



Need for GNSS

Higher Integrity

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ICG 9

PRAGUE

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GNSS and applications

GNSS is technology powerfully enabler of a multitude of applications.

Italy, recognizing that, have undertaken initiatives to **develop pre-operational projects** to provide effective solutions to various domains.

The national projects, have been focussed to increase the **Safety** in the Transport Sectors (Maritime, Civil Aviation, Road Transport and infomobility) and in general improve **Territory Safety and Security**.

Italy is one of the major European contributors to the European GNSS: fund and participate to the Governance of the European GNSS (EGNOS and GALILEO).



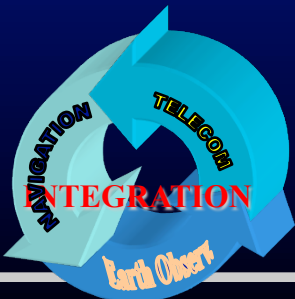
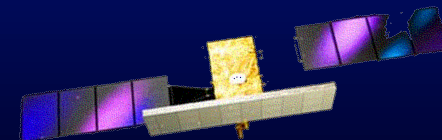
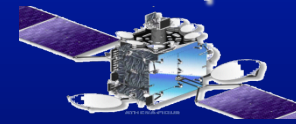
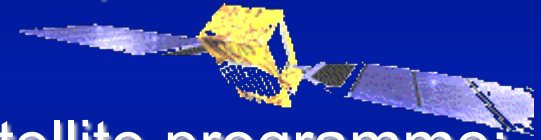
Satellite technologies integration Vision

Italy, in order to guarantee effective solutions Applications and Services, is fostering the **integration of satellite technologies NAV, COM, EO**:

Galileo Programme and its precursor EGNOS;

The national wide band communication satellite programme;

The earth observation programme COSMO-SKYMED, high resolution, dual mode imaging system.



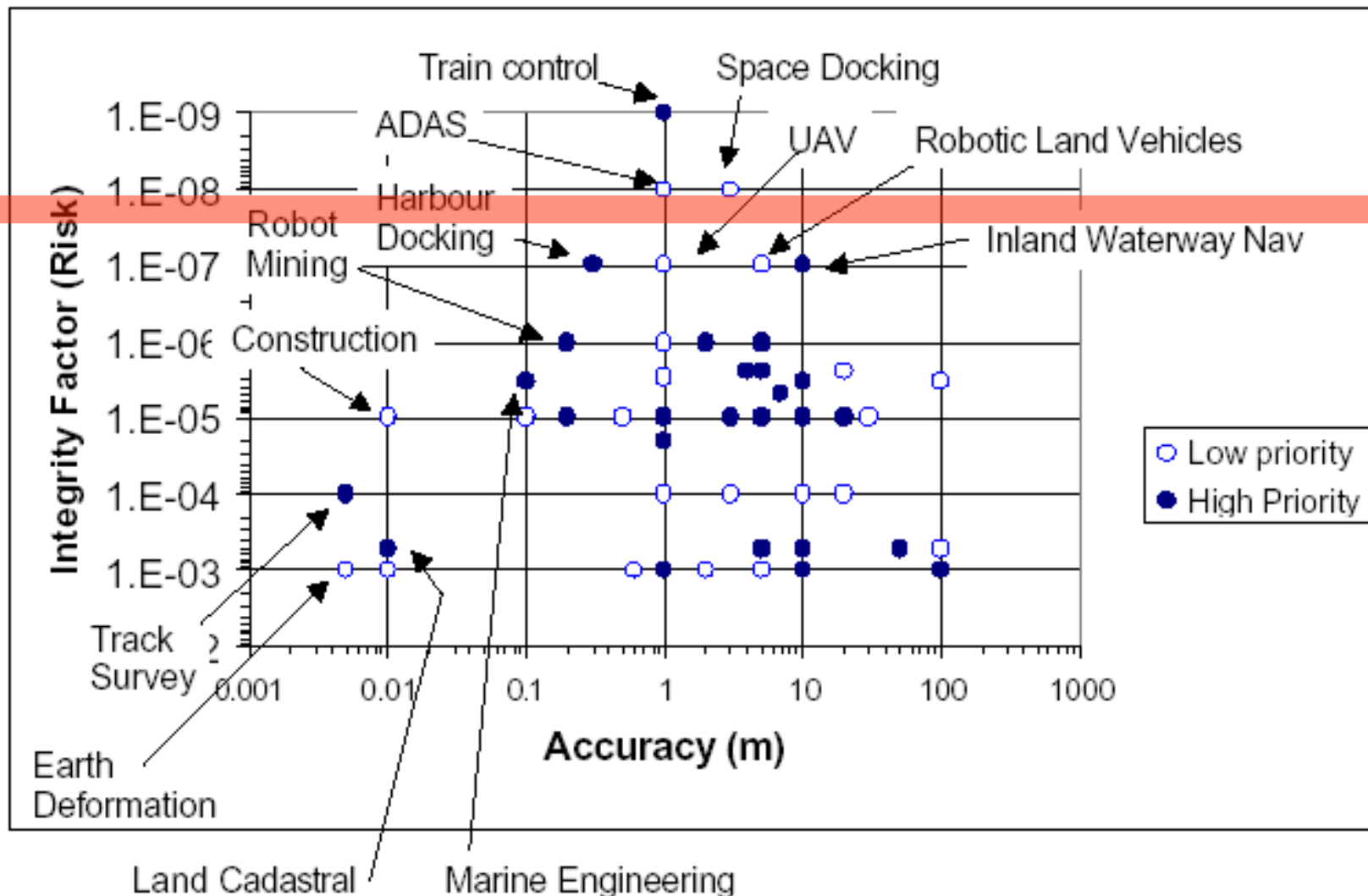
Major User Application Requirements

Appli ID	Market	Application (truncated title)	User Requirements							Phase 2 Service Mapping
			Accuracy		Availability		Integrity			
			Error	Prio	Proba	Prio	Risk	TTA	Prio	
1	Air	Commercial Air Trans. (IFR)	2	H	99.99	H	2.4E-06	6	H	HI
2	Air	Commercial Air Trans. S'llance	2	H	99.99	H	2.4E-06	6	H	HI
3	Air	General Aviation (IFR)	2	H	99.99	H	2.4E-06	6	H	HI
5	Air	General Aviation (S'llance)	2	H	99.99	H	2.4E-06	6	H	HI
6	Rail	Train Control	1	H	99.99	H	1.0E-09	1	H	HI
7	Rail	Train Supervision	7	H	99.98	H	5.0E-06	1	H	AI-1
8	Rail	Energy Optimised Driving (rail)	20	H	99.9	H	1.0E-05	10	M	AI-1
9	Rail	Fleet Management (rail)	50	H	99.9	H	5.0E-04	10	M	PVT
10	Rail	Track Survey (rail)	0.005	H	99.95	H	1.0E-04	15	M	RT
11	Rail	Passenger Info Service (rail)	100	H	99.5	H	5.0E-04	10	M	PVT
12	Maritime	Marine Nav (unregulated)	10	H	99.8	M	3.3E-06	10	H	AI-1
13	Maritime	Marine Nav (regulated)	10	H	99.8	M	1.0E-07	10	H	HI
14	Maritime	Marine S'llance (regulated)	10	H	99.8	M	3.3E-06	10	H	AI-1
15	Maritime	Marine Engineering	0.1	H	99.8	M	3.3E-06	10	H	RT
16	Maritime	Harbour Docking	0.3	H	99.8	M	1.0E-07	10	H	AI-2
17	Ambulances	Ambulance Tracking	20	M	99	M	1.0E-05	60	L	PVT

Service	Accuracy horizontal 95% (m)	Availability	Integrity risk/hour	Time-to-alarm (s)
PVT	6 m	99 %	1.0E-04	30
AI-1	2 m	99.9 %	2.0E-06	10
AI-2	0.2 m	99.5 %	1.0E-05	10
HI	2 m	99.99 %	1.0E-08	6
RT	0.01 m	99.9 %	1.0E-05	20

High priority (H): essential part of the user's core requirement.
 Medium priority (M): optional, may be operationally useful, but not a core need.
 Low priority (L): not needed, of little relevance from the user perspective.
 Not applicable (NA): not applicable

Applications Versus Integrity





EGNOS and GALILEO services Integrity

EGNOS - Source: European GNSS HLD (High Level Document)

Aviation Services	En-route – Non Precision Approach	Approach with Vertical Guidance APV-I (legacy service)	LPV 200 Approach	Cat I Precision Approach
Lateral accuracy	220 m	16 m	16 m	16 m
Vertical accuracy	Not applicable	8 m	4 m	4 m
Integrity	1.10 ⁻⁷ / hour	2.10 ⁻⁷ / 150 s	2.10 ⁻⁷ / 150 s	2.10 ⁻⁷ / 150 s
Time To Alarm	10 s	6 s	6 s	6 s

GALILEO - Source: European GNSS HLD (High Level Document)

4.1.2. Integrity service

It is expected that the provision of integrity data for both GPS and Galileo open signals **will be ensured on a regional basis through EGNOS**.

For the longer term, Galileo could contribute to the provision of an integrity service by means of Galileo OS signals and/or in combination with other satellite constellations. With this objective in mind, the Galileo Programme shall pursue feasibility and definition studies **to investigate emerging techniques, such as Advanced-RAIM**, enabling the provision of integrity with less reliance on ground infrastructure. Cooperation with international partners to work on the development of international standards for such techniques shall also be reinforced.



GNSS INTEGRITY

There is a growing demand for GNSS High Integrity.

The integrity is related to the system's capability to generate alarms in situations of insufficient accuracy.

This capability might vary with time and should therefore be monitored by an integrity monitoring system.

When the integrity risk becomes too high, the user should be notified that there is insufficient guarantee that a timely alarm can be generated in case of lacking accuracy.

There is the Need to:

- **investigate the robustness** of the navigation solution,
- **monitor threats**,
- **develops methods to detect, mitigate or exclude a faulty element** of the system which may lead to an unacceptable error in the navigation solution.

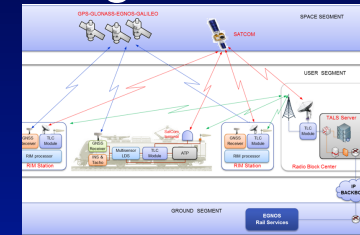


Application Programs integrating more technologies in order to provide improved user solutions

Application Programs funded by ASI integrating more technologies in order to provide improved user solutions

RAIL; Train Control

3InSat



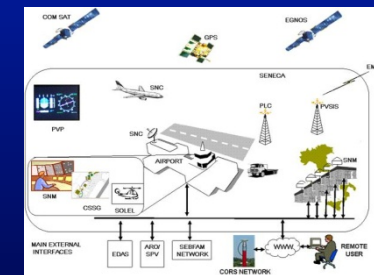
MARITIME: Situational Awareness

SIMONA



CIVIL AVIATION: Air Traffic Control

SENECA



GENERAL AVIATION : control & services

S2BAS



Focus on Rail: Hazards using GNSS for RAIL

GNSS space segment

Faulty satellite can cause unboundary error of train position

GNSS control segment

TTA is not guaranteed

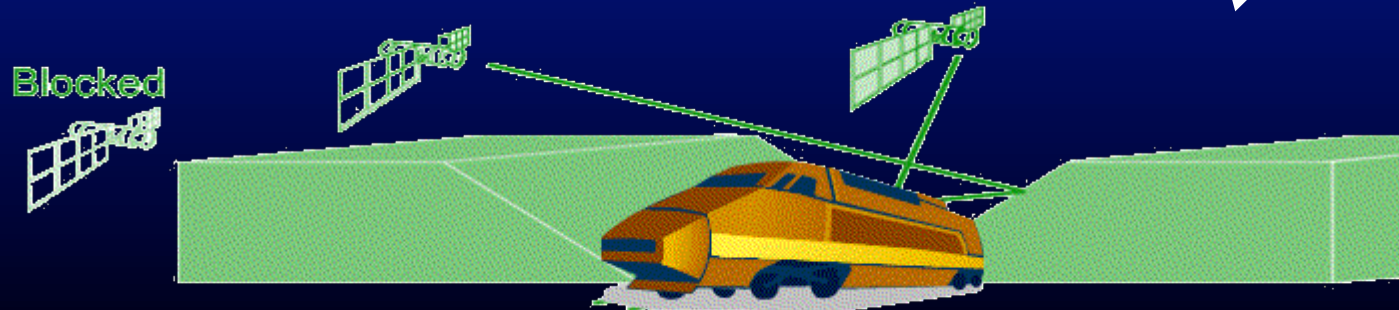
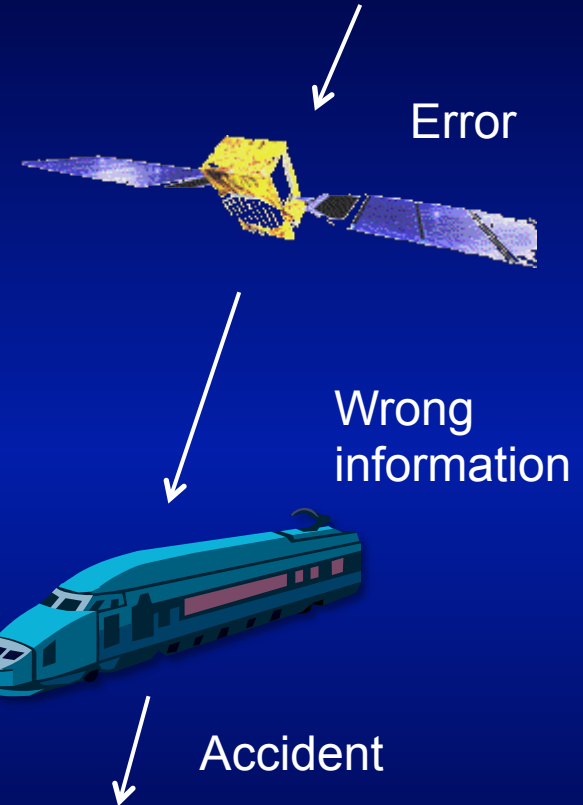
SIS Transmission

Low availability: canyons, tunnels, forests
High availability in stations is needed – poor visibility (urban area)

Multipaths – common in canyons and on the bridges upon the lakes / rivers (reflexive surface)

Atmospheric delays

Jamming – weak signal – easy to jam
Authenticity of message have to be proved





RAIL Safety Requirements and GNSS

- **Single faults (EN50129)**
 - “It is necessary to ensure that **SIL 3 and SIL 4 systems remain safe in the event of any kind of single random hardware fault** which is recognized as possible.”
- **Reactive fault-safety (EN50129)**
 - “**Maximum total time taken for detection + negation shall not exceed the specified limit** for the duration of a transient, potentially hazardous condition.”

Integrity Monitoring Approach

1. **Multi-constellation GNSS capability**, exploiting existing constellations (GPS, GLONASS) and new ones (e.g., GALILEO)
2. **Use of SBASs** (*i.e.*, EGNOS in Europe) augmentation data for both integrity monitoring and accuracy and precision increase;
3. **Deployment of a dedicated Track Area Augmentation and Integrity Monitoring Network** with very high availability;
4. **Independent on-board capability** to further mitigate GNSS errors and autonomously assess the GNSS location integrity.



3InSat - Train Integrated Safety Satellite System

□ **A Project financed by ASI within the ESA ARTES Programme**

Development and validation of a satellite-based platform compatible with the ERTMS- ETCS

- ✓ Exploitation of new satellite TLC technologies
- ✓ Adoption of GNSS and augmentation networks for meeting SIL-4 requirements

□ **Roadmap up to the validation and certification phase**

Benefits:

- ✓ Increased network capacity/ efficiency
- ✓ Lower capex & operational costs



Prioritary applications

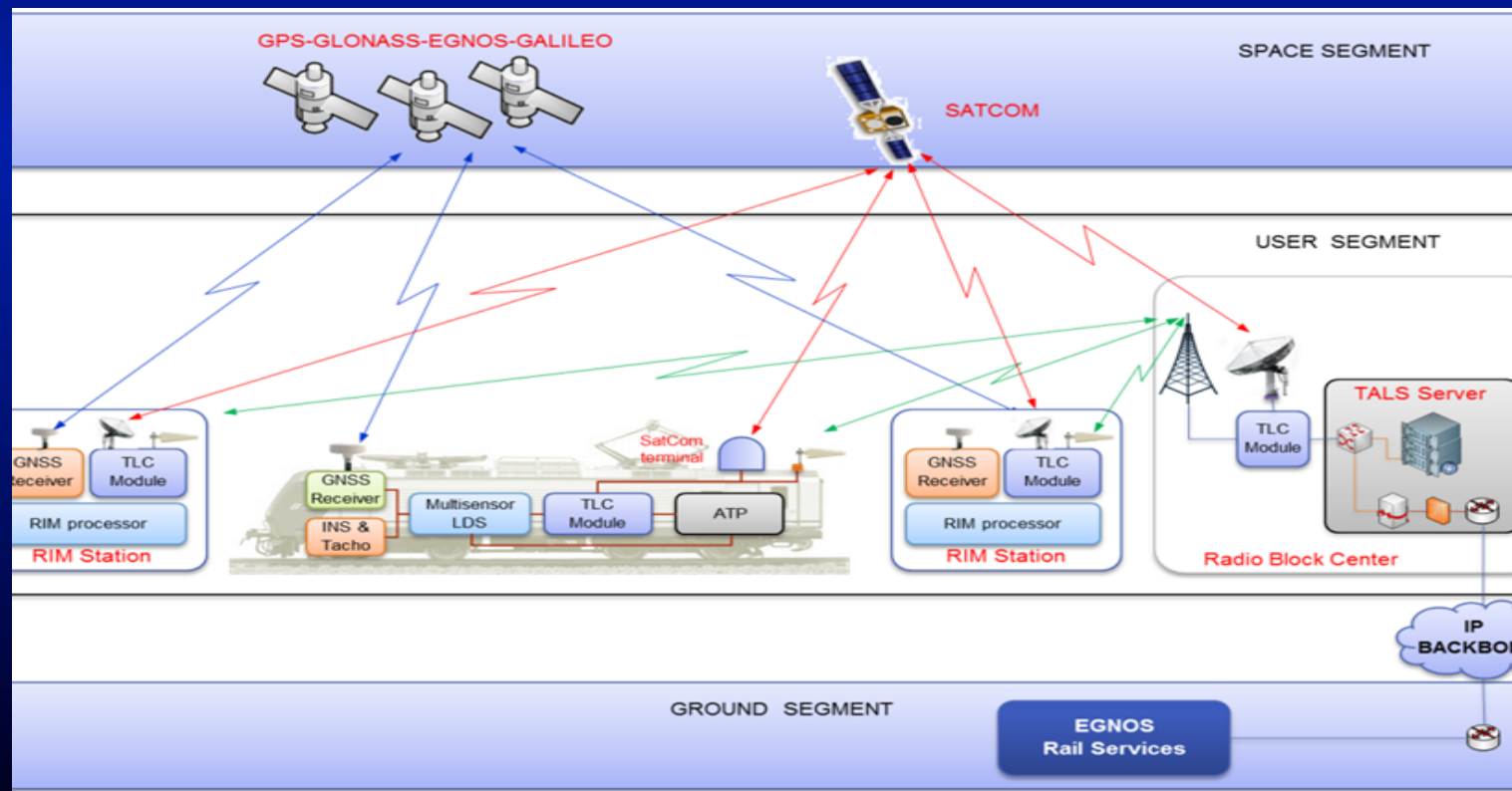
Local lines, low-traffic ,Regional lines, new freight lines on a world-wide level

ERTMS: European Rail Traffic Management System
ETCS: European Train Control System

3InSat - Train Integrated Safety Satellite System

The function of train localization is distributed among the following elements:

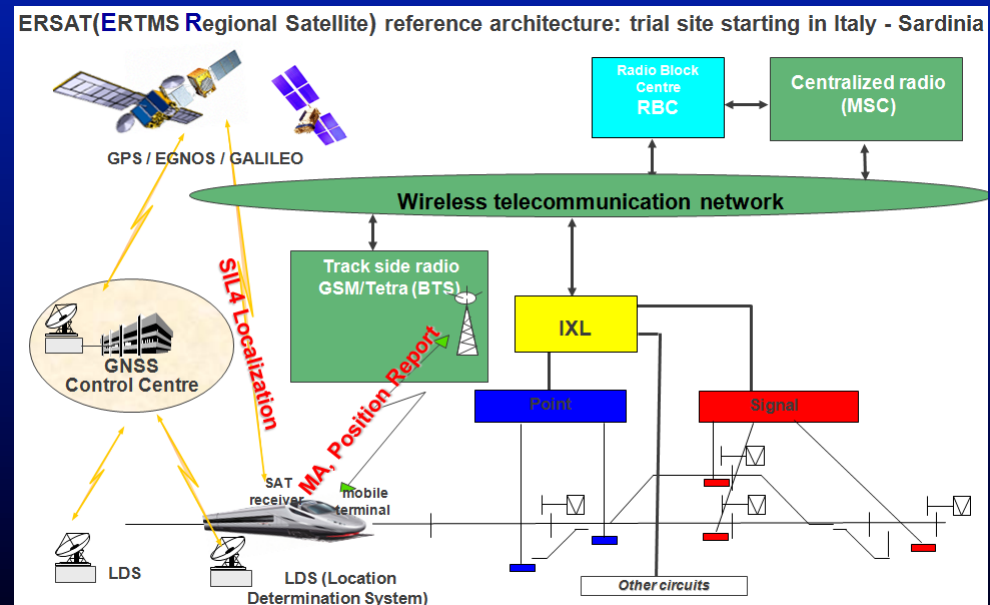
1. Space segment (GPS, GALILEO, GLONASS constellations + EGNOS + SATCOM)
2. Augmentation and Integrity Monitoring network.
3. On board unit (multiconstellation GNSS receiver + Multisensor Localization Determination System (LDS))





3InSat features for satellite assets validation on the test site:

- Total length: approximately 50 km
- Double track: to test train localization on parallel tracks
- Satellite localization system at SIL-4 level
- Multi-bearer TLC network
- Augmentation network validation
- Test Procedures validation
- Independent assessment by a NoBo (Italcertifer)





Future Solutions:

A Multi-constellation ARAIM for Rail ?

An ICG Task Force setup ?



Thanks