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Agenda Item 2: Timely and safe use of new technologies
2.2: Addressing safety risks related to evolving aviation technologies

AVIATION SAFETY AND SECURITY CONCERNS REGARDING INTERFERENCE TO THE GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)

(Presented by Hungary on behalf of the European Union[1] and its Member States, the other Member States of the European Civil Aviation Conference[2], and the European Organisation for the Safety of Air Navigation (EUROCONTROL))

EXECUTIVE SUMMARY

The global navigation satellite system (GNSS) is a fundamental element for providing communication, navigation and surveillance (CNS) and air traffic management (ATM) services worldwide. Positioning and timing information provided by GNSS is used by numerous aircraft avionics systems. Unfortunately, the efforts from ICAO and International Telecommunication Union (ITU) over the past two decades have not resulted in a reduction of GNSS interference affecting civil aviation. In the recent years, there has been a steep increase in the number of interferences events. In particular, spoofing events (intentional radio frequency interferences which causes GNSS receivers to compute incorrect position, navigation and timing data) have been reported since late 2023 and have become a widespread safety concern and a cybersecurity threat for civil aviation, as their impact on flight safety is frequently higher than the impact of jamming events. It will take a long time for aviation to upgrade operational systems to become more robust to interference. If the number of spoofing events keeps growing it may no longer be possible to maintain capacity in some airspaces without compromising safety. Such situation is neither acceptable nor sustainable.

Action: The Conference is invited to agree to recommendations in paragraph 3.

1. INTRODUCTION

1.1 The global navigation satellite system (GNSS) is a fundamental element of communication, navigation and surveillance/air traffic management (CNS/ATM). GNSS is an essential enabler for performance-based navigation (PBN) and automatic dependent surveillance-broadcast (ADS-B). By providing accurate position and timing information, GNSS is used as well by numerous aircraft avionics systems such as controller pilot data link communications (CPDLC), Flight Management

[1] Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden

[2] Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Georgia, Iceland, Republic of Moldova, Monaco, Montenegro, North Macedonia, Norway, San Marino, Serbia, Switzerland, Türkiye, Ukraine, and the United Kingdom.

Systems (FMS), terrain awareness and warning systems (TAWS), transponders and systems providing traffic alerts and fuel indicators.

1.2 In the recent years, there has been a steep increase in the number of GNSS harmful interferences[3], that are affecting civil aviation. There are two types of harmful interferences:

a) Jamming is an intentional radio frequency harmful interference that prevents receivers from providing position and time outputs rendering the GNSS avionics ineffective. Jamming effects are generally detected by avionic systems and often alerts are provided to the flight crew.

b) Spoofing is an intentional radio frequency harmful interference which causes GNSS receivers to compute incorrect position, navigation and timing data. Spoofing events are not automatically detected by the current avionics systems and no specific alert is provided to the flight crew.

Spoofing causing large position jumps have been reported since late 2023. Both jamming and spoofing can cause collateral side effects in aircraft avionics even if aircraft are not the intended target. Most of the spoofing events are detected by the flight crew due to incoherent information displayed on the instruments. The impact of spoofing signals, even if a large position jump is obvious to the flight crew, can have much more severe side effects which can be very challenging for the flight crew.

1.3 Most GNSS interferences affecting civil aviation are being reported in geographical areas close to conflict zones and are linked to the recent escalations in military drone, anti-drone and electronic warfare. However, a large amount of interference also exists in locations where there is no evident proximity to a zone of conflict. In recent months, a number of spoofing cases have been reported in locations where there is no recognizable link to a State security or defence activity. Aircraft flying at en-route altitude are affected by interference over significant distances (up to 200 NM) and in some cases, receivers are not able to recover normal operation after leaving the zone of interference.

1.4 Over the past years, ICAO discussed the matter on several occasions, notably at the 11th and 12th Air Navigation Conference and at the 40th and 41st Sessions of the ICAO Assembly, where Appendix C of Resolution A41-8 was adopted upon Recommendation by Europe. Moreover, the Standard in ICAO Annex 11[4] — *Air Traffic Services* requires that civil or military activities, whether over the territory of a State or over high seas, that are hazardous to civil aviation, shall be coordinated with the appropriate air traffic services authority.

1.5 Furthermore, principles and measures of civil-military coordination have been identified notably in the International Telecommunication Union (ITU) Constitution and Radio Regulations, in order to reduce the number of interferences affecting civil aviation. The right of States to "retain their entire freedom with regard to military radio installations" is recognized in the ITU Constitution Article 48. However, this article also requires that "these installations must, as far as practicable, observe statutory provisions relative to the measures to be taken to prevent harmful interference". It follows from Article 45.1 of the ITU Constitution, that the right of administrations to deny access to GNSS for defense or security purposes, refers to denial of access within States' sovereign territories, and therefore should neither affect

[3] Harmful interference is defined by article 1.169 of the International Telecommunication Union (ITU) Radio Regulations as: Interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with Radio Regulations.

[4] 2.18: Coordination between military authorities and air traffic services, and 2.19: Coordination of activities potentially hazardous to civil aircraft.

neighbouring States nor high seas airspace. Article 47[5] of the ITU Constitution and Radio Regulations 15.5 and 15.22[6] are also relevant to GNSS interference. The ITU addressed the matter at the last World Radiocommunication Conference held in Dubai in 2023[7].

1.6 However, the ICAO and ITU Resolutions, and ICAO State letters[8] and ITU Circular letters over the past two decades have not resulted in a reduction in the number of jamming and spoofing events that have become a widespread safety concern and a cybersecurity threat for civil aviation.

1.7 The European working paper AN-Conf/14-WP/61, "Planning for GNSS contingencies" presented under agenda item 2.2 (phasing out legacy systems) is complementary to this working paper. It proposes recommendations to improve robustness and reduce operational impact of GNSS interferences.

2. IMPACT OF GNSS INTERFERENCES ON SAFETY AND BUSINESS CONTINUITY OF CIVIL AVIATION OPERATIONS

2.1 Civil aviation is more reliant than ever on GNSS. This system has its own vulnerabilities, such as jamming and spoofing, and has become prone to over-reliance that may result in potential loss of position awareness when the GNSS unit fails. The procedure of key interest is reversion to other means of navigation should the GNSS unit malfunctions in flight. Erroneous position information may have severe repercussions if all safety barriers in place fail to mitigate the threat.

2.2 GNSS jamming and/or spoofing effects have been reported by crews in all phases of flight, in some cases leading to re-routing, diversions or deviations from air traffic control (ATC) clearances. The magnitude of the issues generated by these interferences depends upon the extent of the area concerned, on the duration, and how dependant the aircraft systems on GNSS signals are, which may vary between aircraft types. Interferences at low altitude, although less frequent, may have a higher impact on safety.

2.3 Since 2022, around 22 500 occurrences have been recorded in the European Central Repository, including 1 137 mentions of spoofing in the report headline. Both figures have seen a steep increasing trend over the period. The actual number of occurrences is higher as many are not reported. The European Organisation for the Safety of Air Navigation (EUROCONTROL) Voluntary ATM Incident Reporting System (EVAIR) has seen a significant rise in reported Global Positioning System (GPS) outages linked to GNSS interference since 2018 in the European Civil Aviation Conference (ECAC) area. Such GPS outage reports have become the most reported occurrence compared to all other occurrences (around 40 per cent).

2.4 This situation led the European Union Aviation Safety Agency (EASA) to issue in November 2023 a Safety Information Bulletin (EASA SIB 2022-02R2) with recommendations and mitigation actions. This EASA bulletin informs about the fact that GNSS interference can be encountered anywhere in the world and that the most affected areas are: Black Sea, south and eastern Mediterranean, Middle East, Baltic Sea and Arctic. Safety promotion actions from EASA, other civil aviation authorities, air operators, air navigation service providers (ANSPs) and manufacturers are increasing awareness on the issue, and stakeholders are implementing mitigation measures. Aviation has been able to maintain safe

[5] Article 47 of ITU Constitution: "Member States agree to take the steps required to prevent the transmission or circulation of false or deceptive distress, urgency, safety or identification signals, and to collaborate in locating and identifying stations under their jurisdiction transmitting such signals";

[6] ITU Radio Regulation 15.55 to minimize "radiation in and reception from unnecessary directions" and Radio Regulation 15.22 to "exercise the utmost goodwill and mutual assistance in the application of the provisions of Article 45 of the Constitution and of this Section to the settlement of problems of harmful interference".

[7] Resolution 676 (WRC-23)

[8] For example, the most recent ICAO State letter 2024/54, dated 30 April 2024.

operations, but these measures have resulted in a very significant burden for both flight crews and air traffic control staff. Furthermore, despite these measures, intentional GNSS interferences continue to affect flight operations and affect passengers' connectivity.

2.5 New aviation standards for GNSS systems and receivers should facilitate interference detection, and the implementation of mitigation measures to increase robustness and resilience. In addition, there is ongoing work to develop alternative position navigation and timing systems. However, it will take a long time for aviation to upgrade operational systems to be more robust to interference meaning that aircraft operators will continue to be exposed to such interference in the coming years. Therefore, there is a need to enhance capabilities to monitor airspace and aircraft affected by GNSS interferences to support contingency procedures that are needed to maintain safety and reduce operational impacts. If the number of spoofing events keeps growing at the current pace, it may no longer be possible to maintain capacity in some airspaces. This could have significant economic impact on aviation and many related industries, and could impact on air passengers' connectivity around the world. This situation is neither acceptable nor sustainable.

3. CONCLUSION

3.1 In the light of the above, the Conference is invited to agree to the following recommendation to limit the impact of GNSS interferences on civil aviation:

Recommendation 4.2/x – GNSS interferences

That States:

a) express strong concerns on the serious recent escalation of GNSS harmful interference, in particular reported cases of spoofing that represent a significant safety risk and a cybersecurity threat to civil aviation operations;

b) condemn in the strongest possible terms GNSS harmful interferences that are not clearly justified by security or defence needs, in particular those that could impact neighbouring States and/or high seas airspace, that affect civil aviation thereby posing significant risks to the safety of air transport and continuity of civil aviation operations;

c) recall their commitment to abide the ITU Constitution and Radio Regulations[9], in particular in airspace around airports and where interferences could affect neighbouring States or high seas airspace;

d) acknowledge that military shall notify aviation authorities, spectrum regulators and ANSPs about their GNSS intentional interference activities whenever possible;

e) consider implementing appropriate monitoring of airspace and aircraft affected by GNSS interferences, and detection of interference sources; and

f) pursue that adequate mitigation measures are implemented by ANSPs and air operators (e.g., training, operating procedures, reporting,..), and manufacturers (e.g. increase robustness and resilience to interference affecting several aircraft systems);

[9] Notably ITU Constitution Articles 45, 47 and 48, and Radio Regulations 15.5 and 15.22.

that ICAO:

g) further assess the impact of GNSS harmful interferences on safety and continuity of civil aviation operations, define adequate mitigation measures and remind responsibilities of States; and

h) develop guidance material on the Standard in ICAO Annex 11 (2.18 and 2.19) to facilitate the notification about GNSS harmful interference from military to civil aviation in support to recommendation d) above. The guidance material should also be expanded so it can be used by any military in the event of detection of GNSS interference that may affect civil aviation.

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