Rail4Future: toward a cost-effective, convenient, and climate-neutral travel in Europe

by Irene Reichl (VSC Research Center)
translated from German

Limiting the ecological footprint of a steadily growing population is one of the key strategies for mitigating climate change. In the field of mobility, trains play an important role as a means of transport with a comparatively low carbon footprint. And as urban areas grow, rail provides a fast and convenient way for getting from point A to point B. If we used road transport only, there would be endless traffic jams, increased exhaust emissions and, as a result, poor air quality in cities.

The need to transport more and more people with a reliable and practical timetable places high demands on railroads. The project Rail4Future responds to the challenge by strengthening the resilience of rail with the help of digital technologies. Sensors, test benches, models, and calculations have already been successfully in use for a long time. Completely new in this case is the modelling and visualisation of the entire rail network in response to weather and train traffic, which allows the situation to be assessed and decisions to be made in real time.

As one of the most energy-efficient means of transport, rail can bring us closer to the climate goal of saving 90% of CO_2 emissions by 2050. This would be possible if, on the one hand, operations themselves become more energy efficient. On the other hand, if people switch from private motorised transport to rail as an environmentally friendly way to travel. To achieve the latter, rail must become more attractive to the public. This includes cheaper fares as well as denser and more reliable timetables. One pillar of the railroad system is its facilities — be it rails, signals, tunnels, or bridges. Delays and train cancellations can be avoided if faulty infrastructure components are identified and replaced in a timely manner. This is where Rail4Future comes in.

From simulation of a bridge to simulation of the network behaviour

So far, only partial aspects have been simulated — a particular switch/critical curve/tunnel. The innovative aspect of Rail4Future is the simulation of the entire network behaviour. This is unique because real infrastructure has never been simulated until now even in computer games with train simulators or space travel.
”The official kickoff of Rail4Future was April 1, 2021, and the partners are working together in a very focused way," Thomas Petraschek is pleased to report. The team takes a highly interdisciplinary approach, combining artificial intelligence (AI), finite element simulation for analysing the strength of materials, and visualisation of the entire railroad line including spatially resolved faulty components.

Thomas Petraschek
Head of Research & Development ÖBB,
Rail4Future - Consortium Leader

50 km test track Bruck - Graz

The Bruck - Graz line has already been digitised as a point cloud so that AI could identify components such as tracks, railroad ties, signals, or noise protection. This will show how accurately the theoretical models with all their simplifications and assumptions can represent reality. The requirements for the accepted uncertainty are enormously high, being less than 10^{-13}. Apart from the fact that keeping to a schedule is essential for rail operations, faulty components must be detected in time to prevent damage to trains and equipment and, in extreme cases, to people in the event of accidents.

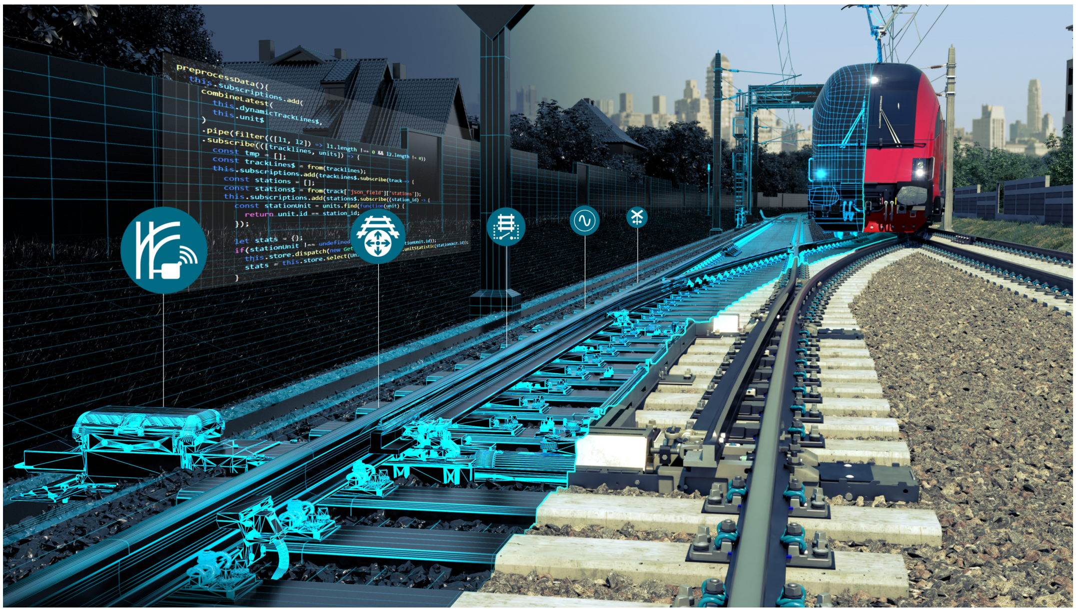
Densification of the timetable

Time intervals between trains cannot be shortened at will, because there are natural limits imposed by the principles of railway signalling. One way that timetable densification can be achieved is through greater rail capacity. Or alternatively, by replacing signals with a communication system among trains to reduce delays. Such technology has already been implemented on the road with C-ITS (Cooperative Intelligent Transport Systems).

For the infrastructure, a denser schedule means a higher load, especially when it involves not only passenger trains but also the much heavier freight rail transport. A bridge, for example, is designed for a lifespan of 80 years; if the load increases, it would have to be re-designed. With help of simulation, however, different timetables are used to calculate the structure's response to the stress caused by trains per unit of time.

Reducing time-to-market

It can take up to 30 years for a new concept to be implemented on the railway because it takes a very long time to actually cover the accident-free distance specified for approval. What has long been state-of-the-art for autonomous driving on the road, namely that 70% of the kilometres may be driven on a simulator for approval, could also significantly shorten the time-to-market on the railways. Therefore, it makes perfect sense to seek solutions offered by powerful software and High-Performance Computing (HPC). During the run of the Rail4Future project, a digital twin library will be created to reduce the amount of on-track testing.



Vision of a Railway Digital Twin of the track system
Image: voestalpine Railway Systems GmbH

Efficient software and powerful computing

“I calculate one meter of rail myself with Abaqus on the PC," says Thomas Petraschek, “but simulating an entire rail network in real time, detecting and responding to deviations requires very strong computing power and smart programmes.” Deviations occur continuously during operation, e.g. mudslides onto the rail track, deformation of rails due to extreme temperatures or rescue operations. The goal is to use algorithms and AI to instantly calculate a new route or a modified timetable. Structural mechanics calculations, consideration of friction and wear require very powerful computers. And last but not least, the data-intensive visualisation of the entire rail network benefits from an HPC system.

Competitive advantage strengthens Austrian industry

Testing components such as switches or chassis at the ÖBB facilities also improves the know-how of the project's industrial partners and their international competitiveness, which in turn secures the industrial strength and thousands of jobs in Austria.

What's next?

Put simply, Rail4Future deals with the system's response to the weather situation and the trains' load on the rails as they travel according to the intervals of the timetable. Another ongoing project (TARO - Towards Automated Railway Operation) studies the opposite — the train's response to the system. Once both projects are completed, the gained knowledge will be combined to simulate the interaction as a mutual feedback between the system and the rail vehicle. And if that is not enough of a task, the energy networks will also be simulated. Avoiding unnecessary braking and acceleration, especially for the very heavy freight trains going uphill, saves immense amounts of energy.

Rail4Future Consortium:

Consortium leader

ÖBB Infrastruktur AG

Industrial partners

Voestalpine Metal Engineering
FCP FRITSCH, CHIARI & PARTNER
Hottinger, Brüel & Kjær
Vermessung Schubert ZT
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TARO project:
https://konzern.oebb.at/de/taro

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Original text (German) by **Irene Reichl**
Published by **EuroCC Austria -** National Competence Centre for Supercomputing, Big Data and Artificial Intelligence
eurocc-austria.at