民 航 意 外 調 查 機 構

AAIA

Air Accident Investigation Authority

Turbulence Encounter

Investigation Report

Accident to Airbus A330-243, B-LHA
Nansha District, Guangzhou City,
Guangdong Province, China
18 June 2019

01-2023

AAIA Investigations

Pursuant to Annex 13 to the Convention on International Civil Aviation and the Hong Kong Civil Aviation (Investigation of Accidents) Regulations (Cap. 448B), the sole objective of the investigation and the Investigation Report is the prevention of accidents and incidents. It is not the purpose of the investigation to apportion blame or liability.

The Chief Inspector ordered an inspector's investigation into the accident in accordance with the provisions in Cap. 448B.

This accident Investigation Report contains information of an occurrence involving an Airbus A330 aircraft, registration B-LHA, operated by Hong Kong Airlines Limited (HKA), which occurred on 18 June 2019.

The Bureau d'enquêtes et d'analyses pour la sécurité de l'aviation civile (BEA), being the investigation authority of the State of Design and the State of Manufacture, Civil Aviation Department (CAD), Airbus, and the aircraft operator, provided assistance to the investigation.

Unless otherwise indicated, recommendations in this report are addressed to the regulatory authorities of the State or Administration having responsibility for the matters with which the recommendation is concerned. It is for those authorities to decide what action is taken.

This Investigation Report supersedes all previous Preliminary Report and Interim Statements concerning this accident investigation.

All times in this Report are in Coordinated Universal Time (UTC). Hong Kong Local Time is UTC + 8 hours and is shown in parenthesis where appropriate.

Chief Accident and Safety Investigator

Air Accident Investigation Authority

Transport and Logistics Bureau

Hong Kong

January 2023

Synopsis

On 18 June 2019 at 0418 (1218), a HKA Airbus A330, registration B-LHA, enroute from Beijing to Hong Kong encountered turbulence.

The aircraft was experiencing moderate turbulence during the cruise. Thirty minutes before the estimated time of arrival (ETA) and prior to descent, the Captain informed the cabin crew manager that the weather in Hong Kong was bad and to prepare the cabin for an early arrival.

During the cabin crew pre-landing checks, while the seat belt sign was on, the aircraft encountered moderate to severe turbulence and the Captain made a public announcement ‘Cabin crew please take your seats’.

During the turbulence encounter, one of the cabin crew sustained a right foot injury. The aircraft landed at Hong Kong International Airport (HKIA). The injured cabin crew was immediately sent to the airport clinic for medical treatment before she was conveyed to North Lantau Hospital. She was later transferred to Prince Margaret Hospital. The diagnosis of the injury was “acute traumatic fracture of the right foot – metatarsal bones”.

The investigation team has made one safety recommendation.

Contents

1. Factual Information

1.1. History of the Flight

(1) On 18 June 2019 at 0418 (1218), a HKA Airbus A330, registration B-LHA, enroute from Beijing to Hong Kong encountered turbulence.

(2) The aircraft had been avoiding weather and occasionally experiencing moderate turbulence. Thirty minutes prior to the estimated time of arrival (ETA), the Captain informed the cabin crew manager that the weather in Hong Kong was bad and to prepare the cabin for an early arrival.

(3) During the cabin crew pre-landing checks, while the seat belt sign was on, the aircraft encountered an area of severe turbulence and the Captain made a public announcement 'Cabin crew please take your seats'.

(4) During the turbulence encounter, one of the cabin crew sustained a right foot injury.

(5) After the aircraft landed at HKIA, the injured cabin crew was immediately sent to airport clinic for medical treatment before she was conveyed to North Lantau Hospital. She was later transferred to Prince Margaret Hospital.

1.2. Injuries to Persons

(1) There were two pilots, nine cabin crew and 230 passengers on board the aircraft.

Injuries to Persons						
Persons on board:	Crew	11	Passengers	230	Others	0
Injuries	Crew	1	Passengers	0		

Table 1: Injuries to Persons

(2) One cabin crew sustained right foot injury in the turbulence. The diagnosis of the injury was "acute traumatic fracture of the right foot – metatarsal bones". Pursuant to Regulation 2, Hong Kong Civil Aviation (Investigation of Accidents) Regulations (Cap. 448B), "Serious Injury" means an injury which is sustained by person in an accident and which….. (b) results in a fracture of any bone (except simple fractures of fingers, toes or nose).

1.3. Damage - Aircraft

There was no damage to the aircraft.

1.4. Other Damages

There was no damage to other object.

1.5. Occurrence Details

The occurrence details are in Section 6.1.

1.6. Personnel Information

(1) The Captain, the pilot-in-command (Pilot), was the “pilot monitoring” in the left-hand seat. The First Officer (FO) was the “pilot flying” in the right-hand seat.[1]

(2) The crew information is in Section 6.2.

1.7. Aircraft Information

1.7.1. Aircraft

(1) The aircraft was an Airbus A330 equipped with Rolls-Royce Trent 700 engines. The aircraft was equipped with the Electronic Flight Instrumentation System (EFIS) including the flight and navigation displays and the Electronic Centralised Aircraft Monitor (ECAM). The ECAM monitors and displays engine and aircraft system information to the pilots.

(2) The aircraft was registered in Hong Kong and held a valid Certificate of Airworthiness. Further details of the aircraft are in Section 6.3.

(3) The aircraft was equipped with a Honeywell RDR-4B weather radar transceiver produced by Honeywell International Inc..

[1] PILOT FLYING (PF) AND PILOT MONITORING (PM) are procedurally assigned roles with specifically assigned duties at specific stages of a flight. The PF does most of the flying, except in defined circumstances. The PM carries out support duties and monitors the PF’s actions and the aircraft’s flight path.

1.7.2. Maintenance History

(1) The last A Check of the aircraft was accomplished on 19 Mar 2019.

(2) The last C Check was accomplished on 05 Feb 2018 before the transfer of the aircraft to HKA.

(3) The Post Flight Report did not record any system failure relevant to the turbulence event.

1.7.3. Weather Radar System

(1) The aircraft was equipped with an X-band dual Weather Radar System with predictive windshear system. The Weather Radar System is mainly used to detect and localize various types of atmospheric disturbances and windshear events in the area scanned by the antenna. The system shows the disturbance intensity through the use of colors which vary with the atmospheric precipitation rate.

(2) The weather radar image is shown on the Pilot and FO Navigation Display (ND) with different colors:

(a) black, green, yellow, red to quantify the precipitation rates

(b) magenta to represent the turbulence areas up to 40 Nautical Mile (NM)

(3) The Weather Radar System enables the following:

(a) detection and localization of the atmospheric disturbances in the area defined by the antenna scanning: plus or minus 90 degrees of aircraft centerline and up to 320NM in front of the aircraft.

(b) detection of turbulence areas caused by the presence of precipitations up to a distance of 40NM.

(c) presentation of terrain mapping information by the combination of the orientation of the radar beam and of the receiver gain.

(d) detection and warning of microburst windshear areas defined by the antenna scanning: plus or minus 45 degrees of aircraft centerline and up to a distance of 5NM.

(4) The A33O Weather Radar consists of the following major components:

(a) In the Cockpit

A – EFIS Switching Panel
B – Flight Control Unit - Electronic Flight Instrument System (FCU-EFIS) Control Panel
C - Switching Control Panel
D - Navigation Display
E - Weather Radar Control Unit

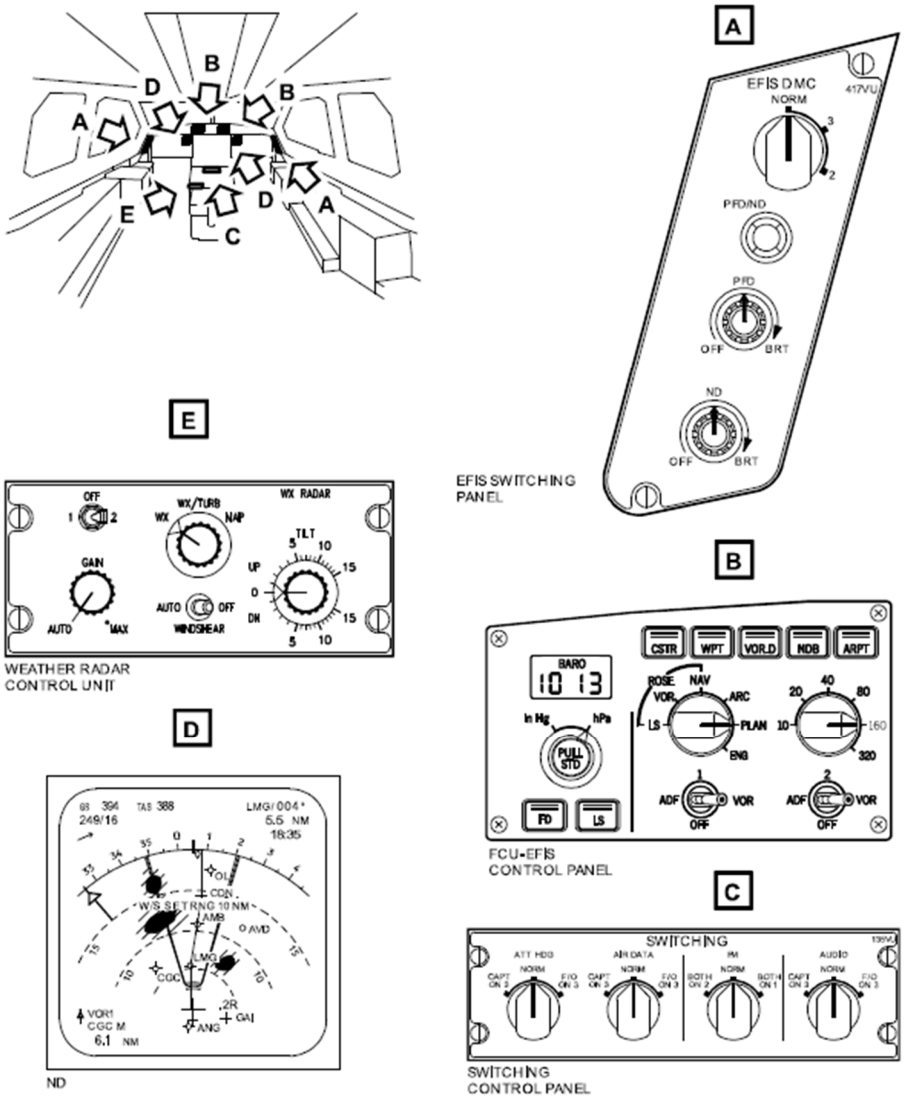

Figure 1: Weather Radar System Major Components in the Cockpit

(b) In the Nose Section

(i) Weather Radar Transceiver (2ea)

(ii) Weather Radar Antenna Drive

(iii) Weather Radar Antenna

(iv) Wave Guide Assembly

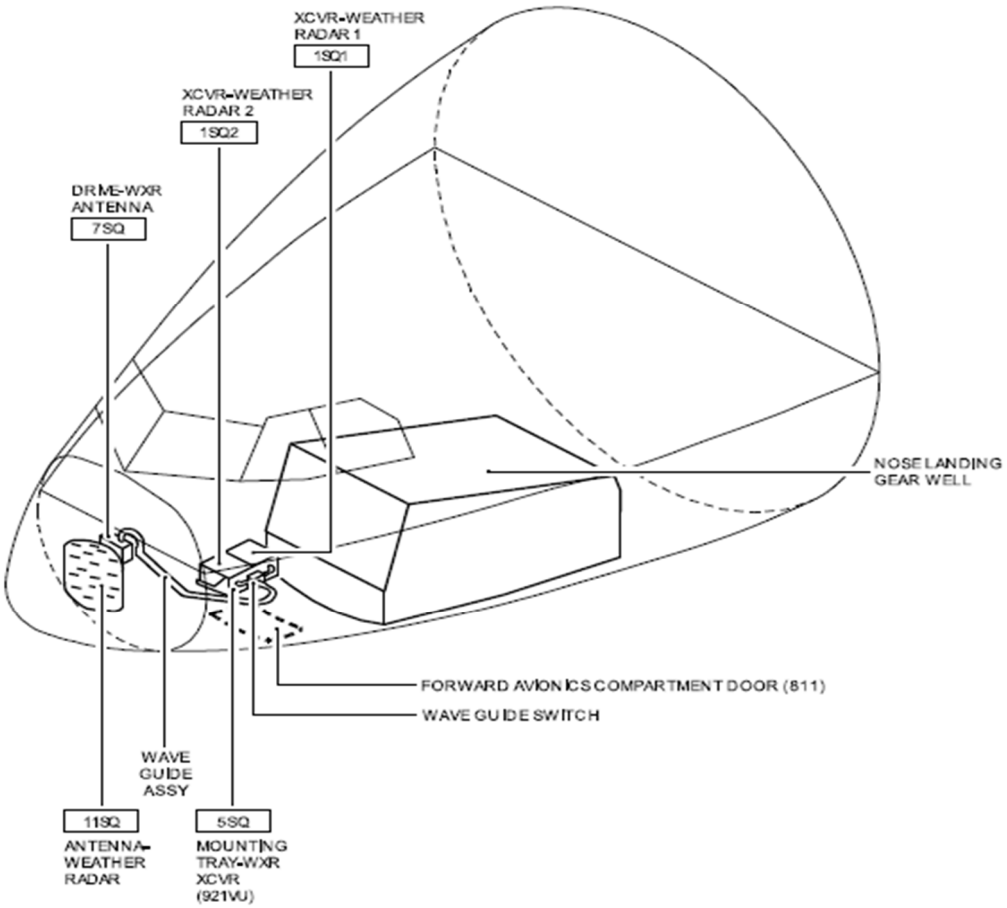

Figure 2: Weather Radar System Major Components in the Nose Section

1.8. Meteorological Factors

1.8.1. Weather Reports

(1) The aerodrome weather report for VHHH[2] at 0400 (1200) indicated that the wind was from 140 degrees at 11 knots gusting 24 knots (kt). The visibility was in excess of 10 kilometres (km). There was some cloud at 1500 feet (ft) and scattered cloud at 2500 ft. The temperature was 32 degrees Celcius (°C) with a dewpoint of 26°C. Temporarily 4000 metres (m) visibility in showers of rain was forecasted.

METAR/SPECI from VHHH, Hong Kong international airport (Hong Kong)
METAR VHHH 180430Z 15012KT 9999 TS FEW012 FEW015CB SCT025 32/26 Q1008 TEMPO 3000 -TSRA SHRA FEW012CB SCT022=
SPECI VHHH 180423Z 15011KT 120V180 9999 VCTS FEW012 FEW015CB SCT025 31/26 Q1008 TEMPO 3000 -TSRA SHRA FEW012CB SCT022=
METAR VHHH 180400Z 14011G24KT 110V180 9999 FEW015 SCT025 32/26 Q1008 TEMPO 4000 SHRA=

Figure 3: METAR/SPECI[3] around time of event

(2) SPECI published at 0423 (1223) after the event indicates:

(a) Wind direction 150 degrees (true) varying from 120 to 180 degrees

(b) Wind speed at 11 kt

(c) Visibility 10km or more

(d) Thunderstorms in the vicinity

(e) Base of few cloud layers at 1200 ft and 1500 ft (cumulonimbus) and scattered clouds at 2500 ft

(f) Temperature 31°C with dewpoint of 26°C

(g) QNH 1008 hectopascals (hPA)

(h) TEMPO[4]

(i) Visibility 3000 meters

(j) Thunderstorms with light rain

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[2] International Civil Aviation Organisation code for Hong Kong International Airport.

[3] METAR is a routine weather report issued at hourly or half-hourly intervals. It is a description of the meteorological elements observed at an airport at a specific time. Encompasses the area within an 8 km radius from the aerodrome reference point. SPECI is a special weather report issued when there is significant deterioration or improvement in airport weather conditions, such as significant changes of surface winds, visibility, cloud base height and occurrence of severe weather.

[4] TEMPO Temporary fluctuation in some of the elements lasting for periods of 30 minutes or more but not longer than one hour.

(k) Moderate rain showers

(l) Base of few cumulonimbus at 1200 ft

(m) Scattered clouds at 2200 ft

(3) Figure 4 is a section of the Significant Weather Forecast chart provided to the crew pre-departure. The 'call-out' box, outlined in red, specifying ISOL EMBD CB 480 XXX, points to the relevant area of black 'scalloped' lines. The delineated area indicates that isolated cumulonimbus (CB) cloud embedded within other types of cloud layers, and not readily apparent to flight crew, could be expected in less than 50% of that area up to FL480.

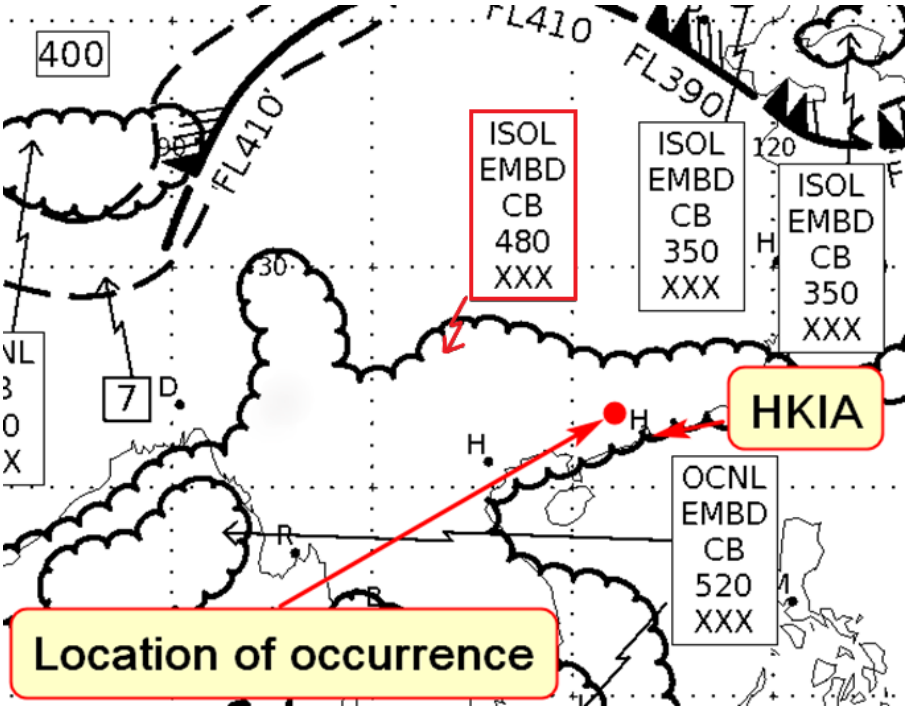


Figure 4: Weather Forecast at the Location of Occurrence

1.8.2. Internal Reports of the Operator

(1) The following is a quote of the Air Safety Report:

"About 30 NM before SIERA encountered moderate to severe turbulence. Immediately turn away from weather cell and PA crew to be seated. Before get close to weather seat belt light is already on and advice crew weather is not good in HKG[5] request prepare for landing earlier. Weather shows green on ND somehow turbulence scale is more than we expected. Cause cabin crew twist her ankle and back injury."

[5] International Air Transport Association code for Hong Kong

(2) The following is a quote of the Manage eReport – CSR529-19:

"(From light to moderate turbulence) It was in light turbulence before decent. 30 min (UTC04:15) prior ETA(UTC04:45) Captain called COC[6] *said that HKG weather was bad. Let's get preparing cabin for landing early. CIC agreed. Then he made landing PA. CIC did PA right aft Captain's. Meanwhile, it was sudden bumps and Captain PA, 'Cabin Crew, pls take your seats". We heats*[7] *that and sat down and fasten our seat belt……..."*

1.8.3. Information Provided by Injured Cabin Crew

(1) According to the information provided by the injured cabin crew in the interview by AAIA, at about 0400 (1200), the Fasten Seatbelt sign was 'ON' due to turbulence. The aircraft encountered turbulence when she was preparing water at the aft galley for serving a passenger on seat 62D. The turbulence was severe enough to get her feet off the floor. She could not find anything to grip on but the 1-to-2cm protruding edge of the countertop. She could only squatted down and tried to secure herself in the squat position. The turbulence persisted as she was trying to return to L4A crew seat. At that point, the captain made a Passenger Address (PA) announcement "Cabin crew, please be seated". Another turbulence threw her off the floor. She felt pain in her back and right ankle after landing back on the floor. She had to crawl from the aft galley to L4A crew seat and secured herself to the seat. After landing, she received X-ray examination at the airport clinic before she was conveyed to North Lantau Hospital. She was later transferred to Prince Margaret Hospital.

(2) According to the representations made by the injured cabin crew on the draft Investigation Report, she never received any weather information for this flight. She did not receive any updated bad weather information from her colleague and she did not know that the weather would be turbulent with heavy rain.

6 According to the correction of the operator, 'COC' should be 'CIC' which is the abbreviation of 'Cabin Crew in Charge'.

7 According to the correction of the operator, 'heats' should be 'heard'.

1.9. Pre-departure Crew Briefing

(1) OM - A GEN Operating Procedures Flight Preparation 8.1.15 provides the company procedures of the operator for pre-departure crew briefing. Below is a quote of the procedures.

8.1.15 Joint Crew Briefing

Flight Crew shall provide a briefing to the Cabin Crew prior to the commencement of the flight. A typical briefing may include:

- Introduction of Flight Crew members and their duties (e.g. Commander, RSQ, F/O)[8]
- Flight time
- Flight deck security procedures (Company Standard Only)
- Sterile cockpit procedures
- Departure and Enroute weather
- Expected significant turbulence during flight (e.g. approximate time after takeoff)
- Special airport information (e.g. short taxi time)
- Handling of abnormal situation
- Cabin crew procedure for checking of flight crew well-being in-flight
- Others deemed necessary by the Commander

(2) According to the information provided by the Captain, he always told the cabin crew to be cautious about weather if the weather was not perfectly nice. He was sure that before the descent, he made PA and also called the Senior Purser (SP) that the weather would be bad during descent and asked the cabin crew to be ready early.

1.10. Navigation Aids

All navigation aids were serviceable.

[8] RSQ = Right Seat Qualified, F/O = First Officer

1.11. Communications

The aircraft was equipped with Very High Frequency (VHF) radio communication systems. All VHF radios were serviceable.

1.12. Flight Recorders

1.12.1. Flight Data Recorder

The aircraft was equipped with a 25-hour flight data recorder (FDR)[9] of P/N 2100-4045-00. The FDR was functional and recording data. The download captured all of the flight parameters required for the analysis of this occurrence.

1.12.2. Cockpit Voice Recorder

The aircraft was equipped with a 120-minute cockpit voice recorder (CVR)[10] of P/N 980-6022-001. The CVR was not downloaded as it was not anticipated at the time that this event would be classified as an accident.

1.12.2.1. Flight Data Download

(1) The data from the FDR was recovered and provided to Air Accident Investigation Authority (AAIA).

(2) As part of the customer support activity and to support the investigation, Airbus conducted an analysis on the FDR data and produced Airbus Report - Severe turbulence during descent to Hong Kong International Airport (VHF) June 18th 2019, Hong Kong Airlines (CRK), A330-243 – MSN 0396 (B-LHA). (Hereafter referred to as FDR data report.)

[9] FDR - device used to record specific aircraft performance parameters. The purpose of an FDR is to collect and record data from a variety of aircraft sensors onto a medium designed to survive an accident.

[10] CVR - a device used to record the audio environment in the flight deck for accidents and incident investigation purposes. The CVR records and stores the audio signals of the microphones and earphones of the pilots' headsets and of an area microphone installed in the cockpit.

1.13. Wind Reconstruction

(1) A specific wind reconstruction computed by Airbus to determine the influence of the wind on the aircraft behavior during the event is shown in Figure 5.

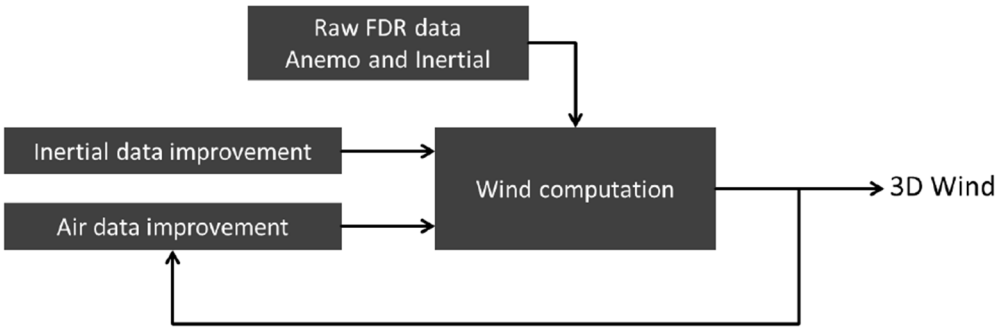


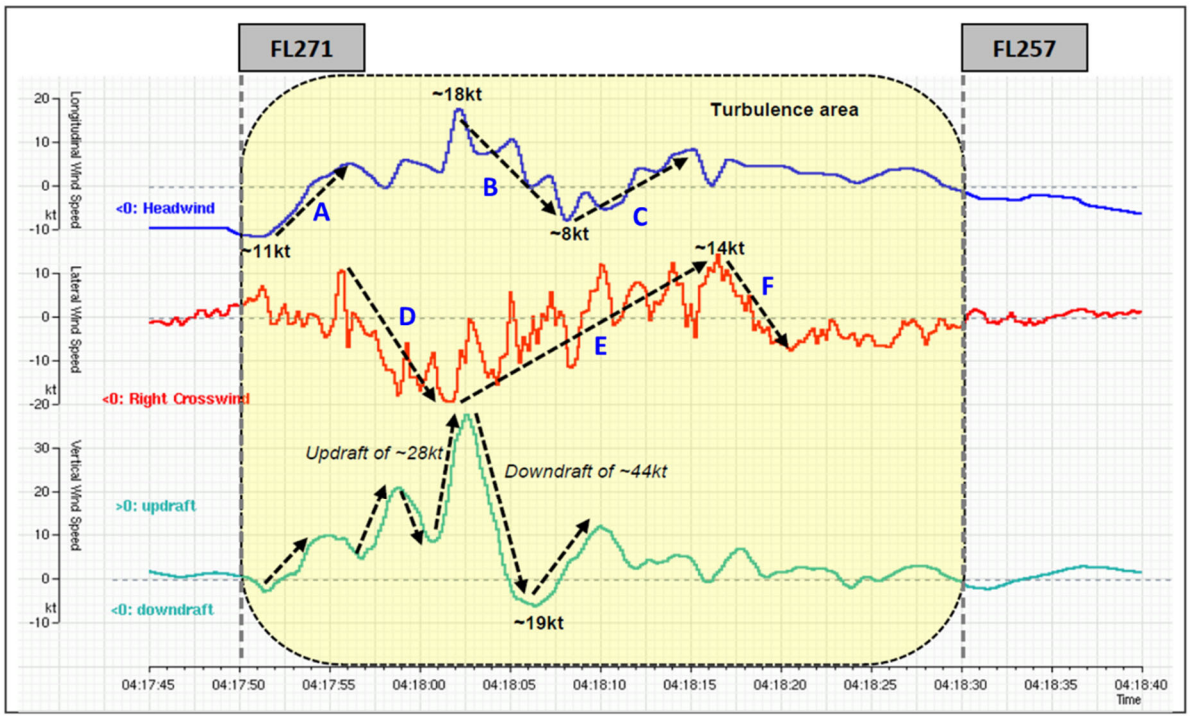
Figure 5: Wind Reconstruction

(2) Figure 6 shows the result of the wind reconstruction along the three aircraft axes. The wind reconstruction was based on:

(a) Anemometric and Inertial data from FDR

(b) Anemometric correction: estimation of sideslip

(c) Inertial bias reconstruction



(source: Flight Data Recorder)

Figure 6: Reconstructed Wind along the Aircraft Axes

1.14. Critical Parameters During Turbulence

(1) Figure 7 is an extract from the FDR data report (from 04:17:40 to 04:18:30) showing the variation on vertical wind speed, vertical load factor and angle of attack during the turbulence period from 04:17:50 to 04:18:42.

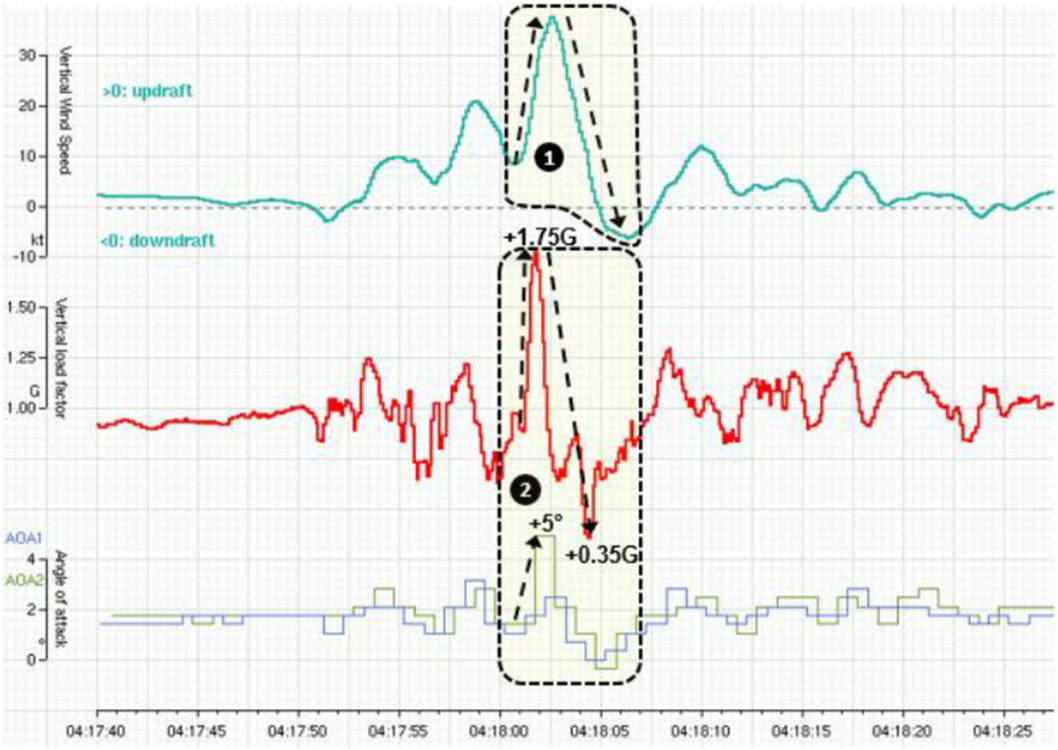


Figure 7: Variation of Vertical Wind Speed, Vertical Load Factor and Angle of Attack during Turbulence

(2) The FDR analysis established the following during the turbulence:

(a) Vertical load factor varied between +0.35G and +1.75G (maximum △VRTG[11] of +0.90G / -1.15G).

(b) Lateral load factor varied between -0.1G and +0.1G (maximum △ LATG[12] of +0.15G / -0.15G).

(c) Angle of attack varied between -0.5° and +5.0°.

[11] VRTG = Vertical Acceleration
[12] LATG = Lateral Acceleration

1.15. ICAO Specification on Turbulence

(1) International Civil Aviation Organisation (ICAO) Doc. 4444 Procedures for Air Navigation Services Air Traffic Management, Sixteen Edition 2016 provides the following specifications:

(2) Moderate — Conditions in which moderate changes in aircraft attitude and/or altitude may occur but the aircraft remains in positive control at all times. Usually, small variations in airspeed. Changes in accelerometer readings of 0.5 g to 1.0 g at the aircraft's centre of gravity. Difficulty in walking. Occupants feel strain against seat belts. Loose objects move about.

(3) Severe — Conditions in which abrupt changes in aircraft attitude and/or altitude occur; aircraft may be out of control for short periods. Usually, large variations in airspeed. Changes in accelerometer readings greater than 1.0 g at the aircraft's centre of gravity. Occupants are forced violently against seat belts. Loose objects are tossed about.

1.16. Flight Operations Procedures

1.16.1. Weather Detection

(1) A330 Flight Crew Techniques Manual (FCTM) of the operator provides procedural guidance on the use of the weather radar for weather detection in various flight phases. Of particular relevance is the guidance for level flight / cruise. See Figure 8.

WEATHER DETECTION

USE OF THE WEATHER RADAR IN ACCORDANCE WITH THE FLIGHT PHASE

Manual Tilt

[...]

Manual Weather Radars (or Automatic Weather Radars in Manual Tilt Mode)		
Flight Phase	**Tilt Control**	**Comments**
LEVEL FLIGHT/CRUISE	1. Adjust ND range as required 2. Regularly modify the tilt to scan the weather ahead of the aircraft 3. When the weather scan is completed, adjust the tilt so that the ground returns appear on the top of the ND (2)(3).	In cruise, the combination of the following ND ranges provides good weather awareness(1): - 160 NM on the PM ND - 80 NM on the PF ND. Use shorter ND ranges to track/avoid short-distance weather.
DESCENT	During descent, adjust the tilt to maintain the ground returns on the top of the ND.	-
APPROACH	Set the tilt to 4 ° up.	This tilt setting (4 ° up) prevents the display of too many ground returns.

Figure 8: Extract from FCTM AS-WXR - Weather Detection

(2) Per the FDR data report, the Navigation Display and Weather Radar status are as follows.

(a) CM1[13] ND was in ARC mode with a range at 40NM and weather radar (WXR) information displayed.

(b) CM2[14] ND was in ARC mode with a range at 80NM and weather radar (WXR) information displayed.

(c) Weather radar was in Weather and Turbulence (RADWXRTURB FDR parameter).

Note: During the previous 12 minutes before the event, CM2 ND range was changed four times (between 80NM and 160NM) and CM1 ND range was changed seven times (between 40NM and 160NM).

1.16.2. Selection of Autopilot and Autothrust

(1) A330 Flight Crew Operating Manual (FCOM) of the operator provides abnormal and emergency procedures during severe turbulence. Of particular relevance is the application of Autopilot and Autothrust. See Figure 9.

[QRH] SEVERE TURBULENCE

Ident.: PRO-ABN-MISC-10-00002018.0001001 / 17 MAR 17
Applicable to: ALL

When possible, the flight crew should plan to fly above or around areas of severe turbulence. If turbulence is unavoidable, aim to keep the speed in the region of the target speed given in this section, so as to provide the best protection against the effect of gust on the aircraft structure, whilst maintaining an adequate margin above VLS.
Sufficient buffet margin exists at optimum altitude. In order to further increase the margin to buffet onset, consider descending to a lower altitude.
Severe turbulence is defined as turbulence that causes large, abrupt changes in altitude and/or attitude. It usually causes large variations in airspeed.
Occupants are forced violently against their seat belts and loose objects will move around the aircraft.
If severe turbulence occurs during a flight, the flight crew must make a logbook entry in order to initiate maintenance action.

Note: Recommendations for severe turbulence are also applicable to extreme turbulence.

Before the aircraft enters an area where turbulence is expected:
- All loose equipment must be secured in the cockpit and in the cabin
- The flight crew must set the SEAT BELTS sw to ON.

Keep the autopilot ON.
When thrust changes are excessive : Disconnect autothrust.
For approach : Use autothrust for managed speed.

Figure 9: Extract from FCOM PRO-ABN-MISC-10 - Severe Turbulence

[13] CM1 is the designator for Pilot position
[14] CM2 is the designator for FO position

(2) Per the FDR data report, Autopilot (AP) 2 and Autothrust (A/THR) remained engaged during the turbulence period.

1.16.3. Avoidance of Turbulence

(1) A330 FCTM of the operator provides guidance on avoidance of known turbulence associated with CBs. See Figure 10.

Weather Turbulence

[...]

IN FLIGHT

USE OF THE RADAR

Areas of known turbulence, associated with CBs, must be avoided. Good management of the radar tilt is essential, in order to accurately assess and evaluate the vertical development of CBs. Usually, the gain should be left in AUTO. However, selective use of manual gain may help to assess the general weather conditions. Manual gain is particularly useful, when operating in heavy rain, if the radar picture is saturated. In this case, reduced gain will help the flight crew to identify the areas of heaviest rainfall, that are usually associated with active CB cells. After using manual gain, it should be reset to AUTO, in order to recover optimum radar sensitivity. A weak echo should not be a reason for the flight crew to underestimate a CB, because only the wet parts of the CB are detected. The decision to avoid a CB must be taken as early as possible, and lateral avoidance should, ideally, be at 20 NM upwind.

Figure 10: Extract from FCTM PR-NP-SP-10-10-3 – In Flight

(2) Per the FDR data report, at the beginning of the turbulence phase, due to wind variations, roll angle started to vary between +3.5° (right wing down) and -5.0° (left wing down). Then at 04:18:05, AP lateral mode was changed from "NAV" to "HDG" mode and the flight crew selected a heading target at 195°. As current heading was around 180°, the aircraft began to turn right towards the selected heading. Roll angle progressively increased up to +17° leading the heading to increase from 178° to 199°. At around 04:18:42, the aircraft exited the turbulence area and continued its descent uneventfully to land at HKIA.

(3) Refer to Section 1.7.3 for Weather Radar System and Navigation Display information.

1.17. Wreckage and Impact

Not applicable.

1.18. Medical/Pathological Information

Medical Report of the injured cabin crew was provided by the Hospital Authority.

1.19. Smoke, Fire, and Fumes

Not applicable.

1.20. Survival Aspects

Not applicable.

1.21. Tests and Research

Not applicable.

1.22. Organisation, Management, System Safety

1.22.1. Civil Aviation Department

Civil Aviation Department (CAD) regulates HKA as an Air Operator's Certificate (AOC) holder and a maintenance organisation based on the Air Navigation (Hong Kong) Order 1995 (Cap. 448C). CAD is the regulatory authority responsible for the registration and the safety oversight of the incident aircraft.

1.22.2. Hong Kong Airlines Limited

HKA held an AOC issued by the CAD. The operator has been using Hong Kong as the base for passenger and cargo operations since 2006. The fleet consisted of Airbus A320, A330 and A350 aircraft types for passenger operations.

1.22.3. HKA Safety Management System

HKA implements a Safety Management System (SMS) per the requirement of Article 102, Air Navigation (Hong Kong) Order (Cap. 448C) and CAD 712 Safety Management System for Air Operators, International Non-Public Transport Operators, Maintenance Organisations and Flying Training Organisations - A Guide to Implementation. The SMS manual published by the company sets out the policies and procedures of the company pertaining to safety management.

1.22.3.1. HKA SMS approach on Turbulence Event

(1) HKA SMS Manual 6.3.3 Cabin Safety Report stipulates that:

Cabin Safety reporting is accomplished by submitting a Cabin Safety Report (CSR). This may be done electronically via AQD[15]*. The CSR process is designed for use by cabin crew. Flight deck crew should use the Air Safety Report (ASR) to report all safety concerns, including cabin issues (e.g. unruly passengers, serious passenger illness, turbulence injury, cabin fires etc.).*

(2) Subsequent to the report of the turbulence event on 18 June 2019, HKA formed '2019 Turbulence Working Group' and met on 11 July 2019 to review previous occurrences, lost time through injury due to turbulence from May 2018 to May 2019 and existing procedures. The Working Group was chaired by Corporate Safety, Quality Assurance and Security Department.

(3) The Working Group conducted a workshop to discuss risk assessment and prospective improvement actions, including review of passenger injury related turbulence occurrences, pre-landing check requirements, and regulatory requirements, etc.

(4) The meeting requested participants to consider the above-mentioned actions in their respective departments.

(5) On 12 September 2019, the 2019 Turbulence Working Group held the second meeting to follow up on the outstanding items of the first meeting and to continue to explore means to enhance cabin safety and mitigate risks from turbulence events.

1.23. Additional Information

Not applicable.

1.24. Useful or Effective Investigation Techniques

Not applicable.

[15] AQD = Aviation Quality Database

2. Safety Analysis

The Safety Analysis provides a detailed discussion of the safety factors identified during the investigation, providing the evidence required to establish the findings, causes, contributing factors and the safety recommendations.

2.1. Aircraft Maintenance

The aircraft held valid Certificate of Airworthiness. The investigation team did not identify any maintenance related issue, nor inherent aircraft defect that may lead to the accident. Aircraft maintenance was not a factor.

2.2. Weather Radar System

The Post Flight Report did not record any system failure relevant to the turbulence event. The Weather Radar System functioned normally at the time of the turbulence.

2.3. Flight Crew Qualification

The flight crew members were licensed and qualified.

2.4. Crew Injury and Occurrence Classification

The injury of the cabin crew meets the interpretation of “serious injury” in Regulation 2, Cap. 448B. As the cabin crew was seriously injured, the occurrence meets the interpretation of “accident” in Regulation 2A, Cap. 448B.

2.5. Crew Weather Briefing

(1) According to OM - A GEN Operating Procedures Flight Preparation 8.1.15, pre-departure crew briefing includes departure and enroute and expected significant turbulence during the flight, etc. The Captain informed the investigation team that if the weather was not perfectly nice, he always told the cabin crew to be cautious about weather.

(2) According to the representations made by the injured cabin crew, she never received any weather information for this flight. Without evidence such as voice recording, the investigation team was unable to resolve the reason for the difference in information provided by different parties concerning the provisioning of weather information to cabin crew. The investigation team noticed that the seatbelt sign had been on before the accident.

2.6. Weather

2.6.1. Wind Reconstruction

The recomputed wind evolution in Figure 6 highlights that the aircraft experienced adverse wind conditions during descent.

2.6.1.1. Turbulence Area

Referring to Figure 6, significant wind variations are recorded in the flight raw data during the turbulence period between 04:17:50 and 04:18:42.

(1) On the longitudinal axis, 3 significant wind gradients were recorded:

(a) A tailwind gradient of 17kt (A in Figure 6)

(b) A headwind gradient of 26kt (B in Figure 6)

(c) A tailwind gradient of 16kt (C in Figure 6)

(2) On the lateral axis, 3 significant wind gradients were recorded:

(a) A right gradient of 29kt (D in Figure 6)

(b) A left gradient of 34kt (E in Figure 6)

(c) A right gradient of 21kt (F in Figure 6)

(3) On the vertical axis, the variations in vertical wind speed highlight severe turbulent weather conditions with several updraft and downdraft including an updraft of ~28kt followed by a significant downwind gradient of ~44kt in 3 seconds.

2.6.2. Turbulence Encountered by Aircraft

(1) At 04:18:01, the aircraft encountered a severe updraft of ~28kt in 2 seconds followed by a significant downwind gradient of ~44kt in 3 seconds. See Figure 6 and ❶ in Figure 7.

(2) From 04:17:50 to 04:18:42, some uncommanded variations in vertical and lateral load factors were met with a maximum delta of vertical load factor of -1.15G. See Section 1.14(2)(a).

(3) This vertical turbulence led to the vertical load factor to increase up to +1.75G before decreasing to +0.35G. See ❷ in Figure 7.

(4) The lateral load factor varied between -0.1G and +0.1G. See Section 1.14(2)(b).

(5) The angle of attack increased up to +5° before decreasing to -0.5°. See Section 1.14(2)(c). The variations of vertical load factor and angle of attack are fully consistent with the vertical wind variations.

(6) The event occurred close to HKIA and the SPECI issued about 5 minutes after the event indicated a thunderstorm in the airport vicinity. The weather was consistent with the meteorological reports which indicated that embedded cumulonimbus cloud might be encountered at or before the descent into Hong Kong in Guangdong airspace. The aircraft flew through an area of isolated embedded cumulonimbus which most probably led it to experience significant wind gusts and corresponding vertical and lateral acceleration variations. These significant wind variations and their associated turbulence occurred between 04:17:50 and 04:18:42. See Section 1.14.

(7) At 04:18:05 the AP lateral mode was changed from “NAV” to “HDG” mode and the flight crew selected a heading of 195°. As current heading was around 180°, the aircraft began to turn right towards its target. Roll angle progressively increased up to +17° leading the heading to increase from 178° to 199°. See Section 1.16.3(2).

(8) At around 04:18:42 the aircraft exited the turbulence area and continued its descent to land at HKIA. See Section 1.16.3(2).

2.6.3. ICAO Specification on Turbulence

(1) Referring to Section 1.14, the vertical load factor experienced by the aircraft during turbulence varied between +0.35G and +1.75G while lateral load factor varied between -0.1G and +0.1G, and the angle of attack varied between -0.5° and +5°.

(2) The aircraft experienced acceleration of more than 1.0g during the event. Based on ICAO Doc 4444 specification, the aircraft encountered “Severe Turbulence”.

2.7. Compliance with FCOM / FCTM

2.7.1. Seatbelt Sign On

(1) Prior to landing, the cabin crew will secure the cabin for landing. This entails among other duties the storage of galley equipment and ensuring the passengers are seated with their seat belts fastened. As the weather was expected to be turbulent with heavy rain in the Hong Kong area, the crew had briefed the cabin crew manager to secure the cabin earlier than normal for the arrival into Hong Kong. This is an established practice and was appropriate given the weather conditions expected in Hong Kong and demonstrated good planning.

(2) The Air Safety Report and the report of the injured cabin crew indicated that the seatbelt sign had been on before the accident. This complies with the respective FCOM on seat belt sign. See FCOM procedures in Figure 9.

(3) HKA OM-E SEP[16] P9 valid at the time of the accident states that …*if at any time cabin crew experiences turbulence with no notice from the Flight Deck, they shall secure themselves and inform the Flight Crew…*

2.7.2. Operation of Weather Radar

(1) Referring to Section 1.16.1, the Captain had his ND in ARC mode with a range of 40 NM and weather radar information displayed. The FO also had his ND in ARC mode with a range of 80 NM and also with weather radar information displayed. The weather radar was selected to Weather and Turbulence (WX+T) mode.

(2) Per the FDR data report, it can be seen that during the 12 minutes before the event the FO's ND range was changed four times (between 80NM and 160NM) and the Captain's ND range was changed seven times (between 40 NM and 160 NM).

(3) The operation of the Weather Radar complied the respective FCTM, indicating the crew's situational awareness and effective weather avoidance up to the unexpected turbulence encounter.

[16] SEP = Safety & Emergency Procedures

2.7.3. Selection of Autopilot and Autothrust

AP2 and A/THR remained engaged during the whole turbulence encounter. This is the recommended practice and complied with the respective FCOM. See Section 1.16.2.

2.7.4. Avoidance of Weather

(1) Prior to the encounter, the crew operation of the onboard radar was appropriate to the conditions encountered and complied with the respective FCTM. See Sections 1.16.1.

(2) During the encounter, the switching of AP lateral mode and the selection of heading by the crew allowed the aircraft to turn away from and exit the perceived area of turbulence. This practice complied with the respective FCTM. See Section 1.16.3.

2.8. Turbulence Working Group

(1) After the accident, the operator formed '2019 Turbulence Working Group' chaired by Corporate Safety, Quality Assurance and Security Department to follow up on cabin safety issues arising from turbulence events. The Working Group held two meetings on 11 July 2019 and 12 September 2019.

(2) In the first meeting, the Working Group reviewed previous occurrences, lost time through injury due to turbulence, and existing procedures. The Working Group also conducted a workshop to discuss risk assessment and prospective improvement actions, including review of passenger injury related turbulence occurrences, pre-landing check requirements, and regulatory requirements, etc. The second meeting was a follow up of the first one.

(3) The investigation team takes note of the initiative of the operator to form the Working Group to follow up on cabin safety issues arising from turbulence events and consider that there would be safety benefit to maintain the Workshop Group as a routine safety function.

3. Conclusions

3.1. Findings

From the evidence available, the following findings are made with respect to the occurrence. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

(1) The aircraft was airworthy when dispatched for the flight. (2.1)

(2) The Weather Radar System functioned normally at the time of the turbulence. (2.2)

(3) The flight crew members were licensed and qualified. (2.3)

(4) The injury of the cabin crew meets the interpretation of “serious injury” in Regulation 2, Cap. 448B. The occurrence meets the interpretation of “accident” in Regulation 2A, Cap. 448B. (2.4)

(5) Pre-departure crew briefing procedure was published in OM - A GEN Operating Procedures Flight Preparation 8.1.15, which includes departure and enroute weather and expected significant turbulence during the flight, etc. (2.5)

(6) The wind reconstruction based on the raw wind data recorded by the FDR indicates significant wind variations between 04:17:50 and 04:18:42. The variations in vertical wind speed highlight severe turbulent weather conditions with several updraft and downdraft. (2.6.1)

(7) The vertical turbulence led to the vertical load factor to increase up to +1.75G before decreasing to +0.35G. (2.6.2)

(8) At 04:18:42, the aircraft exited the turbulence area and continued its descent to land at Hong Kong International Airport. (2.6.2)

(9) Based on ICAO Doc 4444 specification, the aircraft encountered “Severe Turbulence”. (2.6.3)

(10) The Seatbelt Sign had been on before the accident. This complied with the respective FCOM. (2.7.1)

(11) The operation of the Weather Radar complied with the respective FCTM. (2.7.2)

(12) AP2 and A/THR remained engaged during the whole turbulence period. This practice complied with the respective FCOM. (2.7.3)

(13) The crew operation of the onboard radar prior to the turbulence encounter was appropriate and complied with the respective FCTM. (2.7.4)

(14) The switching of AP lateral mode and the selection of heading by the crew during the turbulence encounter allowed the aircraft to turn away from and exit the perceived area of turbulence. This practice complied with the respective FCTM. (2.7.4)

(15) After the accident, the operator formed '2019 Turbulence Working Group' to follow up on cabin safety issues arising from turbulence events. The Working Group held two meetings on 11 July 2019 and 12 September 2019 to discuss risk assessment and prospective improvement actions. (2.8)

(16) There would be a safety benefit to make the Turbulence Working Group meeting a routine safety function. (2.8)

3.2. Cause

The accident was caused by unexpectedly severe turbulence during the aircraft's descent into Hong Kong. [3.1(4), 3.1(6), 3.1(7), 3.1(9)]

4. Safety Actions Already Implemented

Whether or not AAIA identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. AAIA has been advised of the following proactive safety action in response to this occurrence.

4.1. Safety Actions Already Implemented by Hong Kong Airlines After the Accident

(1) A Turbulence Working Group was formed to review the Standard Operating Procedures (SOP) related to Turbulence management and previous occurrences, in order to identify areas with potential for improvement.

(2) Several Cabin in-flight inspections (16 in total) were conducted by HKA departments of Corporate Safety, Quality Assurance & Security and Service Delivery, which included items to verify Turbulence management and related SOP compliance.

(3) Communications were issued to Cabin Crew via Cabin Crew Times (newsletter) to remind of the necessary compliance to Turbulence management SOPs and to exercise proper coordination with Flight Crew prior to the descent phase to allow for a review of the cabin service with relation to any expected turbulence.

(4) A review of the Safety & Emergency Procedures training was completed to ensure appropriate coverage of turbulence procedures in the syllabus for both Flight and Cabin Crew.

5. Safety Recommendations

5.1. Safety Recommendation 09-2022

It is recommended that the operator maintains the Turbulence Working Group as a routine safety function.

Safety Recommendation Owner: Hong Kong Airlines

6. General Details

6.1. Occurrence Details

Date and time:	18 June 2019, 0418 (1218)	
Occurrence category:	Accident	
Occurrence type:	Turbulence Encounter	
Location:	Above Nansha District, Guangzhou City, Guangdong Province, China	
	Latitude: 22° 44' 41.3"N	Longitude: 113° 30' 17.1"E

6.2. Pilot Information

6.2.1. Pilot-in-Command

Age:	43 years
Licence:	Hong Kong Airline Transport Pilot's Licence, issued on 02 August 2012.
Aircraft ratings:	A330
Date of first issue of aircraft rating on type:	01 April 1998 (perpetual)
Instrument rating:	06 January 2019
Medical certificate:	Class 1, valid to 30 November 2019
Date of last proficiency check on type:	06 January 2019
Date of last line check on type:	12 Feb 2019
Date of last emergency drills check:	30 January 2019
Limitation:	Corrective Lenses to be worn and additional spectacles to be available.
Flying Experience:	
Total all types:	8,421 hours
Total on type (A330) :	6,243 hours

Total in last 28 days :	37 hours
Total in last 7 days:	13 hours
Total in last 24 hours:	4 hours
Duty Time:	
Day up to the incident flight (Hours:Mins) :	2 hours 55 minutes

6.2.2. First Officer

Age:	33 years
Licence:	Hong Kong Commercial Pilot's Licence, issued on 08 October 2018.
Aircraft ratings:	A330
Instrument rating:	06 March 2019
Medical certificate:	Class 1, valid to 31 March 2020
Date of last proficiency check on type:	06 March 2019
Date of last line check on type:	15 November 2018
Date of last emergency drills check:	07 September 2018
Limitation:	Nil
Flying Experience:	
Total all types:	3,138 hours
Total on type (A330) :	452 hours
Total in last 28 days :	63 hours
Total in last 7 days:	12 hours
Total in last 24 hours:	4 hours
Duty Time:	
Day up to the incident flight (Hours:Mins) :	2 hours 55 minutes

6.3. Aircraft Details

Manufacturer and model:	Airbus A330-243	
Registration:	B-LHA	
Aircraft Serial number:	0396	
Year of Manufacture	2001	
Engine	Two Rolls-Royce Trent 772B-60 turbo-fan engines	
Operator:	Hong Kong Airlines Limited	
Type of Operation:	Scheduled Passenger Service	
Certificate of Registration	Certificate Number 901 Issued on 12 February 2018	
Certificate of Airworthiness	Certificate Number 753-1 Issued on 29 January 2019 valid until 14 February 2020	
Departure:	Beijing Capital International Airport (ZBAA)	
Destination:	Hong Kong International Airport (VHHH)	
Maximum Take-off Weight	233,000 kg	
Total Airframe Hours	63,827	
Total Airframe Cycles	19,389	
Persons on board:	Crew – 11	Passengers – 230
Injuries:	Crew – 1	Passengers – 0
Aircraft damage:	Not applicable	

7. Abbreviations

AAIA	Air Accident Investigation Authority
Annex 13	Annex 13 to the Convention on International Civil Aviation
AOC	Air Operator’s Certificate
AP	Autopilot
AQD	Aviation Quality Database
A/THR	Autothrust
ATC	Air Traffic Control
ATPL	Airline Transport Pilot's Licence
BEA	Bureau’d'Enquêtes et d'Analyses pour ’a sécurité de l'aviation civile
°C	degree Celsius
CAD	Civil Aviation Department, Hong Kong
CAD 712	Safety Management System For Air Operators, International Non-Public Transport Operators, Maintenance Organisations and Flying Training Organisations - A Guide to Implementation
Cap. 448B	Hong Kong Civil Aviation (Investigation of Accidents) Regulations
Cap. 448C	Air Navigation (Hong Kong) Order 1995
CB	Cumulonimbus
CIC	Cabin Crew in Charge
CVR	Cockpit Voice Recorder
E&M	Engineering and Maintenance
ECAM	Electronic Centralized Aircraft Monitoring
EFIS	Electronic Flight Instrumentation System
ETA	Estimated Time of Arrival
EWD	Engine/Warning Display
FCOM	Flight Crew Operating Manual
FCTM	Flight Crew Techniques Manual
FCU	Flight Control Unit
FDR	Flight Data Recorder
FL	Flight Level

FO	First Officer
FOP	Flight Operations
ft	Feet
HKA	Hong Kong Airlines Limited
HKG	Hong Kong (IATA Code)
HKIA	Hong Kong International Airport
hPA	Hectopascal
hrs	Hours
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
kg	Kilograms
km	Kilometres
kt	Knots (nautical miles per hour)
m	Metres
METAR	Meteorological Aerodrome Weather Report
MOR	Mandatory Occurrence Report
Mpa	Megapascal
OEM	Original Equipment Manufacturer
ND	Navigation Display
NM	Nautical Mile
PA	Passenger Address
PF	Pilot Flying
PM	Pilot Monitoring
QRH	Quick Reference Handbook
SEP	Safety & Emergency Procedures
SD	System Display SD
SMS	Safety Management System
SP	Senior Purser
SPECI	Special Weather Report
UTC	Coordinated Universal Time
VHHH	Hong Kong International Airport (ICAO code)
VFR	Visual Flight Rules

VHF	Very High Frequency
WXR	Weather Radar
ZBAA	Beijing Capital International Airport

8. Table of Figures

Remarks:

The above figures are provided by courtesy of Airbus.

a) Figure 1 and Figure 2 are extracted from Airbus A330 Aircraft Maintenance Manual.

b) Figure 3 to Figure 10 are extracted from Airbus Report - Severe turbulence during descent to Hong Kong International Airport (VHF) June 18th 2019, Hong Kong Airlines (CRK), A330-243 – MSN 0396 (B-LHA).