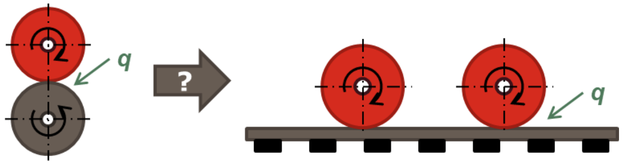




High-pressure-tortion

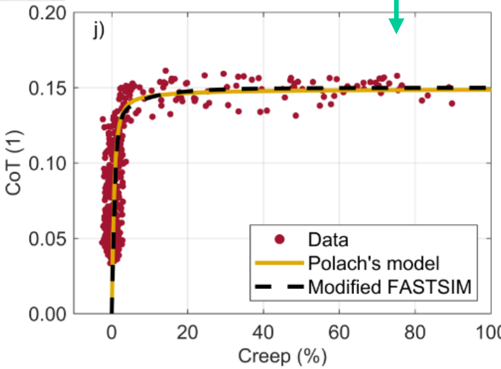


Redistribution



Full-scale twin-disc

Field tribometer



Activities in **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

4-WP05-007: **Onboard lubrication unit for advanced friction management**

4-WP05-008: **Prediction of friction in the wheel-rail interface**

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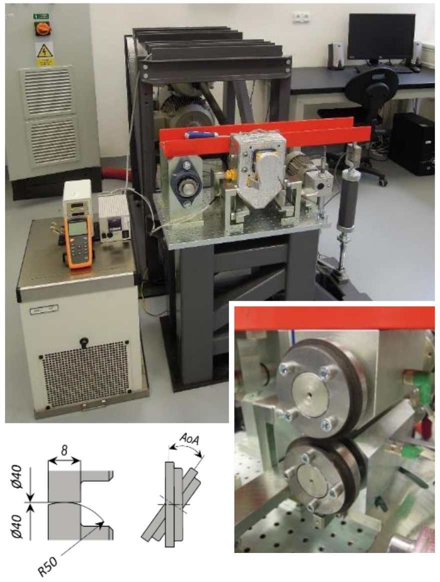
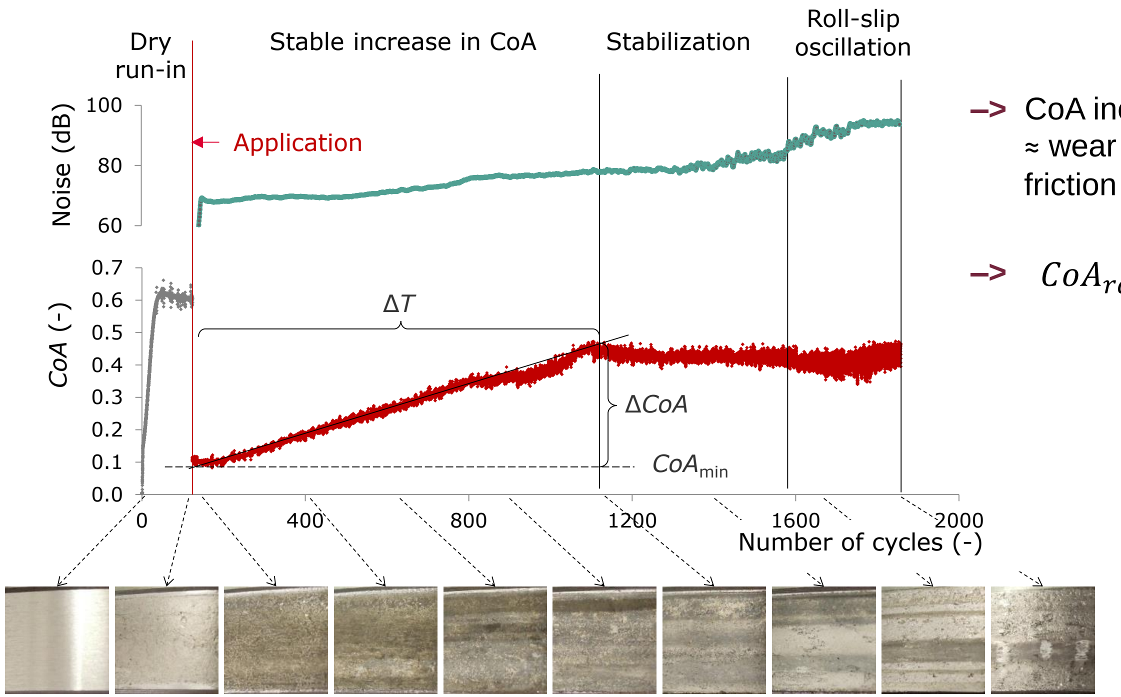


Tribology of the wheel-rail interface

CoA - Retentivity



Speed 1 m/s; Slip 8 %; Pressure 1 GPa; OFM 5 µl

–> CoA increase ≈ wear of friction layer

–> $$CoA_{rate} = \frac{\Delta CoA}{\Delta T}$$

- *On-board noise monitoring?*

Activities in **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

4-WP05-007: **Onboard lubrication unit for advanced friction management**

4-WP05-008: **Prediction of friction in the wheel-rail interface**

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26. MEDZINÁRODNÁ KONFERENCIA „SÚČASNÉ PROBLÉMY V KOĽAJOVÝCH VOZIDLÁCH - PRORAIL 2023“
20. – 22. septembra 2023, Žilina, Slovensko

VLIV POVĚTRNOSTNÍCH PODMÍNEK NA HLUKOVÉ PROJEVY A SOUČINITEL TRAKCE V TRAŤOVÝCH OBLOUCÍCH MALÝCH POLOMĚRŮ

INFLUENCE OF WEATHER CONDITIONS ON THE NOISE AND THE TRACTION COEFFICIENT IN CURVES WITH A SMALL RADIUS

Martin VALENA, Milan OMASTA, Martin HARTL*)

1 ÚVOD

Kolejová doprava je velmi rozšířený způsob přepravy nejen cestujících ale i nákladu, a to zejména kvůli její nízké energetické náročnosti a velkým přepravním kapacitám. Má ovšem i své stinné stránky. Jednou z nich je hluk generovaný při průjezdu traťovým obloukem, tzv. kvílivý hluk. Ten může pocházet z kontaktu na temeni kolejnice (tzv. squealing) nebo z kontaktu na pojížděné hraně kolejnice (tzv. flanging). Kvílivému hluku je vystaveno 12 % obyvatel Evropy, tedy 1,5 milionu lidí.

Kvílivý hluk ovlivňuje velké množství parametrů, což zapříčiňuje jeho obtížnou predikci, a to, že se objevuje pouze s určitou pravděpodobností [1]. Mezi hlavní parametry, které jej ovlivňují, patří teplota, vlhkost, rychlost vozidla, geometrie trati a opotřebení kola a kolejnice [2]. Jedním z mechanismů vzniku je tzv. „stick-slip“ efekt, který je způsoben negativní trakční křivkou – pro nízké skluzy součinitel trakce roste a po dosažení bodu saturace začne klesat. Po dosažení maximální trakce, kterou je kontakt schopen přenést, dojde k prokluzu, čímž se sníží i trakce pod maximum a kolo se znovu začne odvalovat. Periodické střídání fáze skluzu a lpění způsobí vibrace kola, které se dále šíři ve formě hluku.

Výzkum provedený v Rakousku studoval vliv teploty a relativní vlhkosti na četnost výskytu kvílivého hluku a jeho akustický výkon [3]. Z výsledků vyplývá, že četnost klesá s rostoucí teplotou a tento vliv je markantnější u hluku od okolku. Akustický výkon rovněž klesal. Vliv vlhkosti není monotónní a maximum četností výskytu se objevuje v okolí 70% vlhkosti. Po překročení této hodnoty četnost klesá ve všech případech. Při vlhkosti pod 70 % teplota kolejnice definuje, jestli četnost výskyt ubude rostoucí nebo klesající. Obecně lze říci, že akustický výkon roste se zvyšující se vlhkostí, pokud teplota kolejnice přesahuje 10 °C. Z výsledků studie [4] vyplývá, že rostoucí vlhkost zvyšuje šanci výskytu hluku, pokud je teplota nad 10 °C a v případě nižší teploty je tomu obrácené.

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26. MEDZINÁRODNÁ KONFERENCIA „SÚČASNÉ PROBLÉMY V KOĽAJOVÝCH VOZIDLÁCH - PRORAIL 2023“
20. – 22. septembra 2023, Žilina, Slovensko

MODELOVÁNÍ TŘECÍ VRSTVY V KONTAKTU KOLA A KOLEJNICE ZA PŘÍTOMNOSTI MAZIV

THIRD BODY LAYER MODELLING OF WHEEL-RAIL CONTACT IN PRESENCE OF LUBRICANTS

Daniel KVARDA*), Milan OMASTA, Radovan GALAS, Martin HARTL

1 ÚVOD

Tribologické procesy v kontaktu kola a kolejnice jsou důležité pro komfortní, spolehlivý a bezpečný provoz kolejových vozidel, jelikož veškeré trakční a brzdné síly jsou přenášeny tímto kontaktem. Již desetiletí je běžnou praxí zvyšování přenosu trakčních a brzdných sil pomocí pískování. Během posledních dekád se rozšířilo cílené řízení tření na temeni kolejnice za účelem snížit tření, opotřebení, hluku a energetických nároků. K tomu jsou využívány modifikátory tření, což jsou látky na bázi oleje, vody nebo ve formě tuhých tyčinek. Pokud uvažujeme hodnotu součinitele tření na suché kolejnici nad 0,6, tak modifikátory tření míří na hodnoty 0,3 – 0,4 [1]. Navíc je potřeba zmínit, že v mnoha publikacích je součinitel tření a součinitel adheze zaměnitelný. Nicméně, součinitel tření primárně definuje poměr třecí a normálové síly za plně skluzového kontaktu. Naopak součinitel adheze, popisuje poměr třecí a normálové síly při valivě-skluzovém kontaktu. Tato definice bude nadále používána pro popis dat získaných v tomto článku.

Testování těchto produktů je prováděno hlavně v laboratoři. Zde nastává problém, že různé testovací zařízení a odlišné parametry experimentu vedou na rozdílné výsledky. Na ***Obr. 1*** jsou vidět výsledky z testování za podmínek suchých, vodou zaplavených, aplikaci modifikátoru tření a aplikaci maziva pro okolek. Je zde patrné, že i pro suchý kontakt se různá zařízení odlišují v rozmezí součinitele tření 0,4 – 0,8. To je způsobeno nejen odlišnou konfigurací měřicích zařízení a parametrů experimentu, ale i samotnými povrchy testovacích těles a jejich stav. Odlišné materiály a jejich povrchové drsnosti vedou na odlišné chování. Za

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An approach for the creep-curve assessment using a new rail tribometer

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1 Abstract

The friction properties of the wheel-rail contact are characterized by a coefficient of traction (CoT), which can be affected by many contaminants. Numerous devices for assessing CoT are available; however, only a small number of them are capable of recording creep curves. This work introduced a rail-mounted tribometer that uses controlled changes in braking torque on a measuring wheel to induce creep in the contact. A methodology for assessing creep curve parameters was proposed, utilizing both analytical and numerical models of the contact. The experiments were performed both in the field and in the laboratory to investigate the effect of railhead conditions under various contact pressures and to track the evolution of the CoT during a measurement.

Keywords: Wheel-rail tribology, Portable tribometer, Creep curve, Coefficient of traction,

Sample presentation of results at international conferences.

Fulfillment of goals and deliverables of **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

Current State of Deliverables and Fulfillment of Goals

- 4-WP05-001 | MBS model of a virtual low-floor articulated tram with active elements,O, XII/2025
  FME CTU 0.75 + STRN 0.2 + VÚKV 0.05

  – **in progress & no major delays:**

  – Active silent block technology brings the possibility of applying active wheel guidance technology to modern trams, for which the technology is very suitable
  – A control principle has been proposed that does not incur additional costs for equipping the vehicle with sensors and enables the verification of input values for actuator control from two independent sources
  – The results of MBS calculations of the passage of an articulated modern tram along a real track brought a significant (73%) reduction in the wear index or energy dissipated in the contact between wheel and rail
  – Active wheel guidance technology thus has great potential:
    - reduce the costs of operating trams,
    - increase the comfort of passengers and people moving around the tram line,
    - reduce vehicle energy consumption,
    - enable the wider deployment of cheaper and more capable vehicles with non-rotating chassis even on lines with curves of smaller radii and thus contribute to the further development of tram transport

Fulfillment of goals and deliverables of **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

Current State of Deliverables and Fulfillment of Goals

- 4-WP05-002 | Methodology of design of parameters of elements passive safety of railway vehicles, O, III/2025 FME CTU 0.9 + SIEMENS Mobility 0.1
- 4-WP05-003 | Methodology of design of shape solution of passive protective elements of given parameters for railway vehicles,O, XII/2025 FME CTU 0.9 + SIEMENS Mobility 0.1
  - **in progress & no major delays:**
    - a model of a side collision between a middle-class passenger car and a low-floor tram was created
    - findings from the field of compatibility of car body stiffness and road vehicle geometry were evaluated
    - a model of a side collision between a medium-class passenger car and a light rail regional vehicle is being developed

- 4-WP05-003 Analysis of the possibilities of the conceptual solution of sensors for determining the current position of the wheelset in the track, XII/2025 FME CTU 1.0
  - **in progress & no major delays**:
    - suitable sensors were selected, the development of a product for detailed sensor sensitivity testing began

Fulfillment of goals and deliverables of **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

Current State of Deliverables and Fulfillment of Goals

- 4-WP05-005 | Test sample of a key part of the railway bogie, G_{Funk}, XII/2025,
  VUKV 0.2 + Tatravagonka Poprad 0.8
- 4-WP05-006 | Report on Milestones - New bogie for freight wagons,O, XII/2025
  VUKV 0.8 + Tatravagonka Poprad 0.2

– **in progress & no major delays:**
  - activities within the FEFEFOV project extend results received within the CKDV WP02 project (2012-2019)
  - agreed an overview of planned activities and outputs within the FEFEFOV project (2023 - 2028)
  - prepared preliminary plan o testing (test devices => validation program)
  - development of rubber suspension elements and communication with supplier is underway
  - development of the FV1 test device and procurement of its main components is underway
  - production of steel components of FV1 is started in cooperation with TVP and VÚKV
  - development of the FV2 test device (conceptual proposal), preliminary discussions about casting parts

Fulfillment of goals and deliverables of **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

Current State of Deliverables and Fulfillment of Goals

- 4-WP05-007 | Onboard lubrication unit for advanced friction management,G_{funk} , XII/2025,
  FME VUT 0.3 , Tribotec 0.7
- 4-WP05-008 | Prediction of friction in the wheel-rail interface,O, XII/2025
  FME BTU 0.4 + STRN 0.3 + UPa 0.3

– **in progress & no major delays:**

- the development and implementation of the friction and adhesion control technique by applying the digital twin approach of the Regio Panter electric unit supplied by Skoda Transportation for the South Moravian Region was started.
- a computer map of the railway line Brno - Blansko is created
- tribological models of the wheel-rail interface are improved
- on-board vibration and noise monitoring – methods of identifying vibration and noise monitoring are specified

Fulfillment of goals and deliverables of **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

List of Due Deliverables and Their Added Value

- **4-WP05-001** – Research into the use of active elements in low-floor trams enables STRN to maintain its market position. Modern trams with active elements can significantly reduce track wear (approx. 70%) and vehicle noise, especially when driving in curves.
- **4-WP05-002, 4 – WP05-003** – Research and development of new impact elements on the fronts of low-floor trams and regional vehicles is made possible by STRN and Siemens Mobility to contribute to the fulfillment of the goals of the Vision "O" project and to maintain its position on the market. Modern rolling stock meeting EN 12 663 and EN 15227 standards can reduce the consequences of collisions with passenger cars at level crossings by using a flexible passive crash element and thus become friendly to road vehicles.
- **4-WP05-004** – The development of a sensor for the instantaneous position of two wheels in the track can contribute to the acceleration of the introduction of active elements into the bogies of rail vehicles, reducing the guiding forces and the wear of wheels and rails.
- **4-WP05-005, 4 – WP05-006** – Research and development of new two-axle bogie for freights wagons will allow the manufacturer Tatravagónka Poprad to maintain its important position on the world market and will contribute to the reduction of noise, guiding forces and wear of wheels and rails.

Fulfillment of goals and deliverables of **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

List of Due Deliverables and Their Added Value

- **4-WP05-007, 4 – WP05-008** – The development and implementation of the friction and adhesion control technique through the application of the digital twin approach to the Regio Panter electric units will enable the ŠKoda Group manufacturer to optimize costs for a 30-year full service and will contribute to a number of findings leading to the reduction of guiding forces and wear of wheels and rails.

Current contribution of **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

Assessment of the Contribution of Deliverables

- The issue of partial research works carried out in this package cooperates with and follows on from the partial research works carried out in packages 4-WP01-001 (FEFEFOF).
- Realized research activities should contribute to improving the efficiency of rail vehicles.
- The activities contribute to the expansion of knowledge about new ways of driving rail vehicles, their investigation into driving dynamics and reliability/lifetime.
- New findings and outputs can be applied in the construction of bogies for new rail vehicles, e.g. in Skoda Transportation, Siemens Mobility, Tatravagonka Poprad and others.
- The knowledge gained is regularly presented at professional conferences.

Current contribution of **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles

Assessment of the Formal/Administrative Goals of the Work Package

We assume that the use of allocated funds, the commercialization of research, and the fulfillment of contractual research will be fulfilled by all partners participating in the implementation of 3-WP13 during the years 2023-2026.

Acknowledgment

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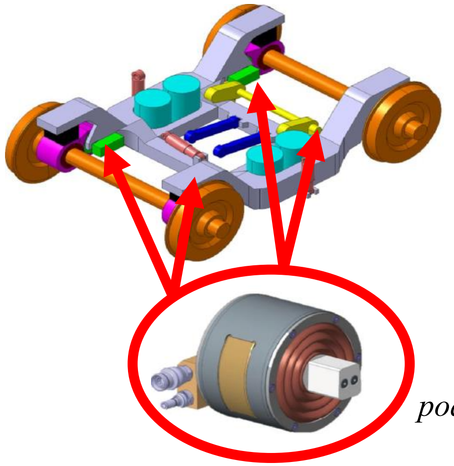
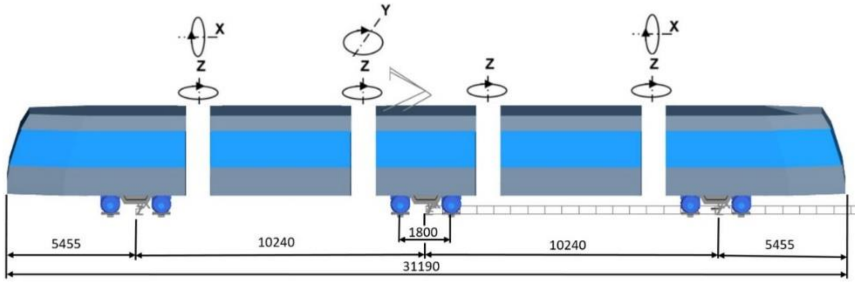
Výtah z prací 2023-2025 na DP4-WP05 Bezpečnost, design, aktivní řízení a mazání okolků u budoucích kolejových vozidel – dosaženo 2023

4 – WP05 - 001 (O) (ČVUT FS 0.75 + STRN 0.20 + VUKV 0.05) Termín: 1.12.2025

MBS model virtuální článkové nízkopodlažní tramvaje s aktivními prvky



MBS model tramvajového podvozku s aktivními prvky Liebherr



MBS model článkové nízkopodlažní tramvaje

Vedení dvojkolí	Rychlost [km/h]	Naložení	Třecí koef.	Index opotřebení [N]	Snížení indexu opotř. [%]	Disipovaná energie [J]	Snížení disip. energie [%]
pasivní	max	EL4	0,4	1 124 368		7 460 732	
pasivní	max	EL4	0,15	342 539		2 517 519	
pasivní	max	ELE	0,4	886 817		5 922 422	
pasivní	max	ELE	0,15	266 268		1 937 006	
pasivní	15	EL4	0,4	1 525 949		6 301 704	
pasivní	15	EL4	0,15	617 168		2 571 533	
pasivní	15	ELE	0,4	1 512 409		6 358 121	
pasivní	15	ELE	0,15	496 158		2 067 325	
aktivní	max	EL4	0,4	338 534	70	1 601 659	79
aktivní	max	EL4	0,15	141 621	59	1 055 892	58
aktivní	max	ELE	0,4	270 397	70	1 055 203	82
aktivní	max	ELE	0,15	111 156	58	812 322	58
aktivní	15	EL4	0,4	381 586	75	1 589 942	75
aktivní	15	EL4	0,15	167 917	73	699 654	73
aktivní	15	ELE	0,4	304 153	80	1 267 304	80
aktivní	15	ELE	0,15	134 726	73	561 358	73
pasivní vedení dvojkolí celkem				**6 771 676**		**35 136 362**	
aktivní vedení dvojkolí celkem				**1 850 090**	**73**	**8 643 334**	**75**

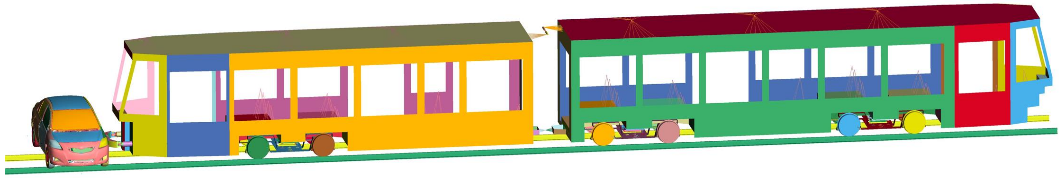
Výsledky výpočtů MBS průjezdu kloubové moderní tramvaje po reálné trati přinesly výrazné (73 %) snížení indexu opotřebení nebo energie rozptýlené při kontaktu kola s kolejnicí.

4 – WP05 - 002 (O), (ČVUT FS 0.9 + SIEMENS Mobility 0.1) Termín: 1.3.2025

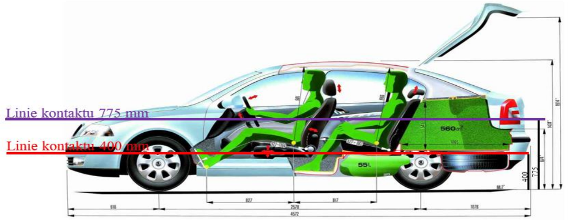
Metodika návrhu parametrů prvků pasivní bezpečnosti kolejových vozidel

4 – WP05 - 003 (O), (ČVUT FS 0.9 + SIEMENS Mobility 0.1) Termín: 1.12.2025

Metodika návrhu tvarového řešení pasivních ochranných prvků daných parametrů pro kolejová vozidla



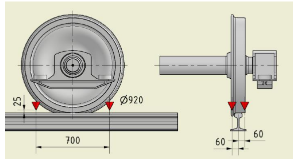
Model boční srážky automobilu s článkovou tramvají

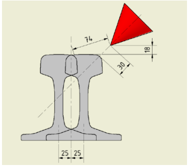


Oblast výškové čáry bočního kontaktu nárazu

4 – WP05 - 004 (O), ČVUT FS 1.0 Termín:1.12.2025

Rozbor možností koncepčního řešení snímačů pro zjišťování aktuální polohy dvojkolí v koleji



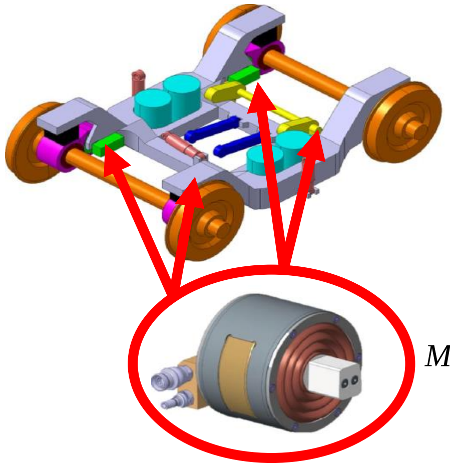


Přípravek pro základní test citlivosti senzoru

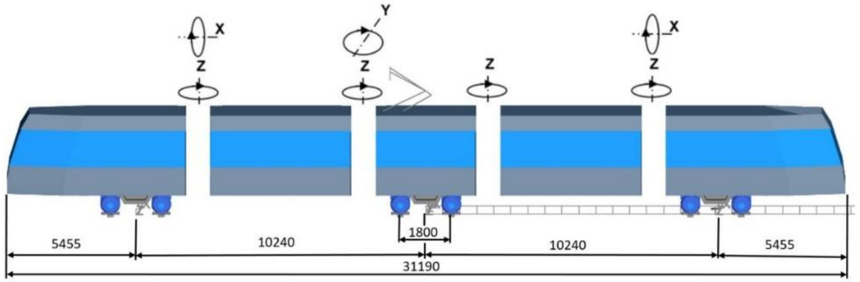
Results of **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles – Achieved 2023

4 – WP05 - 001 (O) (CTU FME 0.75 + STRN 0.20 + VUKV 0.05) *Project deadline:* 1.12.2025

MBS model of a virtual low-floor articulated tram with active elements



MBS model of the tram bogie with active elements Liebherr



MBS model of articulated low floor tram

Vedení dvojkolí	Rychlost [km/h]	Naložení	Třecí koef.	Index opotřebení [N]	Snížení indexu opotř. [%]	Disipovaná energie [J]	Snížení disip. energie [%]
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pasivní	15	EL4	0,15	617 168		2 571 533	
pasivní	15	ELE	0,4	1 512 409		6 358 121	
pasivní	15	ELE	0,15	496 158		2 067 325	
aktivní	max	EL4	0,4	338 534	70	1 601 659	79
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aktivní	15	ELE	0,15	134 726	73	561 358	73
pasivní vedení dvojkolí celkem				**6 771 676**		**35 136 362**	
aktivní vedení dvojkolí celkem				**1 850 090**	**73**	**8 643 334**	**75**

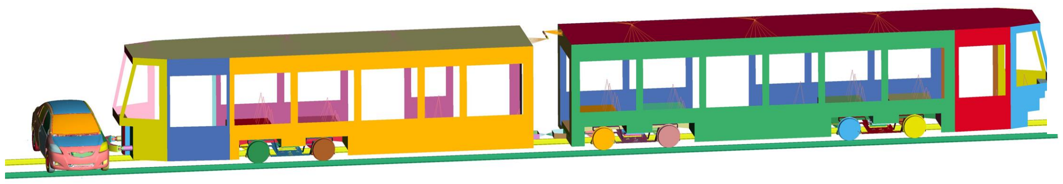
The results of MBS calculations of the passage of an articulated modern tram along a real track brought a significant (73%) reduction in the wear index or energy dissipated in the contact between wheel and rail.

4 – WP05 - 002 (O), (CTU FME 0.9 + SIEMENS Mobility 0.1) *Project deadline:* 1.3.2025

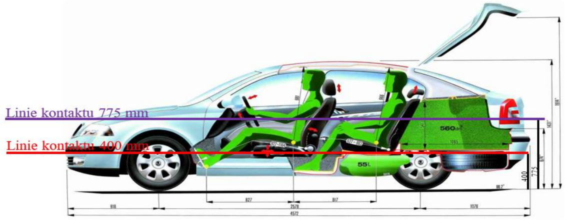
Methodology of design of parameters of elements passive safety of railway vehicles

4 – WP05 - 003 (O), (CTU FME 0.9 + SIEMENS Mobility 0.1) *Project deadline:* 1.12.2025

Methodology of design of shape solution of passive protective elements of given parameters for railway vehicles



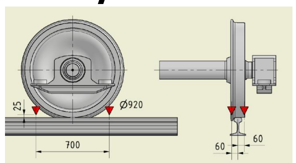
Side impact model of a passenger car and an articulated low-floor tram

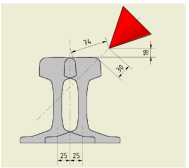


The area of the height line of the crash side contact

4 – WP05 - 004 (O), CTU FME 1.0 *Project deadline:* 1.12.2025

Analysis of the possibilities of the conceptual solution of sensors for determining the current position of the wheelset in the track





A stand for a basic sensor sensitivity test

Results of **4-WP05** Safety, Design, Active Control and Lubrication of Future Rail Vehicles – Achieved 2023

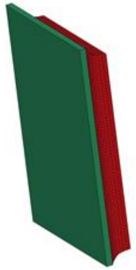
4 – WP05 - 005 (Gfunk) (VUKV 0.2, Tatra Vagonka 0.8) Project deadline: 1.12.2025

Test sample of a key part of the railway bogie

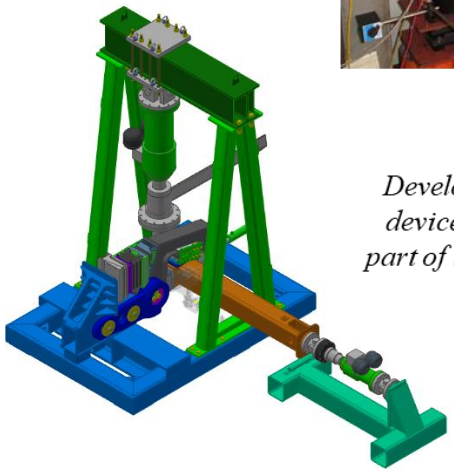
4 – WP05 - 006 (O) (VUKV 0.8, Tatra Vagonka 0,2) Project deadline: 1.12.2025

Report on Milestones - New bogie for freight wagons

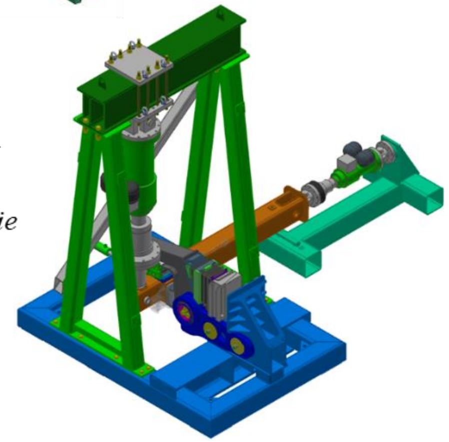
Testing on existing devices



Validation of calculation models



Development of a test device for tests of key part of the railway bogie (FV1)



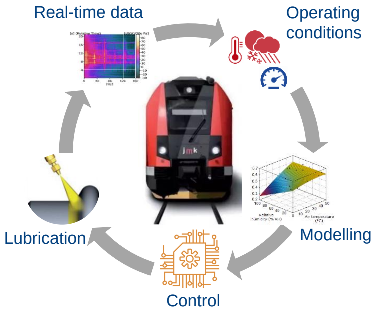
4 – WP05 - 007 (Gfunk) (FME BTU 0.3 , Tribotec 0.7) *Project deadline:* 1.12.2025

Onboard lubrication unit for advanced friction management

4 – WP05 - 008 (O) (FME BTU 0.4 , STRN 0.3, UPa 0.3) *Project deadline:* 1.12.2025

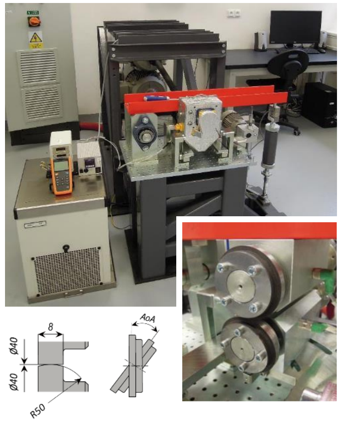
Prediction of friction in the wheel-rail interface

Concept solution of a digital twin electric unit.



Redistribution

Field tribometer



Small-scale twin-disc

On-board noise monitoring?

Výtah z prací 2023-2025 na DP4-WP05 Bezpečnost, design, aktivní řízení a mazání okolků u budoucích kolejových vozidel – dosaženo 2023

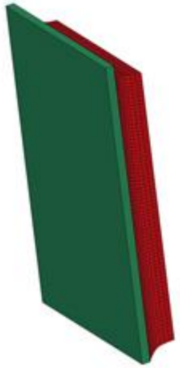
4 – WP05 - 005 (Gfunk) (VÚKV 0.2, TatraVagónka 0,8) Termín: 1.12.2025

Testování zkušebních vzorků klíčové části železničního podvozku

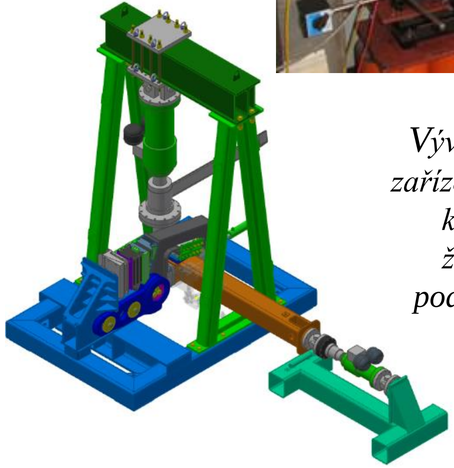
4 – WP05 - 006 (O) (VÚKV 0.8, Tatra Vagónka 0,2) Termín: 1.12.2025

Zpráva o milnících – nový podvozek pro nákladní vozy

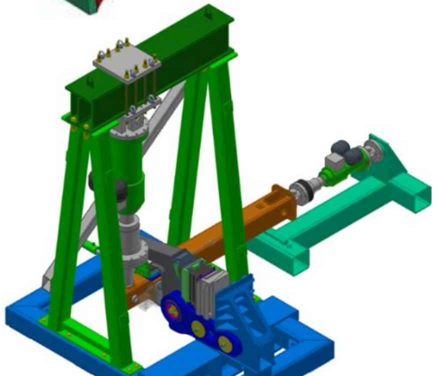
Testování na stávajících zařízeních



Validace výpočtového modelu



Vývoj zkušebního zařízení pro zkoušky klíčové části železničního podvozku (FV1)



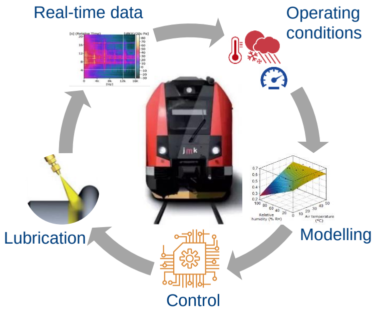
4 – WP05 - 007 (Gfunk) (FSI VUT 0.3 , Tribotec 0.7) Termín: 1.12.2025

Palubní mazací jednotka pro pokročilé řízení tření a adheze

4 – WP05 - 008 (O) (FSI VTU 0.4 + STRN 0.3 + UPa 0.3) Termín: 1.12.2025

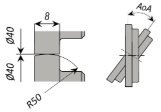
Predikce tření na rozhraní kolo-kolejnice

Koncept řešení digitálních dvojčat elektrické jednotky.



Přerozdělování

Tribometr



Malý kladkový stend

Měření hluku ?