CIVIL AVIATION SAFETY AUTHORITY OF PAPUA NEW GUINEA

SAFETY ALERT BULLETIN

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A SAB contains important safety information and may include recommended action. SAB content should be especially valuable to air carriers in meeting their statutory duty to provide service with the highest degree of safety in the public interest. Besides the specific action recommended in a SAB, an alternative action may be as effective in addressing the safety issue named in the SAB.

TITLE: Clear Air Turbulence (CAT).

OBJECTIVE: This SAB serves to alert all Air Operators of the risks associated with clear air turbulence and provides recommendations for air operators and civil aviation authorities to enhance safety measures and prevent serious injury to passengers and crew.

This SAB also contains information and recommended actions that the Civil Aviation Safety Authority of Papua New Guinea (CASA PNG) strongly recommends, for air operators to consider when developing risk mitigation measures to safeguard against CAT.

BACKGROUND:

Accidents and Incidents history of CAT.

Some examples of Clear Air Turbulence encounters:

B763, Hong Kong to Port Moresby, 2025

On 01 September 2025, a PNG registered Boeing B767-300 flying from Hong Kong (HKG) to Port Moresby (POM) encountered clear severe air turbulence for up to 30 seconds, and resulted in injuries to two cabin crew members.

B738, en-route, south southwest of Toulouse France, 2015

On 25 February 2015, a Boeing 737-800 encountered severe clear air turbulence as it crossed the Pyrenees northbound at FL 380. Two of the four cabin crew sustained serious injuries and it was decided to divert to Bordeaux where the flight arrived 35 minutes later. The turbulence and its consequences were attributed to the flight's lateral and vertical closeness to a correctly forecast opposite-direction jet stream core and specifically to allowing cabin service to commence despite being near the boundary associated with severe turbulence following a negative ATC response when asked whether other flights had reported severe turbulence.

A359, vicinity Cayenne French Guiana, 2021

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On 5 December 2021, an Airbus A359-900 crew encountered a very brief episode of unexpected clear air turbulence associated with visible signs of convective weather in the vicinity. Not having had prior warning, the senior cabin crew member fell and was seriously injured. The investigation concluded that the risk of turbulence prevailing for the location and season as the end of daylight approached was greater than perceived by the pilots, despite their familiarity with the local area and its weather. The investigation further concluded that releasing the cabin crew from their previously secured positions had been inappropriate.

A320, en-route, near Okayama Japan, 2022

On 16 January 2022, an Airbus A320 in cruise unexpectedly and very briefly encountered light clear air turbulence. Despite being secured in a seat, one passenger sustained a serious injury not assessed as such by the passenger or the cabin crew at the time, but which subsequently resulted in hospitalisation with a broken rib. The minor turbulence encountered had included a lateral movement which caused firm impact with the seat armrest. The operators' response included amending the safety briefing and related procedures and introducing a new video on turbulence awareness to be shown immediately after the briefing.

AT45, en-route, north northwest of Tanegashima Japan, 2019

On 12 October 2019, an ATR 42-500 on which Captain upgrade line training was being conducted encountered mild clear air turbulence soon after descent began and despite setting flight idle power, a concurrent speed increase led to concern at a possible VMO exceedence. An abrupt and ultimately simultaneous manual increase in pitch attitude followed leading to serious injury to the unsecured cabin crew which rendered them unfit to work. The Investigation found that the upset - a change in pitch from -2.3° to +6.3°in one second - was almost entirely due to pitch input from both pilots rather than turbulence.

B773, en-route, west of Haifa Israel, 2021

On 17 January 2021, a Boeing 777-300 which had just begun descent into Beirut encountered unexpected moderate to severe clear air turbulence which resulted in one major and several minor injuries to unsecured occupants including cabin crew. The Investigation found that the flight crew had acted in accordance with all applicable procedures on the basis of information available to them but noted that the operator's flight watch system had failed to generate and communicate a message about a relevant SIGMET until after the severe turbulence episode due to a data processing issue not identified as representing an operational safety risk.

Turbulence Injury - Cabin Crew

A320, en-route, southwest Caribbean, 2023

On 25 September 2023, an Airbus A320 in the cruise at FL340 entered cloud at night and encountered unexpected severe turbulence which resulted in serious injuries to four passengers and minor injuries to two other passengers and three of the four cabin crew. The scheduled flight to Fort Lauderdale was completed. The flight crew stated that they had not seen weather radar returns indicating any en-route turbulence ahead but when the weather radar was removed from the aircraft and subjected to functional testing, it was found to be fully serviceable. How the weather radar was being used was not investigated.

B738, en-route, southeast of Brisbane Australia, 2024

On 4 May 2024, a Boeing 737-800 descending en-route towards Brisbane encountered unanticipated brief severe convective turbulence passing through convective cloud and three unsecured cabin crew

were injured, one seriously who could not then be moved from the rear galley. Risk of injury was found to have been increased by the absence of any company requirement to confirm cabin secure for landing to the flight crew. An absence of company procedures to validate fitness to operate after injury meant that concussion sustained by one of the cabin crew was only detected by colleagues after a premature return to flying duties.

B773, en-route, central Iceland, 2023
On 13 February 2023 a Boeing 777-300 encountered unforecast severe mountain wave turbulence at FL350. The PF was an inexperienced first officer undergoing line training. A line captain was in the cockpit whilst the training captain-in-command was taking crew rest. Although the line captain responded with control inputs, he did not announce this and the trainee continued his own inputs. As a consequence of competing pitch commands, the aircraft lost 8,000 feet of altitude in approximately one minute at up to 17,100 fpm before stabilised flight was regained and a recovery climb initiated. The flight continued to Istanbul where the injured crew and passengers were hospitalised.

A339, en-route, north of Madagascar, 2023
On 2 March 2023, an Airbus A330-900 level at FL390 encountered en route turbulence unanticipated by the two first officers occupying the pilot seats whilst the captain was in the crew rest area. All three pilots had only recently qualified on type. The risk of significant convective turbulence was not recognized in advance, which led to the seat belt signs being off until just prior to turbulence onset. The turbulence resulted in 6 severe and 16 minor injuries, all requiring hospital treatment. Multiple safety actions were implemented by the aircraft operator to reduce the risk of recurrence.

A332, en-route, northeast of the Hawaiian Islands USA, 2022
On 18 December 2022, an Airbus A330-200 in cruise at FL400 in visual meteorological conditions (VMC) was flown through the isolated top of a building convective cloud after its vertical development rate was underestimated. A short but severe turbulence upset and brief loss of control resulted. A few minutes earlier air traffic control (ATC) had advised that “moderate to extreme precipitation and turbulence could be expected for the next 40 miles." Cabin service was in progress, and the turbulence resulted in 24 unsecured cabin crew and passengers being injured, four seriously. Some cabin trim detached and some equipment was damaged.

Pax Turbulence Injury - Seat Belt Signs off

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A388, en-route, north northeast of Beira Mozambique, 2020

On 16 January 2020 an Airbus A380 in the cruise at FL 400 in an area of correctly forecast convective turbulence encountered severe turbulence not anticipated by the crew who had not put on the seatbelt signs or alerted the cabin crew in time for the cabin to be secured. An unsecured passenger was seriously injured and several other passengers and an unsecured member of cabin crew were lifted off their feet but managed to avoid injury. The Investigation concluded that the flight crew had not made full use of the capabilities of the available on board weather radar equipment.

B788, en-route, Chengde China, 2019

On 15 August 2019, a Boeing 787 descending towards destination Beijing received ATC approval for convective weather avoidance but this was then modified with both a new track requirement and a request to descend which diminished its effectiveness. A very brief encounter with violent turbulence followed but as the seat belt signs had not been proactively switched on, the cabin was not secured and two passengers sustained serious injuries and two cabin crew sustained minor injuries. The Investigation noted that weather deviation requests could usefully be accompanied by an indication of how long they were required for.

DISCUSSION:

Common causes and sources of CAT are:

1. ***Jet Stream***. A Jet Stream is a narrow, fast moving current of air, normally close to the Tropopause and generated as a result of the temperature gradient between air masses. Although not all jet streams have CAT associated with them, there can be significant vertical and horizontal Wind Shear on the edges of the jet stream giving rise to sometimes severe clear air turbulence. Any CAT is strongest on the cold side of the jet stream where the wind shear is greatest. In the vicinity of a jet stream, CAT can be encountered anywhere from 7,000 feet below to about 3,000 feet above the tropopause. Because the strong vertical and horizontal wind shear occurs over short distances, this jet stream related CAT tends to be shallow and patchy so a descent or climb of as little as 2,000 feet is often enough to exit the turbulence.
2. ***Terrain.*** High ground disturbs the horizontal flow of air over it, causing turbulence. The severity of the turbulence depends on the strength of the air flow, the roughness of the terrain, the rate of change and curvature of contours, and the elevation of the high ground above surrounding terrain. For further information, refer to the article entitled Mountain Waves.

3. ***Thunderstorm Complexes***. Cumulonimbus (Cb) cells have strong vertical currents. Aircraft passing within 20 nautical miles horizontally, or less than 5,000 feet above the top, of a Cb may encounter CAT.
4. ***Cyclogenesis:*** The process of cyclone development.

The Effects of CAT include:

1. ***Structural Damage***. Aircraft can suffer structural damage as a result of encountering severe clear air turbulence. In extreme cases this can lead to the break-up of the aircraft. In even moderate turbulence, damage can occur to fittings within the aircraft, especially as a result of collision with unrestrained items of cargo or passenger luggage. Prolonged exposure to turbulence will shorten the fatigue life of the aircraft. Encounters with severe turbulence require a maintenance inspection.
2. ***Physical Injury to Crew/Passengers***. If caught unaware, passengers and crew moving around in the aircraft cabin can be injured. In one case, where a B747 encountered CAT over the Pacific ocean, several passengers and crew were severely injured and one passenger subsequently died. In a 2021 study, the U.S. National Transportation Safety Board (NTSB) found that between 2009 and 2018, turbulence was involved in more than one third of U.S. airline accidents.
3. ***Impaired Flight Crew Performance***. Moderate or Severe turbulence can make simple tasks, including reading instruments, near impossible.

CASA PNG RECOMMENDED ACTIONS:

Based on the above, CASA PNG strongly recommends the following action(s) to be considered by air operators when reviewing their standard operating procedures (SOPs) relating to Turbulence/CAT and in their safety risk assessments to safeguard against CAT:

Some suggested Defences against CAT:

1. ***Awareness.*** SIGMET charts give forecasts of the location and level of clear air turbulence. Information on local terrain induced CAT may be contained in appropriate Aeronautical Information Publications (AIPs) e.g. Approach plates for Gibraltar contain information on turbulence to be expected for given wind directions. In addition, Electronic Flight Bag (EFP) applications provide pilots with tools that gather information on reported and forecast turbulence. An example is the Turbulence Aware platform from the International Air Transport Association (IATA).
2. ***Communication.*** When pilots become aware of impending turbulence, they should let cabin crew know as quickly as possible. This can be done via interphone or through a public address announcement. If time is critical, a warning can be signaled by multiple chimes and/or flashing the seat belt signs. Preflight communication is important, as well. Captains should brief flight attendants on expected timing and duration of forecast turbulence.
3. ***Restraint Systems.*** Passengers and crew should fit seat belts and harnesses when seated to protect them in the event of unforeseen turbulence.
4. ***Cabin modifications. FAA*** Advisory Circular 120-88A offers guidelines on preventing turbulence injuries. They include cabin modifications such as minimizing cabin structures with hard or

angular surfaces or corners. Other recommendations include emergency handholds and "grab bars."

5. ***Turbulence penetration procedures.*** Slow to the aircraft's published turbulence penetration speed or less. Maintain aircraft attitude rather than altitude. Do not fight the turbulence. Airbus recommends keeping the autopilot and autothrust on as long as they are performing as desired. Consider a descent to widen the aircraft's buffet margins, and consult performance charts for buffet margin guidance.
6. ***Upset recovery training.*** Severe or extreme turbulence can cause a stall or loss of control. Simulator training for such events can help prepare pilots for this disorienting and stressful situation. At high altitudes, airspeed recovery can take significantly longer than at lower altitudes. If an inadequately trained pilot attempts to resume level flight too early, a secondary stall can result.

Some suggested Solutions to CAT:

1. ***Slow down***. Reducing the aircraft speed reduces the risk of structural damage and reduces vibration making instruments easier to read.
2. ***Strap in.*** Notify the crew/illuminate seat belt sign. All passengers and crew should immediately sit down and fit seat belts/harnesses.
3. ***Switch on Engine Ignition*** - Certain aircraft types recommend turning ignition on to prevent the turbulent airflow from flaming out engines.
4. ***Inform ATC.*** Notify ATC/warn other aircraft on chat or guard/emergency frequency (121.5 or 243.0).
5. ***Request clearance*** to climb/descend or diverge from track to escape turbulence.
6. ***Assess Damage/Injuries.*** Carry out a damage assessment and ascertain condition of any injured passengers or crew.
7. ***Consider precautionary diversion.***
8. ***Suspend Cabin Service.*** Obviously the serving of hot drinks and meals during turbulent conditions puts both cabin crew and passengers at risk.

OTHER REFERENCE INFORMATION: Other related information on the above can be found in:

1. Aviation Weather Handbook, FAA-H-8083-28, Federal Aviation Administration, 25 Nov. 2022.
2. FAA AC 00-30C: Clear Air Turbulence Avoidance, March 2016 (AC has been cancelled but is still valuable resource).
3. Incidents in Air Transport No 5 - Wind Gradients and Turbulence, Bureau d'Enquêtes et d'Analyses (BEA), Dec 2006.
4. Preventing Turbulence-Related Injuries in Air Carrier Operations Conducted Under Title 14 Code of Federal Regulations Part 121, NTSB (USA), August 2021
5. JTSB Digests: Digest of Aircraft Accident Analyses For Prevention of Accidents due to the Shaking of the Aircraft, JTSB (Japan), January 2015
6. "Turbulence and Icing," International Civil Aviation Organisation, Jose Manuel Galvez, 9 Jan. 2023.
7. "Managing Severe Turbulence," Airbus safety magazine Safety First, Nov., 2019
8. FAA AC 120-88A: Preventing Injuries Caused by Turbulence, November 2007.
9. Skybrary article on Turbulence: https://skybrary.aero/index.php/Turbulence.