Calculating realistic minimal train running times.

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Who needs minimal running times?

The train running calculator (ZLR = Zuglaufrechnung) calculates a minimal running time for all trains in planning an disposition. It is expected that this minimum running time can be realised in case of a delay.

The minimal running time is basis

- For signal planning
- To calculate headway times
- In time table planning (Viriato and NeTS)

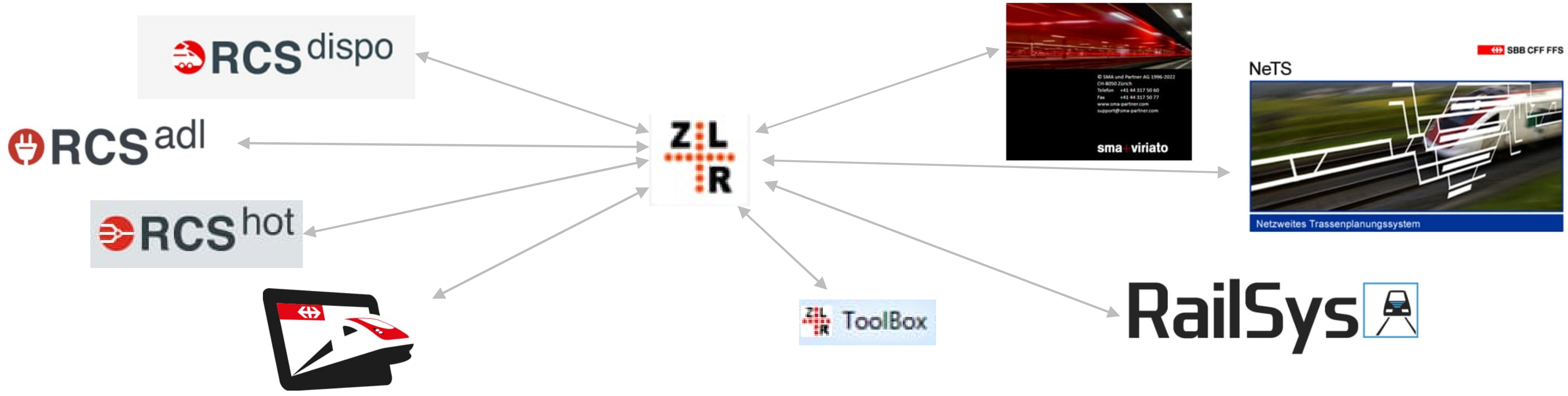
- In determining the loss of time due to speed restriction in construction site planning
- To determine the vPro-Speeds (Driving advice how to consume the running reserves in case of punctuality)
- In the RCS-Prognosis (RCS=Rail Control System, Disposition System.) which is the basis for conflict detection and customer information
- For automatic dispositions by RCS (e.g. decisions if a connection has to be broken or not)
- To calculate the driving advices by ADL/Hot in case of a conflict.

Model and systemintegration

The minimal running time calculation takes into accout

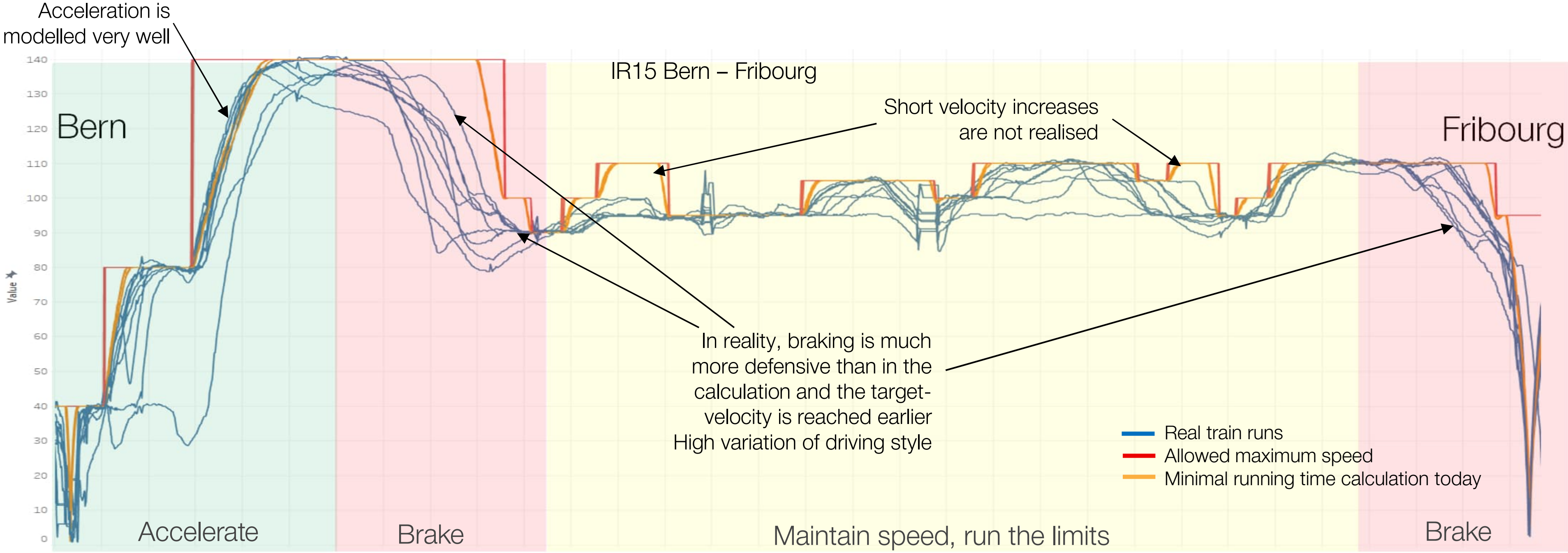
- The permitted speed
- The properties of the rolling stock (e.g. acceleration capacity (Z/V-Diagram), weight, length, braking system, resistance factors, etc.)
- Topographie (curves, slopes, tunnels, signalling mode...)
- Parameters like adhesion factor, buffer force limits, deceleration restriction, ...
- Rules like sawtooth-brake, mbspeedlimit, nsecondsrule, ...

The model runs as one service called by planning and disposition systems. The request gives the infrastructure, rolling stock and parameter values and receives the running times.

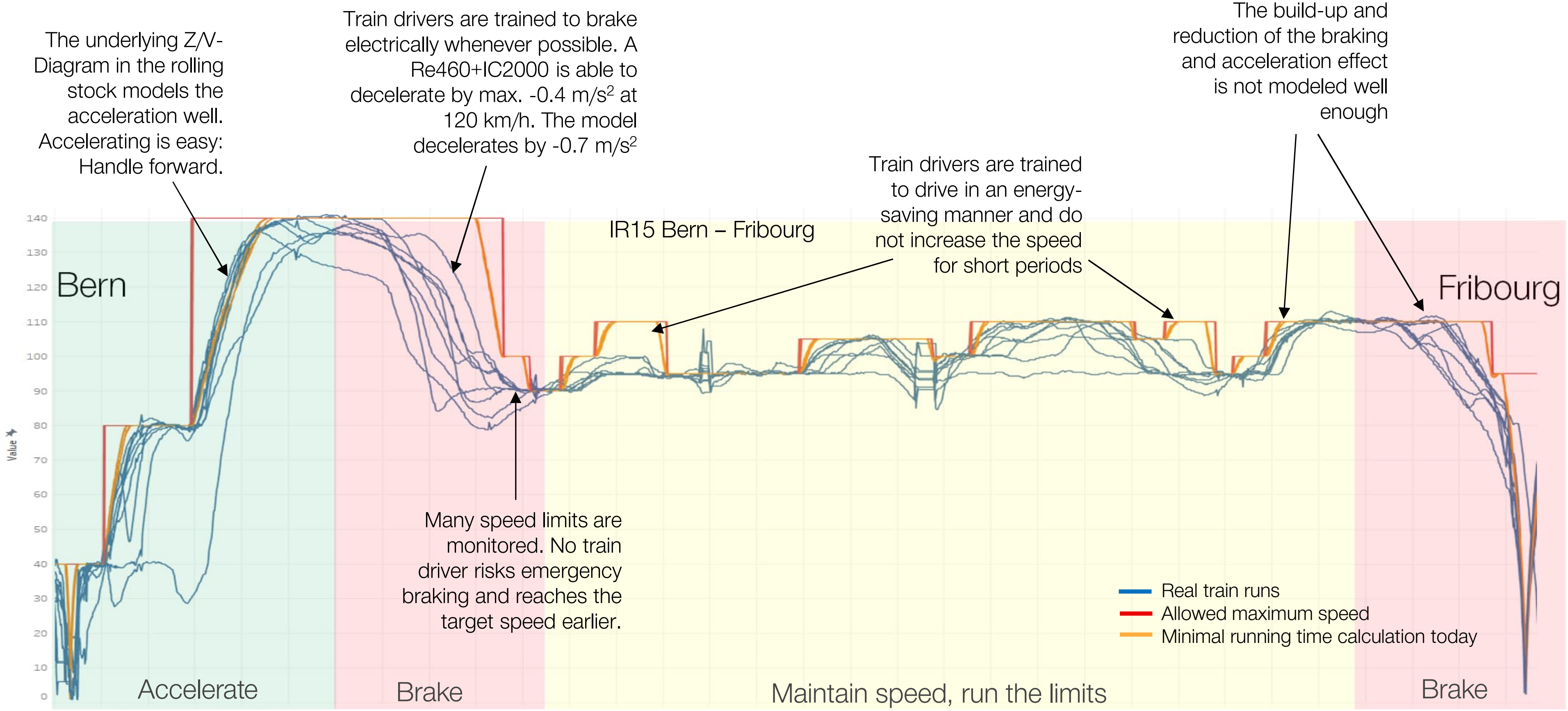


Insights

a) The planned standard reserves in the planning tools are not sufficient for punctual operation for all trains
b) The progosis in RCS is too optimistic and has to be corrected regulary
c) The basis for automatic dispositions and driving devices is not realistic



Reasons


The underlying Z/V-Diagram in the rolling stock models the acceleration well. Accelerating is easy: Handle forward.
Train drivers are trained to brake electrically whenever possible. A Re460+IC2000 is able to decelerate by max. -0.4 m/s² at 120 km/h. The model decelerates by -0.7 m/s²
Train drivers are trained to drive in an energy-saving manner and do not increase the speed for short periods
The build-up and reduction of the braking and acceleration effect is not modeled well enough
IR15 Bern – Fribourg
Bern
Fribourg
Many speed limits are monitored. No train driver risks emergency braking and reaches the target speed earlier.
Real train runs
Allowed maximum speed
Minimal running time calculation today
Accelerate
Brake
Maintain speed, run the limits
Brake
Value
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

Goals

- Driveability: The goal is that the minimal running times calculated by the ZLR should be realistically driveable in the event of a delay. Therefore, we are looking for a parameterization that corresponds approximately to the 10% percentile of the delayed actual journeys. I.e. one orients oneself to the "10% fastest train".

- As simple as possible: The parameterization must remain as simple as possible. Everything else cannot be kept up to date and traceability is no longer guaranteed.

- The computing time must remain fast.

- Implementation in practice: The trained driving style in the event of a delay should be as close as possible to the minimal running time calculation. This requires an exchange with train driver examination experts. The aim here is in particular to reduce the variation in driving style.

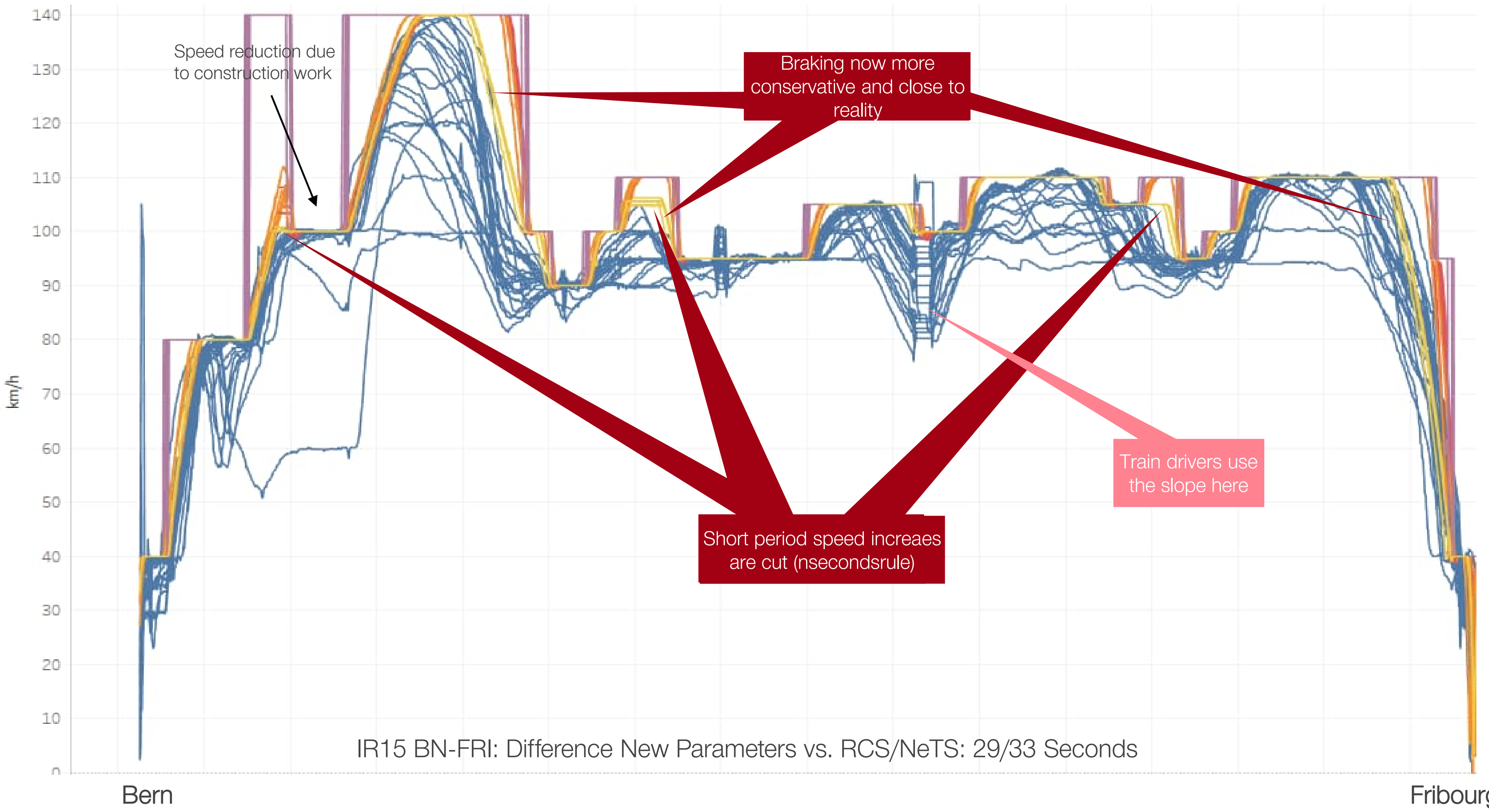
Main points to improve the calculation

- Before starting the calibration of the parameters, some basic errors had to be corrected.
- Parameters are no longer global but per product category
- New parameters are implemented in the modell:
  - Different braking decelerations on speed thresholds versus stop (very simplified electric braking)
  - Reach speed limits earlier by x seconds.
- Use of existing parameters (new)
  - nSecondsRule (max speed hold by n seconds)
  - vMaxMargin (reduce maximum speed by x km/h)
  - jerkRestriction
- Unused parameters (old and new):
  - mbSpeedLimit (costs too much calculation time)

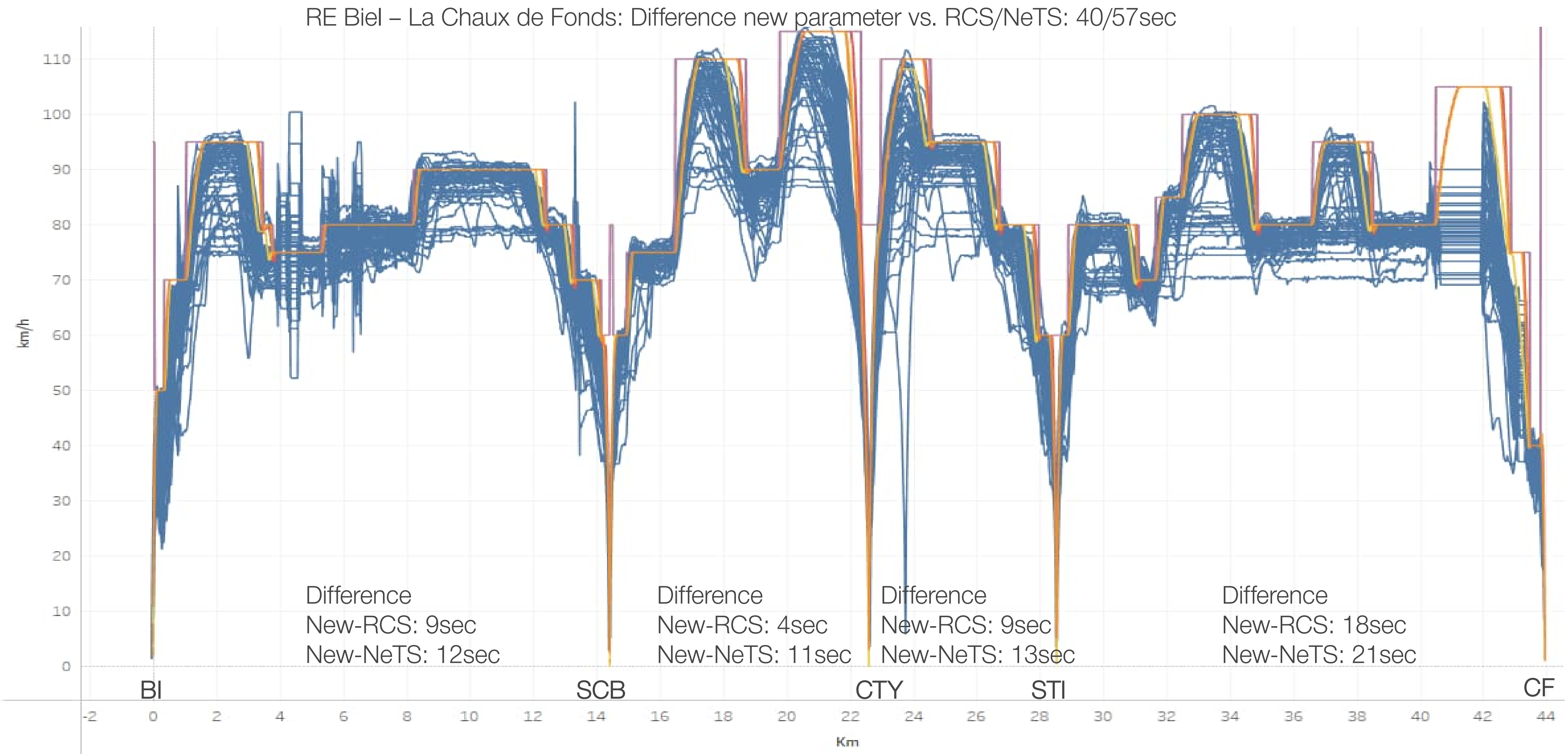
Results

Legend:
Purple: Allowed maximum speed
Yellow: Minimal running times with new parameters
Orange: Minimal running times with parameters used by RCS today
Red: Minimal running times with parameters used by Viriato/NeTS.
Blue: Real train runs

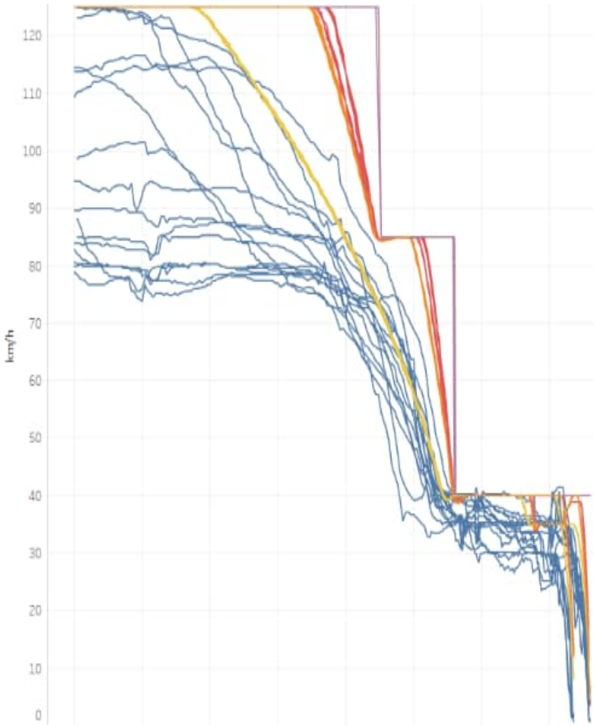
Large difference on routes with many speed changes



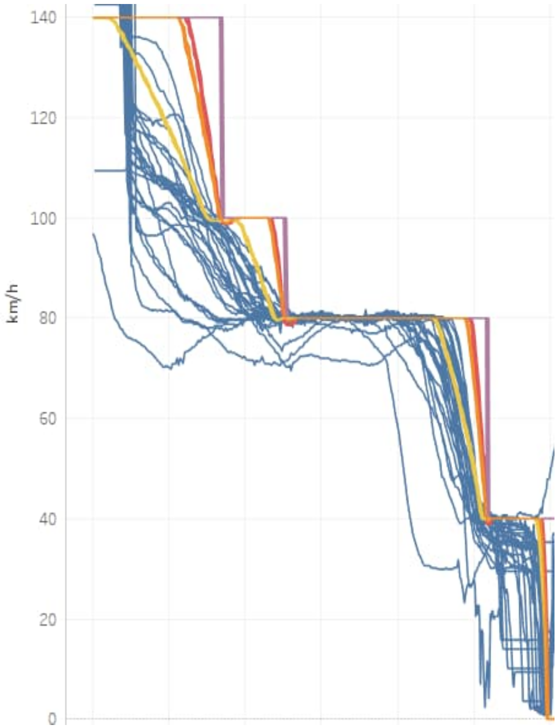
Large difference on routes with many speed changes



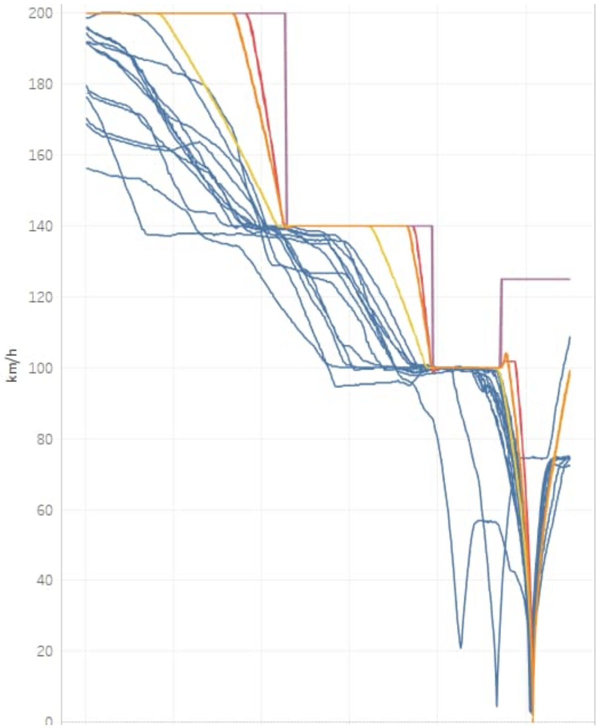
Large difference in approach to lange stations.



IC 3 Approach Basel. Difference: New vs. RCS/NeTS from Muttenz: 22/27 Sec



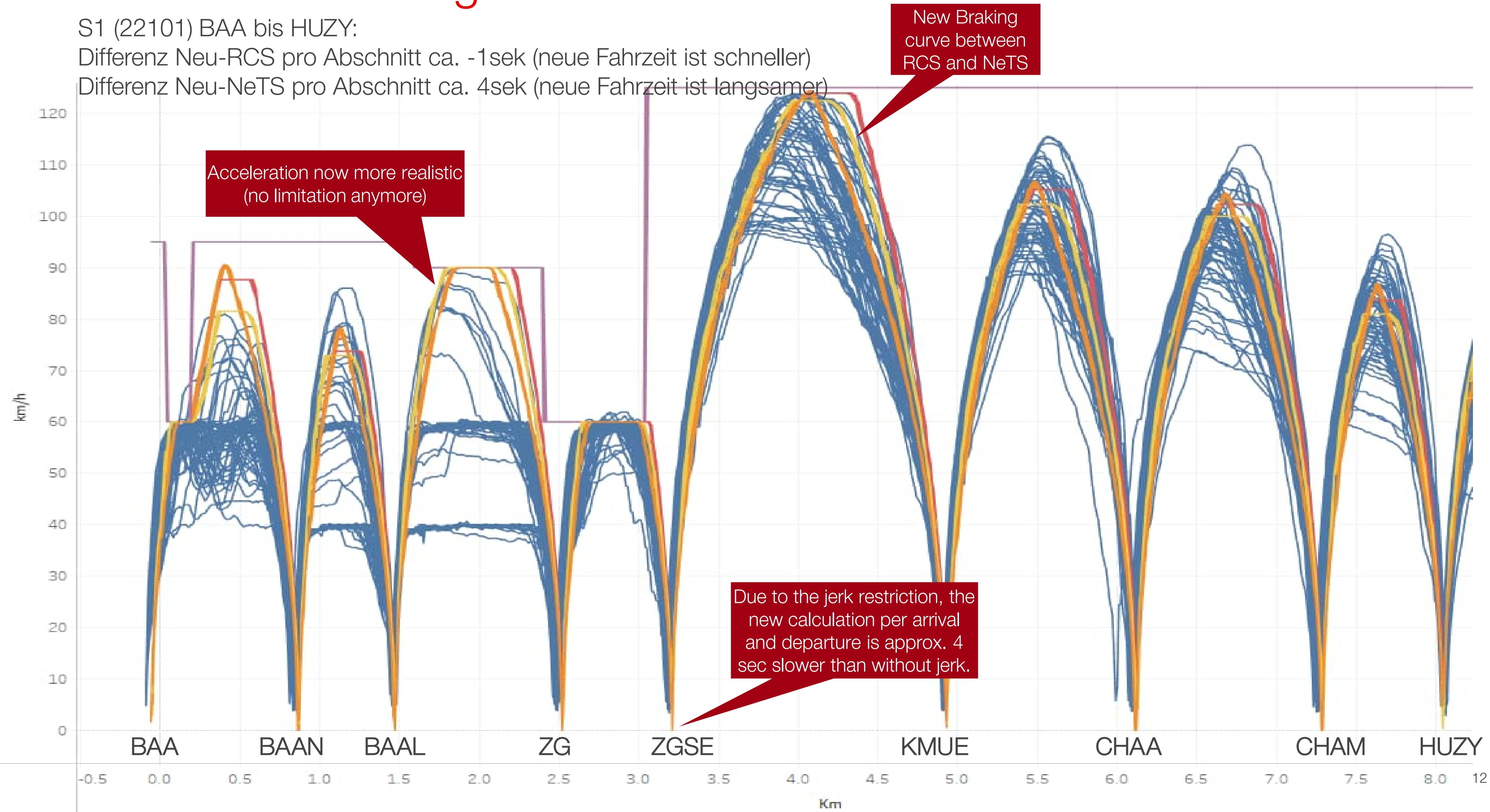
IC 8 Approach Bern from Grauholz. Difference: New vs. RCS/NeTS ab LGUT: 22/24 Sec



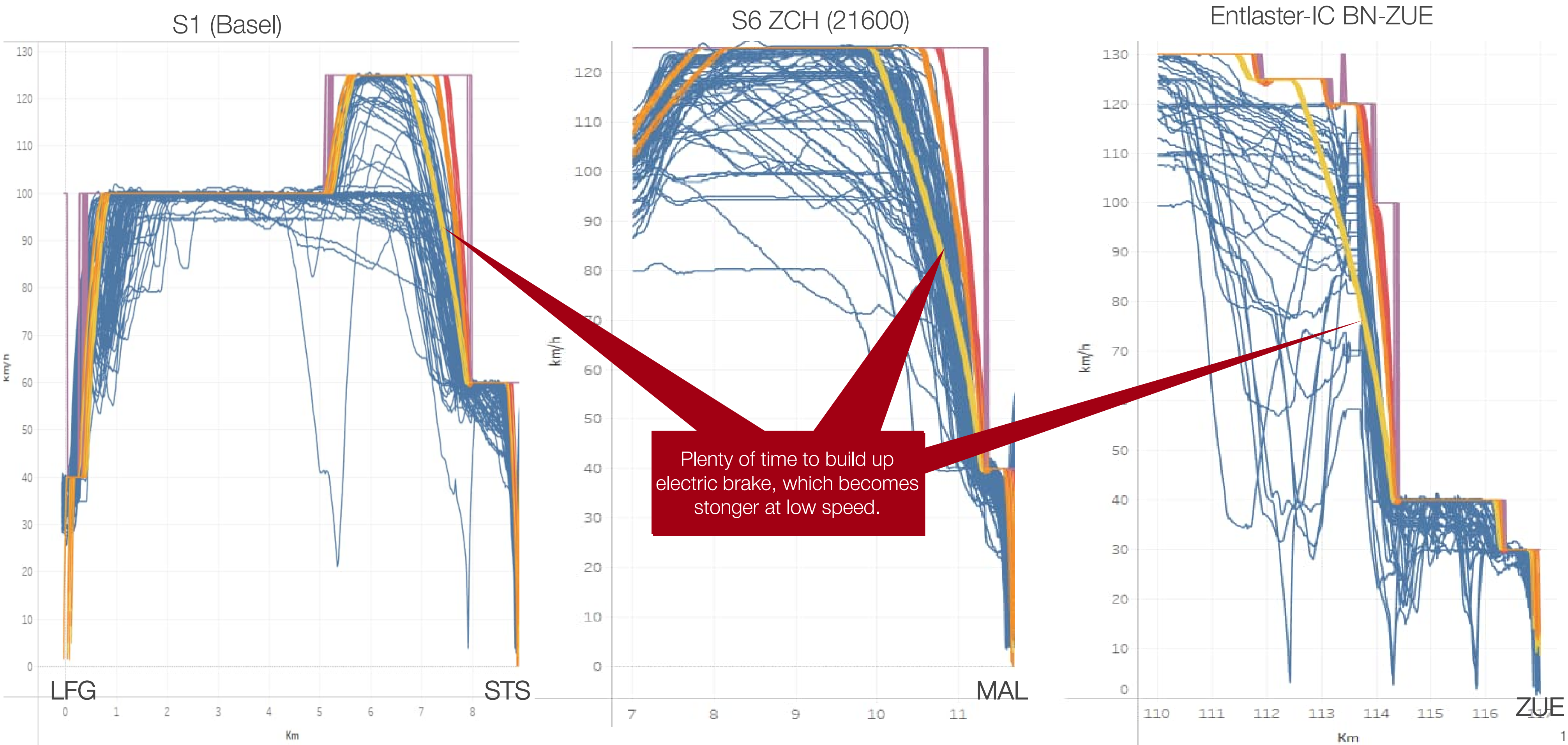
IC 5 Approach Solothurn from NBS/ABS. Difference: New vs. RCS/NeTS ab RTR: 21/29 Sec

Differences in regional trains are in the details

S1 (22101) BAA bis HUZY:
Differenz Neu-RCS pro Abschnitt ca. -1sek (neue Fahrzeit ist schneller)
Differenz Neu-NeTS pro Abschnitt ca. 4sek (neue Fahrzeit ist langsamer)



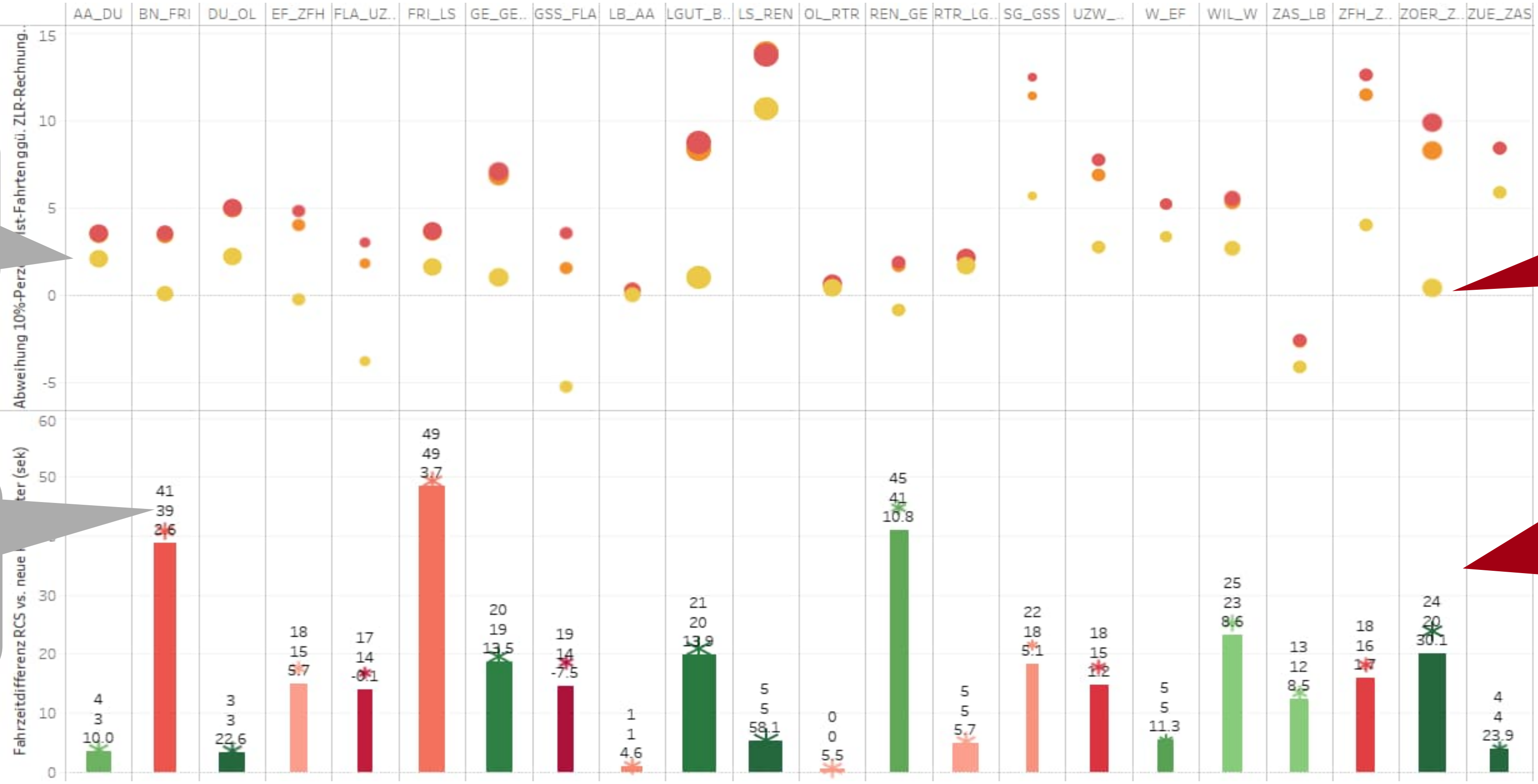
Limitation: Possibly too conservative braking at large speed reduction with low target speed



Additional statistics created for Passenger traffic for quality and impact assessment.

Example: IC1 SG-GEAP with FVD: On top: How well is the 10%-percentile hit? Below: How bis is the absolute difference to the calculation in NeTS and RCS and how many reserves could have remained with timetable 21?

Percentage deviation from the 10% percentile of the actual trips compared to: Red: NeTS, Orange: RCS, Yellow: New Parameters



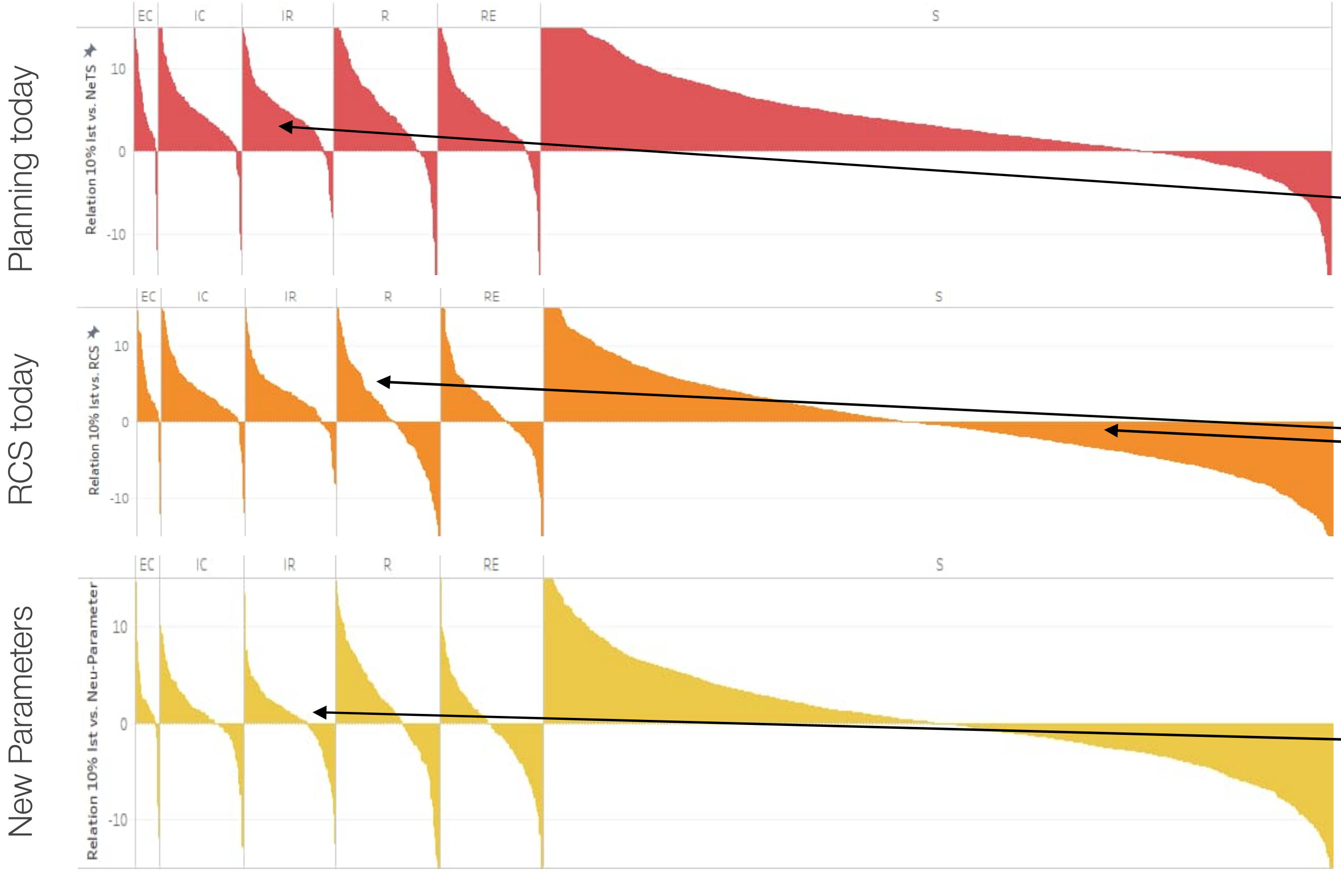
Absolute difference in minimal running time compared to:
Star: NeTS (numer above)
Bars: RCS (middle number)
Coloring: remaining reserve compared to the target driving time in Timetable 21 (number below)

With the new parametrization, almost all sections end up near the 10% percentile.

In half of the sections, less then 7% reserve (red) remains compared to timetable 21. This is especially true where there are punctuality problems (BN-LS) or where delays can be reduced at the stops (SG-W)

Overall statistic for passenger traffic

Goal: Minimal running time approx. 10%-Percentile of delayed actual journeys

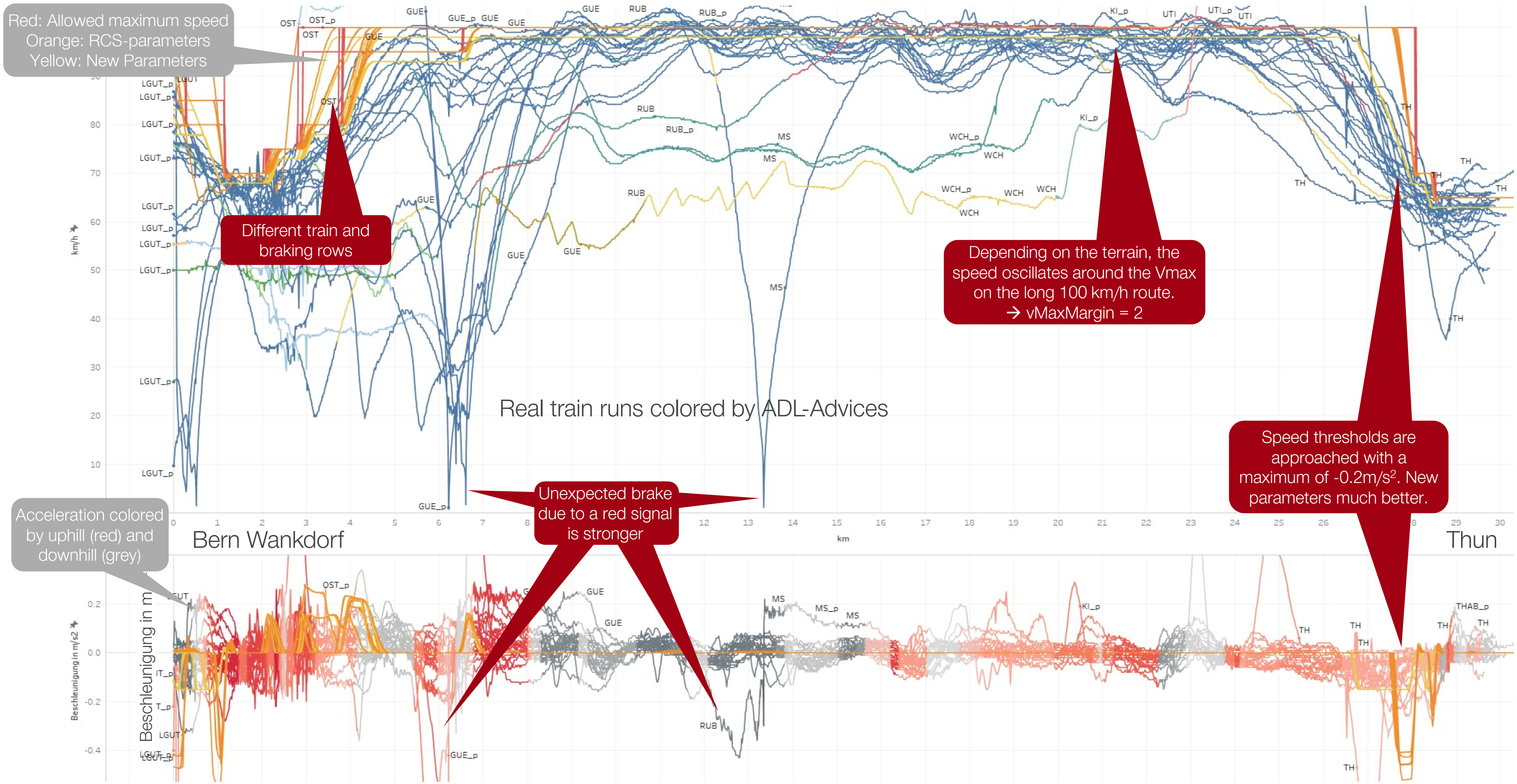


Minimal running times used in planning today, are significantly shorter than the "10% fastest train". The planned reserves are already consumed by the overly optimistic running times and are no longer available for reducing delays or planning construction sites.

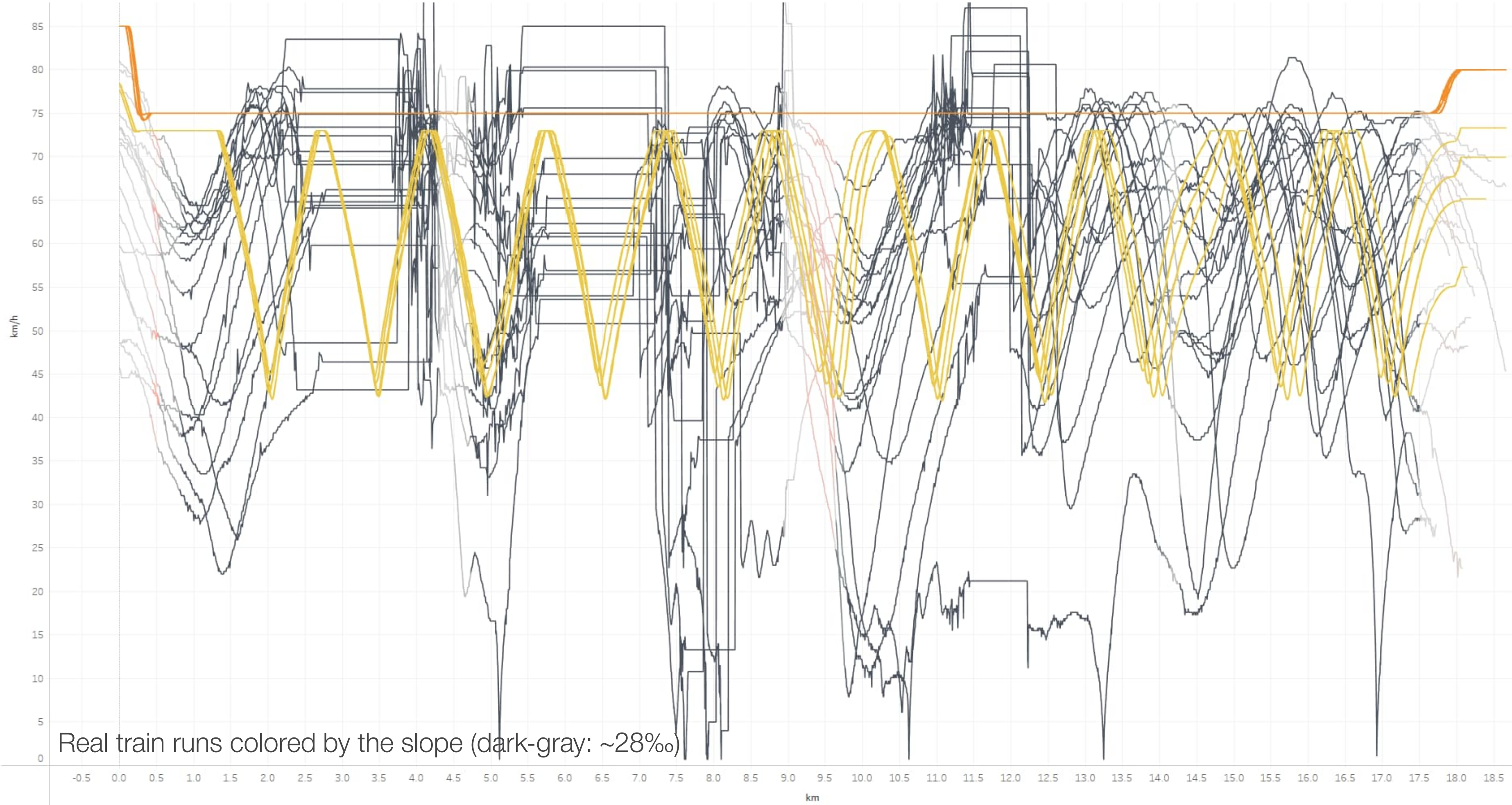
RCS is slightly better especially for regional trains.

With the new parameterization, the goal is achieved well overall

Freight trains make heavy use of the terrain and brake much more defensively



Sawtooth-Rule: Kandersteg - Frutigen



Remaining Problems

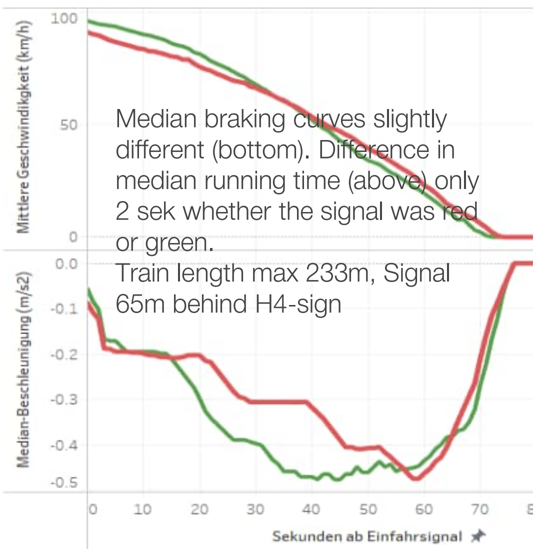
Brake on a red signal at planned stops

The braking behavior in response to a red signal depends on:

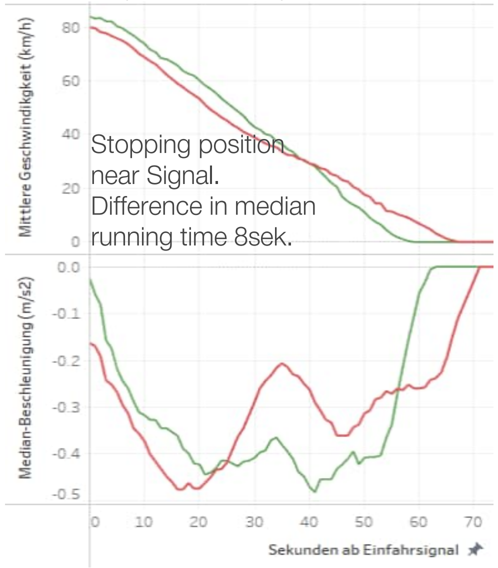
a) Stopping position (distance to the red signal)
b) ETCS L2 or visual signaling
c) Whether vehicles are equipped bith BL3 or not.

Whether a signal is red or green depends in most cases on other trains and cannot be easily predicted!

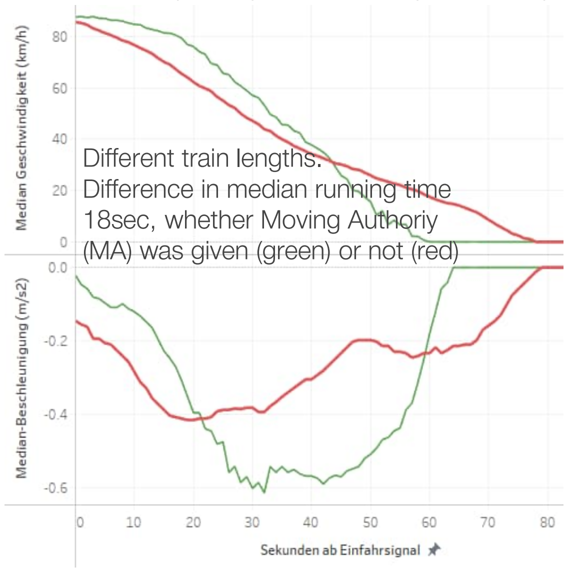
IC3 (550) Arrival LQ.



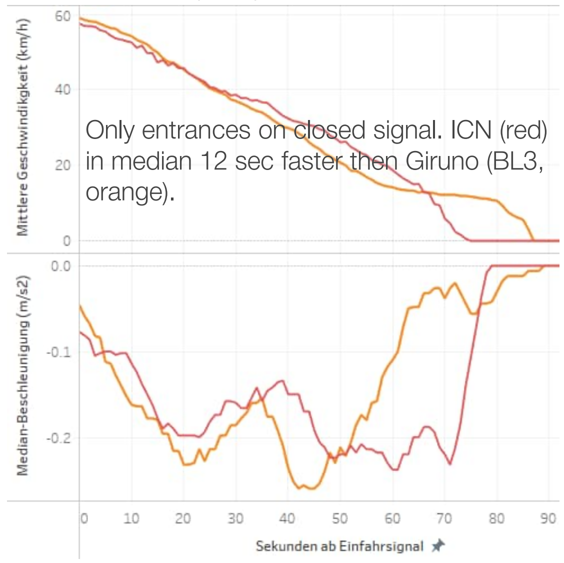
IC5 (1500 2ICN) Arrival BI



IR90 (1800) Arrival VV (ETCS L2)



IC2 (851) Arrival GD.



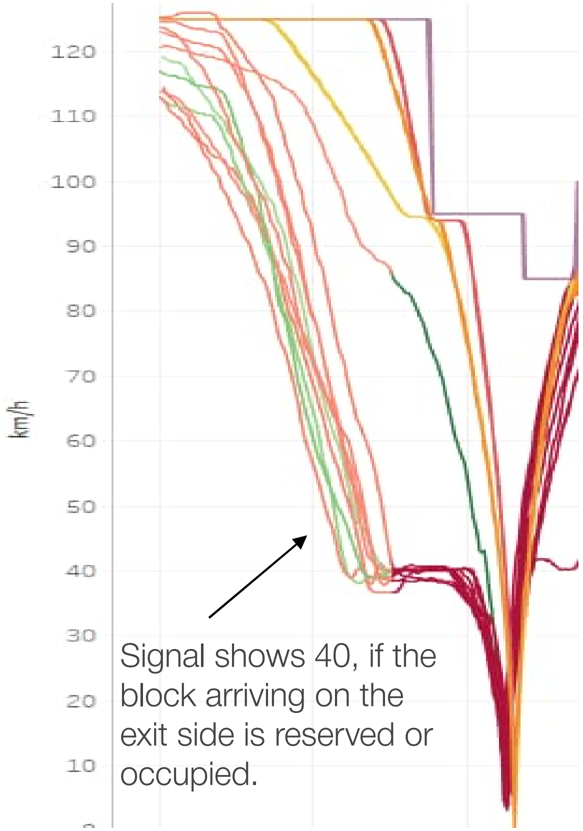
Signaled reduced speed

Reduced speed is signaled if, for example, the slipping distance at the next signal is not sufficient or if the braking distance to the next main signal is too small.

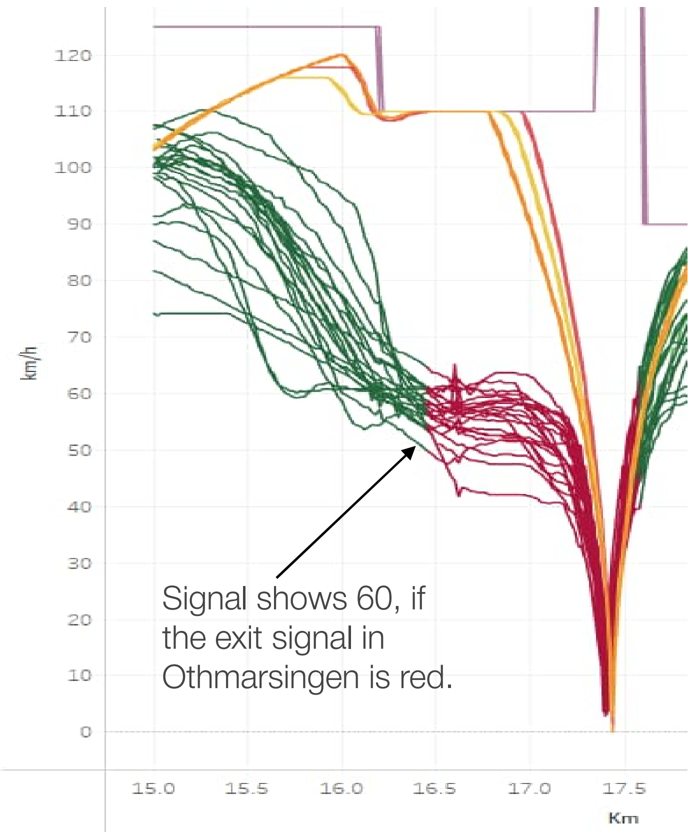
Whether a a redused speed is signaled depends on other trains and cannot be easily predicted!

IC1 (700) Approaching LS

IR13 (3275) Approaching ALT

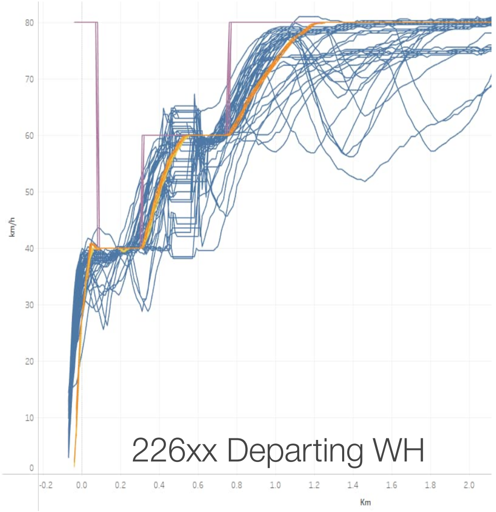


S23 (8400) Approaching OTH

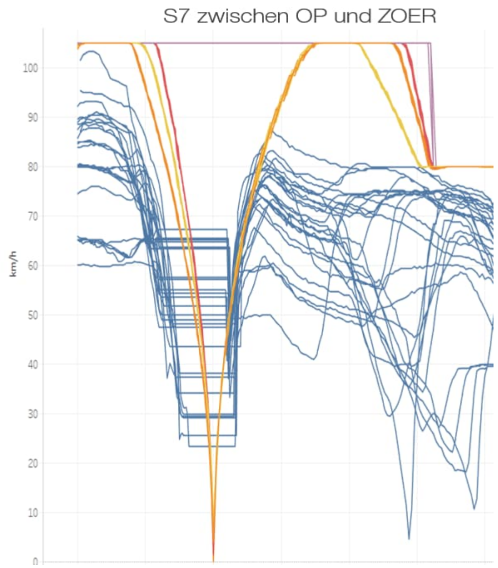


And…

- Effectiveness brake



- Schutzstrecken (Dead Sections?)



- Tunnel resistance / Resistance formula
  → Very important for calculating the energy consumption

- Correct stopping places

- …

Implementation plan of the new Parameters

Integration of a new release of the ZLR-Service and the ability to define the parameters by traincategory:

- RCS (with ADL, HOT, vPro): Development completed, in testing. Plan: productive by September.

- NeTS: Development completed, in testing. Plan: Timetable 2025 planned on the basis of the new Parameters.

- Virato: Plan: Development completed by autumn.

- ZLR-Toolbox: In production.


Voie
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Questions?