Train on Line in Dutch Railway Operations

Comparing different configurations of a Centrally Guided Train Operation System

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Introduction

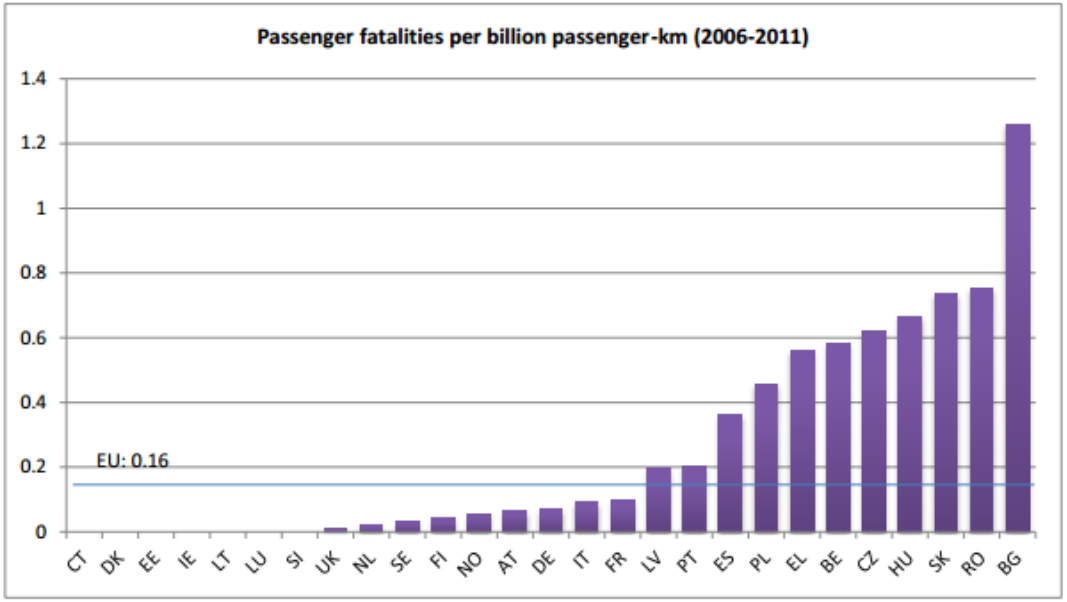
- The Dutch Railway Network
- Train on Line
- Problem description
- Simulation of driving and traffic control strategies in a Centrally Guided Train Operation System
- Simulated areas and disturbance levels
- Computational results
- Future research

The Dutch Railway Network

- ProRail owns the network of approx. 2,800 kilometres
- Netherlands Railways main passenger operator
- Well over 1 mln passengers per day
- Marketshare > 50% during peak hours in the urban area

Safety background

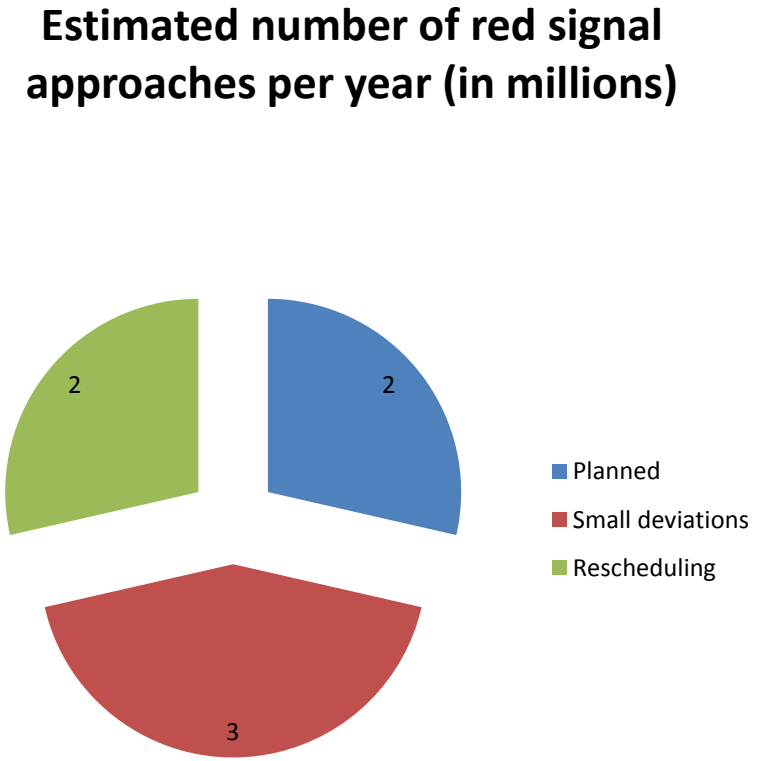
- Train operation in the Netherlands is one of the safest in the European Union:



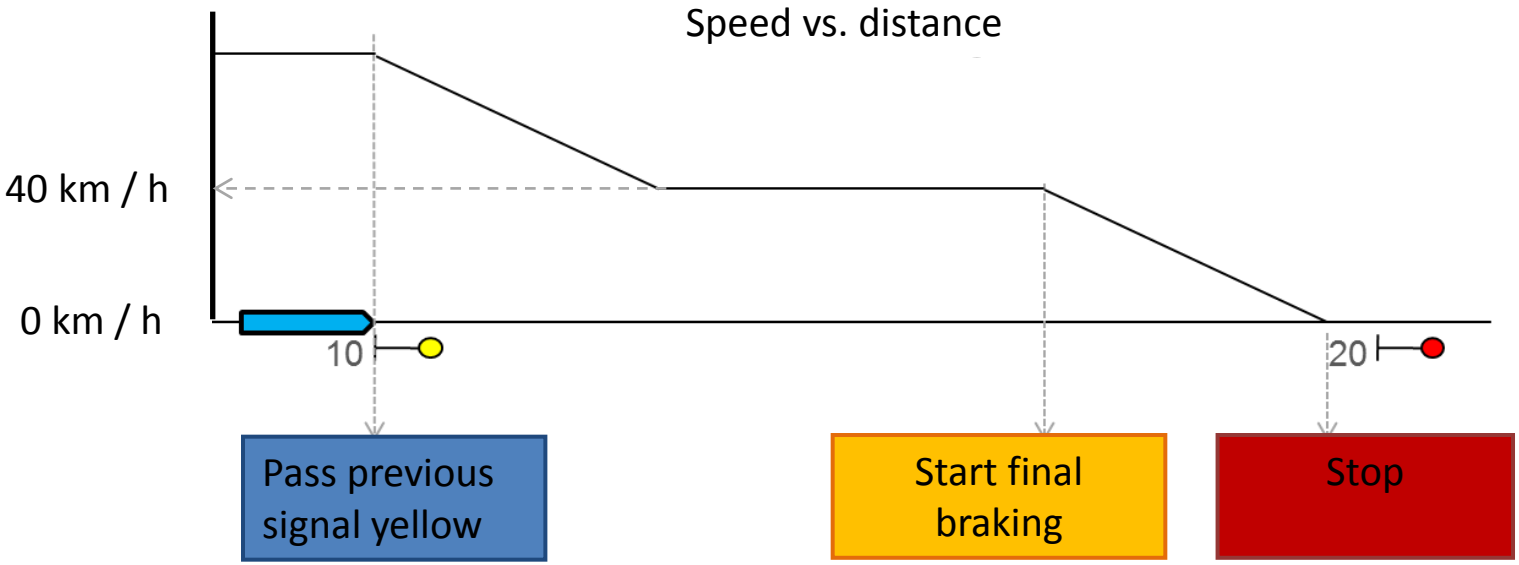
- Fatal accident near Amsterdam Central Station in 2012 emphasized safety as a top priority
- Programme installed to reduce the number of signals passed at danger (SPADs)
- Resulted in a 40% reduction in 2014 (49 in total in 2014)

Train on Line

- The right information for the drivers at the right time, to operate an unchanged timetable
- One of the measures of the SPAD Reduction Programme
- Goal: reduce exposure to red signals
- Step by step approach



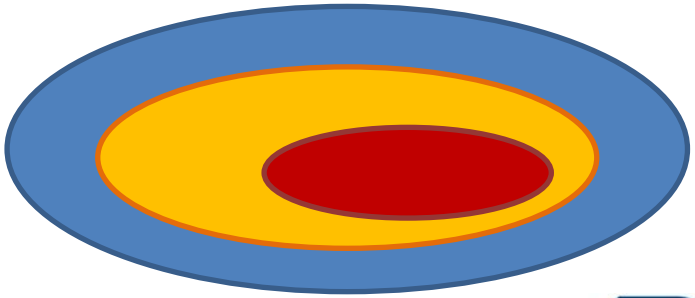
Approaching a red signal



Two types of stops:

1. Commercial stop: a published stop along platform track where passengers board and alight the train
2. Non-commercial stops: all others stops

The color of a signal might improve along the way:

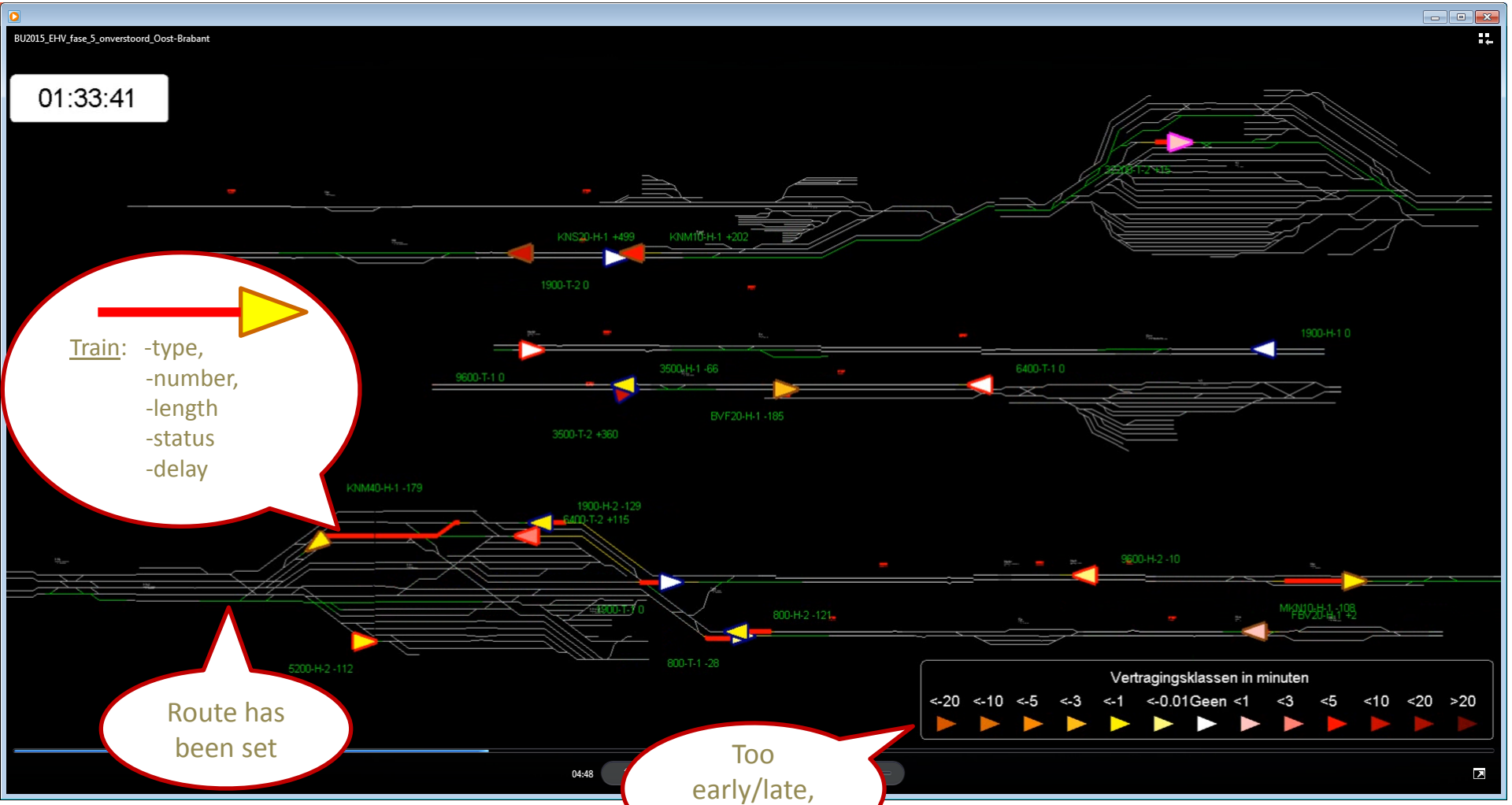


Simulation of a Centrally Guided Train Operation System (CGTOS)

- Goal is to improve safety
- Industry standard is focus on punctuality or energy efficiency

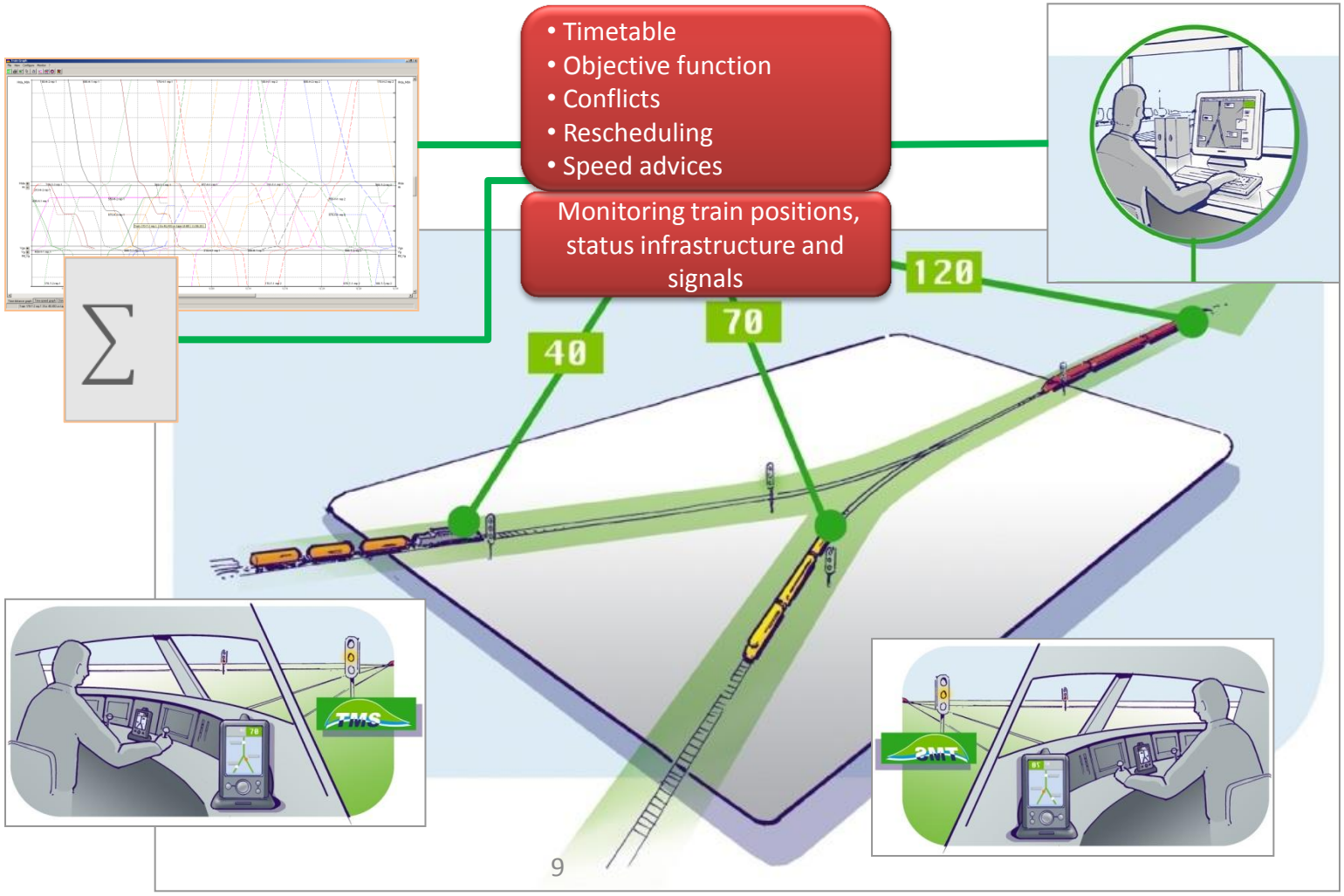
- ProRail and NS use Friso in combination with TMS (subject of the next couple of slides)

Flexible Rail Infra Simulation of Operations (FRISO)



TRAFFIC MANAGEMENT SYSTEM

HOW DOES IT WORK?



TRAFFIC MANAGEMENT SYSTEM

HOW DOES IT WORK?

Performance optimisation

- Predict conflicts
- Order change at intersections
- Adapt planned times
- Use of alternative routes [optional]
- Calculate optimal speed profiles

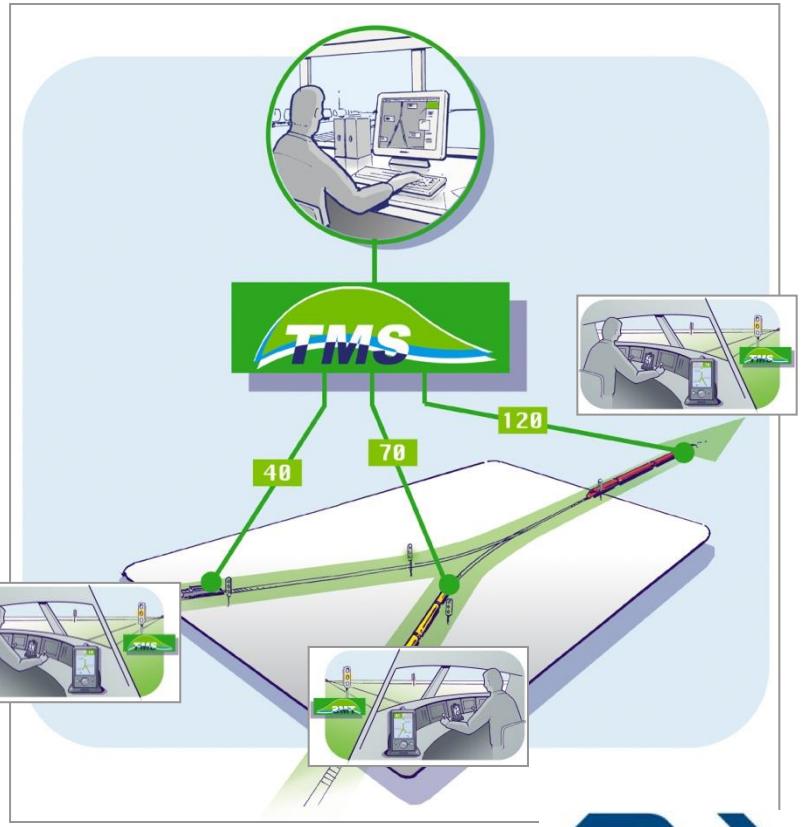
Continuously monitoring all trains in area

- Actual train positions and status of infrastructure

Route booking management

- Route assignment
- Setting times
- Update status

Communication to drivers and traffic control



Driving and traffic control strategies

1. Max Speed

   Drive as fast as possible. Here the train driver tries to drive at the maximum speed according to the safety system and the rolling stock.

2. Follow Plan

   Follow the planned timetable without speed advices. Depending on the delay, the train driver estimates a speed such that the next activity of the train will be executed in time, where the train should not drive unrealistically slow (at least 80% of the maximum speed).

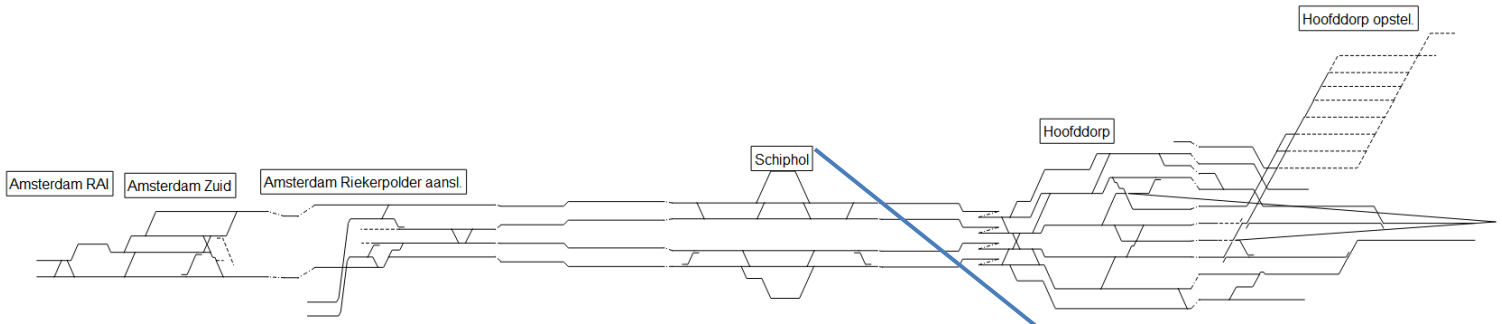
3. Advisory Speed

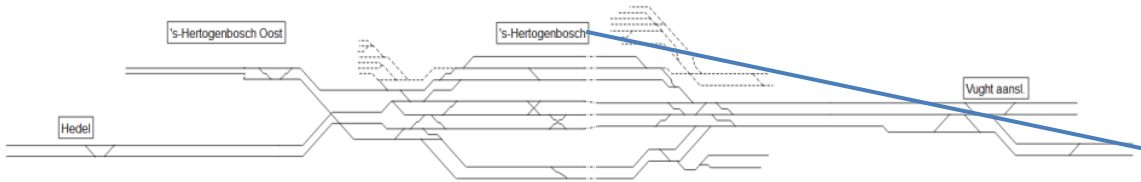
   Based on the current traffic situation in the whole area, including disturbances, TMS first calculates a new feasible plan. Followed by advisory speeds for all trains are calculated. TMS is allowed to use advisory speeds only (no changes in order of trains or in routes).

4. Limited CGTOS

   In addition to the Advisory Speed strategy, TMS now also controls route booking times and the order of trains.

Simulated areas



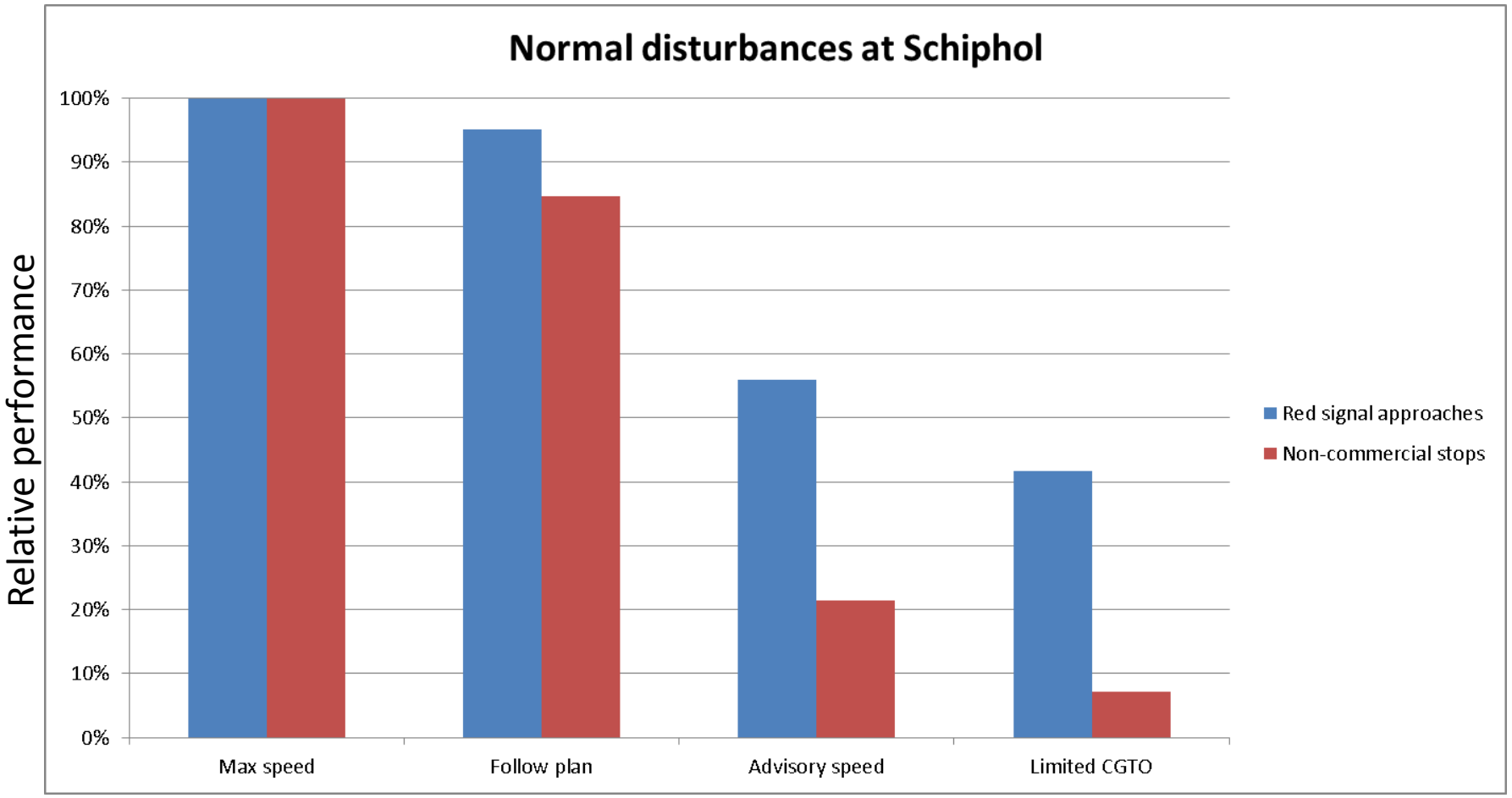


Area	# Platform tracks	# Trains per hour	Distance from border to station
Schiphol	6	42	9 km
Den Bosch	6	24	17 km

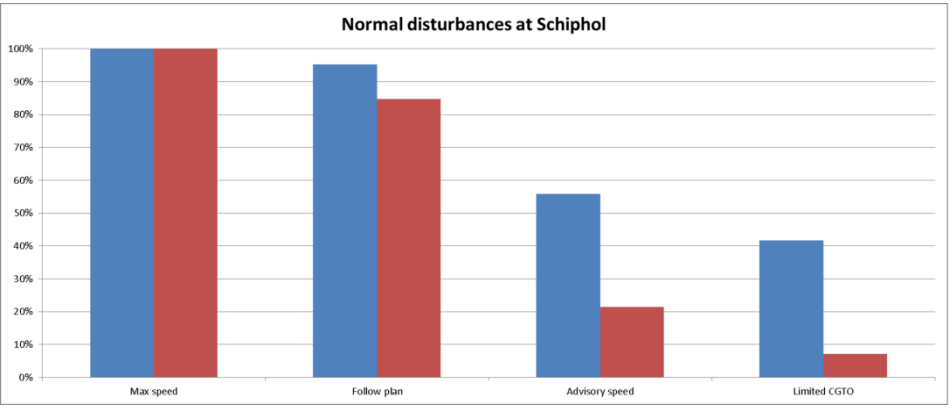
Set up of experiments

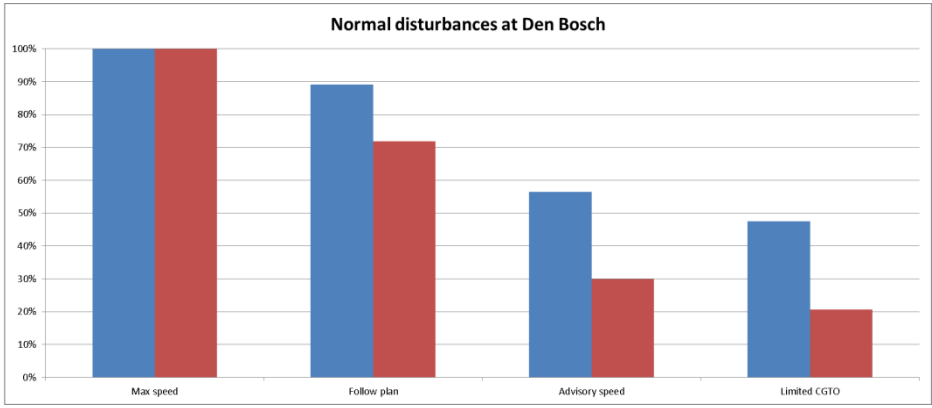
- Timetable: basic hourly pattern 2014
- Disturbances on entry times and dwell times
- Distributions of disturbances were fitted on realization data
- Within one scenario, trains receive the same disturbances in the 4 different strategies
- We ran 20 runs of 5 hours, where the first hour is used to warm up

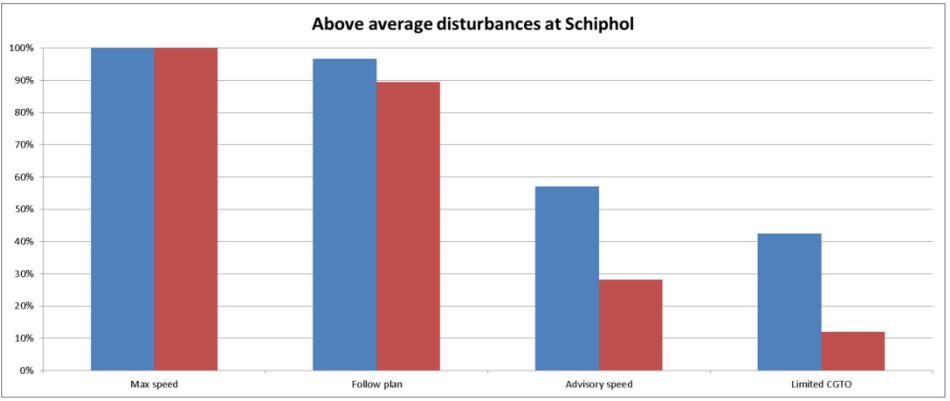
Simulation experiments

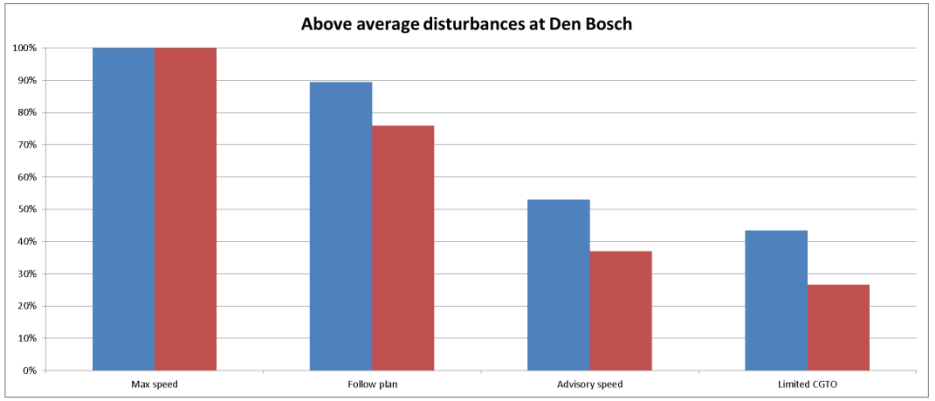


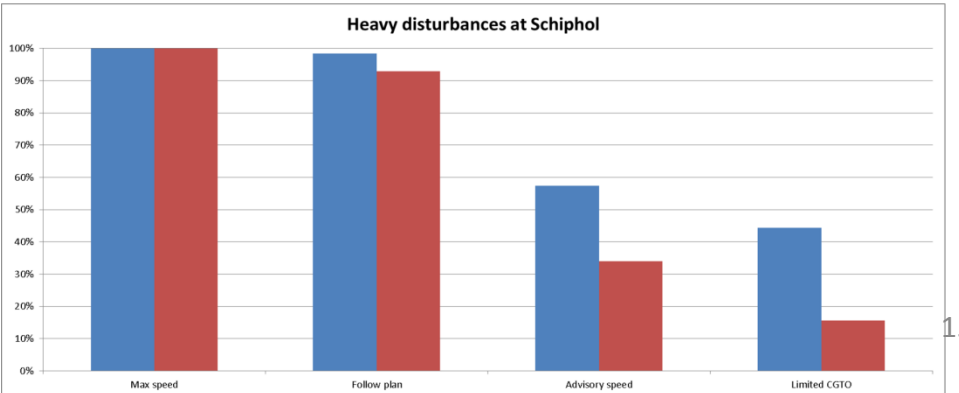
Computational results (red signal approaches in blue, non-commercial stops in red)

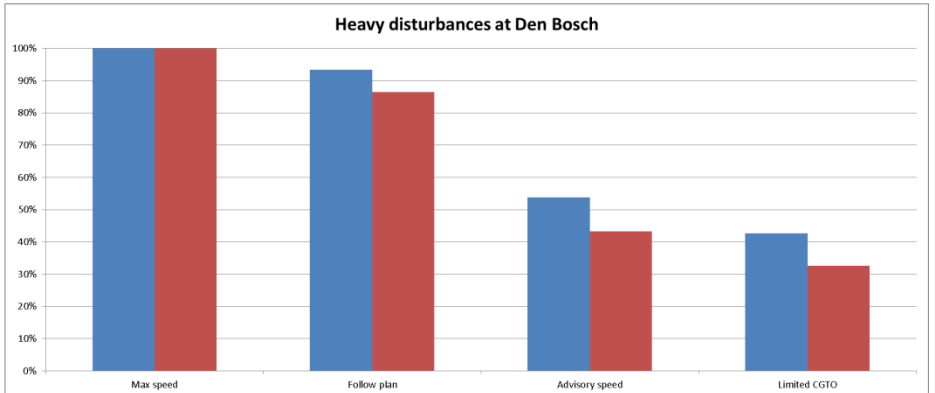












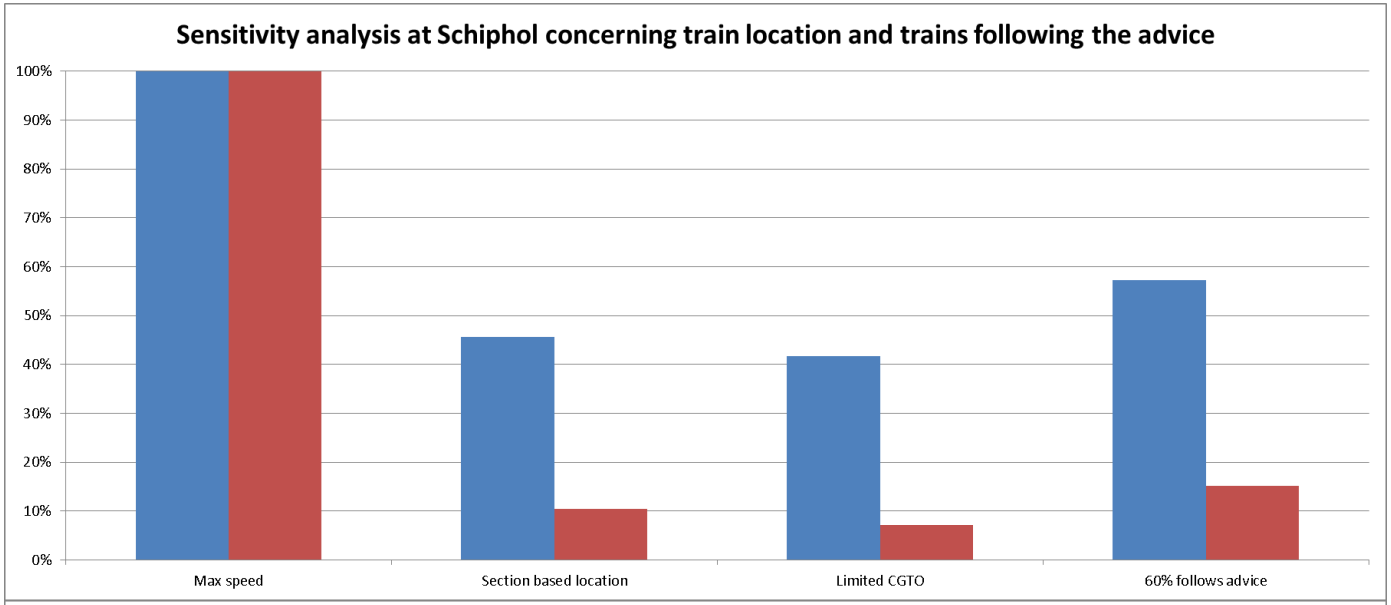
What does this mean?

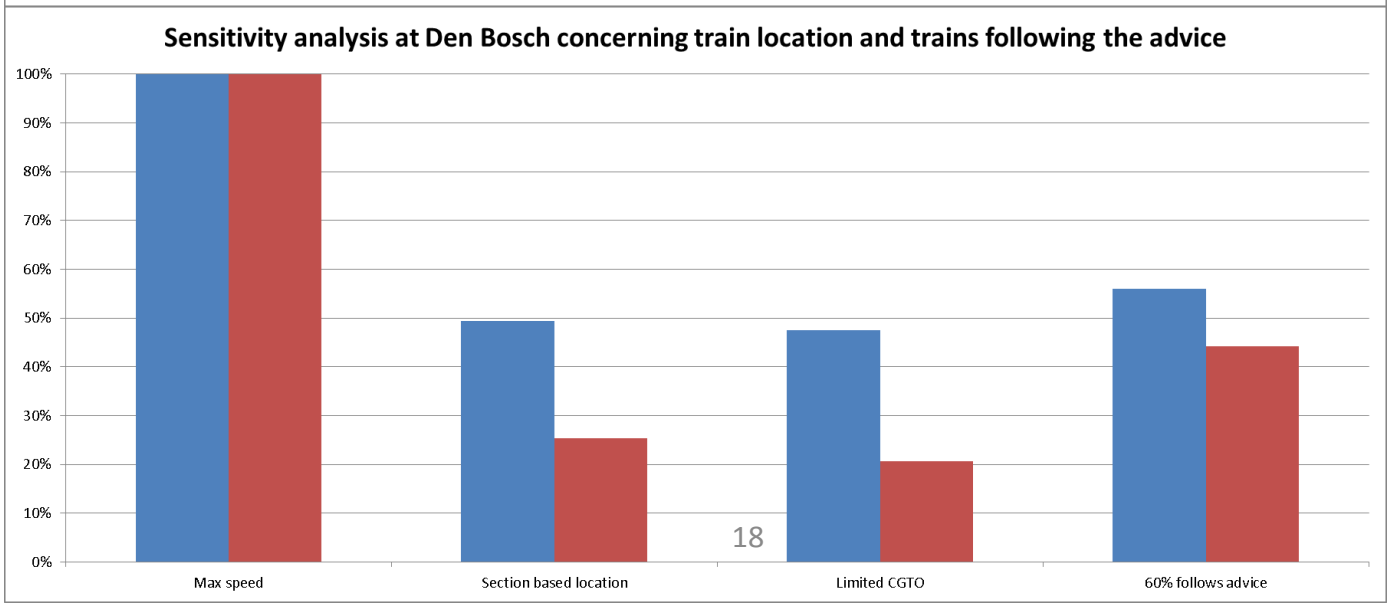
- The limited CGTOS performs well, with some additional potential if dispatchers are also allowed to change routes and orders of trains
- Advisory Speeds reap a large part of the benefits of the limited CGTOS
- Support for our approach to start with assisting train drivers, and focus on dispatchers later

Sensitivity analyses of control strategies

- Section based train position determination, where train positions are not given by a GPS, but by information from the safety system.
- 40% of the trains are not able to follow its given speed advice (which the CGTOS knows in this case). This scenario represents the situation where not all drivers use the advices

Sensitivity analyses





Red signal approaches

Non-commercial stops

Future research

- More refined implementation of the behaviour of the individual drivers
- Application at station Zwolle
- Incorporate other goals than safety in the CGTOS simulator
- Pilot stage: success factors for an implementation in practice as well as improvements on the CGTOS simulator

Thank you for your attention!

- Any questions or remarks?