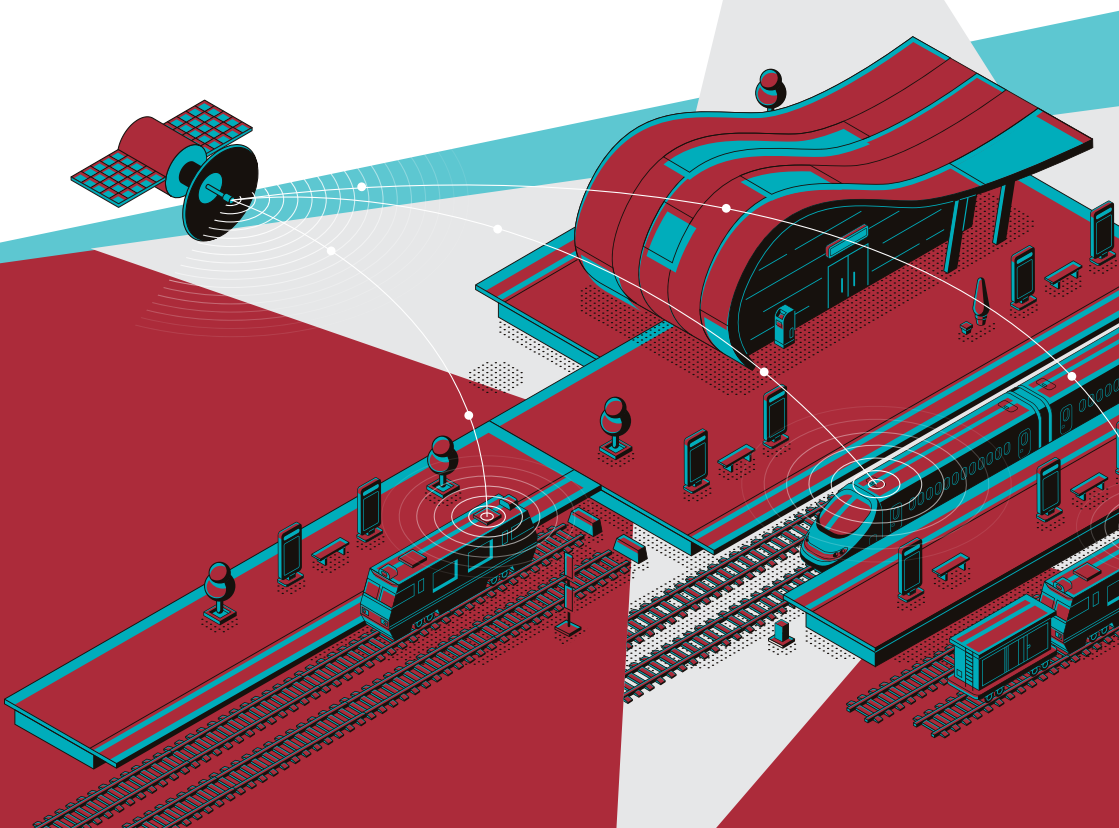




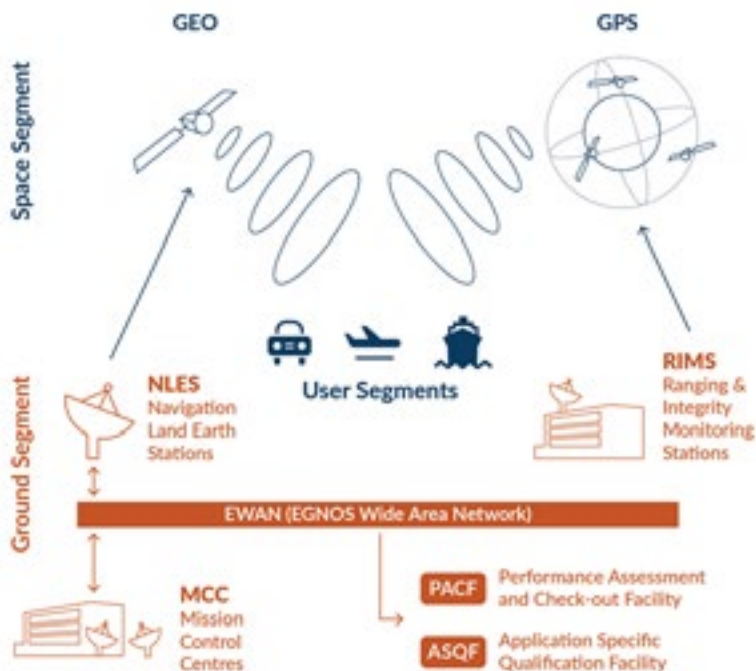
SAtellite-based Signalling
and Automation SysTems on RaiLways along
with Formal Method and Moving Block validation

GNSS MINIMUM PERFORMANCE REQUIREMENTS FOR RAIL

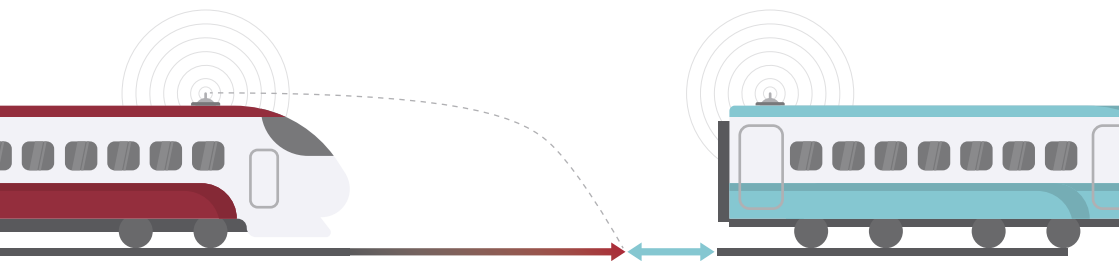


TRAIN CONTROL AND SIGNALING POSITION, NAVIGATION AND TIME (PNT) APPLICATIONS WITH GNSS

The GNSS Based Localisation System (GBLS) is a multiple layer GNSS augmentation to the core constellations (GPS, Galileo,.....) that with the aid of SBAS corrections provides integrity and performance information to support rail localisation operations. SBAS implementations (WAAS, EGNOS,.....) are safety critical systems consisting of a reference receiver network and integrity monitoring sites to assess GNSS constellation performance.



Approach accounts for the communication delay, the SBAS time-to-alert, confidence intervals on the position and velocity of the train; it is based on the use of topographic height data as a basis for characterising the local environment along the rail route network.



In the ASTRail project we analysed a GNSS-Based Localisation System (GBLS) applied to the Moving Block signalling system according to ERTMS lev.3.

Three modes of GBLS operation were considered:

Legacy:

use of existing physical balises and odometry employing non-GNSS dead-reckoning sensors

Enhanced Odometry:

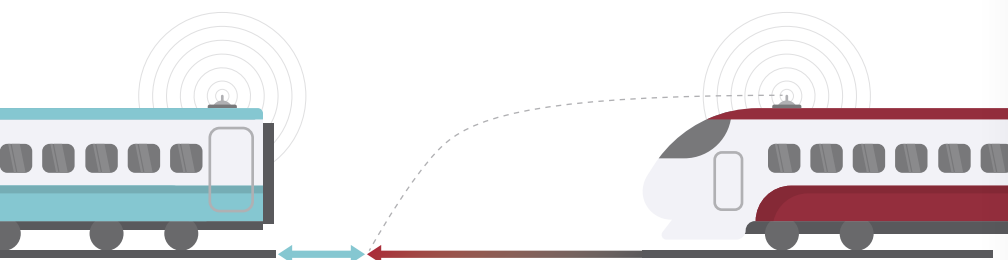
reduction in the number of physical balises through enhanced odometry using hybridization between existing sensors (Doppler Radar, Wheel Sensor) and GNSS measurements

Virtual Balise (VB):

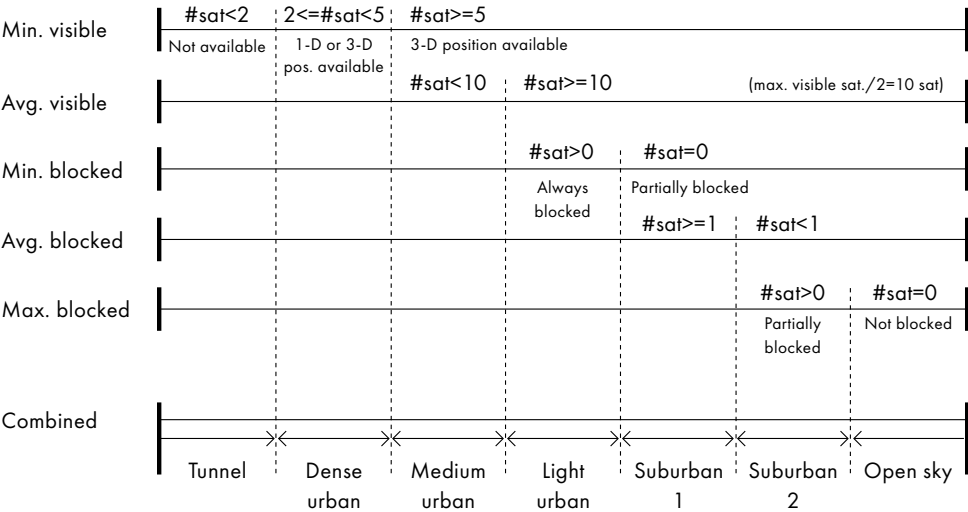
reduction in the number of physical balises to be replaced by GNSS-based virtual balises, that provide the reference location.

Not considered:

Track Identification: unable to determine the train location on parallel tracks in a robust manner using carrier phase techniques.



GNSS RECEIVER OPERATIONAL PERFORMANCE REQUIREMENTS



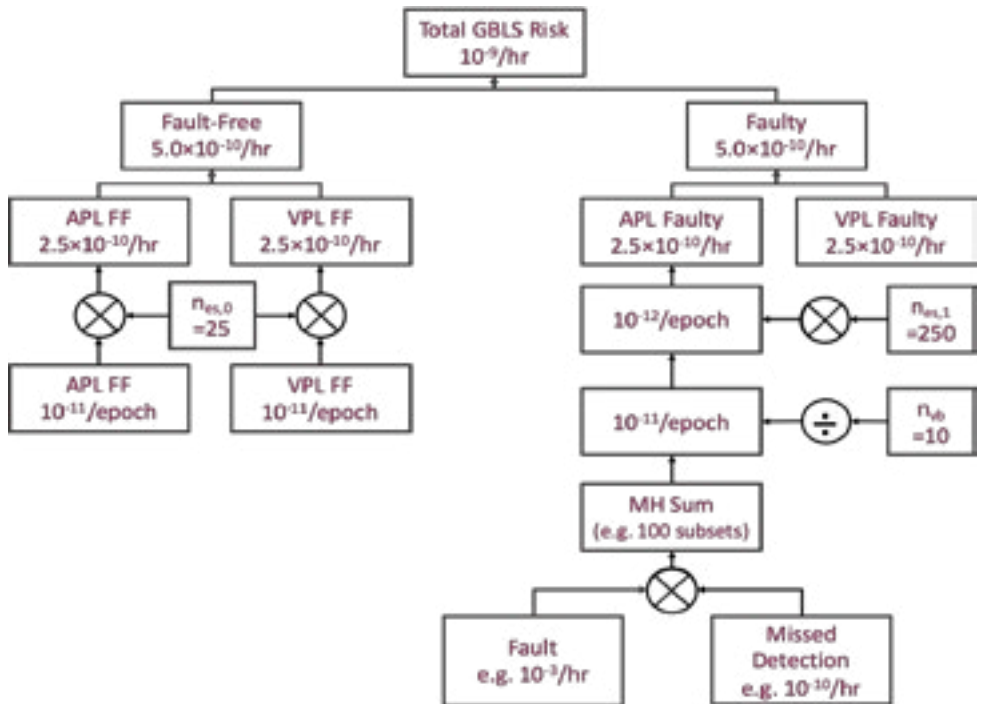
LEGACY	ENHANCED ODOMETRY	VIRTUAL BALISE
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GNSS MOPS must be written to apply to the system in a variety of environments.

The needs, operational mode and specific requirements will vary as a function of the environment and the associated mode. Each location will have an associated environment attached to it.

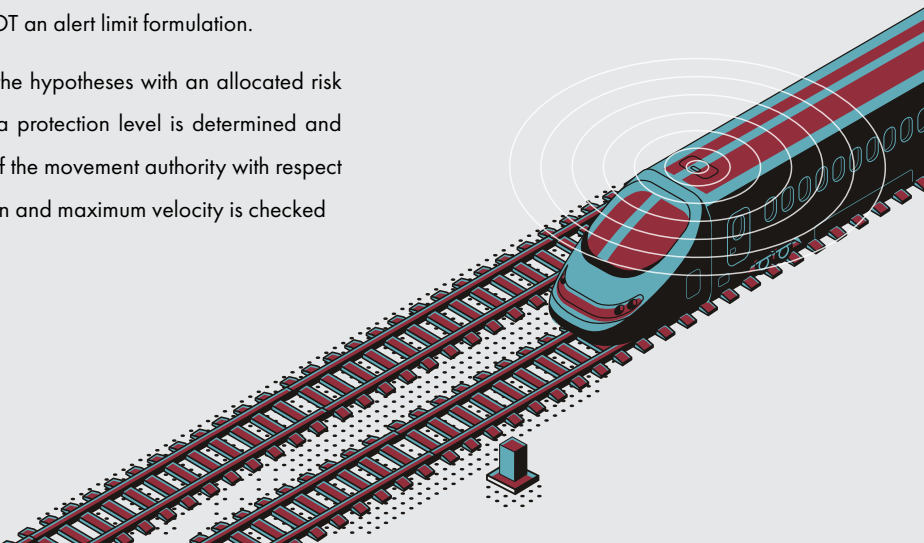
7 environments were defined (Min/Ave/Max over 48hours):

- Tunnel** - Maximum number of visible satellites is 0
- Dense urban** - Minimum number of visible satellites is less than 5
- Medium urban** - Average number of visible satellites less than 10
- Light urban** - Minimum number of blocked satellites greater than 0
- Suburban 1** - Average number of blocked satellites greater than 1
- Suburban 2** - Maximum number of blocked satellites greater than 0
- Open Sky** - Maximum number of blocked satellites is 0



Integrity concept based on a variable protection level and NOT an alert limit formulation.

For each of the hypotheses with an allocated risk (see figure) a protection level is determined and the validity of the movement authority with respect to the position and maximum velocity is checked



PROJECT MEMBERS

PROJECT COORDINATOR



TECHNICAL LEADER



PROJECT PARTNERS



Ardanuy



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