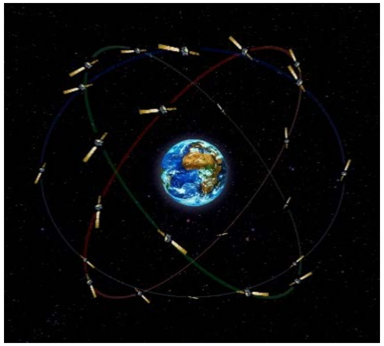
Perspectives of GNSS applications in Italy: Rail/Road synergy as selected example

Alberto Tuozzi Alessandro Neri

ICG-12 Kyoto

Satellite Navigation: Italian Perspective



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

A strategic plan called *Space Economy* was issued to define the Italian national policy for space, including a navigation related strategy currently referred as “Mirror Galileo”

Italian Space Agency initiatives

ASI carried out several initiative in the following sectors:

- 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)

Space Economy plan: Navigation

The mail objective of "*Space Economy*" plan is to promote the space activities as propulsive factor in the national economy stepping up the vision of this business from mainly research objectives into applications useful for immediate benefit of the society.

The navigation part of the plan is built around a set of National Operational Infrastructures, (ION = Infrastrutture Operative Nazionali) :

- ION Train command and control on regional lines by the use of satellite navigation;
- ION Navigation of Unmanned Aerial Vehicles by satellite (weight<150 kg);
- ION Management of harbour access by means of satellite navigation;
- ION Access control for automotive, public fleet management and customer geofencing by means of satellite navigation.

A major transversal infrastructure called ION RINSA (Rete Italiana per la Navigazione Satellitare Aumentata), i.e. Italian Newtork for Augmented Satellite Navigation will serve the above disciplinary IONs

agenzia spaziale italiana

Space Economy plan: Navigation

RINSA will support the transportation services in Italy in its various typology of road, railway, sea and air. The network will be used in conjunction with dedicated local equipment and receivers on board of moving vehicles

ION Train objective is the adoption of ERTMS (European Railway Train Management System)/ETCS of level3, which is based on the concept of Virtual Balise. Its use is foreseen on local and regional lines at low traffic (48% of the whole Italian network)

ION Navigation of Unmanned Aerial Vehicles by satellite addresses the segment of light RPAS/UAV (class micro, mini and small, up to 150 Kg of weight), ensuring precise localization and tracking in support of both VLOS (Visual Line of Sigth) and BVLOS (Beyond Visual Line of Sight) Operations

ION Management of harbor will integrate by means of satellite navigation the current VTS and be built around the future new maritime communication standard VDES (VHF Data Exchange System for maritime Applications)

ION Access control for automotive, public fleet management also considered a technological incubator for evolutions in the automotive sector, in particular benchmark for edge computing allowing for sub-meter accuracy for connected cars and decimetric accuracy for autonomous car

Road – Rail synergies: the EMERGE project

EMERGE focal points are the research and the innovation on the enablig technologies for driverless cars and train control. It is possibly a unique project in Europe with such objective.

Project is aimed to be exported in other Regions with some potentiality to become a reference in Europe.

Satellite technologies are the pillars of EMERGE:

- **Research and innovation:** geo-localization, safety, 5G telecom;
- **«Intelligent» transportation:** integrated platform vehicle-infrastructure road & rail;
- **Emergency management:** vehicle movement for secure communication on site.
  Athena-Fidus (Italian-France geostationary satellite) for emergency secure communications

The EMERGE Initiative

Innovation, Research, Development and Validation of enabling technologies for Connected Vehicles.
First example in Europe af integrated applications **GALILEO - 5G**

Connected Vehicle
FCA-CRF

↔

EMERGE
Navigation (Radiolabs)

↔

Center of Execellence (UnivAQ)

↔

STEV (Radiolabs)

Vehicle Applications

- Safety buffers
- Dynamical Navigation

Daily and Emergency Operations

MISE cofunded

↔

Technological Platforms & Applications

- Geolocalization
- Connecticity
- CyberSecurity

Vehicle prototypes

MISE cofunded
RADIOLABS, TELESPAZIO
LEONARDO, ELITAL UnivAQ

↔

Research

Labs & Testbed

- GALILEO
- 5G

International Research Center Network

University Funds
L'Aquila University

↔

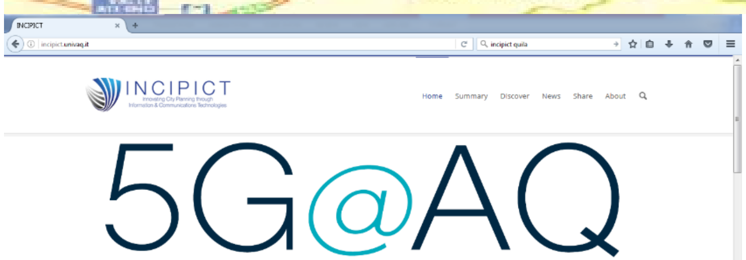
Technological Platforms & Applications

Test bed for validation and certification of automotive solutions

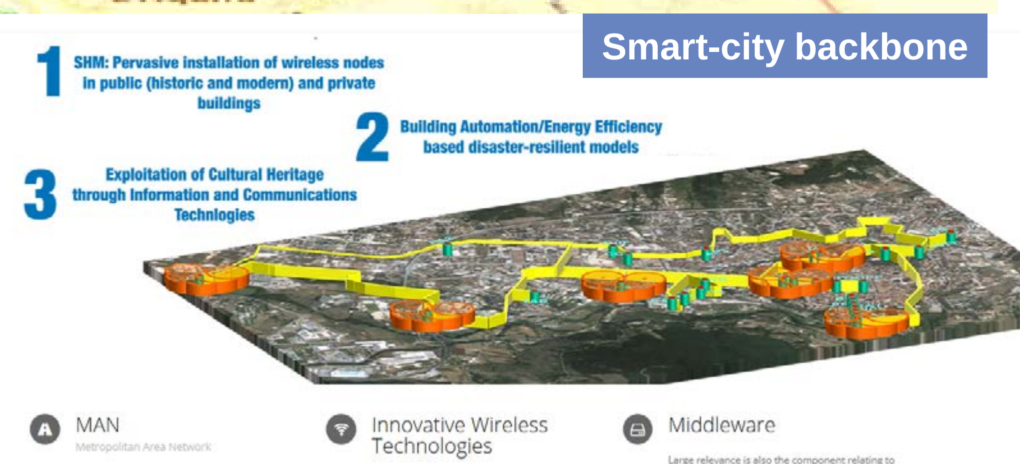
ESA GSTP
ASI funds

Living Test Bed @ L'Aquila

- *Hub for the deployment of the EMERGE initiative co-ordinated by FCA*
- *Pre commercial trials with 5G (EC 5G Action Plan)*
- *A smart city with a pervasive broadband infrastructure and test facilities*
- *Collaboration with international research Centers and Space Agencies*



5G network deployed by WIND-TRE selected after a competitive tender by Ministry of Develeopment
(University of l'Aquila and CRF partners of the Consortium)



agenzia spaziale italiana

Railway-Road sinergy «Optimizes» the ITC infrastructure

Italian railways are a worldwide level technological benchmark. The signalling system designed by FS has been adopted in all the Europe.

RFI is a main promoter in Europe for the satellite-based system certification

Digitalization that made our railways distinguishable at international level must be applied also for the roads.

* Renato Mazzoncini AD, FSI

agenzia spaziale italiana

GALILEO avantages: robustness and accuracy

Thanks to the dual frequency GALILEO is enabler of the high accuracy high integrity for ERTSM services
(Ionospheric delay compensation and faster ambiguity resolution)
Moreover, it reduces the vulnerability risk to jamming and/or spoofing and it better provides multipath mitigation.

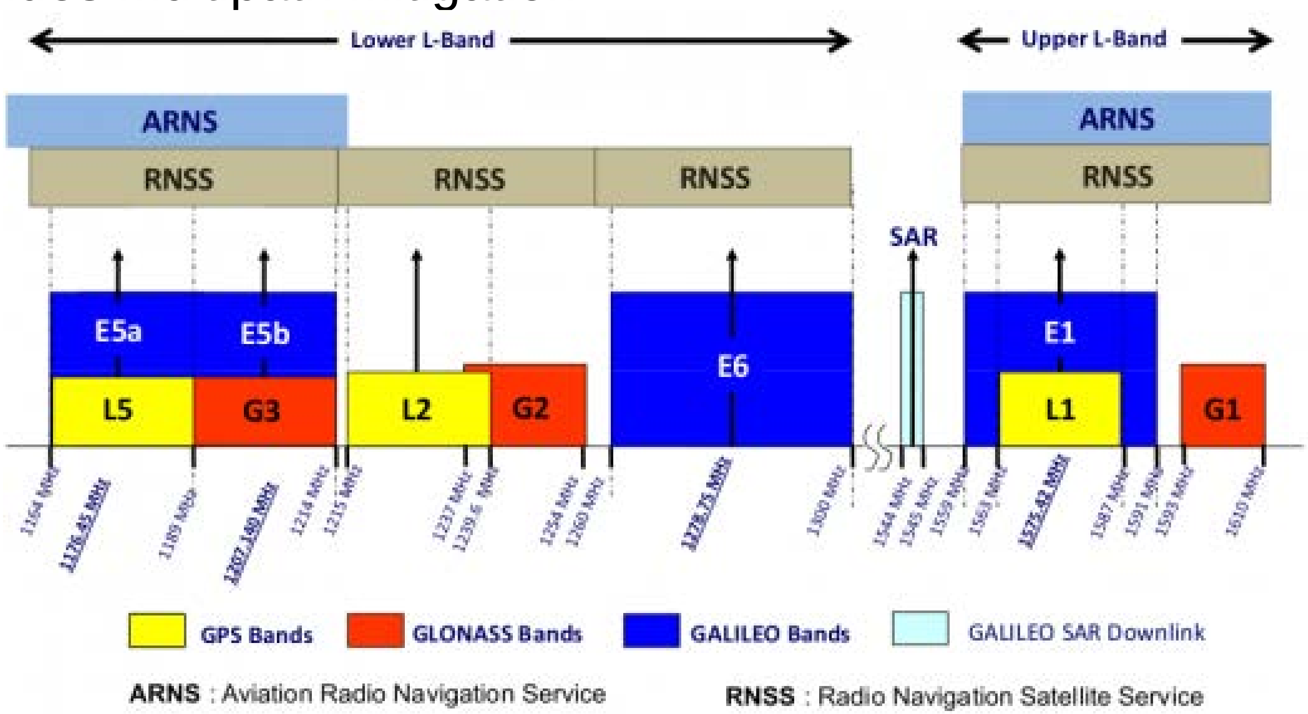


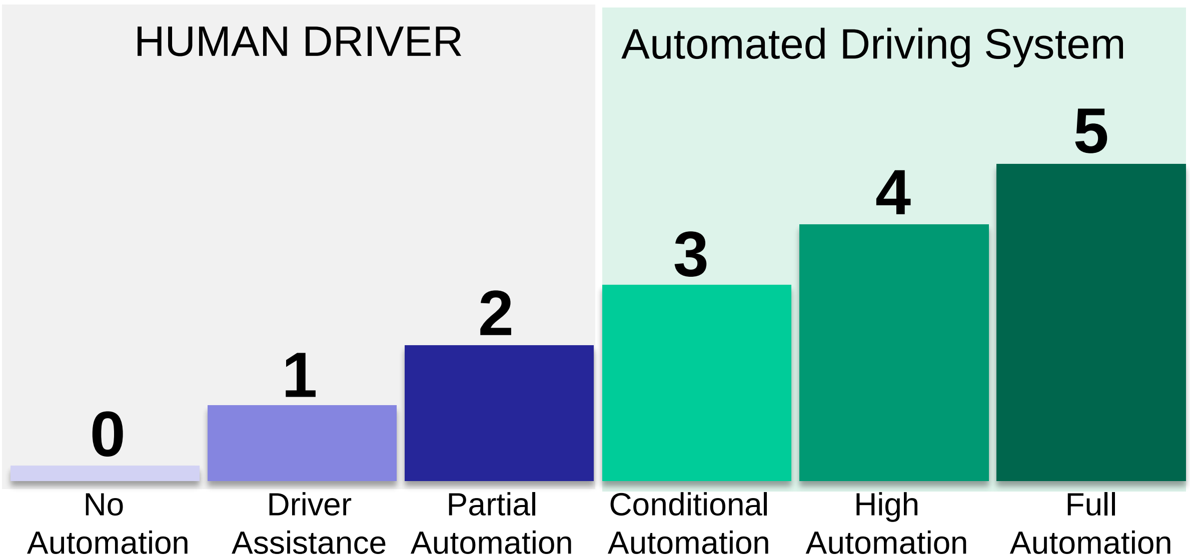
Image source:
http://www.navipedia.net/images/thumb/f/f6/GNSS_navigational_frequency_bands.png/520px-GNSS_navigational_frequency_bands.png

Automotive Requirements (from GSA report)

Focus on

APPLICATIONS	SAFETY CRITICAL	PAYMENT CRITICAL RUC pay-as–yuo-drive, taxi meter	REGULATED Smart tachgraph, eCall, Tracking and tracing	SMART MOBILITY Road navigation, automated parking, dynamic ride sharing
KEY GNSS REQUIREMENTS	**Accuracy** **Integrity** Availability Authentication Robustness TTFF	Accuracy Authentication Integrity Robustness	Authentication Integrity Robustness TTFF	Authentication Integrity
OTHER REQUIREMENTS	(Short range) Connectivity Interoperability	(Short and long ange) Connectivity	(Short and long ange) Connectivity	(Long ange) Connectivity

SAFETY CRITICAL Requirements Review



KPI	Value
Position accuracy	**< 30 cm**
Trajectory handshake latency	<100 msec
Trajectory Handshake loss rate	$< 10^{-5}$
Status message latency	<10 msec
Status message loss rate	$< 10^{-6}$
Status message rate	> 10 Hz

Vehicles and Road users

- position
- speed
- acceleration
- direction (heading)
- Yaw rate

Static obstacles

- Position

From other sources

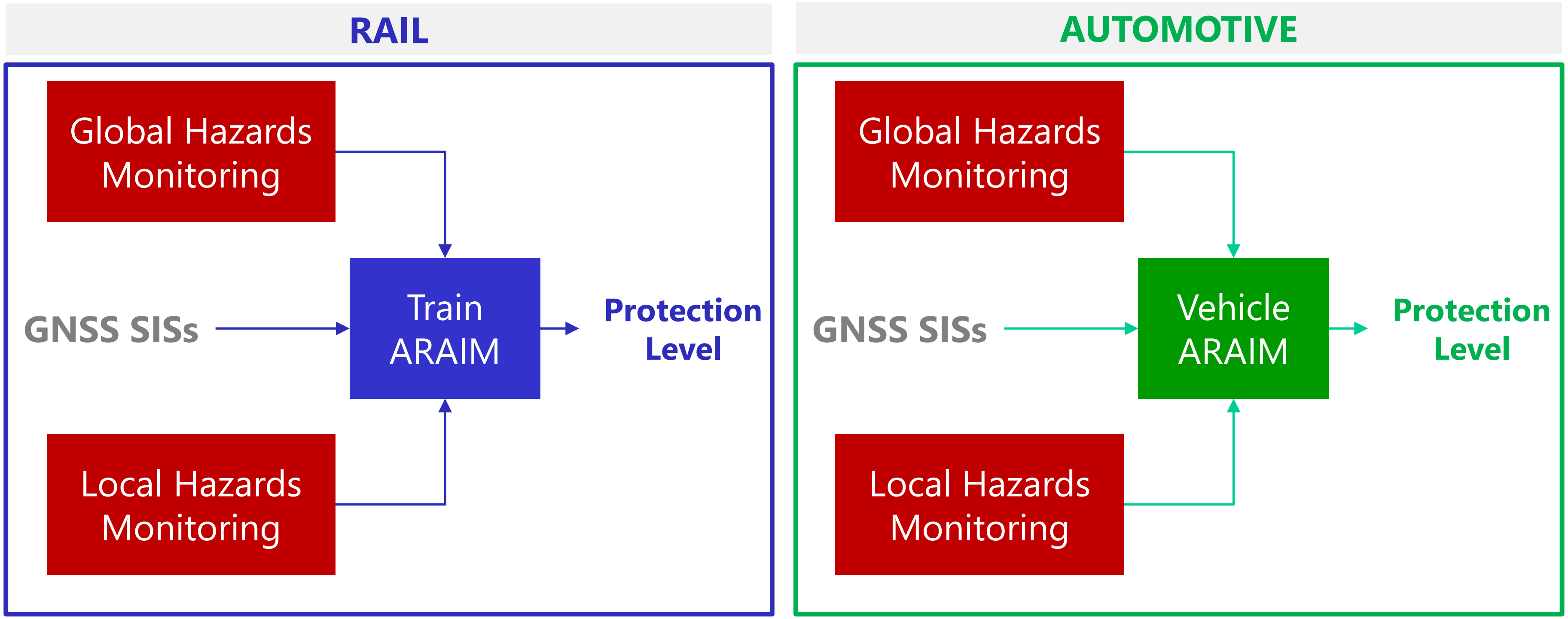
- Digital map with speed limit information
- traffic
- weather information

The role of GNSS in autonomous vehicles

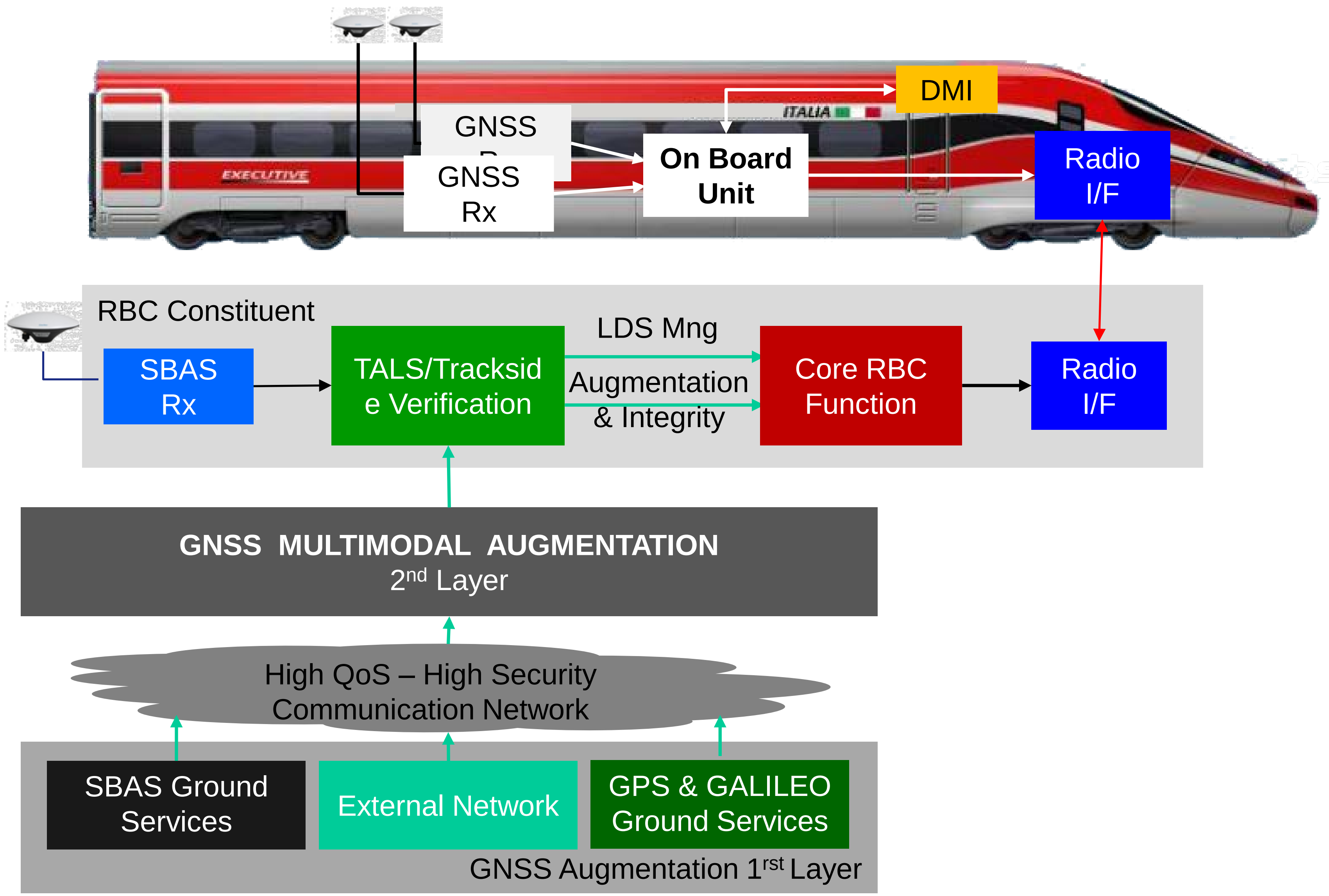
- Autonomous driving technology requires **HIGH ACCURACY** and **HIGH INTEGRITY** position and navigation
- no individual technology can currently meet these requirements anywhere, anytime and under any condition, requirements.
- **sensor fusion** is considered as the go-to-solution for the development of fully autonomous driving technology.
- GNSS is an element of a sensor fusion based navigation system that includes LiDARs/Radars, Inertial sensors and cameras.

AUTOMOTIVE Reference Architecture

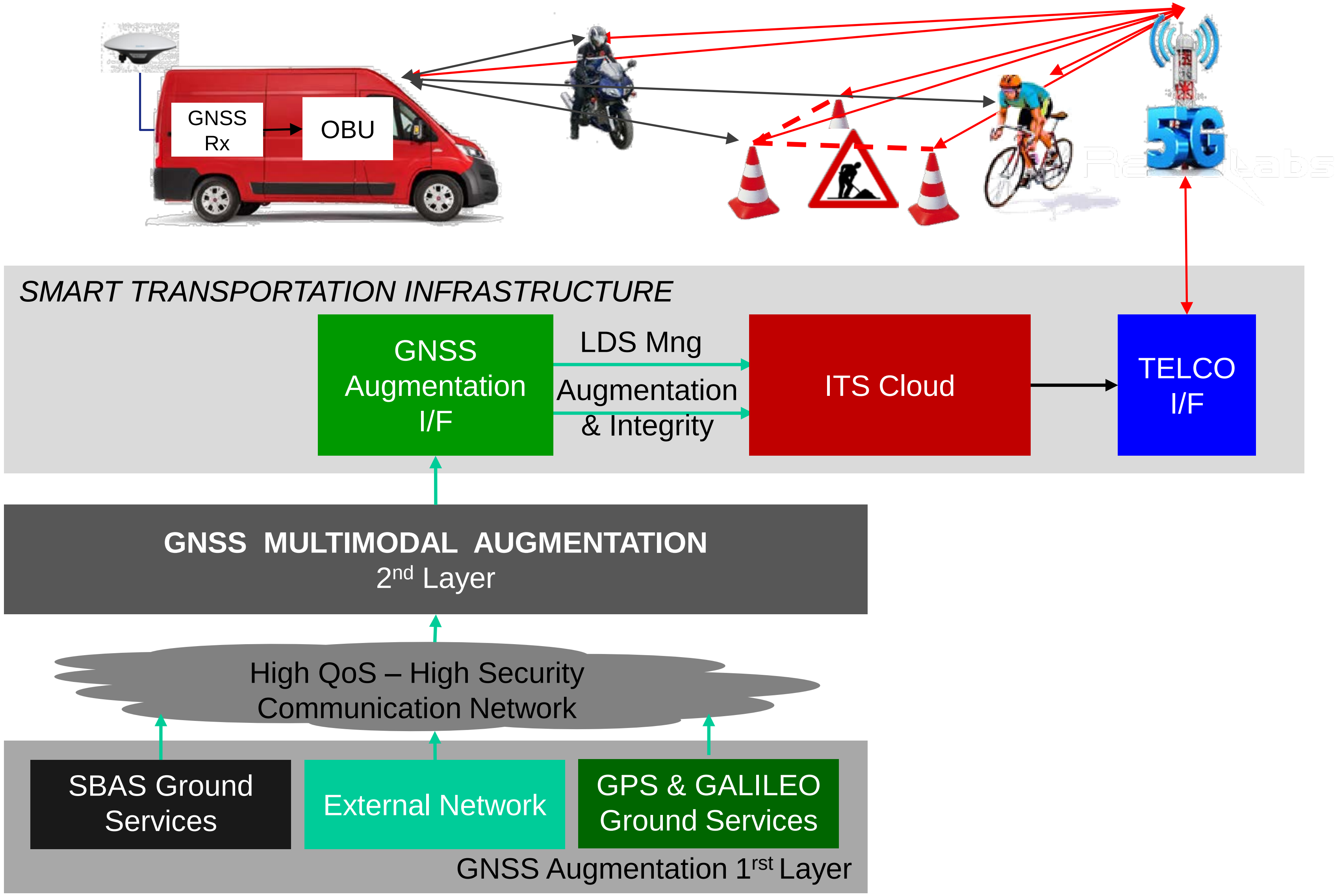
1. Based on Road **ENVIRONMENT MODELLING**
2. **Candidate solution(s) Architecture derived from Rail (RHINOS)**
   - Integrity Monitoring and Augmentation System Reference **Architecture**
   - On Board System Reference **Architecture**
   - **Local** hazards detection and effects mitigation,



RAIL Reference Architecture



AUTOMOTIVE Reference Architecture

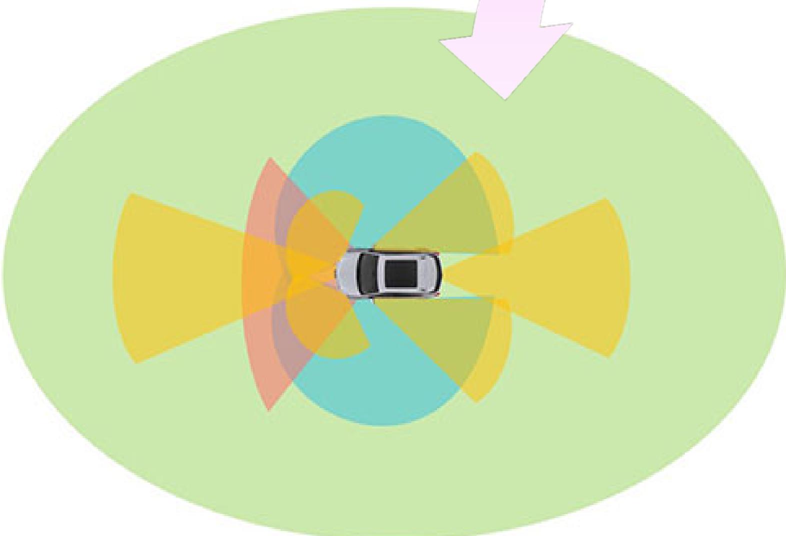


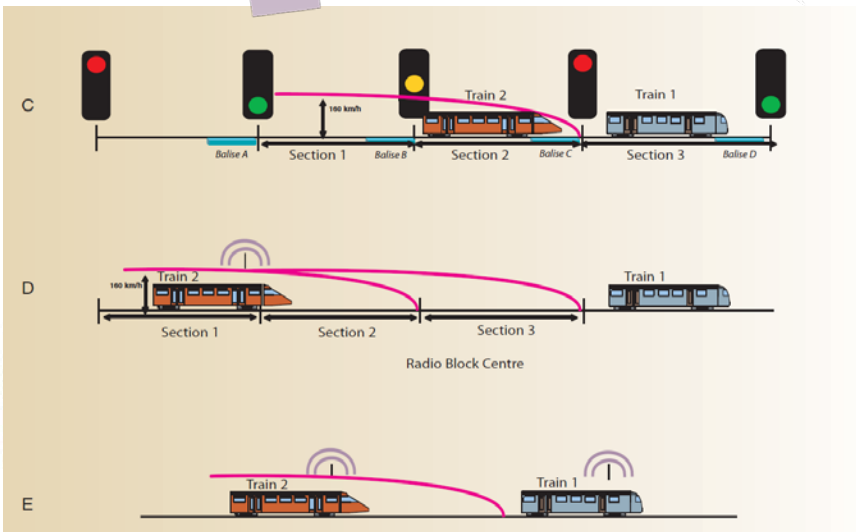
Rail-Automotive Sinergy

High Integrity High Accuracy Localization
Real time vehicle reaction

ERSAT

ERTMS over SATellite
(European Rail Train Management System)





New sensors
Smart Roads

From Centralized control
to autonomous vehicle

Conclusions and Recommendations

- RHINOS proof-of-concept architecture that has been developed from earlier baseline has been extended to Automotive

- Proof-of-Concept architecture combines SBAS/LDGNSS and local monitoring via ARAIM along with (optional) additional monitoring to mitigate multipath.

- Lesson learned from rail applications
  - HPLs are mostly driven by ARAIM, which is constrained by both satellite geometry and anomalous multipath.
  - SBAS and LDGNSS mitigate satellite and atmospheric anomalies before ARAIM is applied by users.
  - Detection and Exclusion of a faulted satellite that happens to be most useful (geometrically) significantly increases HPL.
  - OBU multipath mitigation is key to making ARAIM monitoring practical.