Just in time: optimization of freight trains operation for increasing energy savings

Freight train operation sensibly differs from rail services for passengers. Train composition, total weight, wagons disposition within the convoy, number of empty wagons, exact departure time are known only few hours before real departure. These variables may change train performances and affect the adherence to planned schedules, forcing dispatchers to continuously modify the train trajectory, by adding or deleting stops.

Within the research field of introducing automation in rail traffic management, a model for freight train operation optimization to perform before departure is proposed, aiming at enhancing train operation performances in terms of energy efficiency.

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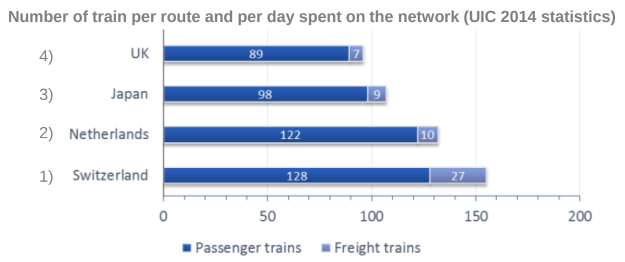
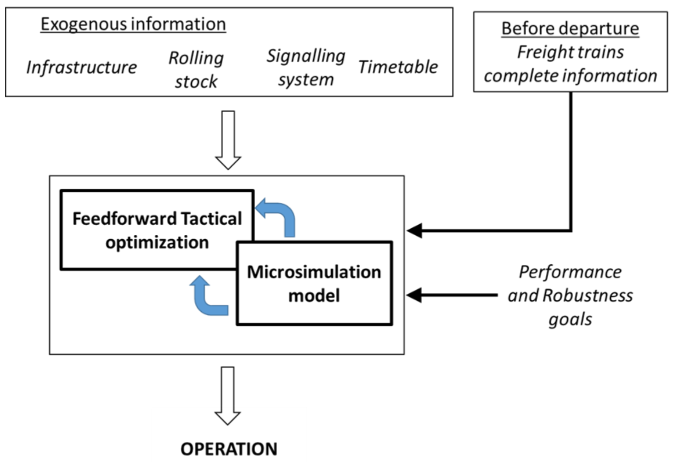
Introduction

Here a feedforward simulation-based optimization model for freight trains operation, which performs speed profile optimization together with minor rescheduling actions, is presented. The main aim is to provide railway operators and infrastructure managers with energy efficient solutions that are shaped for freight trains and suitable for the Swiss rail traffic.



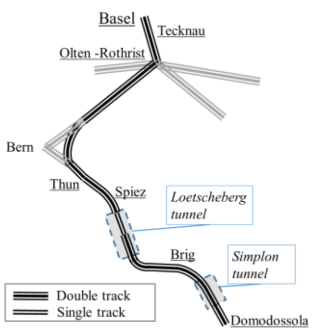
Problem statement and Model description



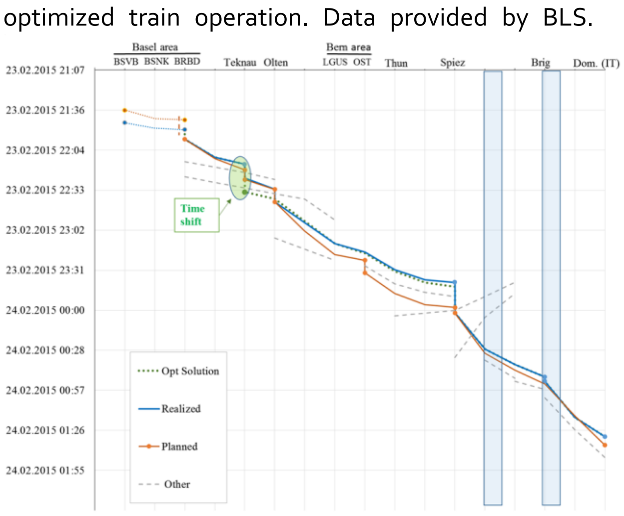
Need: energy efficiency is an important objective in making competitive and attractive railway systems.
Problem: the current knowledge has been developed on models for passenger trains, not easily adaptable to rail freight operation. Mainly, complete characteristics of trains are known only few hours before real departure.
Opportunities: small, focused adjustments on routes, speed profiles and stops are possible.
Solution: a feedforward simulation-based optimization, which optimize both number of stops and speed profiles.

Case study with real data

BLS Re485	Characteristics
2002-2003	Year
84 tons	Weight
87 mph (140km/h)	Max speed
5.6 MW	Power class
18.9 m	Length
300 kN	Tractive effort
240 kN	Braking effort

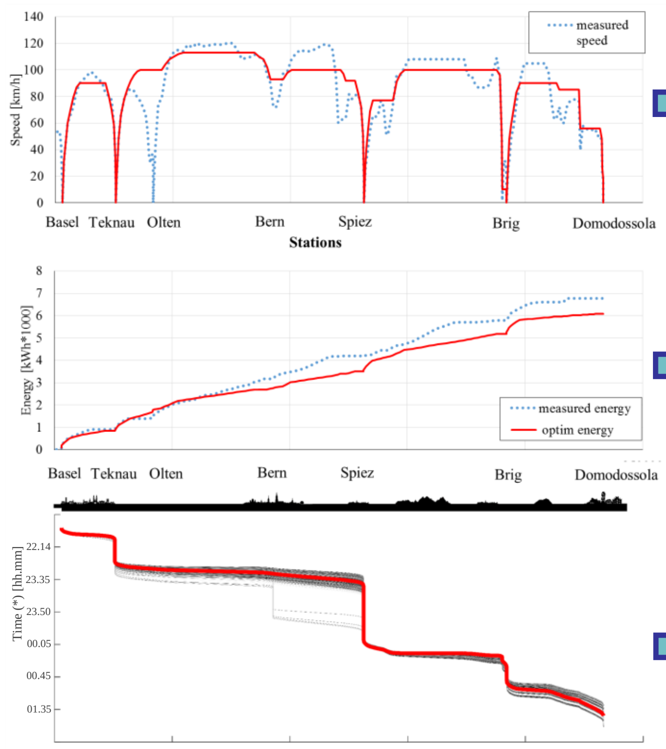


Above: traction unit characteristics and track topology of the analyzed freight train (Basel-Domodossola corridor).
Below: comparison between planned, observed and optimized train operation. Data provided by BLS.



Optimization results

Optimal speed profile has been calculated with respect of the surrounding traffic conditions and real data on speeds and energy consumptions. Arrival time at destination has not changed. Solution robustness has been evaluated by varying departure time within Swiss initial delay (i.e. delay at departure) distribution.



(*) trajectories have been scaled by distances in order to emphasize the difference within the set. It results that running times and dwell times are not in the same scale. Therefore, Y-axes values are just for reference and not scaled.

Main results:

- Same arrival time at destination
- -12% energy consumption
- Robust solution within 300 seconds of initial delay

Conclusion and further investigations

The solution generated by proposed model allows arriving at destination on time. The number of speed targets is limited, thus driver can easily follow the instructions. However a perfect adherence to the optimal solution is possible only when Automatic Train Operation (ATO) systems are installed.

The energy efficient speed profile allows saving up to 12% of the total energy consumed. This result is strictly connected to the conclusion hereinabove. Therefore, ATO systems or Driving Assistance Systems are required to reach these results in real life. Moreover, a models calibration is needed for output precision. This will be further investigated.

Robustness is here intended as the possibility to adopt the proposed solution within the rail traffic. With over 1000 simulations, it has been found that the proposed solution can be adopted up to 300 seconds of initial delays. A higher delay would force the train to an unplanned stop and subsequent reacceleration, which is highly energy expensive.

References

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Partners

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