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Making railway operators ready for automation – project TARO

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Abstract

This paper shows the goals and the status and gives an overview of resent results and planned activities of the research project "TARO – Towards Automated Railway Operations", an Austrian cooperative technology initiative led by the Austrian Federal Railways (ÖBB). Automation of railway operation including digitisation of relevant processes from operations planning to maintenance is the key to increase capacity, productivity and reliability of existing railway systems.
Automation & digitalisation in the railway system are important factors for climate protection, in order to achieve further traffic shifts to the more climate-friendly railway through capacity increases in rail transport, as well as to further reduce the greenhouse gas emissions of the railway itself.
The research project is built on three thematic areas, Digital Twin, Processes and Automated Train Operation, which are organised as separate, but interconnected subprojects.

Keywords: ATO, railway operation, digital twin, cooperative technology initiative, DAC, regional railways.

1 Introduction

Rail is now widely regarded as the most-environmentally-friendly form of surface transport, and yet there is an urgent need to increase capacity, productivity as well as quality of the railway. These key challenges will be tackled by the project TARO ("Towards Automated Railway Operation").

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Not only in terms of railway usage, Austria is a leading railway country in the European Union (no. 1 passenger-kilometres per capita, no. 2 freight transport, no. 1 night trains) but also regarding its railway industry (no. 5 global export, no. 1 in railway patents per capita). Given such an excellent starting position, taking railway to the next level with the help of automation and digitalisation technology should be self-evident. Hence, TARO focuses on 3 different areas:

- Digital Twin development of digital twin vehicle with special regard to condition-based maintenance and predictive maintenance; development and simulation of digital twin infrastructure, as it is one of the fundamentals of automated train operation.
- Process automation in freight transport, in particular in terms of automated coupling, as well as shunting and planning.
- Automated railway solutions such as low-cost autonomous on-track side elements, low-cost train control systems for regional railway lines, as well as location of vehicles.

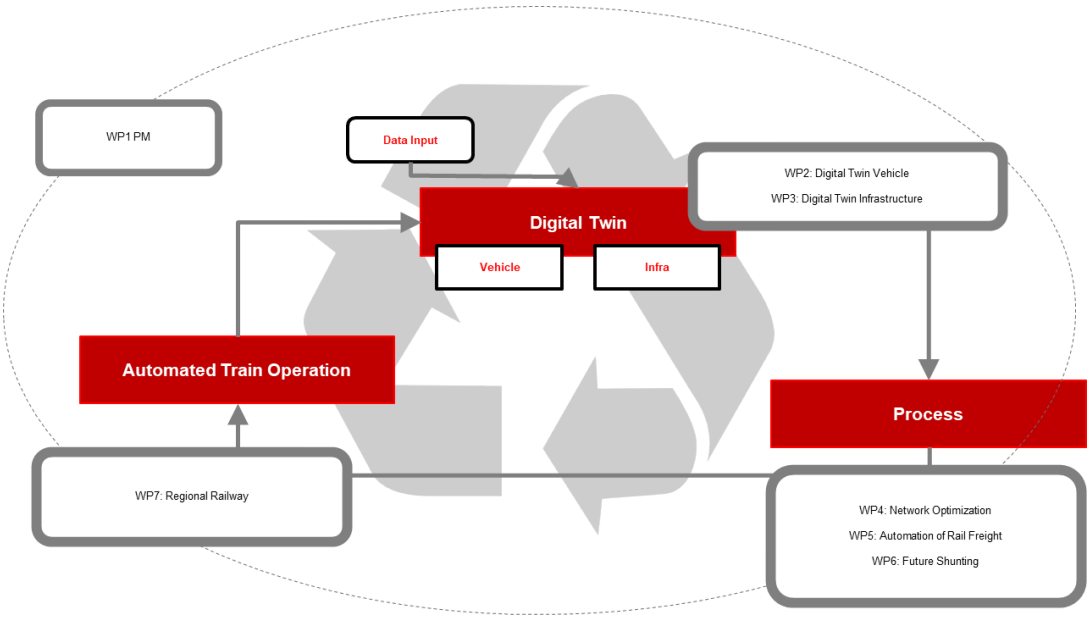

Figure 1: Interaction of the 3 project aeras of TARO

The main objective of the TARO project is to realise R&D projects in various areas of the railway system that make a significant contribution to the automation &

digitalisation of the railway system and contribute to an increase in capacity, productivity and quality. This goal will be achieved by embedding the project contents in various other national and international R&D projects, such as Europe´s Rail Joint Undertaking, or through close exchange with them.

The estimated project results are expected to contribute to an increase in capacity, productivity and quality of the entire railway system.

2 Methods

The research project is based on 3 thematic areas: Digital Twin, Processes and Automated Train Operation. In the Digital Twin thematic field, the "Digital Twin Vehicle" project aims to create the basis for the future digital representation of the entire rail vehicle and the "Digital Twin Infrastructure" project aims to create the basis for future (partially) automated train operation.
The focus of the "Processes" thematic field is primarily on rail freight transport: projects on optimised empty wagon dispatching, the testing and operational trials of digital automatic coupling and questions on the shunting of the future are intended to increase the attractiveness of rail freight transport. In the third thematic field, "Automated Train Operation", the focus is entirely on regional railway technology of the future, such as train protection systems without external elements and the supply of autonomous, digital elements along regional railway lines.

In the area of digital twins, the goal is to develop a "Digital Twin Vehicle" and a "Digital Twin Infrastructure". The "Digital Twin Vehicle" makes it possible to continuously collect vehicle data from a wide variety of sources and intelligently combine them. This enables maintenance processes and, subsequently, availability to be optimised. The "Digital Twin Infrastructure" in turn aims at the digital mapping of the infrastructure and thus creates the basis for predictive maintenance of track infrastructure, for example, as well as for Automated Train Operation (ATO) in the longer term.

The focus of the processes here is primarily on process optimisation and the automation steps this enables for automated and improved operational processes, scheduling planning and network optimisation. The testing of a digital, automatic coupling (DAC; in coordination with other European railways and European R&D projects such as European DAC delivery programme and DAC4EU) and optimised shunting are further project plans. These projects should benefit rail freight transport and shunting processes in terms of innovation, which will subsequently lead to cost reductions and increased competitiveness.

Automated Train Operation sees potential for implementation above all in regional railways, and within the framework of TARO, concrete preliminary stage projects are to be advanced above all in this subject area. These include, among others, the prototypical development of a train control system (without signalling systems on the railway side) for regional railway lines as well as the project on "communication & supply of autonomous, digital elements along the line"; as a result, for example, a

demonstrator for a highly automated, energy-autonomous railway crossing is to be developed.

3 Results

Since the project start in June 2020, numerous basic principles such as data sets, use cases and concepts have been developed, which are now to be successively implemented. In the further course of the project, it is now important to ensure that the developed basics can be transferred into concrete implementation steps in the short or long term and that the exchange between the individual work packages as well as with other national and European research and development programmes (e.g., Europe's Rail Joint Undertaking [1], European DAC Delivery Programme, DAC4EU [2], Rail4Future [3]) continues to be well coordinated.
The Digital Twin Vehicle has been defined and enables the identification of local and temporal hotspots and durations of detected errors messages per train type. With the help of an advanced tool set trends of the condition of relevant components can be identified and will start the relevant maintenance processes in future.
The Digital Twin Infrastructure is based on a new developed 3D representation of the railway corridor as a building block for the virtual mapping of the infrastructure is available, and in preparation for simulations.
As part of the aera processes a new dispatching logic for network optimisation was developed based on an advanced mathematical model. In the next step the tool will be tested to dispatch a special waggon type with real data.
The second part of processes is focussing on automation in rail freight. The activities are coordinated with the work on European level regarding the Digital Automatic Coupling .After the choice of the coupler head (Scharfenberg design) and the experience with the DAC4EU demonstrator train the adaption of the shunting processes was started. To identify the needed process reconfigurations a simulation tool was developed to assess future processes and scenarios.
In the third part of the area processes “Shunting of the future” a simulation and visualisation tool for any type of marshalling yards (infrastructure, processes, vehicles) was created.
Regional railway technology of the future as part of the automation pillar was started by developing a new railway safety system based on 5G technology. The technology was tested in first field test to get knowledge of the behaviour of safe and non-safe functions of the interlocking cores for regional railway lines. The system architecture represents an interlocking and signalling system with a self-sufficient, decentralised energy supply and information exchange with the railway operations centre only based on 5G communication.

4 Conclusions and Contributions

The contents of the TARO project are to be transferred into concrete implementations in the short or long term and are oriented towards the objective of increasing the productivity, capacity and quality of the railway system. Therefore, the connection of the project contents to concrete use cases or requirements from railway operations as

well as the exchange of contents between the work packages is being pushed accordingly.
The second phase of the project will strongly focus on the implementation and the field tests of the developed systems and advanced processes to produce and collect resilient data sets to be examined in the evaluation and dissemination phase.
At the same time the link with other European programs, Europe´s Rail Joint Undertaking, the European DAC Delivery Programme and the DAC4EU consortium, also characterizes the project and underline the demand-oriented orientation and the cross-programme and cross-project approach of the project.

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