GNSS RFI Mitigation: European Efforts & Proposals

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Overview

- GNSS RFI Mitigation Plan Development
  - Introduction & Principles
  - Implementation Support

- Threat Monitoring and Risk Assessment: Global and Regional Processes (Short Term)

- Long Term Strategic Objective

*Note: Developed through SESAR*
Introduction

- GNSS RFI Mitigation Plan History & Context
  - Initiated by Spring 2013 Workshop at Eurocontrol Navigation Steering Group Meeting
  - Guidance developed through ICAO Navigation Systems Panel
  - In response to ICAO 12th Air Navigation Conference Job Card
  - Proposed for inclusion in GNSS Manual, ICAO DOC 9849
    - Dec 2015 Change Package
  - Beginning of document very technical (definitions and classification), but rest should be accessible to general audience

- Scope
  - Limited to threats requiring radio frequency propagation
  - Not dealing with corruption of position once it has left receiver
Moving from Vulnerability to Mitigation

• Objective of RFI Mitigation Plan
  • Define set of activities for States to ensure that risks to aviation from GNSS RFI are sufficiently mitigated
  • Checklists of set of activities to be considered
  • Much is already in place, State to decide depending on local environment
  • To enable reliance on GNSS and associated aviation benefits

• Focused on States
  • Spectrum a sovereign responsibility
  • Regulation and enforcement part of national oversight
  • Framework to encourage coordination and exchange of best practices
  • Current work focused on regional and global support
Mitigation Plan Framework

Monitor Threats
- Proactive & Reactive Monitoring
- Environment Evolution

Assess Risks
- Scenario Variation & Escalation
- Impact Assessment
- Identify Existing Barriers

Deploy Mitigation Measures
- Reduce Risks to Acceptable Levels
- Integrate in Safety Management System
Risk Trade Space

- Normal Events, Limited Severity
- Unpredictable Catastrophic Event

If probability difficult to quantify, only approach is to limit impact.
Implementing Mitigation Barriers

Prevent Transmission of RFI
- Regulatory Control and Enforcement
- Outreach

Prevent GNSS Service Outage
- GNSS Resilience
- On-board Integration

Limit Severity of Impact
- CNS/ATM Integration
- A-PNT
- Detection & Resolution

GNSS RFI Vulnerability

Supported by (Reactive) Threat Monitoring Networks
Starting Challenges

• Observability: Difficult to get data on incidents
  • Existing Spectrum Groups receive few reports
  • NOTAM search produced few results

• Event Confirmation:
  • Difficult to conclude that GNSS outage is result of RFI

• Event Scope
  • Difficult to quantify geographical extent, duration and impact

• Best to monitor at the impact source: aircraft receiver
  • Currently, only pilot can observe receiver outage
  • Subsequent reporting requires support at regional and global level
  • Ground networks useful complement, but limited use
    • Apart from visibility issues, lacks essential risk assessment link: what is the impact at the aircraft?
Identification of Probable Cause Through Elimination

Due to Constellation / Satellite?
- CSP Centers (GPS NAVCEN, etc.)
- Augmentation User Support (ESSP, etc.)

Due to Space Weather?
- Space Wx Agencies
- Iono Monitoring Networks

Reported GNSS Outage Event

Due to Receiver Problem?
- Receiver Manufacturers
- Avionics Integrators

If all else can be excluded, must be RFI!
- Local Verification & Resolution

Due to Military Testing?
- Civil-Military Coordination, NATO National Defense
GPS OUT Reporting Streams Today

**GNSS Multi-Modal**
Aviation one User among many

- GPS NAVCEN
- ESSP

**Aviation Specific**
GNSS Out One Issue among many

- IATA
- Eurocontrol Network Manager

**First Step: Align Aviation Coordination**
- AO
  - Airline OPS Center
  - FOQA Monitoring?
  - PIREP: Local AIS

**Second Step: Interfaces with GNSS System Providers**

- Local ANSP ?
  - AIS to Technical Services
  - Technical Services activate subsequent process?

No aggregate vision of events ➔ Incomplete threat picture
Resolution depends on awareness of many individuals
Implemented: GNSS in EVAIR

- EVAIR = Eurocontrol Voluntary ATM Incident Reporting
  - Established Safety Process (Confidentiality, Anonymity)
  - 250 Participating Aircraft Operators
  - Coverage: Europe, Middle East, Northern Africa
  - Close cooperation with IATA
  - Part of Network Manager Functions

- Info Bulletin / Request sent beginning 2015
  - Initial wave of reports received covering 2013/2014
  - Additional reports coming in every few weeks
  - GNSS Outage one issue among many
  - Simple to set up because it is an existing process / framework
  - Working on further awareness materials

www.eurocontrol.int/services/evair
GPS Issues: EVAIR Findings

(Status May 2015)

- First reports received in 2013
- # of reports in the DB - 42
- # of AOs (Aircraft Operator) reporting GPS outages so far - 11
- # of locations identified – 17
- En-route flight phase most affected
GPS Issues: EVAIR Findings

Type of reported GPS issues 2013 – 2014

- Loss of GPS Signal
- GPS Outage
- GPS Jamming
- Total Loss of GPS
- GPS 1 and 2 Lost
- GPS 1 Lost

**GPS System Failure 2013 - 2014**

- GPS 1 and 2; 21; 88%
- GPS 1; 3; 12%

**GPS failure duration 2013 - 2014**

- Duration btw 5 - 10 min 7%
- Duration btw 1 - 5 min 43%
- Duration btw 10 - 30 min 50%
GNSS in EVAIR: Threat Monitoring

• Return to normal operations & impact on both receivers on few aircraft point to RFI with high probability
  • **Proves that RFI Outages are REAL but also limited in operational impact currently**

• Time-limited, single events do not warrant action
  • **Supports strategic objective of threat monitoring**
  • Enables setting boundaries on event probability and severity
  • Provides detection if environment changes

• Maintain central repository and statistics of GNSS Outage events
  • Consultation of GNSS service and space weather monitoring reports provides further refinement
  • May also benefit from data from local ground receivers
  • Clarify interfaces for aviation-relevant reporting
EVAIR: GPS Issues Information Flow

EVAIR-GPS focal point

Review

“GPS Group” Review & Next Step

Determine probable cause through consultation with GNSS channels

Yes, potential issue

Heads-up to AO’s

Inform if important

Heads-up to Other Stakeholders

Inform if important

Notify ANSP(s)

Inform if important

NM Coordination

ECTL NM internal

No Action (await more reports)

No Action (await more reports)

EASA
EVAIR: Trigger for Detection & Mitigation

- Significant accumulation of events in specific area leads to detection and triggers mitigation action
- Ensuring timely resolution reduces vulnerability / exposure

Detection by EVAIR

3rd Party Reports → Inform AO’s

Local ANSP - Confirm RFI Case

Pilot / Voice Reports

Locate & Eliminate Source in cooperation with local regulatory & enforcement authorities

- Deploy Operational Contingency Measures
- Publish NOTAM if reqd.
Interfaces with GNSS System Operators (GSO)

• Currently, mainly GPS NAVCEN and ESSP
  • Multi-constellation: GLONASS, Galileo, Beidou Service Centers
  • Regional SBAS User Support Centers (GBAS with local ANSP)

• **Case 1: Strategic Long Term Threat Monitoring**
  • Info from GSO to Aviation: Ensure comprehensive view of all aviation-relevant cases

• **Case 2: Tactical Mitigation: Actual Significant Outage Event**
  • Request from Aviation to GSO: Support in identifying probable cause
  • Benefit from established links (receiver issues, ionosphere, RFI testing)
Medium Term Improvements

• Not really Pilot’s job to determine cause of GPS outage or to report signal in space issues
  • In the age of SWIM, reporting should be automated
  • GPS Outage Simulation: ATCO & Planners want to know geographic extent, start and end of outage (Budapest simulation outcome)

• Reporting through ADS-B Figure of Merit
  • Part of ongoing SESAR investigations
  • Feasibility demonstration: Australia (Sydney case)
  • Need to build experience in how to integrate information

• Some guessing remains with respect to probable cause
  • Especially for wide-area outage where resolution should be fast
  • Implement RFI detection standard feature in all receivers ?
Long Term RFI Mitigation Improvements

• A lot can be done with current capabilities at reasonable cost
  • EVAIR is available now
  • Mostly a matter of setting up interfaces and data integration
  • ADS-B FoM Monitoring excellent example of CNS synergy use without introducing additional complexity
  • Still want to reduce guesswork in future equipment

• Next Generation MC GNSS Avionics
  • ICAO NSP requested implementation of reasonable mitigation capabilities from RTCA / EUROCAE
  • Detection capability seen as a feasible minimum:
    • Permit aircraft to switch to “A-PNT capability”
  • Information must reach ANSP
    • Quick Access Recorder, Flight Operations Quality Monitoring
    • Future: SUR Downlink Aircraft Parameters (DAP) ??
Proposed Actions for CGSIC Consideration

1. **Support Aviation GNSS RFI Mitigation Plan**
   - Aviation-relevant threat monitoring & event resolution
   - May be suitable for other transport modes & user segments also

2. **Support Setup & Alignment of Global Interfaces**
   - Encourage EVAIR example to be used in other regions
   - Requires channels which can handle sensitive information
   - Multi-constellation GNSS will increase complexity & need for global exchange

3. **Support strategic long term objective: Closed-loop service provision for space based infrastructure**
   - Detect signal-in-space issues at receiver without requiring pilot intervention
   - Provide means to make information available to ANSP & radio authorities with goal to reduce intervention times
   - Investigate best options to support future implementation