

Extending GPS and Galileo **interoperability:** from frequency/signals to **integrity**

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Presentation Overview



- **EUROCONTROL and its role on GNSS**
- **Use of GNSS in aviation applications and GNSS policy**
- **Interoperability on GNSS**
- **Extending interoperability to integrity**



EUROCONTROL, the European organization for the Safety of Air navigation

- A civil and military organisation which currently numbers 38 Member States.
- Primary objective is to **ensure safety** in the development of a seamless, pan-European Air Traffic Management (ATM) system to cope with capacity needs and environmental aspects.
- Core business processes:
 - ✓ Harmonise and integrate Air Navigation services aiming at having a “Single Sky” in Europe.
 - ✓ SESAR: Research, design and implementation of the future air traffic management (ATM) network across the European continent.
 - ✓ Pan-European functions (e.g. Flow Control)
 - ✓ Provision of regional ATC services
 - ✓ Support to EU regulation and system performance review
- Partnership with European and international stakeholders (e.g. EC, ICAO, FAA,...)
- More information: <http://www.eurocontrol.int/>



EUROCONTROL role on GNSS



- Long term involvement on GNSS matters

- EUROCONTROL is contributing to the development of GNSS applications addressing different aspects:
 - ✓ Safety
 - ✓ Technical
 - ✓ Operational
 - ✓ Economic
 - ✓ Institutional
 - ✓ Legal
 - ✓ Security

- Focal point in the definition of the needs of aviation regarding GNSS
- Playing a major role in the operational validation of GNSS performance according to aviation requirements.



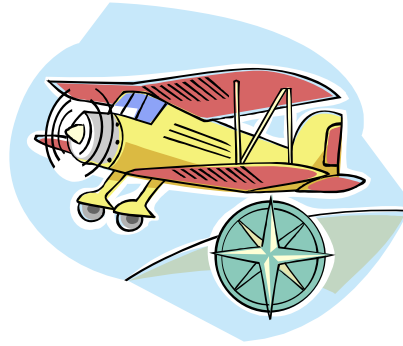
Overall use of GNSS in aviation applications



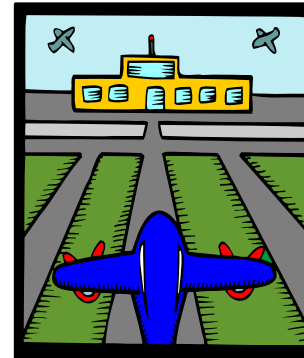
Civil domain



**Surveillance
(ADS-B)**



Navigation

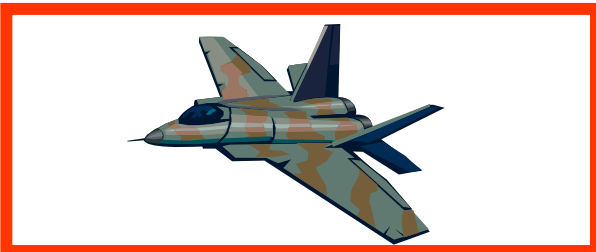


**Airport
operations**



Timing

Military domain (based on GPS PPS & Galileo PRS)



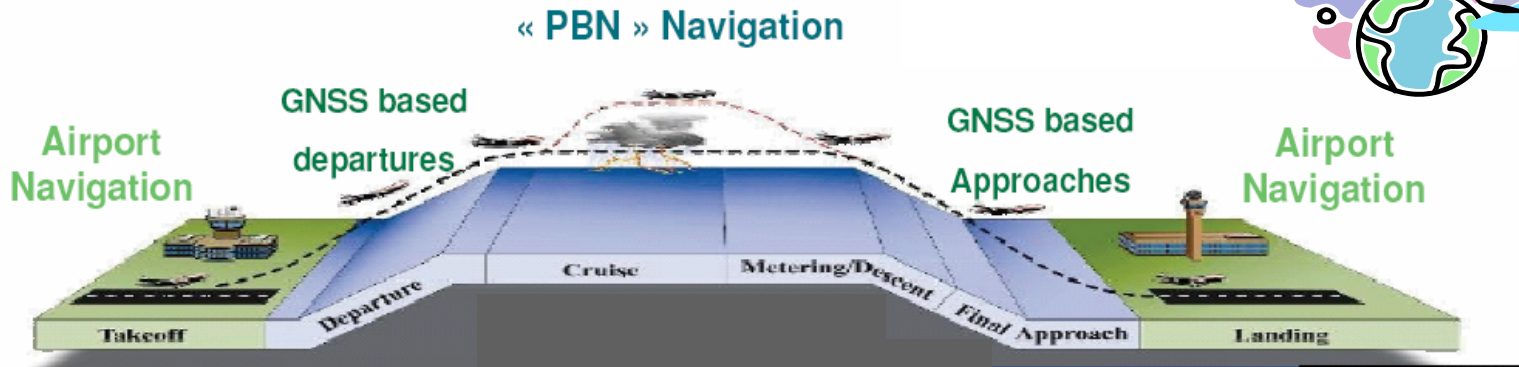
Use of GPS in European aviation today



- Around 70 % of flights are made by aircraft equipped with GPS/RAIM.
- GPS offers a very efficient and free service nominally.....but current GNSS based on GPS only has some deficiencies impeding its comprehensive use in aviation:
 - ✓ single system/operator
 - ✓ single frequency
 - ✓ low power signals
 - ✓ number of satellites
 - ✓ lack of sufficient guarantees
- The use of GPS is authorized in Europe since 1998 (for some operations and under certain conditions) based on a Safety assessment, the existence of ICAO Standards and a letter with a political commitment sent from the US government to ICAO.
- Safety Case relies upon reversion to conventional means.



Transition to GNSS in European aviation



Operational needs

- More capacity to cope with increasing traffic demands
- Improve safety
- Reduce environmental impact
- Less costs

Technical Realisation

- More flexible routes (e.g. RNAV)
- More demanding performance (e.g. Integrity, Accuracy,..).
- Safety (e.g. Vertical guidance in approaches)
- Better surveillance capabilities (ADS-B) to reduce separations
- Improved low visibility operations
- Common and accurate time reference

In line with :

- ICAO global strategy
- SESAR Master Plan

Infrastructure

Transition to a multiconstellation GNSS



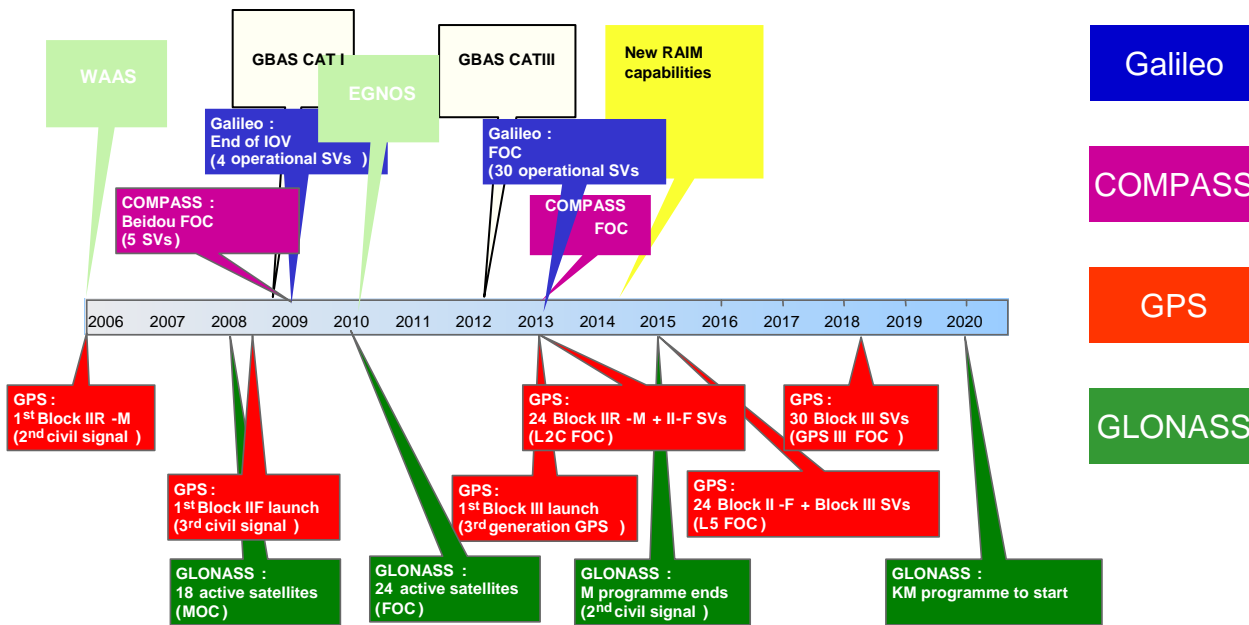
GNSS policy for Navigation applications in civil aviation



- **Gradual** reliance on GNSS for all phases of flight as it will become **more robust** progressively.
- **A multi-constellation and multi-frequency GNSS** environment in 2020. Galileo signals will be used in combination with GPS and other GNSS components to have:
 - ✓ Better performance (accuracy, availability, continuity and integrity).
 - ✓ More robustness against vulnerabilities.
- User receivers will process signals from different GNSS constellations in diverse frequency bands in combination with augmentations, depending on individual business cases and the phase of flight.
- **Final goal** is its use as sole service to the extent that this can be shown to be the **most cost beneficial** solution and if supported by successful **safety** and **security** analyses.
- A rationalised terrestrial infrastructure must be retained for the foreseeable future.



The scene: GNSS developments and aviation



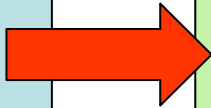
- Galileo
- COMPASS
- GPS
- GLONASS

a) Moving schedule and many uncertainties !

b) Many potential combinations of Signals, constellations and augmentations (SBAS, GBAS, RAIM, INS,...)

c) A new GNSS configuration every 2-3 years ... whereas aviation equipment has very long lifecycle and very high installation & certification costs

d) Different integrity schemes/concepts not always compatible.



- 1) Share a GNSS baseline
- 2) Extending interoperability to integrity
- 3) Define a Multi-constellation receiver architecture:
Robustness vs Complexity/costs



GNSS components and interoperability level



GNSS component	Interoperability level
Constellations: GPS, Galileo, GLONASS, COMPASS, QZZS,...	States level agreements (e.g. US- EU agreement)
SBAS (WAAS EGNOS, MSAS)	ICAO standards Interoperability Working Group
GBAS (CAT I and CAT II/III)	ICAO standards
On board augmentations (e.g. RAIM) and receivers	Standardisation bodies (RTCA, EUROCAE,..)



Why interoperability is important for aviation ?



Aviation is a global business and interoperability is a key element to enable:

- ✓ **Global harmonisation**
- ✓ **Standardisation process**
- ✓ **Reduce avionics costs (installation, certification,...)**
- ✓ **Seamless navigation performance**

ICAO standards (SARPS) ensure global interoperability of aviation systems like SBAS and GBAS:

✓ A SBAS receiver that works in the US (WAAS) will work in Europe (EGNOS)

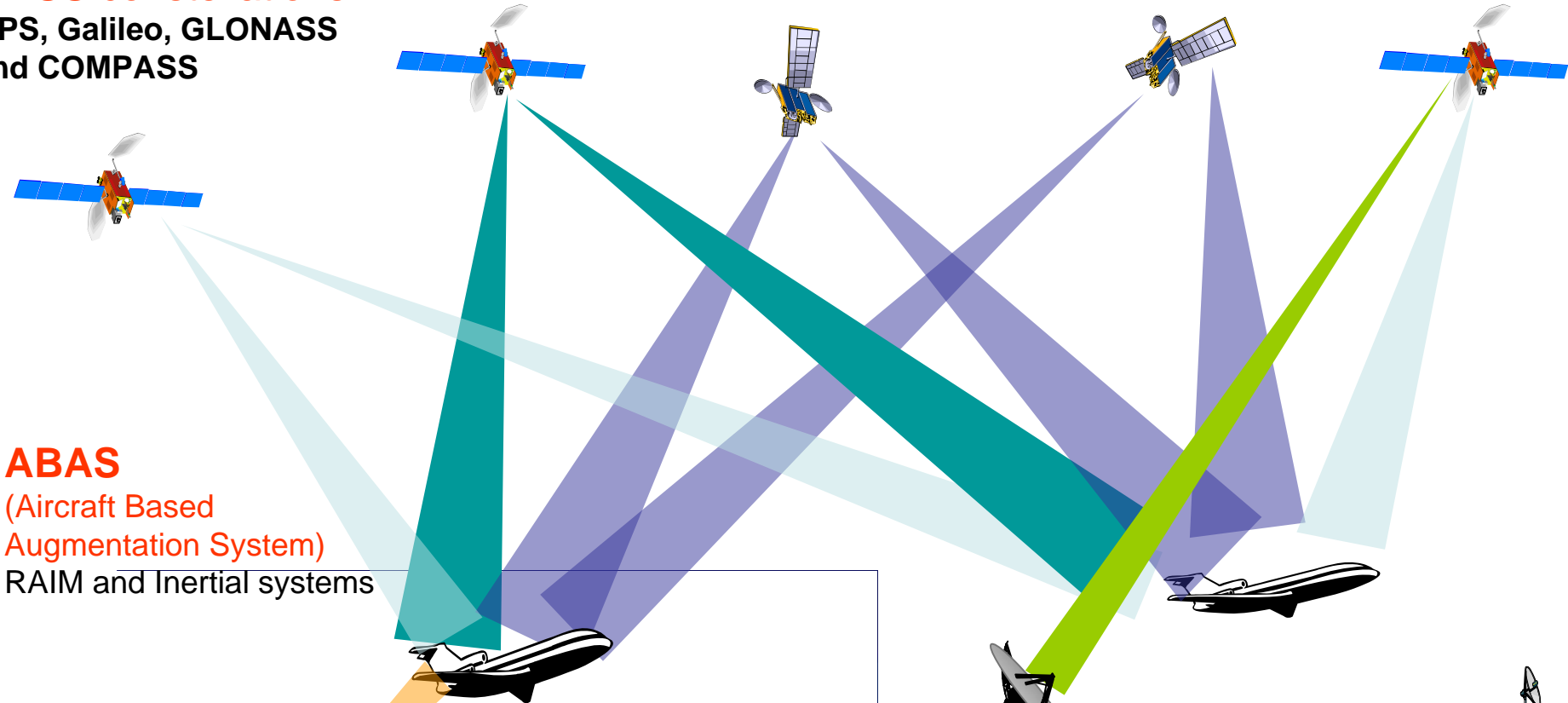
✓ Same aircraft can use a GBAS station in Australia, Brazil, US or Europe.



GNSS components and integrity

GNSS constellations

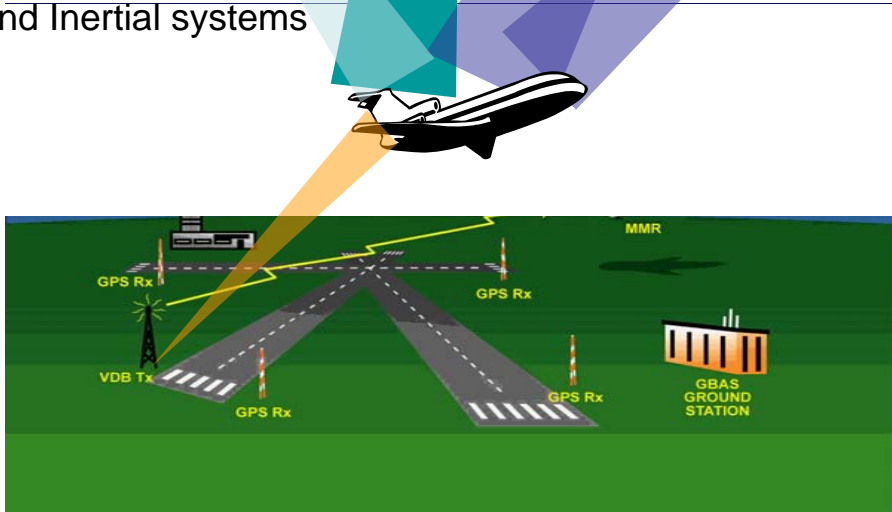
GPS, Galileo, GLONASS and COMPASS



ABAS

(Aircraft Based Augmentation System)

RAIM and Inertial systems



GBAS (Ground Based Augmentation System)

SBAS (Satellite Based Augmentation System)

WAAS, EGNOS, MSAS, GAGAN,...



Why we need to extend interoperability to integrity ?

Initial ideas for early discussion. External consultation need to be established among stakeholders



- 1) Aviation welcomed the agreement between US and Europe. It is focused on frequencies /signals, time offset and security aspects. **Integrity aspects are not covered.**
- 2) GNSS integrity is key for aviation **safety**. Aviation needs interoperability worldwide.
- 3) **Integrity will become more complex** in a multi frequency multi constellation environment. Different integrity mechanisms and concepts exist but are difficult to be combined at user receiver level in an efficient way:
 - SBAS integrity (applied at regional level). Potential extension to Galileo
 - GBAS integrity (applied at local level. Extension to Galileo to support CAT II/III operations)
 - RAIM integrity concepts and new capabilities (Detection of multiple failures, RRAIM, ARAIM,..)
 - Galileo SoL integrity concept
 - GPS III integrity concept
- 4) Integrity is one of the drivers for GNSS systems architectures. There is a need to define a **cost effective allocation of integrity** burden between constellations, augmentations and user receiver.
 - GEAS study is assessing architectures to provide LPV 200 worldwide based on GPS (GIC, RRAIM and ARAIM). Phase I of GEAS study is based on GPS only, could consider Galileo in future work.
 - Galileo SoL is being defined to provide LPV 200 worldwide based on Galileo only.

Interoperability is not detrimental to independence.

- 5) **Lack of an agreed GNSS baseline on integrity could delay transition to GNSS.**
- 6) There is a risk of having **different receivers standards** at regional level.



How to extend interoperability to integrity ?

Initial ideas for early discussion. External consultation need to be established among stakeholders



Goal: Promote and harmonise integrity concepts and mechanisms that can be applied at user level worldwide.

Recommendation. To reinforce international cooperation at different levels:

1. US–EU at programme and political level to assess interoperability between GPS and Galileo at integrity level.
2. **Coordination** between GPS evolution studies (e.g. GEAS) and European activities.
3. **Assess the impact** of changing/adapting (on-going and future) technical concepts/developments to improve interoperability.
4. IWG (Interoperability Working Group) for SBAS developments
5. **Share a GNSS baseline** and a transition path between FAA and EUROCONTROL. Coordination between GNSS baseline in SESAR and Next Gen
5. Support **ICAO standardization** processes for global interoperability in aviation
6. Promote **cooperation** between RTCA and EUROCAE for receivers standardization





QUESTIONS ?

