International Civil Aviation Organization

WORKING PAPER

ASSEMBLY — 40TH SESSION

TECHNICAL COMMISSION

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

TOWARDS GNSS RESILIENCE TO SUPPORT SUSTAINABLE IMPLEMENTATION OF ASBU MODULES

(Presented by Saudi Arabia)

EXECUTIVE SUMMARY

The sixth edition of the *Global Air Navigation Plan* (GANP) has defined a global technical level (level 2) the technical global which includes an updated draft of the aviation system block upgrades (ASBUs) framework. The ASBU modules/elements covering information management, operational performance, communications, navigation, and surveillance (CNS) technology and services are heavily relying on Global Navigation Satellite System (GNSS) either for positioning, navigation or timing (ANT) and can be impacted directly or indirectly from any loss of GNSS services.

The Assembly Resolution A32-19 defines a Charter on the rights and obligations of States relating to GNSS Services. However, this resolution is not covering obligations to protect GNSS signals and mitigate in appropriate manner GNSS vulnerabilities through appropriate level of cooperation and planning.

Action: The Assembly is invited to:

a) urge States to:
   1) assess the likelihood and effects of global navigation satellite system vulnerabilities in their airspace and apply, as necessary, ICAO mitigation methods;
   2) provide effective spectrum management and protection of global navigation satellite systems (GNSS) frequencies to reduce the likelihood of unintentional interference or degradation of GNSS performance; and
   3) cooperate for design, development and realization of Ground and on-board mitigation techniques of GNSS loss of service; and

b) direct ICAO to:
   1) compile and publish more detailed guidance for States to use in the assessment and mitigations of global navigation satellite system vulnerabilities; and
   2) support the regional activities to define alternative position, navigation and timing system where needed.

Strategic Objectives:	This working paper relates to the Safety and Air Navigation Capacity and Efficiency Strategic Objectives.
Financial implications:	No additional resources required.

References:	Annex 10 — *Aeronautical Telecommunications*, Volume I — *Radio Navigation Aids* Doc 10075, *Assembly Resolutions in Force (as of 6 October 2016)* Doc 9849, *ICAO Global Navigation Satellite System (GNSS) Manual*. Doc 9750, *Global Air Navigation Plan (GANP).* GNSS Strategy endorsed by MIDANPIRG 15.

1. INTRODUCTION

1.1 The sixth edition of the *Global Air Navigation Plan* (GANP) (A40- WP/24-TE/4 refers) is the result of feedback provided by States and international organizations on the fifth edition of the GANP during the 39th Session of the ICAO Assembly, discussions and recommendations on the technical content from the Thirteenth Air Navigation Conference (AN-Conf/13), and feedback gathered from experts during workshops and through the ICAO Regional Offices.

1.2 The global technical level (Level 2 in the new GANP structure), it includes an updated draft of the ASBU framework, its associated performance framework and an initial version of the Basic Building Blocks (BBB) framework.

1.3 The ASBU modules/elements covering information management, operational performance, communications, navigation, and surveillance (CNS) technology and services (https://www4.icao.int/ganpportal/ASBU/Thread refers) are heavily relying on Global Navigation Satellite System (GNSS) either for positioning, navigation or timing (ANT) and can be impacted directly or indirectly from any loss or interference caused on GNSS signals.

2. IMPACT OF GNSS DISTURBANCE

2.1 The very low strength of GNSS signals received from satellites at user receivers make GNSS vulnerable to interference and other effects that have the potential to affect multiple aircraft over a wide area. The sources of GNSS vulnerabilities include unintentional interference, intentional interference, effects of the ionosphere and solar activity (space weather) and others technical outages.

2.2 As GNSS enables performance-based navigation (PBN) and provides navigation guidance for all phases of flight, from en-route through to precision approach, any GNSS interference, disturbance or degradation affects the navigation performance and capabilities.

2.3 By providing position information, GNSS enables also automatic dependent surveillance — broadcast (ADS-B), automatic dependent surveillance — contract (ADS-C), moving map displays, terrain awareness and warning systems (TAWS) and synthetic vision systems. All these applications are impacted by any GNSS loss of service.

2.4 The GNSS is also providing position data for emergency locator transmitters (ELTs) and supports a wide variety of precision timing applications that are used in many aviation systems to synchronize local clocks to Co-ordinated Universal Time (UTC). Synchronized clocks may then be used to assign a globally valid and comparable time stamp to events. Consequently, GNSS disturbance impacts all positioning and timing applications that may lead to degradation or unavailability of critical functions.

2.5 The AN-Conf/13 held in October 2018 recognized that the evolution of the GNSS towards the introduction of dual-frequency, multi-constellation (DFMC) services could provide operational benefits by improving performance and robustness for all CNS applications based on GNSS.

2.6 The new constellations and frequencies for GNSS will significantly reduce the probability of loss of service caused by unintentional interference, by virtue of the diversity of frequencies and increased number of satellites in view. The availability of dual GNSS frequencies will also help compensate for the ionosphere delay effect.

2.7 The ICAO *Global Navigation Satellite System (*GNSS) *Manual* (Doc 9849) describes a radio frequency interference (RFI) mitigation strategy and measures. The primary means to reduce the likelihood of both intentional and unintentional interference is effective spectrum management. This involves the creation of a strong regulatory framework controlling the allocation and use of spectrum in such a way as to secure protection of GNSS frequencies. At the national level, this is the responsibility of the radio regulatory authorities in each State. At the international level, the International Telecommunication Union (ITU) provides such a framework through its Radio Regulations.

2.8 2.5 Although the likelihood of GNSS signal disruption can be significantly reduced as described in ICAO Doc 9849, disruption cannot be completely ruled out, and therefore the aircraft operators and air navigation services providers (ANSPs) should be prepared to deal with potential loss of GNSS signals. This requires the completion of a risk assessment that will determine the residual likelihood of service outages and the impact of an outage in specific airspace, and the application of realistic and effective mitigation strategies to ensure the safety and regularity of air services.

3. GNSS DISTURBANCE MITIGATION STRATEGIES

3.1 The ICAO Doc 9849 describes three principal methods to mitigate GNSS loss of service which can be applied in combination:

a) taking advantage of on-board equipment, such as inertial reference system (IRS) provides a short-term area navigation capability after the loss of GNSS updating;

b) taking advantage of conventional navigation aids and radar; and

c) employing procedural (aircrew and/or ATC) methods.

3.2 The ICAO guidance indicates also several States have identified the need for an alternative position, navigation and timing system (APNT) strategy with the goal of maintaining services to the maximum extent possible in the event of a GNSS signal outage. The APNT strategy must have global application and must be implemented in a short time.

3.3 The conventional aids can provide alternative sources of guidance. distance measuring equipment (DME) is the most appropriate conventional aid available in the near- to mid-term for supporting PBN operations, since it currently provides input to multi-sensor navigation systems that allow area navigation in both en-route and terminal airspace.

3.4 The procedural (aircrew or ATC) methods can provide effective mitigation taking due consideration of:

a) the airspace classification and the availability of surveillance data;

b) the avionics in aircraft using the airspace (e.g. most aircraft in high-level airspace will have IRS and/or DME/DME updating of navigation systems);

c) aircrew and air traffic controller workload implications and the availability of controller decision support tools;

d) the impact that the loss of GNSS will have on other functions, such as surveillance in an ADS-B or ADS-C environment;

e) the potential for providing the necessary increase in aircraft route spacing and/or separation in the airspace under consideration; and

f) use of pre-defined ATS routes network based on ground-based navigation aids.

3.5 As the loss of GNSS service may impact small or wide area, there is a need to adopt mitigations that can be deployed at national and regional levels where an adequate terrestrial navigation and air traffic management infrastructure remains available. The infrastructure will support navigation continuity both for en-route, in terminal and approach phases.

3.6 The Assembly Resolution A-32-19 defines the rights and obligations of States relating to GNSS services. This resolution states that each State providing GNSS services shall ensure the continuity, availability, integrity, accuracy and reliability of such services, including effective arrangements to minimize the operational impact of system malfunctions or failure, and to achieve expeditious service recovery. The GNSS Services and performance are subject of detailed SARPs in Annex 10, Volume I.

4. CONCLUSION

4.1 As the GNSS loss of service is impacting a large number of ASBU modules/elements and all applications providing positioning, navigation and timing, there is a need to strength the current obligations on GNSS services and its continuity and identify mitigation methods that can be applied at national, regional and global levels.

4.2 The collaborative engagement between States, ICAO and the industry will ensure the continuity of GNSS services and reduce the likelihood of unexpected loss of GNSS signals that may impact critical functions and applications associated with ABSUs.

4.3 The protection of GNSS signals starts with an effective spectrum management and protection of GNSS frequencies to reduce the likelihood of unintentional interference or degradation of GNSS performance. This can be achieved through:

a) the development and enforcement of a strong regulatory framework governing the use of global navigation satellite system repeaters, pseudofiles, spoofers and jammers; and

b) cooperation between States, ICAO and the industry for design and development of effective and efficient ground and on-board mitigation techniques of GNSS service loss.

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