Virtual Vehicle Research

Rail Research @ Virtual Vehicle

Department Rail

August 2026

virtual vehicle


Virtual Vehicle Research

From the initial spark to a global player

2002-2007
Foundation

Initiation of a research center for **virtual vehicle development**

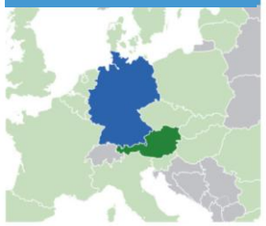
2008-2017
Structure & Growth

- R&D center for **sustainable mobility**
- Focus on EU projects and contract research

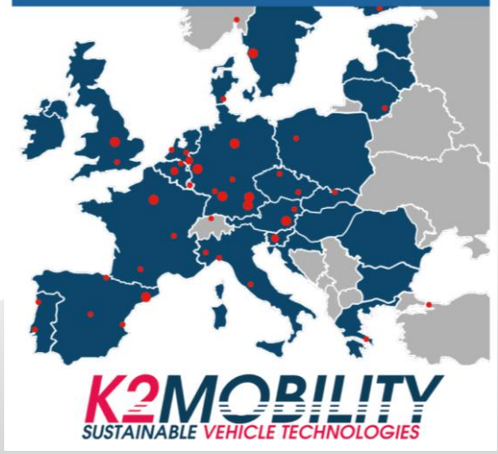
2018-2026 / 2027-2034
Long-term stability & international success

- Recognized international player
- Strategic partner for road and rail
- **Additional domains**: robotics, energy, health-tech, defense, …
- Putting innovations from 300+ experts into practice

AUSTRIA & GERMANY

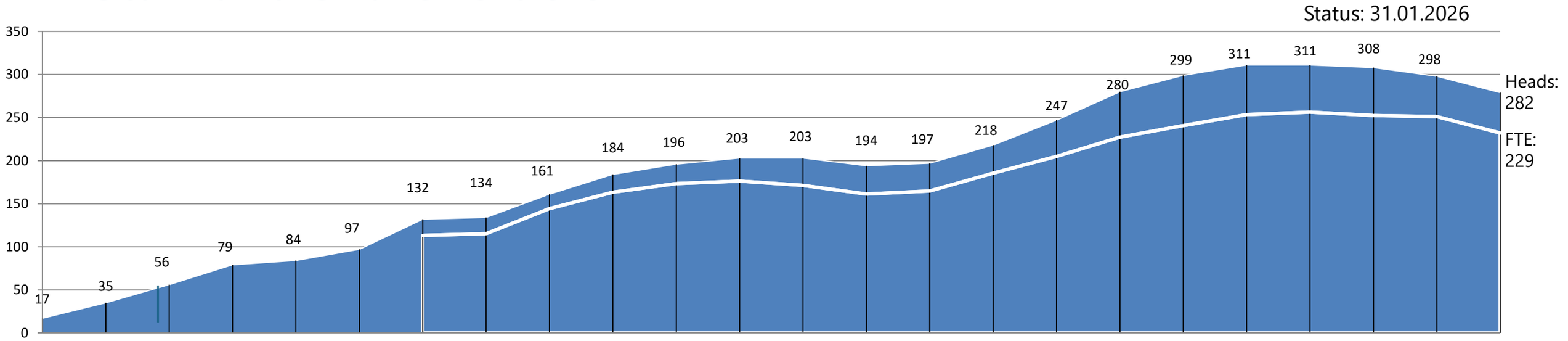


EUROPA+



WORLD-WIDE NETWORK

Staff and Shareholders



2002 AVL MAGNA TU Graz JOANNEUM RESEARCH

2008 SIEMENS

Additional Shareholder

2019 infineon voestalpine ONE STEP AHEAD.

Additional Shareholders

2021 SETLabs

Foundation 2021

2024 CONTEXT64AI

Spin-off 2024

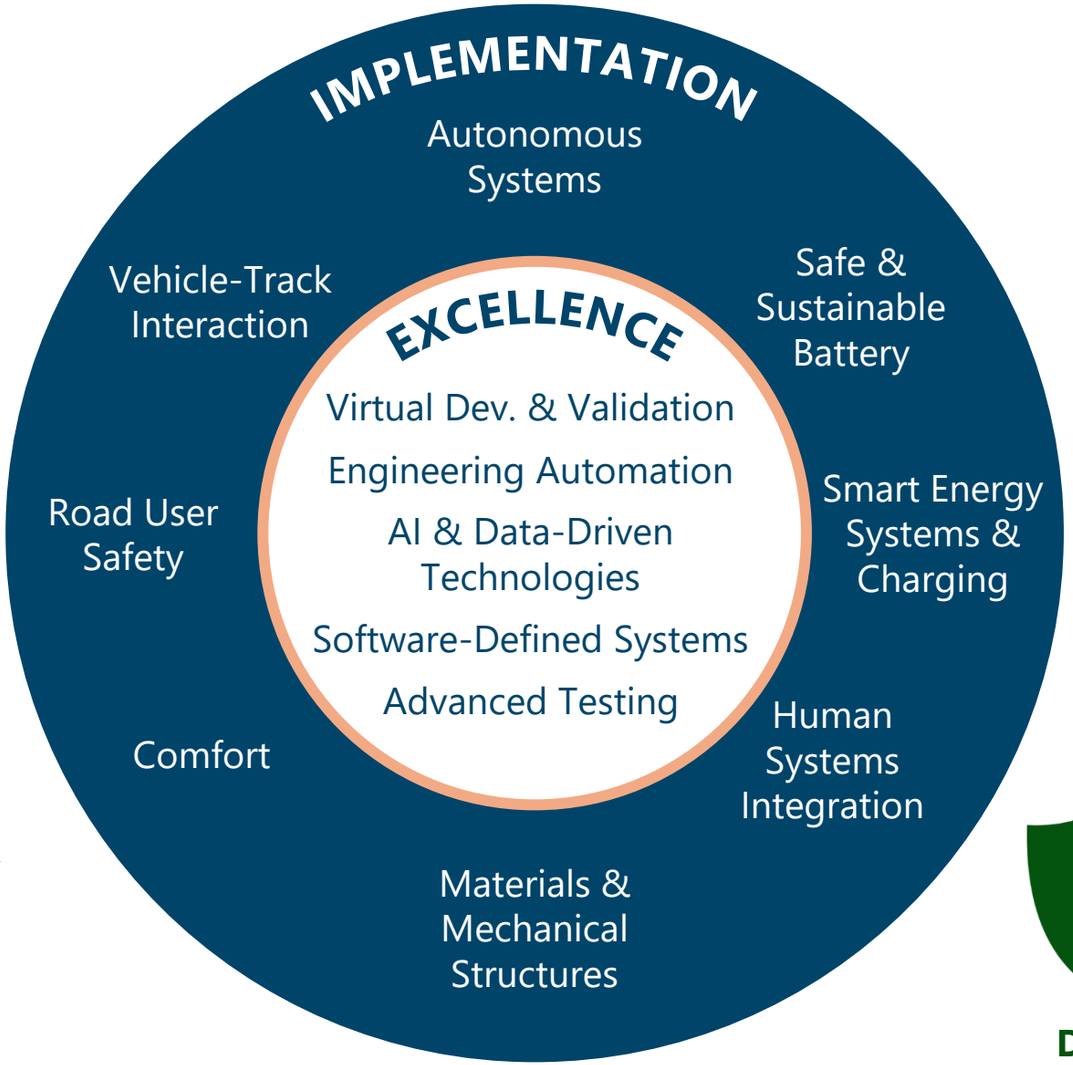
Graduate ratio: 90 %

130+ finished PhDs at VIRTUAL VEHICLE (since 2008)

40+ ongoing PhD dissertations

21 Nations

Fields of activities



Automotive

Rail

Energy

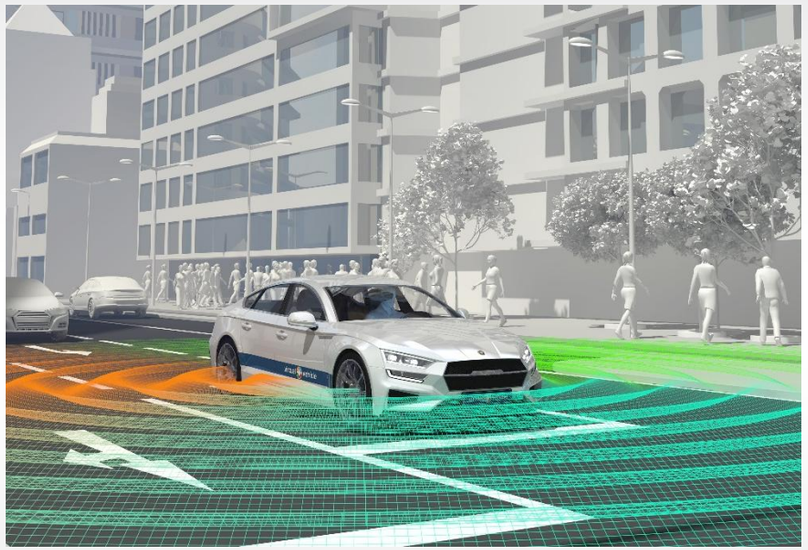
Defense

Maritime

Health Tech

Bridge between science and industry

COMET K2

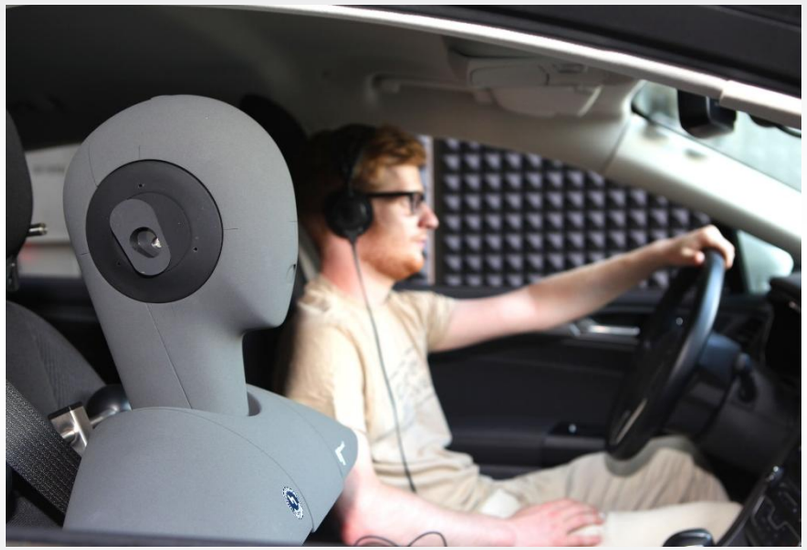


- COMET K2 Digital Mobility
- Long term co-operative research
- Leveraging investment

FUNDED PROJECTS

- 50+ ongoing EU projects
- 100+ completed EU projects
- International visibility and reputation

CONTRACT WORK



- Research & development
- Test bed & demonstrators
- Industry agreements

VIRTUAL VEHICLE - high performance ecosystem

Opportunities and competences for all maturity levels

TRL

Basic Research | Applied Research | Tech Development | Prototype Development

1 2 3 4 5 6 7 8 9

PhD Cooperations

COMET K2 DM

COMET

Competence Centers for Excellent Technologies

EU-Joint Undertaking

Europe's Rail

Chips JU

EU-funded Projects

MARIE CURIE ACTIONS

European Commission

Horizon Europe 2021-2027

ICOS Independent Co-Simulation

FWF-funded Projects

FWF

Der Wissenschaftsfonds.

Strategic Projects

FFG-funded Projects

FFG Forschung wirkt.

Knowledge Transfer

- Bridge Program
- Living Innovation Lab

Partner network

International industry and research network (excerpt)

INDUSTRY

Audi, BMW, Volkswagen, MAN, Skoda, Mercedes-Benz, Peugeot, Porsche, Volvo, Liebherr, Jaguar, Land Rover, Renault – Passion for life

Autoliv, AVL, Bosch, Dyna More, NXP, Nvidia, Continental, Cray – The Supercomputer Company, Infineon, Magna, ZF, Samsung, Indra, IBM

SCIENCE

Joanneum Research, TU Graz, TU Wien, Fraunhofer, Technische Universität Berlin, KTH Vetenskap och Konst, Stanford University, Berkeley – University of California, MIT – Massachusetts Institute of Technology

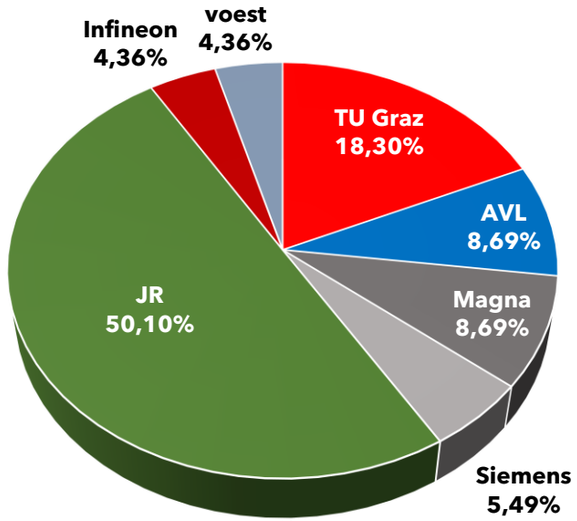
RAIL-SPECIFIC

Alstom, DB, Knorr-Bremse, LB Foster, ÖBB, CAF, SBB CFF FFS, Siemens – Ingenuity for life, Stadler, voestalpine – Einen Schritt voraus., PJM, StB

HEALTH

Siemens Healthineers, human.technology.styria.

Shareholder



virtual vehicle

- 30+ MEUR turnover
- 180+ industry partners
- 80+ scientific partners

Today, VIRTUAL VEHICLE is Europe's largest research center for virtual vehicle development

Further domains

ENERGY

HEALTH TECH

MARITIME

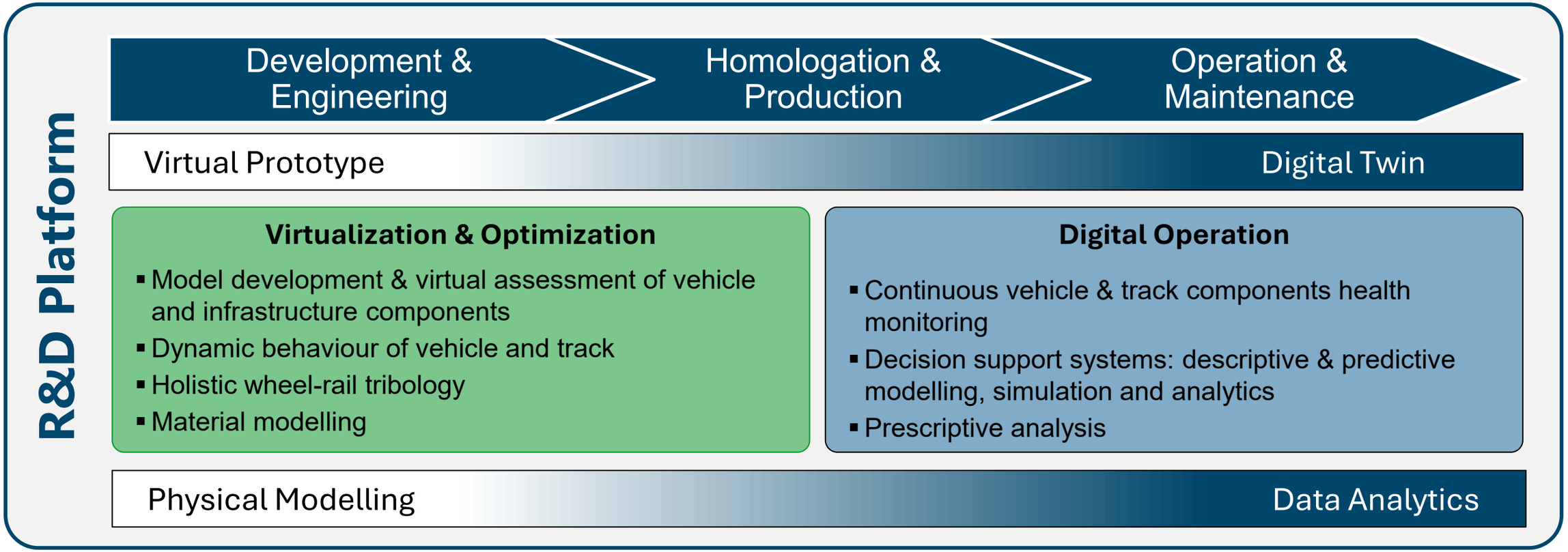
DEFENSE

Vehicle-Track Interaction

Overview

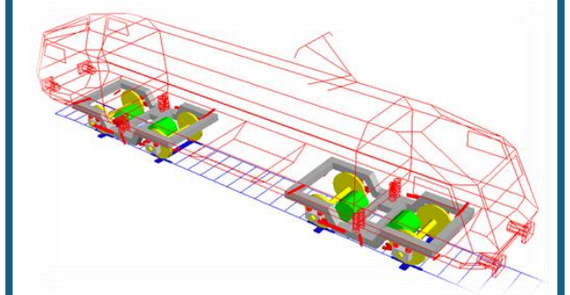
Mission

Provide a **R&D platform** for de-risking **future rail system technologies**, by means of research and technology development with a focus on a service oriented, **modular virtual validation framework.**



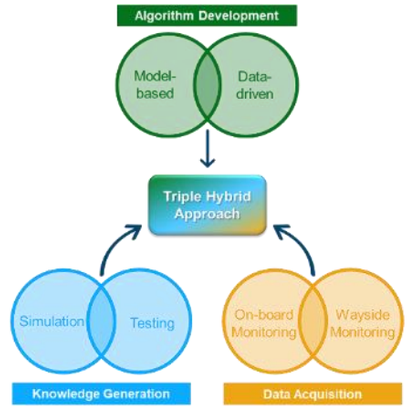
Fields of Activity

Vehicle Dynamics & Operation Analysis



- Profound knowledge of vehicle system dynamics
- Simulation and modelling of vehicle/track interaction
- Vehicle and track parameter identification
- Virtual homologation of running behaviour (EN 14363)
- Probabilistic vehicle and track design

Monitoring & Diagnosis



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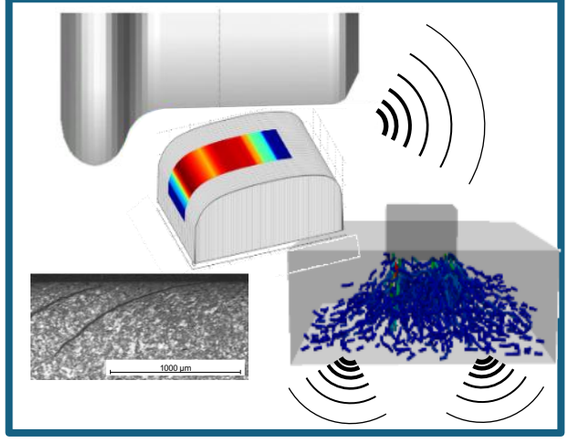
Wheel-Rail Interaction & Deterioration Phenomena



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Digital Twins Network

- Vertical integration: Analysis of interaction between digital twins
- Horizontal integration: System or component behaviour during all life cycle phases
- Single point of truth: Consistent and continuous system data and models

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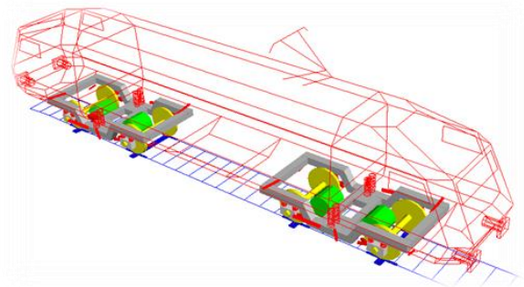

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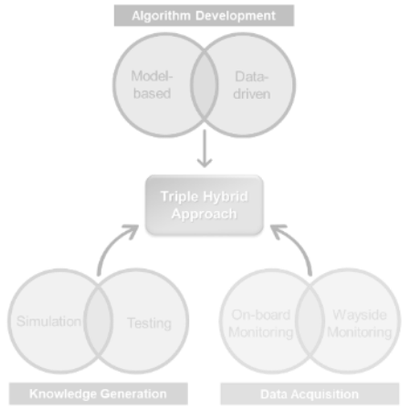

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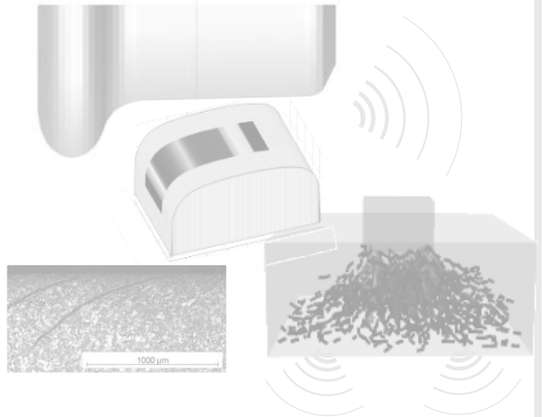

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Vehicle Dynamics & Operation Analysis

Design | Homologation | Operation

Probabilistic Design

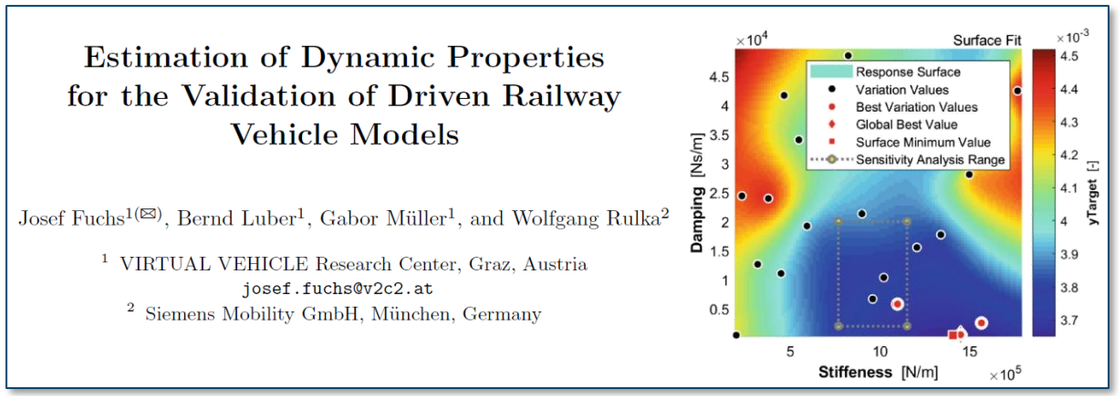
- Dimensioning of design parameters based on varying operating conditions

Virtual Homologation

- Methods for quantifying uncertainties in the model validation process
- Automation of calculation methods for vehicle homologation
- Methods for the parameterization of simulation models

Operational Analysis

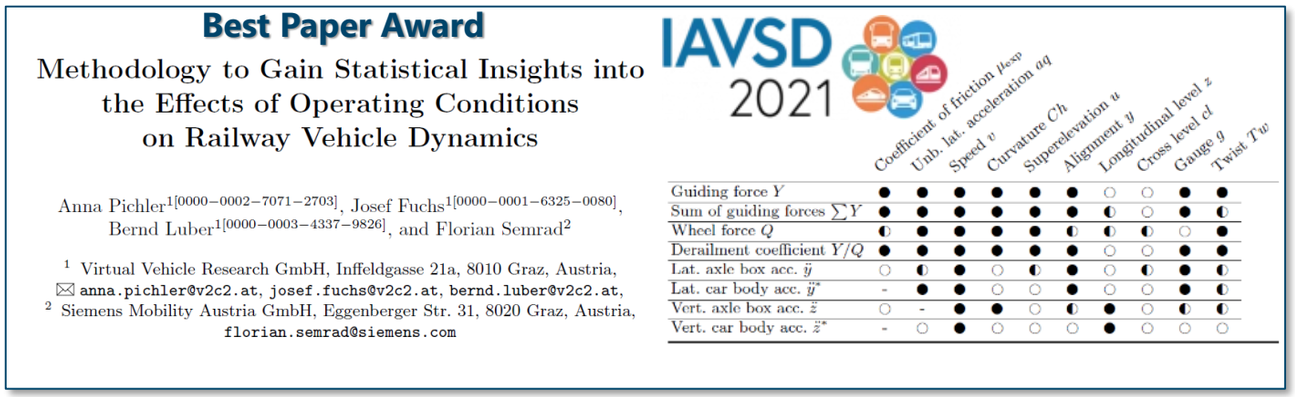
- Description of operating conditions
- Generation of load assumptions
- Scenarios for virtual vehicle design



Estimation of Dynamic Properties for the Validation of Driven Railway Vehicle Models

Josef Fuchs[1(✉)], Bernd Luber[1], Gabor Müller[1], and Wolfgang Rulka[2]

[1] VIRTUAL VEHICLE Research Center, Graz, Austria
josef.fuchs@v2c2.at
[2] Siemens Mobility GmbH, München, Germany



Best Paper Award

Methodology to Gain Statistical Insights into the Effects of Operating Conditions on Railway Vehicle Dynamics

Anna Pichler[1[0000−0002−7071−2703]], Josef Fuchs[1[0000−0001−6325−0080]], Bernd Luber[1[0000−0003−4337−9826]], and Florian Semrad[2]

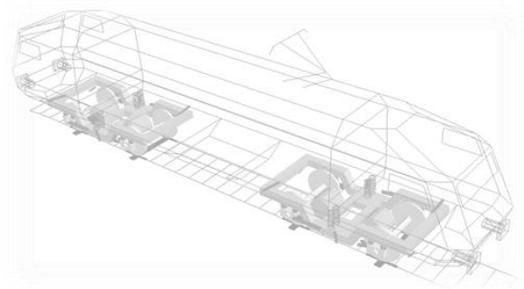
[1] Virtual Vehicle Research GmbH, Inffeldgasse 21a, 8010 Graz, Austria,
✉ anna.pichler@v2c2.at, josef.fuchs@v2c2.at, bernd.luber@v2c2.at,
[2] Siemens Mobility Austria GmbH, Eggenberger Str. 31, 8020 Graz, Austria,
florian.semrad@siemens.com

IAVSD 2021

	Coefficient of friction μ_{esp}	Unb. lat. acceleration aq	Speed v	Curvature Ch	Superelevation u	Alignment y	Longitudinal level z	Cross level cl	Gauge g	Twist Tw
Guiding force Y	●	●	●	●	●	●	○	○	●	●
Sum of guiding forces $\sum Y$	●	●	●	●	●	●	◐	○	●	◐
Wheel force Q	◐	●	●	●	●	◐	◐	◐	○	●
Derailment coefficient Y/Q	●	●	●	●	●	●	○	○	●	●
Lat. axle box acc. $\ddot{y}$	○	◐	●	○	◐	●	○	◐	●	◐
Lat. car body acc. $\ddot{y}^*$	-	●	●	○	○	●	○	○	●	◐
Vert. axle box acc. $\ddot{z}$	○	-	●	●	○	◐	●	○	◐	◐
Vert. car body acc. $\ddot{z}^*$	-	○	●	○	○	○	●	○	○	○

Fields of Activity

Vehicle Dynamics & Operation Analysis



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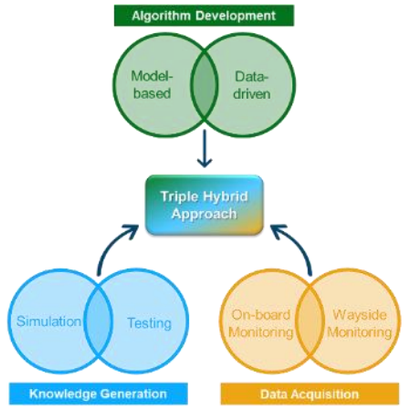

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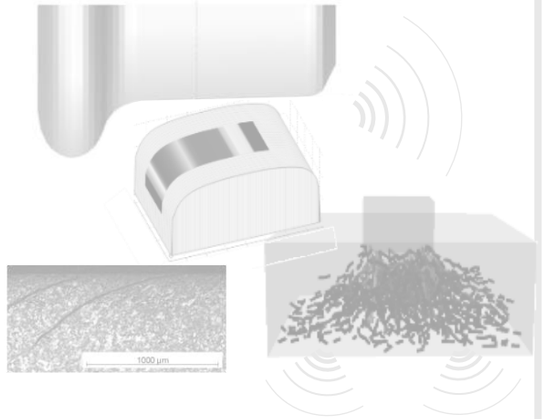

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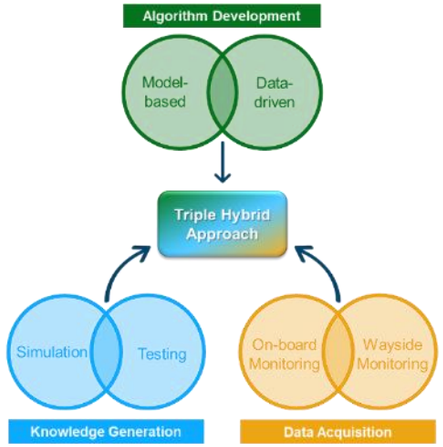
Monitoring & Diagnosis

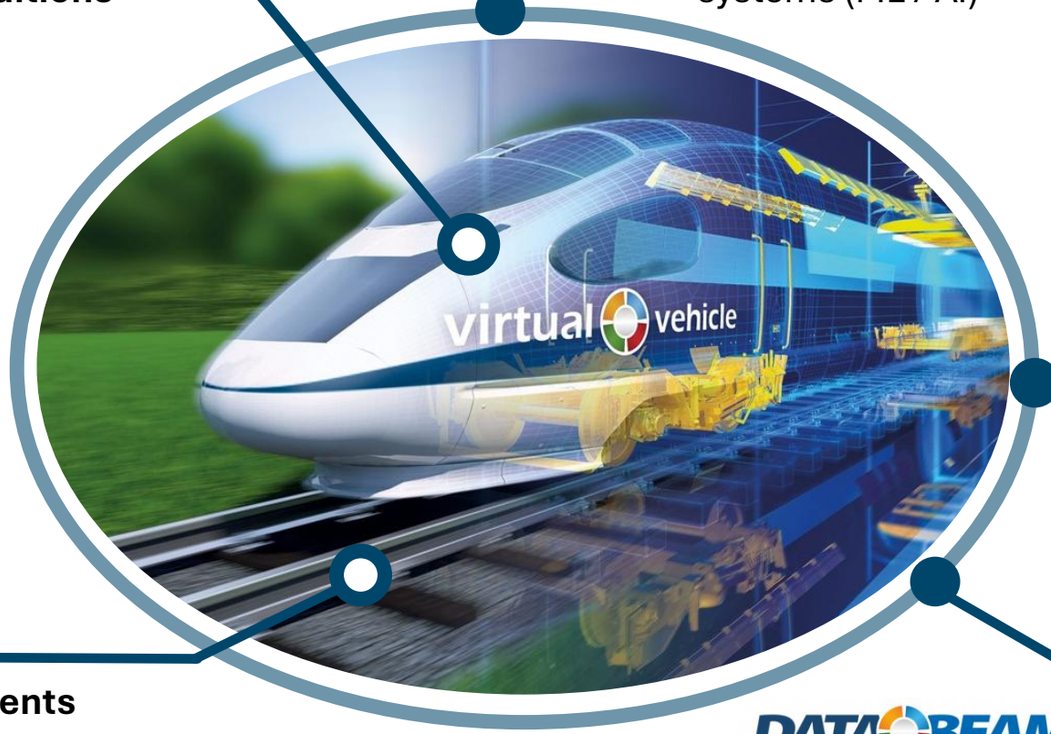
Vehicle Monitoring

- Monitoring of **bogie components**
- **Sensor concepts** for component monitoring
- Estimation of **operating conditions**
- **Wheel flat detection**
- **Wheel wear estimation**

Algorithm Development

- **Model-based methods** for monitoring of component states
- **Data-driven methods** for high complex systems (ML / AI)





Context-based Knowledge

- Description and understanding of **physical effects** based on simulations and testing

Track Monitoring

- Monitoring of **switch components**
- Detection of **rail surface defects** (e.g. corrugation, squats)
- Identification of **track parameters**
- Anomaly detection & assessment of **track irregularities**

Data Acquisition

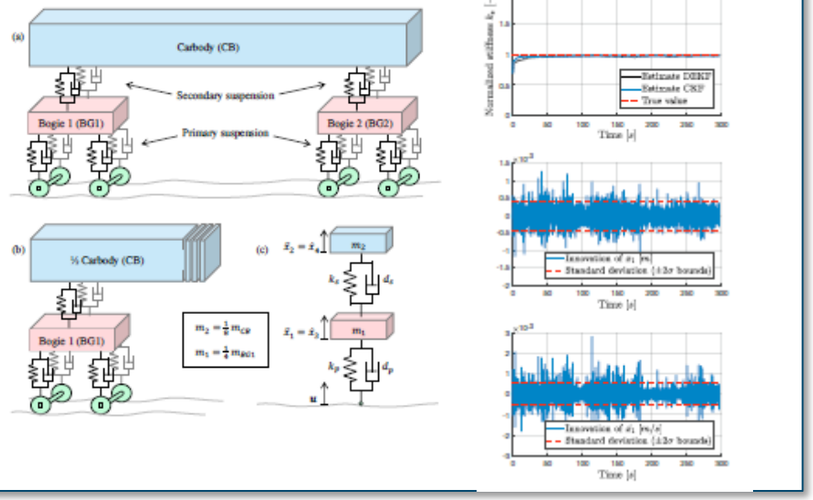
- **Measurement equipment** for ‚Proof-of-Concept' analysis (DataBeam)
- Evaluation of innovative **sensor concepts**

Monitoring & Diagnosis

Available online at www.sciencedirect.com
ScienceDirect
IFAC PapersOnline 51-24 (2018) 1330–1335

Railway Suspension System Fault Diagnosis using Cubature Kalman Filter Techniques

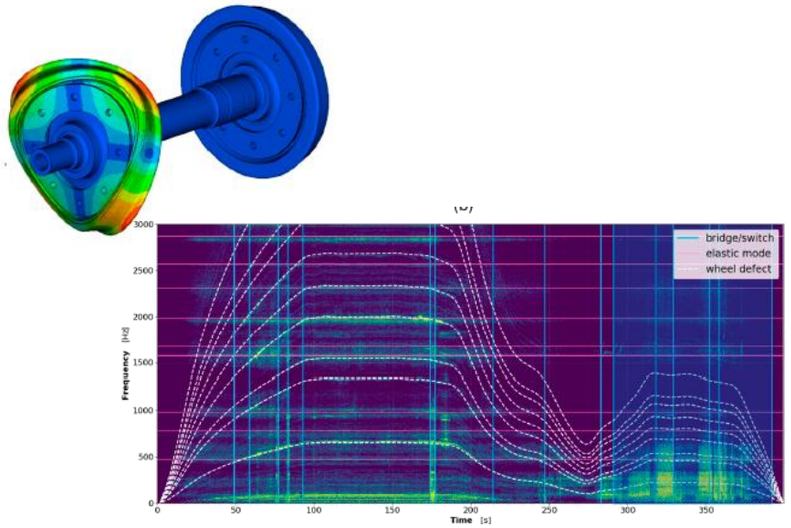
Selma Zoljic-Beglerovic *,** [1] Georg Stettinger *
Bernd Luber * Martin Horn **
* VIRTUAL VEHICLE Research Center, Graz, Austria, (e-mail: {selma.zoljic-beglerovic; georg.stettinger; bernd.luber}@v2c2.at)
** Graz University of Technology, Institute of Automation and Control, Graz, Austria, (e-mail: martin.horn@tugraz.at)



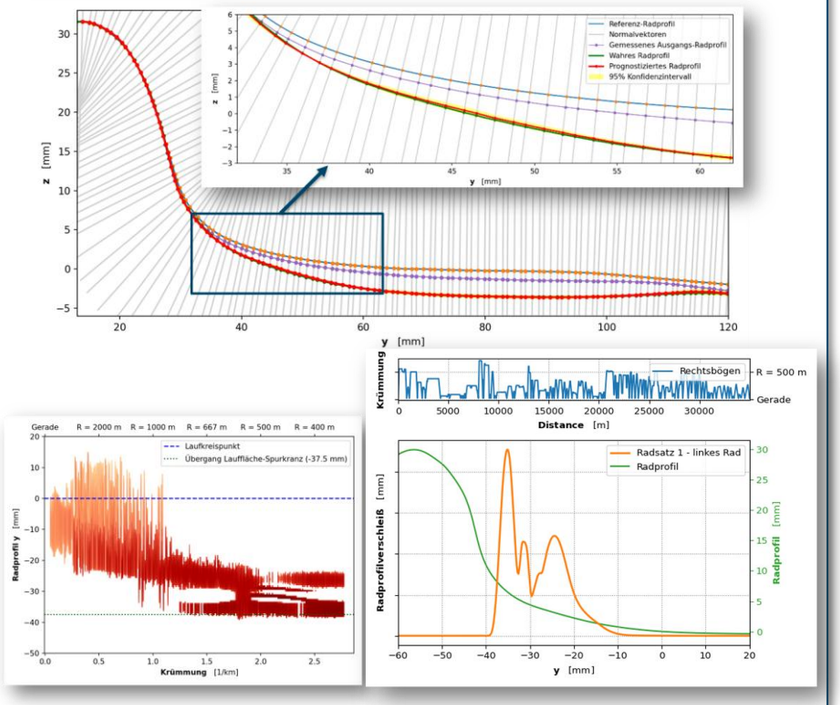
applied sciences
MDPI
Article

Methodology to Detect Rail Corrugation from Vehicle On-Board Measurements by Isolating Effects from Other Sources of Excitation

Anna De Rosa *, Bernd Luber, Gabor Müller and Josef Fuchs



Anforderungen an eine effiziente Radprofilprognose aus Sicht eines Digitalen Zwillings



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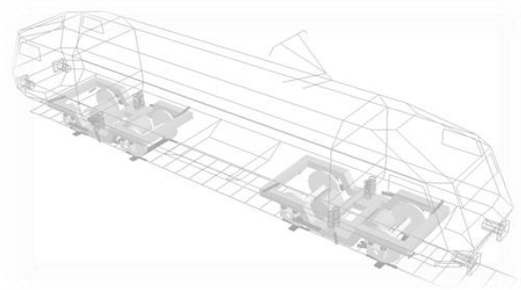

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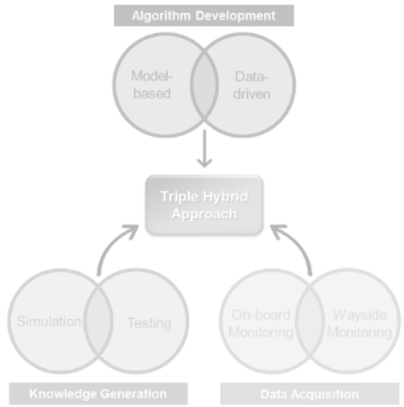

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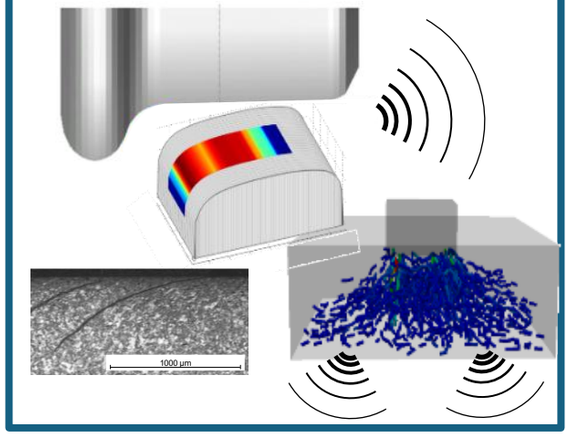

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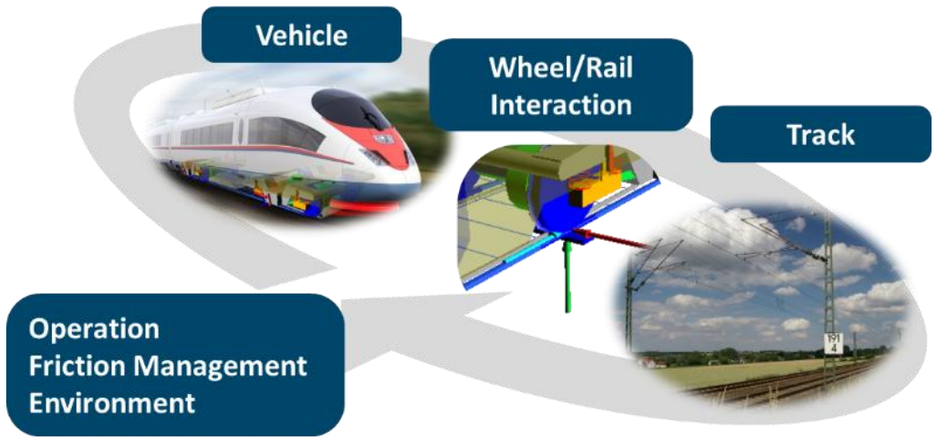

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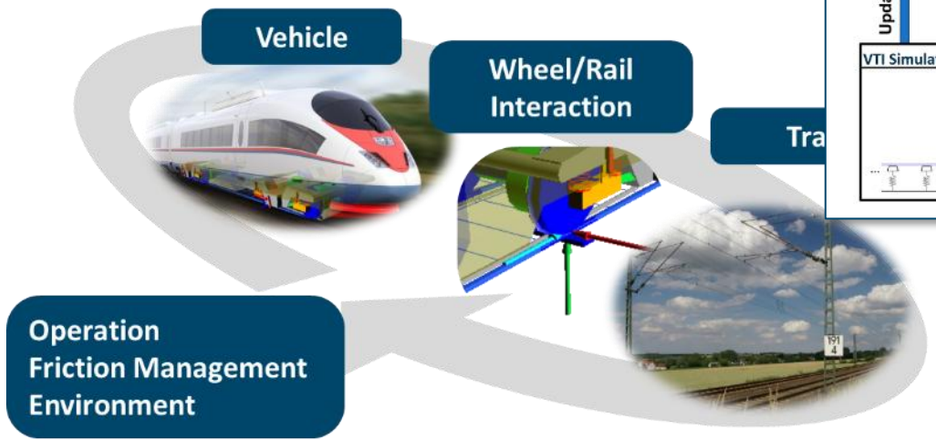

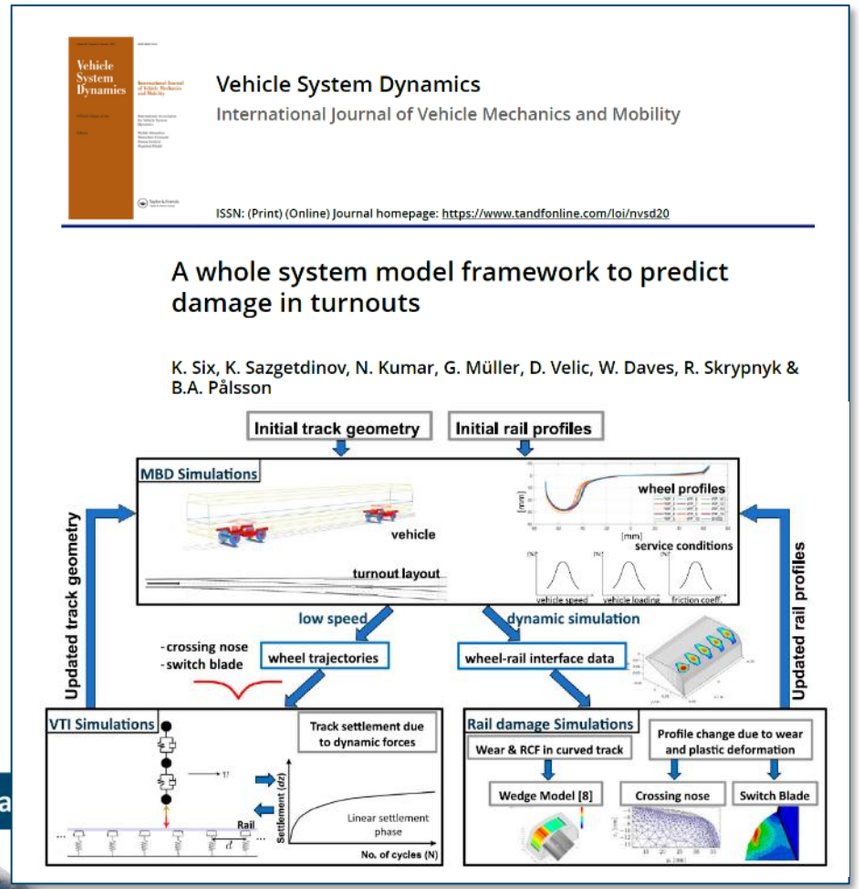

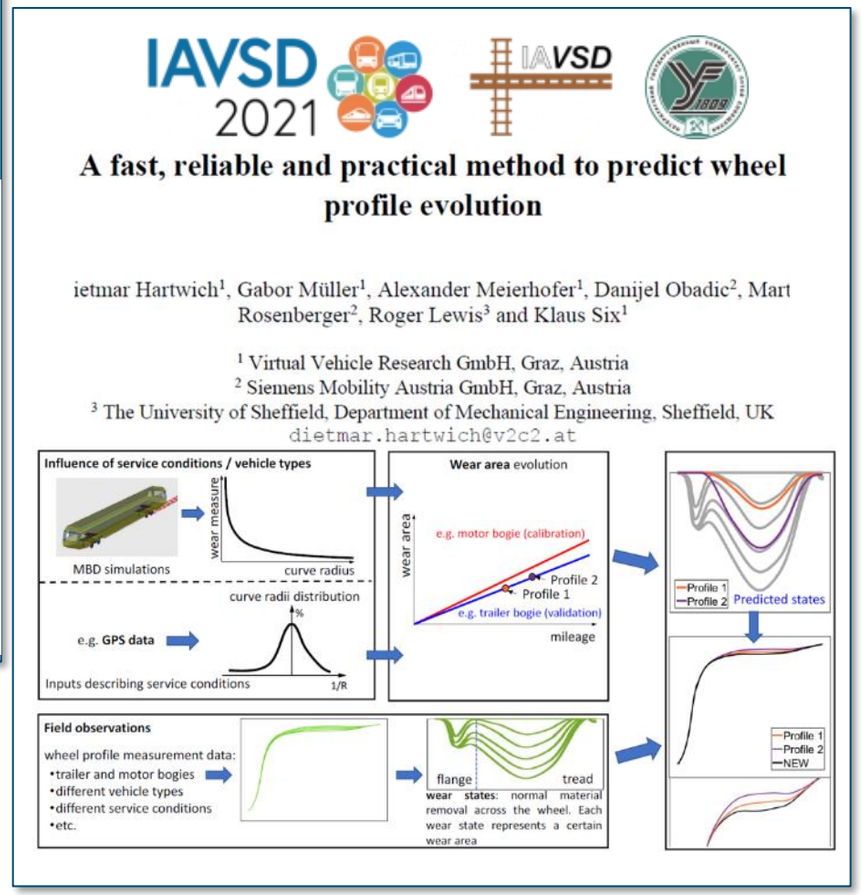

Damage & Deterioration

- RCF
- Wear
- Track settlement

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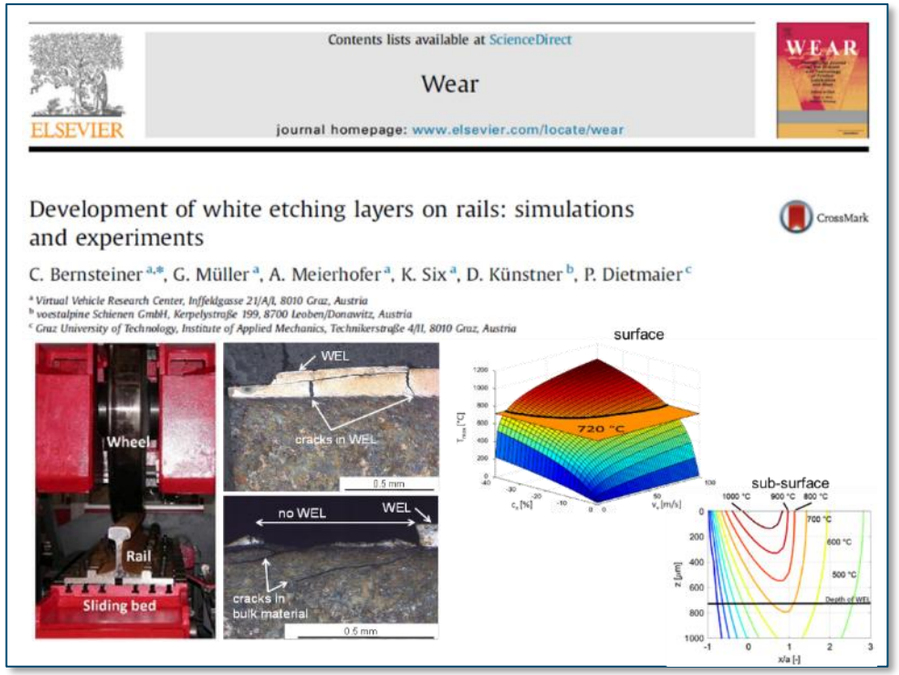

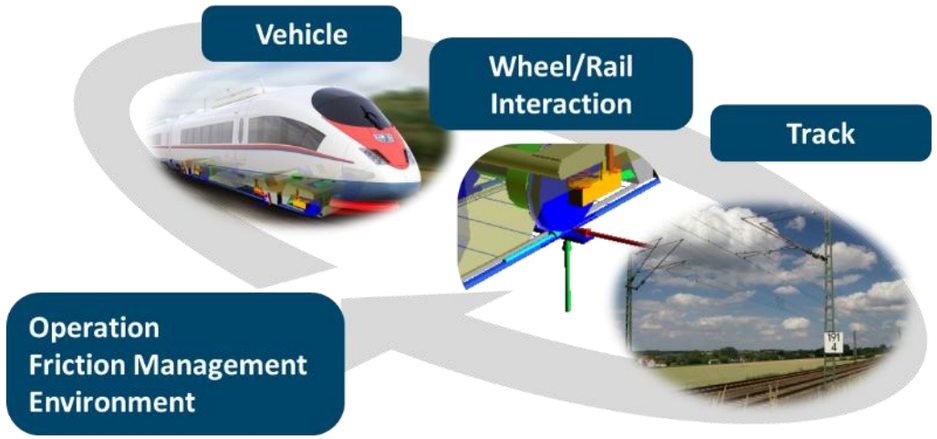

Material Modelling
- Severe plastic deformation
- Thermal phase change
- Ballast behaviour

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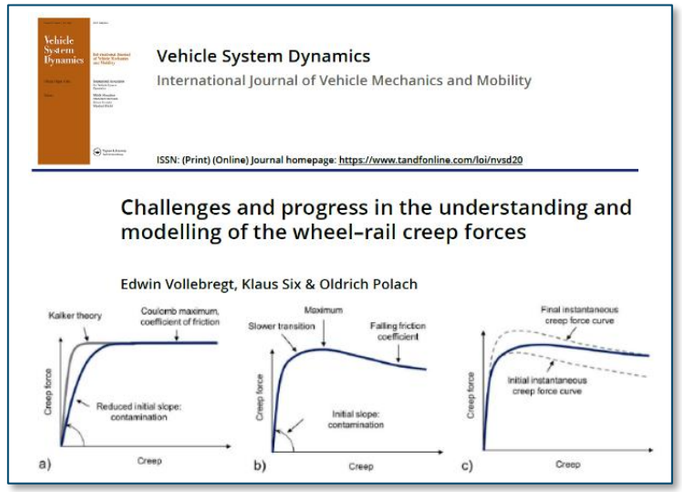
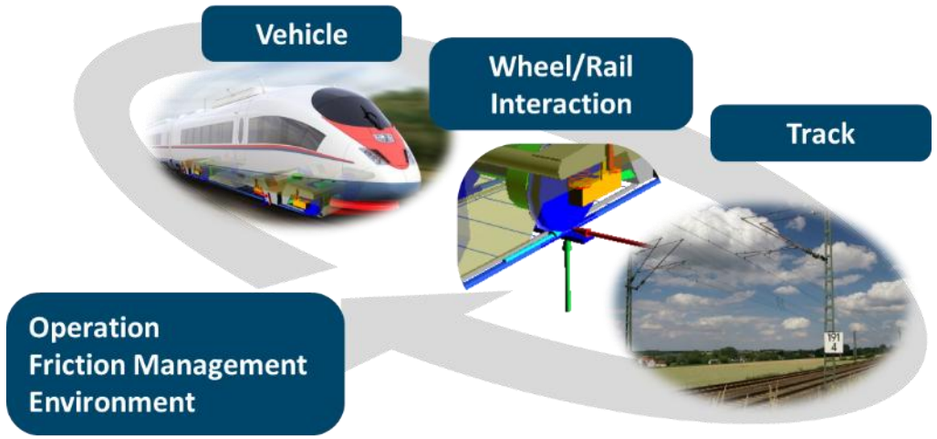


Wheel-Rail Contact
- Normal contact
- Adhesion
- 3rd Body Layer



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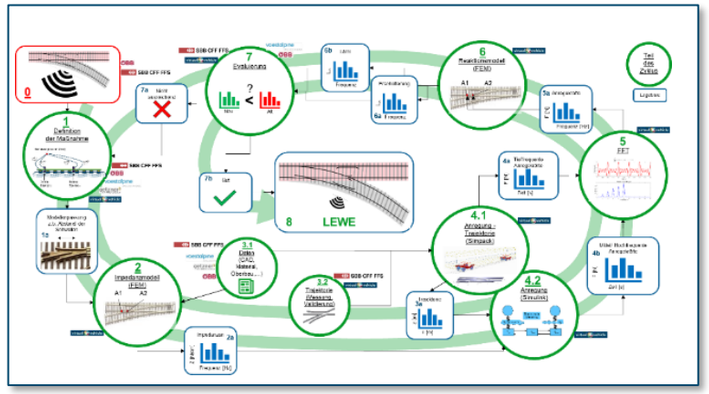
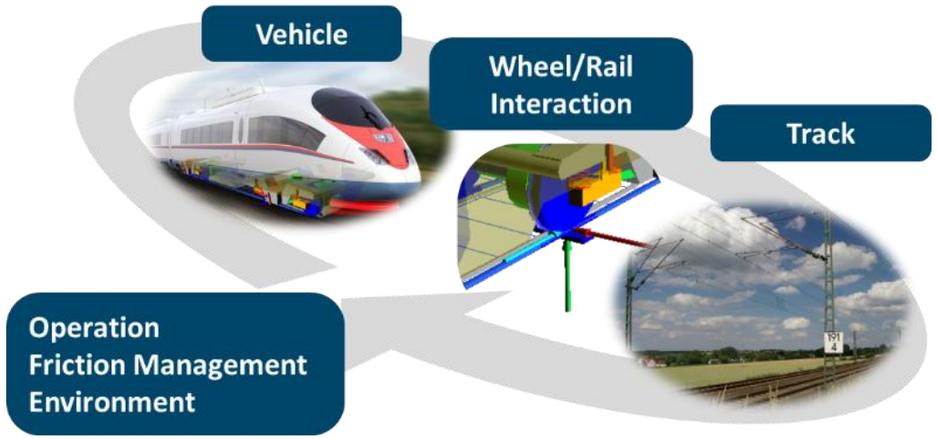


Noise & Vibrations
- Modular approach
- Combination of sub-modules to describe complex situations

Wheel-Rail Contact
- Normal contact
- Adhesion
- 3rd Body Layer

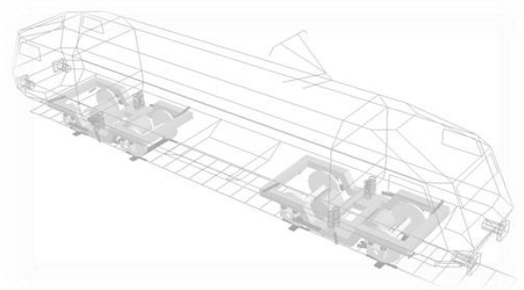


Material Modelling
- Severe plastic deformation
- Thermal phase change
- Ballast behaviour

Damage & Deterioration
- RCF
- Wear
- Track settlement

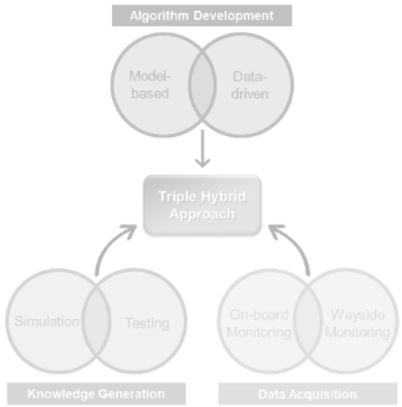
Fields of Activity

Vehicle Dynamics & Operation Analysis



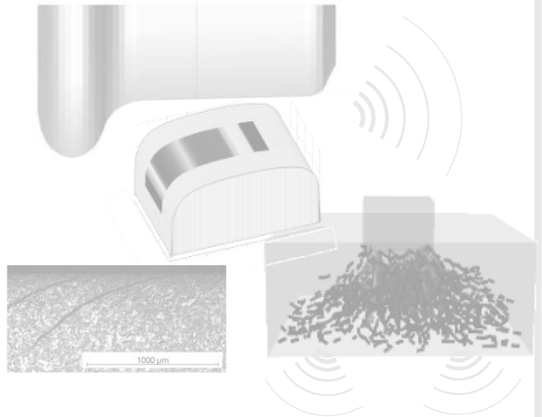
- Profound knowledge of vehicle system dynamics
- Simulation and modelling of vehicle/track interaction
- Vehicle and track parameter identification
- Virtual homologation of running behaviour (EN 14363)
- Probabilistic vehicle and track design

Monitoring & Diagnosis



- Profound context-based knowledge
- Algorithm development based on hybrid approaches
- Model-based and data-driven diagnosis and prognosis methods
- Monitoring, diagnosis and prognosis of vehicle components
- Track monitoring and assessment via on-board and wayside monitoring systems

Wheel-Rail Interaction & Deterioration Phenomena

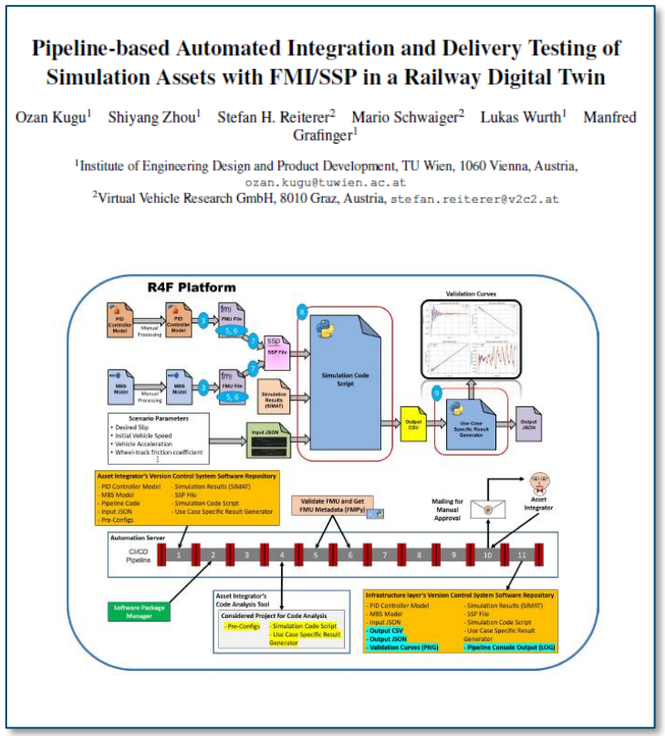


- Profound knowledge of physics
- Modelling of complex interactions and phenomena
- Wheel/Rail profile evolution
- Wheel/Rail surface damage
- Wheel/Rail contact phenomena
- Friction management
- Track degradation
- Noise & Vibrations

Digital Twins Network

- Vertical integration:
  Analysis of interaction between digital twins
- Horizontal integration:
  System or component behaviour during all life cycle phases
- Single point of truth:
  Consistent and continuous system data and models

Digital Twins Network



Pipeline-based Automated Integration and Delivery Testing of Simulation Assets with FMI/SSP in a Railway Digital Twin

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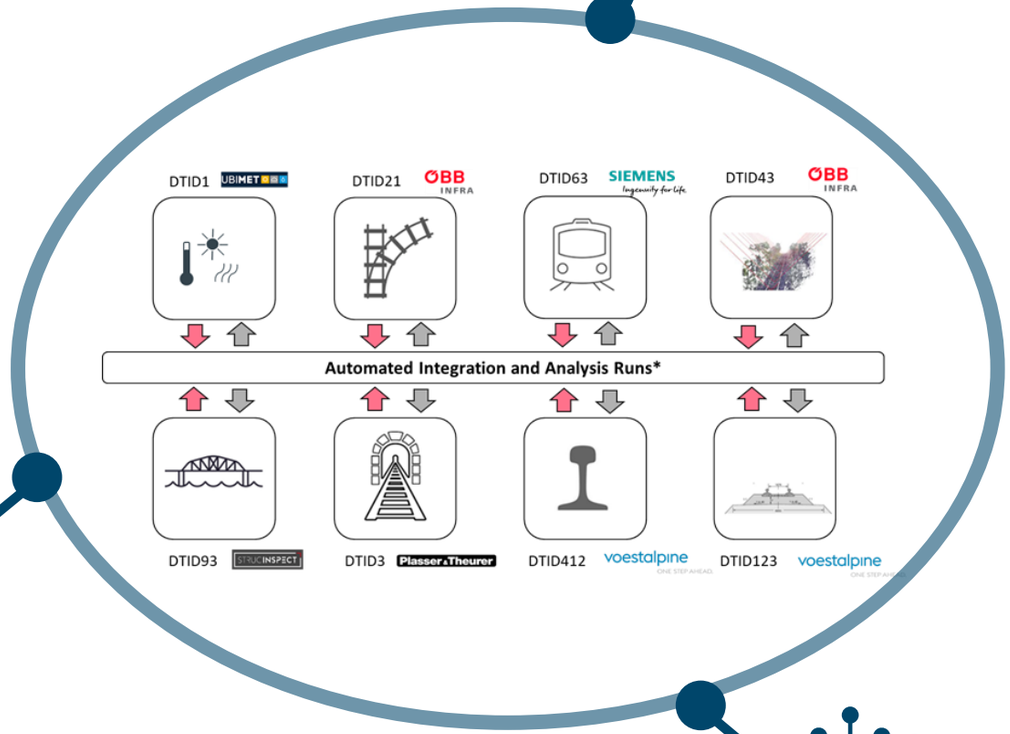
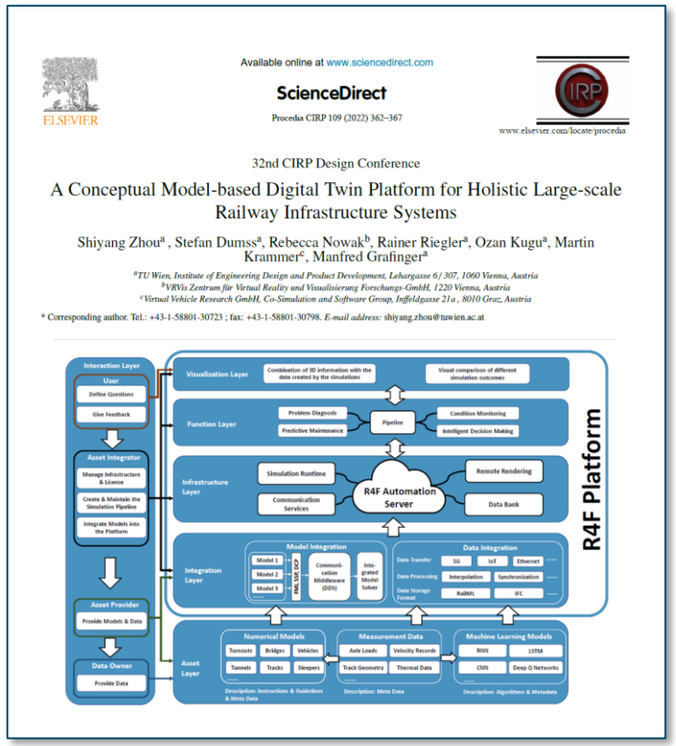
Vertical integration

» Analysis of interaction between digital twins





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A Conceptual Model-based Digital Twin Platform for Holistic Large-scale Railway Infrastructure Systems

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Horizontal integration

» System or component behavior during all life cycle phases

Single point of truth

» Consistent and continuous system data and models

Key partners and associations

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