Phase of Flight: ALL	**Applicable CNS:** Navigation, Surveillance
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Topic: Harmful Interference to Global Navigation Satellite System (GNSS) and its impacts on flight and air traffic management operations

Introduction

Global Navigation Satellite System (GNSS) includes navigation satellite infrastructures and constellations which provide position and timing information supporting aircraft and air traffic management operations.

GNSS satellite constellations which are currently recognized by International Civil Aviation Organization (ICAO) include the US. Global Positioning System (GPS), the Russian GLONASS, the European Galileo and the Chinese BeiDou. Frequencies for GNSS signals supporting safety-of-life applications, such as aviation, are globally harmonized and legally protected under the International Telecommunication Union (ITU) Radio Regulations.

Aircraft GNSS receiver is a safety-critical equipment and the main source of position information which drives aircraft navigation system in most commercial aircraft. The GNSS receiver is the primary equipment supporting Required Navigation Performance (RNP) operations and provides position input to many aircraft avionics, such as Navigation Display (ND), Ground-Proximity Warning System (GPWS) and Automatic Dependent Surveillance (ADS). GNSS also provides timing information to some satellite communication systems. Moreover, some business aircraft are referencing GNSS for flight control and stability systems.

Note: Impacts and causes of "spoofing" on GNSS are beyond the scope of this document.

Detecting Interference and Understanding Impacts on Aircraft Operations

Reported impacts on airline flight operations received from various airlines and airspace users include:

- Sustained loss of on-board GNSS functionality - [GPS-L INVALID] and/or [GPS-R INVALID] messages appear.
    - Some aircraft may lose its area navigation capability, including directing to a waypoint.
- Decrease in navigation performance leading to RNP alert
    - Through increasing aircraft horizontal position error, Actual Navigation Performance (ANP) decreases beyond RNP requirement. - [NAV UNABLE RNP] message appears.
    - In some aircraft, navigation reverted to inertial (INS/IRU) or DME/DME after GNSS loss.
- Impact on Navigation Display - A large "map shift" was observed.
- Sustained loss of capabilities for GNSS-based approach and landing.
- Impact on GPWS - [TERR POS] and [EICAS TERRAIN POSITION] messages appear.
- Impact on Runway Alerting systems
- Loss of GNSS positioning input to ADS position reporting, ELT and PFD/MFD.

For some business aircraft which are using GNSS as a reference source for aircraft flight stability systems, the US FAA has advised that the unavailability and unreliability of GNSS may impact aircraft's Attitude and Heading Reference System (AHRS), Stall Warning Protection System (SWPS), Ventral Rudder, Yaw Damper and Auto Pilot. The interference may also generate warning messages associated with unexpected rolling and yawing oscillations (Dutch Roll) at high airspeeds. For more information, please see http://www.faa.gov/documentLibrary/media/Notice/GENOT_7110_711_EMB-300.pdf.

Understanding Harmful Interference to GNSS

a) High-power transmitters

High-power radio interference transmitted near GNSS frequencies, such as GPS L1 (1575.42 MHz) and GLONASS L1OF (1602.0 MHz centre), can overwhelm relatively weaker GNSS signals. This harmful interference increases noise level at the GNSS frequencies, thus decreases the desired signal-to-noise ratio perceived by the aircraft GNSS receiver. Once the desired signal-to-noise ratio decreases to an unacceptable level, the receiver will start losing its capability to decode GNSS satellite signals and can eventually lose its functionality in providing aircraft position information.

This high-power interference is one of the simplest forms of GNSS interference and is mostly intentional. In some cases, the interferences were reported to cover 300+ NM from the assumed source.

<u>There are reported cases of interference to aircraft GNSS in areas with military activities. Airlines intending to transit through such areas are strongly advised to assess risks and operational limitations that may occur during loss of on-board GNSS and/or RNP capability. On-board availability of alternative navigation capability using INS/IRU or other conventional radio navigation aids can be helpful.</u>

b) Other potential interference sources

Other reported sources of GPS interferences include Personal Privacy Devices.[1] Moreover, 1.2GHz-transmitters used in certain First-Person View (FPV) video and Closed Circuit Television (CCTV) are being analyzed as potential interference sources to certain GNSS constellations.[2]

Reporting the Interference

Airlines and airspace users are encouraged to report harmful interference to GNSS to appropriate national aviation and frequency authorities. Airlines participating in the Incident Data Exchange (IDX) program are encouraged to share the ASRs regarding GNSS interference with IATA through IDX.

Useful Reference

Appendix F - GNSS RADIO FREQUENCY INTERFERENCE MITIGATION PLAN, *Doc 9849 – Global Navigation Satellite System Manual*, 3rd edition – 2017, International Civil Aviation Organization (ICAO).
ICAO State Letter AN 7/5-20/89, dated 28 August 2020, *Strengthening of communications, navigation, and surveillance (CNS) systems resilience and mitigation of interference to global navigation satellite system (GNSS)*

[1] Source: *"PERSONAL PRIVACY DEVICES EFFECTS ON AVIATION,"* ICAO NSP/4 – IP/13.
[2] Source: *"EVALUATION OF POTENTIAL THREAT TO AVIATION SYSTEMS FROM CONSUMER VIDEO TRANSMITTERS OPERATING IN 1.2 GHz BAND,"* ICAO NSP/4 – WP/5.

Recommendations

To address this issue of harmful interference to GNSS, IATA invites:

1. States to implement appropriate mitigation measures as contained in ICAO GNSS Manual (Doc 9849) as a matter of high priority and to report progress and any difficulties to ICAO; and

2. States, while using GNSS jammers during military exercises and operations, to recognize the unintended impact of harmful interference to civil flight operations and to exercise caution to the maximum extent possible to protect the safety of civil aircraft; and

3. States to establish and ensure appropriate frequency regulations are in place and maintained to protect allocated GNSS frequencies from harmful interference in line with ITU Radio Regulations; and

4. States and Air Navigation Service Providers (ANSPs) to carefully consider operational risks associated to harmful interference to GNSS during their planning for rationalization of conventional navigation and surveillance infrastructures and to incorporate inputs from airspace users while developing a CNS rationalization plan; and

5. States to ensure that contingency procedures are established in coordination with air navigation service providers and airspace users and that essential conventional navigation infrastructure, particularly Instrument Landing System (ILS), are retained and fully operational; and

6. Airspace users and ANSPs to inform flight crews and air traffic controllers about the impact of GNSS interference and establish effective contingency procedures and capabilities as appropriate; and

7. Airlines intending to transit areas with reported GNSS interference to assess operational risks and limitations that may occur during loss of on-board GNSS capability. Alternative navigation capability based on INS/IRU or other conventional navigation aids can be helpful; and

8. ANSPs to promptly notify airlines and airspace users once interference to GNSS was notified; and

9. Airspace users to report occurrences of harmful interference to GNSS to relevant national aviation and frequency authorities; and

10. ICAO, in coordination with manufacturers and airspace user communities, to develop a global strategy on Alternative Position, Navigation and Timing. This A-PNT strategy should aim to ensure continuity of flight and ATM operations during interruptions of GNSS and should include the increasing capabilities and roles of on-board INS/IRU; and

11. ITU in cooperation with ICAO to analyse the reported cases of harmful interference to GNSS and establish appropriate measures to address the safety impact on aviation.
