International Civil Aviation Organization

WORKING PAPER

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FOURTEENTH AIR NAVIGATION CONFERENCE

Montréal, Canada, 26 August to 6 September 2024

Agenda Item 2: Timely and safe use of new technologies
2.3: 2026-2028 Edition of the Global Aviation Safety Plan (GASP)

TURBULENCE ENCOUNTERS AS GLOBAL OPERATIONAL SAFETY RISK

(Presented by Japan and Singapore and co-sponsored by Philippines, Thailand, Airports Council International (ACI) and International Air Transport Association (IATA))

EXECUTIVE SUMMARY

Turbulence encounters has 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 the safety risk. This paper highlights some countermeasures from promotional activities for passengers to the utilization of technology and supports the turbulence encounter initiative by ICAO, Member States and industries.

Action: The Conference is invited to agree to the recommendation in paragraph 3.3.

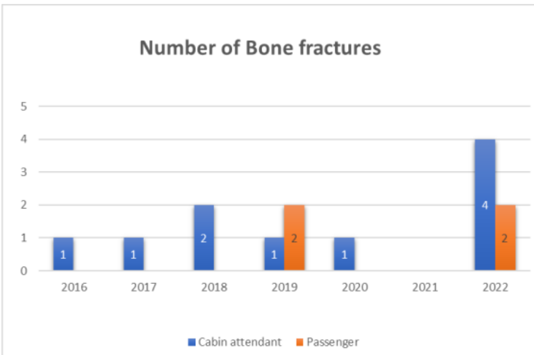
1. INTRODUCTION

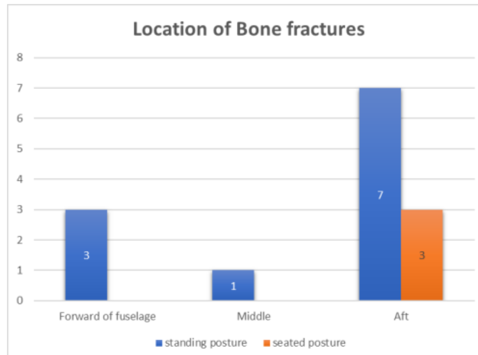
1.1 According to ICAO Annual Safety Report 2023, the turbulence encounter occurrence category accounted for the most accidents for scheduled commercial operations involving aircraft with a certified maximum take-off weight over 5700kg, accounting for as much as 40 per cent of all accidents. While countermeasures against accidents caused by turbulence are required, Regional Aviation Safety Group – Asia Pacific (RASG-APAC/13-WP/5) states that the Global Aviation Safety Plan Study Group (GASP-SG) developed a series of proposals to revise the 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.

2. DISCUSSION

2.1 Turbulence encounters has 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 passenger aircraft experienced severe turbulence whilst operating a commercial flight from London to Singapore leading to one passenger fatality and multiple injuries. Preliminary investigation findings indicate that the aircraft encountered sudden and significant gravitational forces, and an updraft while likely flying through an area of developing convective activity.

2.2 Japan Civil Aviation Bureau (JCAB) has reviewed incidents of bone fractures since 2016 and found that severe turbulence could occur at all points 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.





2.3 After the review, JCAB issued an alert letter to some Japanese operators on 30 June 2023. The letter requested flight crews 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).

2.4 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.

2.5 Special air-reports (ARS) containing encountered turbulence information are essential sources to recognize existence of the phenomenon. The Annex 3 — *Meteorological Service for International Air Navigation* requires all aircrafts to make special observation whenever they encounter moderate or severe turbulence and report the outcomes as ARS. The Annex 11 — *Air Traffic* Services 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.

2.6 Annex 3 requires aircrafts to report turbulence in terms of the eddy dissipation rate (EDR) when air-ground data link is used. Such aircrafts 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 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 aircrafts 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 — *Operation of Aircraft.*

2.7 Applying advanced technologies such as turbulence detection and advisory system using onboard Doppler Light Detection and Ranging (LIDAR) in combating turbulence encounter. 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[1].

2.8 By using the airflow information obtained from detection forward of the aircraft, control inputs are calculated that will enable the aircraft to fly into the turbulence without lurching. On normal autopilot, the calculation would only reflect the current state of the aircraft, but by also using airflow information forward of the aircraft, it is possible to calculate control inputs that can fully counteract the effects of the turbulence. The computation results of the control are transmitted to the actuators which move the flight control surfaces in preparation for the airflow turbulence to reduce the lurching of the aircraft.

2.9 In addition to conventional AIREP and weather information services, it may also be useful to identify and analyze turbulence trends based on regional, terrain, or seasonal characteristics, and share these with crews and stakeholders without delay. As one example, terrain-induced turbulence may cause runway excursion of landing aircraft, and although the safety risk of such excursion varies from airport to airport, historical flight data accumulated by airline flight safety divisions and reports from pilots are extremely valuable in supporting the reliability of wind condition analysis.

2.10 JAXA, with the cooperation of several Japanese operators is developing *an airport wind condition determination support system* to provide to pilots and flight dispatchers. This system aims to a) provide high-resolution turbulence guidance that reproduces airflow through terrain irregularities using Large Eddy Simulation, a wind analysis method that has been used extensively in recent years, and b) analyze the constantly changing turbulence at the destination airport, predicts conditions a short time ahead, and delivers the information in a simple format that pilots need.

2.11 Other turbulence and weather awareness software tools are becoming more widely available on pilot electronic flight bag (EFB) devices, such as International Air Transport Association (IATA) Turbulence Aware[2]. 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 AIREPS 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

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[1] Topics | R&D of onboard safety avionics technology to prevent turbulence-induced aircraft accidents (SafeAvio) | Sky4All | Research & Development | Aviation Technology Directorate (jaxa.jp)

[2] Turbulence Aware: https://www.iata.org/en/services/data/safety/turbulence-platform/

encounters as it allows pilots to either take avoiding action or apply turbulence management measures.

3. CONCLUSION

3.1 Given that turbulence encounters are prominent among all aircraft accident numbers and will be treated as an additional category of occurrences in the 2026-2028 edition of the GASP, ICAO, Member State, and industry should cooperate to enhance activities to reduce the safety risk.

3.2 While there may be an assumption that turbulence is a natural phenomenon and therefore difficult to control, a variety of methods exist and will continue to be developed to reduce its safety risks, ranging from promotional activities for passengers to the utilization of technology. It may be useful for ICAO to develop guidance materials, organize workshops and webinars, and to consider updating the Aviation System Block Upgrade (ASBU) elements of the GANP to make it easier for States, equipment original equipment manufacturers (OEMs), aircraft manufacturers, and operators to develop and adopt technologies such as Doppler LIDAR to reduce the related safety risks. Close collaboration of all stakeholders is crucial to identify the technical hurdles to be tackled to make solutions such as the airborne Doppler LIDAR system a practical application to be incorporated into aircraft in the future.

3.3 In light of the above, the Conference is invited to agree to the following recommendation;

Recommendation 2.3/x — Turbulence Encounters as Global Operational Safety Risk

That the Conference:

a) acknowledge that turbulence encounter continues to be a global operational risk in the 2026-2028 edition of Global Aviation Safety Plan (GASP);

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

c) further encourage States and operators to consider making necessary arrangements to improve availability of air-reports including special air-report (ARS), especially those made routinely and containing quantitative turbulence information;

d) urge that the scientific /meteorological community investigate how to enhance clear-air turbulence (CAT) forecasting models, narrow down areas of probability;

e) request ICAO to organize a workshop or webinar related to turbulence encounters, and update the Aviation System Block Upgrade (ASBU) elements of the Global Air Navigation Plan (GANP) to make it easier for States, equipment original equipment manufacturers (OEMs), aircraft manufacturers, and operators to develop and adopt technologies such as Doppler Light Detection and Ranging (LIDAR); and

f) request that ICAO review which Annexes should be consequently amended to reflect and improve the requirements on the reporting of turbulence encounters by aircraft and its use.

— END —