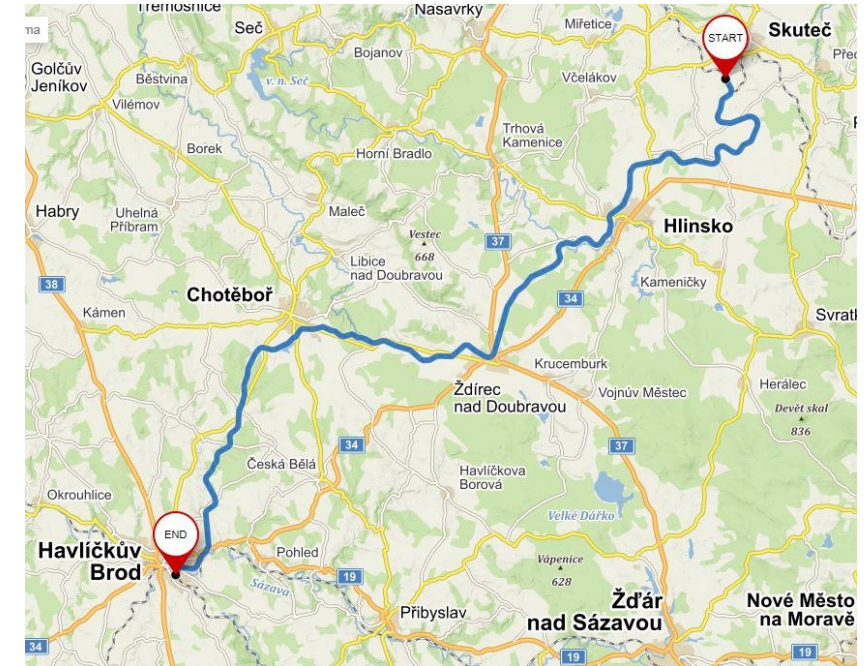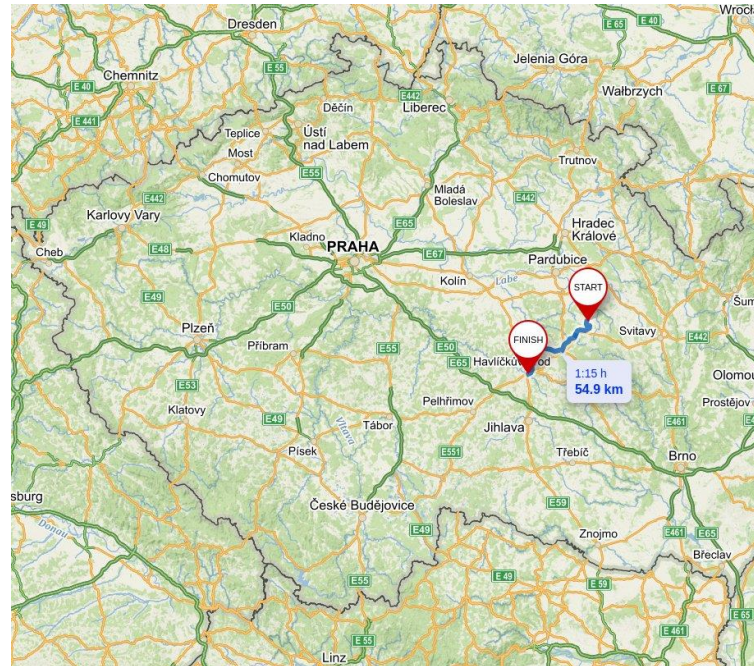# GNSS Fail-safe Train Positioning

AŽD Praha s.r.o.

GNSS Fail-safe Train Positioning

- The technical solution follows the specifications agreed in X2Rail-2 and evolved in X2Rail-5

- The current focus is now on Virtual Balise concept however most of the gained knowledge is also applicable for Stand-alone Train Positioning

- The key elements used in AZD's positioning solution include:
  - Multi-constellation (GPS + Galileo) and Multi-frequency (L1 + L5) position estimation
  - Utilization of redundancy in GNSS measurements (RAIM)
  - Utilization of track map (track axis) together with additional a priori information regarding reception conditions along the track
 - GNSS and kinematic (speed) sensor fusion in a spatial moving window

Line: Havlickuv Brod – Zdarec u Skutce (HBZ)

- The line is situated in Czechia and owned by the state infrastructure provider (Sprava zeleznic)
- The line was used for an extensive data collection campaign in 2020
- The utilized railway vehicle was in regular commercial operation
- Recorded data include GNSS raw measurements, kinematic sensor data, RF samples in L1 and L5 bans

Test line: Kopidlno – Dolni Bousov (KDB)

- The line is situated in Czechia (Central Bohemian region) and it is a test line owned by AZD
- This test line is intended for a live demonstration of the Fail-Safe Train Positioning Demonstrator at the end of X2Rail-5
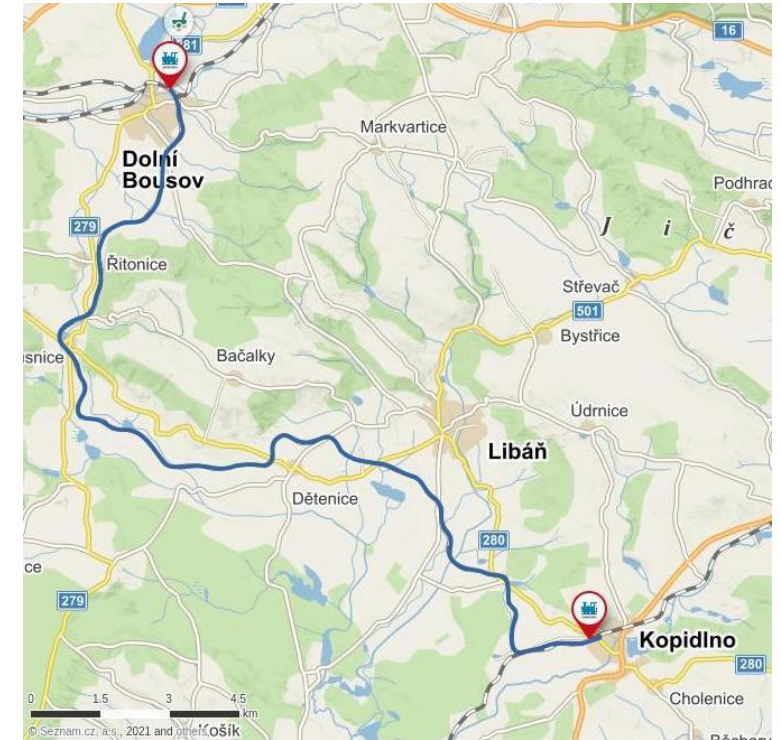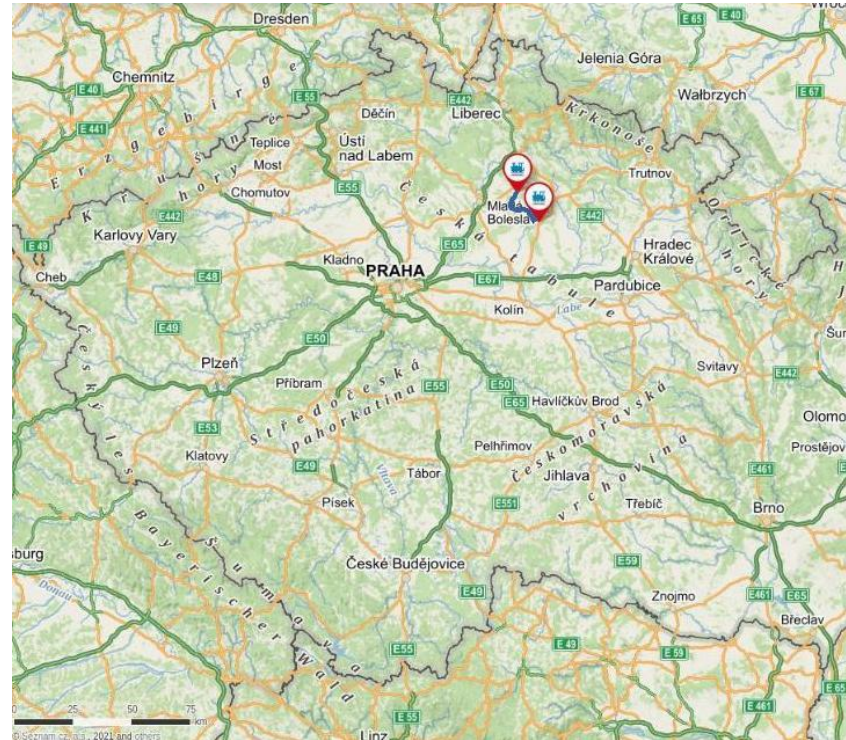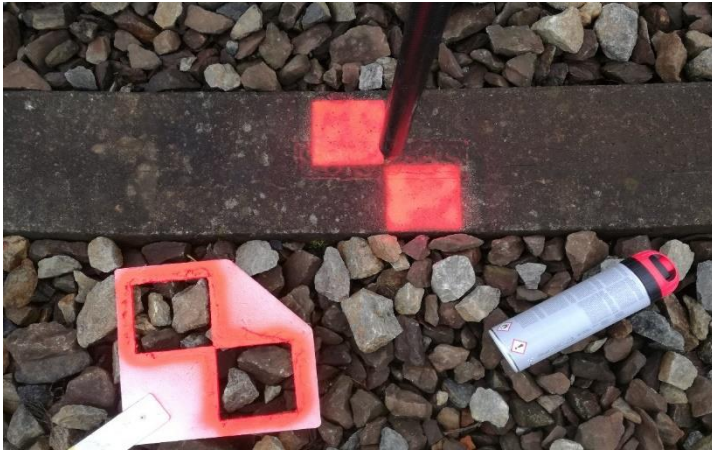
Equipment for GNSS and sensor data record

- Equipment testing in laboratory

- Equipment installed on a vehicle
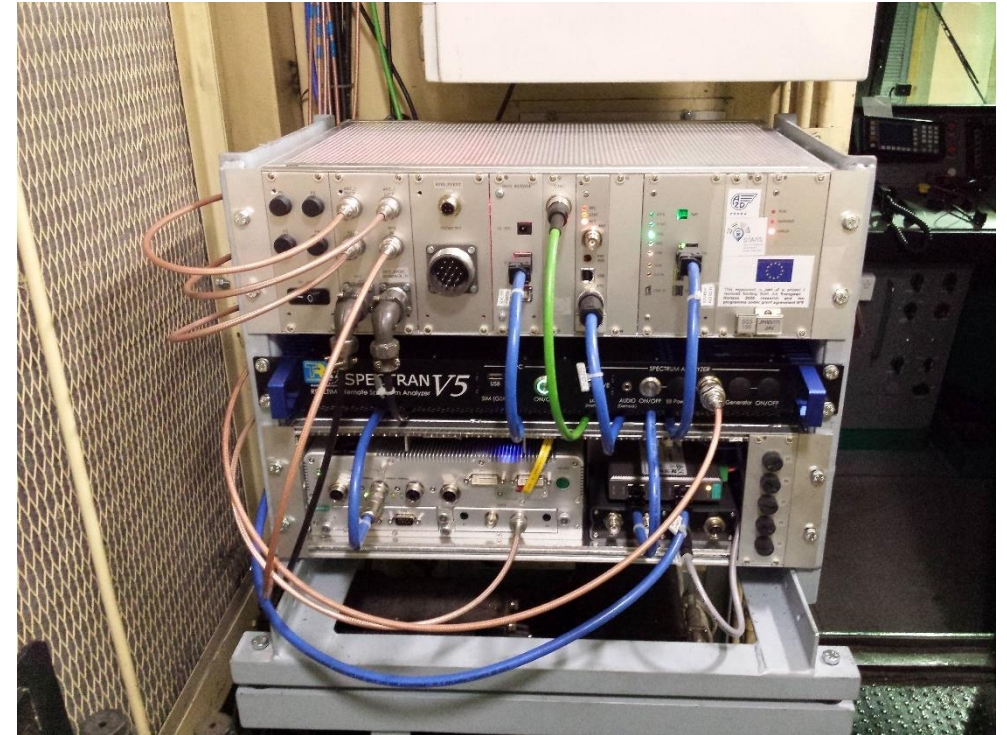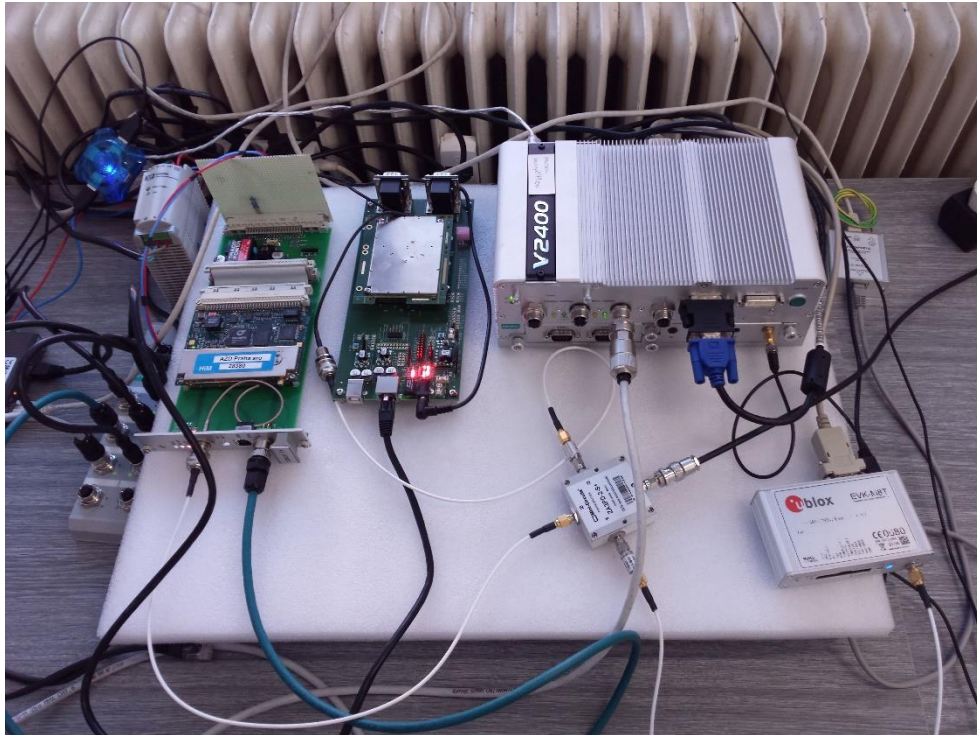
Track map - Geodetic survey

- Geodetic points on track centrelines are essential inputs for Track map

- Also necessary for alignment of cloud points from laser scanning measurement
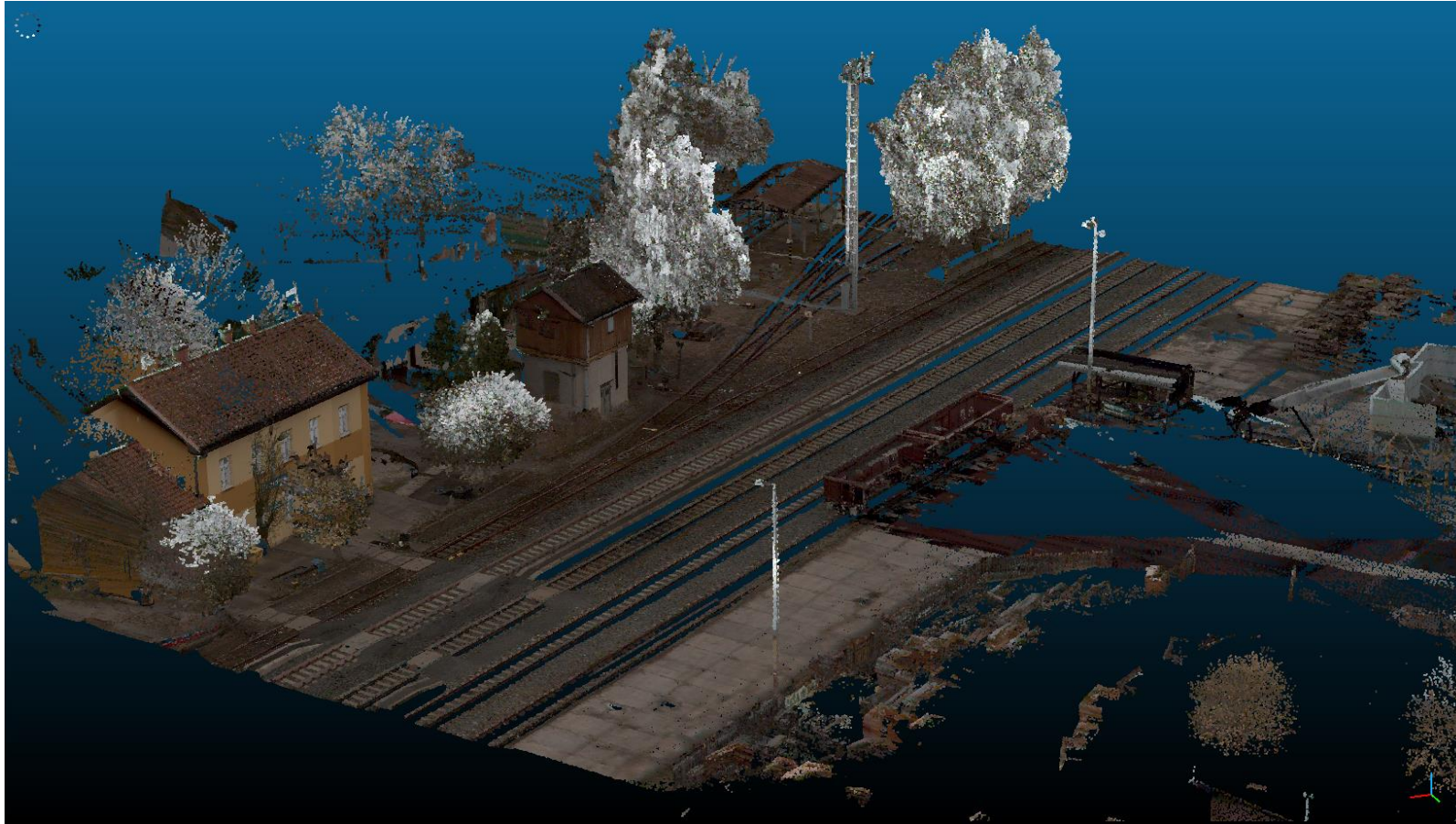
Track map – laser scanning

- Making measurements on Havlickuv Brod – Zdarec u Skutce line

Track map – laser scanning

- Point cloud visualization (colourized) of Kopidlno station, on the Kopidlno – Dolni Bousov line

Track map – panoramic figures

- Making Measurements on Kopidlno – Dolni Bousov line

Track map – a priori reception information

- A priori reception information is implemented using a set of sky-visibility masks
- Masks can be prepared either from panoramic figures or from cloud points of laser scanning
- Creating of sky-visibility masks from panoramic figures is presented below
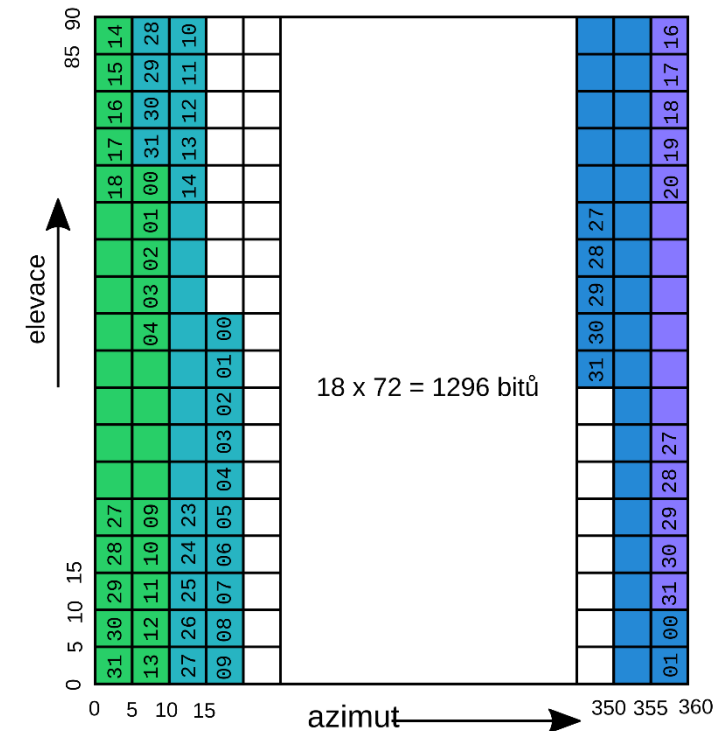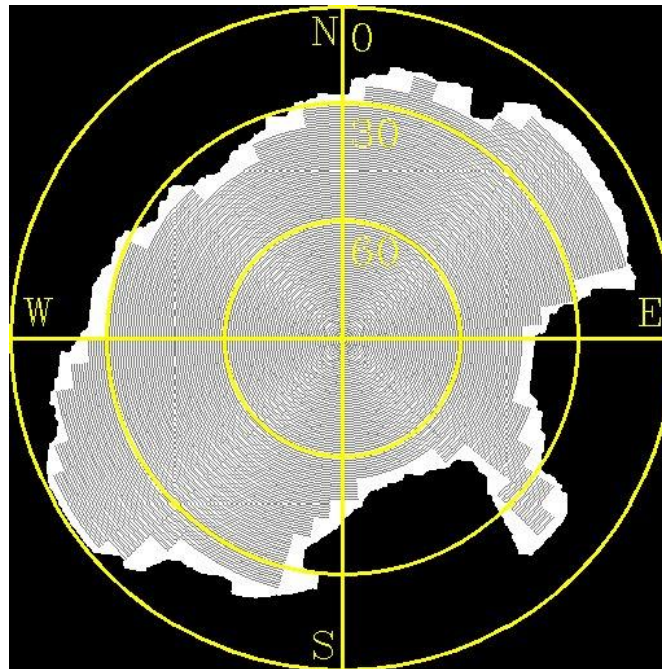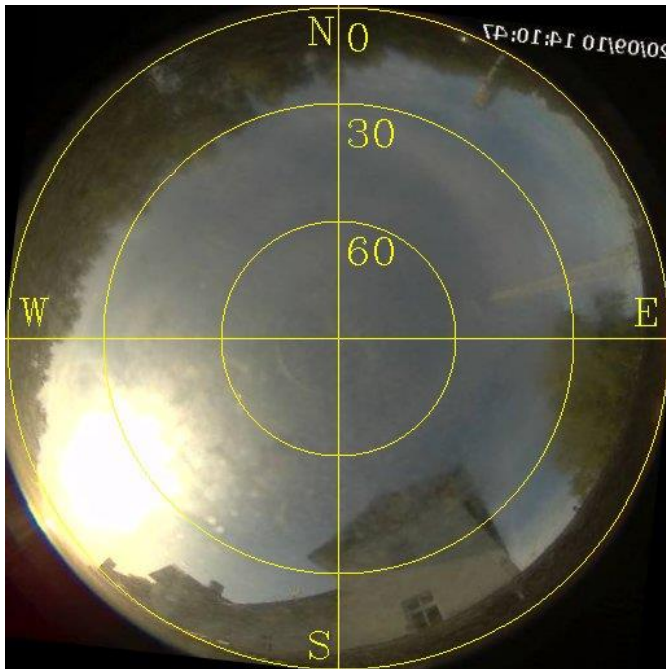
Identification of local feared events – multipath

- Multipath analysis using CmC technique: static measurement on the selected spot

- Multipath analysis using receiver's built-in function determining multipath error: analysis on the selected train run
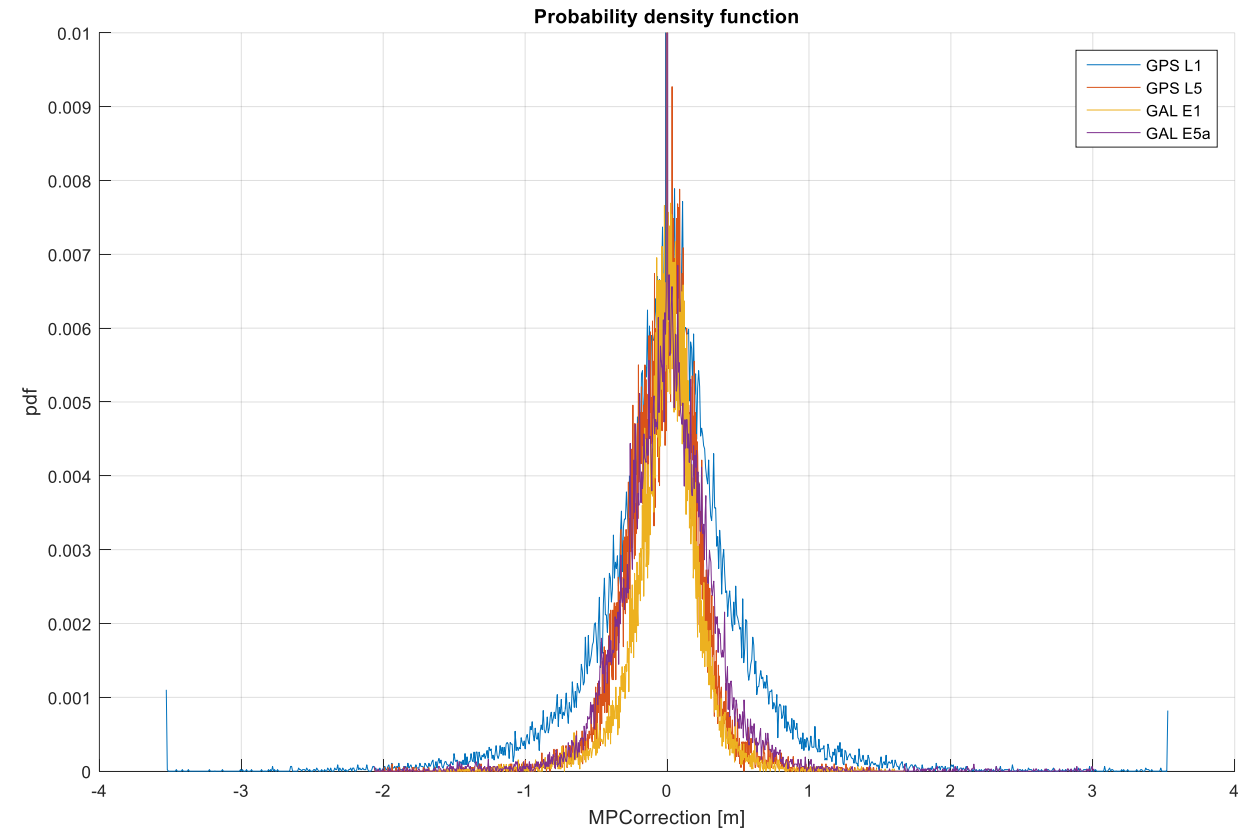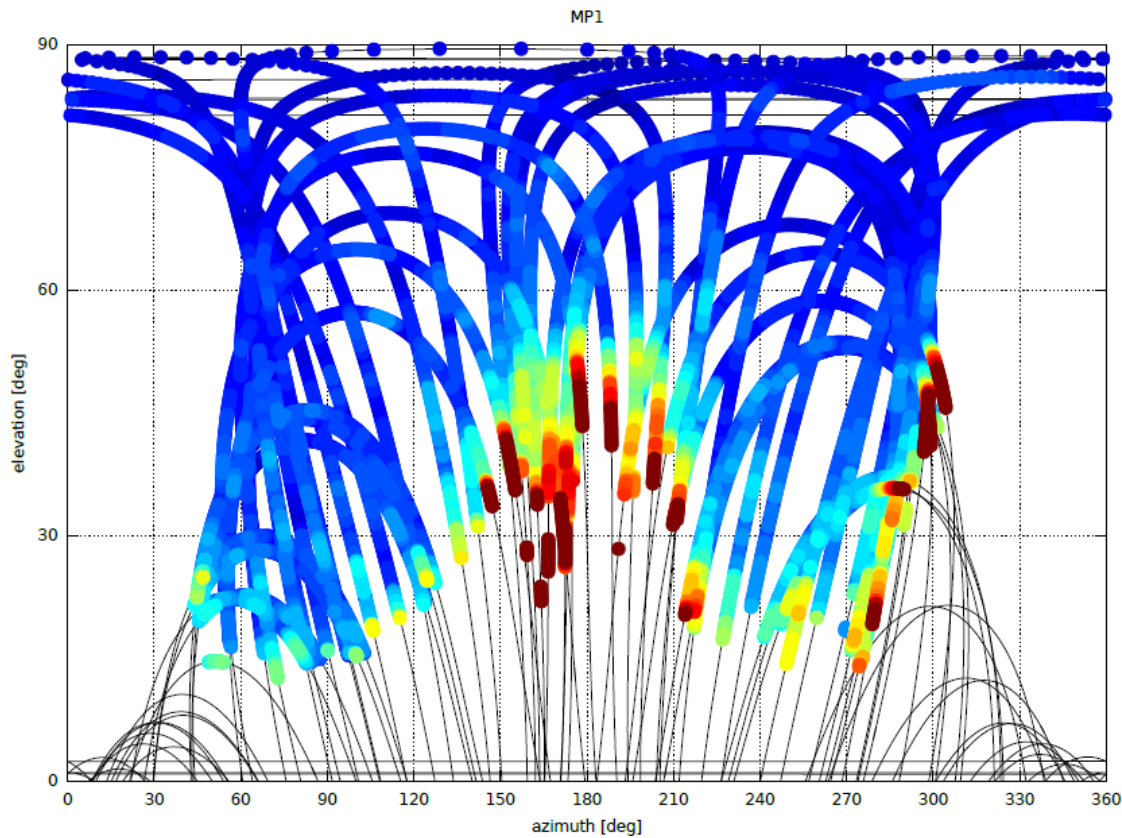
Identification of local feared events – RF interference

- **Histogram of RF samples (L1 band)**

data: 210320065735.L1.hist_ii.mat

data: 210320065735.L1.hist_ii.mat
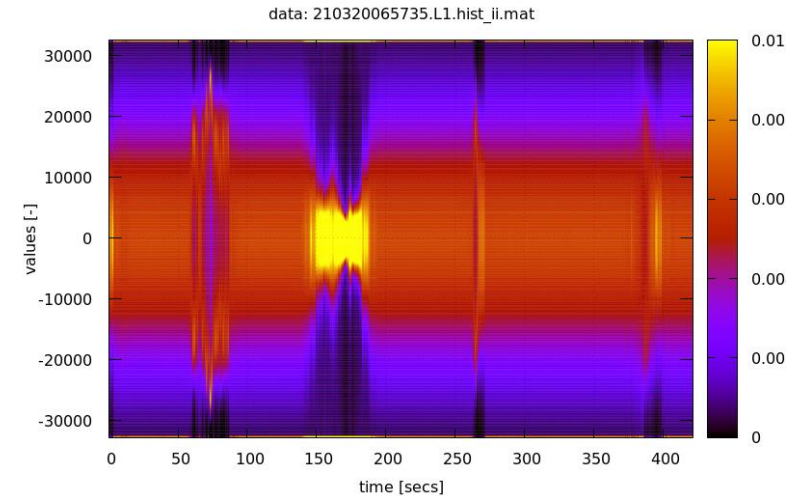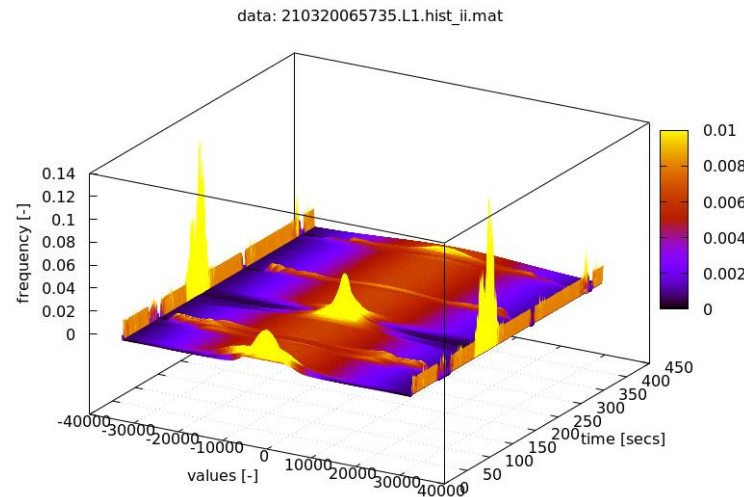
- **Power spectral density (L1 band)**

data: 210320065735.L1.psdout.mat

data: 210320065735.L1.psdout.mat
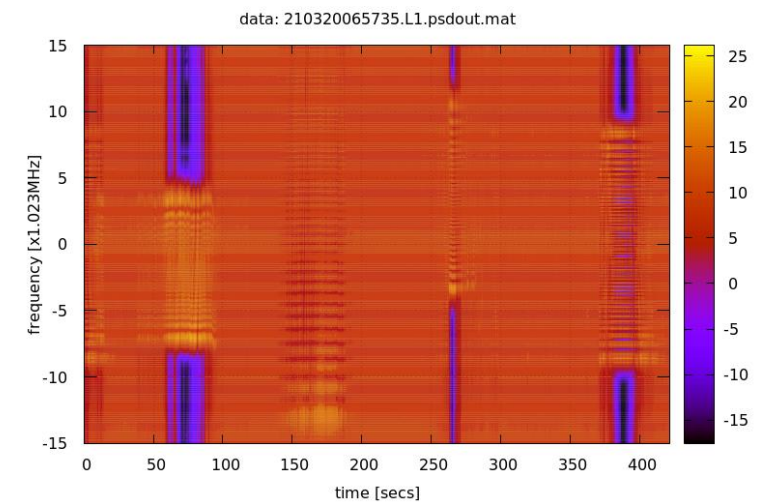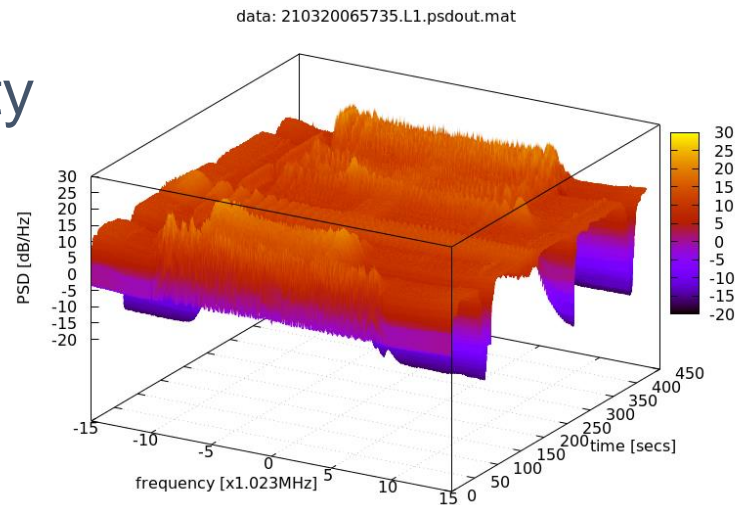
Performance evaluation – localization availability

- Figures show availability (in % of entire train run duration) of particular observables (left for GPS satellites, right for Galileo)

AŽD - PVT Viewer

Recorded with iTop Screen Recorder

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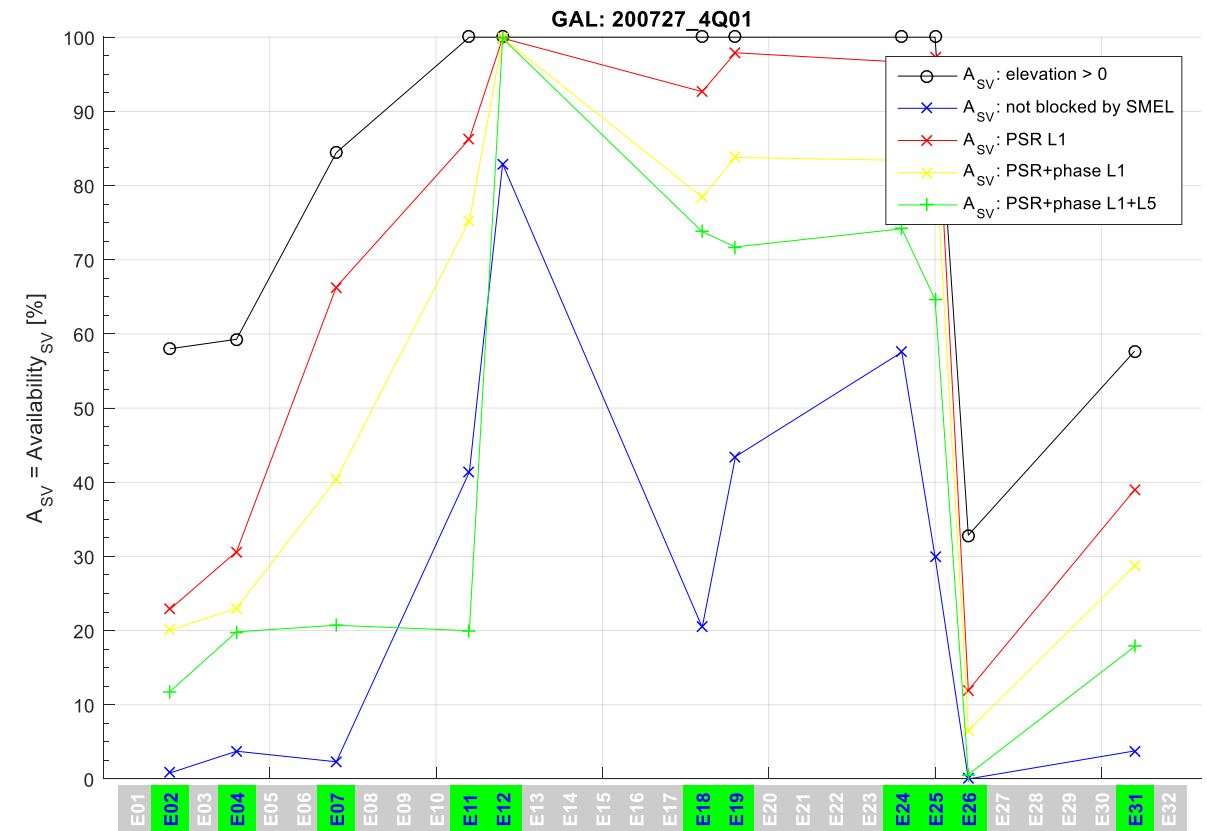
☑ Centre   Centre   Stop   Prev   Next

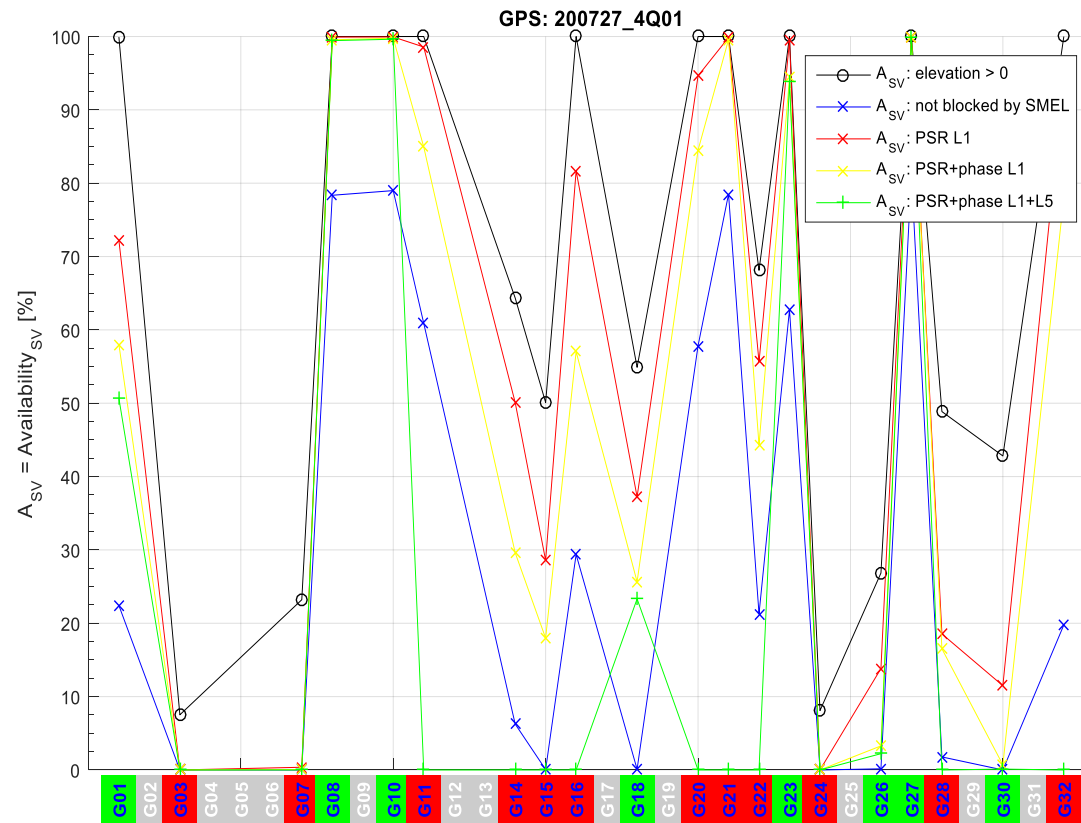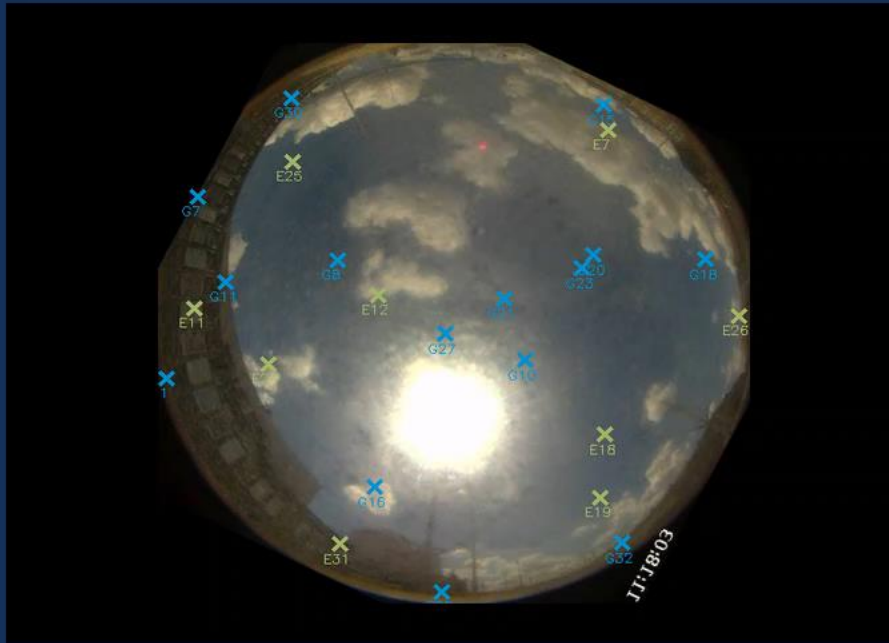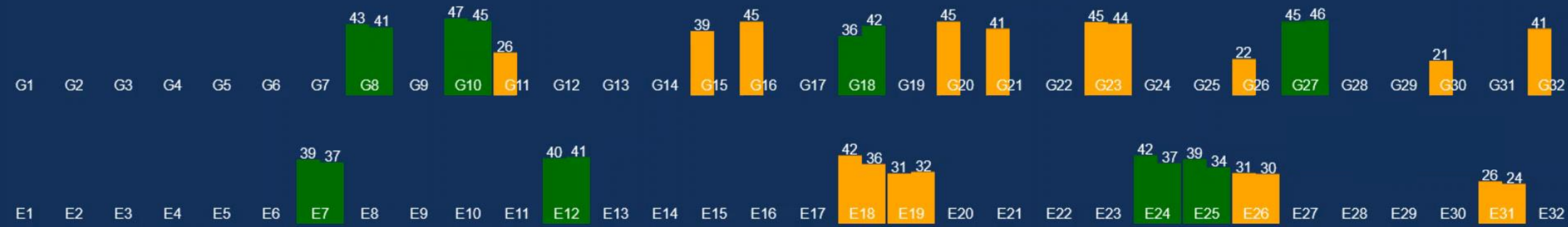| time		DOP	
TOW:	127101 s	GDOP:	3.3
WN:	2116	HDOP:	1.7
satellites in used (received)		1D position	
GPS:	4 (13)	Lenght of confidence interval:	19.03 m
Galileo:	4 (8)	Centre of confidence interval:	214.20 m

G1 G2 G3 G4 G5 G6 G7 G8 G9 G10 G11 G12 G13 G14 G15 G16 G17 G18 G19 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 G32

43 41   47 45   26   39 45   36 42   45 41   45 44   45 46   22   21   41

E1 E2 E3 E4 E5 E6 E7 E8 E9 E10 E11 E12 E13 E14 E15 E16 E17 E18 E19 E20 E21 E22 E23 E24 E25 E26 E27 E28 E29 E30 E31 E32

39 37   40 41   42 36 31 32   42 37 39 34 31 30   26 24

Onsite testing of Fail-safe Train Positioning

- The figure presents a concept of onsite testing
- Estimate Safe Train Position (ESTP) represents vehicle safe localization function
- ESTP consist of:
  - "GNSS Based Position" function – EGBP
  - "Coasting" function – CGBP
- The communication between trackside and on-board constituents will be ensured with public internet connection
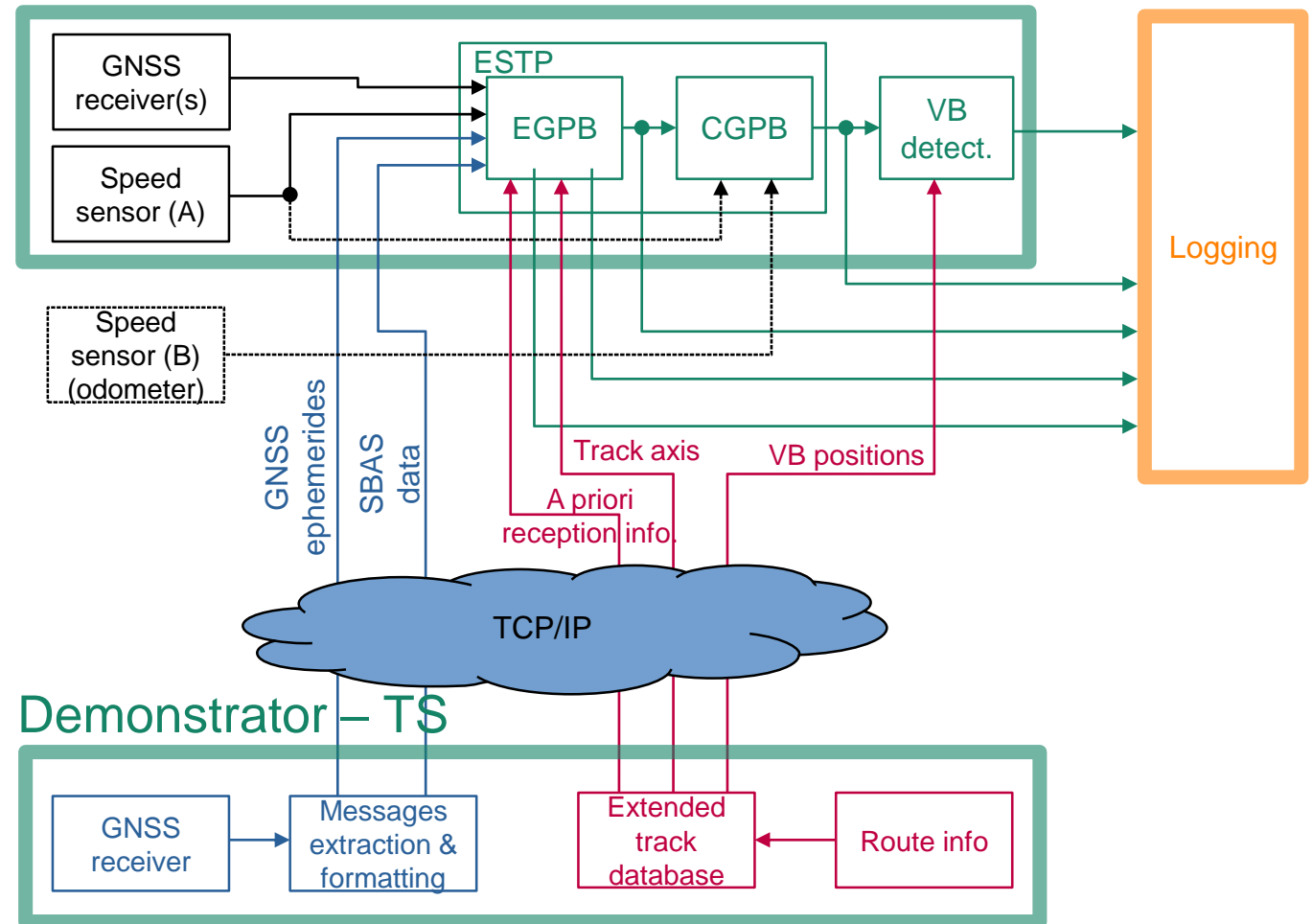
Onsite testing – prototype development

- The focus of onside testing is on the on-board constituent – the goal is to implement and test of a full-scale ESTP (including all proposed safety measures)

- The prototype of the on-board constituent is under development

- The significant milestone will be a presentation of Demonstrator on the Kopidlno – Dolni Bousov line at the end of X2Rail-5 (spring 2023)

- The next evolution of AZD's Fail-safe train positioning is foreseen in Europe's Rail