ICAO DOC 8071
Manual on Testing of Radio Navigation Aids
Volume II: GNSS
and current GNSS Operational Issues

ICAO Webinar on *Flight Inspection*

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Update of Volume 2 on GNSS

• With removal of flight validation, GNSS Volume is becoming thin
  • GNSS Signal in Space analysis is best done with data collection receivers (or network of receivers) on ground
  • Nature of “testing” evolving toward engineering data analysis
  • Main content in terms of size will be GBAS
  • Maintaining two volumes to minimize editorial efforts
    • Doc 8071 often used in contract specifications

• Sometimes boundary between flight inspection and flight validation can be argued
  • In particular with landing systems reference path as it is the reference for guidance signals

• Sometimes people forget that Doc 8071 is GROUND and flight test
  • Thorough ground preparation prevents wasting resources using flight hours (both in inspection and validation)
  • Improved guidance on flight path alignment verification
Volume 2 Revised Structure

1. General: GNSS-specifics only, no more duplication of chapter 1 in Vol I

2. ABAS for NPA becomes GNSS Core Constellations and ABAS
   • Link to new material in Doc 9849, GNSS Manual, on Performance Monitoring

3. SBAS: Testing relevant to SBAS service provider, TBD?

4. GBAS: Most significant update including GAST D

5. Flight Validation becomes new GNSS RFI measurement chapter
   • Building on attachment 3 to chapter 1
Moving from Vulnerability to Mitigation

GNSS RFI Mitigation Plan published in ICAO Doc 9849, GNSS Manual

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 SMS
Implementing Mitigation Barriers

(Protect)
Prevent Transmission of RFI
- Regulatory Control and Enforcement
- Outreach

(Toughen)
Prevent GNSS Service Outage
- GNSS Resilience
- On-board Integration

(Augment)
Limit Severity of Impact
- CNS/ATM Integration
- Terrestrial Systems
- Detection & Resolution

Supported by Threat Monitoring Networks
(Preventive & Reactive Role)

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First Step: Visibility!
EUROCONTROL Voluntary ATM Incident Reporting (EVAIR)

- 250 Participating Aircraft Operators
  - Coverage: Europe, Middle East, Northern Africa
  - Detail reports subject to confidentiality (just culture reporting)
- RFI most probable cause in absence of rx, constellation or solar issues
- 2018/2019 trend continues: average of 10 GPS reports DAILY!
  - 2020 decrease due to reduced flights (COVID), RFI persists in many locations

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EUROCONTROL Voluntary ATM Incident Reporting (EVAIR)

Reported failures:

- Failure of one or both GPS units
- Disagreement between GPS positions and Flight Management System
- Terrain warnings, sometimes with pull up requests
  - (In the majority of cases pull up warnings were disregarded by pilots or function switched off)
- Unable to fly GNSS procedure and request for radar vectoring
- Wind and ground speed wrong presentations
- Lost ADS-B, wind shear, terrain and surface functionalities
- Aircraft clock irregularities

- Many aircraft manufacturers are publishing more detailed guidance on GNSS RFI impact on avionics for their operators
- **Flight inspection system (FIS) operators should also assess the vulnerability of the FIS to GNSS RFI and resulting operational impact**
EUROCONTROL Voluntary ATM Incident Reporting (EVAIR)

→ 35 Flight Information Regions FIR affected
→ Several measurements clearly confirm narrowband RFI on L1 at significant distances (300+ km) and altitudes (10km)

→ Most affected regions:
   • Middle East – Europe across the Black Sea / Caspian Sea
   • Middle East – Europe via Mediterranean Sea (Cyprus Airspace, Malta)
   • Middle East – Canada and USA via cross polar routes

→ Several events also in West European Terminal areas (airports)

→ Significant number of events in a specific area leads to further investigation: Cyprus example (Nicosia FIR)

ENR = En-Route
APP = Approach
LND = Landing
TOF = Take Off
TXY = Taxi
STN = At Gate / Stand
DLR Airbus A320 Test Flight in Cyprus Airspace

13 FEB 2020 Flight Track

- DLR: German Aerospace Research Center

- Flight conducted in an area about 250km (east-west) x 170km (north-south) between 10’000 – 30’000 ft altitude

- GNSS signal reception heavily affected for most part of the flight

- Multiple GPS-related alerts in cockpit (GPS 1 Fault, GPS 2 Fault, GPS Primary Lost)

*Parts of track where GPS position was available!*
• Catherine Dunn, Fortune Magazine, “Mysterious GPS outages are wracking the shipping industry”, 22 January 2020
What can we do with detected GPS Outages?
3h slot – FL>290 – VIA LCCCUIR – reported by ADS-B stations (179 Flights)

21% of flights crossing Nicosia FIR are impacted
(Over 50% impacted flights if considering adjacent areas!)
ADS-B Data Analysis

1st Priority: Manage Operational Impact (Air Traffic can identify which aircraft need support)

Clearly confirms multiple aircraft impact: given calm ionosphere, highly likely due to RFI

2nd Priority: Identify Probable RFI Source: Geolocation to Stop RFI Source!?

Using Power Difference of Arrival (PDOA) approach: multiple RFI sources, possibly moving!
Recommendations of ICAO State Letter 2020/89
AN 7/5-20/89, 28 August 2020

• **Subject:** Strengthening of communications, navigation, and surveillance (CNS) systems resilience and mitigation of interference to global navigation satellite system (GNSS)

• **Action required:** Note the criticality of the issue and the importance of action by States to address it by making use of the ICAO guidance provided in Doc 9849, *Global Navigation Satellite System (GNSS) Manual* and by taking any other measures as appropriate

• Doc 9849 Appendix F, 8.2 **Reactive measure checklist** (items a, b, c, g):
  • measurement capabilities exist for all potentially required monitoring tasks ;
  • where supported by a corresponding risk analysis, airports perform monitoring for RFI at critical points within or near airport perimeter ;
  • **capabilities to detect, locate and identify RFI sources are in place**
  • all involved personnel is trained to recognize and deal with RFI events as appropriate
Complementary Capabilities

• Advantage of Pilot reports and ADS-B analysis is evidence of operational impact
  • Disadvantage: No solid proof or RFI
  • Such proof is highly desirable for suitable radio regulatory action

• Ground vs. Airborne Measurement Capabilities
  • Ground receiver often will not “see” RFI impacting aircraft at altitude
    • But can record continuously
  • Aircraft can’t stay in the air forever
    • If successful at confirmation and geolocation, can reduce search space for efficient deployment of ground resources

• FI / FV Providers should do whatever possible to increase GNSS RFI detection capabilities
  • Many measurement quality GNSS receivers have RFI detection features
  • Suitable RF signal capture recommended with access to GPS antenna
  • Best is direction finding capability
Proposed Principle of Operations

- Rockwell Collins DIGAR: Digital GNSS Anti-jam Receiver
- Algorithms able to detect wide range of RFI sources (Continuous Wave (CW), swept CW, Broadband, …)
- AHRS and Direct Geolocation Processing NOT YET implemented / investigated

Installed system includes:
- CRPA
- Antenna & interface cabling
- DIGAR with GNSS Baseband Processing
- Laptop with DF Software

Jammer Direction Finder Display
- White area: possible RFI direction
- Red dot: received power above specified threshold

Use of CRPA for In-flight RFI LOC? (2016 ION)
Conclusions

- Efficient Aviation Operations are enabled by GNSS (PBN, ADS-B)
  - For both capacity and reduced environmental impact
  - INS, DME/DME and ILS are the main alternative navigation capabilities today, VOR/DME is complementary (but VOR can be reduced)
    - Keep them going! (See Doc 8071 Volume I)

- Most significant GNSS Operational issue today is RFI
  - Hard to beat an airborne spectrum measurement, if available
    - Keep it on during ferry flight!
    - Consider recording on other aerial work aircraft
      - Example: Helicopter Emergency Medical Service HEMS
    - Even a very basic GNSS receiver can provide MUCH more detail than a pilot
  - Especially near conflict zones, an independent measurement can be very valuable
  - Future aviation GNSS receivers may detect and downlink RFI information

- Variety of projects ongoing to help establish best practice
  - Need continued exchange of experiences
  - Need to develop balanced & complementary capabilities
    - Technology, Procedures, Human Factors
Thanks & Questions ???

- Data Processing and Analysis by Hamdi Nasser, Valeriu Vitan, EUROCONTROL
- EVAIR Manager: Dragica Stankovic, EUROCONTROL
- DLR Cyprus Flight: Dr. Okuary Osechas, Dr. Michael Felux, DLR
- ADS-B Data provided by Air Traffic Control of Cyprus and Malta
- Further data provided by French Flight Inspection Service, DSNA/DTI

Aircraft bottom mounted direction-finding array (multiple frequency bands), French Flight Inspection

“Waterfall” Spectrum Measurement at 1575.42 MHz by DLR near Cyprus
Further Reading and Links

• EUROCONTROL EVAIR: https://www.eurocontrol.int/service/eurocontrol-voluntary-atm-incident-reporting

• EUROCONTROL CNS Dashboard: https://www.eurocontrol.int/communications-navigation-and-surveillance


• Interference Localization using a Controlled Radiation Pattern Antenna, Berz et al, ION GNSS Portland USA September 2016
  • Also in FEB 2017 GPS World, “Tracking RFI: Interference Localization using a CRPA”