Arrival time robustness of eco-driving strategies under two ATP systems

Jan Hoogenraad, Helen Willeboordse, Rob Goverde

27-9-2019

Content

- Background from two previous papers
- Research topics
- Driving after delayed trains for NS’54/ATB
- Driving after delayed trains for ETCS L2
- Benefits on the Dutch network
- Questions?

Previous paper 1: comparing ATPs

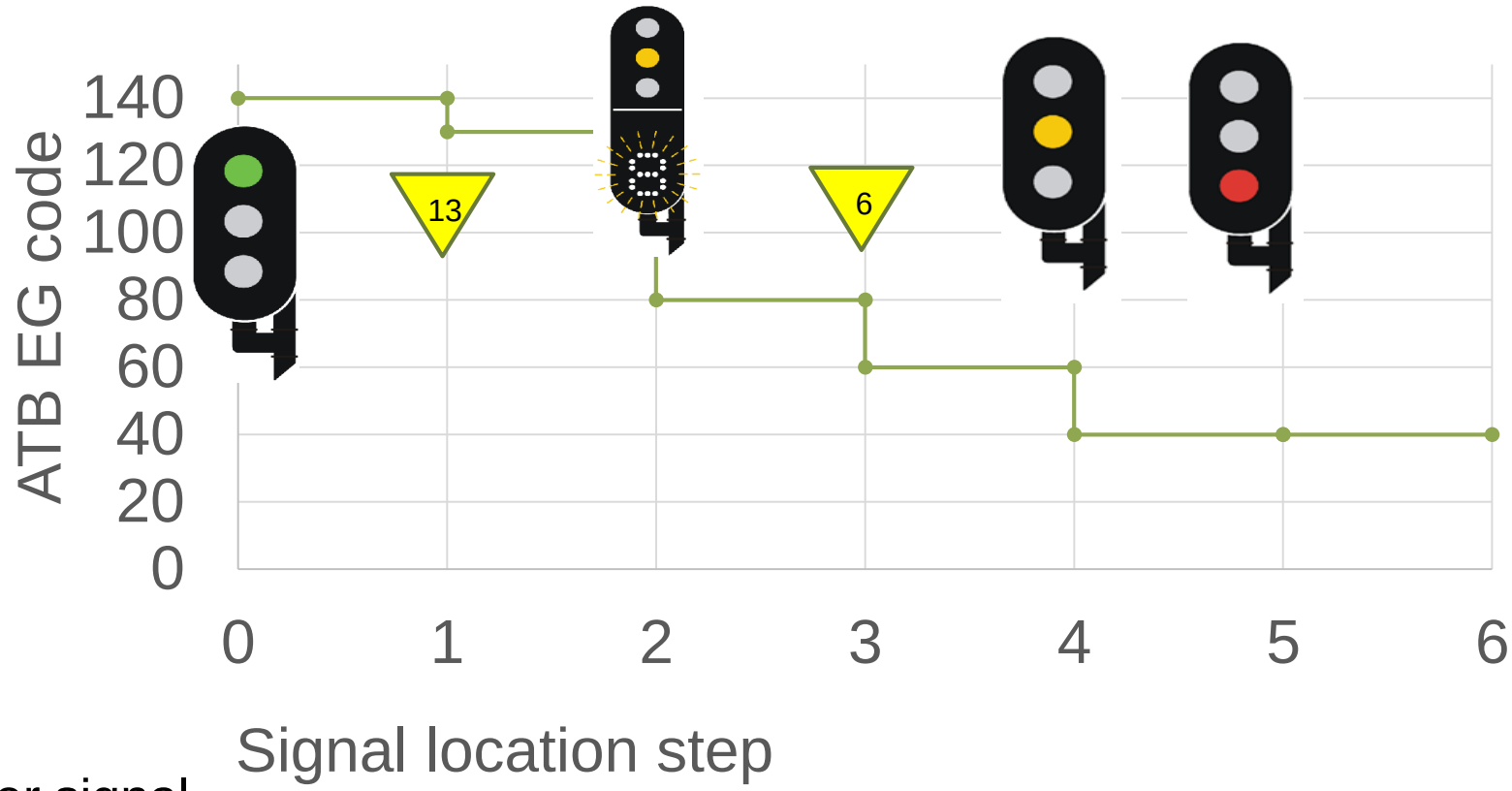
Paper: R. M. P. Goverde, F. Corman, and A. D'Ariano, "Railway line capacity consumption of different railway signalling systems under scheduled and disturbed conditions," Journal of Rail Transport Planning & Management, vol. 3, no. 3, pp. 78–94, 2013.

- Comparison NS'54/ATB and ETCS L2 with same block lengths & with shorter blocks
- Benefits ETCS L2, even on same blocks
  - higher capacity
  - quicker transport
    - Or energy savings
  - higher robustness

Parameter	NS'54/ATB	ETCS L2
Track occupancy	76.0%	63.1%
Running time SPR	00:14:50	00:14:30
Punctuality	82.7%	86.6%

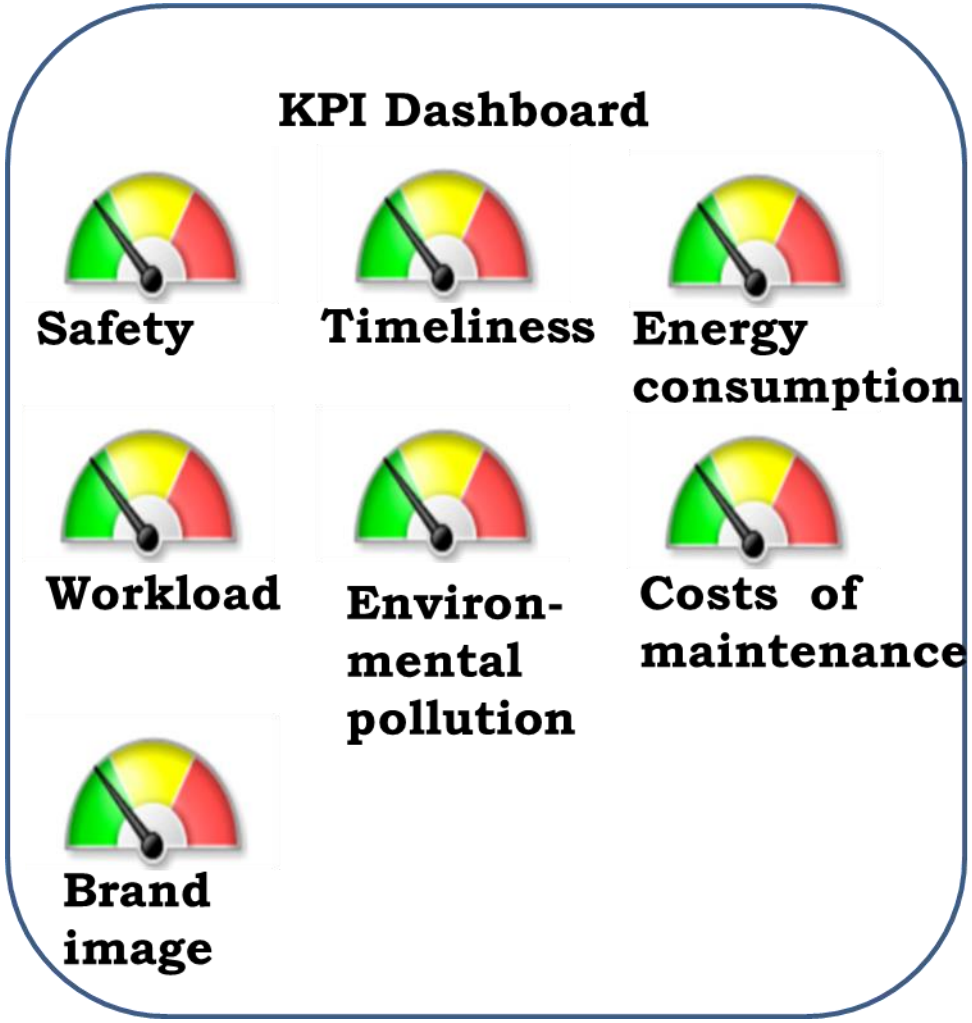
Previous paper 1: ATB-EG principles

- Like TVM-300 (F) and EVM(H)
- Code on track circuits
- Continuous
- 5 speed codes
- Supporting signals
- No distance data
- Braking enforced to next target speed
- On 90 % of network
- Separate protections danger signal



Previous paper 2: comparing driving strategies

- Paper: G. M. Scheepmaker, H. Y. Willeboordse, J. H. Hoogenraad, R. S. Luijt, and R. M. P. Goverde, “Comparing train driving strategies on multiple key performance indicators,” to be Published, 2019.
- Most scenario’s under ETCS L2
- For KPI Safety NS’54/ATB
- Limited to cases respecting headway
- Results for 4 driving strategies



Previous paper 2: (Eco-)driving strategies

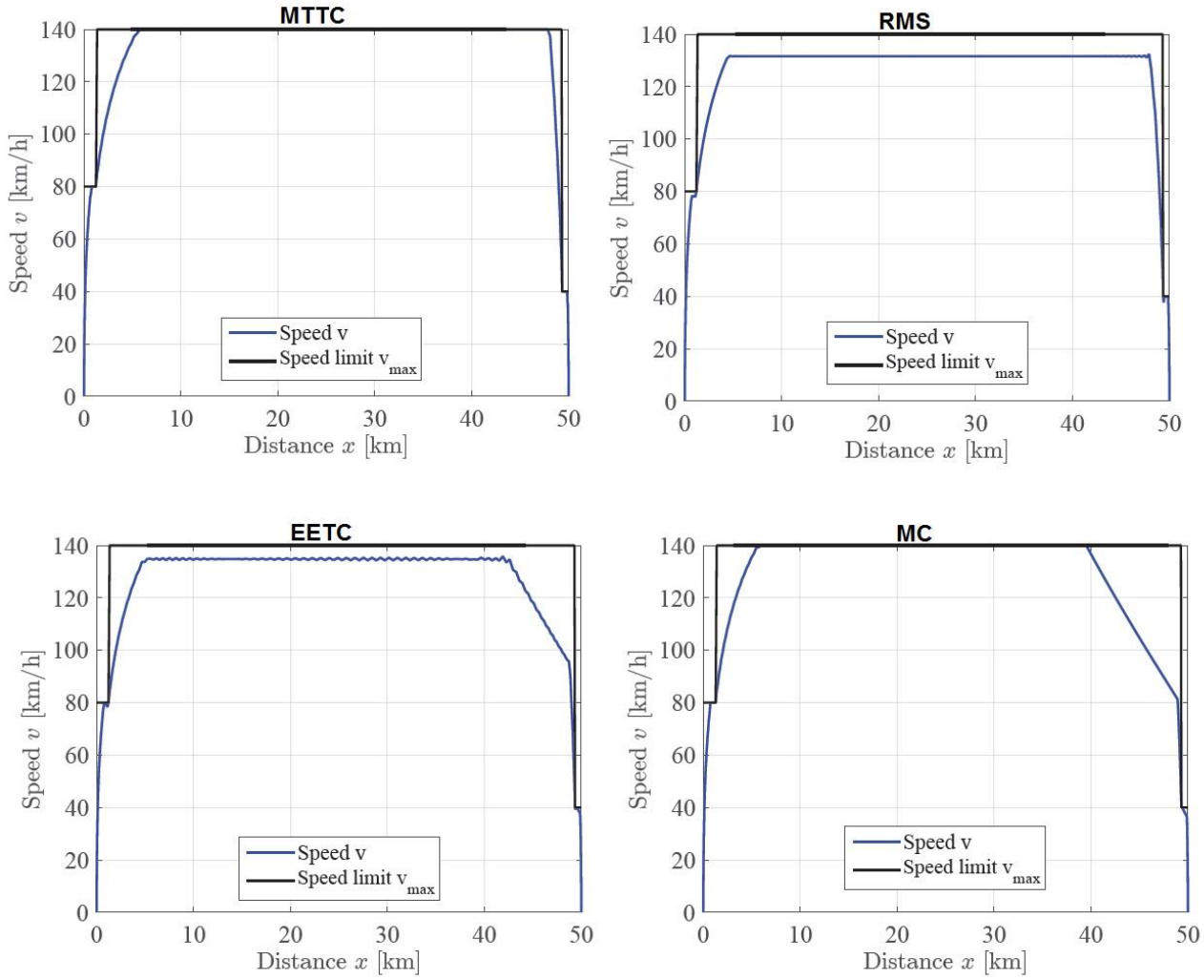
- Minimum time train control (MTTC)

  reference, no eco-driving strategy

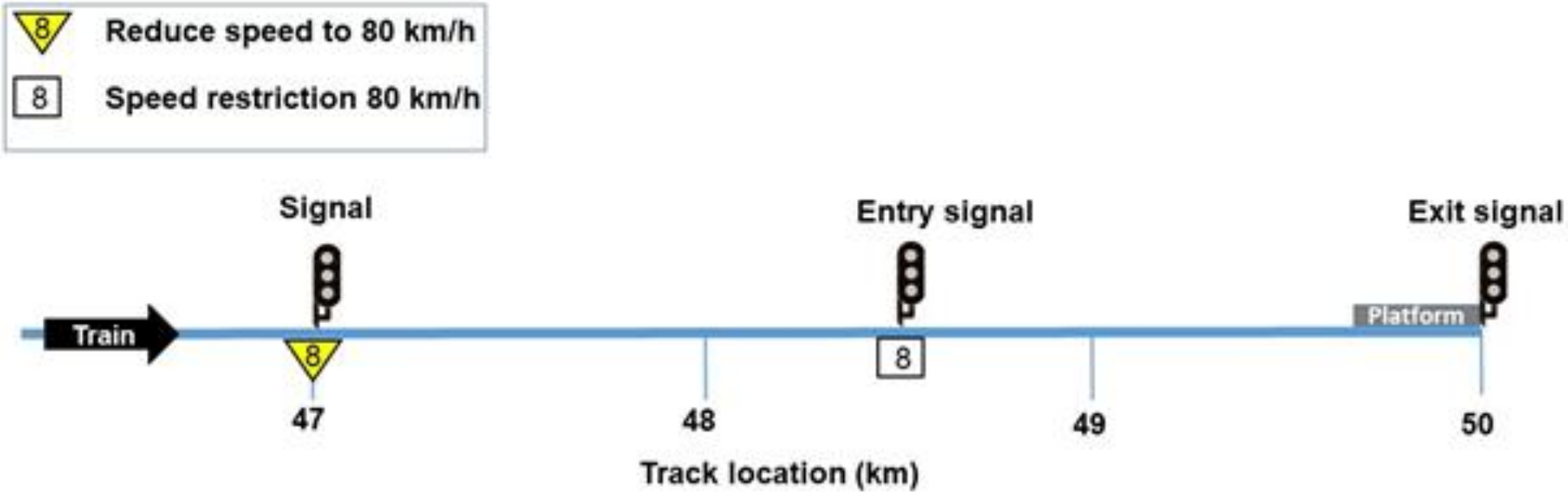
- Reduced Maximum Speed (RMS)

- Energy-efficient train control (EETC)

- Maximal Coasting (MC)

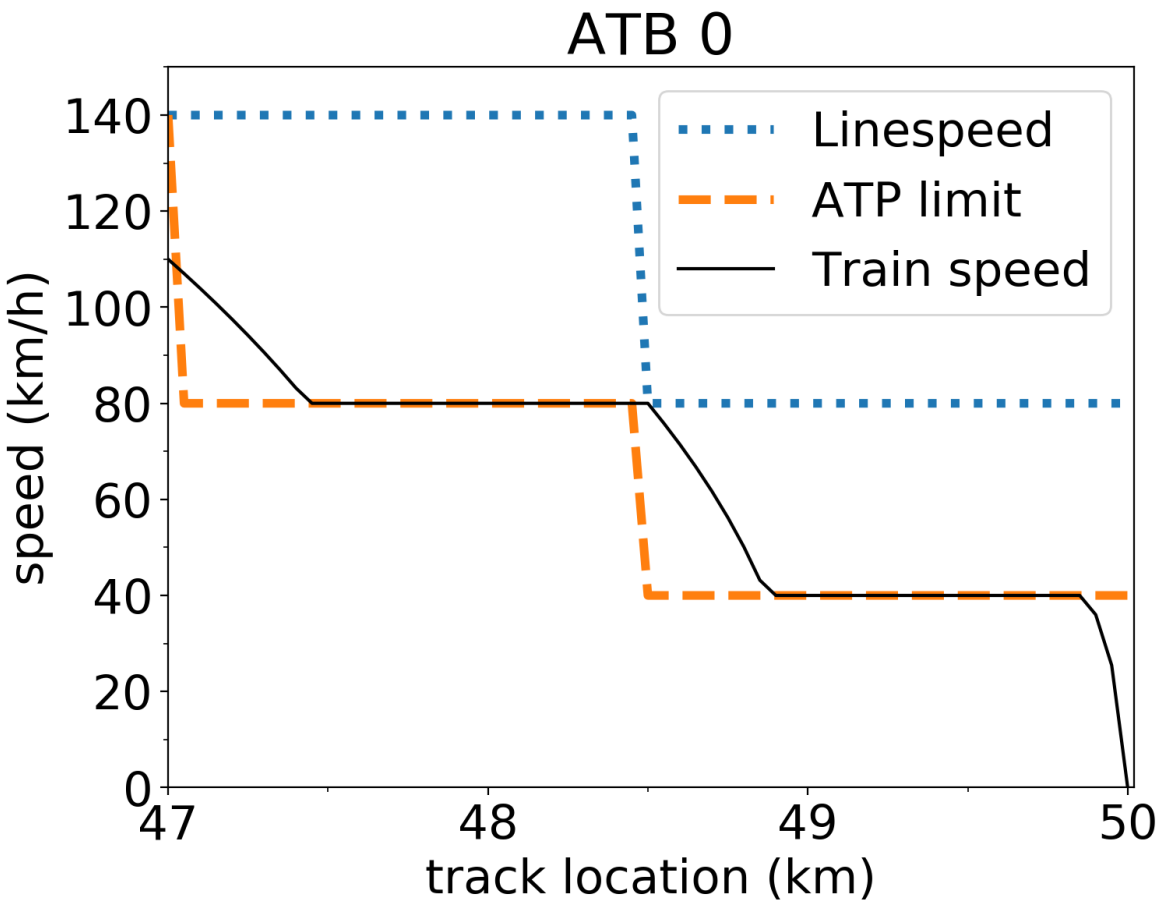


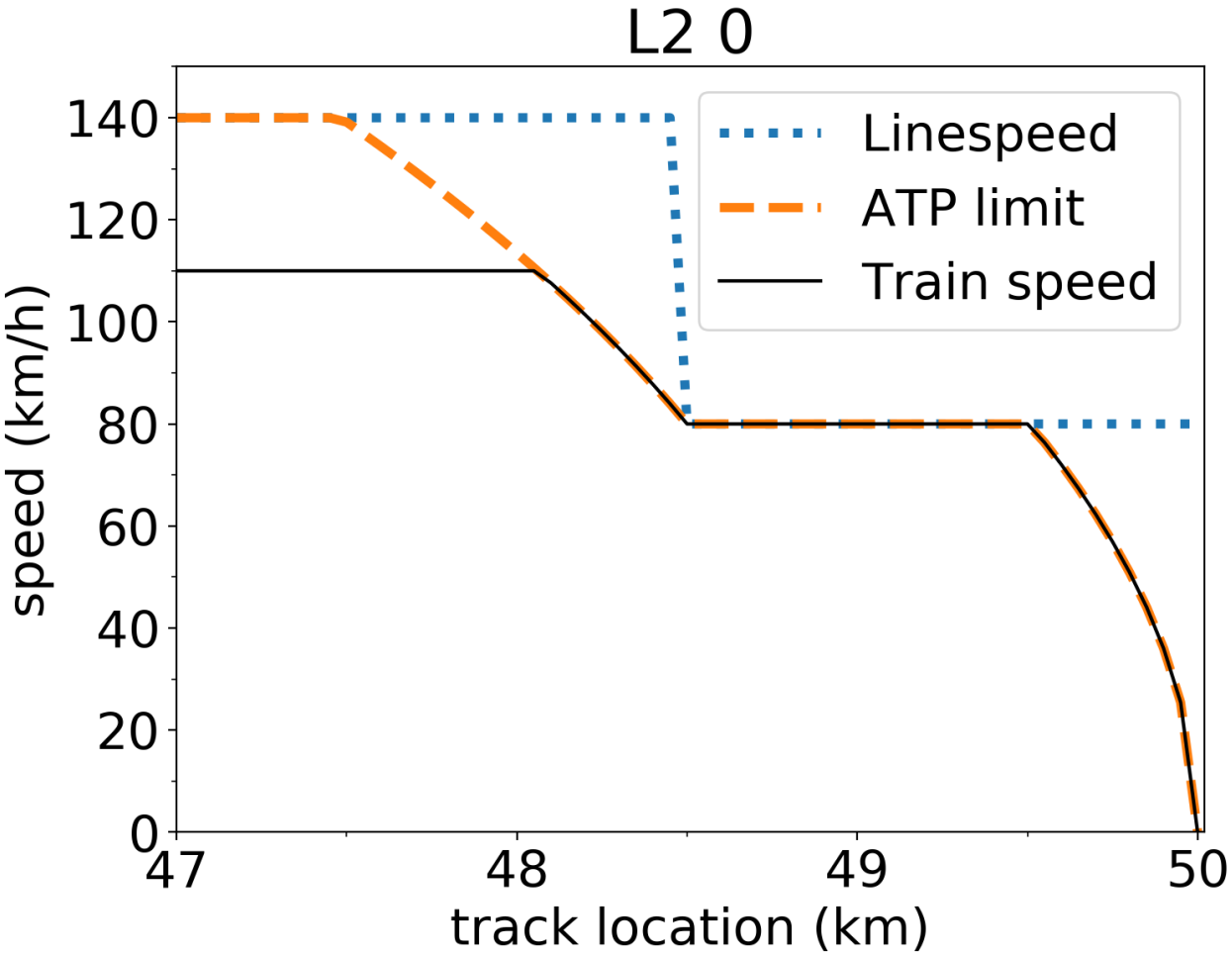
Previous paper 2: station approach



- Track length = 50 km
- Speed restriction at km 47
- Entry signal at km 48.5
- Same block lengths L2 and ATB

Previous paper 2: Undisturbed approach



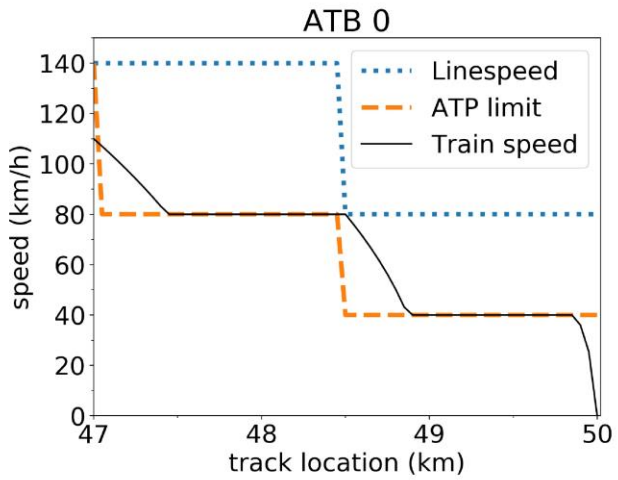


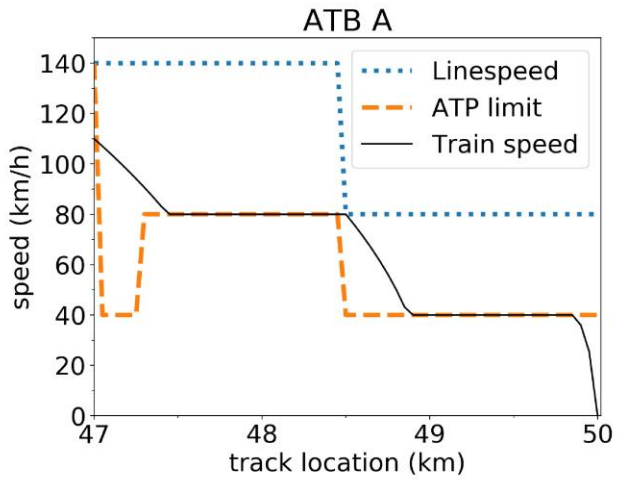
Research topics

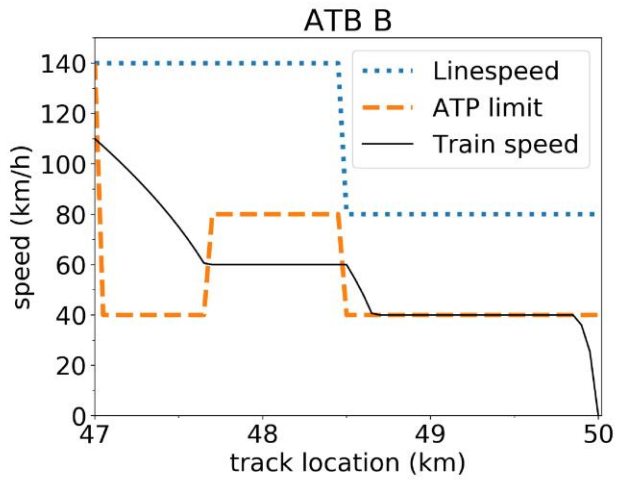
Eco-driving train hindered by previous train

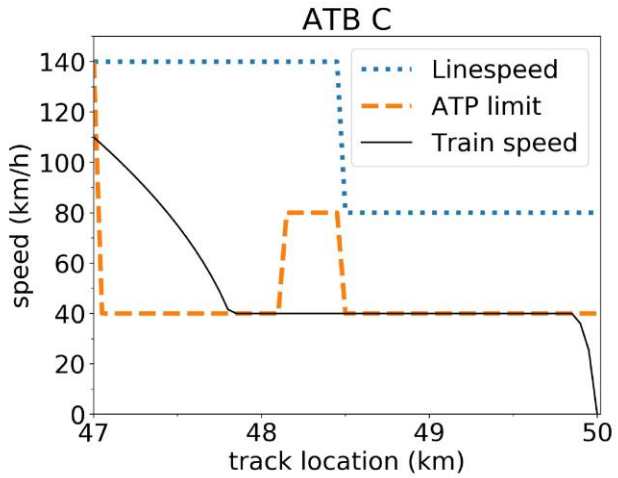
- What happens if previous train is delayed by several amounts of time ?
- Do different amounts of delay lead to different required actions for the driver?
- What is the impact on workload and arrival time?
- Separate analysis for NS’54/ATB and ETCS L2 is required

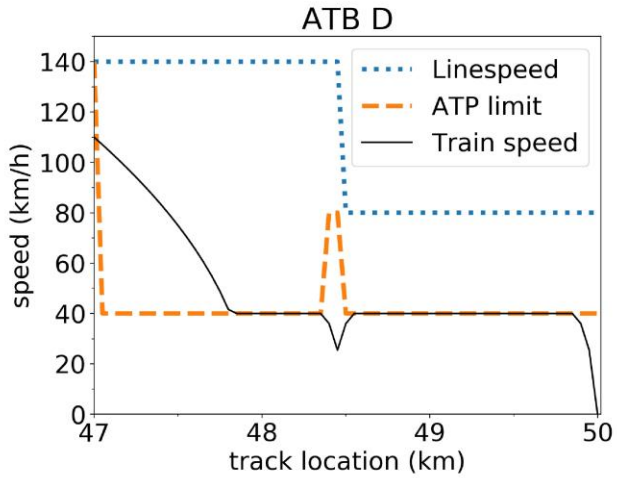
Obstruction classes NS'54/ATB

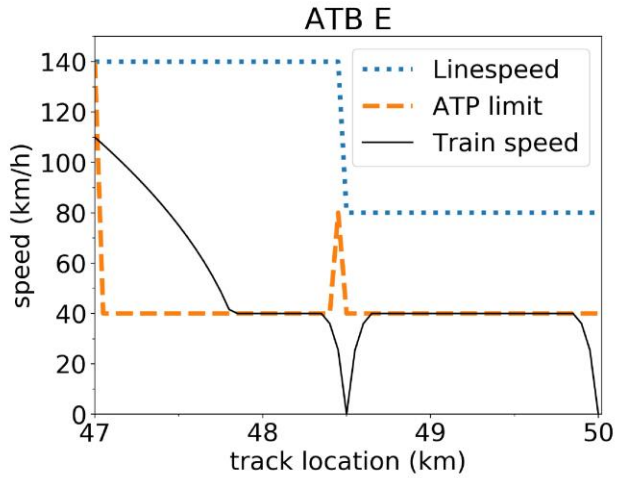




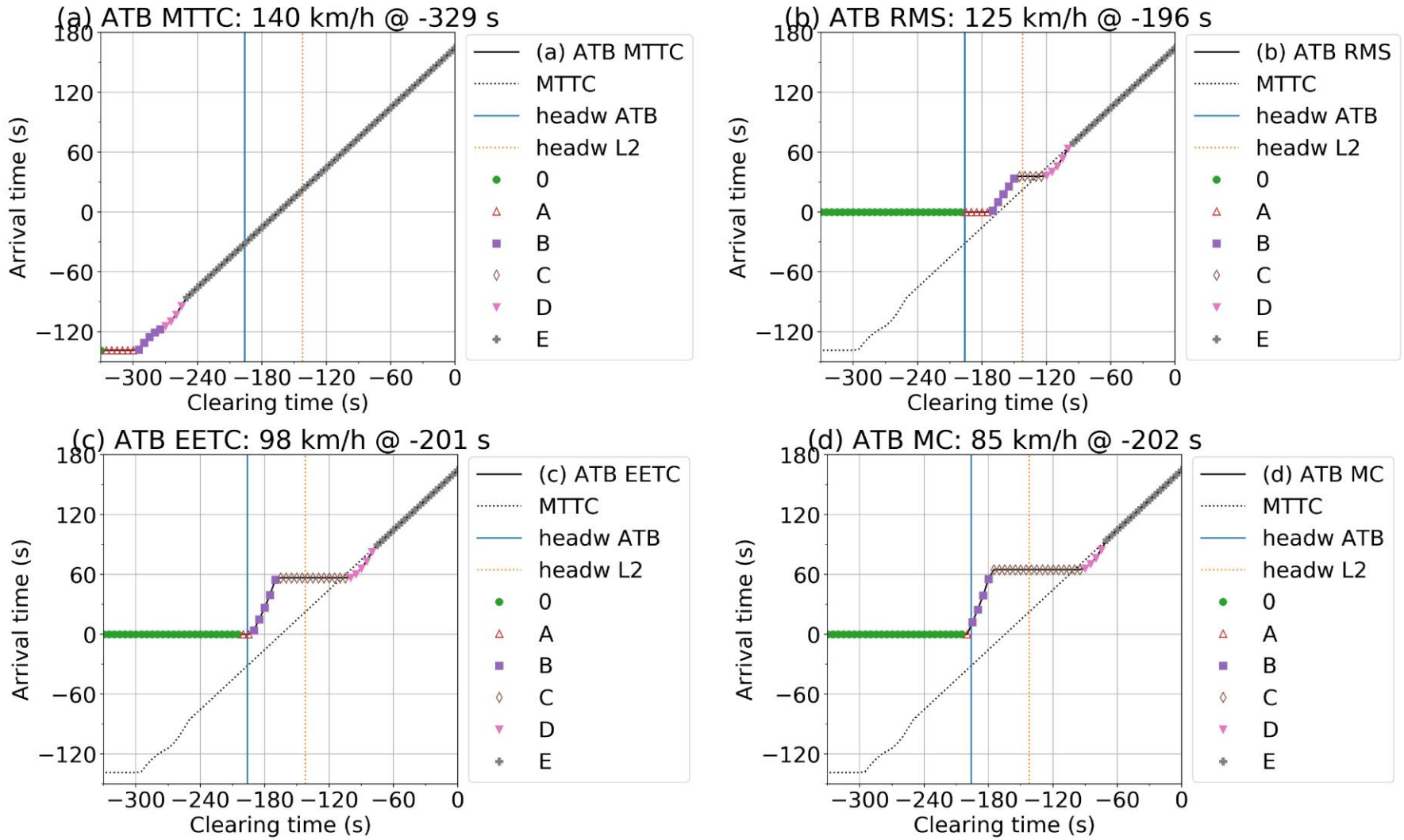




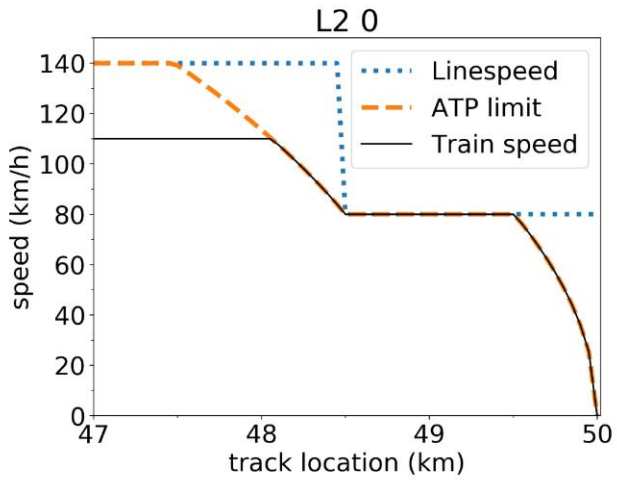


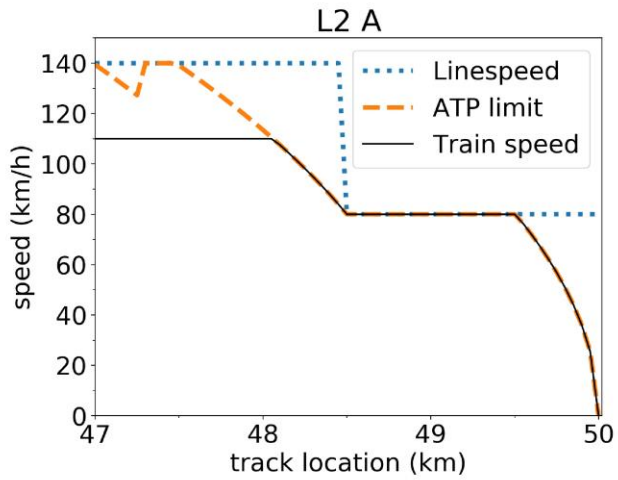


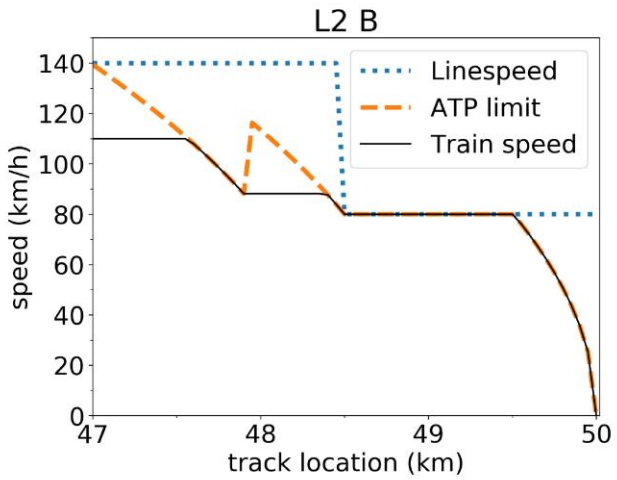
NS'54/ATB per driving strategy

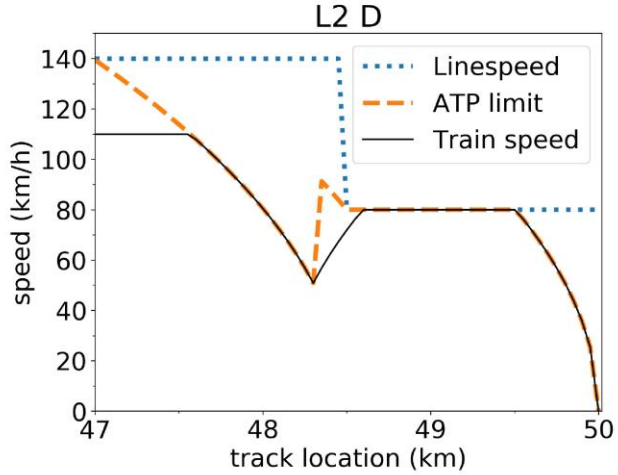


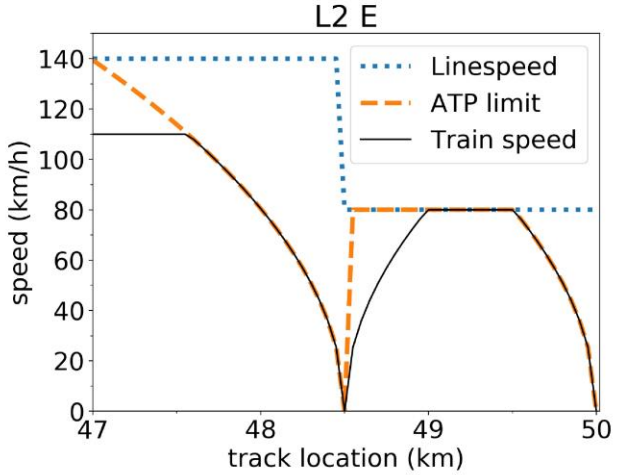
Obstruction classes ETCS L2



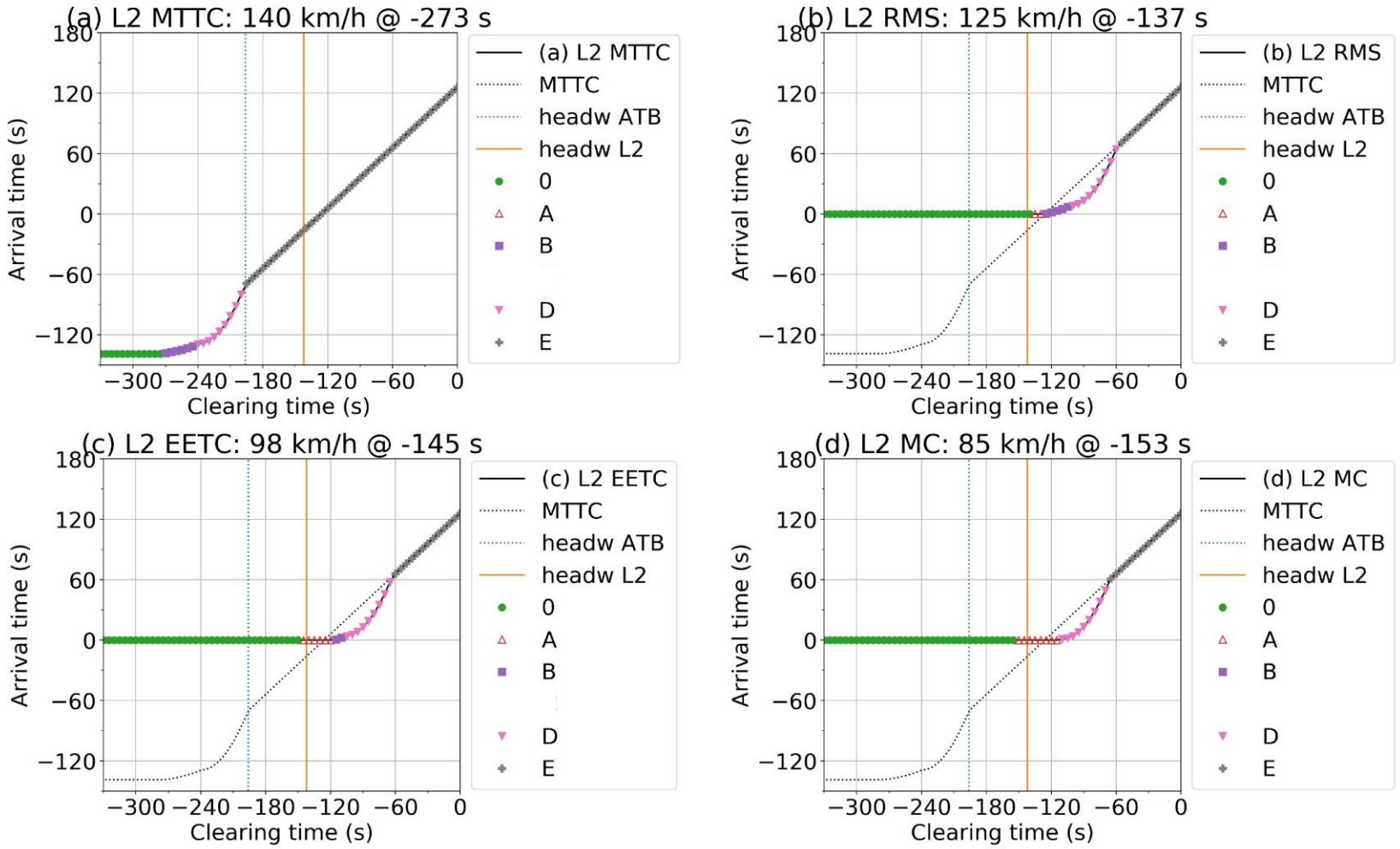








ETCS L2 per driving strategy



Impact on example runs

- ETCS L2 leads to lower headways and lower running times (result from paper 1)
  - Headway NS'54/ATB 196 sec
  - Headway ETCS L2 142 sec
- ETCS L2 arrival times under eco-driving are more robust for delays after the headway. Top table shows values for 30 sec delay of previous train
  - 30 sec delay on ETCS L2 headway = 84 sec delay on NS'54/ATB headway
- Additional running time margin depends on driving strategy and can be used for energy savings (shown in bottom table)

Driving strategy	Impact 30 sec delay ATB (s)	Impact 30 sec delay ETCS L2 (s)	Impact 84 sec delay ETCS L2 (s)
MTTC	-1	-40	14
RMS	9	0	4
EETC	57	0	2
MC	65	0	0

Driving strategy	Extra running margin ETCS L2 (s)	Additional energy savings L2 on ATB timetable (%)
MTTC	56	0.0%
RMS	59	5.2%
EETC	56	5.1%
MC	49	1.9%

Example for benefits: track layout Den Bosch

- Lines in this area are mostly 2-track
  - Exception: below 4-track Boxtel
- Mix of local trains, IC-s and freight on each line
  - Speed differences determine track capacity
  - Punctuality >95%
  - Drivers with DAS
- All tracks currently have NS'54/ATB only
- Some trains already have ETCS L2

- Benefits ETCS L2 largest near station
- Starting at signal before possible speed restriction

Generated benefits

ATB timetable & some L2 trains

Immediate benefits for each L2 train:

- Less hinder while eco-driving
- Better punctuality
- Energy savings

Timetable ATP dependent per series

If > 95 % L2 trains per series

- Reduction of planned running times for L2 trains
- Shorter headways for L2 trains

L2 only optimizations

Additional benefits by optimizing blocks

- Additional energy savings
- shorter headway times

Conclusions

- Headways, capacity and running times are better for ETCS L2 compared with NS'54/ATB on same blocks
  - This is a known result (paper 1)
- In addition, ETCS L2 arrival times under eco-driving are more robust for previous train delays compared to NS'54/ATB on same blocks
  - This is a new result
- Both results are specific to the NS'54/ATB Class B ATP system (and a few equivalents in Europe)
- There are benefits to ERTMS implementation around stations as overlay:
  - Possible before all trains are converted
  - Benefits for each already converted train
  - Headway/ capacity
  - Running time
  - Energy savings
  - Robustness to small delays

Questions?

Thank you for your attention

Jan.Hoogenraad@spoorgloren.nl