HESE

HEadway och Signalpunktsplaceringar i ETCS

Hans Sipilä

Aim and idea

- Develop a tool for calculation of technical headway in ETCS level 2
- **Follows description in ERA Subset 26-3 (Baseline 3.6.0)**
- Input data should be (relatively) easy to vary
  - Headway analyzes can be done faster than using a tool such as RailSys
- Typical question: Can we decrease the technical headway and if so by how much?
  - Adding more marker boards (densifying), i.e., shortening block lengths?
  - Altering positions for existing marker boards?
  - Making changes in the static speed profile (MRSP), for example speed decrease steps?
  - Using another train type?
  - Edit the vertical profiles (gradients)?

Input data

- Train types with parameters (traction, resistance, braking, …) imported from RailSys

- Track data entered in Excel tabs
  - Static speed profile (MRSP) for different speed categories
  - Marker board locations
  - Position balise locations
  - Gradients
  - Stop locations

- ETCS parameters (national and fixed values + other settings) entered in Excel tab

- Track and signal data can also be generated from a BIS-export for existing infrastructure (TRV BanInformationsSystem)

- All coding for HESE tool is done in Python

Technical headway

- Technical headway can be described as the minimum time distance between two trains without the train behind having to start braking towards a signal point at stop (i.e. not affected by a restriction ahead)

- Technical headway depends on a combination of:
  - Signal point locations (block lengths), if not pure moving block
  - Signal system parameters
  - Track characteristics (speeds, gradients)
  - Train parameters

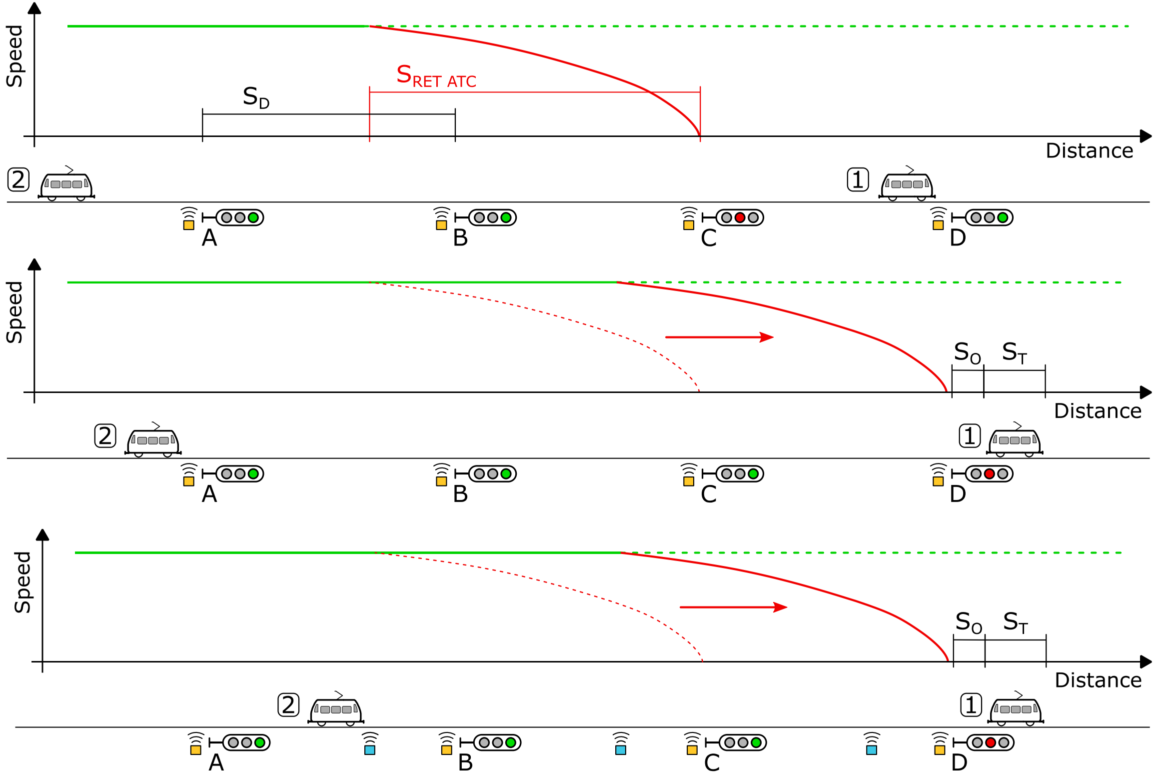
Technical headway varies along a line and the highest value becomes dimensioning (sets the limit)!

- In a simple case:
  - Two identical trains run in the same direction one after the other
  - Constant speed
  - No variation in gradient

- Examples follow

Technical headway in Swedish ATC

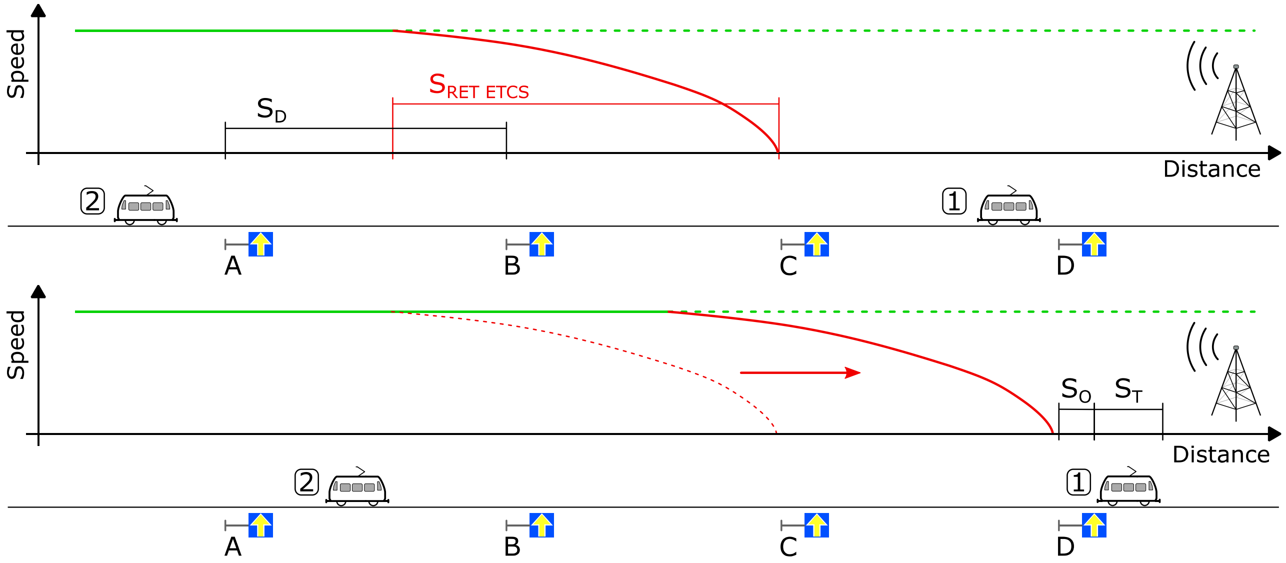
- Signal information only transmitted at information points via balises (**non-continuous updating**)
- If train 2 passes signal A before movement authority is extended from C to D it will encountrer an active braking curve (since the braking curve exceeds the block section length in the example) even though C–D was cleared before train 2 reaches start of braking curve
- Infill-balises can improve technical headway, train 2 can run ”closer” to train 1



Technical headway in ETCS L2

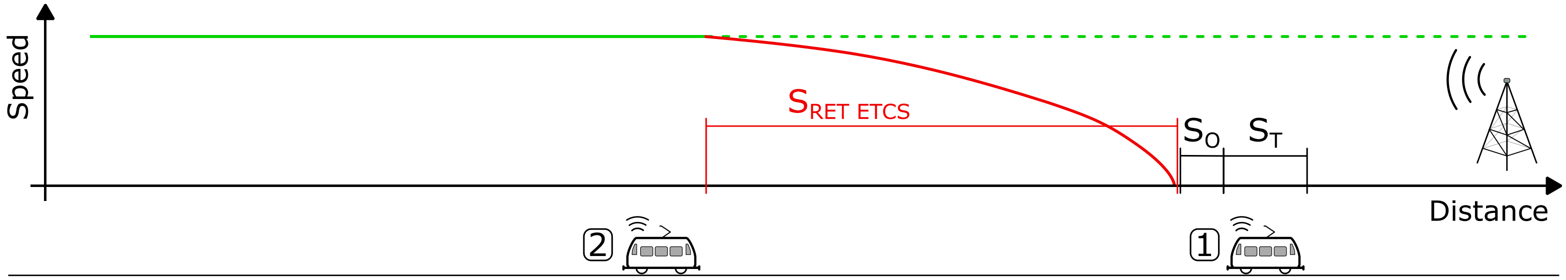
- Signal information transmitted **continuously** via radio – like having infill-balises everywhere in ATC
- Marker boars replace optical signals, block sections still in use

- ETCS curves conservative
  - ”Worst case”, transmission times, in some cases longer running times
- Can handle more speed profiles, some trains can run with higher speeds than in ATC



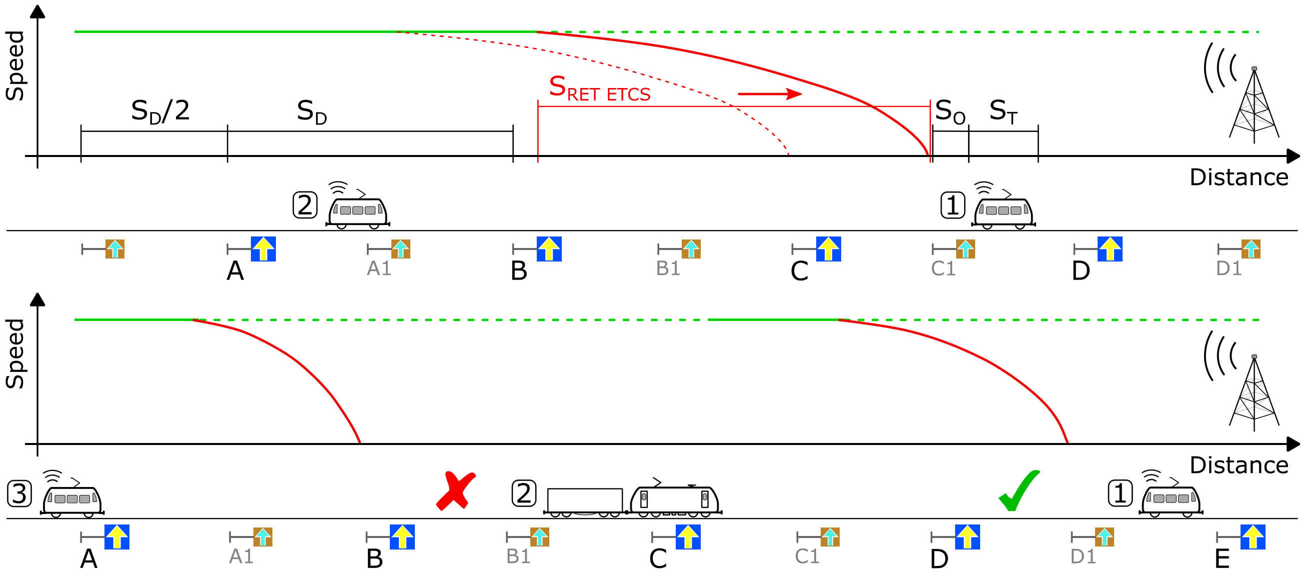
Technical headway in ETCS L3

- Signal information transmitted **continuously** via radio
- **Train integrity and position** transmitted from train
- No marker boards, no block sections – **moving block**
- Train separation from braking distance + safety margin + transmission times



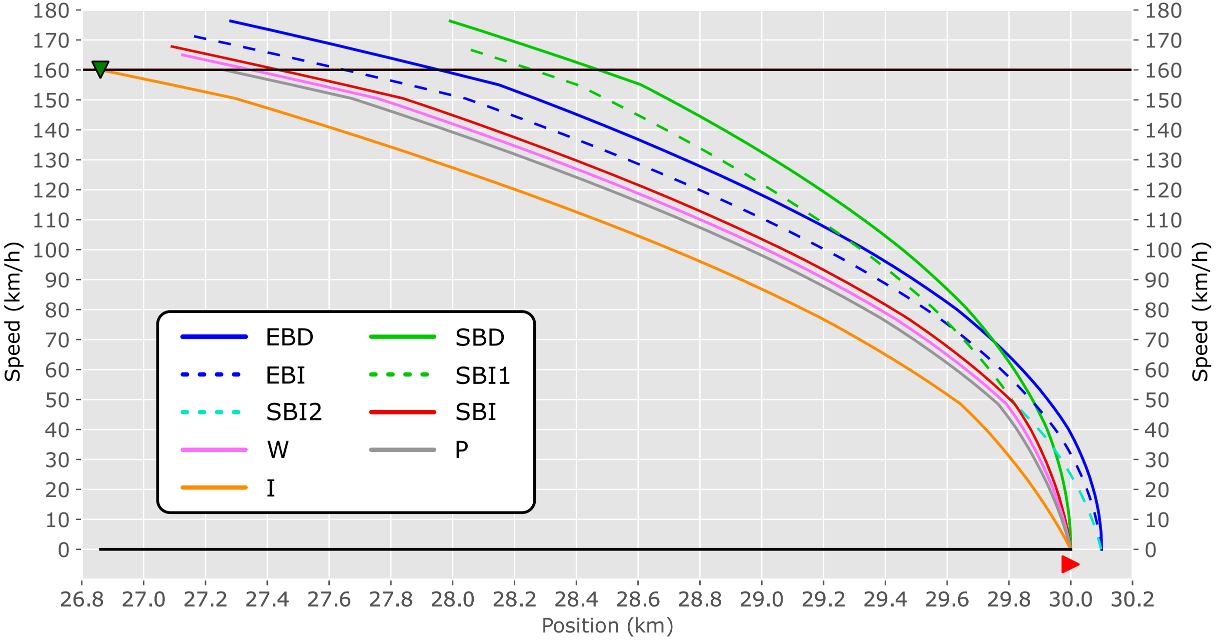
Technical headway in ETCS HL3

- ETCS L2 in which shorter block sections created by **virtual marker boards**
- Trains with train integrity monitoring can **clear virtual block sections** – trains without can only clear regular L2 sections
- Capacity benefits without having to add a lot of trackside equipment
- In bottom example train 2 is not equipped with train integrity monitoring system



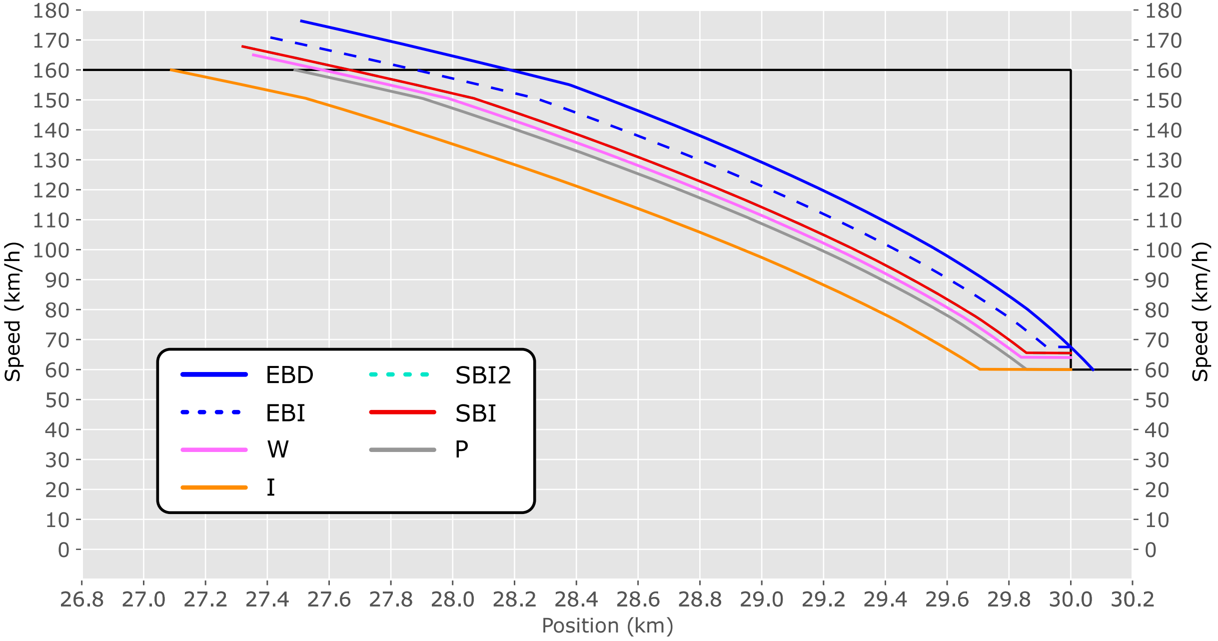
ETCS curves – End Of Authority (EOA)

- **EBD** – Emergency Brake Deceleration
- **EBI** – Emergency Brake Intervention supervision limit
- **SBD** – Service Brake Deceleration
- **SBI** – Service Brake Intervention supervision limit
- **W** – Warning supervision limit
- **P** – Permitted speed supervision limit
- **I** – Indication supervision limit



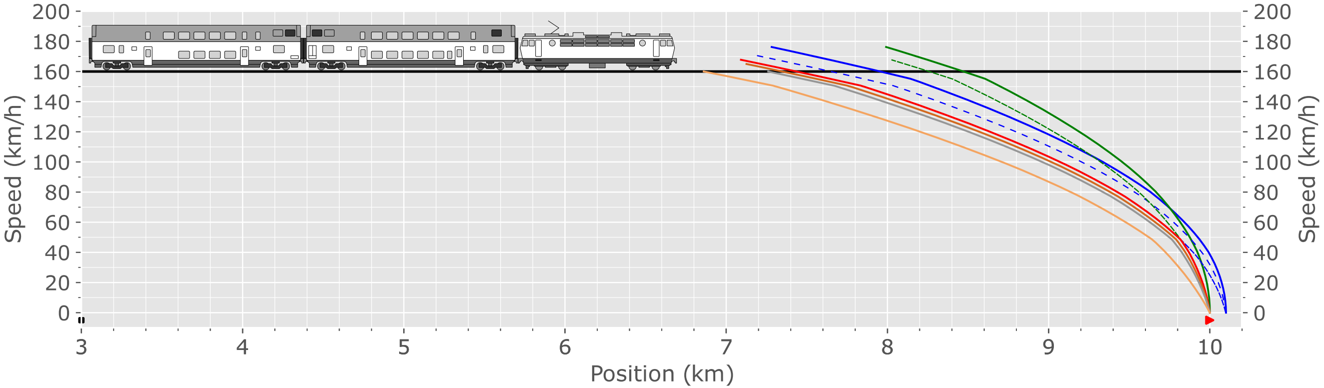
ETCS curves – Limit Of Authority (LOA), Most Restrictive Speed Profile (MRSP)

- **EBD** – Emergency Brake Deceleration
- **EBI** – Emergency Brake Intervention supervision limit
- **SBI** – Service Brake Intervention supervision limit
- **W** – Warning supervision limit
- **P** – Permitted speed supervision limit
- **I** – Indication supervision limit

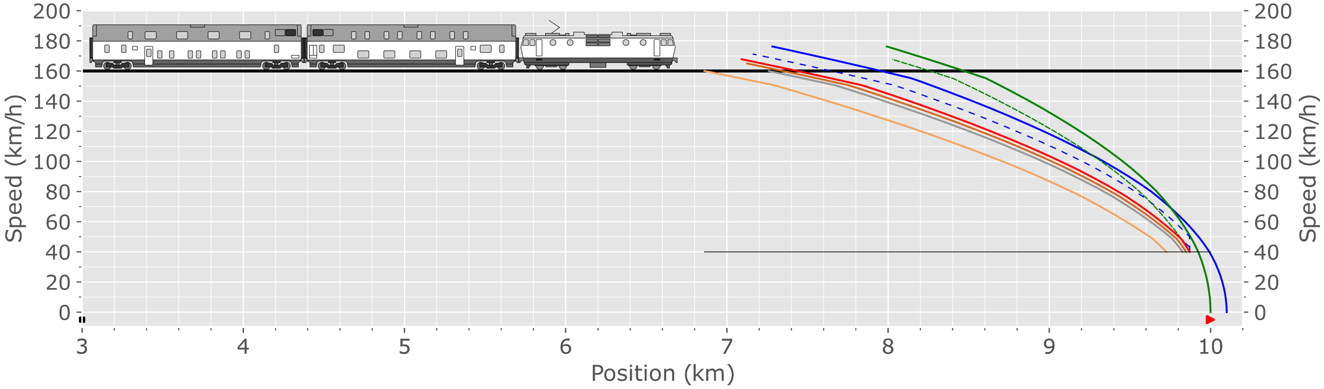


Release speed EOA?

- No release speed set or established (0 km/h)
- Approaching marker board becomes very restrictive

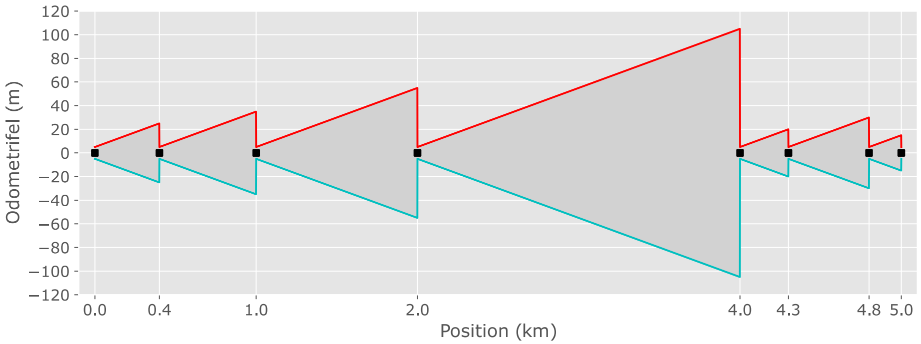


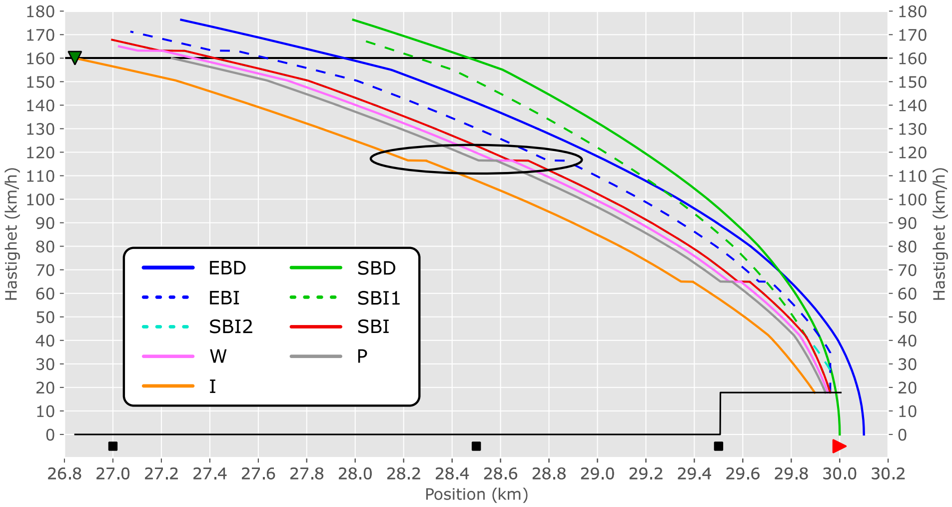
- Example with release speed 40 km/h
- Having a release speed practically easier
- Release speed can be calculated on-board, set from trackside or national value



Position inaccuracy

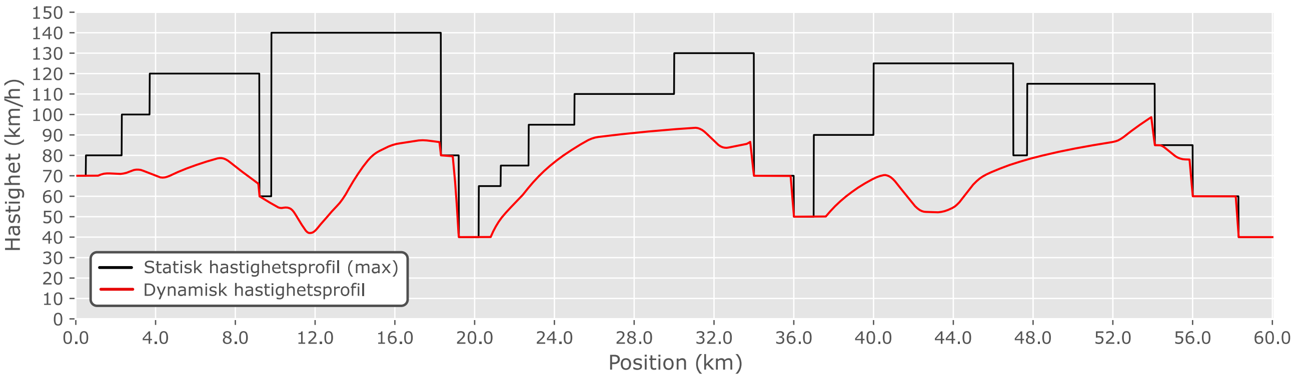
- Position inaccuracy increases with distance from last position balise
- Position balises required to counteract inaccuracy
- Curves are shifted to account for the inaccuracy
- **Speed inaccuracy** must also be dealt with if not inactivated

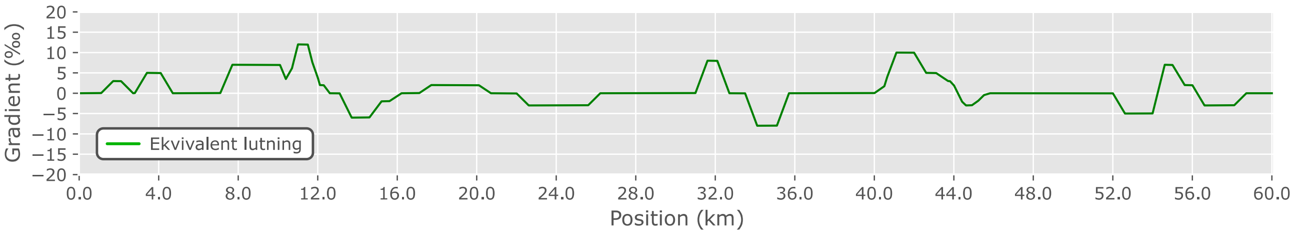




HESE tool
Dynamic profile (running time calculation)

- Running times compared to same cases in RailSys and for different trains
- In first instance compared with ATC braking
- Good agreement, typically within ± 0–5 seconds depending on track case and train type





HESE tool
Braking curves – comparisons

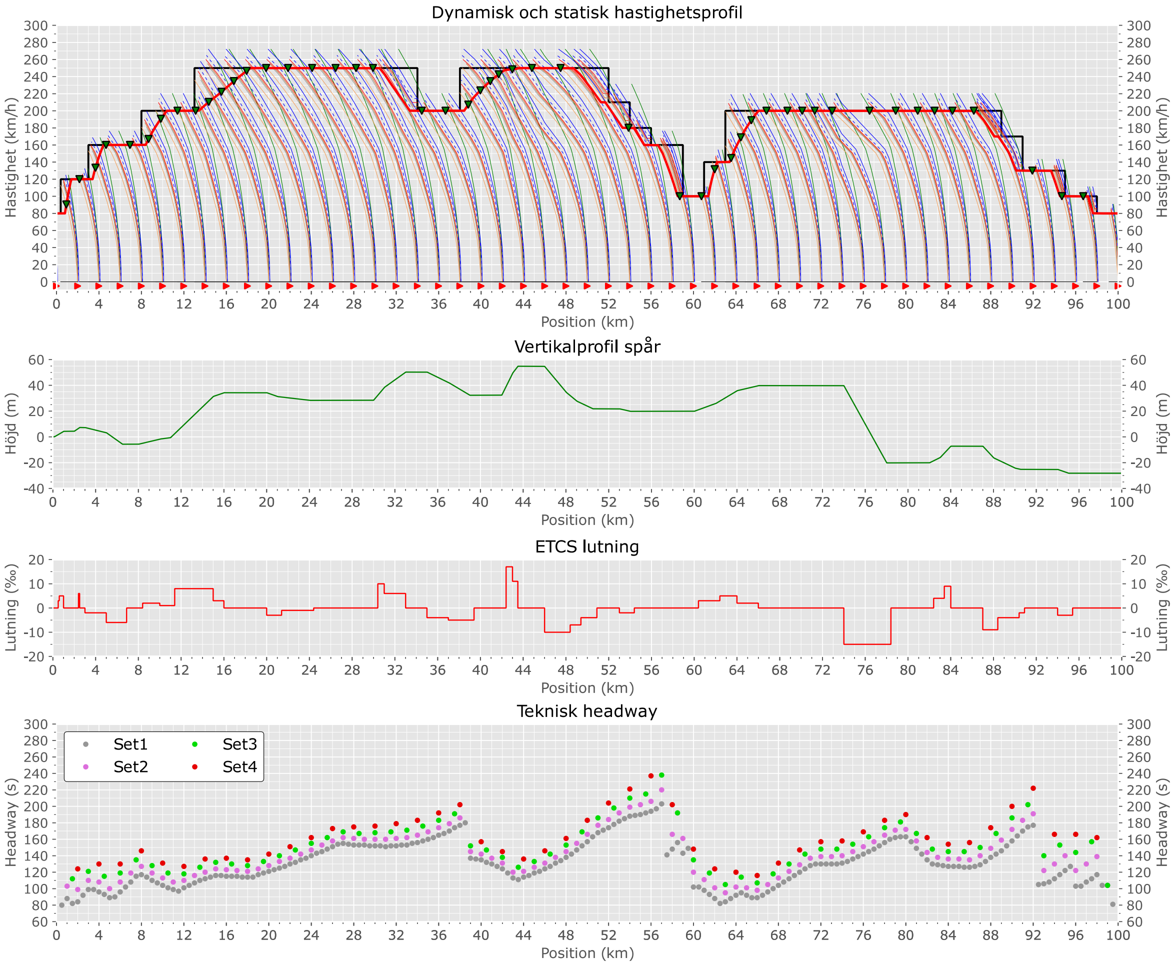
- Calculation of braking curves compared to **ERA Braking Curve Simulation Tool** – some different cases tested
- Good agreement in all cases, in principle equal for EBD and SBD and normally within ± 3 m from EBI and upwards
- EBI involves interpolating values
- Comparisons to RailSys 11 give some differences for P and I curves (in RailSys 11 Baseline 3.6.0 is not implemented)

Example with EOA – distances from target location

	Gamma-train from 200 km/h EOA (SvL 100 m) with position inaccuracy Gradient = 0		Gamma-train from 200 km/h EOA (SvL 100 m) with position and speed inaccuracy Gradient = 0		Gamma-train from 200 km/h EOA (SvL 100 m) with position inaccuracy Varying gradient		Gamma-train from 200 km/h EOA (SvL 100 m) with position and speed inaccuracy Varying gradient	
	ERA	HESE	ERA	HESE	ERA	HESE	ERA	HESE
EBD	3738	3738	3738	3738	4426	4426	4426	4426
SBD	2735	2735	2735	2735	3060	3060	3060	3060
EBI	5102	5100	5350	5348	4877	4878	6054	6053
SBI	5369	5366	5617	5615	5144	5145	6321	6319
W	5480	5477	5728	5726	5255	5256	6432	6430
P	5591	5589	5839	5837	5366	5367	6543	6542
I	6091	6089	6339	6337	5866	5867	7043	7042

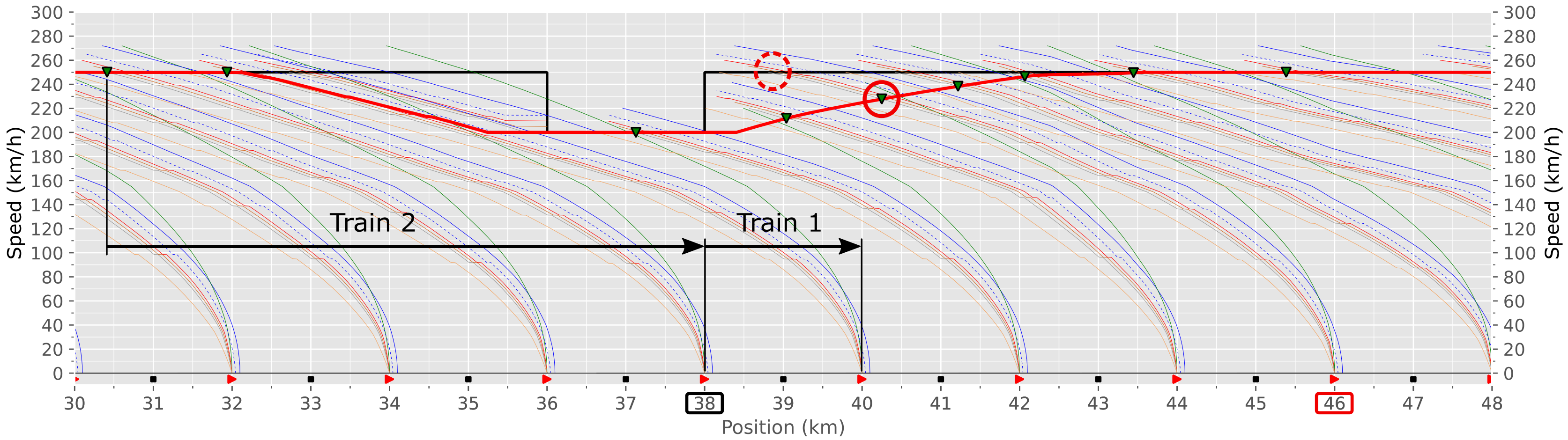
HESE tool Output

- Train dynamic profile with braking curves and MRSP
  - Setting for choosing if train follows Indication or Permitted curve
- Track vertical profile
- ETCS train gradients
- Technical headway
  - In example 4 sets of signal locations are used
  - Block length increases from 500 m in Set1 in steps of 500 m to 2000 m in Set4



HESE tool
Principle for headway calculation – example

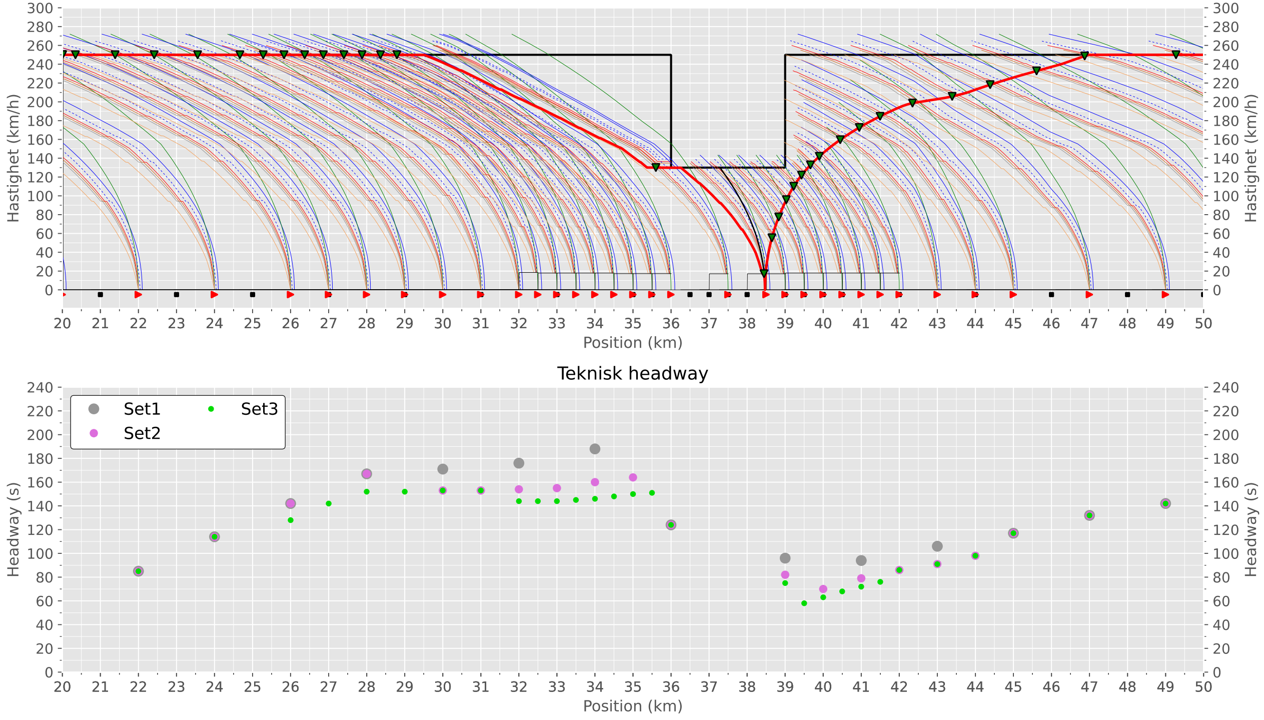
- Technical headway at position 38 (marker board) determined by:
  - Calculating running time (occupation time) for Train 1 from passing 38 and until it clears the section (38–40), i.e., including train length and supervised location if active
  - Calculating running time for Train 2 from point where Movement Authority (MA) from 38 onwards at latest must exist
  - Addition of route set and release times (including transmission time)
- The point where MA must exist (pre-occupation of block sections) can be chosen between Indication, Permitted or some other time separation (±) with reference to Indication



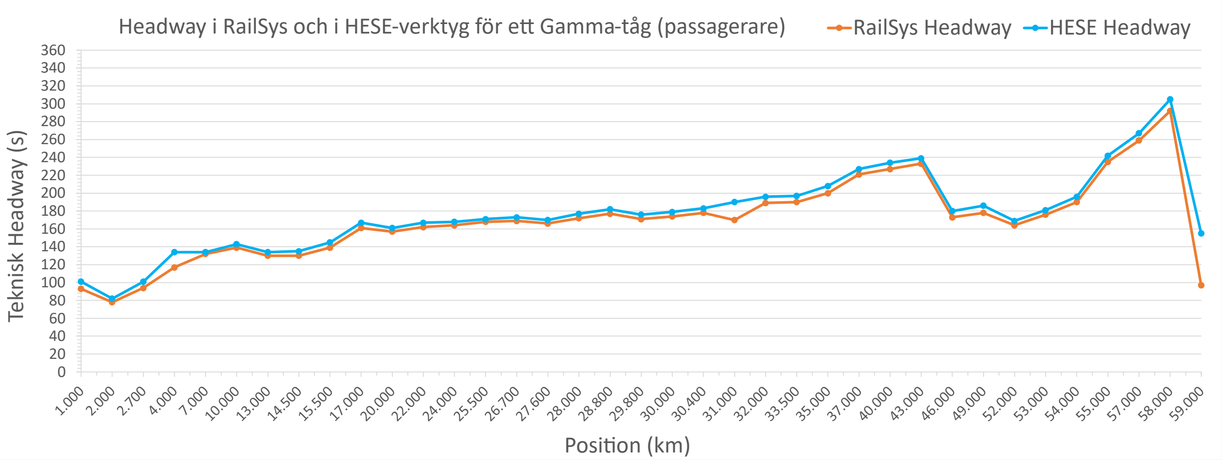
HESE tool
Overtaking scenario – example

- The first train can be set to enter the side track and make a stop somewhere if activated
- The second train is the “main track” train (passing)
- Typically technical headway will increase due to the first train braking (decreasing speed) to a turnout
- Densifying with marker boards can counteract this headway increase to some degree
- In example Set3 has shortest block sections approaching the turnout

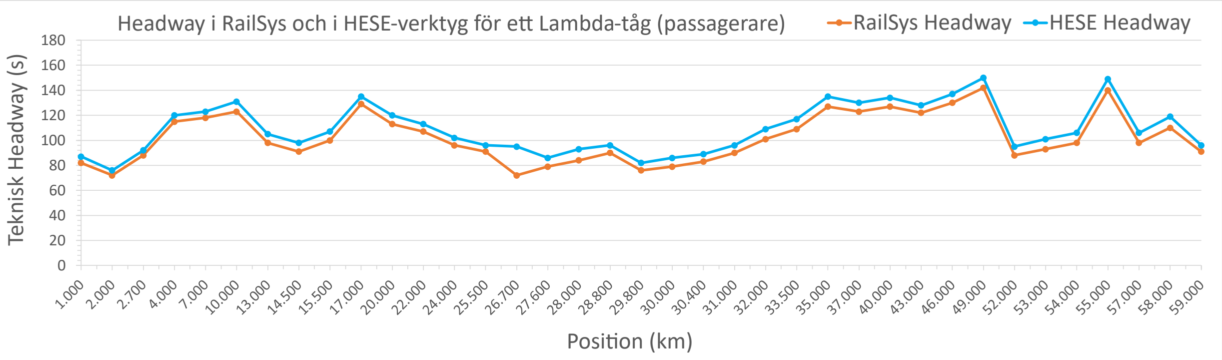
Speed profile for ”side track” train and targets for one of the sets



HESE tool – Comparing headway to RailSys



- Mostly good agreement



- Differences at least partly explained by the observed differences (or mismatch) for Permitted and Indication curves since this affects pre-occupation, i.e., headway

Thanks