High Integrity Navigation Overlay Services For Railway Applications: a selected example of Italian GNSS perspective

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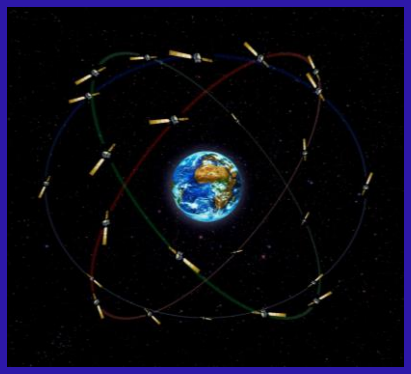
Italy and Satellite Navigation



Italy is one of the four major contributors to the European GNSS

Italian national strategy based on use on EU systems Galileo and EGNOS and on interoperability with other GNSSs; Italy hosts one of the Galileo Control Centre

Italy recognises the potentiality of GNSS to be a pillar for innovation of the society and for SME development

Italy recognises the potentiality of the integration among Navigation, Telecommunication and Earth Observation disciplines

The Italian Space Agency have undertaken initiative to develop pre-operational project for several applicative sectors.

Selected Sectors and Priorities

Mainly the following sectors have been addressed:

Maritime
Civil Aviation
Road (including hazordous transportation)
Infomobility
Rail

Among other programmes undertaken:

- PRESAGO project to define procedural methods and procedures required for PRS (Public Regulated Service - the Galileo classified service)
- SENECA project to promote the GNSS based innovation on Civil Aviation
- Several SME initiatives supporting development of selected applications (e.g. UAV, interport management) and technology developments (e.g. innovative antennas, atomic clocks)

ASI, recognising the importance of the rail sector and the potentiality for satellite based innovation (particularly for regional rail safety and efficiency enhancement), is fostering the role of the Satellite Navigation and Telecommunication for rail

ERTMS-ETCS Market Evolution

Served Railways	80,000 km
Vehicles	10,000

- ERTMS-ETCS (European Rail Traffic Management System – European Train Control System) developed in Europe for high speed lines is *de facto* the railways standard train control system being adopted in most new lines and major upgrades.
- By fact, major limitation to its extensive adoption (i.e. local and regional lines, freight lines) is the cost associated with its implementation and maintenance

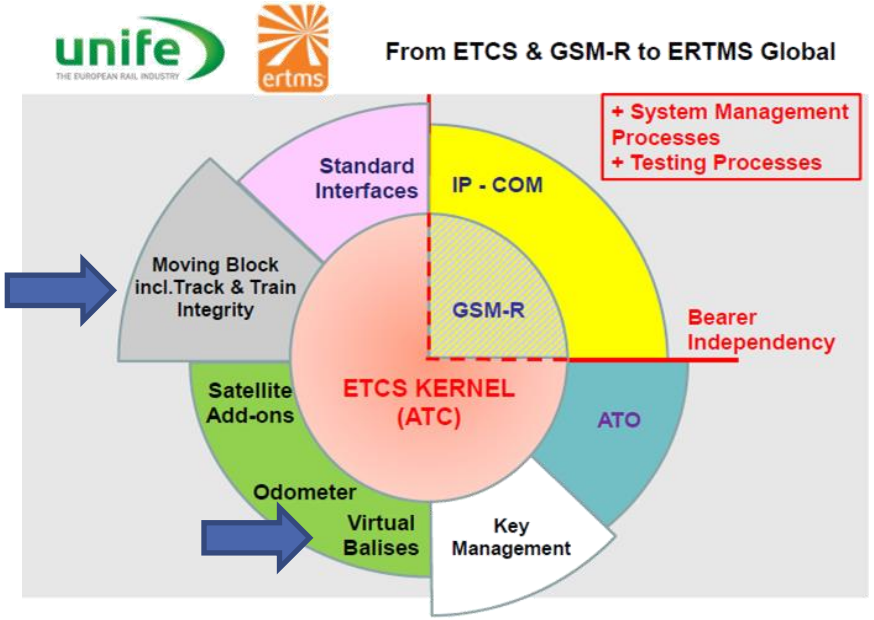
Why satellite technology?

Main advantages

- Reduction of operational and maintenance cost
- Increasing of line capacity

Market perspective:

- Cost-effective solution to increase safety on low traffic lines
- Increase traffic on many lines

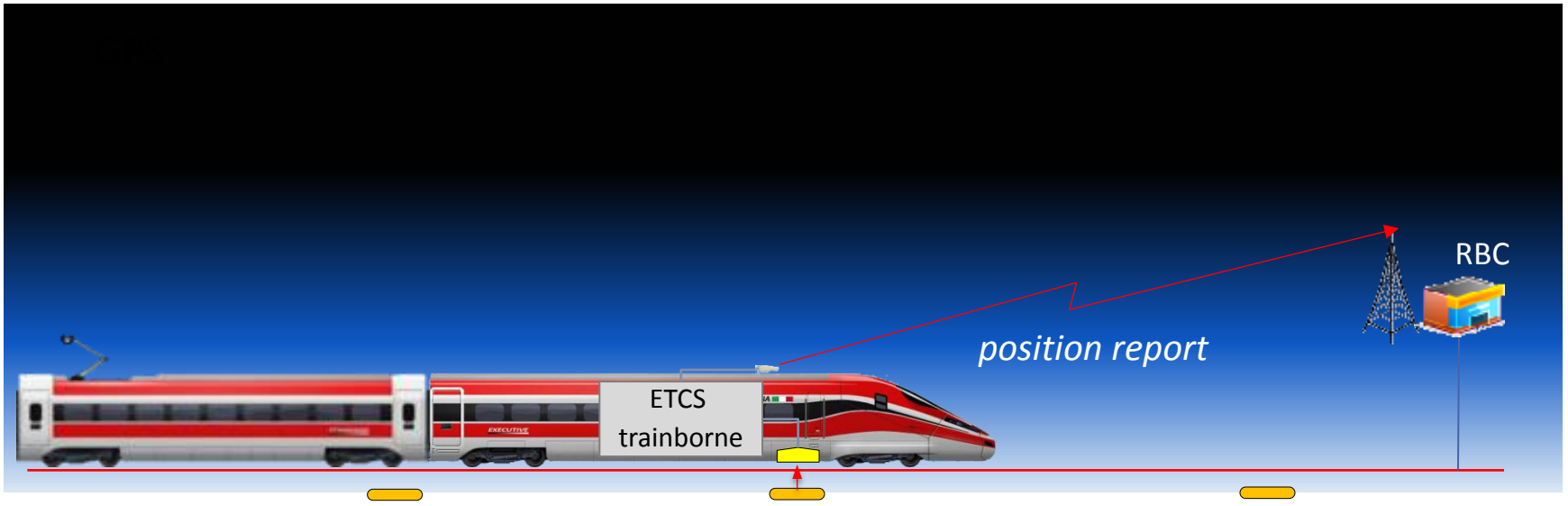


Main challenge:

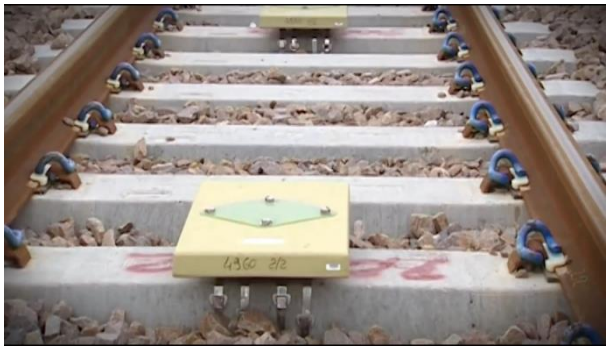
- Fulfill the **Safety Integrity Level SIL-4** requirements in terms of THR (Tolerable Hazard Rate) imposed for railways

THR ≤ 10^{-9}/h

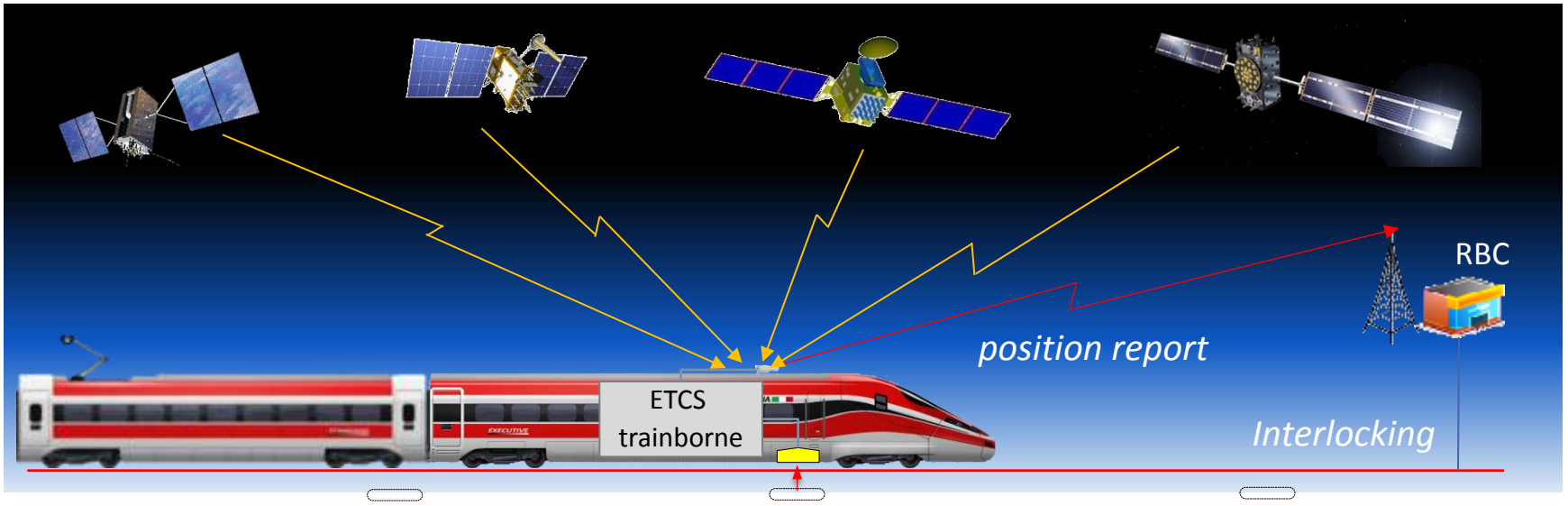
ERTMS/ETCS Train Localization



- In ERTMS/ETCS Train location is determined by means of **Balises** and **Odometry**
- The Balises are transponders deployed at georeferenced points
- The odometer provides the relative positioning w.r.t. the last balise
- When the Balise Reader energizes a balise, it receives a message with the balise Id
- The on board computer (EVC) sends a position report to the Radio Block Center



ERTMS/ETCS – GNSS based Train Localization



Virtual Balise

- The GNSS Location Determination System generates the same signals produced by a Balise Reader detecting a physical Balise, through the same logical and physical interface, then emulating the Balise reader behavior with respect to the train equipment.

- In this way the On Board ERTMS/ETCS location determination functions do not need to be changed.

GNSS-based services for Train Control

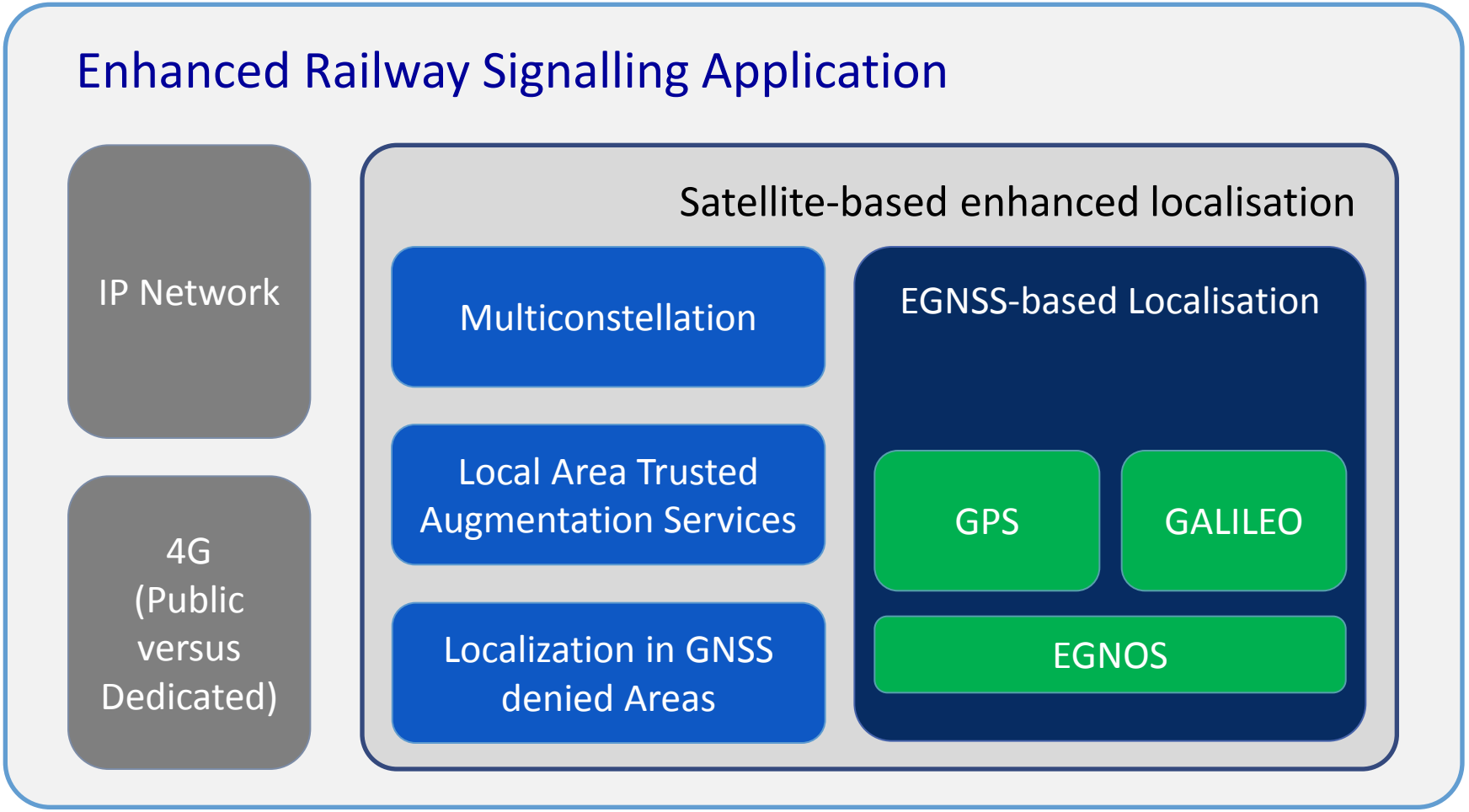
- GNSS based train location determination can be considered a disruptive technology.
- It will succeed in replacing the current technologies based on balises and track circuits if and only if it will be cost-effective.

THR ≤ 10^{-9}/h

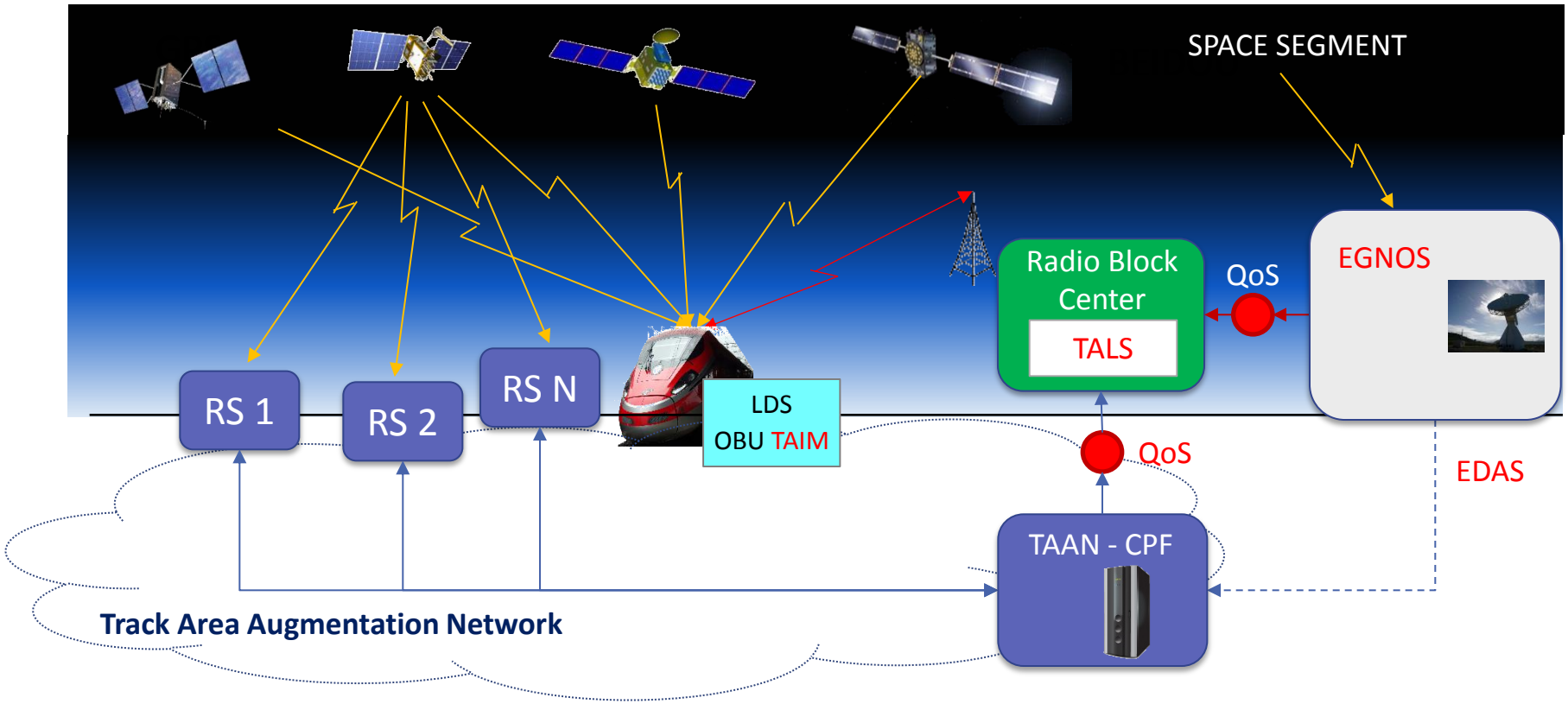
Functionality	Current Technology	SIS Integrity Monitoring	Augmetation	**Accuracy**
Train Location Determination • Single track	Based on Balise	**X**	**X**	Medium
Train Location Determination • Multiple tracks	Based on Balise, Track Circuit	**X**	**X**	Medium, High
Train Integrity	Track Circuit + On Board Circuitry	**X**		High

The ERSAT–EAV project (GSA)

ERTMS ON SATELLITE – Enabling Application Validation



ERSAT EAV High Integrity Augmentation Architecture

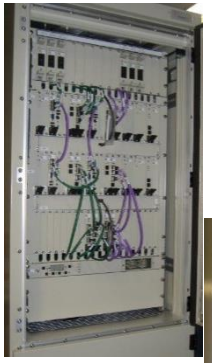


CPF	Central Processing Facilities
TALS	Track Area LDS Server
RS	Reference Station
EDAS	EGNOS Data Access Service
LDS OBU	Location Determination System On Board Unit

3InSAT Test Bed (ESA Artes 20)

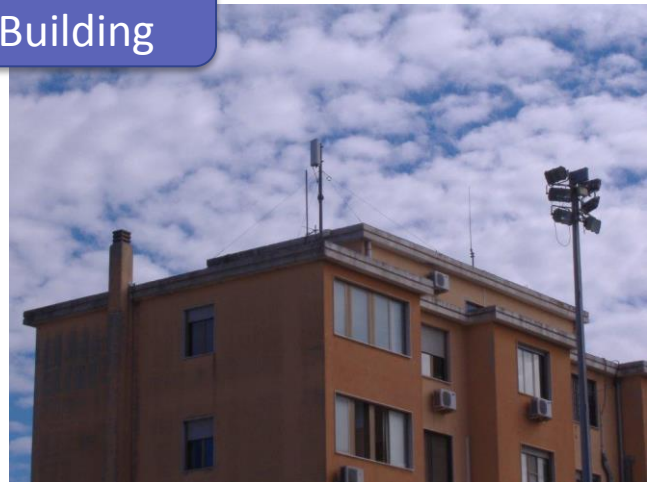
Reference Station

RBC



TALS

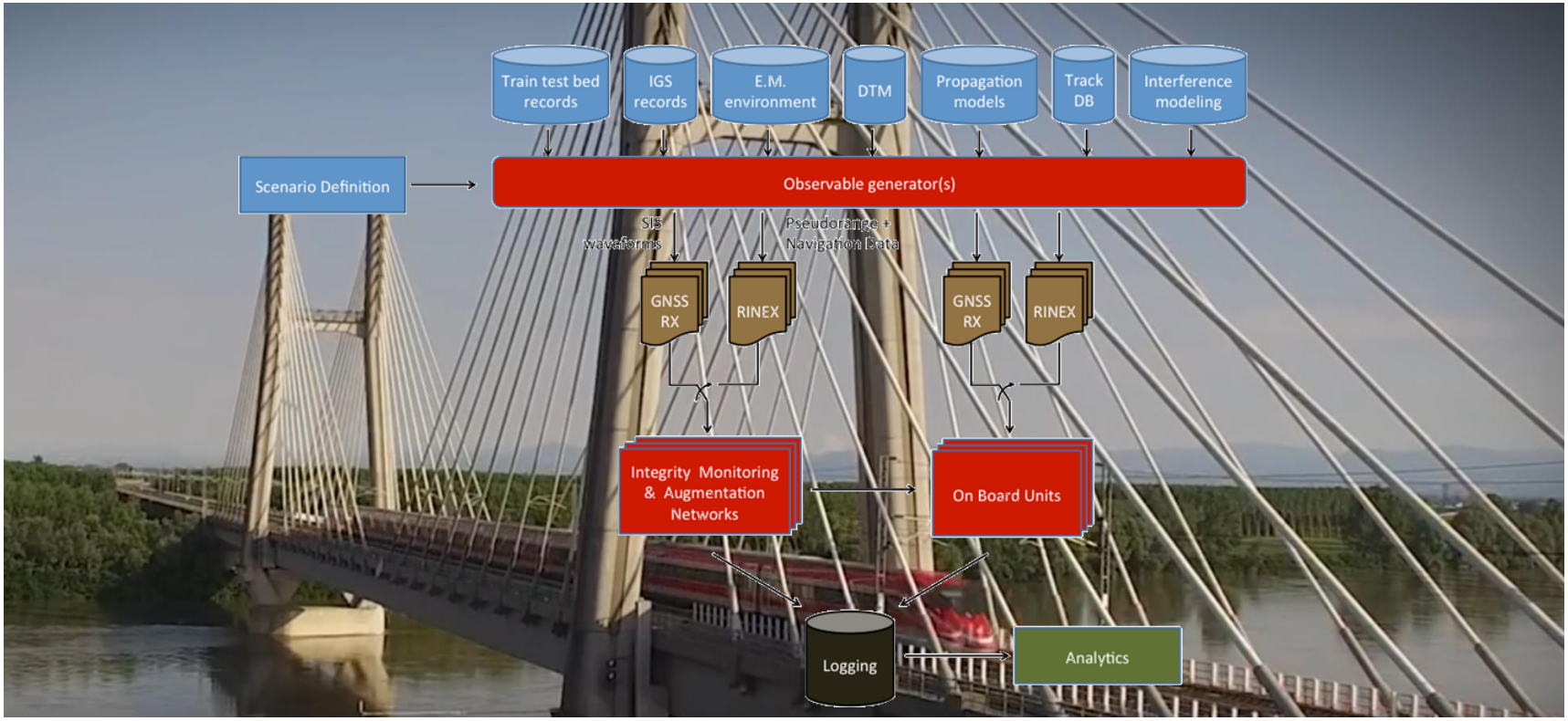
RBC Building



Train antennas

Performance Assessment: The Virtualized Testbed

- Assessing the performance of a Safety of Life system is a rather challenging task due to the fact that very small probabilities are involved.
- Approach: virtualized testbed, with
  - rich sets of data collected in a real railway environment (e.g., 3InSat & ERSAT EAV Test Bed),
  - historical time series related to rare GNSS SIS fault events (satellite malfunctions and atmosphere anomalous behaviors)
  - simulated faults for the new-coming constellations



Conclusions

- Multi-constellation architectures offer higher degree of flexibility to reach the SIL-4 level (recommended for high demanding accuracy in the railways applications).
- Nevertheless, the availability of an augmentation network is of paramount importance in reducing the Protection Level.
- Sharing as much as possible of the supporting (i.e., augmentation) infrastructure and on board processing, including new developments such as Advanced Receiver Autonomous Integrity Monitoring (ARAIM), with the avionics field is a key factor for cost effectiveness.
- Definition of a standard for the Railway High Integrity Navigation Overlay System is a key success factor for spreading the GNSS application into the rail.
- Definition of a strategic roadmap for the adoption of an international standard is of primary concern.


THANKS FOR YOUR ATTENTION

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