EUROCONTROL & GNSS Research Update

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OUTLINE

- **PROGRAMME**
  - SESAR 2020 (2016 – 2021)
- **PARTNERSHIP**
  - ECTL / GSA Framework Partnership Agreement (2015 – 2021)
- **HOT TOPICS**
  - GNSS RFI
  - A-PNT
  - MC GNSS CONOPS
- **QUESTIONS**

PROGRAMME

SESAR 2020 (2016–2021)

PROGRAMME : SESAR 2020 (2016 – 2021)

- Part of H2020 European Framework Programme for Research & Innovation

  https://ec.europa.eu/programmes/horizon2020

- Budget : ~ **€1,6 billion** including 585M€ EU funding / 500M€ ECTL / 500M€ industry members

- 3 phases of research:
  - Exploratory research (**€85 million**)
  - Industrial Research and Validation(**€1,2 billion**)
  - Very Large Scale Demonstration (**€300 million through Open Calls**)

  with Running costs/studies/third parties/support (69M€)

- Duration : 2 waves 2016-2019 & 2019-2021 synchronized with EATM Master Plan

  https://www.atmmasterplan.eu/

PROGRAMME : SESAR 2020 (2016 – 2021)

- 17 Industrial Projects (PJs) in launching phase

- 03 PJs with specific GNSS relevance:
  - PJ 02: Increased Runway & Airport Throughput
  - PJ 03a: Integrated Surface Management
  - PJ14: Communication, Navigation & Surveillance

- Main GNSS-related topics:
  - MC-MF GNSS solutions
    - SBAS/GBAS/ABAS receivers
  - GBAS GAST-D & GAST-F
  - A-PNT medium and long term
  - ADS-B/MLAT
  - New security functions: authentication/continuity of service/jamming-spoofing protection

PROGRAMME : SESAR 2020 (2016 – 2021)

PJ 02 - Increased Runway & Airport Throughput

- Minimum pair separation based on Required Surveillance Performance (RSP): 2Nm minimum for arrivals/final approach
- WAM/ADS-B/GBAS data sharing to meet RSP
- Access to secondary airports in low visibility conditions (operations below 200ft decision height)
- Enhance terminal area for efficient curved operations
  - Curved procedures
  - Use of GNSS-based geometric altitude with benefit of GBAS/SBAS
  - Extended GBAS service volume > 23 Nm

PROGRAMME : SESAR 2020 (2016 – 2021)

PJ 03a – Integrated Surface Management

- Complete guidance assistance to aircraft/vehicle/controllers on airport surface (SBAS/GBAS/ABAS GNSS receivers on-board + GBAS on the ground)
- Navigation & accuracy in low visibility conditions
  - High integrity & continuous navigation information
  - Solutions against GNSS disruption of service

PROGRAMME : SESAR 2020 (2016 – 2021)

PJ 14 – CNS

- Integrated CNS + separated C,N,S solutions including spectrum & security
  - Synergies across COM, NAV &SUR for ground & airborne segment
  - Modernized SBAS (EGNOS V3)
  - GAST-D & GAST-F
  - Cyber-security
  - New security functions (authentication/jamming-spoofing robustness)
  - ADS-B
- GBAS
  - GBAS CAT III L1
  - GBAS CAT II:III based on MCMF GNSS (GPS + Galileo)
  - Compatibility GBAS/PALS (civil/military interoperability)
- Multi Constellation / Multi Frequency GNSS/SBAS
  - Integration of core constellations (GPS/Galileo/Glonass/Beidou) and additional SBAS systems
  - Definition & prototyping of GNSS/SBAS receivers
  - Integrity schemes (MC RAIM, SBAS)
  - Resilience to interference
  - Flight tests

PARTNERSHIP

EUROCONTROL – EUROPEAN GNSS AGENCY

FRAMEWORK PARTNERSHIP AGREEMENT

PARTNERSHIP : ECTL – GSA FPA

WP 1	Aviation users' needs to support the definition of mission level requirements for EGNOS and Galileo
WP 2	Operational introduction of European GNSS services (EGNOS and Galileo) for aviation in European Civil Aviation Conference (ECAC) area
WP 3	Advise on Regulatory and Standardisation aspects, including Spectrum
WP 4	Support to European GNSS Development and Exploitation Activities
WP 5	Coordination of R&D for GNSS in aviation
WP 6	Inclusion of EGNOS and Galileo in future GNSS user terminals for aviation
WP 7	Aviation specific GNSS performance monitoring
WP 8	International activities on GNSS in the aviation domain, including European GNSS activities outside ECAC area
WP 9	Areas 1 to 8 related to ATM sensitive applications & State Aircraft

- **9 WORK AREAS (not all started yet)**
- **FUNDED WITH GRANTS**
- **7-YEARS DURATION**
  2015-2021
- **TOTAL BUDGET OVER THE ENTIRE PERIOD**
  6M€

PARTNERSHIP : ECTL – GSA FPA

- Supersedes the 2006-2014: Cooperation Agreement between GJU & ECTL

- Entered in force 8 April 2015

- In coordination with SESAR 2020
  - Assessment of dependencies / gaps / redundancies / coordination between Horizon2020 and SESAR2020 projects

- First Grant (2015-2016) focused on EGNOS and Research Harmonisation

- Second Grant (2016-2018) consequent focus on RFI mitigations and Galileo developments with regard to MCDF
  - EGNOS & Galileo integration / performance / standardization / operational introduction / mission level requirements

HOT TOPICS

RFI – A-PNT – CONOPS

HOT TOPICS : A-PNT

- SESAR
  - Initial work completed through SESAR Project 15,3,2 “Navigation Infrastructure Rationalisation”
  - Continues in SESAR Program 2020 (PJ14 on CNS)

  - Short term
    - optimised DME/DME network for En-route and all major TMAs
    - VOR/DME minimum operational network for aircraft not equipped with DME/DME avionics
    - New strategy published in ICAO Annex 10
  - Medium term
    - Small updates to current DME/DME functions and standards
    - DME/DME-based RNP?
    - Give credit for current equipment performance (air & ground)
  - Long term
    - leverage new CNS developments : new COM & SUR technologies in early development phase (LDACS and others)
    - explore more efficient spectrum technologies than DME

HOT TOPICS : RFI

- Need to minimize risks to Air Traffic Management
  - Specifically potential threat of wide-area outage
  - Coordinated activity using all available instruments (SESAR, GSA, others)

- ICAO Navigation Systems Panel: RFI Mitigation Plan

- EUROCONTROL : EVAIR (CGSIC SEP 2015)

- Specific In-Flight Localization of GNSS RFI Sources activity (as part of SESAR 15.3.4)

  Please see paper FRI pm Session E6A RFI & Spectrum 1:
  “Interference Localization using a Controlled Radiation Pattern Antenna (CRPA)”

HOT TOPICS : ICAO MC GNSS CONOPS

- ICAO Navigation System Panel was tasked to develop Next Generation CONOPS following ICAO 12th Air Navigation Conference.
- NSP agreed that drafting of the CONOPS be led by Eurocontrol.
  - Paco Salabert (Eurocontrol Panel Member), with external support from Ken Ashton.
- Initial subject content contributed by NSP ‘volunteers’
- The CONOPS (v3) is currently incomplete and some sections are immature.

CONOPS: Objectives

- Define how the new GNSS technology that is being developed and standardised (e.g. SARPS by NSP and MOPS by EUROCAE/RTCA), will bring operational benefits to ATM while addressing the identified interoperability and institutional challenges.

- Describe how CNS applications such as PBN or precision approach operations will be supported by the new constellations, signals and augmentations. Describe how services will be implemented during the next decade and managed from and end-to-end perspective (system design, standardization, airborne, end users, air navigation service provider tasks…).

Air Navigation Conference 12 Rec. 6/6 – Use of multiple constellations

That States, when defining their air navigation strategic plans and introducing new operations:

- a) **take advantage of the improved robustness and availability** made possible by the existence of multiple global navigation satellite system constellations and associated augmentation systems;
- b) **publish information** specifying the global navigation satellite system elements that are approved for use in their airspace;
- c) adopt **a performance-based approach** with regard to the use of global navigation satellite system (GNSS), **and avoid prohibiting the use of GNSS elements** that are compliant with applicable ICAO Standards and Recommended Practices;
- d) carefully **consider and assess if mandates for equipage** or use of any particular global navigation satellite system core constellation or augmentation system **are necessary or appropriate**;

That aircraft operators:

- e) **consider equipage with GNSS receivers able to process more than one** constellation in order to gain the benefits associated with **the support of more demanding operations**.

CONOPS: Principles

- The CONOPS will consider all Stakeholder needs and obligations.
- Termed ‘Next Generation GNSS CONOPS’ as it encompasses a range of capabilities. e.g. SC-DF, MC-SF, MC-DF.
- Will address all future CNS and ATM use of GNSS
- Addresses Core Constellations, SBAS, GBAS and A RAIM.
- The CONOPS needs to address the operational benefits that will be achieved by Next Generation GNSS .
  - Improved robustness through mitigation of current GNSS vulnerabilities.
  - Desire to avoid ‘politically motivated’ GNSS use mandates
  - Has to be ‘economically attractive’ for all stakeholders.
- The CONOPS recognises:
  - Backwards compatibility for legacy avionics and procedures as there will be a long period of co-existence.
  - There will be increased gearing between ATM development and GNSS resilience.
  - There will be operational evolution and innovation.
  - The need to minimise changes to other documentation. SARPS, Manuals, guidance materials and other operational procedures etc.
- The CONOPS will not specify how future avionics should be implemented

Benefits (1)

1 **CNS ROBUSTNESS**

- Improved availability and continuity for CNS applications currently based on GPS L1 (e.g. PBN, ADS-B).
  - En-route/TMA: Reduce likelihood of reversion to DME/DME or INS that may impact capacity.
  - Final Approach: Reduced missed approach rates for RNP-APCH-AR and likelihood to revert to conventional approaches.
  - MCDF GBAS systems will provide a very robust CAT II/III service that could become a real alternative to ILS.
  - Improves business continuity at remote/oceanic/high latitude areas
  - Increased business continuity in areas with poor navaid and/or radar coverage.
  - Reduced likelihood of a GNSS element failure affecting PBN and ADS-B applications simultaneously.

Benefits (2)

2 STABILISED APPROACHES

- Vertical guidance worldwide for all users to reduce CFIT.
  - Aircraft SBAS L1/L5 avionics will facilitate extension of APV I and LPV 200 service areas.
    - Particularly in equatorial areas:
  - LPV service available at more runways.
  - Wider implementation of CATII/III GBAS as DFMC will reduce the impact of ionospheric effects.
  - Vertical A-RAIM could support APV I or LPV 200 worldwide in the long term.

3 INTEROPERABILITY

- Allows compliance with National and Regional CNS mandates
  - A MCDF GNSS receiver may be an attractive option for aircraft having to retrofit to comply with GNSS requirements imposed by regulations (e.g. FAA rulemaking on ADS-B, a PBN mandate in TMA,) if corresponding certified receivers are timely available.

Benefits (3)

4 INNOVATION

- Facilitate new concepts and applications.
  - Improved performances to support innovative concepts/applications that are not currently possible or considered:
  - Geometric Vertical navigation in TMAs
  - Use of geometric vertical positioning to support RVSM
  - Support a future PBN spec,
  - New types of approach such as CAT I / CAT II Autoland or RNP-APCH-AR without the need for hybridization to sustain continuity.
  - Support ADSB applications worldwide.
  - Potential to use MC-DF capability to detect ‘spoofing? (Not discussed at NSP)

5 IMPROVED 3D APPROACHES

- Increased availability and utilization of LPV
  - The inclusion of SBAS or Vertical A RAIM in the longer term in new GNSS receivers would allow more aircraft to benefit from LPV benefits such as :
  - LPV capability instead of LNAV/VNAV
  - Approaches with minima less than 200’
  - Avoid QNH setting issues. This is of particular relevance for regions with limited QNH information availability.

Benefits (4)

6 AIRBORNE EQUIPMENT

- Rationalization of airborne equipment
  - Potential to relax some airborne equipment requirements
  - e.g. not requiring ADF or VOR equipment on board if aircraft is equipped with a next generation GNSS receiver.

7 GROUND INFRASTRUCTURE

- Rationalization of ground infrastructure.
  - Enables further optimization of conventional nav aids depending on the equipage uptake of the fleet with next generation GNSS receivers.

8 INSTITUTIONAL CONCERNS

- Mitigation of Institutional issues.
  - Alleviation of institutional concerns related to the dependence on a single foreign constellation
  - Improve accessibility to airspace managed by States with institutional/legal concerns about the use of GPS.

Benefits (5)

9 IMPROVED TIMING

- Improved redundancy and resilience for timing.
  - Diversity of constellation and frequencies providing time for CNS/ATM airborne and ground systems and applications.
  - Depends on the use and criticality of GPS time in ground and on board systems.

10 FLIGHT PLANNING

- No need for operators to perform RAIM Prediction.
  - It is currently assumed that it will be unnecessary to predict RAIM availability when positioning is determined combining ranging sources from several constellations.

Key Stakeholder Responsibilities

Core Constellation and SBAS Providers Responsible for indicating the compliance with SARPS and the operational status of individual signals for Aviation through Letters of Commitment to ICAO.

ICAO Responsible for ensuring that the Letters of Commitment will be distributed to all member States.

States To approve the GNSS elements for all of FIRs under the State's responsibility and to publish the approval status within the State Aeronautical Information Publication in accordance with the Provisions within ICAO ANNEX 15. These approvals are not expected to happen at the same time in every State.

Aircraft Operators Responsible for operating in accordance with their National Operating Regulations. GNSS Elements may be prescribed depending on the State of Registry and/or the airspace route or procedures

Principles agreed on the approval of GNSS elements by States. (1)

At the June 2016 Meeting, the ICAO NSP agreed 16 high level Principles to initiate discussions on implementation solutions with RTCA SC-159 and EUROCAE WG-62.

Core Constellation Principles

Principle #1. Core constellations are GNSS elements. States will publish the approval status of the core constellations: GPS, GLONASS, Galileo and BeiDou to be augmented by ABAS.

Principle #2. The State approval of a core constellation consists of individual approval of the signals provided by that system that are standardized within ICAO SARPS for aeronautical use.

Principles agreed on the approval of GNSS elements by States. (2)

SBAS Principles

Principle #3. Core Constellation and SBAS providers will indicate operational status of individual signals through commitment letters to ICAO that will be distributed to States.

Principle #4. The State approval of an SBAS system implies the approval of all SBAS signals of this system that are standardized within ICAO SARPS for aeronautical use.

Principle #5. SBAS systems are GNSS elements. States will publish the approval status for individual SBAS systems.

Principle #6. The approval status of an SBAS system applies to all SBAS functions (e.g. ranging , integrity and correction functions) of that system.

Principle #7. When a State Approves an SBAS the approval includes the use of the SBAS and all of the Core Constellations that are augmented by the SBAS, even if the core constellations are not approved for use with ABAS.

Principles agreed on the approval of GNSS elements by States. (3)

ARAIM Principle

Note: A-RAIM Concept is under development and Principles #8 may require review as the concept matures. In particular the definition of the ISM for A-RAIM is still an open issue.

Principle #8. States will publish the approval status of the ISM for V-ARAIM.

> **Note:** For H-ARAIM there is no need for State Approval of the ISM within the Airspace Approval. The ISM parameters will be specified in MOPS /TSO/Other (TBC) and are part of the airworthiness approval.

GBAS Principle

Principle #9. GBAS is considered to be a National system not to be considered as a GNSS element subject to different approvals by States.

Principles agreed on the approval of GNSS elements by States. (4)

Airspace Principles

Principle #10. If there is no information in the AIP on the State approval status for any GNSS element within a given airspace, it is considered that all GNSS elements are available for use.

Principle #11. It is assumed that a GNSS element has the same status in all contiguous FIRs managed by a State.

> **Note 1** In the case of international airspace that may be managed by a group of States, the approval will be determined through existing regional arrangements
>
> **Note 2** A distinct approach may be required for a State's overseas FIRs (e.g. French overseas FIR having a distinct approval statement from the French metropolitan FIRs).

Principle #12. It is assumed that a GNSS element has the same approval status for all CNS applications within airspace managed by a State.

Principle #13. A State's approval of a GNSS element applies to all phases of flight where routes or procedures require the use of GNSS.

> **Note:** Specific provisions exist for States to approve the GNSS elements that can be used for critical operations, (e.g. FAS DB for geometric vertically guided approach operations)

Principles agreed on the approval of GNSS elements by States. (5)

Approval Update Principles

Principle #14. It is expected that most of the changes in the approval status will need to be applied with a frequency that is commensurate with the AIRAC promulgation cycle (28 days).

Principle #15. There is a need for user equipment to accommodate contingency situations that may require temporary suspension of use of some GNSS elements.

Expansion Principle

Principle #16. The approval scheme will be expandable to accommodate new GNSS elements (new core constellations, new SBAS systems), new States and airspace approval status.

Actions and Way Forward

Coordination with EUROCAE WG 62 and RTCA SC 159:

- Consider the implications of the proposed Principles on the architecture and design of next generation GNSS systems.
- Provide feedback to the ICAO NSP on the impact of the Principles on the architecture and design of next generation GNSS systems.
- Propose implementation solutions to be discussed with ICAO NSP considering the view of pilots/operators and AIM experts to be eventually reflected in corresponding section of the CONOPS dealing with receiver aspects.
- Consider the operational benefits identified in this presentation as an input for RTCA/EUROCAE trade off analysis

Objective is to have a first version of CONOPS by NSP 3 December 2016.

  - Beneficial to include high level system considerations in next version of CONOPS.