Rail4Future

Projekttitel:	**Resilient Digital Railway Systems to enhance performance**
Projektnummer:	**882504**
Deliverable:	**D1.3.2 Generic Model Definition for multi-level optimization**

This report presents a generic model definition for multi-level optimization in railway systems, which encompasses different model types and their corresponding use cases relevant to railways. It outlines the methodology for developing and implementing the model, along with a modular and scalable architecture called the Rail4Future (R4F) platform. The R4F platform integrates various components and subsystems of the railway system. The railway digital twin system should develop different models to represent the system at different levels, capturing its physical, operational, and maintenance aspects.

In this report, different types of models are presented with actual use cases. Type 1 - Mathematical Model: RLD Model (Restlebensdauer Model): This part provides an overview of the model used to calculate the residual lifetime of a steel bridge. It involves input, influence lines, detail categories, a deterministic RLD calculation algorithm, and output/visualization for evaluation and reporting By ensuring accuracy and reliability, the model enables well-informed maintenance and repair decisions, contributing to the longevity and safety of the steel bridge. Type 2 - MBD Model (Manchester Erlkönig Model): This part provides a Multibody Dynamics (MBD) model, which is an essential tool for simulations of various scenarios based on inputs such as scenario- and model parameters, including variables such as vehicle speeds, additional passenger and luggage masses, track arc radius, and superelevations. By modeling these different scenarios. It offers insights into the dynamic behavior of railway vehicles, particularly the interaction between wheels and tracks. The model uses commercial software SimPACK to analyze dynamic behaviours on track elements and vehicles, enhancing railway safety and efficiency. Type 3 - ML Model: ML-based Surrogate Model for MBD Simulation: In this part, a surrogate modeling approach is utilized to reduce computation time and integrate submodels effectively. An ML-based surrogate model for multibody simulation of railway vehicle-track dynamics is created, replacing the traditional MBD Model. The model accurately predicts dynamic responses, validated with different input data and algorithms. It shows promise for building a holistic railway DT platform.

In the end, the generic model definition for multi-level optimization may ensure that reliable and valuable data can continuously flow throughout the whole life span of the holistic system and its subsystems, helping to build a fully connected and digitized railway infrastructure system. For more details on the mentioned models, please refer to the long version of D1.3.2.