”BLIXTEN”

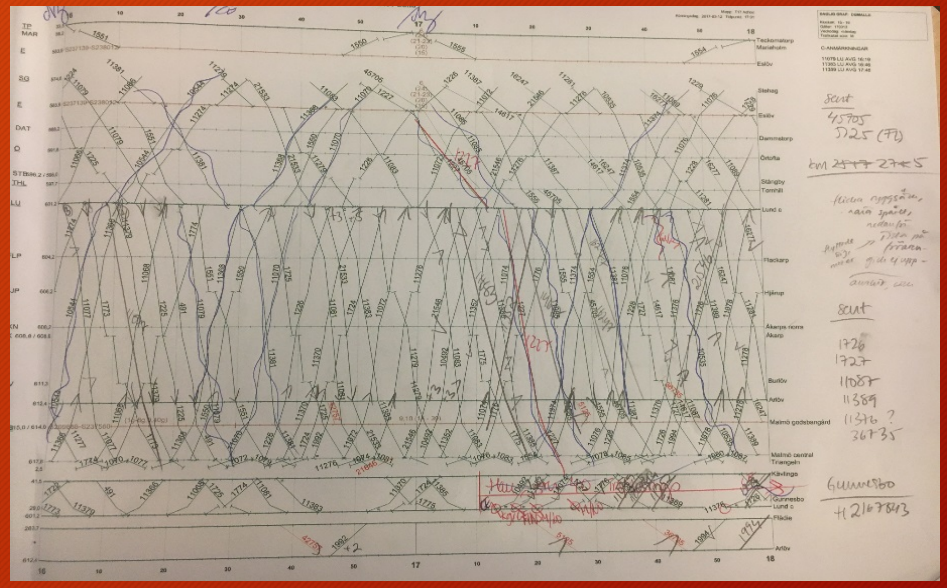
a pre-study Februry 2018-January 2019

Beslutstöd för trafik**L**edare: approx**I**mativa och e**X**akta op**T**im**E**ra**N**de metoder

A continuation of the research project ”FLOAT”

Project group at BTH: Johanna Törnquist Krasemann & Omid Gholami

Main contact person at Trafikverket: Göran Eskérs



Källa: Trafikverket, används med tillstånd från Sandra Stefanovic, sektionschef vid tågtrafikledningen/DLC i Malmö.

Purpose and objectives

The main purpose of the research is to:

1. Build on previous research in FLOAT, while considering more practical aspects regarding the development and application of optimization-based computational support for Swedish real-time train dispatching during minor disturbances.

2. Increase cooperation with related projects within Trafikverket (i.e. NTL foremost) to enable a better knowledge transfer.

- Analyse state-of-the-art and state-of-practice.
- Analyse the Swedish perspective.
- Analyse methods developed in FLOAT and their applicability.
- Suggest future research directions.

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Analyzing process

- Objective based evaluation:
  - Summation of Trains' Final station Delays (TFD).
  - Number of Delayed Trains at the final station (NDT).
  - Summation of Trains' Delay at Commercial stops for passenger trains (TDC).
  - Number of Trains' Delay at Commercial stops for passenger trains (NDC).
  - Number of Changes in the Platform assignment (NCP).
  - Number of passenger Trains with time Alteration at commercial stops (NTA).
  - Trains' Maximum Delay on commercial stops (TMD).
  - Time to return the service to a Normal Operation (TNO).

Private operators, Passengers, Trafikverket.

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Analyzing process…

- Event based evaluation:
  - The **punctuality** is defined as the summation of departure delays at stations during a specified period.
  - **Regularity** defines the service periodic behavior.
  - The **resilience** measures a schedule's ability to absorb the possible perturbation.
  - **Journey plan** is the average travel time between two places.
  - An **interchange time** is defined as the amount of time available for passengers to get off a train and get on the next train at connection points.
  - **Resource usage** is the average or total number of trains passing a point during a specified period.

Disturbance scenarios

- Category 1 refers to that a train suffers from a temporary delay at one particular section, and it can occur due to, e.g., delayed train staff, or crowding at platforms resulting in increasing dwell times at stations.
- Category 2 refers to that a train has a permanent malfunction resulting in increased running times on all line sections it is planned to occupy.
- Category 3 refers to an infrastructure failure causing, e.g., a speed reduction on a particular section, which results in increased running times for all trains running through that section.

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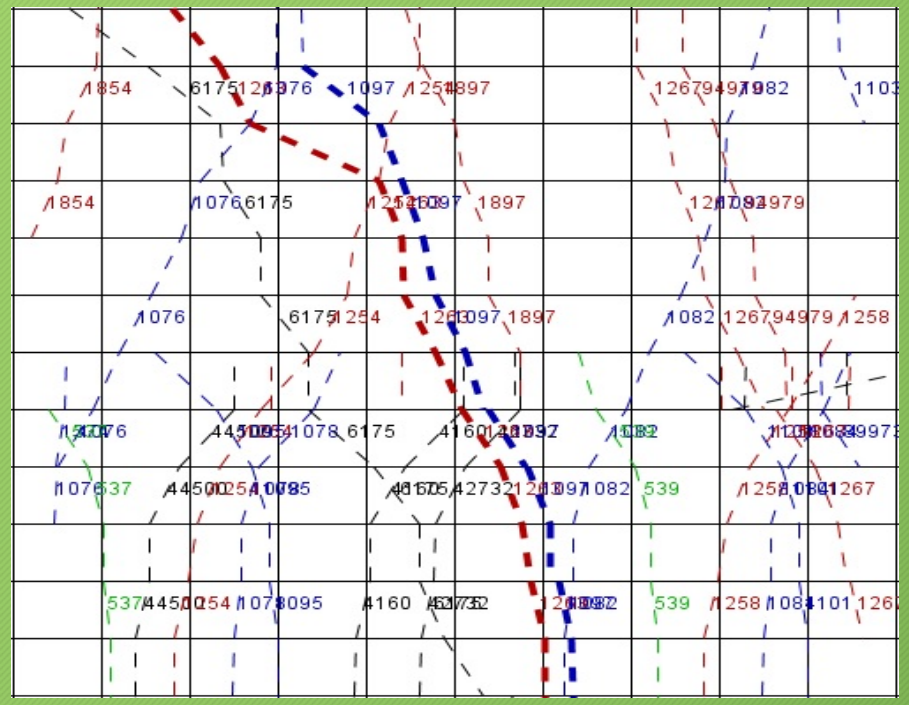
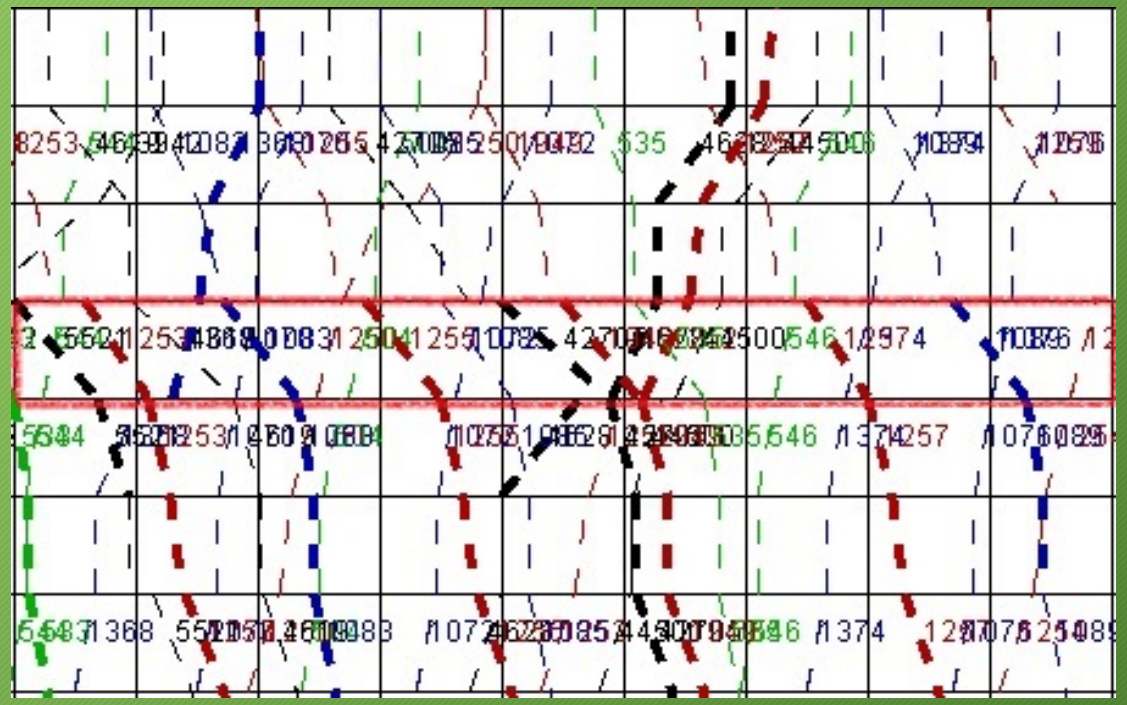
The platform

- We defined a benchmark from Swedish railway network (Karlskrona city center, to the Malmo).
  - From Karlskrona centre to Hassleholn the network is single-track.
  - From Hasslehol to Arlov the network is double-track.
  - From Arlov to Malmo four parallel tracks are available.
- The disturbance scenarios happen to trains scheduled between 16:00 and 18:00 which is a peak traffic time.
  - The time windows are 60 and 90 minutes.
- The number of running trains in the benchmark file is 237.
- The number of block request for those trains is around 2000.
- The number of railroad sections is 90.
- The number of blocks is 290.
- More than 40 stations.

Supporting content





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2. More delay goes first
3. Less real buffer time goes first.
4. Less programmed buffer time goes first.
5. Less total buffer goes first
6. Less total processing time

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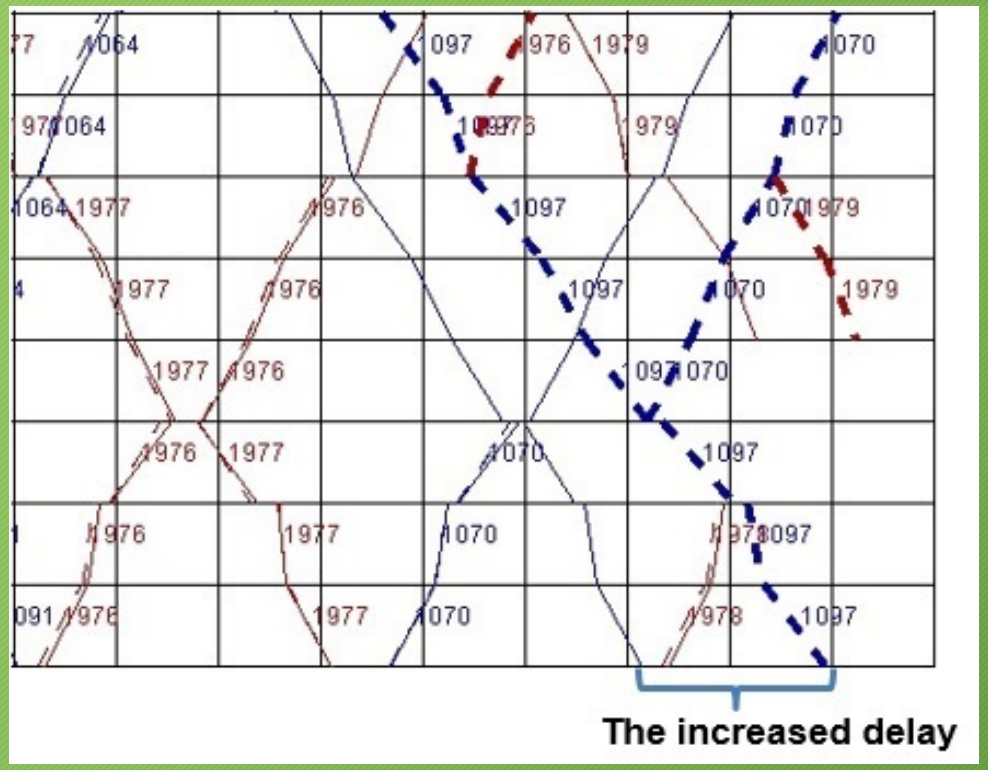

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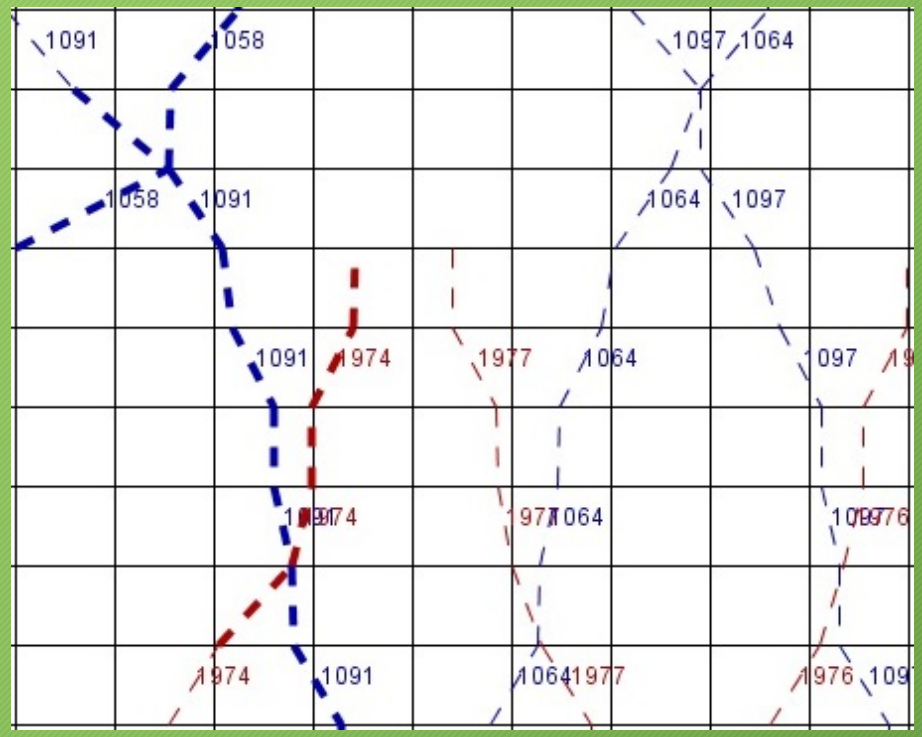

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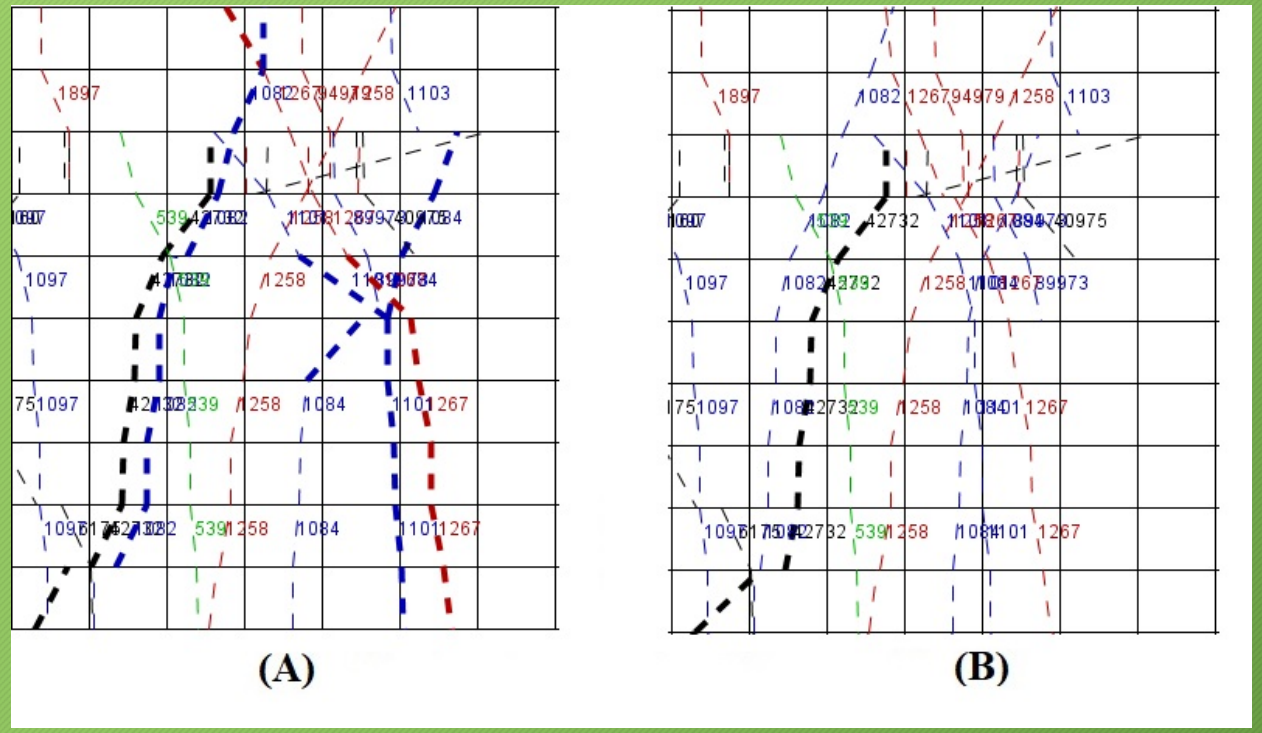

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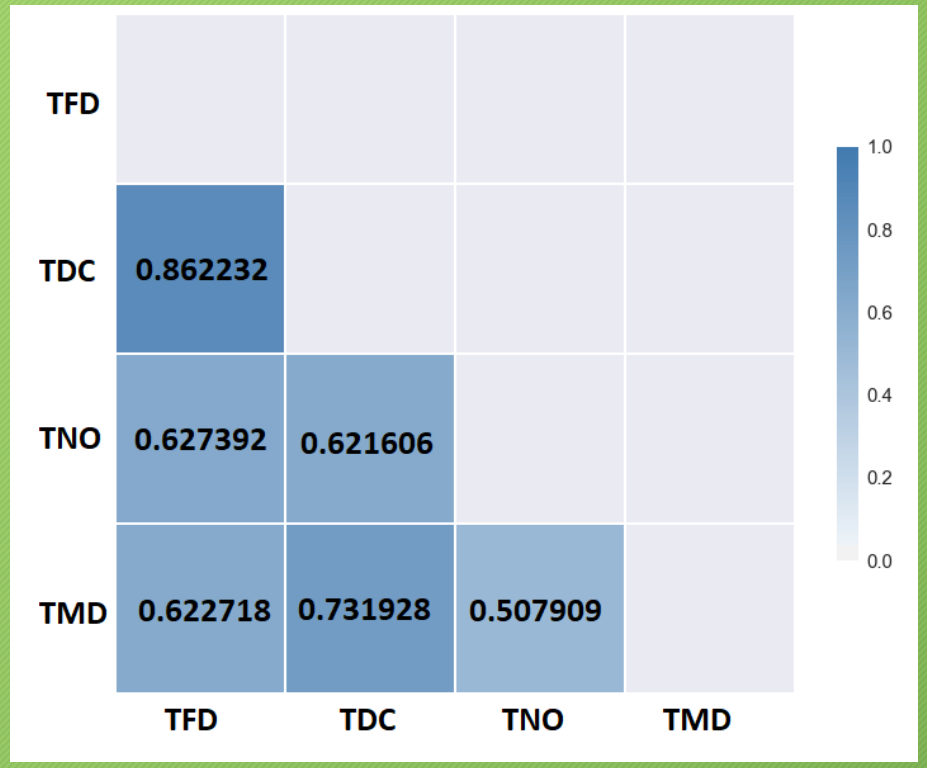
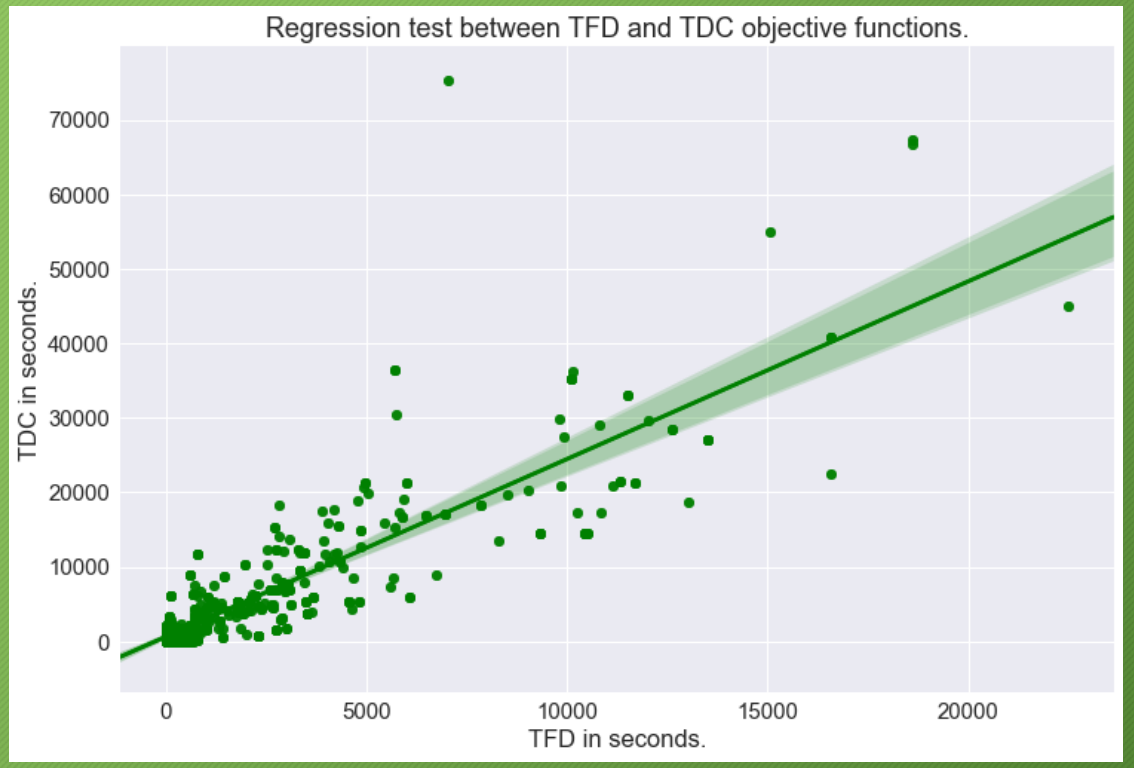
Correlation Test Between Objectives





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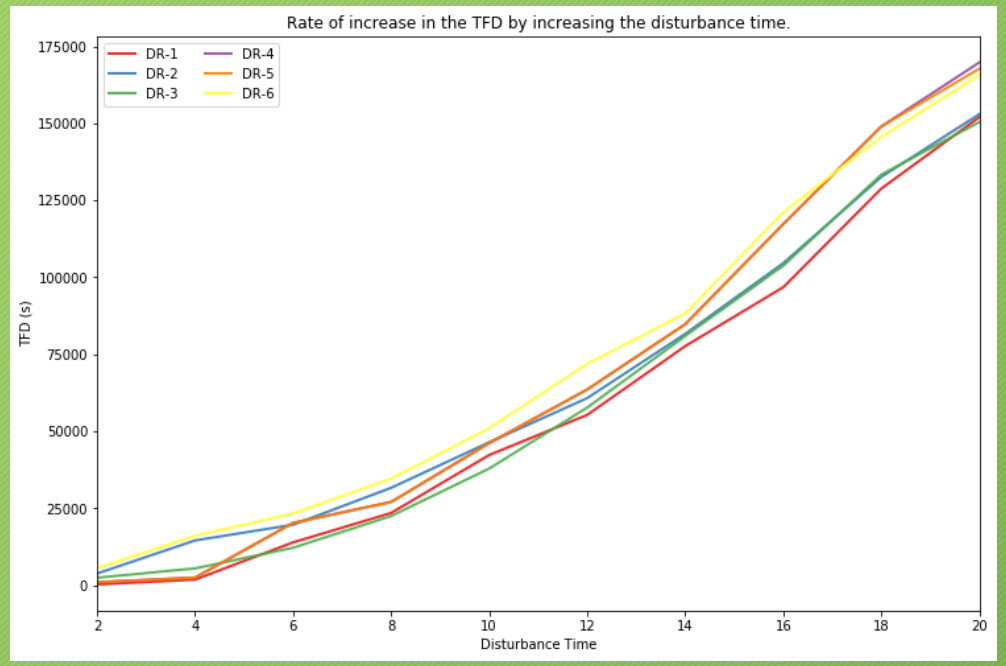
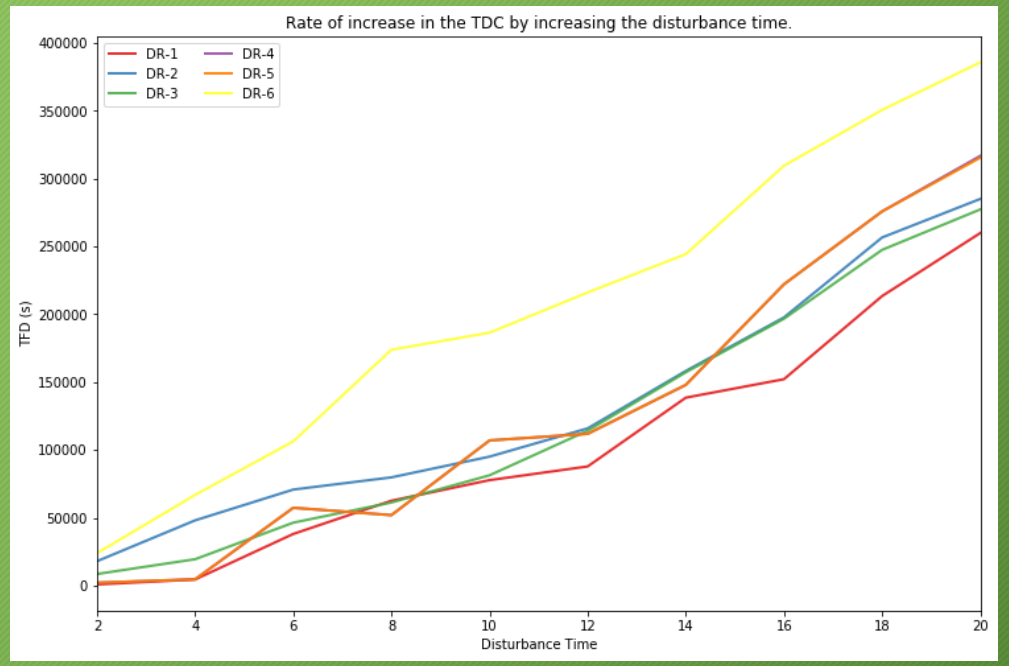
3. Trains' Maximum Delay on commercial stops (TMD).
4. Time to return the service to a Normal Operation (TNO).

Disturbance Time Increase Side-effects





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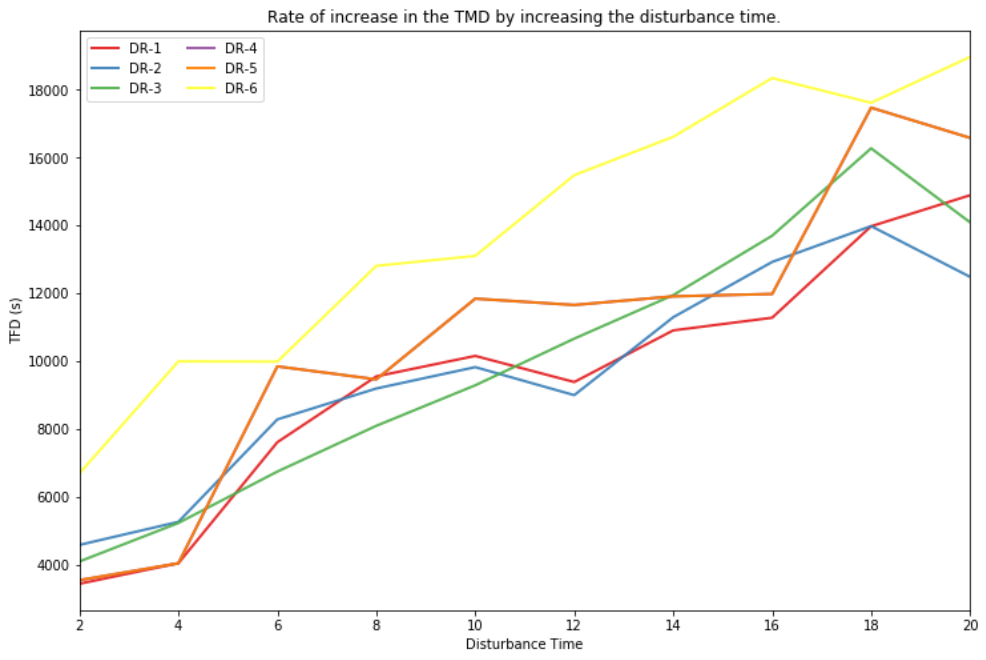

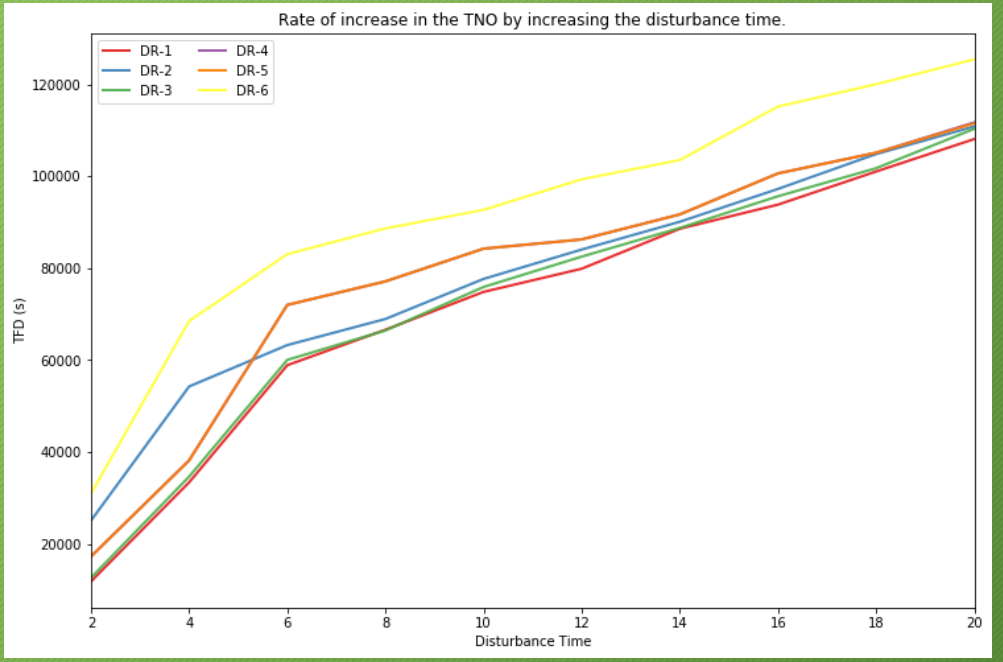

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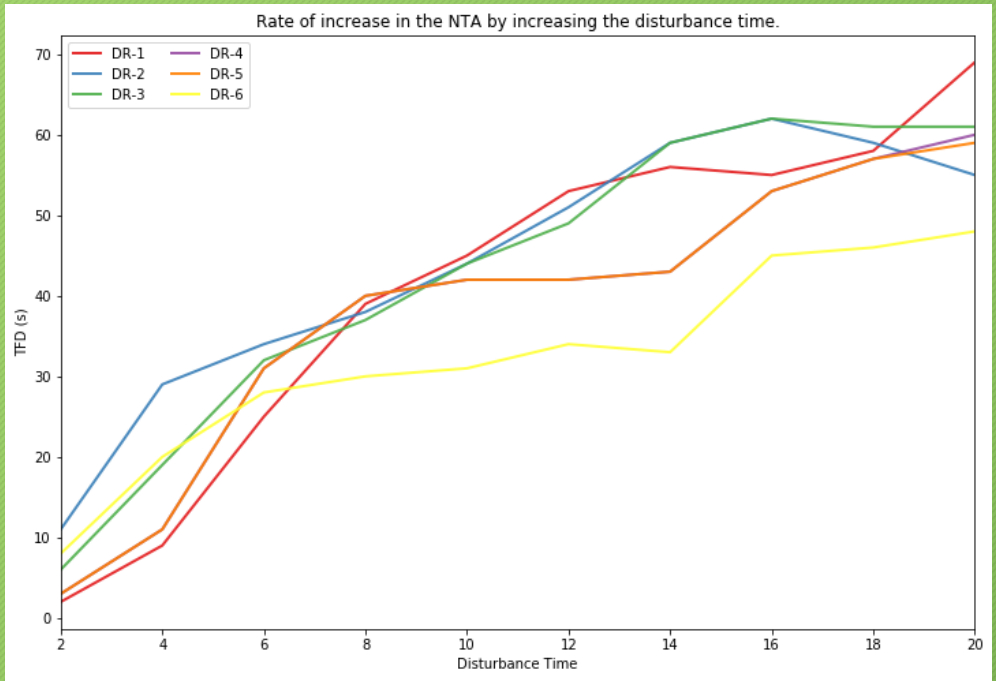

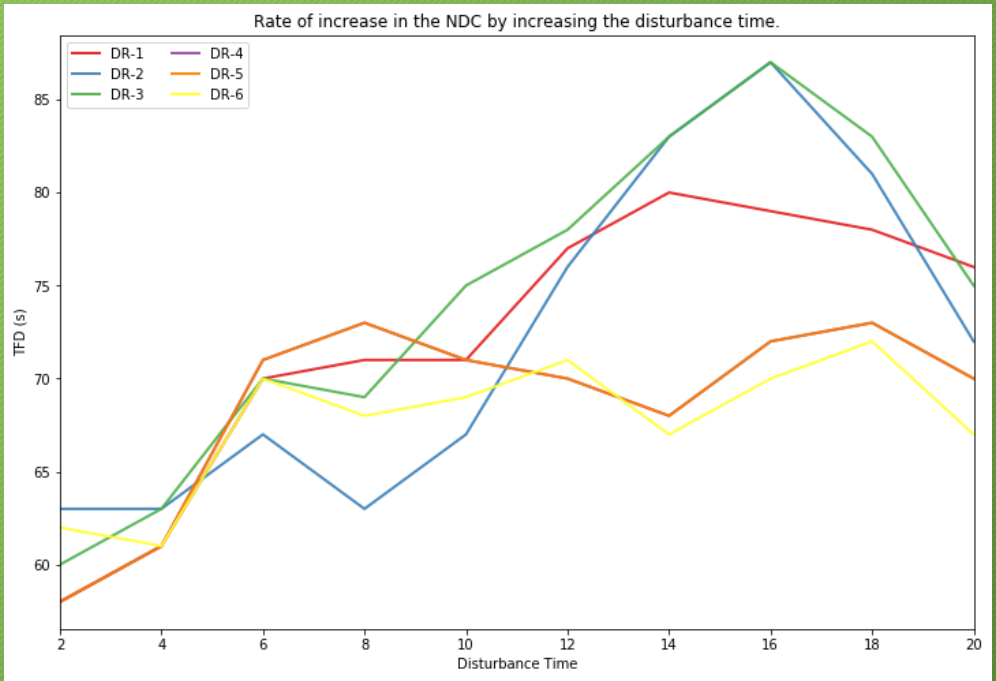

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Conclusion

- Different types of disturbances need different attention. A one to all approach is not a good idea.
- The side-effects of disturbances are predictable and manageable.
- There is a correlation between different objectives which can be considered in optimization.

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Thank you!

Questions?

Project-related publications so far:

- Gholami, O., Törnquist Krasemann, J. (2018) "An Investigation of a Rule-Based Train Re-scheduling Approach for Disturbance Management", Accepted abstract, EURO/ALIO, June 25-27, Bologna, 2018.
- Gholami, O., Törnquist Krasemann, J. (2018), "A Heuristic Approach to Solve the Train Traffic Re-scheduling Problem in Real-time" (to appear), *Algorithms* (special issue on "Algorithms for scheduling problems"), MDPI.
- Lamorgese, L., Mannino, C., Pacciarelli, D., & Törnquist Krasemann, J., (2018), *Train Dispatching*, In (eds.) Borndörfer, R., Klug, T., Lamorgese, L., Mannino, C., Reuther, M., Schlechte, T., *Handbook of Optimization in the Railway Industry*, International Series in Operations Research & Management Science 268, Springer, https://doi.org/10.1007/978-3-319-72153-8_12.

Future perspectives

- The time window for the re-scheduling process is unknown.
  - Predicting appropriate time window for re-scheduling.
  - or developing a dynamic graph which can grow until no running delayed train exist.

- Using the log files in TRAFIKVERKET system to use machine learning techniques for predicting a disturbance and getting ready before hand.
  - Reducing the side effects as much as possible by predicting and reacting earlier.

- Big potential analyzes are possible with the data gathered by TRAFIKVERKET.

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