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AGENDA ITEM 7: AVIATION ENVIRONMENT

HUMAN PERFORMANCE AND POSITIVE SAFETY CULTURE IN SUPPORT OF AVIATION ENVIRONMENTAL TARGETS

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INFORMATION PAPER

SUMMARY

Environmental ambition and workforce capability are complementary priorities; neither can succeed without the other. Environmentally focused ATM initiatives—such as trajectory-based operations, free-route airspace, and continuous climb and descent procedures—deliver their designed benefits only to the extent that controllers have the capacity, competency, and confidence to manage the associated complexity.

When these conditions are not met, the gap shows up in daily operations as vectoring, sub-optimal level allocation, re-routing, and holding. Each carries a fuel and CO_2 penalty that is rarely captured in any environmental account. Human performance therefore determines how much of the intended benefit is delivered, and a positive safety culture determines whether a State can identify where, and why, that benefit is being lost.

HUMAN PERFORMANCE AND POSITIVE SAFETY CULTURE IN SUPPORT OF AVIATION ENVIRONMENTAL TARGETS

1. INTRODUCTION

1.1 The aviation sector continues to pursue improvements in efficiency, capacity, and connectivity while responding to growing environmental challenges. Achieving these objectives requires the adoption of innovative operational and technological solutions without compromising safety.

1.2 In 2022, ICAO adopted a Long-Term Aspirational Goal (LTAG) of achieving net-zero carbon emissions from international aviation by 2050. The LTAG supports the objectives of the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, which seek to limit the impacts of climate change through the reduction of global greenhouse gas emissions.

1.3 Within the basket of measures supporting the LTAG, operational improvements are recognized as offering the highest potential for CO2 reduction, in short to medium term, as the associated benefits do not depend upon fleet renewal cycles or fuel supply chains. Such operational improvements comprise changes to ATM systems, airspace and procedures, framed by the Global Air Navigation Plan (GANP). These operational elements differ from the others in one significant respect: technology and fuel benefits are realized at the point of manufacture or supply, whereas operational benefit is realized only at the point of delivery, through the trajectory each individual flight follows.

1.4 However, the benefit designed into an airspace or trajectory concept and the benefit delivered in daily operations are not the same quantity. The difference between them is determined largely by human performance: by the workload the concept imposes, the competency available to manage it, and the confidence with which controllers apply it under real traffic conditions. Positive safety culture regulates the balance of success in this relationship, determining whether the reasons for any shortfall reach the State at all, or are instead absorbed silently within day-to-day operational practice.

1.5 This paper accordingly examines ATM as the delivery mechanism for environmental commitments, workforce capability as the determinant of delivered benefit, and positive safety culture as the feedback loop through which shortfalls become visible and correctable.

2. DISCUSSION

2.1. Air Traffic Management (ATM) as the Delivery Mechanism for State Environmental Commitments

2.1.1 ATM directly impacts the outcome of environmental commitments through the ability to deliver enabling initiatives. Such initiatives, adopted for the purpose of economy, efficiency and environmental harm reduction, include Trajectory Based Operations (TBO), Free Route Airspace (FRA), User Preferred Routes (UPR), Collaborative Air Traffic Flow Management (ATFM), Continuous Climb and Descent Operations (CCO/CDO), Dynamic Airspace Management, reduced separations and cross-border airspace harmonization initiatives. As airspace users seek increasingly optimized routes, ATM systems and operational personnel become critical enablers of State environmental performance objectives.

2.1.2 As an example, trajectory-based operations within the operational European Free Route Airspace (FRA) have shown that 44% of ANSPs reported an increase in controller workload, with 20% reporting an increase in sector workload. Additionally, UPR/FRA operations within the South Pacific regularly create complexities due to RNP criteria versus capability and weather-related wind idiosyncrasies. This demonstrates that economic, environmental, and operational efficiencies may be accompanied by changes in controller workload, traffic complexity, and sector management requirements. The workload consequences of trajectory-based operations are therefore not incidental to their environmental benefit; they are the principal constraint on delivering it.

2.1.3 Where ATM capacity, system support, or workforce readiness are insufficient, the shortfall does not appear as a failed initiative but as tactical intervention—vectoring, sub-optimal level allocation, re-routing, or holding—each carrying a measurable fuel and CO_2 penalty. The same initiative may therefore deliver its full benefit in one FIR and only a fraction of it in another, with the difference arising from the human-performance conditions under which it is delivered.

2.1.4 Environmental ambition and workforce capability are inherently complementary. Introducing an initiative without assessing staffing levels, competency requirements, and workload implications risks diminishing workforce resilience and compromising the initiative's ability to sustain its intended environmental benefit. States should therefore regard ATM capability, workforce capacity, and operational safety performance as integral components of national aviation environmental strategies**.**

2.2. Workforce Capability as a Determinant of Delivered Environmental Benefit

2.2.1 If the delivery of environmental benefit depends upon controller decisions made in real time, workforce capability becomes an environmental variable in its own right. Concepts such as dynamic airspace management or free-route airspace reduce fuel burn only when controllers are able and willing to accommodate the associated requests.

2.2.2 As environmentally driven initiatives are more widely implemented, controllers will encounter new operational challenges, increased coordination requirements, and evolving traffic patterns. Anticipating these changes enables States and service providers to develop the necessary competencies proactively through continuous professional development and targeted training.

2.2.3 Investment in controller competency and workforce readiness should be regarded not solely as a safety and capacity requirement, but as a critical contributor to the effective realization of aviation environmental objectives.

2.2.4 Regional harmonization and the achievement of seamless air traffic management will increasingly depend upon effective cross-border coordination. States are encouraged to strengthen inter-FIR interoperability and pursue joint training and knowledge-sharing arrangements that foster a common operational understanding and support the safe and orderly implementation of future ATM concepts across the region.

2.3. Positive Safety Culture as the Feedback Loop for Environmental Performance

2.3.1 Positive safety culture refers to an organizational environment in which safety-relevant information is shared openly, human error is treated as an opportunity for learning rather than blame, and personnel are encouraged to report occurrences without fear of punitive consequences. It forms a foundational element of an effective Safety Management System (SMS) by shaping how operational challenges and emerging risks are identified, reported, and addressed.

2.3.2 Although the term *Just Culture* does not appear explicitly in the ICAO Annexes, its principles are embedded within existing Standards and Recommended Practices. Annex 19 requires States to promote a positive safety culture and protect safety data and their sources, while Annex 13 provides equivalent protections in the context of accident and incident investigation. The conference may therefore wish to consider Just Culture not as a new or externally imposed concept, but as the practical expression—at the level of the individual controller—of obligations already undertaken by Asia-Pacific Contracting States.

2.3.3 A positive safety culture can directly influence ATM capacity and operational efficiency. Controllers who operate within a trusted Just Culture environment are more likely to apply established procedures and separation standards confidently and consistently, supported by

the assurance that safety occurrences will be evaluated fairly and used to strengthen organizational learning.

2.3.4 Where punitive practices or a lack of transparency are perceived to exist, operational personnel may adopt wider protective margins, including larger separation buffers, earlier tactical intervention, reluctance to approve non-standard trajectory requests, and more conservative flow restrictions. While individually defensible, these behaviours cumulatively impose persistent efficiency costs in additional track miles, non-optimum flight levels, and increased fuel burn.

2.3.5 Safety reporting provides essential insight into the relationship between traffic complexity, controller workload, and ATM capacity. Operational personnel are often the first to identify unintended consequences, emerging risks, or capacity constraints associated with new environmental initiatives. A positive safety culture encourages the reporting of such observations and enables organizations to take proactive action before safety or efficiency is adversely affected.

2.3.6 Reliable safety data is fundamental to the effective functioning of Safety Management Systems (SMS) and State Safety Programmes (SSP). Without accurate reporting and a trusted reporting environment, States may be unable to assess the operational impacts of environmental initiatives, identify capacity limitations, or implement effective mitigation measures. Positive safety culture therefore serves not only as a safety enabler but also as a key contributor to the successful realization of aviation environmental objectives.

2.4. Conclusion

2.4.1 The successful realization of aviation environmental objectives requires States to recognize human performance, controller workload, and ATM capacity as pivotal determinants of environmental outcomes, alongside direct emissions-reduction measures. Operational initiatives can deliver their intended environmental benefits only when supported by sufficient ATM capacity, coherent procedures, and a capable, well-prepared workforce.

2.4.2 Positive safety culture and non-punitive Just Culture are central to this capability. By enabling operational personnel to report emerging challenges openly and without fear of blame, a positive safety culture allows States and service providers to identify capacity constraints, workload pressures, and operational risks at an early stage and to respond before safety or efficiency is compromised.

2.4.3 States should therefore recognize that investment in workforce capability, positive safety culture, and regional cooperation is not solely a safety consideration but a strategic enabler of national and regional aviation environmental commitments. Supporting ATC service providers in these areas will allow environmentally driven ATM initiatives to be implemented safely, efficiently, and sustainably across the APAC region.

3. ACTION BY THE CONFERENCE

3.1 The Conference is invited to:

a) recognize that the environmental benefit of ATM operational initiatives is realized only at the point of delivery, and that human performance and workforce capability therefore determine how much of the designed benefit is achieved;

b) acknowledge that environmental ambition and workforce capability are complementary rather than competing priorities, and encourage States and service

providers to ensure that resource implications and human performance impacts are captured within the impact assessment, benefit analysis and post-implementation review of environmentally driven initiatives;

c) recognize safety reporting under a non-punitive Just Culture as a necessary information source for managing the environmental performance of the ATM system; and

d) recognize regional cooperation, safety information sharing, and collaborative learning to facilitate the harmonized implementation of environmentally driven ATM initiatives across the APAC region.

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