Australian Government
Australian Transport Safety Bureau

Publication Date: June 2010 ISBN 978-1-74251-072-9

ATSB TRANSPORT SAFETY REPORT
Aviation Occurrence Investigation AO-2009-029
Final

Turbulence event, VH-QPI 58km N of Kota Kinabalu, Malaysia 22 June 2009

Australian Transport Safety Bureau
PO Box 967, Civic Square ACT 2608
Australia

1800 020 616

+61 2 6257 4150 from overseas

www.atsb.gov.au

Jun10/ATSB103

Released in accordance with section 25 of the *Transport Safety*

Abstract

In the early hours of 22 June 2009, an Airbus Industrie A330 (A330), registered VH-QPI (QPI), encountered an area of severe turbulence associated with convective activity while en route from Hong Kong to Perth, Western Australia. As a result of the incident, a combined total of seven passengers and crew members received minor injuries. After consultation with medical and operational personnel, the pilot in command continued the flight to Perth. The aircraft suffered minor internal damage and, after a maintenance check, was returned to service.

The cloud associated with the convective activity consisted of ice crystals; a form of water that has minimal detectability by aircraft weather radar. Consequently, the convective activity itself was not detectable by QPI's radar. As the event occurred at night with no moon, there was little opportunity for the crew to see the weather.

The operator intends to upgrade the weather radar fitted to its A330 fleet, which will increase the fleet's capability to detect convective turbulence. Two other minor safety issues were identified during the investigation relating to the risks associated with the use of the pilot flight library when turbulent conditions are encountered, and the engagement of the manual latch to the cockpit door preventing timely access to the flight deck by other operational staff. The operator has taken, or is proposing, relevant safety action to address those issues.

FACTUAL INFORMATION

Sequence of events

At 0012[1] on 22 June 2009, an Airbus Industrie A330-300, registered VH-QPI, with

Figure 1: Malaysian Borneo with inbound track to Kota Kinabalu in red.

1 The 24-hour clock is used in this report to describe the local time of day, Western Standard Time (WST), as particular events occurred. Western Standard Time was Coordinated Universal Time (UTC) + 8 hours. The flight also included transit through the Hong Kong Time, and Malaysian Standard Time zones, both of which were also UTC + 8 hours.

206 passengers and 13 crew, departed Hong Kong on a scheduled flight to Perth, Western Australia. Two hours and 10 minutes after takeoff, while tracking towards Kota Kinabalu at flight level (FL)[2] 380, the aircraft encountered an area of severe turbulence (Figure 1).

There were minor injuries to six passengers and one crewmember. After consideration of opportunistic medical advice on board the aircraft, and consultation with Medlink[3] and the operator's dispatch support, the pilot in command (PIC) continued the flight, landing in Perth at 0746.

The injured were treated at a Perth hospital on 22 June 2009 before being discharged later that day. The injuries were confined to passengers and crew who were not seated at the time of the incident.

The aircraft sustained minor internal damage.

Pilot information

At the time of the occurrence, the PIC was occupying the left seat and was acting as the 'support pilot'. The right seat was occupied by the Second Officer copilot, who was the 'pilot flying'. The First Officer was on a rostered break in the crew rest area.

The PIC was qualified for the flight and at the time of the occurrence, had logged 14,488 hours total flying experience, of which 5,561 hours were in command.

The Second Officer was endorsed to fly the A330 as copilot and at the time of the occurrence, had logged 4,916 hours total flying experience and 1,041 hours on the A330.

There was no evidence that fatigue or other physiological issues affected the pilots' performance during the incident flight.

Operational information

The aircraft operator and the radar manufacturer provided comprehensive guidance to the flight crew (crew) on the operation of the aircraft's radar. That guidance also included detailed discussion on the limitations of weather-detecting radar in relation to certain types of weather, as well as techniques to maximise detection opportunities against all forms of convective turbulence. The crew were conversant with those limitations and techniques, and reported operating the radar in accordance with the manufacturer's and company's procedures. The company also provided a comprehensive policy relating to the use of seat belts by passengers and crew, and procedures to be followed when turbulence is anticipated or unexpectedly encountered.

There was no evidence that the crew was not maintaining a visual lookout leading up to the occurrence. The aircraft operator's Flight Crew Training Manual included a requirement that the flight crew were to ensure that '...one head [is] up at all times'. That was, at least one crewmember was to maintain a visual lookout at all times.

Aircraft information

Radar installation - general

The aircraft was fitted with a hybrid weather radar, comprising:[4]

- a Rockwell Collins (RC) Multiscan™ [5] WRT-2100 weather radar transceiver (2100), operating as a manual radar only
- other MultiScan-capable units, such as the antenna and antenna mount
- a non-MultiScan-capable control panel.

At the time of the incident, the most recent software release for the 2100 was SB No.3.

In comparison with earlier weather radars, the 2100 included a number of enhancements that

2 Flight Level (FL). A level of constant atmospheric pressure related to a datum of 1013.25 hPa, expressed in hundreds of feet. Therefore, FL380 indicates 38,000 ft above mean sea level (AMSL).

3 Medlink was a commercial, all-hours medical advisory service that was contracted by the aircraft operator to provide immediate, on-request medical advice to a pilot in command via radio or satellite phone.

4 The radar used extensive computing algorithms, as modified by a number of software upgrades that were identified by the Service Bulletin number. Rockwell Collins designators for particular equipment and software releases are used in this report for simplicity. The equivalent equipment, software and upgrades as fitted to Airbus Industrie aircraft used different designators.

5 MultiScan™ is a trademark of Rockwell Collins Inc. All future references in this report relating to this radar type and associated methods of operation will use the term MultiScan.

greatly improved the detection, and therefore avoidance, of convective turbulence. Those enhancements included an automatic scanning (MultiScan) mode and computer processing algorithms. However, the aircraft's radar had many of these features disabled through the:

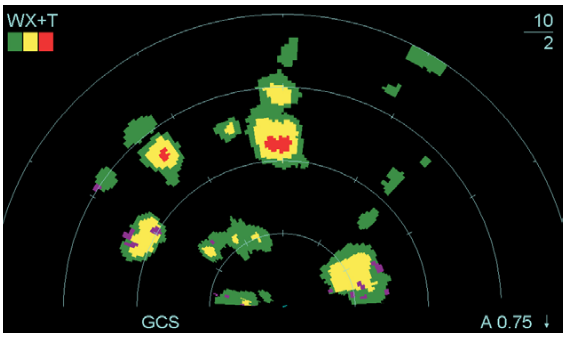
- fitment of a control unit that did not allow for the selection of MultiScan mode (as a result, the antenna tilt required manual control by the crew)
- disabling of the algorithms associated with the MultiScan function
- reversion by the operator to SB No.2, which removed other algorithms that sought to improve the detection of convective turbulence.

The operator reported that the action to revert to SB No.2 was taken due to issues with the weather detection algorithms contained within SB No.3. SB No.4, which addressed the operator's issues with SB No.3 and also provided further enhancements, was being assessed by the operator and the aircraft manufacturer at the time of the incident.

Radar installation – capability and display

Any detected weather was displayed to the crew according to a colour-calibrated scale that corresponded to the amount of water in the atmosphere (water in the atmosphere acts to reflect radar signals—see *Airborne weather radar principles* discussion later in this report). On the 2100, black indicated a minimal return and therefore minimal rainfall; green corresponded with light precipitation; yellow indicated moderate rainfall; and red indicated heavy rainfall (Figure 2).

Figure 2: Example of a radar display indicating various levels of signal return.



Provided a turbulence detection mode was selected by the crew, the radar was also capable of detecting and displaying turbulent weather returns on all range scales, out to a maximum range of 40 NM (74 km), through the utilization of the Doppler Shift Effect[6] on the received signal. Turbulence was displayed as magenta on the radar display. The magenta display indicated areas where there was the greatest variation in the velocity of the detected water molecules, provided the velocity was above a preset minimum speed. The turbulence detection function and the display of returns indicating turbulence was not dependent on the amount of the return signal.

Radar performance during the flight

The crew stated that the aircraft's radar did not detect any cloud or turbulence before encountering the area of severe turbulence. The crew also reported that the radar system operated normally throughout the flight, with normal returns from known targets.

A post-flight maintenance check determined that the radar was serviceable. There was no history of unserviceability with the aircraft's weather radar.

Meteorological information

Forecast conditions

The crew received a meteorological briefing package during pre-flight briefing at Hong Kong. The briefing package included:

- A company-derived extract of meteorological watch office warnings that identified potentially significant hazardous en route weather phenomena (SIGMET information) relevant to the flight. This extract did not contain any warnings with respect to the Kota Kinabalu region.
- A SIGMET summary that was collated by the Hong Kong Meteorological Office. That summary included a SIGMET for the Kota Kinabalu region, which advised that an area of embedded cumulonimbus cloud and thunderstorms (CB/TS) was observed in that region over an area that included the aircraft's proposed track. The SIGMET expired

6 The increase or decrease in frequency of the transmitted radar signal sensed by the receiver as a result of the difference in relative speed between the aircraft and the water droplet. A practical example is the apparent change in pitch of an automobile as it passes a stationary observer at high speed.

1 hour before the aircraft was planned to arrive at the affected area.

- Two charts that were valid for 0200 and 0800 on the day of the occurrence, mapped SIGMET areas in the Asian and Australian regions. Those charts indicated that the Kota Kinabalu region was clear of any potentially hazardous weather at the time the aircraft passed through that region.

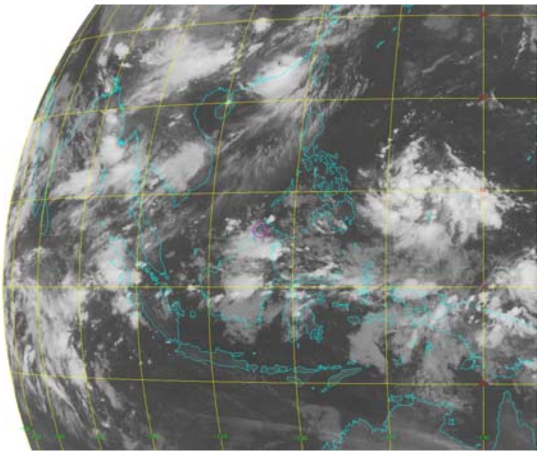
The crew stated that they were aware of the content of the warning contained within the Hong Kong Meteorological Office summary concerning the Kota Kinabalu region.

In-flight conditions

Geoscience Australia astronomical information[7] showed that the moon was not due to rise in the Kota Kinabalu area until about 3 hours after the aircraft had transited the region. As a result, the pilots' forward visibility would have been very limited.

Infrared satellite photography from 0030 to 0230 on 22 June 2009 showed the presence of convective activity covering the majority of the north-eastern part of the island of Borneo, including the approaches to Kota Kinabalu (Figure 3).

Figure 3: Infra-red satellite image at 0230 of the South-east Asia region.[8]



The pilots stated that, approaching the coast of Borneo, the aircraft was in clear air with no indication of cloud either visually or on the weather radar. The lights of Kota Kinabalu and other coastal cities in the region were visible below the aircraft as it approached the coast of Borneo.

The crew reported that the severe turbulence began as the aircraft entered cloud. They believed that the cloud was probably composed of ice crystals, due to the noise of particles impacting the aircraft, the outside air temperature of -50 °C, and the high reflectivity of the aircraft strobe lights from the cloud.

Recorded information

An examination of the data from the aircraft's flight data recorder showed significant disturbance in a number of the atmospheric conditions affecting the flight during the severe turbulence event. The disturbance lasted for about 20 seconds, and included variations in the:

- wind speed – reducing from a stable 20 kts to 5 kts before increasing to 38 kts and again stabilising
- wind direction – changing up to 75° either side of 125° true
- temperature – varying from a stable -51 °C before the turbulence event, rising to -46 °C before dropping and stabilising at -52 °C at the completion of the event.

During that time, the aircraft experienced a vertical acceleration of between minus 0.48 and plus 1.59g.[9] There was an almost instantaneous change in wind direction of about 150° at the point of maximum negative g. The variations in g over a short period of time indicated that the aircraft encountered severe turbulence.[10]

Additional information

Airborne weather radar - principles of operation

Turbulence can be a result of strong convective activity, such as in cumuliform cloud, but can also result from windshear or clear air turbulence. Airborne weather radar relies on the detection of water droplets in cloud to identify any weather

7 Available at http://www.ga.gov.au/geodesy/astro/

8 Courtesy of the Bureau of Meteorology.

9 1g equates to the Earth's normal gravitational force.

10 The Aeronautical Information Publication Part 1 General (AIP GEN) 3.4 page 107 defined certain conditions that were considered to be severe turbulence. Included within that definition were 'changes in accelerometer readings greater than 1.0 g at the aircraft's centre of gravity'.

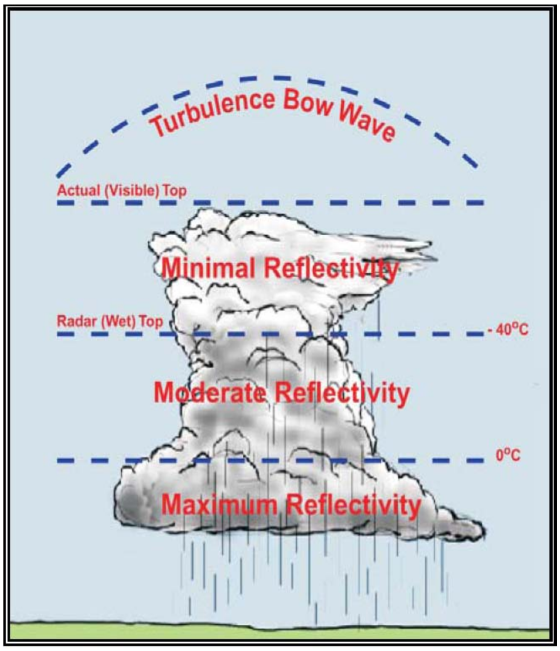
that should be avoided. In the absence of water droplets, turbulent air cannot be detected by radar.

In the case of a cumuliform cloud, with its potentially extensive turbulence as a result of associated up and downdrafts, water droplets can be in different states, sizes and amounts depending on their location in the cloud (Figure 4). In that context, the radar reflectivity of cumuliform cloud is:

- greatest in the lower portion, where there is a significant proportion of moisture in the liquid state
- moderate in the middle section, between the freezing level and around -40 °C, where water exists as either supercooled droplets[11] or ice crystals — the presence of ice crystals reducing the radar reflectivity
- minimal in the top layer, above the height consistent with a temperature of -40 °C, where water exists entirely as ice crystals.

Jet transport aircraft normally operate at altitudes associated with temperatures below -40 °C.

Figure 4: Thunderstorm Reflectivity Levels.[12]



During flight in aircraft fitted with manual tilt control radars, pilots tilt their aircraft's weather radar up and down as required to scan for any cloud and associated weather ahead of their aircraft.

The latest generation of weather radars includes computing algorithms and the automatic operation of antenna tilt and sweep (referred to as MultiScan) to optimise the detection of weather. As such, the need for pilots to manipulate the radar's tilt is minimised, and the pilot's task of weather detection and avoidance is enhanced and simplified.

In-cockpit effects of the turbulence

At the time of the occurrence, the PIC was returning a publication to the flight library.[13] Accessing the flight library required the PIC to move his seat to the fully aft position. It was reported that the turbulence caused the contents of the flight library to be deposited onto the PIC's lap and that, in combination with the position of the PIC's seat, initially restricted the PIC's access to the flight controls during the incident.

Electronic flight bags (EFB) are electronic devices that replace paper-based reference books, aeronautical charts and other publications required by crew. Various types of EFB are certified for use on commercial jet aircraft including, in the Airbus Industrie A340, a laptop-based software tool (see interim factual report AO-2009-012, available at www.atsb.gov.au).

The turbulence also caused the cockpit door manual latch to engage, preventing access to the cockpit by the resting crew immediately after the occurrence. To enable access to the flight deck, one of the flight crew was required to vacate their seat and reset the manual lock. The aircraft operator advised that, as part of the pre-flight procedure, the crew was to ensure that the latch was disengaged and stowed. However, the operator determined that it was possible to disengage the latch and leave it in a position that, without careful examination, appeared to be but

11 Vapour and finely dispersed water droplets that exist at below 0 °C and freeze immediately on contact with a solid object.

12 Courtesy of Rockwell Collins.

13 A storage case that was secured on the outboard bulkhead aft of each pilot's seat, and contained a number of publications for in-flight use by the flight crew. The flight bag had no lid. The documents within the library were secured by two straps that crossed over the top of the case and that were, in turn, attached by Velcro to each other.

was not in the stowed position. From this position it was possible for the latch to engage in turbulent conditions. The aircraft flight documentation did not include advice concerning this possibility. The operator's maintenance personnel advised that, when aircraft of this type entered the hangar for maintenance work, the latch had been observed to be incorrectly stowed on a number of occasions.

ANALYSIS

The rapid changes in wind speed and direction during the recorded disturbance were consistent with the aircraft encountering severe turbulence. The variation in the air temperature at that time was consistent with the pilot reports that the aircraft entered cloud. The pilot reports of the noise of particles striking the aircraft was consistent with the cloud comprising ice crystals, and was supported by the recorded data, which shows that the air temperature was between minus 46 °C and minus 52 °C, temperatures at which water can only exist in ice form.

The inability of the crew to detect the area of convective turbulence either visually or by radar precluded any opportunity for them to avoid the area, or at least to seat the passengers and crew and select the seat belt sign ON prior to the onset of the turbulence. The PIC made the observation that the passengers and crew that had been injured were not seated with their seat belt on.

The report by the crew that the radar did not detect any reflectivity in the cloud prior to the occurrence would suggest that the cloud did not extend into the lower levels where radar was able to detect the cloud at range. This is supported by the pilot in command's statement that, shortly before the occurrence, the lights of the coastal cities were visible below the aircraft.

Recent advancements in airborne radar technology will probably significantly improve the timely detection of convective turbulence for regular public transport aircraft. It could not be determined whether a fully capable 2100 type radar, fitted with the latest software release, would have detected the area of convective turbulence encountered in this incident.

As evidenced in this incident, the use and storage of the pilot's flight library has the potential to increase risk during a turbulence event. That risk may be reduced through the use of electronic flight bags.

Similarly, the inadvertent engagement of the manual cockpit door latch restricted access to the cockpit. Although relatively benign in this instance, had one or both crew been injured as a result of the incident, or required assistance to recover the aircraft, the outcome could have been different.

FINDINGS

From the evidence available, the following findings are made with respect to the turbulence event that occurred 58 km north of Kota Kinabalu, Malaysia on 22 June 2009 involving Airbus Industrie A330-300 aircraft, registered VH-QPI, and should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- The crew did not detect an area of convective turbulence (cloud), either visually or by radar.
- The aircraft penetrated an area of severe convective turbulence.
- The area of convective turbulence encountered by the aircraft comprised ice crystals.
- The aircraft radar had limited capability to detect cloud that comprised ice crystals. *[Minor safety issue]*

Other safety factors

- The pilot's flight library represents a potential hazard on the flight deck when left open and turbulent conditions are encountered. *[Minor safety issue]*.
- A crewmember did not ensure that the cockpit door manual latch was correctly stowed. Subsequently, the turbulence event caused the latch to engage, preventing access to the cockpit.
- There was no documentation to alert flight crews of the potential for the cockpit door manual latch to engage if not stowed correctly. *[Minor safety issue]*

SAFETY ACTION

The safety issues identified during this investigation are listed in the Findings and Safety

Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

Aircraft operator

Aircraft radar capability

Safety Issue

The aircraft radar had limited capability to detect cloud that comprised ice crystals.

Action taken by the aircraft operator

The aircraft manufacturer has certified the equivalent of Rockwell Collins SB No.4 for use on Airbus Industrie A330 type aircraft. The aircraft operator is modifying all company aircraft radars of this type to be capable of operating in the full MultiScan mode as well as incorporating SB No.4.

ATSB assessment of response/action

The ATSB is satisfied that the action taken by the aircraft operator adequately addresses the safety issue.

Replacement of flight library with Electronic Flight Bag

Safety Issue

The pilot's flight library represents a potential hazard on the flight deck when left open and turbulent conditions are encountered.

Action taken by the aircraft operator

The aircraft operator advised that the first electronic flight bag (EFB) would be installed on each A330 by May 2010 and the second in July 2010. Once fitted, the crew will be restricted from using the EFB unless all crew members on board for a flight have been trained in its use. All A330 flight crew are undergoing training in the use of the EFB. The operator has not committed to removing any manuals from the flight deck, but will be attempting to do so over the next few months.

ATSB assessment of response/action

The ATSB is satisfied that the action taken by the aircraft operator adequately addresses the safety issue.

Cockpit door manual latch

Safety Issue

There was no documentation to alert flight crews of the potential for the cockpit door manual latch to engage if not stowed correctly

Action taken by the aircraft operator

The operator has issued a Flight Standing Order advising all A330 flight crew of new procedures to ensure the correct stowage of the cockpit door back-up locking mechanism. The operator will amend the appropriate operating manuals to reflect the new procedural requirement during the next amendment cycle.

ATSB assessment of response/action

The ATSB is satisfied that the action taken by the aircraft operator adequately addresses the safety issue.

SOURCES AND SUBMISSIONS

Sources of Information

The sources of information during the investigation included:

- the flight crew
- the aircraft operator
- the aircraft manufacturer
- the manufacturer of the aircraft’s weather radar
- the Bureau of Meteorology
- Geoscience Australia.

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003*, the Australian Transport Safety Bureau (ATSB) may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the flight crew, the aircraft operator, the aircraft and weather radar manufacturers, the US National Transportation Safety Board, the French Bureau d'Enquêtes et d'Analyses, and the Civil Aviation Safety Authority.

Submissions were received from the aircraft operator, the aircraft and weather radar manufacturers and the French Bureau d'Enquêtes et d'Analyses. The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.