Use of ADS-B for GNSS RFI Monitoring

Hamdi NASSER, EUROCONTROL
hamdi.nasser@eurocontrol.int
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GNSS RFI: a global problem

- Ops contingency procedures
- Retain essential CNS infrastructure
- Monitoring and reporting
- Better integration and resilience of airborne systems
- Coordination between authorities
- Legal framework

Satellite Interference Reporting and Resolution System
https://www.itu.int/en/ITU-R/space/SIRRS/Pages/default.aspx

Official reports are essential to justify actions
Motivation

• GNSS RFI has become a widespread problem affecting aviation
• GNSS is the primary enabler for PBN and ADS-B applications and is becoming an increasingly essential technology used in various other CNS applications
• Reporting does not reflect real field conditions

The number of reports gives a small indication but does not reflect the full picture (dependent on the willingness to report)

→ Need for a tool allowing automatic detection and reporting of GNSS RFI

2018 / 2019 trend: average of 10 GPS reports DAILY!
2020/2021 decrease due to reduced flights (COVID) and reporting
2022: increase due to the war in Ukraine (main peak in March/April)

2021: 10843 events detected worldwide
RFI continues despite reduced pilot reports
OPS Requirement

• 2014: Preparation for EU PBN Implementing Rule:
  • ATC Human in the Loop Impact Studies for impact assessment including GPS Loss
  • Budapest simulation, high level of “GPS-only for PBN” traffic (20%)
  • ATCO Statement: “I can deal with GPS RFI, just tell me when it starts, how many sectors are affected, and when it ends”

• Validated OPS Requirement through EUROCONTROL NETOPS
  • NETOPS Conclusion 23/10: NETOPS agreed the following recommendations:
    • b) With reference to paragraph 3.2: confirm the Operational need to be aware of the geographic area of GPS outages and that they (ATC) intend to use this information in the context of contingency operations.

Summary Report Twenty-third Meeting (NETOPS/23) Brussels, 28 Feb - 1 March 2019, NETOPS/24 WP02
Developing Solutions: ADS-B Monitoring

- Monitoring Objectives
  - **Operational Risk Management:**
    - Detect RFI area and notify airspace users
    - Identify affected flights: depends on other available CNS capabilities and aircraft equipage
    - Prevent a potential ATC/pilot workload increase
  - **Technical Intervention**
    - Determine RFI Source Location if possible
    - Report incident to radio regulator for resolution

Detection criteria of RFI:
- A degraded NIC value reported by several aircraft in the same area
- A good satellite geometry in the concerned area
- Absence of bad space weather conditions in the concerned area

Validation of the RFI glocalization capability

Simulation results with real aviation GNSS receivers (GRIT project)

Match with EVAIR reports

ADS-B NIC

ADS-B missing position reports

ADS-B geolocation match with HawkEye360 Data (LEO capability)

Match with EVAIR reports

ADS-B PIC

ADS-B missing position reports
Navigation status monitoring (NASM) – IOC and weekly update

**Operational impact assessment**

**Tactical: Near real time capability**
Ensure that there is a timely reaction to a significant event, allowing to identify affected flights, inform all concerned actors and implement appropriate mitigation measures (such as reducing certain traffic through an impacted airspace).
Envisioned Next Generation RFI Mitigation Function

**Functional architecture**

- **ICAO NSP** agreed job card to work on “GNSS RFI detection and status Downlink”
- Concept presented to EUROCAE / RTCA CSC in 2018
- Concept presented to ASWG and supported by the SUR community
- RTCA SC159 / EUROCAE WG62 is working on the inclusion of an RFI detection function in next generation GNSS standards
- ADS-B is the most suitable link due to commonality of interest (use of GNSS)
- Work on going with the SUR community to define the downlink message and the update rate – will be presented to TSG
PEGASUS – EUROCONTROL GNSS data processing tool

- Implementation of the current MOPS RFI draft requirement in PEGASUS

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**IMPL-MOPS-RFI-DRAFT-1**

The equipment shall provide an indication of “L1 RFI detected” if any of the following conditions is met:

- a) A variation of at least 5dB of the averaged “standardized” CN0 absolute value in the last 60 seconds using at least 5 (TBC) L1/E1 signals broadcast by GPS or GAL satellites passing the Satellite Use Criteria defined in Section 3.1.1.6.3 or
- b) The number of GPS and GAL L1/E1 signals passing the Satellite Use Criteria defined in Section 3.1.1.6.3 is less than or equal to 4

*Equipment class: A1*

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**IMPL-MOPS-RFI-DRAFT-1**

The “L1 RFI detected” indicator shall return to its normal state if any of the following conditions is met:

- a) Equipment power-on until the number of GPS and GAL L1/E1 signals passing the Satellite Use Criteria defined in Section 3.1.1.6.3 is higher than or equal to 5 during 60 seconds or
- b) All following conditions are met:
  - i) At least 10 (TBC) tracked L1/E1 signals broadcast by GPS or GAL satellites passing the Satellite Use Criteria defined in Section 3.1.1.6.3
  - ii) A variation lower than 5dB of the averaged “standardized” CN0 absolute value in the last 60 seconds using at least 5 (TBC) L1/E1 signals broadcast by GPS or GAL satellites passing the Satellite Use Criteria defined in Section 3.1.1.6.3

*Equipment class: A1*
GRIT project – Aviation Receivers testing and jamming detection

- ION GNSS+ 2022 paper
  - [https://www.ion.org/gnss/abstracts.cfm?paperID=11415](https://www.ion.org/gnss/abstracts.cfm?paperID=11415)
- Supporting the definition of DFMC MOPS RFI requirements
- Possible integration in the PEGASUS toolset
  - Flight data analysis
  - RFI detection on ground
The purpose of this document is to describe a process for the planning, notification and execution of GNSS interference testing.

https://www.eurocontrol.int/publication/eurocontrol-guidelines-process-civil-military-gnss-interference-testing

- **GNSS testing planning**
  - Impact assessment
  - Approval process
    - Within national borders testing
    - Cross borders testing
    - High seas testing
  - Testing coordination

- **GNSS testing execution**
  - Airspace users
  - ANSP

- **GNSS testing notification**
  - AIS (NOTAM, AIP SUP, AIC)
  - Notification to NM
  - Notification to other impacted users

- Initial version released in September 2021
- Publication of v2 planned for Q4 2022
EUROCONTROL Guidelines for GNSS Interference Testing

Objectives

- Web-based platform:
  - Calculation of the impacted area / required interference power
  - Graphical display of planned GNSS/RF testing
  - Workflow with roles and decisions for users
  - Generation of publications proposals (NOTAM and/or AIP SUP)
  - Supports the INTERRUPT procedure and nominated PoC

Update finalised:

- Expansion of the scope to include for any state authorized RFI activities
- Review of the impact assessment prior to GNSS interference testing
- Consideration of other notification means (AIP SUP, AIC)
- Consideration of spoofing
- Consideration of danger and restricted areas
- Reviewed and endorsed by MAB
- Publication of v2 planned for Q4 2022
C-UAS

- An **ad hoc group** composed of representatives from EUROCONTROL, EDA, NATO, EC JRC and European police forces/frequency regulators/military

- **Objective**: Determine possible collateral risks to the use of C-UAS jammers
  - i.e. possible risks to non-participating GNSS receivers, including receivers in civil aviation aircraft
  - Risk assessment as a basis for authorizing the safe use of C-UAS

- **Planned activities**: Test plan, Test campaign at JRC (Measure of the 3D radiation pattern of commonly used CUAS), Report including recommendations on the use of state authorized CUAS.
  - Technical characteristics and mitigation: on going in JRC, Results expected in Q4 2022.
  - operational/tactical mitigation planned for 2023

- **Expected outcome**: Risk mitigation measures to ensure the safe use of CUAS capabilities
GNSS interference course - [NAV-GNSS-RFI]

- GNSS vulnerabilities - Day 1 Morning
  - Overview of the different sources of GNSS errors
  - GNSS Interference sources and classification
- Impact of GNSS interferences - Day 1 afternoon – Day 2 morning
  - Group work and discussion: This module aims to encourage the audience to exchange their experiences and to focus on the main problems they are facing with regard to GNSS interferences.
  - GNSS RFI impact on airborne and ground systems
  - Impact on ATM operations
- GNSS interference mitigation – Day 2 Morning - afternoon
  - GNSS threat risk assessment
  - Strategic mitigation measures
  - Tactical mitigation measures
  - Airspace concept: Contingency and reversion strategies
  - Takeaways

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<td>DAY 2</td>
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<td>GNSS interference mitigation</td>
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Location
Aviation Learning Centre, Luxembourg

Dates
7-8 June 2023

https://learningzone.eurocontrol.int/lip/pages/description.jsf#/users/@self/catalogues/896269/coursetemplates/13958757/description
Summary

- GNSS interferences continue to affect aviation operations and may increase further in the future
  - GNSS testing, CUAS, proliferation of jammers
  - GNSS RFI may escalate beyond “operational nuisance”
  - Importance of **automatic detection and reporting to** the relevant national authorities

- EUROCONTROL is developing monitoring capabilities
  - IOC and weekly updates: RFI detection and localisation using ADS-B
  - Objective is to move to a near real time tool and to combine with other data in order to support ATM ops
    - **Impact on operations** depends on the fleet capabilities and the available infrastructure: Importance of defining suitable contingency procedures taking into account those factors
    - Importance of **continuous monitoring** to enable **timely reaction** to a significant event and implement appropriate mitigation measures

- Exploit multi-mode strengths
  - ADS-B provides indirect **monitor** of GNSS RFI – already today
  - **Additional** aircraft, ground and space **capabilities** can provide independent confirmation
  - **Standards**: Work on going to define the “GNSS RFI detection and status downlink” functions

- Prepare the future
  - Robust **multi-sensor** positioning preventing a single point failure
  - Use of the **RFI downlink** function

- EUROCONTROL guidelines on a process for Civil-military GNSS interference testing – Coordination of state authorized GNSS RFI testing
  - CUAS study could feed the guidelines with recommendations related to the safe use of CUAS (unplanned events).