Disturbance management: Some insights from projects BLIXTEN I and II

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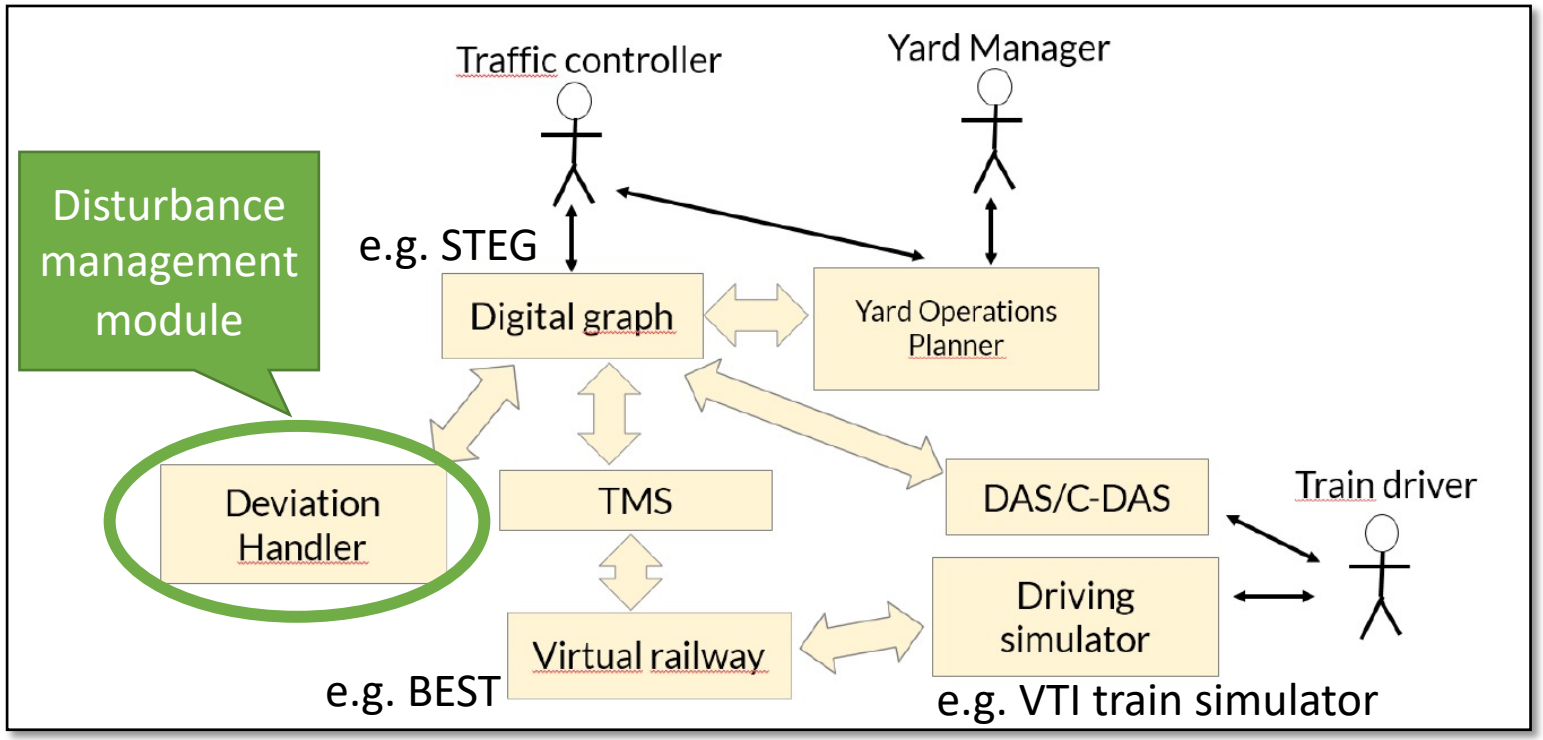
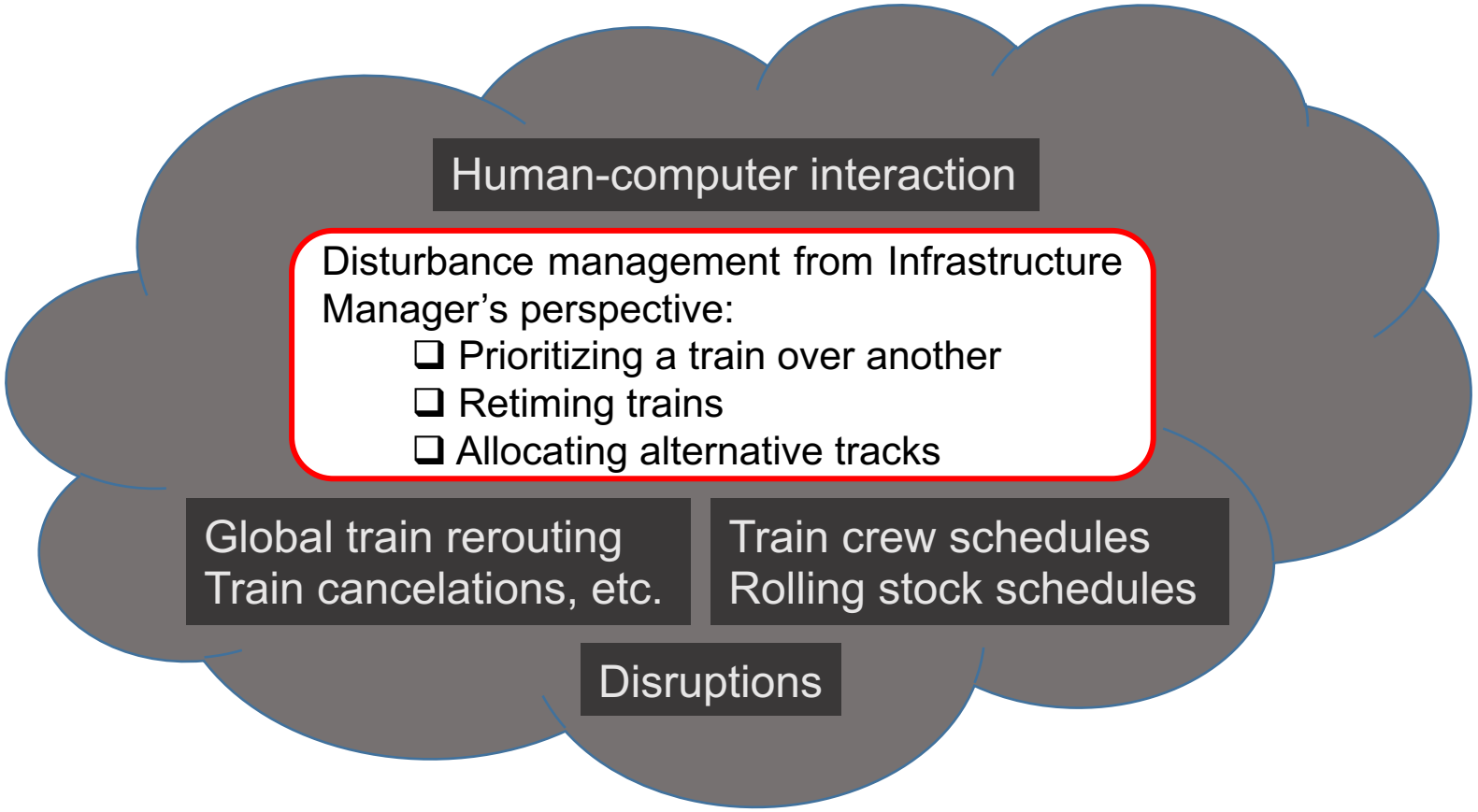
Real-time railway timetable rescheduling

Components and actors in advanced real-time railway network management



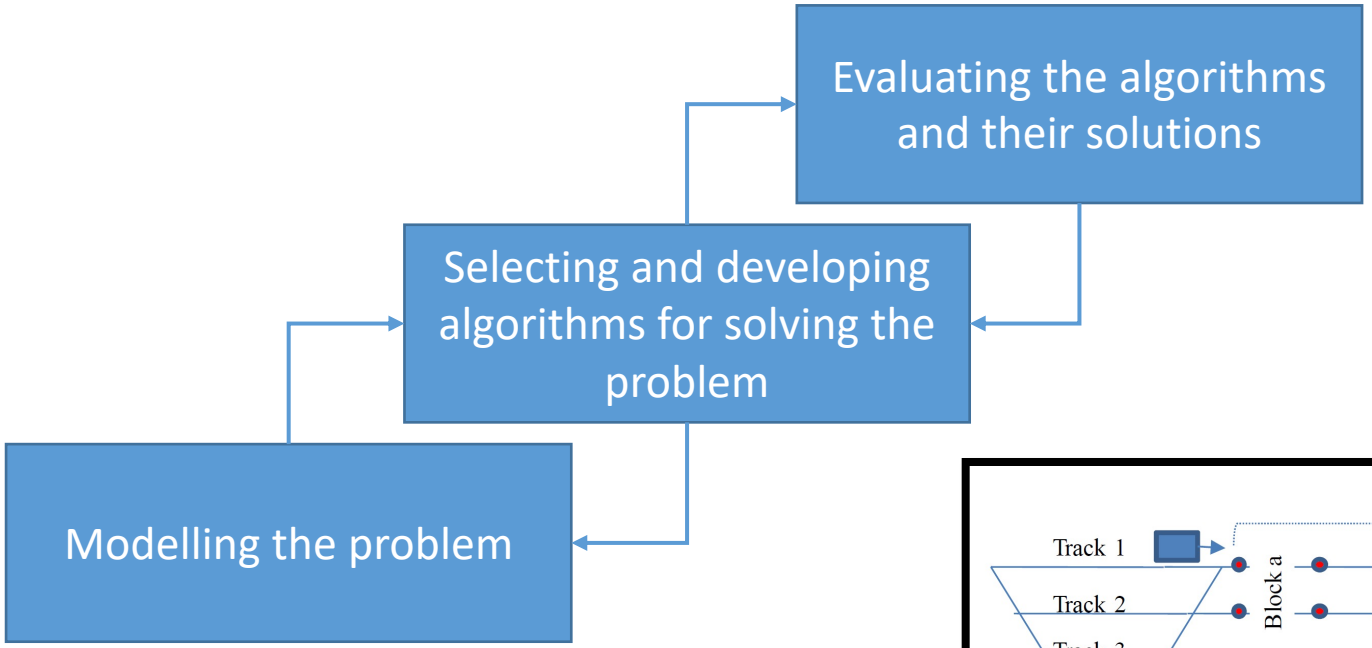
Source: M. Joborn, J. Törnquist Krasemann, B. Thorslund, S. P. Josyula, Z. Ranjbar, T. Liden, M. Wahlborg, “Description of a decision support tool aimed at advanced Real Time Network Management and requirements for a demonstrator”, 2020. (FR8Rail II Deliverable 3.2). http://www.diva-portal.org/smash/record.jsf?pid=diva2:1510579

Scope and research focus

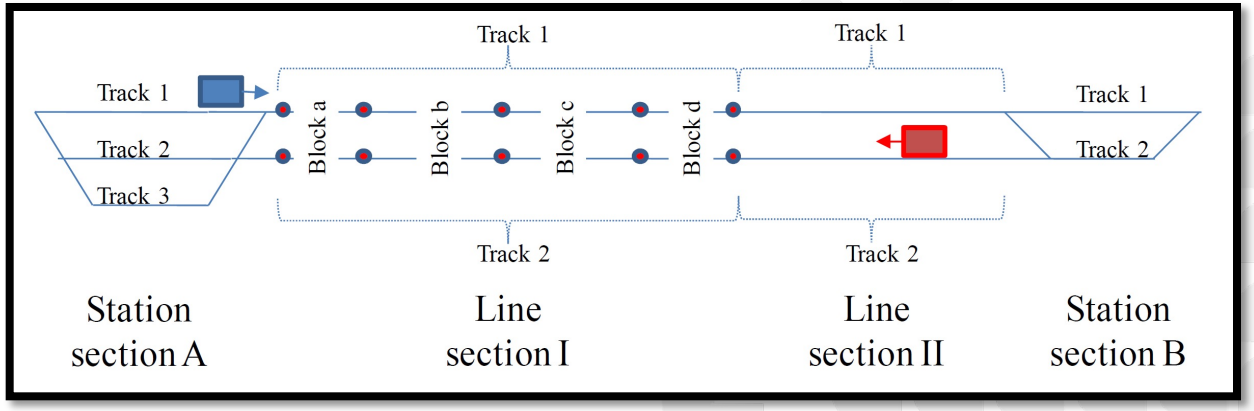


Some challenges

- How to model the problem?
- How to design and implement the algorithm?
- How to analyze its applicability, strengths, and limitations?



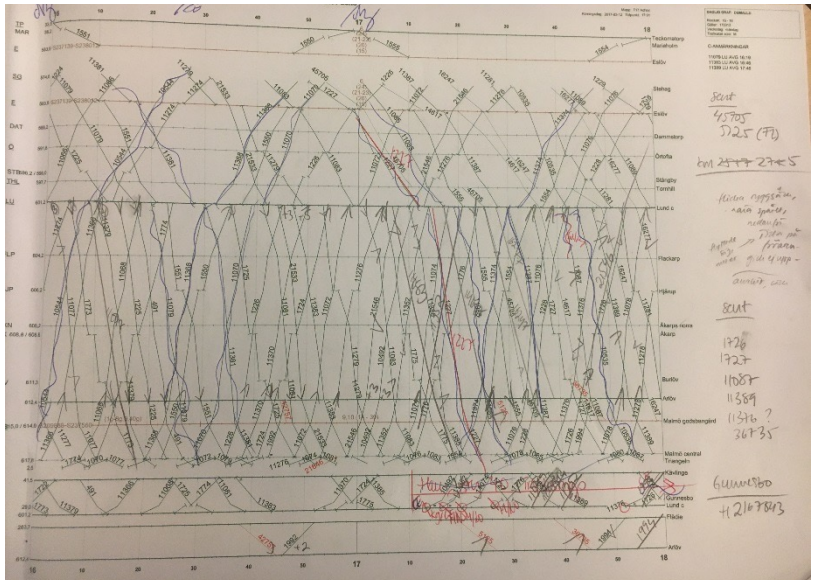
- Choice of Micro/Meso/Macroscopic
- Track and platform length restrictions
- Trains' running times and speed profiles
- Rescheduling objectives



State of the practice

- Only very few examples of computer algorithms for rescheduling
  - ❑ Regional lines in Italy (2011- ongoing).
  - ❑ Certain lines in Latvia (2017-ongoing).
  - ❑ A system in greater Oslo area (not in operation yet).

- In Sweden, disturbances are handled…



Source: Trafikverket. Permission to be used was given by Sandra Stefanovic, sektionschef vid tågtrafikledningen/DLC Malmö in Oct 23rd, 2017.

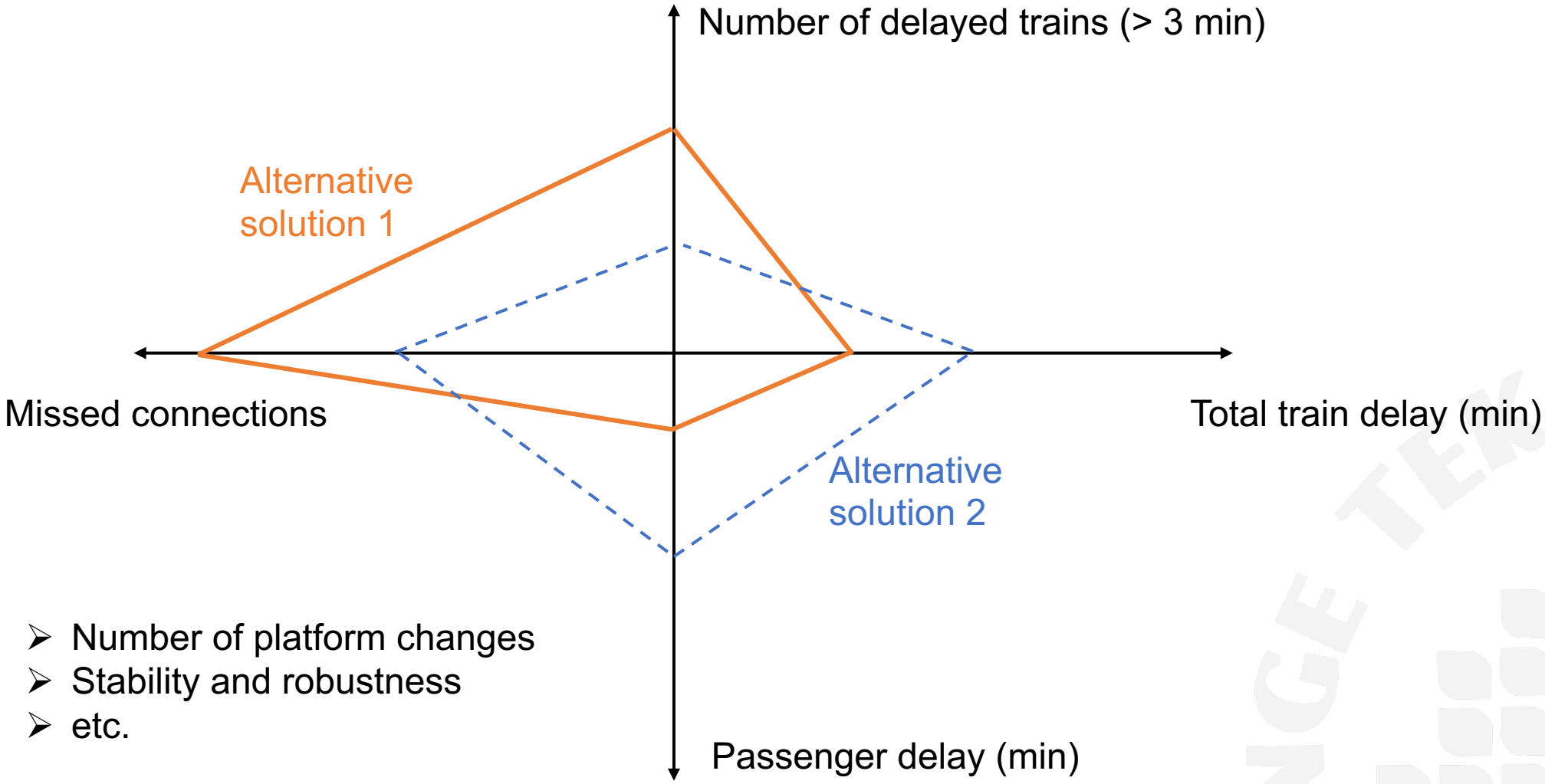
Research need: Evaluating algorithms

A wide range of solution approaches:

- Local rules and conflict resolution principles (e.g., FCFS)
- Various mathematical formulations solved with exact methods (e.g., using commercial solvers)
- Problem decomposition techniques:
  - Decomposition in time, e.g., a rolling-time horizon
  - Decomposition in space, e.g., making the decisions at different levels and solving iteratively.
- Algorithmic approaches, including a combination of above.

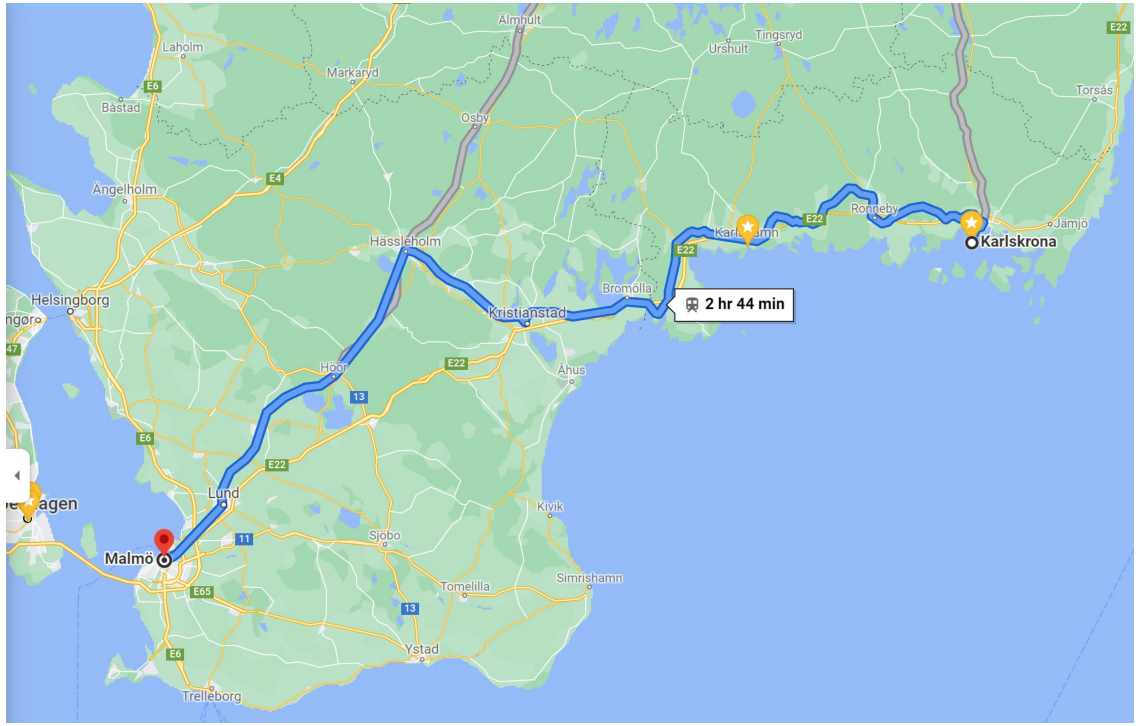
All approaches have their own strengths and limitations!

Research need: To identify objectives and KPIs



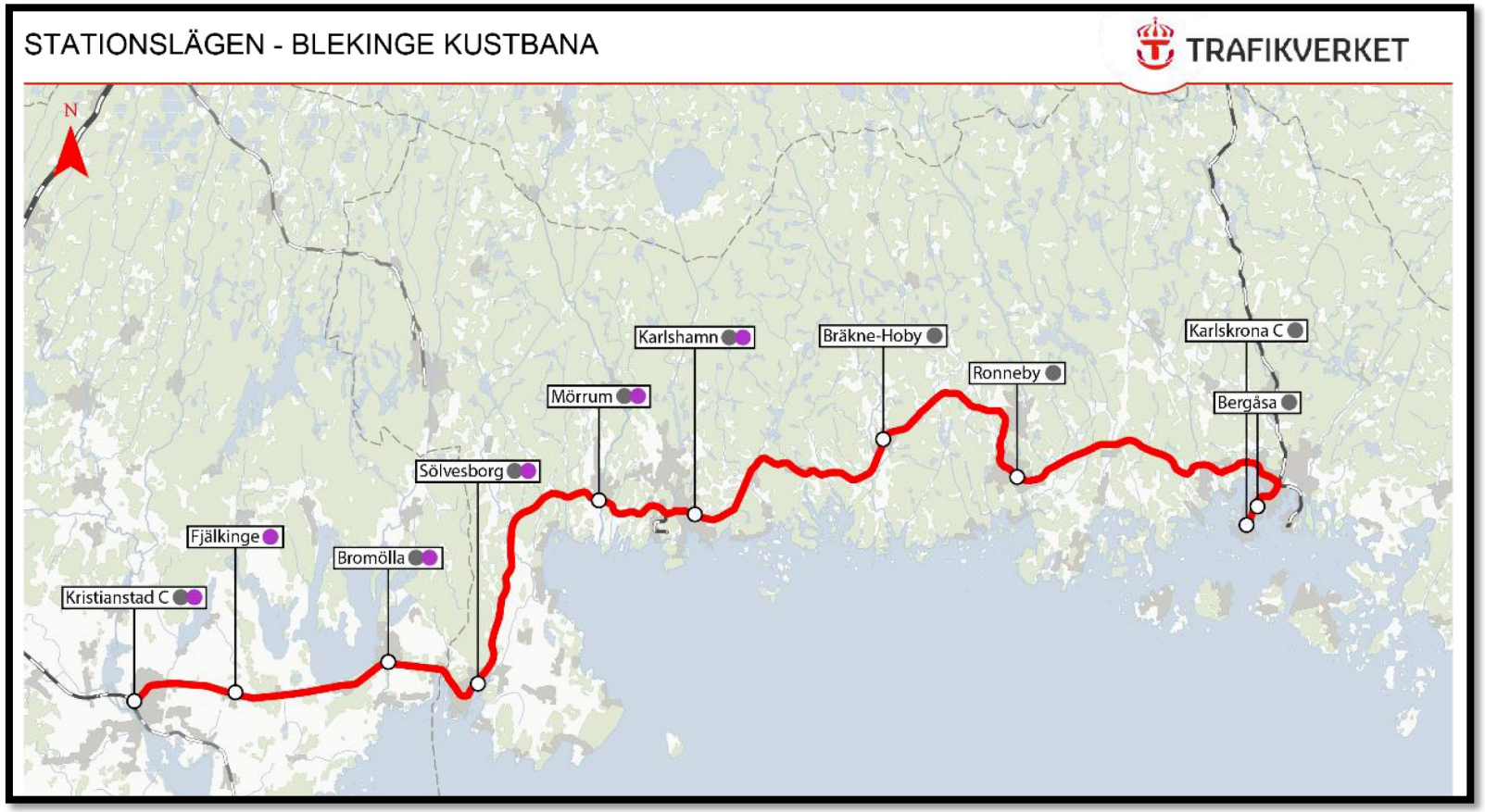
- Number of platform changes
- Stability and robustness
- etc.

Results and conclusions from a Swedish case study



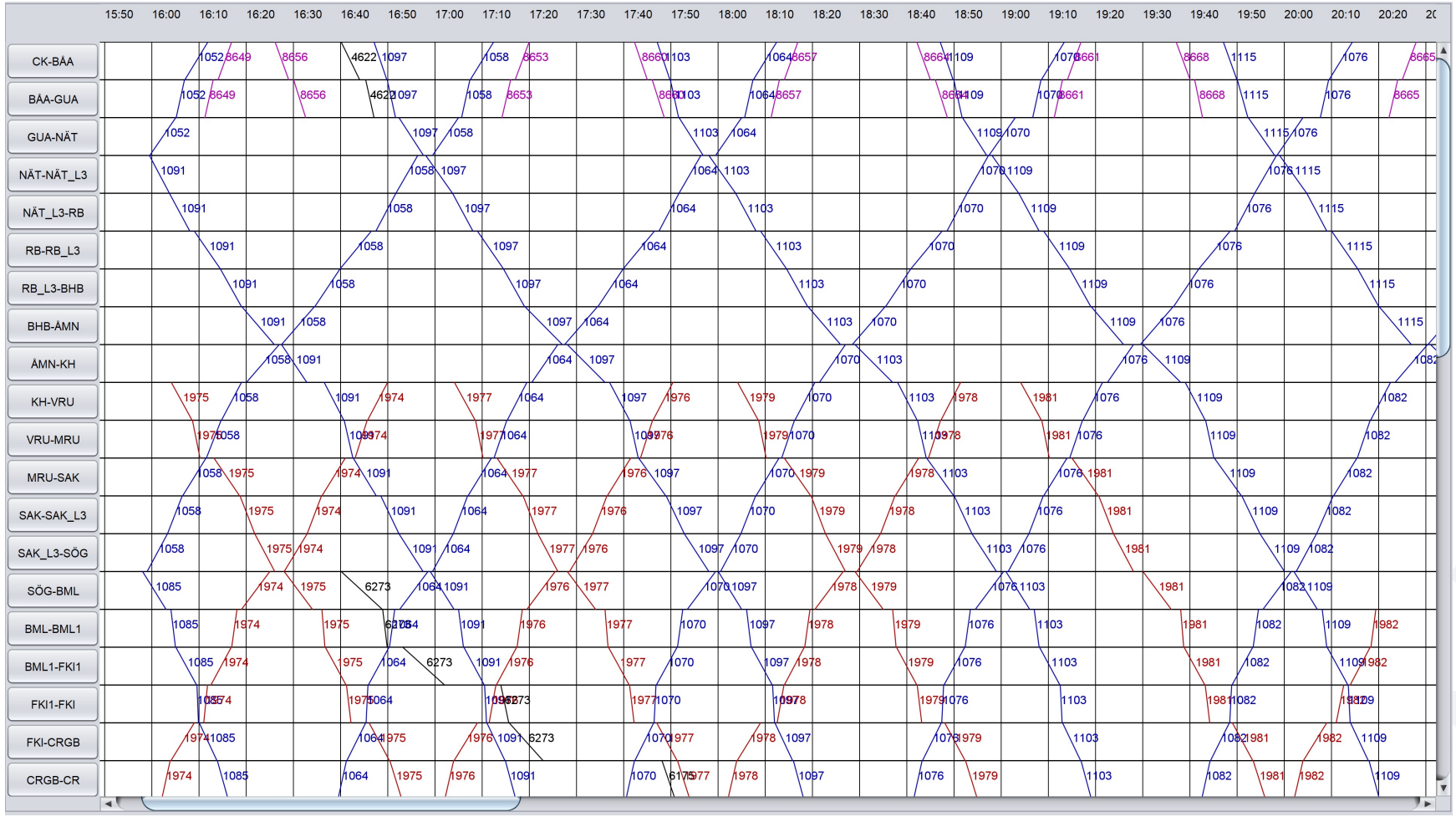
- The railway stretch between Karlskrona–Malmö, via Kristianstad and Hässleholm
- 90 sections, 42 stations
- Mixed traffic: Regional passenger trains, freight trains, long-distance passenger trains

Blekinge Kustbana



Source: Page 10 of the document *Blekinge kustbana, fördjupad utredning för etapp 2* https://www.trafikverket.se/contentassets/a0a574ba8c6743bd87cd23febdd07a98/fordjupad_utredning_trafikverket_bkbe2_signerad.pdf

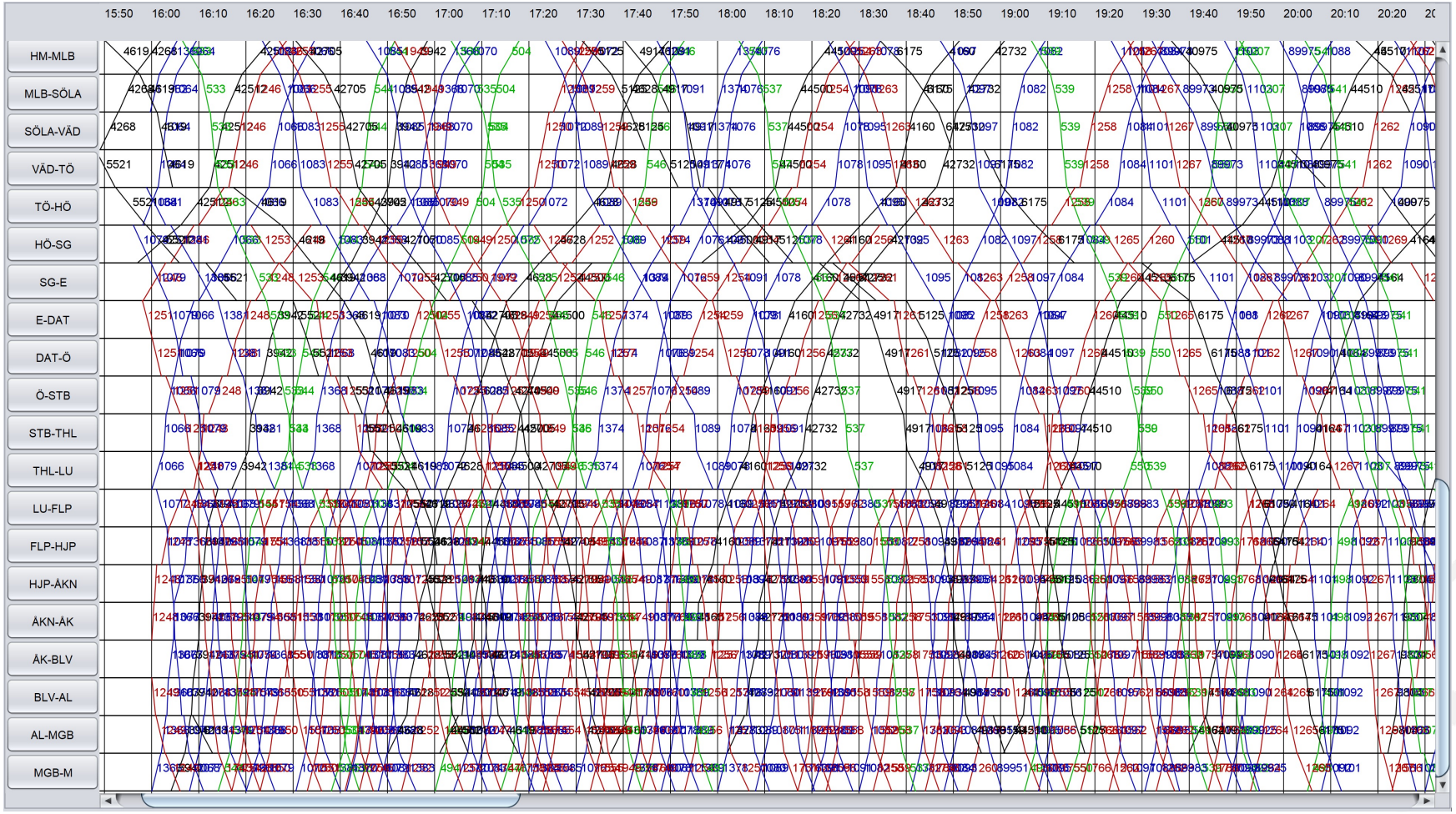
Train timetable



Timetable from Karlskrona to Kristianstad (4:00 PM to 9:00 PM)

- A calibrated version of the train timetable from October 2016 for a weekday.

Train timetable (contd.)



Timetable from Hässleholm to Malmö (4:00 PM to 9:00 PM)

- Currently operational timetable contains more traffic nowadays

An example rescheduling scenario

Trains	Disturbance location	Wall-clock time, Disturbed train	Initial delay	Potential conflicts	Extended runtime
107	Hässleholm:Mellby	5:40 PM, Westbound freight train	50% increase in its runtime	23	37 min

Solution	Total delay of trains at final stations
Rescheduling solution 1	55 min
Rescheduling solution 2	48 min

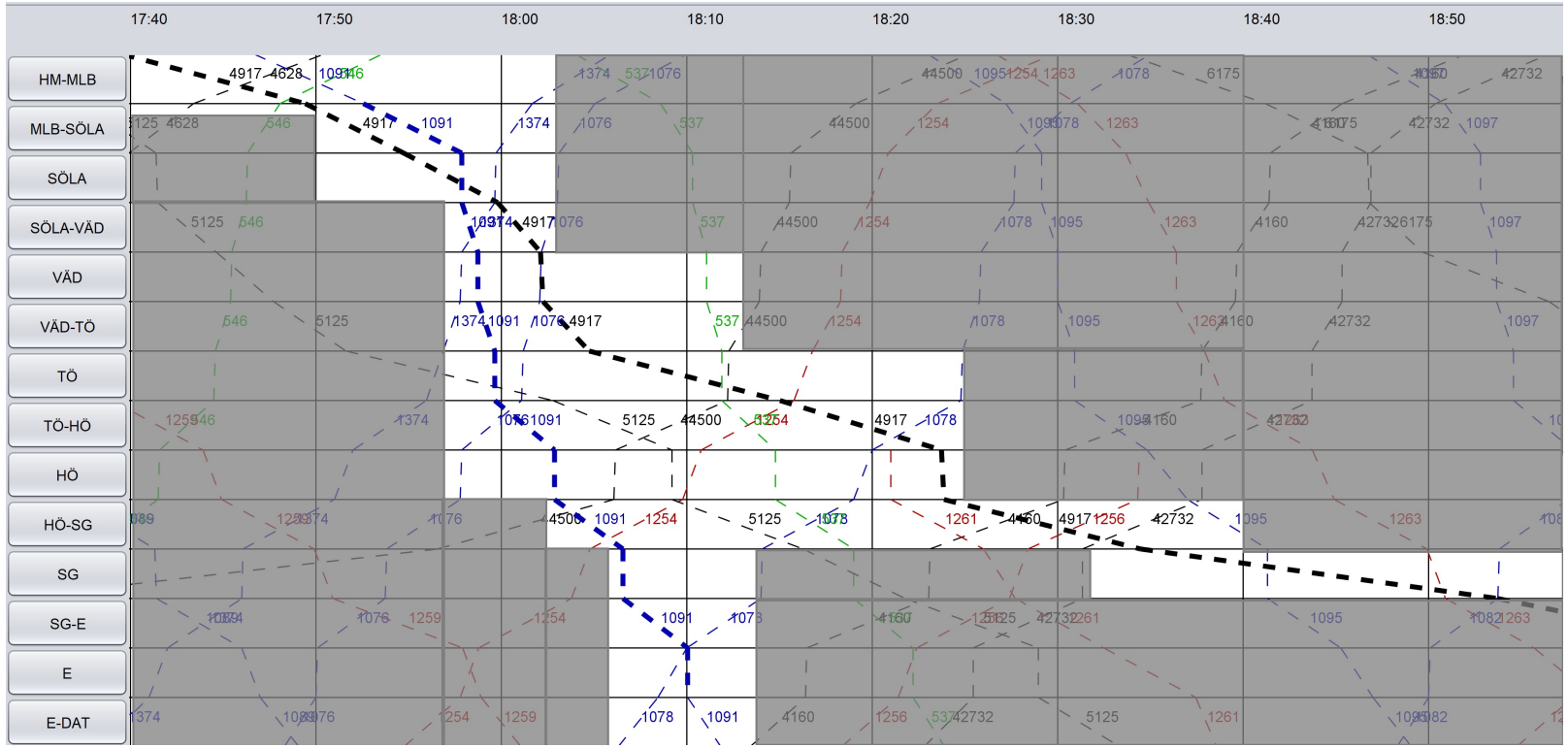
Solutions from our tailormade rescheduling algorithm

Q) How can the numerical and visual analysis of the solutions be beneficial?

Solution	Total delay of trains at final stations	Trains with secondary delay	Platform track reassignments
Rescheduling solution 1	55 min	1	1
Rescheduling solution 2	48 min	3	0

An example rescheduling scenario

Trains	Disturbance location	Wall-clock time, Disturbed train (remaining events)	Initial delay	Potential conflicts	Extended runtime
107	Hässleholm:Mellby	5:40 PM, Westbound freight train 4917 (35 events)	50% increase in its runtime	23	37 min

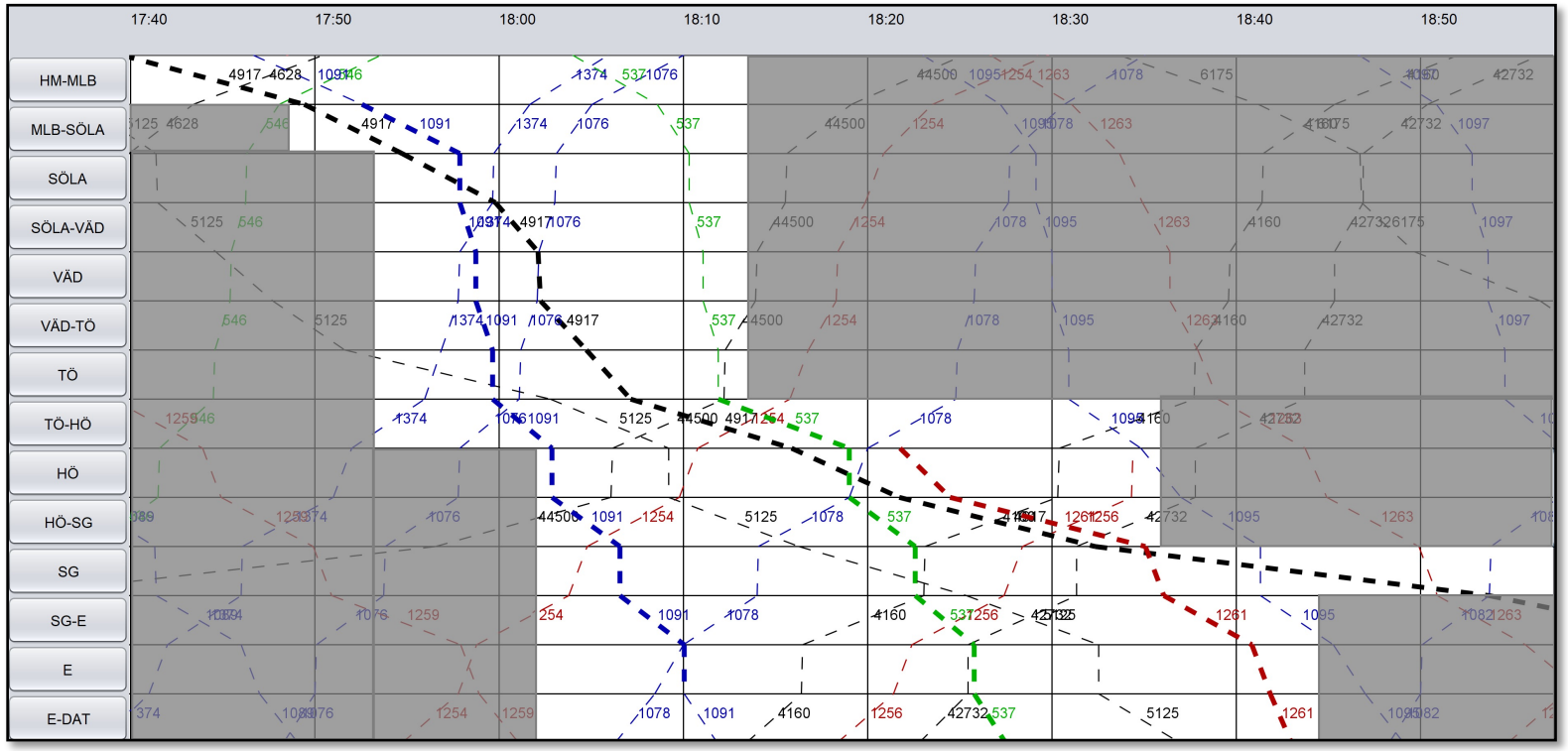


Total final delay = 55 min, Number of trains with a secondary delay = 1

In the algorithm's rescheduled timetable:

- only the initially disturbed freight train experiences a delay at its final station.

An example rescheduling scenario (contd.)



An alternative solution found by the algorithm:

- A smaller total final delay at stations,
- But three trains with secondary delays in their route.

Algorithm's main solution	Algorithm's alternative solution
(55 min, 1 train)	(48 min, 3 trains)

- **Which alternative to prefer over the other and why?**
- **What other KPIs are important to consider?**

Some conclusions

- Numerical evaluation of rescheduled timetables using various KPIs is important (we proposed an evaluation framework)
- Different algorithms may be suitable for different types of disturbances (we evaluated an exact algorithm and a tailormade algorithm)
- Possible to increase the modelling detail while retaining the algorithm's speed (we increased the detail of problem model)
- Possible for the dispatcher and the algorithm to complement each other (to quickly find the best rescheduled timetables)

Thank you for the attention

Questions and Discussion