International Civil Aviation Organization

WORKING PAPER

ASSEMBLY — 40TH SESSION

TECHNICAL COMMISSION

Agenda Item 30: Other issues to be considered by the Technical Commission

INTERFERENCE-RESILIENT SATELLITE-BASED CNS SYSTEMS

(Presented by Finland on behalf of Member States of the European Union[1], the other Member States of the European Civil Aviation Conference[2]; and by EUROCONTROL)

EXECUTIVE SUMMARY

The air traffic management/ communications, navigation, and surveillance (ATM/CNS) systems are evolving and so are the associated CNS threats and vulnerabilities. While satellite-based CNS systems take a growing part in the overall ATM system, the occurrences of interferences against those systems have significantly increased. CNS resiliency to interference needs to be addressed at global level with a holistic approach, ensuring an efficient and coordinated evolution between the infrastructure architecture, new technological capabilities, operational procedures, radio regulatory authorities and civil-military coordination.

Any lack of resiliency to interference needs to be compensated and can use a combination of an independent minimum operational networks (MON), based on ground and airborne components and air traffic control (ATC) procedural methods, which provide contingency of the CNS services in case of satellite-based service unavailability.

In addition, both the on-board and ground segments of the satellite-based CNS systems need to be adapted to potentially increasing threats by developing interference detection and reporting capabilities and mitigation measures to ensure flight safety. Combined with an appropriate legal framework, it will allow for the relevant authorities to act upon harmful interferences caused by illegal transmitters or other sources of electromagnetic radiation and avoid the proliferation and the use of such illegal transmitters. A civil military coordination should facilitate the sharing of relevant information with airspace users either during civil or military testing activities or when flying in the vicinity of a conflict zone.

[1] Austria, Belgium, Bulgaria, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.

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

Action: The Assembly is invited to:

a) urge States to:
   1) transition from a CNS system-based concept towards secure CNS services, mainly based on a satellite-based infrastructure while addressing its resiliency to interference through independent MON based on ground and/or airborne components;
   2) apply necessary measures to avoid the commercialisation / proliferation and the use of illegal transmitters such as jammers which may impact satellite-based CNS systems;
   3) ensure, considering that the use of radio frequency spectrum by aeronautical safety services requires special measures, close collaboration between aviation authorities, service providers, radio regulatory and spectrum enforcement authorities to ensure that this spectrum is free from harmful interference;
   4) reinforce civil-military collaboration regarding global navigation satellite system (GNSS) testing and other activities, which may impact satellite-based CNS systems, with the air navigation services provider (ANSP) responsible for the affected airspace; and
   5) consider, when assessing the interference risks associated with conflict zones, that the use of satellite-based CNS systems can potentially be impacted beyond that zone.

b) direct ICAO to develop guidelines and best practices for use at the State, regional and global levels to mitigate safety risks related to any civil or military GNSS testing activities or other activities which may impact CNS systems (e.g. intentional jamming); and

c) call upon industry standardization bodies and industry to develop appropriate interference detection, mitigation and reporting capabilities for both the on-board and ground segments of the satellite-based CNS systems, in order to ensure higher CNS resiliency.

Strategic Objectives:	This working paper relates to Strategic Objectives of Safety and Air Navigation Capacity and Efficiency.
Financial implications:	The activities referred to in this paper will continue subject to the resources available in the 2020-2022 Regular Programme Budget and/or from extra budgetary contributions
References:	A32-19, A32-20, A39-11 Appendix F

1. GLOBAL CNS RESILIENCY

1.1 The traditional communications, navigation and surveillance (CNS) system, which is currently organised around the 3 C, N and S pillars, relies on the logic that while one pillar can have a complete failure, the two others enable, as a minimum, the safe landing of aircraft. Resulting from the transition to performance-based concepts and the introduction of global navigation satellite system (GNSS) as an integral enabler in multiple areas of CNS, the traditional, single system CNS safety concept needs to evolve.

1.2 An integrated CNS concept is being developed to manage this CNS concept evolution and to address the existing and upcoming CNS challenges: global CNS resiliency is to be achieved by defining a future CNS infrastructure based on two layers:

a) a backbone of recently standardised or being standardised and global technologies, mainly satellite-based (including satellite communication (SatCOM), GNSS, automatic dependent surveillance — broadcast (ADS-B) and ADS-B satellite-based), supporting resilient CNS services, complemented by

b) a minimum operating network (MON) composed of legacy ground and/or airborne components (e.g. inertial reference system(IRS)) independent from the backbone which provide continuity of the CNS services in case of satellite-based CNS service interruptions.

1.3 Any lack of resiliency to interference needs to be compensated. This compensation can be built with a combination of an independent MON, based on ground and airborne components and ATC procedural methods, which provide contingency of the CNS services in case of satellite-based service unavailability.

2. CNS INTERFERENCE, DETECTION AND REQUIRED ACTIONS

2.1 Interference can degrade civil satellite-based CNS signals (e.g. GNSS) and services which are the main enablers of integrated CNS, and in some cases results in unusual system behaviour. Satellite signals are by nature very weak when they arrive at the receiver and thus vulnerable to interference, both natural or artificial, intentional (including jamming and spoofing) or unintentional. The subsequent discussion illustrates the issues already encountered by navigation, being the first CNS domain moving to satellite-based services. However, surveillance and communication may suffer from comparable threats with a need to define actions to address CNS as a whole.

2.2 The aviation community is well-aware of the threats due to the proliferation of interference capable equipment including portable electronic devices (PEDs), personal privacy devices (PPDs), incorrectly operated GNSS repeaters, miss-operated test equipment and the foreseeable proliferation of sophisticated spoofing devices in the future. Improved protection against such interference is under consideration in the development of next-generation avionics and CNS system standards.

2.3 An increasing number of partial or complete loss of GNSS services are reported by pilots (several hundred of occurrences with interruption from generally 10 to 20 minutes were reported by 60 airlines in 2018). This represents a significant increase compared to previous years. The International Air Transport Association (IATA) member airlines and other aircraft operators are experiencing and reporting unavailability of GNSS equipment on a regular basis today. In most cases, the likely cause was groundoriginated jamming. So far, no spoofing event was identified. A limited number of those events were caused by low power PPDs. Whilst illegal, these devices intend to jam GNSS signals only closely around the user, but might still interfere with aircraft or airport ground-based augmentation system (GBAS) and ADS-B ground stations at close distance. Several occurrences have been reported among which the majority were encountered during the en-route phase of flight, in areas where political tensions prevail. In some cases high power jammers have been used, impacting a large volume of airspace.

2.4 Once the degradation of GNSS performance is recognised, the consequences may differ from case to case. In some most severe cases, not only the required navigation capability is affected, but the airplane may experience terrain avoidance and warning system (TAWS) errors, and trigger sudden "'terrain-pull up" warnings, including during instrument landing system (ILS) approaches. This could lead to inappropriate action by flight crews.

2.5 Finally, it shall be noted that the aforementioned interference impacts may be in many cases reduced within States which have set-up simultaneously: 1) an efficient spectrum regulation policy, involving civil aviation, to alleviate the impact of unexpected interference events; and 2) a civil aviation coordination mechanism with State military authorities.

2.6 In the future, technical means should be deployed to detect and identify areas of frequent interference, so that operational and technical mitigations can be put in place in advance, and that negative impacts on safety related to the aircrew “surprise” effect can be alleviated. It is not expected that ground-based interference estimation systems alone be either practical or efficient: aircraft are in an ideal position to assess interference areas in real-time. Airborne technical means should be developed to e.g. detect interference on-board and broadcast a position message at the start and end of the detected interference event. These positions would then be used by the ground-based systems to locate more precisely the interferer.

2.7 Given the global nature of aviation operations, it is desirable that States ensure that a radio frequency interference risk mitigation framework, including agreements, processes and equipment capabilities for mitigation actions, are in place, tested and exercised regularly. For GNSS, a radio frequency interference (RFI) mitigation plan is described in the ICAO *Global Navigation Satellite System (*GNSS) Manual (Doc 9849). Such framework should be built on the International Telecommunication Union’s (ITU) radio regulations, which includes provisions for the prevention and removal of radio interference, whether between radio services or countries, between frequency assignments, or from other sources of electromagnetic radiation. At national level, radio-regulatory authorities are normally responsible for radio spectrum inspection and compliance functions which should enable the identification and measurement of interfering signals, the verification of proper technical and operational characteristics of radiated signals, and the detection and identification of illegal transmitters. If a safety service is affected, urgent action shall be taken.

2.8 Identification of an interference source can be a difficult and often time-consuming activity. Some States have found that, when aviation stakeholders assist the national radio-regulatory authority in local detection actions, resolutions are more time-effective. States are encouraged to continue to report their experiences to the spectrum and frequency working groups in ICAO to ensure knowledge sharing and establishment of best practices.

3. GNSS AND OTHER TESTING ACTIVITIES AND NEED FOR AN ENHANCED CIVIL/MILITARY COORDINATION

3.1 As stated above, statistical data[3] established based on ATM incident and voluntary reporting in European Civil Aviation Conference (ECAC) airspace and neighbouring airspace are showing a significant increase in the number of global positioning system (GPS) outage reports. While further investigations of the reported GPS failures cannot confirm military activities as causes of the outages with certainty, this nonetheless remains probable for cases near zones of conflict. Therefore, it is appropriate to reiterate that States should use caution when conducting civil and military GNSS and other testing activities which could contribute to operational impact on aviation CNS systems. Airspace users should be informed accordingly.

3.2 Many States have already put in place efficient civil-military processes to coordinate testing activities, in particular in the context of military exercises. Considering the potential negative impact of GNSS testing on the safety of flights, States are strongly encouraged to further enhance civil-military coordination related to GNSS and associated testing[4]. States should therefore strive to establish through the involvement of both civil and military stakeholders, at State, regional or global level guidelines and best practices sharing for any civil or military GNSS testing activities.

4. CONFLICT ZONE MANAGEMENT

4.1 With increased reliance on digital and space-based CNS services, interference to such services (regardless of the origin of such interference) is becoming more operationally relevant. While closure of airspace due to conflict causes a re-routing of air traffic around that zone, interference to CNS services can extend to regions far outside of the closed airspace. Therefore States are urged when assessing the interference risks associated with conflict zones to consider that the use of satellite-based CNS systems can potentially be impacted beyond that zone.

— END —

[3] EVAIR Safety bulletin, https://www.eurocontrol.int/library?f%5B0%5D=product%3A989 and ECR (European Central Repository for accident and incident reports in aviation).

[4] For the military, GNSS testing can occur during exercises or military operations/equipment in areas near conflict zones. For civil purposes, such testing is typically conducted to further develop vulnerability mitigation measures in order to improve the resiliency of GNSS to interference.