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ASSEMBLY — 42ND SESSION

TECHNICAL COMMISSION

Agenda Item 24: Aviation Safety and Air Navigation Priority Initiatives

GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS) RESILIENCE IN A RADIO FREQUENCY INTERFERENCE (RFI) ENVIRONMENT

(Presented by Denmark on behalf of the European Union and its Member States[1], the other Member States[2] of the European Civil Aviation Conference, and by EUROCONTROL, and co-sponsored by Canada, Japan, Singapore and IFALPA)

EXECUTIVE SUMMARY

The safety and security of civil aviation is being eroded by the continuing rise in cases of harmful and unlawful global navigation satellite system (GNSS) radio frequency interference (RFI). This paper explores the current and future operational impact to the air traffic management (ATM) environment, as well as the safety, security and cybersecurity implications of the use of jamming and spoofing equipment on GNSS frequencies. The paper discusses the ease with which transmitters such as jammers can be accessed and used, and the growing need to increase robustness and resilience of current CNS systems to GNSS interference.

Action: The Assembly is invited to note the content of this paper and approve the actions.

a) request ICAO to request its relevant panels and groups to develop resilience measures within avionics standards, and notably make them fit for retrofit on in service aircraft as far as possible;
b) request ICAO to develop standards for manned and unmanned autonomous aircraft and eVTOL to include appropriate measures supporting resilience against GNSS RFI;
c) amend Paragraph 5 of Appendix C to ICAO Assembly Resolution A41-8 as follows:

Urges States to apply necessary measures to avoid the commercialization/proliferation, purchase, possession and use of illegal transmitters such as jammers and the misuse of test and maintenance equipment which may impact CNS systems.

d) request ICAO to coordinate with Standard Developing Organisations (e.g. EUROCAE/RTCA) to make aircraft avionics architectures more resilient and robust to GNSS RFI, including the authentication of GNSS signals and the use of military technologies in civil aviation where possible;
e) request ICAO to consider including in the GANP the need for alternative methods/mechanisms that would enable real-time and systemic collection and dissemination of GNSS interference events and replace the existing NOTAMs to provide accurate, user-friendly information about GNSS degradations;

[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

f) request ICAO to update provisions and guidance regarding phraseology to be used by pilots and air traffic controllers in case of GNSS interference; g) urge States to reinforce regulatory measures against systems which may cause harmful interference to civil aviation. h) invite States to maintain a minimum operational network of navigation and surveillance systems that are independent from GNSS, and to ensure that measures are implemented by ANSPs and aircraft operators (e.g., training, operating procedures, reporting, avionics upgrades, GNSS monitoring tools) to prepare for the loss or degradation of GNSS services and optimise resilience of ground-based navigation and surveillance networks. i) invite manufacturers to support the development and introduction of services which provide robustness in terms of detecting spoofing attacks, such as Galileo OSNMA, SBAS authentication services or similar services that may be provided in the future by GNSS or SBAS providers; j) invite manufacturers to accelerate the development to increase robustness and resilience to interference affecting several aircraft systems, including the use of complementary non GNSS systems, in order to make navigation more robust and to ensure the correct and safe working of dependent systems; k) invite industry to accelerate its activities towards GNSS receivers/avionics with efficient interference signal suppression, direction finding of interference signals, and spatial detection and suppression of false signals.	
Strategic Goals:	This working paper relates to Strategic Goals *Every Flight is Safe and Secure; and Aviation Delivers Seamless, Accessible and Reliable Mobility for all*.
Financial implications:	The activities referred to in this paper will be undertaken with the resources available in the Regular Programme Budget and/or from extra-budgetary contributions.
References:	Assembly Resolution A41-8: Consolidated statement of continuing ICAO policies and practices related to a global air traffic management (ATM) system and communications, navigation, and surveillance/air traffic management (CNS/ATM) systems. Doc 10209, *Report of the Fourteenth Air Navigation Conference* (AN-Conf/14)

1. INTRODUCTION

1.1 Global Navigation Satellite Systems (GNSS) play a pivotal role in air navigation and reliance on these systems will continue to grow as air traffic management (ATM) continues to modernise. As well as providing precise positioning and navigation information, many aircraft and ground systems draw from GNSS data to provide precise timing which is essential for their continuous and safe operation.

1.2 In recent years the incidence of GNSS radio frequency interference (RFI) harmfully affecting civil aviation has increased exponentially[3]. There was a sharp increase in detected jamming events in 2022, and in the subsequent three years there has been a dramatic rise in both jamming and spoofing events. GNSS jamming and spoofing have both become prevalent in specific geographic locations, leading to degraded position, navigation and timing (PNT) capabilities on-board aircraft.

[3] Yearly events reported in Europe increased from 3200 in 2022 to 12000 in 2024, with a consequent reduction in safety margins.

1.3 The European working papers presented to AN-Conf/14[4] on the GNSS interference proposed recommendations that were reflected in the final *Report of the Fourteenth Air Navigation Conference (AN-Conf/14)* (Doc 10209).

1.4 On 30 April 2024, ICAO issued a State Letter on Aviation safety concerns regarding interference to the GNSS which included recommendations from the ICAO EUR/MID Radio Navigation Symposium in Antalya, Türkiye. Whilst these recommendations go some way to harmonizing the response to the threat of harmful interference, more focus should be placed on the role of equipment manufacturers to develop improved integration, resilience and robustness[5] of systems which rely on GNSS data in-flight.

2. DISCUSSION

2.1 The impact of GNSS RFI on civil aviation presents a tangible safety risk which can vary in presentation and severity depending on several factors including aircraft equipage and avionics integration. In general, aircraft with highly integrated avionics are more vulnerable to these impacts. The observed effects are not always predictable and therefore responses to these effects can differ.

2.2 GNSS RFI events can also affect other on-board systems. For example, communication systems (timing provided by GNSS to controller-pilot data link communications (CPDLC)), navigation and surveillance (automatic dependant surveillance-broadcasted (ADS-B)) (CNS) systems and other aircraft systems such as terrain avoidance and warning system (TAWS), and autonomous distress tracking (ADT) as part of the ICAO Global Aeronautical Distress and Safety System (GADSS), to name a few.

2.3 Recovery from a GNSS RFI event on-board aircraft depends on the type of interference taking place and is not always automatic. The effects can continue beyond the point at which the aircraft has exited the affected area if impacted systems cannot be restored during the flight. This phenomenon can continue into new airspace, impacting air traffic management – for example, a need for increased separation and thus reducing airspace capacity. This may result in aircraft not being able to land at the destination aerodrome or presenting unexpected behaviour from an air traffic control (ATC) perspective, such as turns or climbs. Aircraft operators, dispatchers and air crews should remain aware of areas of harmful GNSS interference and plan for contingencies. States and ICAO are therefore invited to emphasize the importance of current, valid Notices to Airmen/Aviation (NOTAM), and eliminate all out of date, non-compliant aeronautical information to ensure that safety critical information on GNSS interference will receive proper attention in the pre-flight planning process. It is essential for air crews to be able to estimate the expected disruption and to choose countermeasures in accordance with the flight crew procedures.

2.4 Efficient communication between ATC and pilots is essential for operational mitigations to maintain safety, and to reduce the workload of pilots and ATC operators in cases of GNSS interference. The current standardised phraseology could be improved to enhance awareness about the impact on both aircraft and airspace, as well as the type of interference taking place. There is an increasing need for air navigation service providers (ANSPs) to monitor the GNSS status in the airspace under their responsibility and the status of the navigation capabilities of individual aircraft entering their airspace that could bring latent RFI effects.

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[4] AN-Conf /14-WP/61, "Planning for GNSS contingencies" and AN-Conf/14-WP/63 aviation safety and security concerns regarding interference to the global navigation satellite system (GNSS).

[5] In this paper robustness is understood as the ability of a system to tolerate and resist to GNSS interference maintaining an acceptable level of performance, and resilience is the ability of a system to recover from interferences.

2.5 States should consider the risk of loss or degradation of GNSS service when optimizing their ground navigation networks (for example, distance measuring equipment (DME), VHF omnidirectional radio range (VOR), instrument landing system (ILS)) and their surveillance networks (combining GNSS-dependent systems like ADS-B with radars) to design their minimum operational network (MON) ground infrastructure.

2.6 Real-time monitoring and anticipation of GNSS RFI events, on the ground and in-flight, could bring immediate benefit. Real-time RFI data sharing, utilizing modern technologies such as electronic flight bags (EFB), would significantly enhance the accuracy and timeliness of warnings and improve hazard mitigation strategies. Implementing countermeasures once a threat is detected involves a multi-layered approach. ICAO should consider establishing a framework to advance a GNSS Interference Information Service (GIIS) to improve global access to RFI data for commercial aviation. Existing work on GADSS may serve as an example where a centrally managed data repository has been successfully developed to collect, store and provide access to data necessary to notify and assist appropriate stakeholders.

2.7 Civil aviation is not usually the primary target of GNSS RFI events. However, it is possible that civil aviation could be the target of an attack in the future. GNSS RFI events could cause accidental airspace infringements due to loss of navigational capabilities, and therefore there is a security risk attached to these events as well as a safety risk.

2.8 Jamming and spoofing equipment is becoming more sophisticated and easier to access. The scope of Paragraph 5 of Appendix C to ICAO Assembly Resolution A41-8: Consolidated statement of continuing ICAO policies and practices related to a global air traffic management (ATM) system and communications, navigation, and surveillance/air traffic management (CNS/ATM) systems, could be expanded to include the purchase and possession of illegal transmitters such as jammers.

2.9 Future technologies such as unmanned aircraft systems (UAS) and electric vertical take-off and landing (eVTOL) aircraft are predicted to rely heavily on GNSS as a means of navigation. Consideration should be given to resilience to loss or degradation of GNSS in the development of standards for these aircraft in order to balance the needs of equipping these aircraft from a cost or weight perspective.

2.10 New aviation standards for GNSS systems and receivers should facilitate interference detection and mitigation measures such as authentication of GNSS signals. Operational systems will take time to upgrade, meaning that aircraft operators will continue to be exposed GNSS RFI in the coming years. Therefore, there is a need to increase robustness and resilience of current systems, and for enhanced monitoring of airspace and aircraft affected by GNSS RFI to support contingency procedures.

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