Future Railway Timetabling and Operations Optimization in Finland

Utilizing Automatic Train Operation (ATO) and Traffic Management System (TMS)

Presentation for Väylät & Liikenne by Markus Helelä on the 22nd of March 2023

Background

ATO (Automatic Train Operation) is part of the larger Digirail project. Its goal is to assist in integration of **TMS (Traffic Management System)** with ATO and to provide useful information and insight for the possible future development process of TMS in Finland.

In the ATO TMS part of the ATO project, one of the focuses is on how TMS could provide support for effective ATO utilization in Finland.

The presentation will focus on how TMS could enable for more efficient and robust timetabling, better service quality, and increase of rail capacity or capacity utilization in Finland when ATO has been implemented.

(This vision is not part of the official/planned migration path – instead, a personal vision of what longer term future could hold for railway timetabling and operations in Finland.)

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ATO System

As **ETCS (European Train Control System)** monitors train movements and speed limits on track, **ATO** reliably controls the train's drive and braking systems for energy-optimized operation, enabling maximum performance through greater capacity and network optimization. ATO needs to fulfill the same requirements for interoperability as ETCS.

The principal architecture and standardized interfaces of the ATO overall system are shown in the picture below. The overall system consists of:
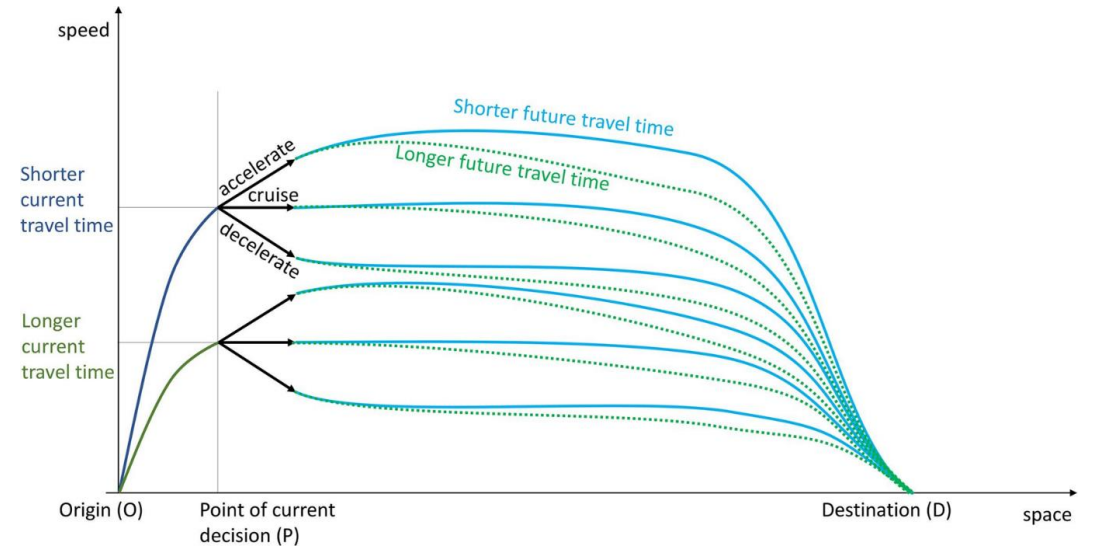
- **TMS** provides dynamic timetable data with detailed information about train movements as well as forecast and possible conflict information. Together with planned route data all information is transmitted to ATO-TS.

- **ATO-TS (trackside)** collects dynamic information from the existing TMS and generates for ATO-OB specific Journey Profiles and Segment Profiles.

- **ATO-OB (onboard)** continuously calculates the optimum speed profile based on the available data of infrastructure, track and timetable information and controls the traction and braking systems for automated train runs, minimizing the energy consumption as much as possible.

(Photo source: www.prose.one)

(Photo source: Siemens

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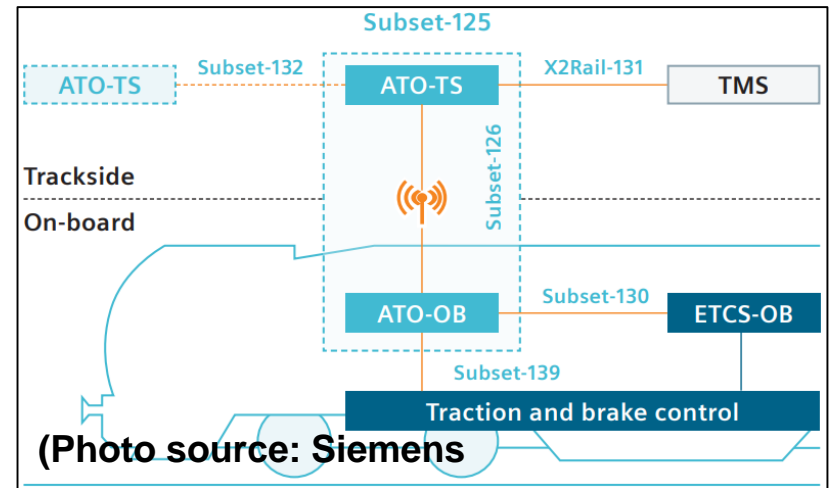
Train Path Optimization

The picture below illustrates the idea behind **train's speed profile optimization scheme**, with timing points serving as check-and-decision points where planned timing is compared to actual timing. ATO-OB optimizes acceleration, deceleration, driving speed, coasting, and braking curves relative to planned travel time between Timing Points. Tolerances in travel and dwell times affect optimization.

Operation with ATO will lead to higher operational accuracy relative to running the trains manually with a current Driver Assisting System (DAS). This will lead to smaller deviation for travel and stopping times, as such apt to improve punctuality and reduce knock-on delays. Further, it will lead to increased rail capacity.

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Optimization Schemes in Railway Timetabling and Operation (Development Stages)

TMS provides dynamic timetable data with detailed information about train movements as well as forecast and possible conflict information. Next, the following schemes of ATO-enabled planning will be described and their utility in railway operations explained:

Development stage 1

- Homogenization of regional traffic headways

- Optimization of power supply

Development stage 2

- Heterogenization of regional traffic headways

- Timetable/System-level optimization of power consumption

- Timetable optimization based on up-to-date forecasts drawn from real-time traffic situation

Other useful schemes have been recognized but won't be introduced in this presentation.

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Stage 1 – Nearer-Term Future

Homogenization of regional traffic headways. This will be based on sufficiently accurate estimation of train dwell times, which in turn requires real-time accrual data on passenger numbers produced with e.g., a camera-based system or stochastic approximations based on recent realized dwell times, or combination of the two. An objective function is required in Fintraffic's ENNE system for optimization.

Optimization of power supply. This enables avoidance of electrified railway line's triggering/tripping and energy transfer from decelerating trains to accelerating trains in the shared electrified railway line area. Optimization scheme of power supply should be implemented into ENNE.

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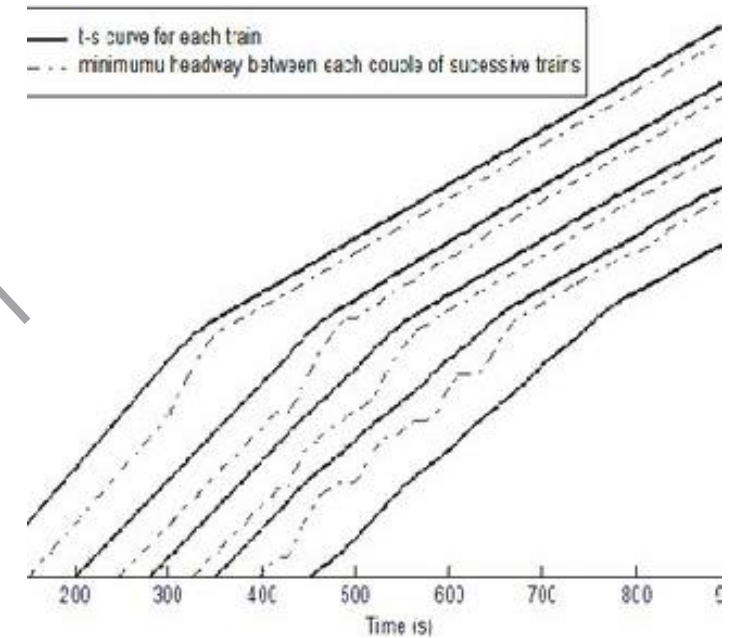
Stage 2 – Longer-Term Future

Heterogenization of regional traffic headways. Passenger numbers inside trains and on platforms affect dwell times. Passenger numbers and accrual on platforms affect optimal arrival frequency of regional trains. Based on these, the optimal a) dwell times and b) arrival timings for regional trains, regional traffic headways shouldn't always be kept constant, regardless of their pre-planned (timetabled) departure frequencies during the peak periods remaining fixed.

For TMS to manage headway optimization, similar technical requirements must be fulfilled as for homogenization of regional traffic headways (see Stage 1 in the previous slide).

Timetable/System-level optimization of power consumption. . Impact is largest on regional trains due to their higher ratio of time spent accelerating and decelerating for station stops relative to travel time. Optimization outside of stopping-related acceleration and deceleration might have larger relative impact on long-distance trains. The scheme relates more to Fintraffic's SAAGA than ENNE system.

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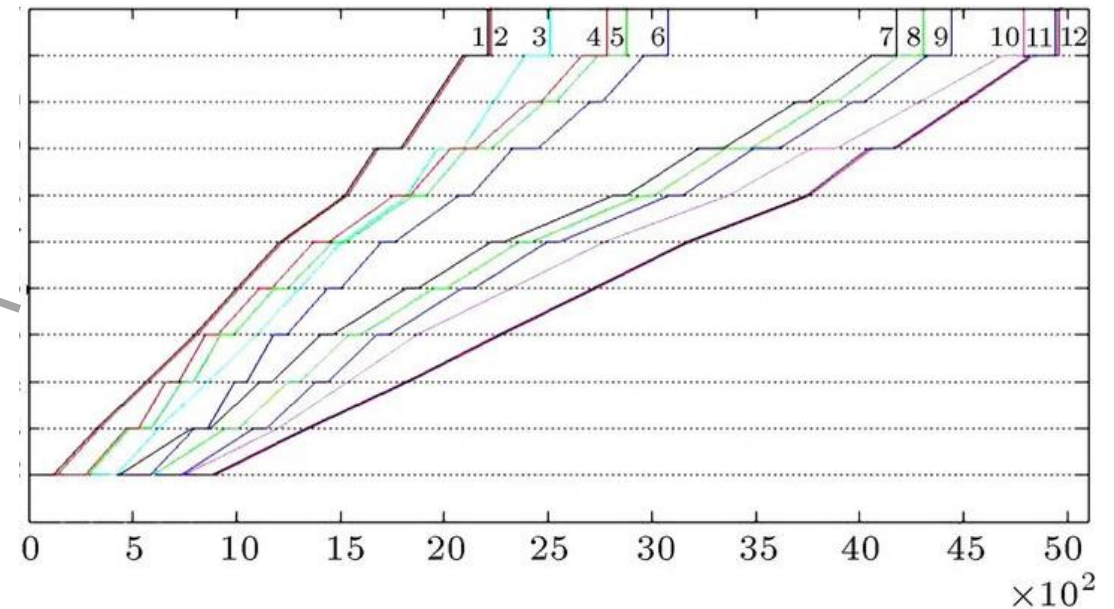
Stage 2 – Longer-Term Future

Timetable optimization based on up-to-date forecasts drawn from real-time traffic situation. ATO improves timetable optimization for it allows for shorter planned additional running times and headway buffer times due to decrease of deviations from planned speed profiles. It possibly increases the consistency and accuracy of optimization. As a result of optimization, capacity and its utilization improve, and number and length of delays and knock-on delays possibly decrease. ATO also makes the solving of forecasted conflicts more efficient and flexible, allowing for tighter plans, and it possibly increases the reliability and accuracy of train operation.

Conflict solving must consider things such as order of trains, train paths, timings between trains, dwell times, speed profiles etc. ATO doesn't aid optimization logic or algorithms. TMS needs to be up to date with minimum technical travel and dwell times. Data transfer and computing must be sufficiently fast.
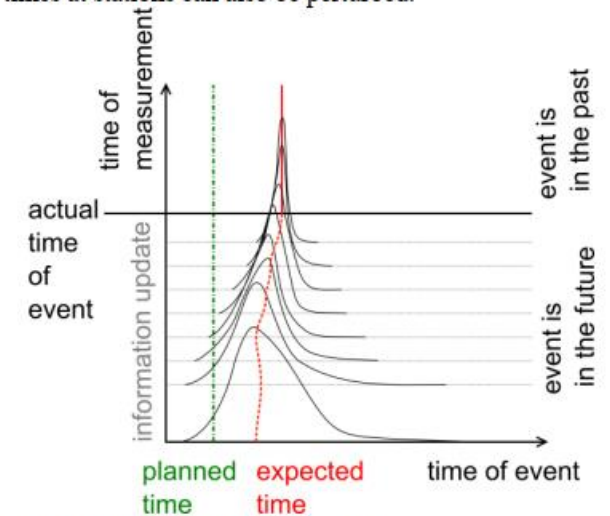

Fig. 3 Dynamic of forecasts of future events

Computing and Data Transfer Requirements in Optimization

For sufficiently fast computing,

- optimal **reliability and accuracy levels** must not exceed certain thresholds,

- **"unnecessary" optimization** (= small impact optimization) must be avoided,

- **portion of timetable being optimized simultaneously** (time and/or area/number of trains) must be kept low enough,

- **distinction between critical and uncritical trains/parts** of timetable in optimization should be considered (necessary to recognize so-called critical points of a timetable),

- **micro- versus macro-level optimization** and a feedback loop/iteration between them should be considered,

- **reduction of optimization criteria** should be considered,

- **history data** and utilization of **stochastic approximation** could be helpful.

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