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ENHANCING THE MONITORING OF OPERATIONAL PERFORMANCE METRICS FOR CRITICAL EQUIPMENT TO IMPROVE THE RESILIENCE OF AIR NAVIGATION SERVICES

(Presented by China)

EXECUTIVE SUMMARY

The International Civil Aviation Organization (ICAO) has designated “enhancing air navigation resilience” as a Strategic Priority and integrated it within the strategic framework of the *Global Air Navigation Plan* (Doc 9750). Nevertheless, recurrent anomalies in recent years – including failures of critical equipment or software in global air navigation service – have exacerbated reductions in operational capacity and deterioration of flight punctuality. These events trigger cascading effects, resulting in widespread flight delays, cancellations, diversions, and alternate aerodrome landings. Such disruptions not only increase aircraft fuel consumption but may also cause reductions to prescribed separation minima, thereby elevating safety risks.

Recognizing that air navigation service resilience is intrinsically linked to the operational performance of critical systems and software, this proposal advocates establishing monitoring mechanisms for the “Equipment (software) Uptime Rate” metric at global, regional, and State levels. This streamlined approach addresses the current absence of resilience-focused performance indicators while providing an efficient foundation for enhancing air navigation service resilience. By guiding resilience-related practices and facilitating consolidation of operational experience and knowledge sharing, this mechanism shall tangibly improve resilience performance levels of air navigation services.

“Implementing targeted mechanisms to achieve systemic impact” – this focused initiative will significantly contribute to building robust air navigation service resilience frameworks.

<i>Strategic Goals:</i>	This paper relates to <i>Every Flight is Safe and Secure; Aviation is Environmentally Sustainable; Aviation Delivers Seamless, Accessible and Reliable Mobility for All; The Economic Development of Air Transport Assures the Delivery of Economic Prosperity and Societal Well-Being for All; and No Country Left Behind.</i>
<i>Financial implications:</i>	This paper has no financial implications.
<i>References:</i>	Doc 9750, <i>Global Air Navigation Plan</i> , Doc 10209, <i>Report of the Fourteenth Air Navigation Conference</i>

¹ English and Chinese versions provided by China.

1. INTRODUCTION

1.1 At the 41st Session of the ICAO Assembly, a resolution was adopted, designating “enhancing aviation system resilience” as a priority. On November 1, 2024, the Council approved the “ICAO Strategic Plan 2026 – 2050”, setting the strategic goals of ensuring “every flight is safe and reliable”, promoting the “environmental sustainability of the aviation industry”, building a “seamless, accessible, and reliable global aviation service network”, and advancing the “inclusive economic and social benefits of air transport”.

1.2 The performance levels of air navigation services are directly correlated with the operational performance of critical systems and software. However, in recent years, recurrent anomalies – including critical equipment failures and software malfunctions in air navigation service worldwide – have precipitated reductions in operational capacity and diminished flight punctuality. These events trigger cascading effects, including widespread flight delays, cancellations, diversions, and alternate aerodrome landings. Such disruptions not only increase aircraft fuel consumption but may also result in reductions to prescribed separation minima, thereby elevating safety risks. This demonstrates that interruptions to air navigation services significantly impact multiple performance domains – safety, efficiency, and sustainability – of aviation activities, impeding the achievement of ICAO’s Strategic Objectives. Concurrently, these occurrences reveal that design parameters of individual equipment/software components (e.g., Mean Time Between Failures, MTBF) cannot represent the operational performance of air navigation services.

1.3 In this regard, ICAO, from the perspective of air navigation, has elevated “maintaining operational performance through enhanced resilience” to a strategic level. It has incorporated this into the strategic framework of the eighth edition of the *Global Air Navigation Plan*, (Doc 9750, GANP). Furthermore, ICAO has established resilience - related performance objectives. That is, air navigation service should effectively address both planned and unplanned disruptions. That disruptions do not cause service interruptions or have a significant impact on system performance should be ensured. At present, air navigation system resilience covers eight Air Navigation system disciplines including airspace management (ASM), air traffic flow management (ATFM), air traffic services (ATS), aeronautical information management (AIM), aeronautical meteorology (MET), and communications, navigation, and surveillance (CNS).

1.4 Member States shall establish air traffic management (ATM) operational systems with interference-resistant, self-adaptive, and rapid recovery capabilities. Implementing real-time monitoring mechanisms for key equipment performance indicators constitutes a streamlined and efficient initial measure. This approach proactively prevents air navigation service interruptions caused by equipment anomalies through operational performance surveillance – a prevailing practice adopted by multiple States, including China.

2. DISCUSSION

2.1 While the Eighth Edition of the Global Air Navigation Plan (GANP) has incorporated resilience as a Critical Domain within its strategic framework, defining associated performance visions and objectives, the Performance Framework for air navigation service currently lacks corresponding performance indicators for the resilience domain. This gap prevents effective measurement of air navigation service resilience levels.

2.2 **Implementing operational performance indicator monitoring for key equipment and software is the breakthrough point for enhancing air navigation system resilience.**

2.2.1 The key equipment and software of air navigation service serve as the core physical carriers for service operations and information hubs for multilateral collaborative decision - making. Their operational performance levels are crucial to air navigation service quality. Thus, establishing operational performance indicator monitoring for key equipment and software can address the current gap in this field.

2.3 Operational performance indicators of key equipment and systems and the threshold values

2.3.1 In 2016, China's civil aviation authority issued the "Civil Aviation Communication, Navigation and Surveillance Operation, Maintenance and Overhaul Regulations", which proposed operational performance indicators for key equipment and systems. These are the "Equipment (software) Uptime Rate", defined as the ratio of the time the equipment functions as intended to the planned operating time. The statistical periods are monthly, quarterly, and annual. Planned operating time (hours) refers to the time the equipment is scheduled to operate normally. Unplanned downtime (hours) refers to the time from equipment failure or other issues causing loss of function until function recovery.

2.3.2 Based on equipment performance, configuration, and operational role and requirements, China classifies equipment into three categories (A, B, and C) with corresponding Equipment (software) Uptime Rate standards:

- Category A: Equipment whose failure directly changes air traffic service operation modes or flight standards, or significantly increases operational risks. Their "Equipment (software) Uptime Rate" must be no less than 99.97 per cent.
- Category B: Equipment whose failure typically doesn't change air traffic service operation modes or flight standards and has a minimal impact on operational risks. Their "Equipment (software) Uptime Rate" must be no less than 99.5 per cent.
- Category C: Backup or redundant equipment whose failure doesn't entirely eliminate backup or redundancy. Their "Equipment (software) Uptime Rate" must be no less than 99.0 per cent.

2.4 The Application of Operational Performance Indicators for Key Equipment and Systems

2.4.1 Establishing a monitoring mechanism for the operational performance indicators -the "Equipment (software) Uptime Rate" of key air navigation system equipment and software helps States summarize and accumulate valuable experience in ensuring the operational performance of key equipment and software. This experience can effectively promote the following efforts and significantly enhance the resilience of air navigation service:

- It helps equipment manufacturers enhance equipment quality, address system design deficiencies, and reduce service interruption probabilities due to equipment issues.
- It assists service providers in optimizing planning and resource allocation, including deploying backup equipment, adding operational alternatives, and implementing digital solutions, thereby improving the continuity and reliability of air navigation services.

- It aids regional service providers in refining emergency response plans and establishing efficient regional collaborative emergency decision-making mechanisms, thus boosting regional air navigation service resilience.

2.4.2 Through continuous monitoring of “Equipment (software) Uptime Rate”, China has gained in-depth knowledge of the operational performance of key equipment and software. Based on this, China has undertaken the three types of work mentioned in 2.4.1, effectively enhancing air navigation service resilience. To date, there have been no air traffic service interruptions in Air Traffic Control (ATC) sectors or Control Areas due to equipment issues. This has provided stable and reliable air navigation services for domestic and cross-border flights, making a significant contribution to strengthening the regional air navigation system resilience.

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