This PhD proposal is a collaboration between TU Delft and ProRail

Optimizing performance of Automatic Train Operation on railway networks

ProRail expects a considerable growth in railway transport of 30% until 2030 and even up to 40% until 2040. However, the current Dutch railway system is already approaching its capacity limits. Therefore, an innovative change in operation and control is required to enable stable and reliable railway traffic at high capacity occupation levels. TU Delft and ProRail collaborate in a research programme that will develop intelligent automation of the planning, operation and management of railway traffic to achieve improved, more frequent, and sustainable railway transport. One of the pillars of this digital transformation is Automatic Train Operation (ATO) connected to intelligent traffic management systems and the European Rail Traffic Management System (ERTMS). ATO will (partially) automate driving tasks depending on the Grade of Automation, with the aim to achieve accurate driving with smaller buffer times and minimal energy consumption.

ATO consists of trackside and onboard subsystems that interact with the trackside Traffic Management System (TMS) and the onboard European Train Control System (ETCS). The ATO trackside determines Journey Profiles based on Timing Points with target times/windows, while the ATO onboard generates and tracks a specific train speed trajectory satisfying the journey profile and the ETCS dynamic speed profile. ATO performance depends on the configuration of the Timing Points, the computation of the associated Journey Profile including the allowed time windows, the computation of the speed trajectory, the tracking of the train trajectories with the allowed bandwidths, the interaction with ETCS, and the interaction with the traffic management system to avoid conflicts. This project will develop new methods to optimize ATO performance based on the ATO-over-ETCS specifications of ERTMS. The main research objective is as follows.

> *Developing methods and algorithms for Automatic Train Operation to optimize capacity on mainline railway networks.*

Research questions that will be answered within this project are

- What is the optimal interaction between ATO, ETCS and TMS to enable stable conflict-free traffic?
- How can optimal Timing Points and Journey Profiles be computed for smooth train movements?
- What are the requirements on the TMS for planning and rescheduling to optimally support ATO?
- Which ETCS characteristics in the track and train configuration are required to optimize ATO?
- How can stable and safe automatic train operation be maintained in reduced adhesion conditions?

The answers to these research questions will also be used to quantify the potential contribution of ATO in solving capacity bottlenecks and to advance the current ATO specifications towards the goal of optimizing capacity.

This PhD research will use state-of-the-art techniques from railway operations research, optimization and train trajectory optimization. The research will be carried out in the Digital Rail Traffic Lab of Delft University of Technology under the supervision of Prof Goverde in close collaboration with the ATO Team within ProRail. The PhD candidate will also work at Prorail for one day per week.

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