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AGENDA ITEM 3: AVIATION SAFETY

TURBULENCE ENCOUNTERS AS A GLOBAL OPERATIONAL SAFETY RISK

(Presented by Republic of Korea, Singapore and Japan)

SUMMARY

Turbulence encounters have long been a leading cause of injuries in-flight. They occur frequently throughout the world, and there is still room for improvement in countermeasures to mitigate this safety risk. This paper highlights some countermeasures from promotional activities for passengers to the utilization of technology and supports the turbulence encounter initiative by the Conference, Member States and industries.

TURBULENCE ENCOUNTERS AS A GLOBAL OPERATIONAL SAFETY RISK

1. INTRODUCTION

1.1 According to ICAO Annual Safety Report 2024, the turbulence encounter occurrence category accounted for the most accidents for scheduled commercial operations involving aircraft with a certified Maximum Takeoff Weight over 5700kg, accounting for as much as 40% of all accidents. While countermeasures against accidents caused by turbulence are required, AN-Conf/14-WP/8 proposed a series of amendment to GASP. In the 2026-2028 edition of the GASP, the turbulence encounter will be treated as an additional category of occurrences of Global operational safety risks – that may not have a high fatality risk, but figure prominently in the most frequent types of accidents and serious incidents across ICAO regions.

1.2 Turbulence encounters have long been a leading cause of injuries in-flight. Scientific evidence suggests that there may be more severe weather patterns brought about by climate change which could lead to more turbulence-related accidents. In May 2024, a Singapore aircraft experienced severe turbulence whilst operating a commercial flight from London to Singapore leading to one passenger fatality and multiple injuries. Preliminary investigation findings indicated that the aircraft most likely encountered an updraft leading to sudden and significant G-forces while likely flying through an area of developing convective activity.

1.3 Japan Civil Aviation Bureau (JCAB) has reviewed incidents of bone fractures occurred in Japan since 2016 and found that severe turbulence could occur at any point during climb, cruise, and descent, making it difficult to predict, that the sharp increase in bone fracture incidents in 2022 was presumably due to environmental changes associated with the resumption of flights after COVID-19 recovery, and that most injuries occurred in the aft section of the aircraft.

1.4 Studies on turbulence indicate that climate change impacts upper atmospheric turbulence, revealing an increase in turbulence due to various factors[1]. Analyses of climatological changes in turbulence in the upper troposphere and lower stratosphere of the Northern Hemisphere confirm an increase in both the frequency and intensity of turbulence due to climate change[2]. This trend is particularly pronounced in the Asia-Pacific region, where the frequency and severity of turbulence encounters have been notably higher. Such turbulence poses a significant threat to the safety of passengers and crew, increasing aircraft structural stress and fatigue, which can result in higher maintenance frequencies, increased maintenance costs, and reduced aircraft lifespan. Additionally, turbulence encounters disturb optimal altitude operations, potentially delaying the achievement of the Long-Term Aspirational Goal (LTAG).

2. DISCUSSION

2.1 After the review, JCAB issued an alert letter to some Japanese operators on June 30, 2023. The letter requested flight crew to coordinate with cabin crew and turn on the early fasten seatbelt sign when turbulence is expected in the air. It also urged flight attendants to inform passengers "to recommend that seatbelts be fastened low on the waist with no looseness at all times while seated," and to take action to prevent injury to the flight attendants themselves (e.g., refrain from offering in-flight services when turbulence is expected).

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[1] Kim, S.-H., J. Kim, J.-H. Kim*, and H.-Y. Chun, 2022: Characteristics of the Derived Energy Dissipation Rate using the 1-Hz Commercial Aircraft Quick Access Recorder (QAR) Data. Atmos. Meas. Tech., 15, 2277-2298

[2] Lee, J. H., Kim, J.-H.*, Sharman, R. D., Kim, J., & Son, S.-W. (2023). Climatology of Clear-Air Turbulence in upper troposphere and lower stratosphere in the Northern Hemisphere using ERA5 reanalysis data. Journal of Geophysical Research: Atmospheres, 128, e2022JD037679.

2.2 As for Singapore operators, the majority of the severe turbulence encounters and injuries were reported during the en-route phase of flight. As part of its continuing effort to prevent injuries caused by turbulence, the Civil Aviation Authority of Singapore (CAAS) issued an advisory circular to guide Singapore operators in developing SOPs and other measures such as incorporating turbulence-related scenarios into the operators' training objectives. CAAS also works with its operators in reviewing their procedures on turbulence management to ascertain their relevance with current weather trends. Nevertheless, more can be done to prevent injuries caused by turbulence through the sharing of real-time turbulence information to minimize turbulence encounters and to provide sufficient reaction time for the passengers and cabin crew to be secured.

2.3 The ROK has identified turbulence encounters as one of the key safety risk areas in its State Safety Program (SSP) since 2019. To mitigate injuries resulting from turbulence, the ROK has recommended various measures to its aircraft operators. In 2022, the ROK initiated a project to establish a 'Public Adverse Weather Dashboard' in collaboration with both public and private sectors. Furthermore, in August this year, the ROK announced a comprehensive set of prevention strategies, which include: enhancing forecast models through collaboration with the operators and meteorological authorities, incorporating turbulence-specific modules into regular training programs for flight dispatchers, pilots and cabin crew, developing standardized guidelines for communication between pilots and cabin crew, and launching nationwide campaigns to promote a culture of seatbelt use during flights.

2.4 Special Air-Reports (ARS) containing encountered turbulence information are essential sources to recognize existence of the phenomenon. The Annex 3 requires all aircraft to make special observation whenever they encounter moderate or severe turbulence and report the outcomes as ARS. The Annex 11 recommends air traffic services (ATS) units to transmit the ARS to other aircraft concerned as well as other stakeholders including the associated meteorological watch office (MWO). The MWO then considers issuance of Significant Meteorological (SIGMET) information to be supplied to operators and flight crew members. Improving ARS availability by encouraging operators to report and ATS units to transmit would enrich turbulence observation information, further improve en-route weather services, and contribute to the aviation safety.

2.5 The Annex 3 requires aircraft to report turbulence in terms of the eddy dissipation rate (EDR) when air-ground data link is used. Such aircraft are also required to make routine aircraft observations and report the outcomes as air-reports (AIREP). Routine observations and reporting of turbulence in EDR have advantages such as 1) quantitative observations and reporting compared to conventional flight crew members' sensation; 2) large number of reports covering weaker turbulence; and 3) exact encountering position recorded compared to manual reporting which is often made after passing the turbulence area. If routine and quantitative turbulence observations and reporting would become common and the reports could be available promptly among stakeholders in future aviation system, more aircraft could take safer flight paths by rerouting as needed during the flights. The reports would also facilitate advanced en-route weather information service provision including turbulence forecast improvements. It would also be beneficial to consider a gap analysis on ICAO Standards and Recommended Practices (SARPs) in order to identify potential gaps therein in relation to addressing turbulence encounter in civil aviation. For example, it may facilitate implementation by air operators for relevant Annex 3 requirements on turbulence reporting by aircraft to also be incorporated in Annex 6.

2.6 Applying advanced technologies such as turbulence detection and advisory system using onboard Doppler Light Detection and Ranging (LIDAR) in combating turbulence encounter is under development. Doppler LIDAR detects air current by emitting laser light and receiving scattering lights reflected from aerosol (fine particles such as water drops and dust) floating in the atmosphere. The developed system measures backscattered light from aerosols forward of the aircraft, detects and warns pilots of clear-air turbulence ahead. The Japan Aerospace Exploration Agency (JAXA) has demonstrated the use of Doppler LIDAR technology in a series of flight tests using both small and large aircraft.

2.7 Turbulence and weather awareness software tools are becoming more widely available on pilot EFB devices, such as IATA Turbulence Aware. Such tools are able to overlay turbulence and weather information from various different sources on to the planned and actual flight route. When connected to a suitable network, the information can be updated to supplement the on-board weather display and allows for the transmission of AIREP and EDR data that can be used to update the information displayed to other pilots. Enhanced awareness is a key mitigation for reducing the outcome severity of turbulence encounters as it allows pilots to either take avoiding action or apply turbulence management measures.

2.8 Another measure which could be adopted in conventional aviation system is to improve operational scheme of information sharing and utilizing. For example, Japan has a scheme among aircraft operators, ATS units and the meteorological service provider to share air-reports including those report weaker phenomena than the ICAO criteria. Shared information helps flight crew to avoid hazardous weather phenomena or take other appropriate actions and supports the meteorological service provider to provide accurate SIGMET and other weather information in timely manner. Mutual cooperation among the stakeholders both within a State and bi-/multi-laterally is essential to ensure aviation safety in the region through improving weather information availability and accuracy. More to say, meteorological service enhancement in current aviation system, inclusion of forecast in SIGMET for instance, would be archivable with utilizing other information sources such as numerical weather prediction data, meteorological satellite imageries and derived products[3].

3. ACTION BY THE CONFERENCE

3.1 The Conference is invited to:

a) encourage States and industries to share experiences or best practices related to turbulence encounters among stakeholders;

b) further encourage States and their operators to consider making necessary arrangements to improve availability of air-reports including Special Air-Reports, especially those made routinely and containing quantitative turbulence information, recognizing the importance of mutual cooperation among the stakeholders;

c) urge scientific/meteorological communities to investigate how to enhance turbulence forecasting models, narrow down areas of probability; and

d) urge ICAO and States to consider organising workshops and/or webinars regarding turbulence encounters which may cover instructions/trainings to enhance turbulence-related meteorological information sharing and providing capacity.

— END —

[3] Some of which are available for the general public. For example,
https://www.jma.go.jp/bosai/map.html#contents=himawari&lang=en
https://www.jma.go.jp/jma/jma-eng/jma-center/nowcasting/