GNSS applications trends and evolutions: a prospective and the Italian contribute

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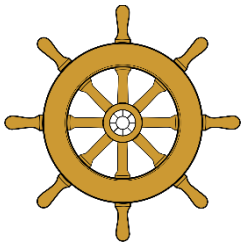
GNSS applications trends and evolution

Synthesis of the GNSS evolution on the last 3 decades:

❑ Observed market evolutions:

1. From Military only to Civil use (dominant)
2. Coexistence among different systems (compatibility)
3. Interoperability among different systems (interoperability at user level) – the so called “system of systems”
4. GNSS market revolution from a niche of professional users to wide and diversified sectors
5. Technology innovation and competitiveness on performances and price

❑ Driven evolutions:



1. International Cooperation and dedicated organization, particularly ICG
2. Cooperation at GNSS infrastructure levels (e.g. Galileo-GPS time offsets provided via signal)
3. Introduction of Safety of Life GNSS services
4. Availability of dedicated facilities for users and services (e.g. Galileo Service Center)
5. Capability to monitor SIS performances (e.g. Galileo Reference Center)

GNSS applications trends and evolution

Expected GNSS trends and evolutions to come:

❑ Market driven:

1. Use of high performance and secure GNSS services (cyber security)
2. Exponential grow of PVT data collections (IoT, Big-Data)
3. Quality standards and trustability for special GNSS applications
4. Availability of GNSS backup to overcome intrinsic vulnerability
5. Availability of sensors and new technology for improved PVT hybridization
6. Availability of Machine Learning and AI for automation and robotics
7. Paradigm shift from space technology to space integrated services (i.e. Space Economy)

❑ Directions:

1. Foster the International Cooperation beyond GNSS domain (ICG success model inspiring)
2. Facilitate the full interoperability between space and ground services and infrastructures (5G/Satellites, SAT-ADSB, etc)
3. Foster and facilitate the private-public partnerships
4. Cooperation between GNSS service centers for multi-constellation users
5. Cooperation between GNSS service providers for a worldwide monitoring capability of SIS performances
6. Improve/Develop quality standards and certification frames for demanding GNSS applications
7. Define common general guidelines for the future AI/Robotics applications

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 has been issued to define the Italian national policy for space, including a navigation related strategy

Satellite Navigation: Italian Perspective

❑ The Italian Space Agency carried out several initiatives for GNSS based innovation in the following sectors:

- **Maritime**
- **Civil Aviation (including UAV and associated U-Space)**
- **Road** (including hazardous transportation and autonomous guidance)
- **Infomobility and smart cities**
- **Rail**

Moreover ASI started 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

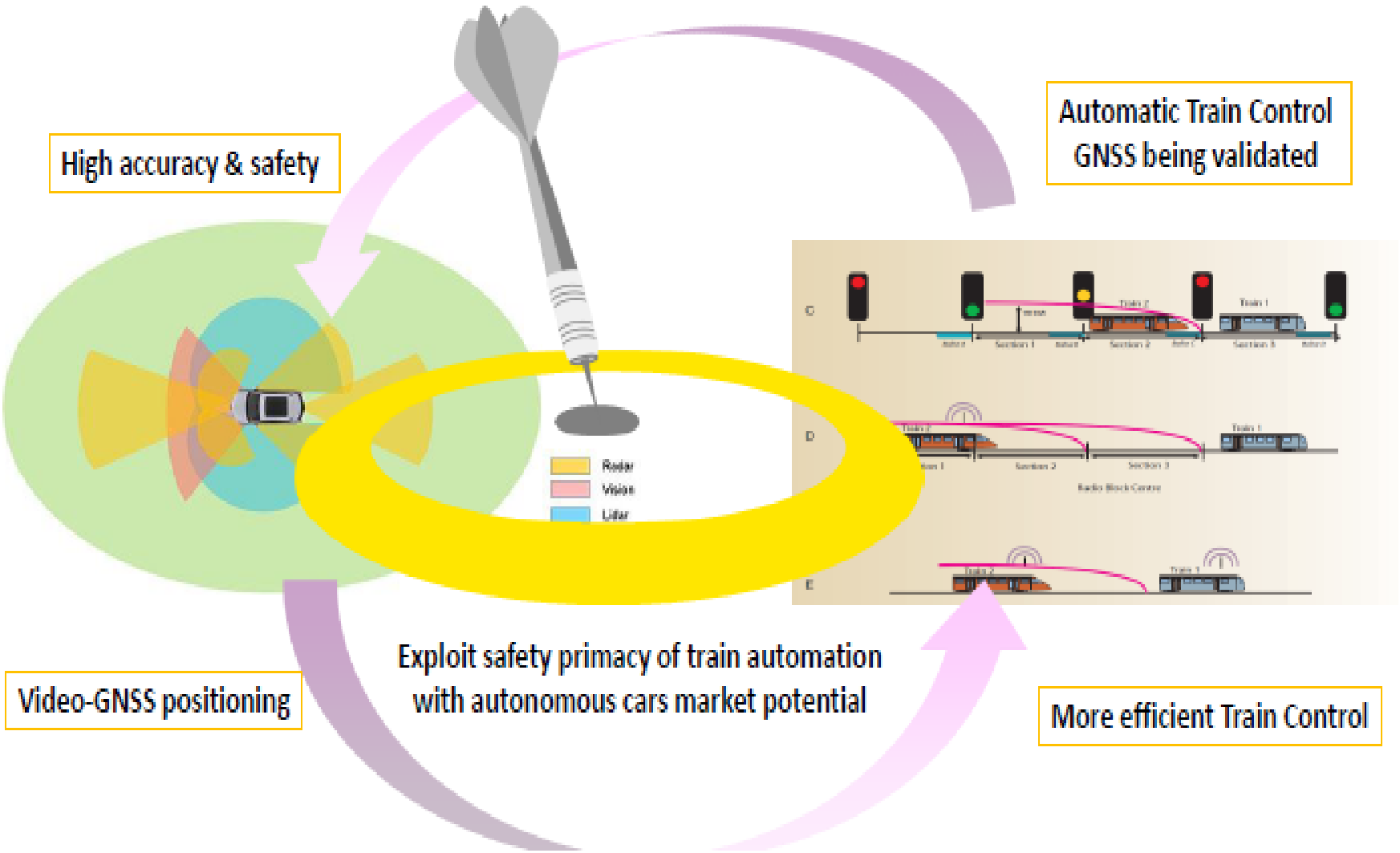
❑ The main objective of "**Space Economy**" plan is to promote the space activities as propulsive factor in the national economy stepping up the vision of this business from mainly research objectives into applications useful for immediate benefit of the society

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

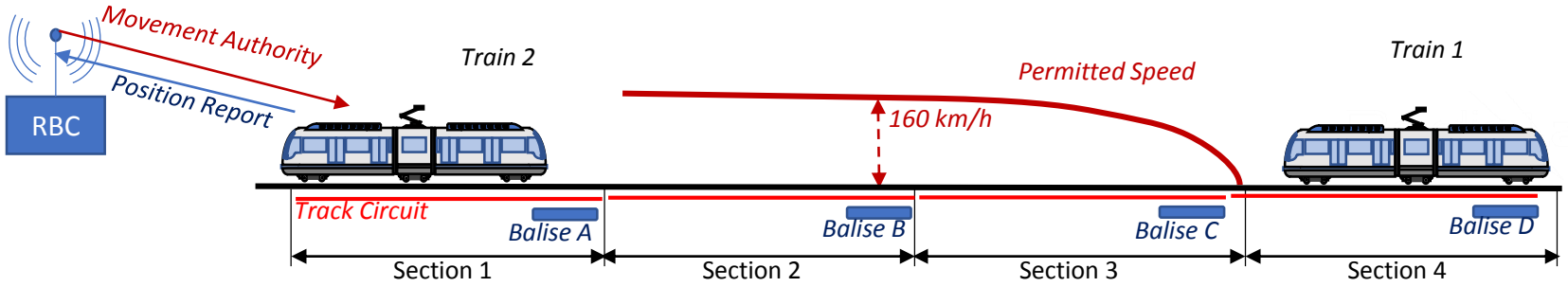
i. **ION Train command and control** on regional and local lines by the use of EGNSS;
ii. **ION Navigation of Unmanned Aerial Vehicles** by EGNSS (weight < 150 kg and > 150Kg)
iii. **ION Management of harbour access** by means of EGNSS;
iv. **ION Access control for automotive, public fleet management and customer geofencing** by means of EGNSS.

❑ 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

Example of innovative development: tuning Rail-Automotive Sinergy vs Autonomous Vehicle



RAIL - SAFETY CRITICAL Requirements

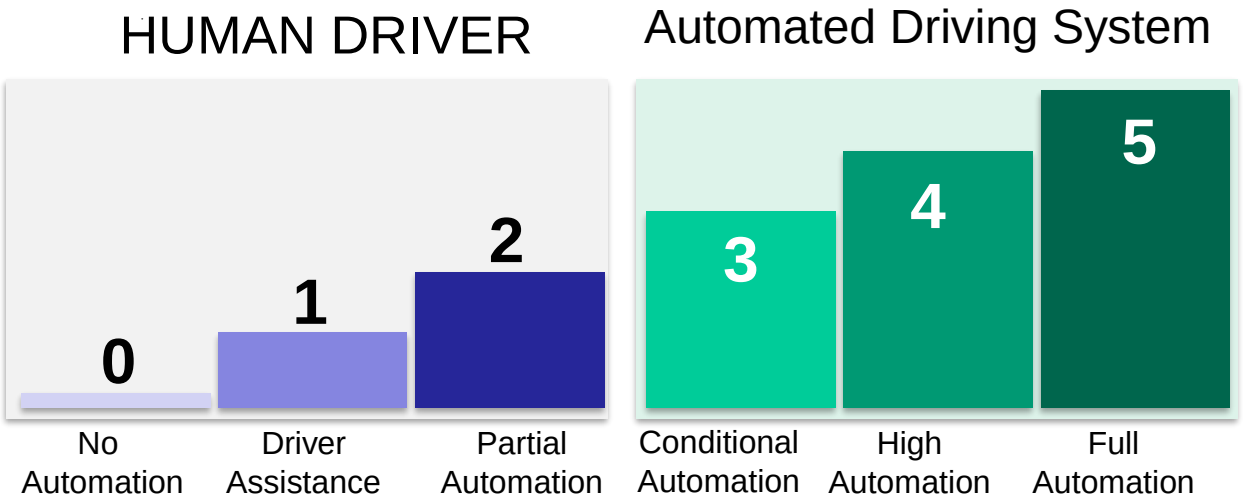


ERTMS/ETCS

Safety Integrity Level SIL-4 THR <10^{-9} [hazard/(h x Train)]

GNSS Functionality	Alert Limit	Accuracy
VB detection VITAL	**1** m	25 cm
VB detection NON VITAL	**5** m	125 cm
Track discrimination	**2** m	50 cm

ROAD - SAFETY CRITICAL Requirements



KPI	Value
Lateral ALERT LIMIT	**< 25 cm**
Longitudinal ALERT LIMIT	**1 m**
Speed accuracy	**?**
Trajectory handshake latency	<100 msec
Status message latency	<10 msec
Status message loss rate	$< 10^{-6}$
Status message rate	> 10 Hz

ELECTRONIC HORIZON

Vehicles and Road users

- Position, speed
- acceleration
- direction (heading)
- Yaw rate

Static obstacles

- Position

Infrastructure

- **High Accuracy Digital map**

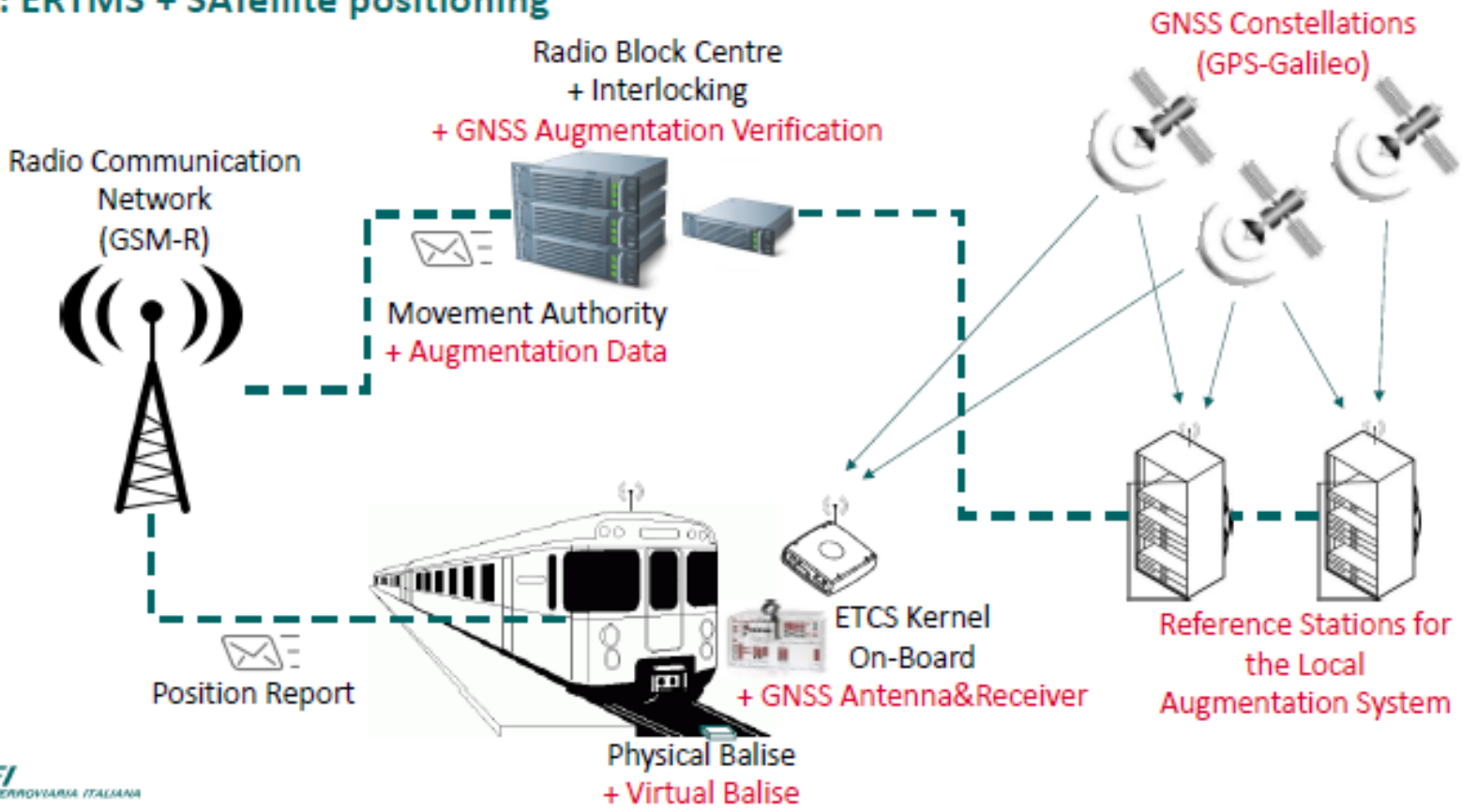
From other sources

- traffic
- weather information

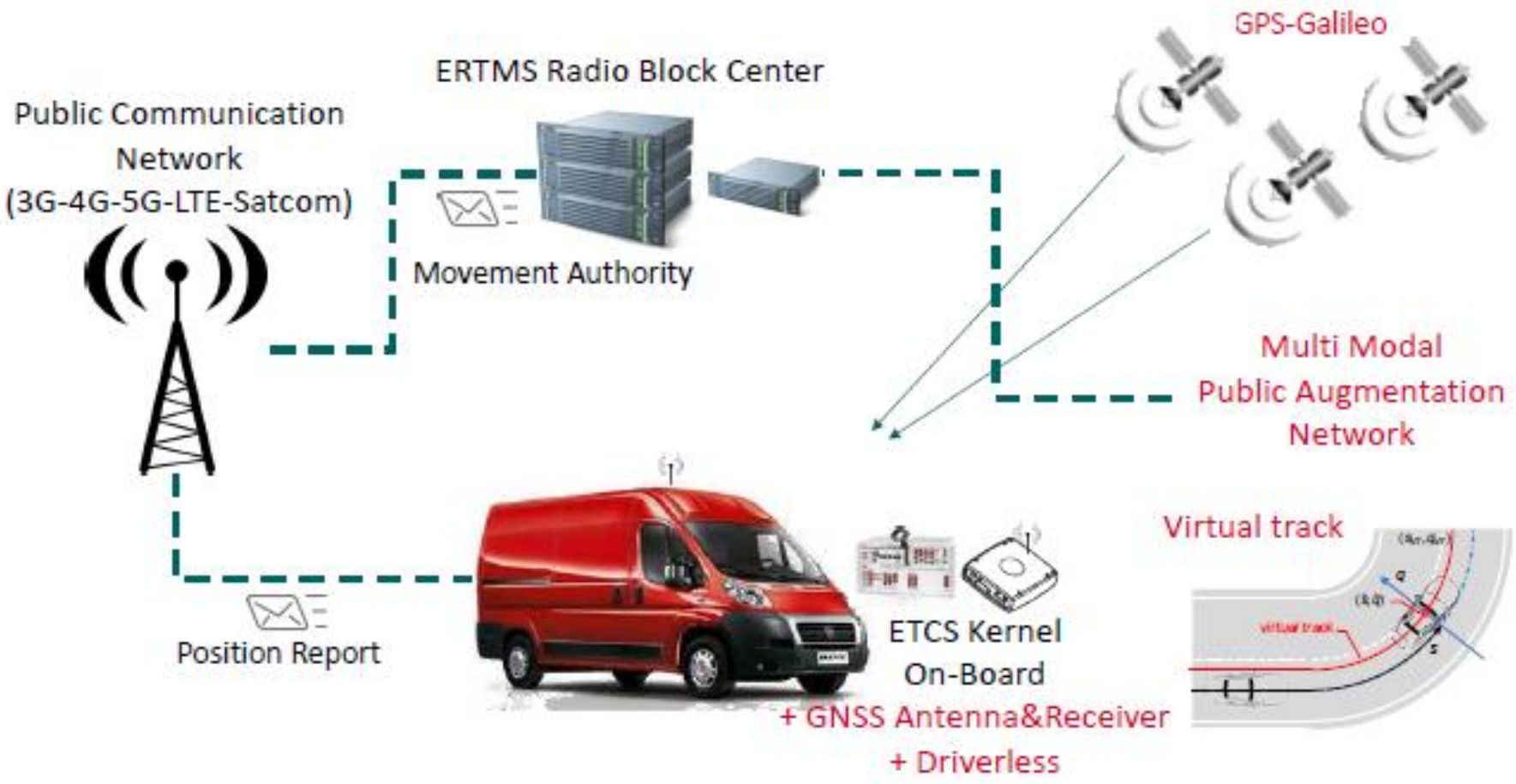
Rail domain: GNSS Positioning in the ERTMS (European Railway Train Management System)

GNSS positioning in the ERTMS

ERSAT: ERTMS + SATellite positioning



Road Domain: Applying the ERTMS concept to Connected Cars



Rispoli, Senesi, Ciaffi, Neri, Enge "GNSS for rail automation and driverless cars : a Give and Take paradigm", ION GNSS 2018.

Conclusions (1/2)

- Italy, at national and EU level, is fully engaged to actively contribute to the future of international GNSS market and for the Space Economy

- International cooperation, if extended to all Space Services following the UN/ICG model, will better satisfy the new market needs

- Improvements and coordination of the user segment support facilities and services, including world-wide GNSS performance monitoring, is necessary in view of the new multi-constellation service provision paradigm

Conclusions (2/2)

- At national level it is necessary to develop the complementary capabilities and local infrastructures and services on the basis of Private-Public Partnership

- The Pillars of Italian Space Economy initiatives are based the Space-based "National Operational Infrastructures" enabled by GNSS, Satellite Communication and Earth Observation:
  - Use of existing national, EU and international space assets (CosmoSkymed, Athena-Fidus, GNSS, Copernicus, GovSatCom) and Developing Reference Multi-Modal Augmentation Network Concept
  - Serving priority sectors like Rail, Road, Unmanned Aerial Vehicles/drones, Maritime, Autonomous vehicles, critical infrastructure monitoring