



**KOMITE NASIONAL KESELAMATAN TRANSPORTASI
REPUBLIC OF INDONESIA**

FINAL

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Aircraft Accident Investigation Report

Etihad Airways

Airbus A330 -243; A6-EYN

Near Bangka Islands

Republic of Indonesia

4 May 2016

This Final Report was produced by the Komite Nasional Keselamatan Transportasi (KNKT), Transportation Building, 3rd Floor, Jalan Medan Merdeka Timur No. 5 Jakarta 10110, Indonesia.

The report is based on the investigation carried out by the KNKT in accordance with Annex 13 to the Convention on International Civil Aviation Organization, the Indonesian Aviation Act (UU No. 1/2009) and Government Regulation (PP No. 62/2013).

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ABBREVIATIONS AND DEFINITIONS

| | | |
|-------|---|---|
| AAIS | : | Air Accident Investigation Sector of the United Arab Emirates |
| ACARS | : | Aircraft Communications Addressing and Reporting System |
| ACC | : | Area Control Centre |
| ADR | : | Air Data Reference |
| AP | : | Autopilot |
| ATPL | : | Airline Transport Pilot License |
| CAS | : | Calibrated Air Speed |
| CM | : | Cabin Manager |
| CVR | : | Cockpit Voice Recorder |
| ECAM | : | Electronic Centralized Aircraft Monitoring |
| FCOM | : | Flight Crew Operating Manual |
| FCPC | : | Flight Control Primary Computer |
| FCTM | : | Flight Crew Training Manual |
| FDR | : | Flight Data Recorder |
| FL | : | Flight Level |
| FOM | : | Flight Operation Message |
| ft | : | Feet |
| FWC | : | Flight Warning Computer |
| GCAA | : | The General Civil Aviation Authority of The United Arab Emirates |
| ISIS | : | Integrated Standby Instrument System |
| Km | : | Kilometre |
| KNKT | : | Komite Nasional Keselamatan Transportasi / National Transportation Safety Committee |
| MNADC | : | Mach Number Air Data Computer |
| ND | : | Navigation Display |
| NITS | : | Nature Intentions Time Special Instructions |
| OM | : | Operations Manual |
| P3 | : | The third pilot |
| pb | : | Push button |
| PF | : | Pilot Flying |
| PIC | : | Pilot in Command |
| PM | : | Pilot Monitoring |

| | | |
|---------|---|---|
| pps | : | Pulse per second |
| SEPM | : | Safety & Emergency Procedure Manual |
| SIC | : | Second in Command |
| UTC | : | Universal Time Coordinated |
| VDL | : | Code for medical limitation, which means the holder shall wear corrective lens for defective distant vision and carry spare set of spectacles |
| VHF | : | Very High Frequency |
| VMO/MMO | : | Maximum Operating Speed |
| WAFC | : | World Area Forecast Centre |

SYNOPSIS

On 4 May 2016, an Airbus A330-243 aircraft registered A6-EYN was being operated by Etihad Airways as a passenger scheduled flight from Abu Dhabi International Airport (OMAA), Abu Dhabi, United Arab Emirates to Soekarno-Hatta International Airport (WIII) Jakarta, Indonesia. The flight departed at 0130 UTC and scheduled to arrive at Soekarno-Hatta International Airport Jakarta, at 0746 UTC on day light time.

The prognosis chart issued by World Area Forecast Center (WAFC) London which was the part of briefing material for the pilots prior to departure, showed possible thunderstorms and development of cumulonimbus clouds up to above FL470 at around Sumatra Island.

On-board the flight was 274 occupants and consisted of three pilots, nine cabin crew and 262 passengers. The flight was uneventful since departure until about 15 minutes commencing to descend when the cabin crews were preparing for arrival procedure and some passengers were not wearing the seatbelt.

At 0640:10 UTC, the aircraft was on cruising at FL 390 and encountered severe turbulence for 22 seconds. The severe turbulence caused one cabin crew and six passengers sustained serious injuries, while three cabin crew and 14 passengers sustained minor injury. Several aircraft interior parts damaged such as detached ceiling, broken passenger service units and oxygen mask container dropped.

Approximate 30 seconds after encountered the severe turbulence, the aircraft was in stable flight and the flight was continued to Soekarno-Hatta International Airport Jakarta. The injured occupants were transported to the nearest hospitals for treatment.

The investigation determined the contributing factor was:

- The aircraft was flying outside the visible cloud which was within the turbulence area of the thunderstorm.
- The turbulence was not anticipated and no warning provided to the cabin crew and passengers.

KNKT had been informed safety actions taken by the Etihad Airways resulting from this occurrence and KNKT considered that the safety actions were relevant to improve their operational safety. In addition, KNKT issued safety recommendations to Etihad Airways and Directorate General of Civil Aviation Indonesia.

1 FACTUAL INFORMATION

1.1 History of the Flight

On 4 May 2016, an Airbus A330-243 aircraft, registered A6-EYN, was being operated by Etihad Airways as a passenger scheduled flight from Abu Dhabi International Airport (OMAA), Abu Dhabi, United Arab Emirates¹ to Soekarno-Hatta International Airport (WIII) Jakarta, Indonesia².

At 0130 UTC, the aircraft departed from Abu Dhabi and the estimated time of arrival Jakarta would be at 0746 UTC. On board the flight were 274 occupants consisting of three pilots, nine cabin crew and 262 passengers. The three pilots consisted of Pilot in Command (PIC) who acted as Pilot Flying (PF), Second in Command (SIC) who acted as Pilot Monitoring (PM) and third pilot (P3) seated on the jump seat. The aircraft was cruising at FL390 (39,000 feet).

When the aircraft was about over Bangka Island, which was about 15 minutes to the top of descent and was under the Jakarta Area Control Center Unit (ACC), the PIC called the cabin manager to come to the cockpit in order to brief the arrival preparation.

The flight crew noticed cumulus cloud on the flight path and decided not to enter the cloud.

At 06:40:10 UTC, while the cabin manager was in the cockpit and the other cabin crew were preparing for arrival procedure, the aircraft encountered severe turbulence³. The aircraft vertical speed fluctuated between -2,500 and +2,000 feet/minute and the SIC turned ON the seat belt sign.



Figure 1: The flight track and the area of the aircraft encounter severe turbulence

-
- 1 Abu Dhabi International Airport (OMAA), Abu Dhabi, United Arab Emirates will be named as Abu Dhabi for the purpose of this report.
 - 2 Soekarno-Hatta International Airport (WIII), Jakarta, Indonesia will be named as Jakarta for the purpose of this report.
 - 3 Severe turbulence is large, abrupt changes in altitude and/or attitude. Usually causes large variation in airspeed. Refer to IATA Guidance for Turbulence Management.

At 06:40:32 UTC, the autopilot disengaged and at 06:40:35 UTC the autopilot reengagement was attempted but not success.

At 06:40:52 UTC, the ACC controller asked the pilot whether the aircraft was starting to descend and the PM replied that the aircraft had experienced turbulence. At this time, the pilot successfully re-engaged the auto pilot while the aircraft altitude was at 39,000 feet however, the aircraft was climbing with the rate of 2,000 feet/minute and the target altitude of 39,000 feet could not be maintained. The PF disengaged the auto pilot and flew manually for 20 seconds and returned the aircraft to the target altitude of 39,000 feet.

At 06:41:30 UTC, the aircraft was in stable flight and the PF was able to re-engage the auto pilot.

The cabin manager, who was in the cockpit when the turbulence occurred, returned to the cabin and conducted a cabin check and announced to the passengers about the recent turbulence.

The cabin manager went to middle right passenger door (R3 door) and informed the PIC through interphone concerning injured occupants and damage to the cabin interior, including dropped passenger oxygen masks as a result of the severe turbulence. The PIC and the cabin manager discussed that the injured occupants required medical assistance. The cabin crew and a passenger who was qualified medical doctor checked the injured passengers and administered first aid as necessary.

At 0653 UTC, the ACC controller instructed the pilot to descend from 39,000 feet to 35,000 feet, afterwards the aircraft was vectored and flew normally following the air traffic control instructions.

At 0654 UTC, the PIC informed the post occurrence condition to the ground handling provider in Jakarta via radio communication, requested assistance on arrival and also informed the Etihad Airways flight operations in Abu Dhabi via the Aircraft Communications Addressing and Reporting System (ACARS) concerning the recent inflight turbulence.

At 0724 UTC, the aircraft landed safely in Jakarta. The non-injured passengers were disembarked normally and the injured occupants were transported to the nearest hospital outside the airport by ambulance.

1.2 Injuries to Persons

The investigation records indicated one cabin crew and six passengers sustained serious injuries, while three cabin crew and 14 passengers sustained minor injury.

One cabin crew sustained serious injuries which included a fracture to her spine and bruising. The following table below shows the sustained serious injuries passengers.

| Patient No. | Comments |
|--------------------|--|
| Patient 1 | One closed fracture of distal tibia and fibula. Spent one night in hospital. No surgery required. |
| Patient 2 | Swelling to her neck and spine causing numbness to her arms and legs. Spent over 48 hours in hospital. |
| Patient 3 | A lot of swelling to his neck and spine causing significant numbness to |

| Patient No. | Comments |
|--------------------|--|
| | his arms and legs. Spent over 48 hours in hospital. |
| Patient 4 | Closed/stable fractures in her spine, long duration in hospital (over 48 hours) and after discharge will require a lot of follow up and home care/assistance. Due to other existing medical conditions she was not a candidate for surgery. |
| Patient 5 | A lot of swelling to her neck and spine causing significant numbness to her arms and legs. Spent over 48 hours in hospital. |
| Patient 6 | The passenger spent over 48 hours in hospital, this passenger developed blood pressure/heart complications due to chest trauma that might be caused by impact then developed complications such as pneumonia and unable breathing properly. The passenger had extensive bruising to the neck, back and left shoulder |

The three cabin crews with minor injury had minor head injuries and bruising. The 14 passengers with minor injuries were sent to hospital, ten passengers were discharged from the Emergency Room, and four passengers stayed in the hospital for further treatment. The passengers with minor injuries experienced soft tissue injuries, minor lacerations, bruising and loss of teeth. Injuries of the 14 passengers were classified as minor injury.

The detail number of injury to person was as follows:

| Injuries | Flight Crew | Passengers | Total in Aircraft | Others |
|----------|-------------|------------|-------------------|--------|
| Fatal | - | - | - | - |
| Serious | 1 | 6 | 7 | - |
| Minor | 3 | 14 | 17 | - |
| None | 8 | 242 | 250 | - |
| Total | 12 | 262 | 274 | - |

1.3 Damage to Aircraft

The aircraft had several interior parts damaged such as damage passenger service units and detached ceiling panels (figure 2). The damage of cabin ceilings occurred above seat 10H and the other damage were spread out in the aft cabin between seat rows 21 to 45 (figure 3). Several passenger oxygen containers were damaged and the oxygen mask dropped (figure 4).



Figure 2: Aft Cabin ceiling and mid galley condition after the severe turbulence

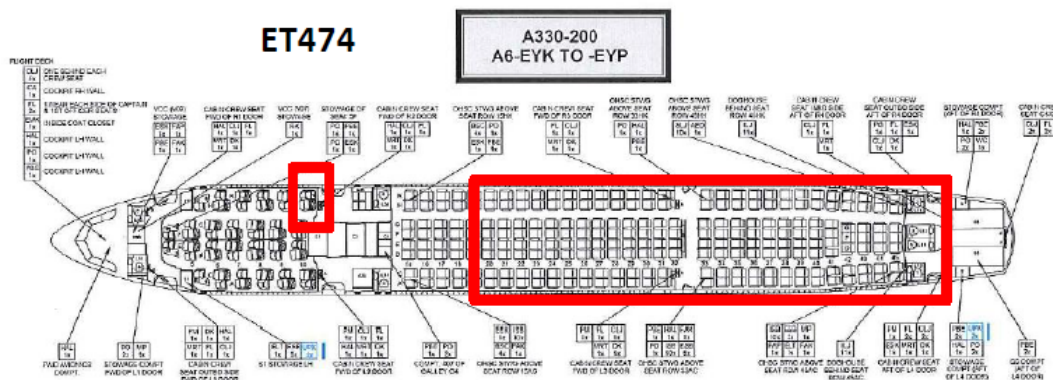


Figure 3: The area of the injured passenger seats and the damaged ceiling



Figure 4: The damaged passenger service unit

1.4 Other Damage

There was no other damage to property and/or the environment.

1.5 Personnel Information

1.5.1 Pilot in Command

| | |
|----------------------------|--|
| License | : ATPL |
| Date of issue | : 21 April 2014 |
| Aircraft type rating | : A320, A330 |
| Instrument rating validity | : 30 November 2016 |
| Medical certificate | : First Class |
| Last of medical | : 14 July 2015 |
| Validity | : 4 August 2016 |
| Medical limitation | : The holder shall wear corrective lens for defective distant vision and carry spare set of spectacles |
| Last line check | : 26 February 2016 |
| Last proficiency check | : 7 November 2015 |
| Flying experience | |
| Total hours | : 11,280 hours 12 minutes |
| Total on type | : 2,337 hours 8 minutes |
| Last 90 days | : 236 hours 47 minutes |
| Last 60 days | : 77 hours 33 minutes |
| Last 24 hours | : 8 hours 11 minutes |
| This flight | : 8 hours 11 minutes |

1.5.2 Second in Command

License : CPL
Date of issue : 16 January 2011
Aircraft type rating : A320, A330
Instrument rating validity : 31 March 2017
Medical certificate : First Class
Last of medical : 24 March 2016
Validity : 31 March 2017
Medical limitation : Nil
Last line check : 18 October 2015
Last proficiency check : 22 March 2016

Flying experience

Total hours : 2,656 hours 38 minutes
Total on type : 1,176 hours 12 minutes
Last 90 days : 224 hours 51 minutes
Last 60 days : 144 hours 15 minutes
Last 24 hours : 8 hours 11 minutes
This flight : 8 hours 11 minutes

1.5.3 Third Pilot

License : ATPL
Date of issue : 11 February 2016
Aircraft type rating : A320, A330
Instrument rating validity : 30 November 2016
Medical certificate : First Class
Last of medical : 28 February 2016
Validity : 5 March 2017
Medical limitation : Nil
Last line check : 19 June 2015
Last proficiency check : 7 November 2015

Flying experience

Total hours : 2,280 hours 12 minutes
Total on type : 568 hours 38 minutes
Last 90 days : 246 hours 13 minutes

Last 60 days : 162 hours 56 minutes
Last 24 hours : 8 hours 11 minutes
This flight : 8 hours 11 minutes

1.5.4 Flight Attendants

All cabin crew on this flight held valid licenses and medical certificates.

1.6 Aircraft Information

1.6.1 General

Registration Mark : A6-EYN
Manufacturer : Airbus
Country of Manufacturer : France
Type/Model : Airbus 330-243
Serial Number : 832
Date of Manufacture : 18 June 2007
Certificate of Airworthiness
Issued : 18 June 2007
Validity : 16 June 2016
Category : Transport (Passenger)
Limitations : None
Certificate of Registration
Number : 35/07
Issued : 18 June 2007
Time Since New : 42,982 hours 50 minutes
Cycles Since New : 7,727 cycles
Last Major Check : 7 February 2016 (C check)
2 April 2016 (A check)
Last Minor Check : 3 May 2016 (daily check)

1.6.2 Engines

Manufacturer : Rolls Royce
Type/Model : RB211 TRENT 772 B60-16
Serial Number-1 engine : 41410
▪ Time Since New : 43,444 hours 59 minutes
▪ Cycles Since New : 7,905 cycles

- Serial Number-2 engine : 41430
 - Time Since New : 41,490 hours 49 minutes
 - Cycles Since New : 7,550 cycles

1.6.3 Weight and Balance

The aircraft departed Abu Dhabi to Jakarta within the proper weight and balance envelope, as shown in the following table:

- Maximum Take-off weight : 233,000 kg
- Actual take-off weight : 216,556 kg
- Maximum landing weight : 182,000 kg
- Estimated landing weight : 171,696 kg
- MAC TOW : 28 %
- CG Limit Zero Fuel Weight : 87.1 (forward); 161.2 (aft)
- CG Take-off Weight : 72.7 (forward); 172 (aft)

1.7 Meteorological Information

The aircraft operator utilized prognosis chart issued by World Area Forecast Center (WAFC) London as weather briefing material for the flight crew prior to departure. The forecast weather (SIGWX chart) issued by WAFC London, valid from 4 May 2016 at 0600 UTC, highlighted cumulonimbus might extend above FL470 at time of occurrence and close to the aircraft trajectory.

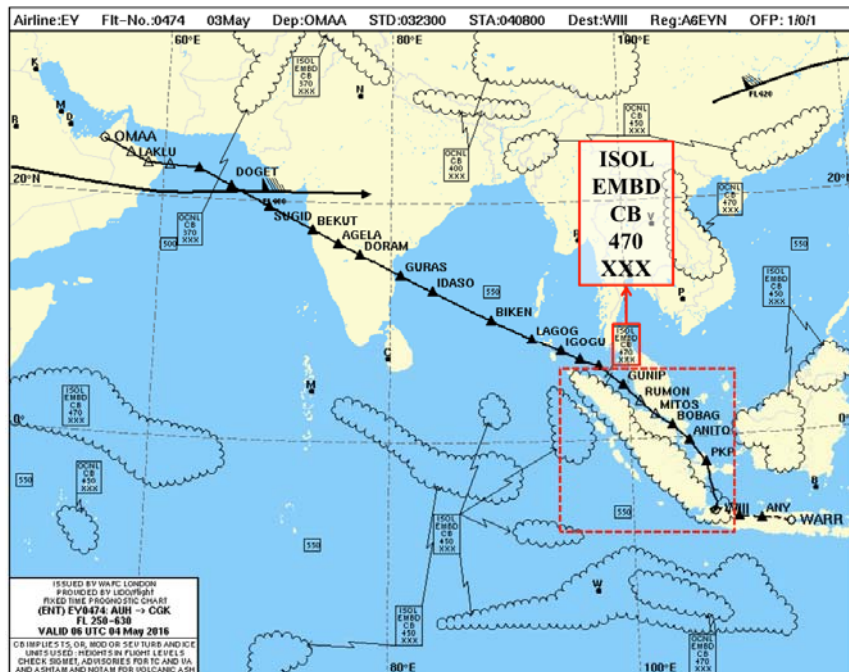


Figure 5: The prognosis chart which highlighted development of cumulonimbus clouds extending above FL470

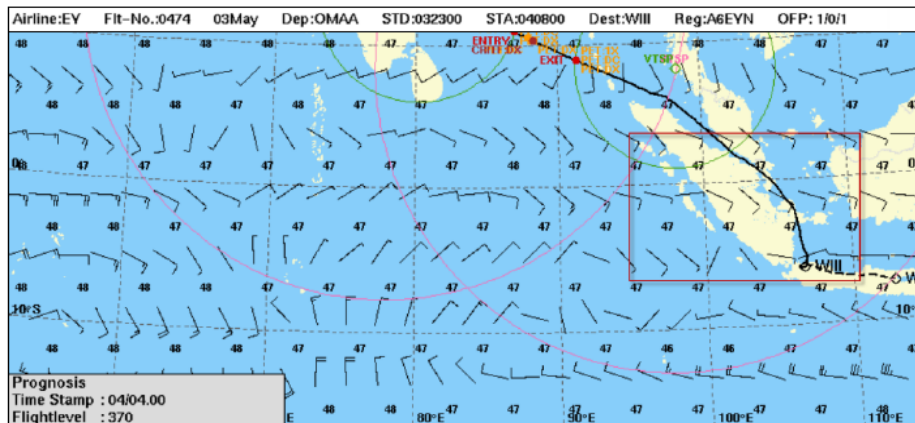


Figure 6: Wind direction at FL370 around the occurrence area shows southeast direction at 10 knots

The wind charts at FL370 time stamp 04/04.00 (effective on 4 May 2016 at 0400 UTC), highlighted the wind direction near the occurrence area was about 10 knots in southeast direction.

Satellite weather image of temperature condition at 0640 UTC provided by Meteo France on the area of the occurrence (yellow circle) are as follows:

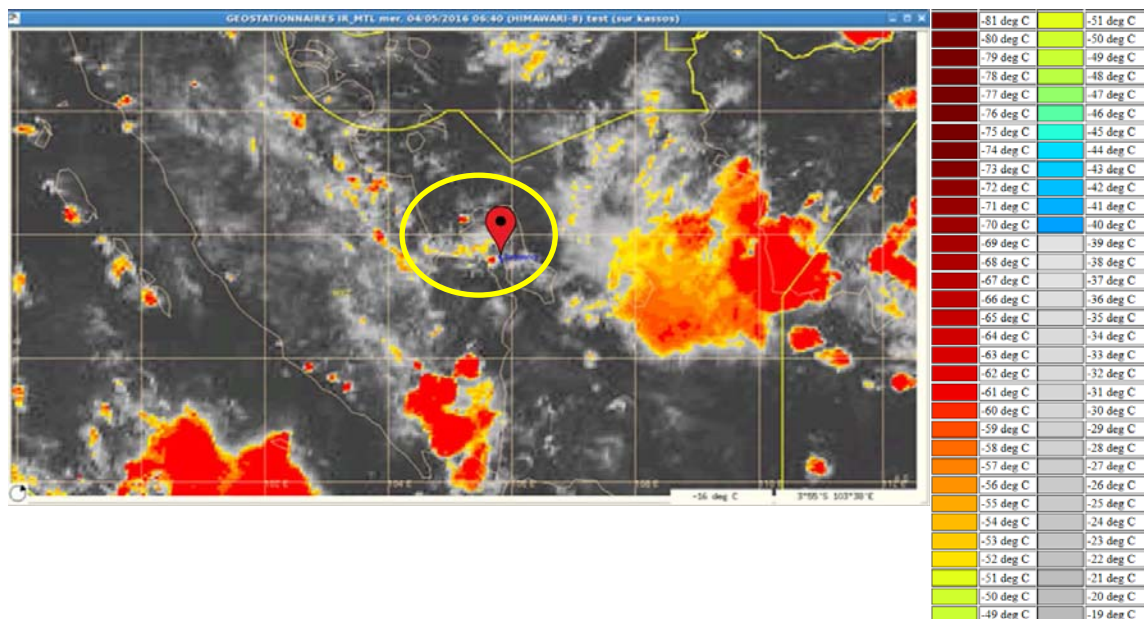


Figure 7: The Satellite weather image at 0640 UTC

The satellite weather image showed low temperature indicating the development of cumulonimbus clouds.

1.8 Aids to Navigation

Ground-based navigation aids / on-board navigation aids / aerodrome visual ground aids and their serviceability were not a factor in this occurrence.

1.9 Communications

The aircraft was equipped with three very high frequency (VHF) radio communication systems. The crew used two of the VHF radios for routine communications with air traffic control, and the remaining set was used for the Aircraft Communications Addressing and Reporting System (ACARS) data link system. All VHF radios were serviceable.

All communications between Jakarta ACC controllers and the pilots were recorded by ground based automatic voice recording equipment and cockpit voice recorder. The quality of the recorded transmissions was good.

1.10 Aerodrome Information

On the day of the occurrence, all the Soekarno-Hatta International Airport facilities such as ground base navigation aids, communication facilities and others were operating normally.

The Soekarno-Hatta International Airport has a Port Health Facility at terminal 2 (International flight terminal) and several general hospitals located within 5-20 Km from the airport.

1.11 Flight Recorders

1.11.1 Flight Data Recorder

The aircraft was equipped with L-3 Communications Flight Data Recorder (FDR) with part number 2100-1020-02 and serial number 113730. The FDR was successfully downloaded in the KNKT recorder facility and contained 1,172 parameters in duration of 333.18 hours which contained 38 flights including the accident flight.

Significant parameters which relate to this accident flight are shown on the following figure.

A6-EYN A330-243

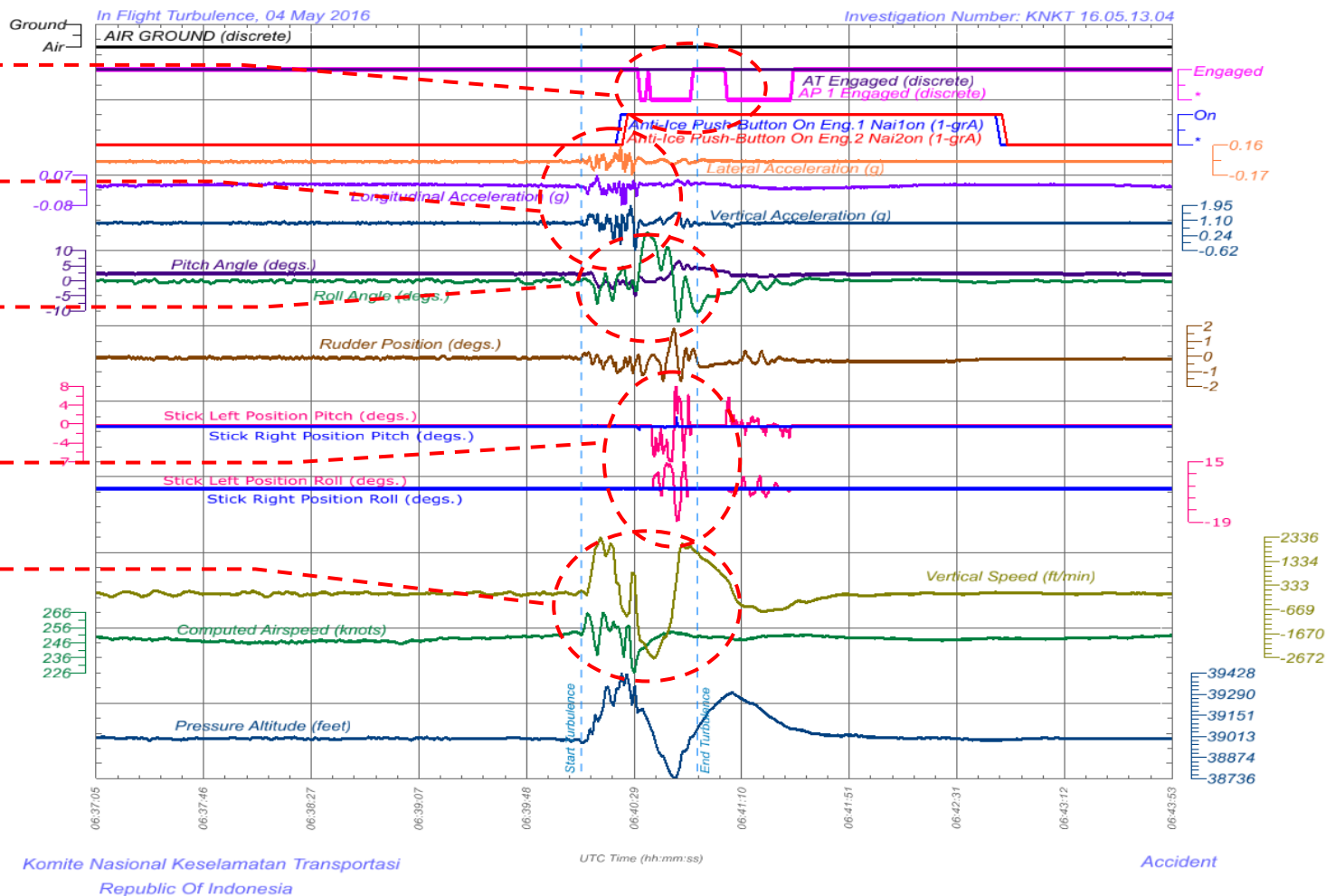


Figure 8: The related in turbulence flight data downloaded from FDR

The significant events recorded on the FDR including the parameters which are not displayed on the graph above are:

- Prior to the turbulence, the aircraft was generally steady at an altitude of 39,000 feet.
- Between 06:40:10 to 06:40:32 UTC.
 - The altitude varied between 38,750 and 39,450 feet. The vertical speed fluctuated between -2,500 and +2,000 feet/minute.
 - The pitch varied between -5° and +2°.
 - The vertical acceleration varied between -0.65 and +1.95 G.
- 06:40:30 – 06:40:40 UTC the flight control law reverted to Alternate Law.
- 06:40:32 UTC, the FDR recorded the “APOFFV” (Auto Pilot voluntary disengaged) which indicated that the Auto Pilot (AP) disengaged via the side-stick instinctive pushbutton.
- 06:40:35 UTC, the AP re-engagement was attempted but not successful.
- 06:40:35 – 06:40:51 UTC activation of pitch and roll on left side-stick. The recorded values of pitch side-stick angle were -7.5 to 7.4 and the values of roll side-stick angle were -19.3 to 14.9.
- 06:40:51 UTC the autopilot engaged and disengaged at 06:41:05 UTC.
- 06:41:30 UTC the autopilot engaged continuously.

1.11.2 Cockpit Voice Recorder

The aircraft was equipped with L-3 Communications Cockpit Voice Recorder (CVR) with part number 2100-4045-00 and serial number 000643370. The CVR was successfully downloaded in the KNKT recorder facility and recorded 2 hours 4 minutes of good quality recording data. The significant excerpt recorded before and after the severe turbulence is as follows:

| TIME (UTC) | FROM | TO | DESCRIPTION |
|------------|------|-------|---|
| 6:21:53 | ACC | Pilot | Provided a clearance to fly direct to BOSLO ⁴ waypoint and to follow standard arrival. |
| 6:38:58 | | | Sound similar with cockpit door open then a communication between Cabin Manager (CM) and PIC concerning the arrival preparation |
| 6:40:11 | | | Noisy sound similar with air turbulence |

⁴ BOSLO is a waypoint which located approximately 150 Nm from Soekarno-Hatta International Airport on heading 354° (03°37.5'S 106°23.5'E).

| TIME (UTC) | FROM | TO | DESCRIPTION |
|--------------------------|-----------------|-----------------|---|
| 6:40:13 | | | Chime (sound similar with aircraft system warning) |
| 6:40:23 | | | Noisy sound similar with air turbulence |
| 6:40:32 | | | Cavalry charge, sound similar with autopilot disengage |
| 6:40:36 | | | Cavalry charge, sound similar with autopilot disengage |
| 6:40:43 | | | The sound of prolong horn |
| 6:40:52 | ACC | Pilot | Asked whether the aircraft was descending. |
| 6:40:54 | Pilot | ACC | Replied that the aircraft just entered turbulence. |
| 6:40:59 | ACC | Pilot | Acknowledged and instructed to maintain FL390 and contact another ACC on the different frequency. |
| 6:41:14 | Pilot | ACC | Acknowledged and informed ACC controller that the aircraft was maintaining FL390. |
| 6:45:38 to 6:47:07 | | | Conversation between PIC and a flight attendant concerning serious injury to passengers and extreme damages in aircraft interior and were acknowledged by the PIC |
| 6:53:16 | Pilot | Ground Handling | Pilot called the ground handling. |
| 6:53:51 | Ground Handling | Pilot | Asked whether the pilot need for assistant on arrival |
| 6:53:52 | ACC | Pilot | Instructed the pilot to descent to FL 350 |
| 6:53:59 | Ground Handling | Pilot | Asked whether the pilot required assistance |
| 6:54:03 | Pilot | Ground Handling | Informed that the pilot required assistance |
| 6:54:07 | Ground Handling | Pilot | Asked the pilot whether required medical assistance for injured occupants and requested the injured passengers seat numbers |
| 6:54:14 | Pilot | Ground Handling | Informed that medical assistant was required and did not have time to give the seat number |

1.12 Wreckage and Impact Information

The aircraft had minor damage in cabin interior most likely due to impact with occupants and the food service cart. The detail of the damage described in subchapter damage to the aircraft in this report.

1.13 Medical and Pathological Information

There were 33 injured occupants required for medical treatment. The six injured occupants stayed in hospital for further treatment and the rest were allowed to return

home. According to the medical report, most of the injured passenger had spinal column and head injury.

1.14 Fire

There was no evidence of fire.

1.15 Survival Aspects

The cabin manager conducted cabin check and announced to the passengers about the recent turbulence after the aircraft was in stable flight. The cabin manager went to middle right passenger door (R3 door) and reported to the PIC regarding the damage to the cabin interior and the injured occupants who required assistance on arrival.

The cabin crew and a passenger qualified as medical doctor checked the injured occupants and administered first aid. The first aid performed by the cabin crew was consistent with their procedures.

The PIC requested assistance on arrival concerning the injured occupants to the ground handling provider in Jakarta. Upon arrival, the injured occupants were transported to the nearest hospital outside the airport.

1.16 Tests and Research

The Airbus participated in this investigation as advisor to the accredited representative. The Airbus had provided to the KNKT the report of research to the FDR data of the accident flight. The report stated that the beginning of the turbulence started on 06:40:10 UTC at coordinate of -2.37562179° ($2^{\circ} 22' 32.24''$ S); 105.81275920° ($105^{\circ} 48' 45.9''$ E). The location would have been in the area near Bangka Island.

The figure below represented the area of the aircraft position during the severe turbulence.

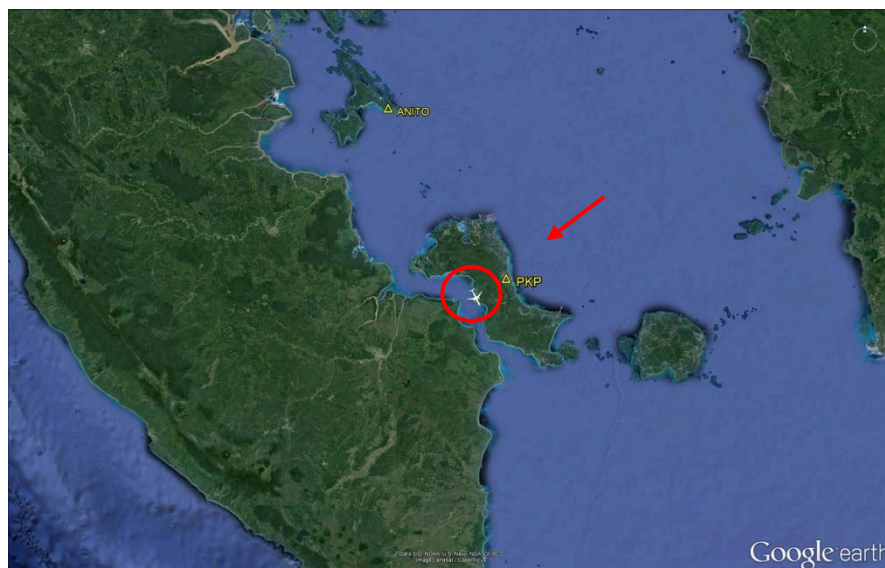


Figure 9: The area where the aircraft experienced in severe turbulence

The Airbus reconstructed three dimensions wind profile that influenced the aircraft behavior utilizing FDR data from 06:40:00 UTC to 06:42:00 UTC, sideslips, ground effect and inertial force reconstruction.

Note the data consensus as follows:

- $t = 0$ corresponds to 06:40:00 UTC in the flight data
- On the longitudinal axis of the aircraft,
 - Wind (X) > 0 means tailwind (positive value)
 - Wind (X) < 0 means headwind (negative value)
- On the lateral axis of the aircraft,
 - Wind (Y) > 0 means left wind (positive value)
 - Wind (Y) < 0 means right wind (negative value)
- On the vertical axis of the aircraft,
 - Wind (Z) > 0 means downdraft wind (positive value)
 - Wind (Z) < 0 means updraft wind (negative value)

The axis related to the aircraft is as follow:



Figure 10: Aircraft axis consensus

The reconstructed wind result was as follows:

Longitudinal Axis

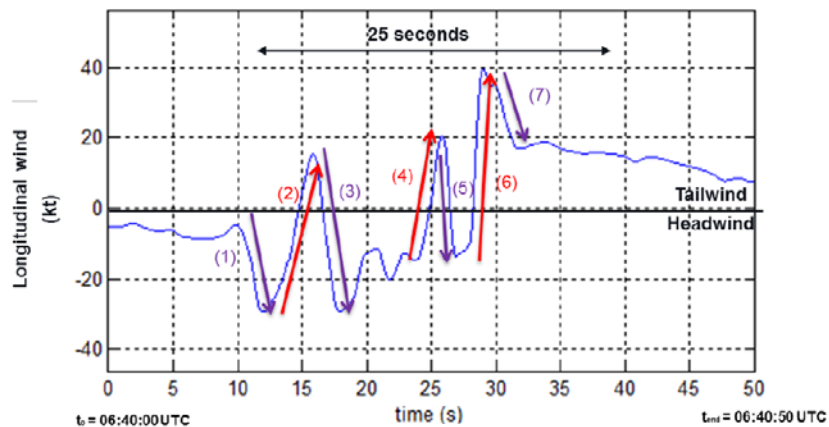


Figure 11: Longitudinal axis wind profile

On the longitudinal axis, the data explanation is as follows:

- (1) The wind value of 5 knots headwind increased to 29 knots headwind in 2.1 seconds

- (11 knots/second).
- (2) The wind value of 29 knots headwind inverted to 15 knots tailwind in 4 seconds (11 knots/second).
- (3) The wind value of 15 knots tailwind inverted to 29 knots headwind in 2 seconds (22 knots/second).
- (4) The wind value of 14 knots headwind inverted to 21 knots tailwind in 2 seconds (18 knots/second).
- (5) The wind value of 21 knots tailwind inverted to 14 knots headwind in 1 second (35 knots/second).
- (6) The wind value of 10 knots headwind inverted to 39 knots tailwind in 1 second (49 knots/second).
- (7) The wind value of 35 knots tailwind decreased to 17 knots in 1.8 seconds (10 knots/second).

Lateral Axis

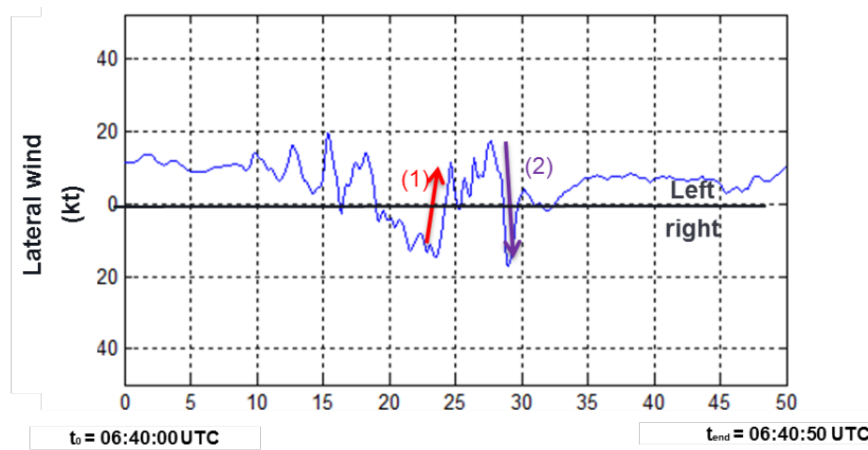


Figure 12: Lateral axis wind profile

On the lateral axis, the data explanation is as follows:

- (1) The wind value of 15 knots from the right inverted to 12 knots from the left in 1.1 seconds (23 knots/second).
- (2) The wind value of 17 knots from the left inverted to 17 knots from the right in 1.2 seconds (28 knots/second).

Vertical Axis

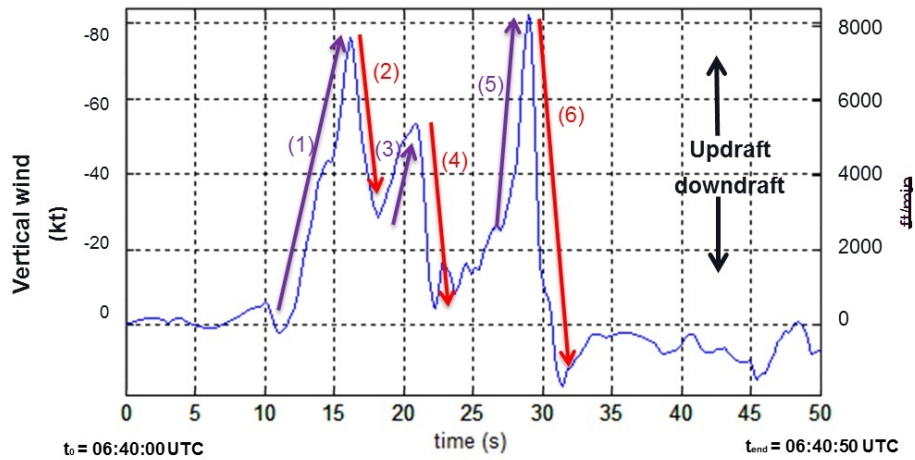


Figure 13: Vertical axis wind profile

On the vertical axis, the data explanation is as follows:

- (1) The upwards gust of 78 knots in 4.4 seconds (18 knots/second).
- (2) The downwards gust of 48 knots in 2 seconds (24 knots/second).
- (3) The upwards gust of 25 knots in 2.8 seconds (9 knots/second).
- (4) The downwards gust of 49 knots in 1.4 seconds (35 knots/second).
- (5) The upwards gust of 57 knots in 2 seconds (28 knots/second).
- (6) The downwards gust of 92 knots in 2.5 seconds (39 knots/second).

The aircraft experienced strong turbulence conditions on all 3-aircraft axis. The recorded wind variations at time of event at 06:40:29 UTC were:

- On the longitudinal axis, the wind value of 49 knots/second tail wind gradient.
- On the lateral axis, the wind value of 17 knots from left inverted to 17 knots from the right in 1.2 seconds (28 knots/second).
- On the vertical axis, the downward gust value of 92 knots in 2.5 seconds (approximately 39 knots/second or vertical speed of 4,000 feet/minute).

The events recorded during the turbulence

The following chart showed events recorded when the aircraft experienced turbulence.

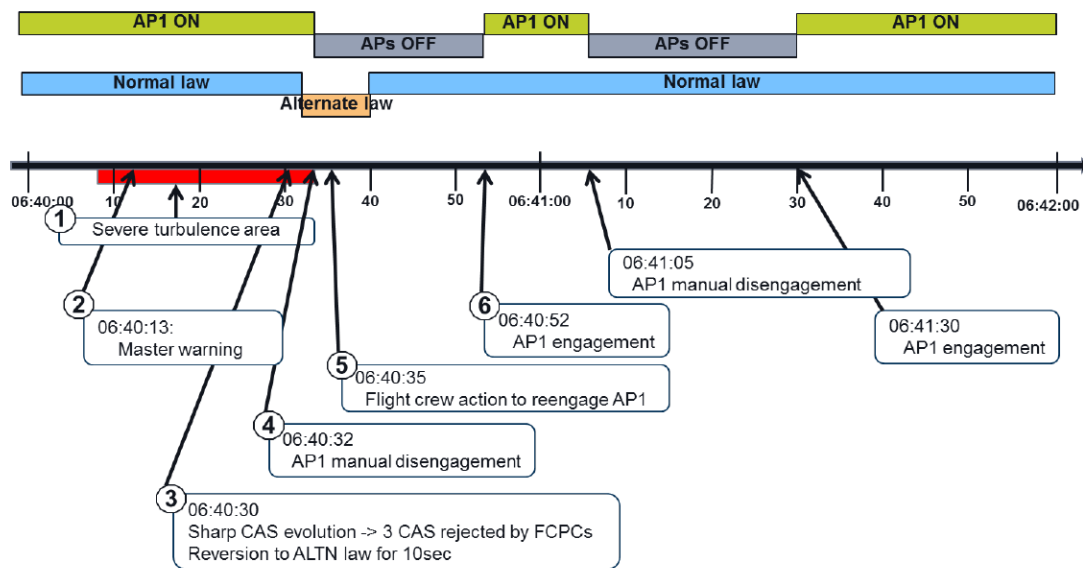


Figure 14: The events recorded during the turbulence

The highlights of the chart between 06:40:00 UTC to 06:42:00 UTC are as follows:

- At 06:40:13 UTC, most likely the master warning triggered by the aircraft speed when experience changed which caused by the change of wind during the turbulence.
- At 06:40:18 UTC, the FDR recorded aircraft speed of 0.856 Mach and changed rapidly to 0.844 Mach.
- At 06:40:30 UTC, the flight control reverted from Normal to Alternate Law most likely due to Computed Air Speed (CAS) dropped for more than 30 knots within one second, as resulted in the change of wind direction during the turbulence.
- At 06:40:32 UTC, the AP disengaged via side stick instinctive pushbutton.
- At 06:40:35 UTC, the autopilot re-engaged with no success. At the same time, the FDR recorded movement of half full back side of the left sidestick.
- At 06:40:52 UTC, the AP1 reengaged. At that time, the altitude matched altitude target and ALT mode engaged. The existing vertical speed was more than 2,000 feet/minute due to the inertia the autopilot could not maintain the target altitude and the aircraft continued to climb. At 06:41:05 UTC and the pilot voluntary disengaged the autopilot to correct the aircraft altitude. The pilot flew the aircraft manually for approximately 20 seconds. Subsequently, the aircraft stabilized, the autopilot re-engaged and the aircraft flown with the autopilot.

High Speed Protection (refer to FCOM DSC-27-20-10-20 P 6/8)

The aircraft automatically recovers following a high speed upset. Depending on the flight conditions (high acceleration, low pitch attitude), the High Speed Protection is activated at/or above VMO/MMO. When it is activated, the pitch trim is frozen. Positive

spiral static stability is introduced to 0° bank angle (instead of 33° in Normal Law), so that with the sidestick released, the aircraft always returns to a bank angle of 0°. The bank angle limit is reduced from 67° to 45°.

As the speed increases above VMO/MMO, the sidestick nose-down authority is progressively reduced, and a permanent nose-up order is applied to aid recovery to normal flight conditions. The High Speed Protection is deactivated when the aircraft speed decreases below VMO/MMO, where the usual normal control laws are recovered.

The autopilot disconnects when high speed protection goes active.

Note: OVERSPEED ECAM warning is provided at:

- VMO +4 knots
- MMO +0.006

At 06:40:13 UTC, the AP1/ATHR was engaged and in Mach mode, with the speed was managed with target of 0.8 Mach. The FDR recorded the aircraft speed was 0.852 Mach (recording sampling rate was 1 pulse per second (pps)), the recalculated wind showed a 15 knots head wind gust (11 knots/second) then the Master Warning was recorded on FWC (recording sampling rate was 1 pps) while VMO/MMO warning was not recorded.

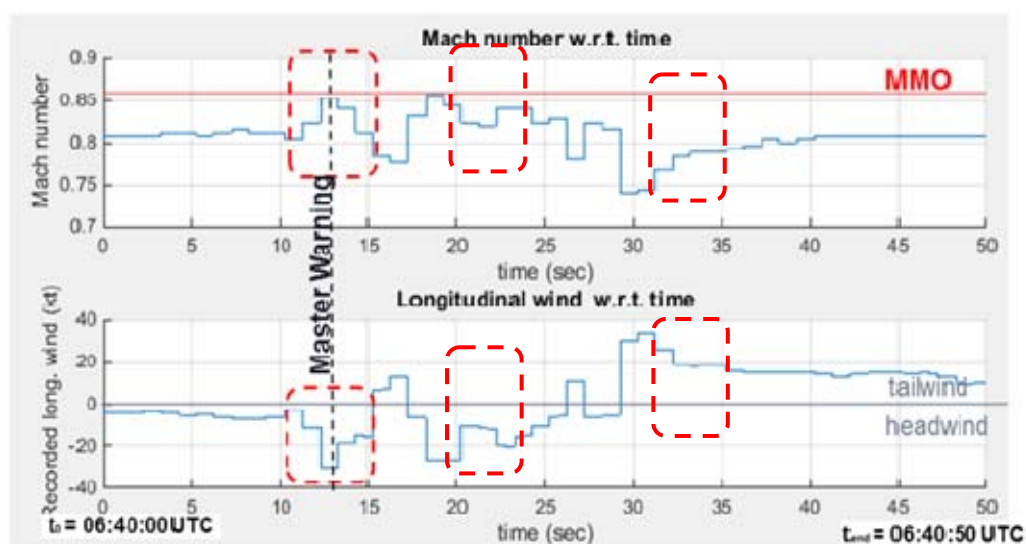


Figure 15: The aircraft speed and the rapid change of wind profile

Analysis of headwind gust:

At 06:40:13 UTC, a headwind gust was recorded and recalculated at that time (refer to wind calculation). Head wind increases the aircraft speed. At that time, the aircraft speed recorded was 0.852 Mach (Mach Number from Air Data Computer/MNADC). Note: MNADC was recorded at 1 pps).

Analysis of MMO and Master warning:

There is no confirmation time in FWC to set MMO master warning. Therefore, as soon as the aircraft speed exceeds MMO + 0.006 (= 0.866), the master warning triggers immediately. MMO is part of aircraft definition and is set to 0.86 in (see FCOM LIM-13 Page 1).

Most likely MMO + 0.006 exceeded and master warning triggered very transiently around 06:40:13 UTC. The Master Warning was recorded only on side 2 in the FDR. This was likely due to a very brief exceedance of MMO + 0.006 (< 1 second) and the sampling rate of Master Warning acquisition (1 pps). Moreover, for the same reason, likely VMO/MMO warning was too brief (< 1 second) to be recorded by the FDR.

Reversion Flight Control Law from Normal to Alternate Law

At 06:40:29 UTC, the FDR recorded wind variation from 10 knots headwind inverted to 39 knots tailwind in one second. The Calibrated Air Speed (CAS) varied from 258 knots to 227 knots in less than one second. The Integrated Standby Instrument System (ISIS) recorded the CAS varied from 258 knots to 227 knots in less than one second. This condition reflected to Flight Control Primary Computer (FCPC), in this time FCPC would not utilize the Air Data Reference (ADR) and the FCPC performed data acquisition for 10 seconds prior utilized the speed data from ADR.

Consequence of this speed variation was recorded in the ECAM message NAV IAS DISCREPANCY and reverted the flight control Normal Law to Alternate Law also triggered the Master Caution.

1.17 Organizational and Management Information

| | | |
|-------------------------------|---|--|
| Aircraft Owner | : | Union Five Leasing Limited |
| Address | : | Walker House, 87 Mary Street, George Town, Grand Cayman KYI-9002, Cayman Islands |
| Aircraft Operator | : | Etihad Airways |
| Address | : | New Airport Road, PO Box 35566, Abu Dhabi, United Arab Emirates |
| Aircraft Operator Certificate | : | AC-0003 |
| Validity | : | 31 October 2017 |

Etihad had been conducting regular flights from Abu Dhabi International Airport (OMAA), Abu Dhabi, United Arab Emirates⁵ to Soekarno-Hatta International Airport (WIII) Jakarta, Indonesia⁶ since 2006

For the purpose as references for analysis, the investigation has included some relevant parts from Etihad procedures and policies which are related to the occurrence.

1.17.1 Operations Manual Part A

The Etihad Operations Manual Part A (OM-A), and related sub-parts, is both the GCAA accepted and approved method of operation by Etihad compliant with CAR-OPS 1 and applicable regulations. The OM-A defines operational policies, procedures, instructions and guidance necessary for company operations personnel to perform their duties.

⁵ Abu Dhabi International Airport (OMAA), Abu Dhabi, United Arab Emirates will be named as Abu Dhabi for the purpose of this report.

⁶ Soekarno-Hatta International Airport (WIII), Jakarta, Indonesia will be named as Jakarta for the purpose of this report.

In chapter 1.4.1 of the OM describes the Commander (PIC) authorities, duties and responsibility, part of this chapter describes the Authority, Duties and Responsibility of Commander and these stated that;

The commander shall:

- Be responsible for the operation and safety of the aircraft from the moment the aircraft is first ready to move for the purpose of taxiing prior to take-off, until the moment it finally comes to rest at the end of the flight and the engine(s) used as primary propulsion units are shut down;
- Familiarize himself with all applicable regulations, documentation and briefing materials for the intended route of flight, destination and alternate airfields. Additionally, the commander shall familiarize himself with both oxygen escape routes and terrain escape routes.

Pre-Flight Preparation and Information

The OM-A subchapter 8.1.12.3 included flight preparation instruction which described several flight documents and forms to be carried onboard for each Etihad flights, and include the update meteorological information. In addition, the subchapter 8.3.1.1 also describe in flight weather monitoring that require pilots to monitor meteorological conditions during the enroute phase of flight to include at least current weather and forecasts for destination airport as well as enroute of alternate airport(s) if applicable.

In this flight, the pilot has been given with the updated meteorological information refer to subchapter 8.3.1.1

Use of Seatbelt during Flight

8.3.16.6 Use of Seatbelt Sign

On Ground before departure

Anytime the "Fasten seatbelt" sign is switched "ON", this indicates that all passengers must be seated with their seatbelt fastened. This does not apply to the cabin crew until "CABIN SECURE" is reported to the flight deck by the Cabin Manager.

It is the Commander's responsibility for the proper usage of "Fasten seatbelt" sign for the safety of passengers and cabin crew.

The "Fasten seatbelt" shall be switched "ON" during the cockpit preparation only after fueling has been completed.

Once the aircraft doors are closed and armed, the cabin crew shall ensure all the passengers are seated in their seats with their seatbelt fastened (including infants – using infant seatbelts or approved CRD) until such time the "Fasten seatbelt" sign is switched OFF by the Commander.

During Climb

When passing 10,000ft AGL, the Commander may switch "OFF" the seatbelt sign or he may advise the CM on the interphone to carry out their duties while the seat belt sign remains ON.

During Cruise

When turbulence is expected / experienced or at any such time the Commander sees necessary, the "Fasten seatbelt" sign should be switched "ON".

During the cruise phase of flight, the CM shall verify with the Flight Crew, and note down two specific time estimates:

- *The estimated time for Top of Descent; and*
- *The estimated time for Arrival (touchdown)*

Within five minutes of the Top of Descent, the Flight Crew should make a PA to passengers (contents in Company owned iPad - Pilot Handbook).

Prior to Top-of-Descent (TOD)

Within five minutes of the Top of Descent, the Flight Crew should make a PA to passengers (contents in Company owned iPad - Pilot Handbook).

At Top-of-Descent (TOD)

Based on actual descent, the CM shall make the Top of Descent PA to advise passengers and cabin crew of the start of cabin preparations for landing (semi cabin securing). Cabin Crew shall semi-secure all cabins except for seatbelts and lavatories.

At 10,000ft AAL (Seat Belt Sign ON)

Just before 10,000 feet AAL, the Flight Crew will make a short PA "Cabin Crew 10 minutes to Arrival". This PA will give the Cabin Crew the time remaining to touch down and should be modified to advise of significantly longer or shorter time remaining. The Pilot Monitoring (PM) will make this short PA. The CM shall make the final approach PA.

If the "Fasten seatbelt" signs are still OFF approaching 10,000 feet AAL, Flight Crew will deliver this PA before switching ON the "Fasten seatbelt" sign to avoid interrupting the automatic PA (if fitted).

On ground after landing

Once the aircraft comes to a complete stop with engines switched "OFF", the flight crew shall make a PA "Cabin Crew disarm doors and cross check".

Once all doors are disarmed, flight crew shall verify cabin doors disarmed before switching OFF the "Fasten seatbelt".

8.3.8.3 Turbulence

8.3.8.3.1 General

Turbulence is the result of atmospheric or environmental effects.

En-route turbulence accounts for a substantial number of passenger and/or cabin crew injuries and can occur at anytime and at any altitude.

Turbulence can be expected or it can be sudden and unexpected, intensity can vary and is relative to location of the occupants in the aircraft. Generally the rear of the aircraft will experience greater turbulence intensity than the front.

The following procedure emphasises the importance of passenger and crew member use of the seatbelts during the flight and to ensure correct communication and

coordination between flight and cabin crew.

The safety of the cabin crew members is paramount during turbulence conditions.

8.3.8.3.2 Crew and Passenger Briefing

The Commander shall include a weather / turbulence briefing with the standard pre-departure crew briefing. This will allow the CM to plan possible service modifications prior to expected turbulence encounter and advise the crew accordingly.

During the welcome PA, the Commander shall advise passengers to keep their seatbelts fastened during the entire flight whilst seated.

Cabin crew shall re-enforce the Commander's brief regarding continued use of seatbelts throughout the duration of the flight whilst seated.

12.12.1 Urgency

A condition concerning the safety of an aircraft or other vehicle, or some person on board or within sight, which does not require immediate assistance. The appropriate phraseology is the word "PAN PAN" repeated three times.

12.12.2 Distress

A condition of being threatened by serious and/or imminent danger and requiring immediate assistance. The appropriate phraseology is the word "MAYDAY" repeated three times.

In case of abnormal conditions "priority for landing" may be requested from ATC to avoid any holding due to traffic. If ATC does not comply with the request the Commander shall decide, depending on the situation, whether an emergency declaration is required.

Note: The Urgent and Distress signal consist of as many as possible of the following elements spoken distinctly and, if possible, in the following order:

- 1. name of the station addressed (time and circumstances permitting);*
- 2. the identification of the aircraft;*
- 3. the nature of the distress condition;*
- 4. intention of the person in command;*
- 5. present position, level (i.e. flight level, altitude, etc., as appropriate) and heading.*

1.17.2 Flight Crew Operating Manual (FCOM)

Auto Flight – General (DSC-22_10-10 P 2/8)

GENERAL PHILOSOPHY

The Flight Management Guidance and Envelope System (FMGES) provide predictions of flight time, mileage, speed, economy profiles and altitude.

It reduces cockpit workload, improves efficiency, and eliminates many routine operations generally performed by the flight crew.

Auto Flight – Flight Guidance (DSC-22_30)

INTERACTION BETWEEN AP/FD AND A/THR MODES (DSC-22_30-10 P 6/6)

The AP and FD pitch modes can control a target SPD/MACH or a vertical trajectory, and the A/THR mode can control a fixed thrust or a target SPD/MACH. However, the AP/FD and the A/THR cannot both control a target SPD/MACH simultaneously.

Therefore, the AP/FD pitch modes and A/THR mode are coordinated as follows:

- If an AP/FD pitch mode controls a vertical trajectory, the A/THR mode controls the target SPD/MACH.*
- If an AP/FD pitch mode controls a target SPD or MACH, the A/THR mode controls the thrust.*
- If no AP/FD pitch mode is engaged, the A/THR mode reverts to controlling the SPD/MACH mode.*

In other words, the selection of an AP/FD pitch mode determines the associated A/THR mode.

AP ENGAGEMENT

The flight crew can engage AP1 or AP2 by pressing the corresponding pushbutton on the FCU if the aircraft has been airborne for at least 5 s.

When one AP is engaged, the corresponding FCU pushbutton comes on and AP1 (or 2) is displayed on the FMAs.

In BACK-UP NAV, AP can be engaged in selected modes if the FG part is available.

AP can be engaged when:

- Aircraft speed is within VLS and VMAX*
- Aircraft pitch angle does not exceed 10 ° nose down or 22 ° nose up*
- Bank angle is less than 40 °*
- On ground, if the engines are not running. It disengages when one engine is started*
- Two APs may be engaged at a time (AP1 active, AP2 in standby), when the localizer/glide-slope, roll out or go-around mode is armed or engaged.*
- Only one AP can be engaged at a time in all other cases*
- If one AP pb is set to ON with both FDs OFF, the AP engages in HDG V/S or TRK FPA mode, depending upon which mode the flight crew has selected on the FCU*
- If one AP pb is set to ON with at least one FD already ON, the AP engages in the current active FD modes*

AP engagement increases the break out force on the sidestick controllers and on the rudder pedals.

AP engagement is indicated by the lighting of the corresponding FCU pushbutton, and by the appearance of AP1 (or 2) on the PFD's FMA.

AP DISENGAGEMENT

AP1 or 2 disengages when:

- The flight crew presses the takeover pb on the sidestick, or*
- The flight crew presses the corresponding AP pb on the FCU, or*

- *The flight crew pushes on the sidestick harder than a certain threshold. (the disengagement with rudder pedals is only active on ground), or*
- *The other AP is engaged, except when localizer/glideslope modes are armed or engaged, or when the rollout or go-around mode is engaged, or*
- *All thrust levers are set above the MCT detent and the aircraft is on ground, or*
- *During a non-precision approach with FINAL APP mode engaged, the aircraft reaches first:*
 - o *Either the Missed Approach Point (MAP), or*
 - o *The MDA/MDH -50 ft (if a MDA/MDH is entered), or 400 ft AGL (if no MDA/MDH is entered), or*
- *One of the engagement conditions is lost.*

In addition, in normal law with all protections available, the AP will disengage when:

- *High speed protection activates, or*
- *Angle-of-attack protection activates:*
 - o *From the liftoff to 100 ft RA during the landing, when $\alpha_{prot} + 1^\circ$ is reached, or*
 - o *Below 100 ft RA during the landing, when α_{MAX} is reached, or*
- *Pitch attitude exceeds 25° up, or 13° down, or bank angle exceeds 45° , or*

The standard manner for the flight crew to disengage the AP is to press the takeover pb on the sidestick.

When the AP is OFF, the associated pushbutton on the FCU goes off, and AP1 (or AP2) disappears from the FMA.

AP WARNINGS

When the AP is disengaged, the system warns the flight crew:

- *If the flight crew disengages it with the takeover pb on the sidestick, the warnings are temporary*
- *If the disengagement results either from a failure, from the flight crew pushing the pushbutton on the FCU, or from a force on the sidestick, the visual and audio warnings are continual.*

1.17.3 Flight Crew Training Manual

The flight procedures for adverse weather and the use of weather radar are explained in the Etihad Flight Crew Training Manual (FCTM) of chapter SI-010 and SI-070.

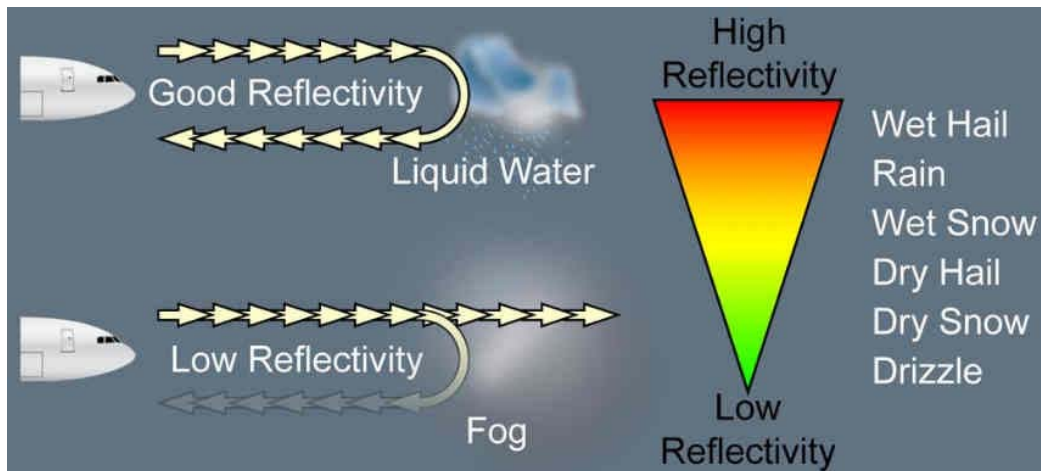
The chapter reflected that the aircraft can suffer the turbulence in the range of 20 Nm, and areas of known turbulence with cumulonimbus clouds (CB) must be avoided at least 20 nm laterally, and the decision must be taken as early as possible. The good management of the radar tilt is essential, in order to accurately assess and evaluate the vertical development of CBs, the gain should be left in Auto.

The weather detection of the weather radar is based on the reflectivity of water droplets. The weather echo appears on the ND with a color scale that goes from red which indicates high reflectivity to green which indicates low reflectivity.

The intensity of the weather echo is associated with the droplet size, composition and quantity, for example the reflectivity of a water particle is five times more than an ice particle of the same size. The pilot must be aware that the weather radar does not detect

weather that has small droplets such as clouds or fog, or that does not have droplets such as clear air turbulence.

Weather Radar Principle

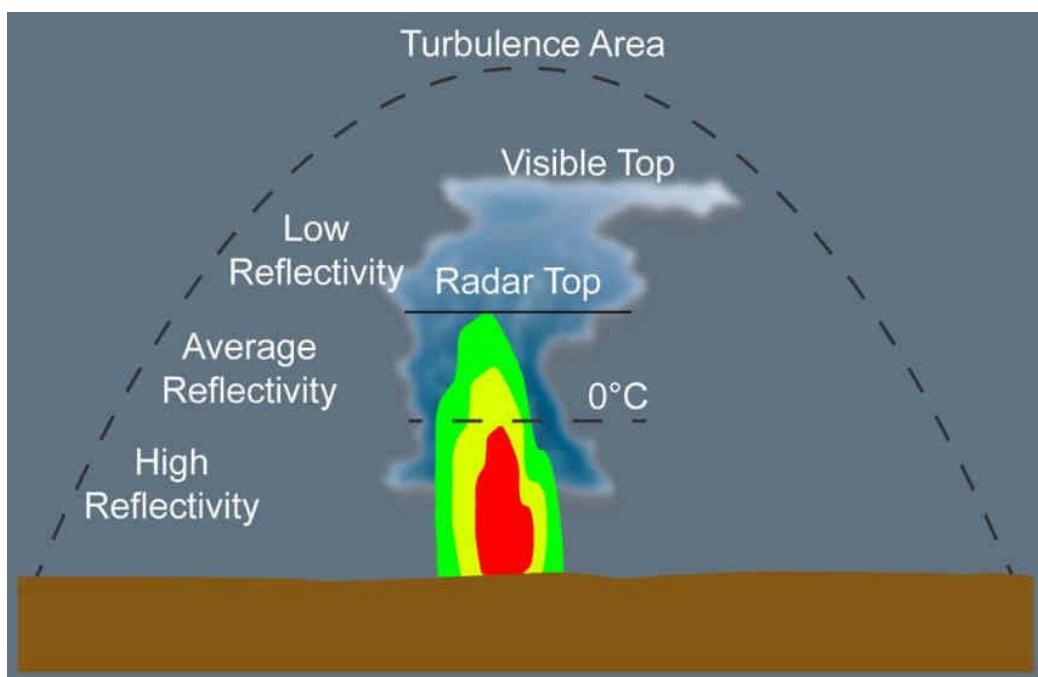


The purpose of the weather radar is to help the flight crew detect and avoid storm cells (e.g. cumulonimbus). Due to its large vertical expansion, a storm cell does not have the same reflectivity depending on the altitude. The quantity of liquid water in the atmosphere decreases with the altitude.

Therefore, the reflectivity of a storm cell decreases with the altitude. The upper detection limit of the weather radar is called the radar top. The flight crew must be aware of both of the following:

- The radar top is not the visible top of the storm cell
- The storm cell and associated turbulence extend significantly above the radar top.

Reflective Image of a Cumulonimbus



Weather Radar - On Path Envelope Boundaries Definition (DSC-34-60-15 P 1/6)

The radar takes into account a vertical envelope along the vertical flight path of the aircraft. It defines if the weather echo is on the aircraft flight path or not.

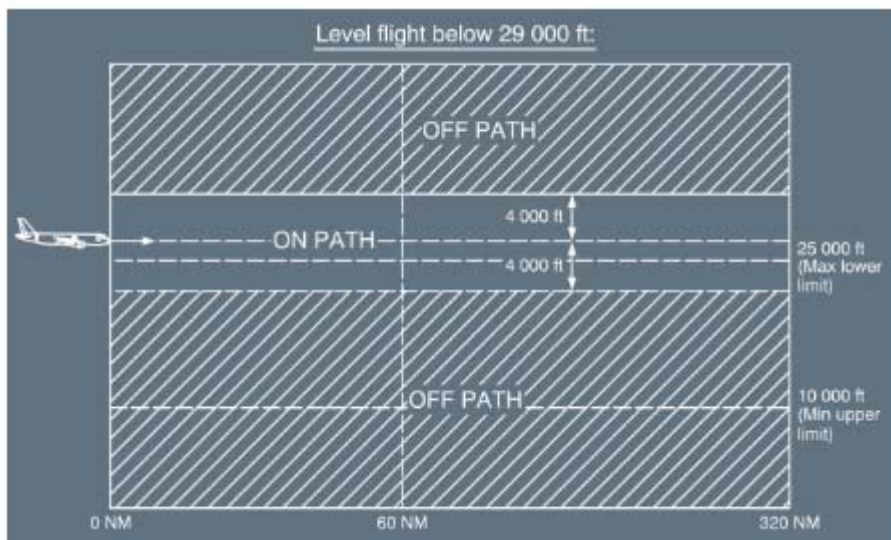
| Aircraft Altitude (feet MSL) | Lower Envelope Boundary (feet MSL) | Upper Envelope Boundary (feet MSL) |
|------------------------------|---|--|
| > 29,000 | 25,000 | Flight Altitude plus 4,000 (max: 60,000) |
| 6,000 to 29,000 | Flight Altitude minus 4,000 (min: Gnd Elev) | |
| < 6,000 | | 10,000 |

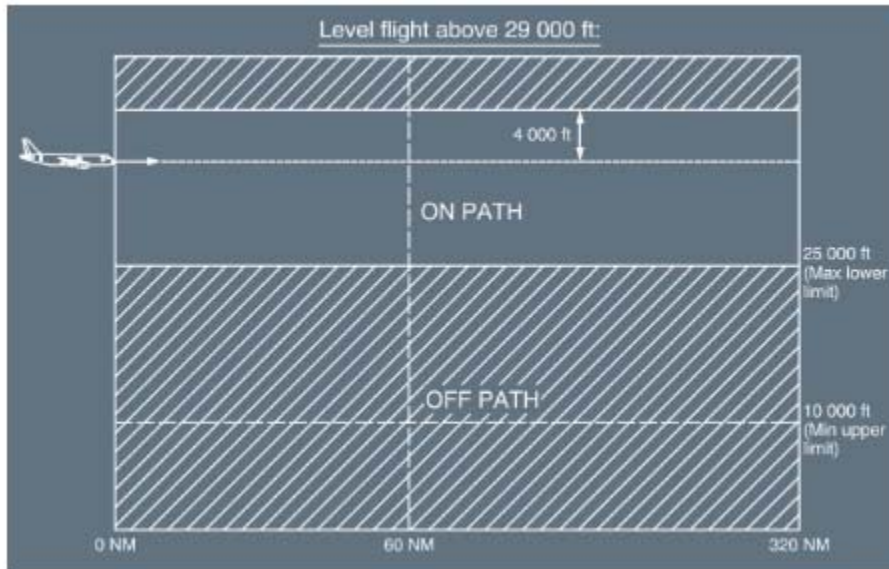
ON PATH envelope limits

The basis ON PATH envelope is bounded at plus and minus 4 000 ft of the reference flight path. The lower envelope boundary is fixed at 25 000 ft when the aircraft is above 29 000 ft. The upper envelope boundary is set at 10 000 ft when the aircraft is below 6 000 ft. The ON PATH envelope is based on a reference flight path defined as follows: The current speed vector is extrapolated to 60 nm ahead of the aircraft based on the ratio between vertical speed and ground speed . Beyond 60 nm, the ON PATH envelope is based to a levelled reference flight path. As a result, the ON PATH envelope is defined as follows:

LEVEL FLIGHT

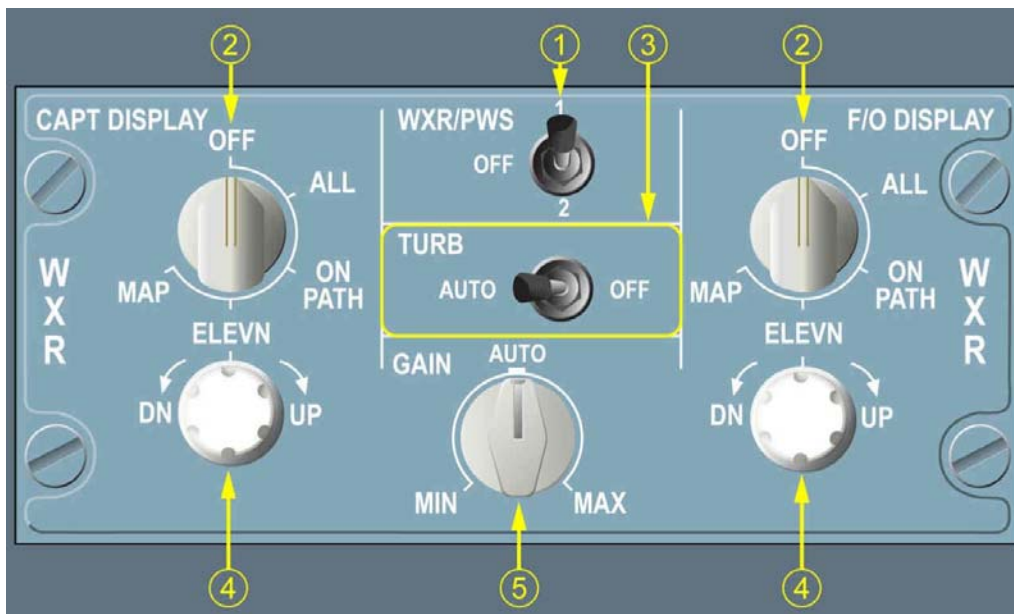
During level flight the ON PATH envelope extends from 4 000 ft above to 4 000 ft below the aircraft's altitude. However, the lower boundary cannot go higher than 25,000 ft and the upper boundary cannot go lower than 10,000 ft.





Weather Radar – Control and Indicators (DSC-34-60-30 P 2/22)

CONTROL PANEL



1.17.4 Pilot Handbook

In section 1.1.1.1.1 of the Pilot Handbook describes that the PIC shall made a welcome announcement prior to departure which advises passenger to have their seat belts fastened even when the seat belt signs are switched off. The recommended text for the pilot announcement was as follows:

"The weather en-route is forecasted to be generally smooth (or mostly smooth with a few bumps occasionally). Kindly observe the seat belt sign and keep your seatbelts fastened while seated in case we encounter any unexpected turbulence even if the seatbelt sign is off".

1.17.5 Safety & Emergency Procedure Manual

The Safety & Emergency Procedure Manual (SEPM) is part of OM-A which contained the safety and emergency procedures performed by Etihad aircrew.

The subchapter 5.4.2 In-flight Announcements describes the procedure of flight attendant announcements related to the safety of the flight, including the use of seat belt, electronic devices and other information while aircraft on the ground and all phases of the flight.

Specifically, one minute after landing gear retraction the passenger announcement contains a recommendation for passenger to keep the seatbelt fastened when seated, asleep and when the seatbelt sign is on.

8.1.1 Notification of an Abnormal Event or Emergency Situation

Abnormal Event

Should an abnormal event arise on the ground or on in-flight, the Commander should alert the cabin crew using the Flight Crew and Cabin Crew Standard Emergency Calls/Communication.

Emergency Situation

Should an emergency situation arise on the ground or in-flight, the Commander shall make a PA: "This is the Captain, Cabin Manager to the Cockpit Immediately" upon hearing the PA:

- The CM must immediately report to the cockpit to receive the NITS briefing from the Commander.*
- The minimum cabin crew will discretely stop any activity and shall stand by their respective stations.*
- Additional cabin crew shall report to CM/CS station and stand by to receive the NITS briefing from the CM.*

8.1.2 NITS (Nature, Intentions, Time and Special Instruction) Briefing and Cabin Crew Actions

NITS briefing is a structured method of communication between the flight crew and cabin crew and the Commander's discretion, it may be used to brief cabin crew in a non-emergency situation, abnormal event or emergency situation. It does not always mean that an emergency situation has arisen.

The Commander shall brief the CM in a clear, precise, structured and concise manner providing the following information:

| <i>NITS BRIEFING</i> | | |
|----------------------|--|---|
| | <i>Definition</i> | <i>Examples</i> |
| <i>Nature</i> | <i>Nature of the abnormal event or emergency situation</i> | <ul style="list-style-type: none"><i>• Diversion</i><i>• Significant technical malfunction</i> |
| <i>Intentions</i> | <i>Intention of the Commander</i> | <i>Landing at (name of airport or</i> |

| | | |
|-----------------------------|---|---|
| | | <i>location), expecting a</i> <ul style="list-style-type: none"> • <i>Normal landing</i> • <i>Emergency Landing (ground or ditching)</i> |
| <i>Time</i> | <i>Time available before touch down</i> | <ul style="list-style-type: none"> • <i>XX minutes to touch down</i> |
| <i>Special Instructions</i> | <i>Special Instructions</i> | <ul style="list-style-type: none"> • <i>Start cabin preparations for a normal landing</i> • <i>Start cabin preparations immediately for emergency landing</i> |

Once the NITS briefing is received, the CM shall repeat the NITS briefing back to the flight crew to ensure that the instructions have been understood correctly. The CM must clarify any doubts before proceeding to the cabin to brief the rest of the crew.

Note: The flight crew and CM should synchronize their watches to assist with time management.

If a NITS briefing is provided following the emergency notification from the flight crew, the CM shall brief the rest of the crew as follows:

- *The CM will initiate an ALL ATTENDANT CALL from CM station*
- *The CM will request an individual confirmation for the cabin crew of their presence in a horse shoe pattern, starting from forward to aft LHS, followed by aft to forward RHS.*

1.17.6 Seatbelt Sign on Aircraft

The Etihad Airways had signage on each passenger seat which reminds passengers to keep their seat belts fastened when seated in English and Arabic language. The following were the examples of the signage.



Figure 16: The signage on passenger seat

1.18 Additional Information

1.18.1 Turbulence

Standard terminology for turbulence adopted from FAA AC No 120-88A, date 1/19/06, titled: Preventing Injuries caused by turbulence.

Parts of the AC states:

STANDARD TERMINOLOGY FOR TURBULENCE

The following terminology is endorsed by the Commercial Aviation Safety Team, from the Aeronautical Information Manual (<http://www.faa.gov/atpubs/>)

DURATION OF TURBULENCE

Occasional : Less than 1/3 of the time.

Intermittent : 1/3 to 2/3 of the time.

Continuous : More than 2/3 of the time.

NOTE: Duration may be based on time between two locations or over a single location. All locations should be readily identifiable.

TURBULENCE INTENSITY

Light Chop: Slight, rapid, and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude.

Light Turbulence: Slight, erratic changes in altitude and/or attitude. Occupants may feel a slight strain against seatbelts. Unsecured objects may be displaced slightly. Food service may be conducted and little to no difficulty is encountered in walking.

Moderate Chop: Rapid bumps or jolts without appreciable changes in aircraft altitude or attitude.

Moderate Turbulence: Changes in altitude and/or attitude occur but the aircraft remains in positive control at all times. It usually causes variations in indicated airspeed. Occupants feel definite strain against seatbelts. Unsecured objects are dislodged. Food service and walking are difficult.

Severe: Large, abrupt changes in altitude and/or attitude. Usually causes large variations in indicated airspeed. Aircraft may be momentarily out of control. Occupants are forced violently against seatbelts. Unsecured objects are tossed about. Food service and walking are impossible.

Extreme: Aircraft is violently tossed about and is practically impossible to control. May cause structural damage.

TURBULENCE TYPES

Thunderstorm Turbulence: Turbulence associated within and in the vicinity of thunderstorms or cumulonimbus clouds. A cumulonimbus cloud with hanging protuberances is usually indicative of severe turbulence.

Clear Air Turbulence: High level turbulence (above 15000') not normally associated with cumuliform cloudiness. Typically, windshear turbulence even when in cirrus clouds.

Mountain Wave Turbulence: Turbulence as a result of air being blown over a mountain range or a sharp bluff causing a series of updrafts and downdrafts.

PROCEDURES KNOWN TO BE EFFECTIVE AGAINST TURBULENCE

The following procedures have been identified by the CAST and are suggested as standard operating procedures for voluntary implementation by U.S. air carriers

MAXIMIZE THE INFORMATION ABOUT YOUR FLIGHT CONDITIONS

- *Inform ATC of turbulence at check in with new controller.*
- *Inform ATC when un-forecasted turbulence is encountered en route.*
- *Inform company via ACARS or dispatch frequency so that following flights will be aware of the flight conditions or be planned on another route.*
- *Inform/query other aircraft operating in the area on a common frequency.*
- *Query ATC about "the rides" when you check in with a new controller/sector.*

WHEN INFORMED OF TURBULENT FLIGHT CONDITIONS:

- *Prior to departure, seek alternate routing to avoid the affected areas or delay departure until conditions improve.*
- *Change en route altitudes or routes to avoid the turbulence.*
- *Slow to the manufacturer's recommended turbulence penetration speed.*
- *Prior to descent, seek alternate routing to avoid the affected areas or, if severity*

dictates, hold or divert to alternate.

- *AVOID any convective activity (CBs) en route by at least 20 nautical miles.*

GENERAL TURBULENCE PROCEDURES

If flight into forecast turbulence is unavoidable, timely notification to the cabin crew is crucial to their safety.

If turbulence is expected before the flight departs, the preflight briefing to the lead flight attendant must include turbulence considerations. The briefing can be the same as an inflight briefing for expected turbulence including:

- *Actions the captain wants the cabin crew to undertake any time turbulence is expected*
- *Intensity of turbulence expected*
- *Methodology for communicating to the cabin the onset or worsening of turbulence, e.g., cabin interphone or PA*
- *Phraseology for the cabin crew to communicate the severity of turbulence*
- *Expected duration of the turbulence and how an “all-clear” will be communicated*

Utilize a positive signal of when cabin crew may commence their duties after takeoff and when they should be seated and secured prior to landing.

Passengers will be informed of routine turbulence via the PA system. Do not rely on the seatbelt sign alone.

Cabin crew will be informed of routine turbulence via the interphone.

If at any time the cabin crew experiences uncomfortable turbulence without notice from the flight crew, they must immediately take their seats and inform the flight crew.

All service items must be properly stowed and secured when not in use.

TURBULENCE ONSET CATEGORIES

Expected Turbulence: Advance notice exists for the Captain to brief the cabin crew either prior to the flight or in-flight via the interphone.

Little Warning: Sufficient warning exists to seat the passengers and for the cabin crew to perform their duties.

Imminent Turbulence or Turbulence Occurring: Sudden, unexpected or imminent turbulence requiring immediate action to protect cabin crew and passengers.

INJURY AVOIDANCE ACTIONS

Expected Turbulence

Captain can thoroughly brief the cabin crew on the expected turbulence level and its duration.

Clearly articulate expectations from the cabin crew and request confirmation of completed actions.

Instruct the cabin crew to immediately and plainly report any deviations from the expected turbulence level.

Develop a method to inform the cabin crew of the completion of the turbulence event.

Little Warning

Captain turns on seatbelt sign and makes a public address announcement, "Flight Attendants stow your service items and take your seats. Passengers please remain seated until this area of turbulence has passed and I have cleared you to move about the cabin."

Cabin crew stows all applicable service items, performs cabin compliance check, and secures themselves in their jump seats.

Lead flight attendant informs captain of the completion of these items.

When conditions improve, captain uses the public-address system to advise the cabin crew that they may resume their duties and whether or not the passengers may move about the cabin.

Imminent Turbulence or Turbulence Occurring

Captain turns on seatbelt sign and makes a public-address announcement, "flight attendants and passengers be seated immediately. Passengers please remain seated until this area of turbulence has passed and I have cleared you to move about the cabin."

Cabin crew take first available seat and secure themselves.

No compliance checks are performed and items are secured only if they present no delay in securing a person in a seat.

When conditions improve, captain makes public address announcement advising the cabin crew that they may resume their duties and whether or not the passengers may move about the cabin.

1.18.2 FAA Advisory Circular (AC) 00-24C: Turbulence

4. GENERAL. *Knowledge of thunderstorms and the associated hazards with thunderstorms is critical to the safety of flight. For a thunderstorm to form, the air must have sufficient water vapor, an unstable lapse rate, and an initial upward boost (lifting). A thunderstorm lifecycle progresses through three stages: the cumulus, the mature, and the dissipating. Figure 1, Mature Stage of Thunderstorm, is an example of a mature thunderstorm and the updrafts and downdrafts contained within them. Weather recognizable as a thunderstorm should be considered hazardous, as penetration of any thunderstorm can lead to an aircraft accident and fatalities to those on board. The current edition of AC 00-6 provides more details regarding the atmospheric conditions leading to the formation of thunderstorms.*

5. THUNDERSTORM TYPES. *Thunderstorms pack just about every weather hazard known to aviation. Pilots may encounter thunderstorms of different size and types. Thunderstorm types may be classified as:*

a. Single Cell. *A single cell (or common) thunderstorm cell often develops on warm and humid summer days. These cells may be severe and produce hail and microburst winds.*

b. Thunderstorm Cluster (Multi Cell). *Thunderstorms often develop in clusters with numerous cells. These can cover large areas. Individual cells within the cluster may move in one direction while the whole system moves in another.*

c. Squall Line. *A squall line is a narrow band of active thunderstorms. Often it develops on or ahead of a cold front in moist, unstable air, but it may develop in unstable air far removed from any front. The line may be too long to detour easily around and too wide and severe to penetrate.*

d. Supercell. *A supercell is a single long-lived thunderstorm which is responsible for nearly all of the significant tornadoes produced in the United States and for most of the hailstones larger than golf ball-size.*

7. HAZARDS TO AVIATION. *All thunderstorms have conditions that are a hazard to aviation. These hazards occur in numerous combinations. While not every thunderstorm contains all hazards, it is not possible to visually determine which hazards a thunderstorm contains.*

b. Turbulence.

(1) *Potentially hazardous turbulence is present in all thunderstorms, and a severe thunderstorm can destroy an aircraft. Strongest turbulence within the cloud occurs between updrafts and downdrafts. Outside the cloud, shear turbulence is encountered several thousand feet above and up to 20 miles laterally from a severe storm. Additionally, clear air turbulence may be encountered 20 or more miles from the anvil cloud edge.*

(2) *It is almost impossible to hold a constant altitude in a thunderstorm, and maneuvering in an attempt to do so greatly increases stress on the aircraft. Stresses are least if the aircraft is held in a constant attitude.*

(3) *A low-level turbulent area is associated with the gust front. Often, a “roll cloud” or “shelf cloud” on the leading edge of the storm marks the top of the extreme turbulence zone. Gust fronts often move far ahead (up to 15 miles) of associated precipitation. The gust front causes a rapid and sometimes drastic change in surface wind ahead of an approaching storm.*

(4) *The downward moving column of air in a typical thunderstorm is large. The resultant outflow may produce wind shear, and in some cases the most severe type of wind shear, the microburst. A microburst is a small-scale, intense downdraft that when reaching the surface, spreads outward in all directions from the downdraft center. Virga, streaks of precipitation falling from a thunderstorm cloud but not reaching the ground, may precede a microburst. The current edition of AC 00-54, Pilot Windshear Guide, explains in greater detail the hazards associated with gust fronts, wind shear, and microbursts.*

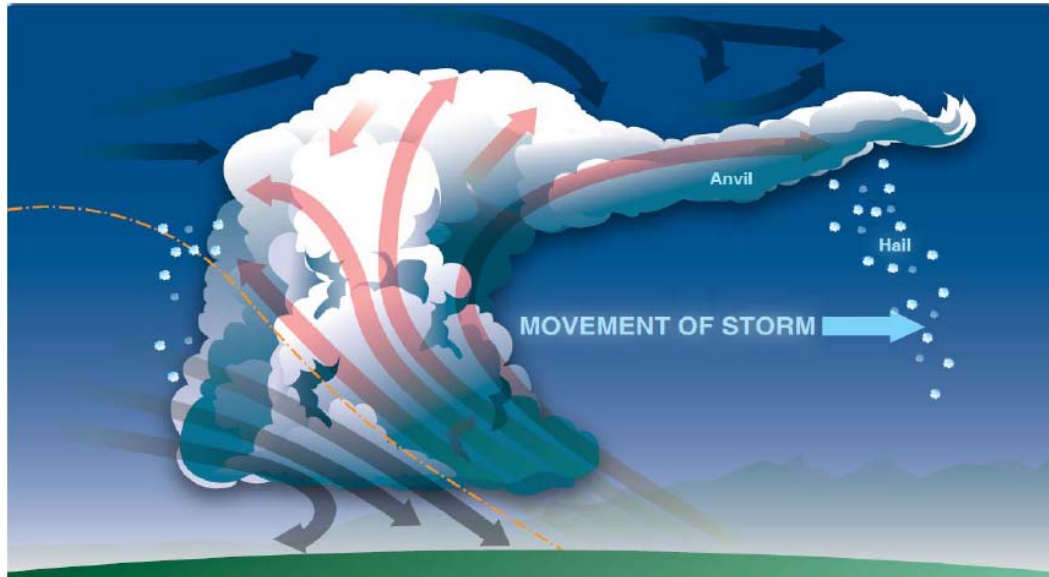


FIGURE 2. MOVEMENT AND TURBULENCE OF A MATURING THUNDERSTORM

9. AIRBORNE WEATHER RADAR.

a. Airborne Weather Avoidance Radar. Airborne weather avoidance radar is, as its name implies, for avoiding severe weather—not for penetrating it. Whether to fly into an area of radar echoes depends on echo intensity, spacing between the echoes, and the capabilities of the pilot and the aircraft. The ability of airborne weather radar to detect weather phenomena is limited in both direction and range. Additionally, weather radar detects only precipitation drops; it does not detect turbulence. Therefore, the radar display provides no assurance of avoiding turbulence. The radar display also does not provide assurance of avoiding instrument weather conditions from clouds and fog. A phenomenon, called attenuation, may exist when a cell absorbs or reflects all of the radio signals sent by the radar system. Attenuation may prevent the radar from detecting additional cells that might lie behind the first cell. This is often referred to as a radar “shadow.” For aircraft equipped with airborne weather radar, pilots should be familiar with the operating techniques and limitations of the specific system.

b. Airborne Weather Radar Echo Avoidance. Remember that while hail always gives a radar echo, it may fall several miles from the nearest visible cloud, and hazardous turbulence may extend to as much as 20 miles from the echo edge.

c. Intense or Extreme Echo Avoidance. Avoid heavy or extreme level echoes by at least 20 miles (i.e., such echoes should be separated by at least 40 miles before flying between them). Pilots may reduce the distance for avoiding weaker echoes.

10. DOS AND DON'TS OF THUNDERSTORM AVOIDANCE.

a. Thunderstorm Avoidance. Never regard any thunderstorm lightly, even when radar observers report the echoes are of light intensity. Avoiding thunderstorms is the best policy. Following are some dos and don'ts of thunderstorm avoidance:

(1) Don't land or takeoff in the face of an approaching thunderstorm. A sudden gust front of low-level turbulence could cause loss of control.

(2) Don't attempt to fly under a thunderstorm even if you can see through to the other side. Turbulence and wind shear under the storm could be hazardous.

- (3) *Don't attempt to fly under the anvil of a thunderstorm. There is a potential for severe and extreme clear air turbulence.*
- (4) *Don't fly without airborne radar into a cloud mass containing scattered embedded thunderstorms. Scattered thunderstorms not embedded usually can be visually circumnavigated.*
- (5) *Don't trust the visual appearance to be a reliable indicator of the turbulence inside a thunderstorm.*
- (6) *Don't assume that ATC will offer radar navigation guidance or deviations around thunderstorms.*
- (7) *Don't use data-linked weather next generation weather radar (NEXRAD) mosaic imagery as the sole means for negotiating a path through a thunderstorm area (tactical maneuvering).*
- (8) *Do remember that the data-linked NEXRAD mosaic imagery shows where the weather was, not where the weather is. The weather conditions may be 15 to 20 minutes older than the age indicated on the display.*
- (9) *Do listen to chatter on the ATC frequency for Pilot Weather Reports (PIREP) and other aircraft requesting to deviate or divert.*
- (10) *Do ask ATC for radar navigation guidance or to approve deviations around thunderstorms, if needed.*
- (11) *Do use data-linked weather NEXRAD mosaic imagery (e.g., Flight Information Service-Broadcast (FIS-B)) for route selection to avoid thunderstorms entirely (strategic maneuvering).*
- (12) *Do advise ATC, when switched to another controller, that you are deviating for thunderstorms before accepting to rejoin the original route.*
- (13) *Do ensure that after an authorized weather deviation, before accepting to rejoin the original route, that the route of flight is clear of thunderstorms.*
- (14) *Do avoid by at least 20 miles any thunderstorm identified as severe or giving an intense radar echo. This is especially true under the anvil of a large cumulonimbus.*
- (15) *Do circumnavigate the entire area if the area has 6/10 thunderstorm coverage.*
- (16) *Do remember that vivid and frequent lightning indicates the probability of a severe thunderstorm.*
- (17) *Do regard as extremely hazardous any thunderstorm with tops 35,000 feet or higher whether the top is visually sighted or determined by radar.*
- (18) *Do give a PIREP for the flight conditions.*
- (19) *Do divert and wait out the thunderstorms on the ground if unable to navigate around an area of thunderstorms.*

1.19 Useful or Effective Investigation Techniques

The investigation was conducted in accordance with the KNKT approved policies and procedures, and in accordance with the standards and recommended practices of Annex 13 to the Chicago Convention.

2 ANALYSIS

The investigation concerns to several safety issues related to the aircraft encounter turbulence and the crewmember action after the turbulence. The aircraft serviceability was considered not related to the event, therefore the analysis will discuss the relevant issues are as follows:

- Adverse weather and turbulence detection;
- Crewmember action;
- Fasten seatbelt policy.

2.1 Adverse Weather and Turbulence Detection

Refer to FAA Advisory Circular Number 00-24C, a potential for hazardous turbulence is present in all thunderstorms, and a severe thunderstorm can destroy an aircraft. Strongest turbulence within the cloud occurs between updrafts and downdrafts while outside the cloud, shear turbulence is encountered several thousand feet above and up to 20 miles laterally from a severe storm.

The Existence of Severe Turbulence

Utilizing the FDR data, the investigation examined the three-dimensional wind profile between 06:40:10 and 06:40:32 UTC, which was the time that turbulence occurred and affected the aircraft behavior for 22 seconds. The result of the examination indicated:

- On the longitudinal axis, wide-ranging wind speed values of varying head to tail wind for two to four second intervals were recorded. The speed variation was greater than 10 knots per second with the highest value of 39 knots/second.
- On the lateral axis, wide-ranging wind speed values of 15 knots from the right, and up to 17 knots from the left, were recorded over approximate 1.2 seconds (average 25 knots/second).
- On the vertical axis, wide-ranging upward and downward gusts between 9 knots/second and 39 knots/second, were recorded within a time interval of between one to four seconds.

The FDR data during the turbulence showed:

- The altitude varied between 38,750 and 39,450 feet. The vertical speed fluctuated between -2,500 and +2,000 feet/minute.
- The pitch varied between -5° and +2°.
- The vertical acceleration varied between -0.65 and +1.95 G.

The result of the examination of wind profile and FDR data showed large and abrupt changes in altitude, attitude and large variation in airspeed.

Refer to FAA Advisory Circular (AC) No 120-88A, date 1/19/06, titled: Preventing Injuries caused by turbulence, severe turbulence defined as large, abrupt changes in altitude and/or attitude. Usually causes large variations in indicated airspeed. Aircraft may be momentarily out of control. Occupants are forced violently against seatbelts. Unsecured objects are tossed about. Food service and walking are impossible.

Based on the definition, it can be concluded that the aircraft experienced severe turbulence.

Turbulence detection

The Honeywell RDR 4000 radar fitted to the aircraft, is capable of detecting weather based on the reflection of water droplets, and to some extent, turbulence based on the Doppler detection of the movement of water droplets ahead of the aircraft.

The prognosis chart also highlighted the development of cumulonimbus cloud which may have extended above FL470 (47,000 feet) in the vicinity of Sumatera Island, where near to the area when the aircraft encountered turbulence.

The pilots stated that they did not enter any cloud at the time of the turbulence encounter.

Based on the information from the prognosis chart combined with satellite weather image, and the evidence of severe turbulence, it is likely that the aircraft was flying in the vicinity of thunderstorm when it encountered severe turbulence. The exact distance from the cloud could not be determined but statements from the pilots indicate that the aircraft did not enter these clouds. As the weather radar detection is based on the presence of water droplets, the area of turbulence may therefore not have been evident to the pilots however, based on the description of the Airbus FCTM and FAA Advisory Circular, turbulence may occur outside the cumulonimbus cloud and may up to 20 Nm laterally.

2.2 Crewmember Action

At 06:40:32 UTC, the autopilot was disengaged by the activation of the side-stick instinctive pushbutton and no side-stick activity recorded. From 06:40:35 UTC, the flight crew attempted to reengage the autopilot, at the same time the FDR recorded sidestick input. The sidestick activation prevented the reengagement of the autopilot.

At 06:40:52 UTC, the autopilot successfully reengaged, the existing vertical speed was more than 2,000 feet/minute due to aircraft inertia as result in the turbulence therefore the autopilot could not maintain the altitude target. The aircraft continued to climb and at 06:41:05 UTC the pilot disengaged the autopilot to correct the aircraft altitude manually.

At 06:41:30 UTC, the autopilot reengaged continuously.

After encountered turbulence, the aircraft resumed steady flight, the cabin manager conducted cabin check and announced to the passengers about the recent unexpected turbulence. The CVR recorded conversation between PIC and cabin manager concerning to the severe damages of the aircraft interior and serious injury to the passengers and crew, and these were acknowledged by the PIC. This particular condition could be classified as an abnormal event and required special attention as well as preparation for the crew.

The Safety & Emergency Procedure Manual (SEPM) subpart 8.1.1 Notification of an Abnormal Event or Emergency Situation described when abnormal event occurred the PIC should call the Cabin Manager to the cockpit to provide the Nature, Intentions, Time Special Instructions (NITS) briefing. The NITS briefing is to organize the effectiveness of preparation prior to and after the aircraft landed.

However, the investigation did not find any indication that the NITS briefing had been conducted by the crewmember prior to and after the aircraft landed.

According to the OM-A on subchapter 12.12.1, a call "PAN PAN" shall be repeated three times to the air traffic controller if there is a condition concerning the safety of the aircraft or some person on board or within sight, which does not require immediate assistance. The call of "PAN PAN" might be interpreted by the air traffic controller by giving a special guidance as priority to land.

While subchapter 12.12.2, a condition of being threatened by serious and/or imminent danger and requiring immediate assistance. The appropriate phraseology is the word "MAYDAY" repeated three times.

After turbulence the cabin manager assessed the condition of the cabin and informed the PIC related to the damages to the cabin interior and the injured occupants. This situation was acknowledged by the PIC who then contacted ground handling provider in Jakarta requesting for assistant on arrival. The PIC also informed the Etihad Airways flight operations in Abu Dhabi via the Aircraft Communications Addressing and Reporting System (ACARS) concerning the recent inflight turbulence.

The PIC considered the urgency message to air traffic controller was not required. Since there was no call of "PAN PAN" the air traffic controller had caused no special attention and priority to shorten the time to land.

2.3 Fasten Seat Belt Policy

The OM-A subchapter 8.3.16.6 Use of Seatbelts stated that once the aircraft doors are closed and armed, the cabin crew shall ensure all the passengers are seated with seatbelt fastened until the "Fasten Seatbelt" sign is switched OFF. The cabin crew shall recommend the passengers to keep the seat belt fastened during seated. In addition, the FCTM describes that before entering the known area of turbulence, the seat belt sign should be switched ON. It means that the passengers have to fasten their seat belt and the cabin crews have to take special awareness while doing their activities in the cabin.

Prior encountering turbulence, the cabin crews were conducting the preparation for arrival after more than 5 hours flying in clear weather, with no turbulence since departure. At this time the fasten seat belt sign was OFF.

These particular conditions most likely degraded the cabin crew ability to identify the passengers who did not have their seatbelts fastened. This condition was consistent with the fact that most of the injured passengers did not wear the seat belt during the severe turbulence.

Golding (2000), in his research of Turbulence and its Impact on Commercial Aviation stated that the policy to fasten the seatbelts whenever passenger seated was not strictly enforced in United States of America. This research is likely also applicable for most commercial aviation in the world.

This may indicate that the policy for passenger to fasten the seat belt whilst seated was not effectively implemented during at least in this flight.

3 CONCLUSIONS

3.1 Findings⁷

This finding should not be read as apportioning blame or liability to any particular organization or individual. These findings were collected from the factual information, ongoing investigation and the safety issues collected from the analyses which are listed as follow:

1. The aircraft was airworthy prior to the occurrence and was operated within the weight and balance envelope.
2. The crew held valid licenses and medical certificates.
3. The forecasted weather highlighted development of cumulonimbus clouds that may develop more than FL470 (47,000 feet) near the area of severe turbulence occurrence.
4. In this flight, the Pilot in Command (PIC) acted as Pilot Flying (PF), Second in Command (SIC) acted as Pilot Monitoring (PM), and third pilot (P3) seated on the jump seat.
5. Prior to the occurrence, the aircraft was generally steady at altitude of 39,000 feet.
6. The aircraft weather radar did not detect any cloud on the aircraft flight track, since its detection is based on the reflectivity of water droplets, the weather radar does not detect weather that has small droplets such as clouds or fog, or that does not have droplets such as clear air turbulence.
7. The FCTM describes that known of turbulence around the CBs must be avoided at least 20 nm laterally, and before entering the known turbulence the Seat Belt sign should be turned ON.
8. The flight crew noticed cumulus cloud on the flight path and decided not to enter the cloud.
9. Between 06:40:10 to 06:40:32 UTC, the aircraft entered severe turbulence. During the turbulence, the cabin crews were conducting the preparation for arrival procedure. The severe turbulence resulted in the damages on the aircraft cabin interior and serious injury to the passengers and cabin crews.
10. 06:40:30 – 06:40:40 UTC the flight control law reverted to Alternate Law due to Computed Air Speed (CAS) dropped for more than 30 knots within one second, as resulted in the change of wind direction during the turbulence. Consequence of this speed variation was recorded in the ECAM message NAV IAS DISCREPANCY and reverted the flight control Normal Law to Alternate Law also triggered the Master Caution.
11. At 06:40:32 UTC, the auto pilot disengaged by activation of the sidestick instinctive push button. At 06:40:35 UTC the autopilot re-engagement was unsuccessfully due

⁷ Findings are statements of all significant conditions, events or circumstances in the accident sequence. The findings are significant steps in the accident sequence, but they are not always causal, or indicate deficiencies. Some findings point out the conditions that pre-existed the accident sequence, but they are usually essential to the understanding of the occurrence, usually in chronological order.

to the activation of sidestick.

12. At 06:40:52 UTC, the autopilot was successfully re-engaged after the altitude target was captured, however the existing vertical speed was more than 2,000 feet/minute due to aircraft inertia as result of the turbulence resulted in the autopilot could not maintain the selected altitude.
13. The PIC acknowledged the injured occupants and the damages to the cabin interior and considered urgency message was not required. This caused no special attention and priority provided by the air traffic controller to shorten the time to land.
14. The Safety & Emergency Procedure manual subchapter 8.1.2 described, when abnormal event occurred the PIC should call the Cabin Manager to the cockpit to provide the Nature, Intentions, Time Special Instructions (NITS) briefing. The CVR did not record that the NITS briefing was conducted.
15. Fasten Seat belt policy was available in the operator manuals and on each passenger seats however, the policy of fasten the seat belt during seated was not effective implemented at least in this flight.
16. The past 5 hours flying in clear weather and the flight attendant activities for arrival most likely degraded the flight attendant attention to identify the passengers who did not fasten the seat belt. The condition was consistent with most of the injured passengers did not wear the seat belt during the severe turbulence.

3.2 Contributing Factors⁸

The aircraft was flying within the turbulence area of the thunderstorm which the turbulence area was not anticipated and no warning provided to the cabin crew and passengers.

- The aircraft was flying outside the visible cloud which was within the turbulence area of the thunderstorm.
 - The turbulence was not anticipated and no warning provided to the cabin crew and passengers.
-

⁸ Contributing Factors are those events in which alone, or in combination with others, resulted in injury or damage. This can be an act, omission, conditions, or circumstances if eliminated or avoided would have prevented the occurrence or would have mitigated the resulting injuries or damages.

4 SAFETY ACTION

At the time of issuing this final report, the Komite Nasional Keselamatan Transportasi had been informed of corrective actions resulting from this occurrence taken by Etihad Airways responding to the KNKT recommendation on preliminary report.

On 12 July 2016, the Etihad Airways issued Flight Operations Message (FOM-218) to remind the entire Etihad Airways flight crew of the proper phraseology and conditions to declare urgency. The detail of the FOM-218 can be found on the appendices.

In the Recurrent Ground Training for April 2017 - September 2017, the Operations Training Department included a module for Thunderstorm Risk Management which addresses the KNKT safety recommendations issued on the Preliminary Report.

5 SAFETY RECOMMENDATIONS

The investigation found that the aircraft was flying into the area of potential turbulence of the thunderstorm.

The KNKT acknowledges the safety actions taken by the Etihad Airways and consider that are relevant, however there still safety issues remain to be considered for the future safety of the flight. Therefore, KNKT issued safety recommendations to address the safety issues identified in this final report and addressed to:

5.1 Etihad Airways

- The Etihad Airways had policies which advises passenger to have their seat belts fastened even when the seat belt signs are switched off. However, the most injured passengers did not wear the seat belt during the severe turbulence.

The KNKT recommends the Etihad Airways to review the effectiveness of the use of seatbelt policies to ensure passenger fastened their seatbelt when seated.

- The Safety Emergency & Procedure manual subchapter 8.1.2 described, when abnormal flight event occurred, the PIC should give the NITS (Nature, Intentions, Time Special Instructions) briefing to cabin crew. However, the investigation did not find NITS briefing to the cabin crew after the turbulence.


The KNKT recommends the Etihad Airways to ensure pilot conducts NITS briefing after abnormal flight event as described in the Safety Emergency & Procedure manual in the subchapter 8.1.2.

5.2 Indonesia Directorate General of Civil Aviation

- The injured passengers were not fastened the seatbelt during the turbulence. KNKT recommends the DGCA to enforce the Indonesia aircraft operators to review the effectiveness of the use of seatbelt policies to ensure passenger fastened their seatbelt when seated.


6 APPENDICES

6.1 Etihad Flight Operations Message



FLIGHT OPERATIONS MESSAGE

FOM-218: July 12, 2016
Subject: PAN/Urgency Call To: All Pilots



Dear Colleagues,

In the interest of promoting best practice, we would like to take this opportunity to highlight the specific details relating to Urgency Calls.

Definition - OM-A 12.12.1 Urgency: A condition concerning the safety of an aircraft or other vehicle, or some person on board or within sight, which does not require immediate assistance. The appropriate phraseology is the word: **"PAN PAN" repeated three times.**

Should an incident occur during a flight that results in injured or critically ill guests or crew on board, it is the Captain's responsibility to declare an Urgency Message to ATC. For clarification purposes, the only call (besides a MAYDAY call) which will automatically give priority during a medical emergency is a PAN call.

The term 'medical emergency' is not appropriate and must not be used. Declaring a 'medical emergency' will not achieve the desired response from Air Traffic Control. Furthermore, without declaring a PAN, there will be no recognition or priority, further wasting time, causing confusion and extra workload for all; especially at a point when arrangements for an expeditious arrival should be a priority.

By following the procedure laid out below, the safest and most expeditious outcome will be assured.

Urgency call procedure:

- "PAN PAN, PAN PAN, PAN PAN"
- Name of station addressed (Abu Dhabi Approach)
- Aircraft Callsign (Etihad 123)
- Type of Aircraft (A320)
- Nature of Emergency (Injured Passengers/Critically ill passengers)
- Intention of Pilot in Command (Request immediate landing at AUH)
- Present or last known position, FL/Altitude and Heading (Only if required)
- Any other information the Pilot in Command deems useful

Thank you all for your continued professionalism, dedication and support.

6.2 Turbulence

Golding, W. L. (2000). *Turbulence and Its Impact on Commercial Aviation*⁹.

The hazards posed by turbulence remain an important issue in commercial aviation. Safety experts say turbulence is the leading cause of in-flight injury to passengers and airline employees, especially flight attendants. Extensive research into methods for alleviating this turbulence hazard has been continuing for many years. This paper addresses the issues pertaining to turbulence, including the causes, impact on commercial aviation, and initiatives undertaken to prevent turbulence-related mishaps today and in the future.

Table 1. Summary of types of turbulence

| Turbulence Type | Cause |
|------------------------|------------------------------------|
| Convective | Uneven heating of earth's surface |
| Mechanical | Obstructions disrupt airflow |
| Mountain-wave | Airflow disrupted by mountains |
| Wake | Aircraft wingtips produce vortices |
| Clear-air | Jet stream associated |

A number of groups, including NASA, FAA and the airlines are working to develop onboard turbulence detection and display systems which are expected to enter service in the future and will provide pilots with a direct indication of the severity of turbulence ahead of their aircraft. Table 2 summarizes these systems.

| Sensor/Display Systems | Capability |
|---------------------------------|--|
| (On-Board) Radar Algorithm | Directly detects convective turbulence |
| SOCRATES | Detects wake turbulence and clear air turbulence |
| LIDAR | Detects clear air turbulence |
| Airborne Doppler Radar | Detects convective turbulence in areas of low reflectivity |
| Wake Vortex Warning and Display | Displays wake vortices on cockpit screen |

CONCLUSION

Despite severe encounters that have damaged large jets, only one crash nearly 40 years ago has been attributed to turbulence, and that occurred because the pilots failed to handle the airliner properly. In addition, those wearing seat belts are seldom injured, and almost never seriously (Morrison, 2001).

A successful program to prevent turbulence-related mishaps must ensure that FAA toughens current in-flight safety regulations to include the airline seat belt policy.

United States carriers encourage passengers to have their seat belts fastened whenever they are seated; however, the policy is not strictly enforced. If FAA were really serious about this issue, seats could be equipped with sensors that would alert the flight attendant when a passenger was seated without the seat belt fastened. Also, incentive programs could be initiated to encourage seat belt use. The cost to airlines in compensation claims and accident investigations has been estimated to be at least \$100 million each year (Anonymous, 1999). An incentive program could operate on a small fraction of that cost. For example, a computer program could reward safe flyers (no seat belt infractions for a mileage prescribed by the airline) with a courtesy flight

⁹ Golding, W. L. (2000). *Turbulence and Its Impact on Commercial Aviation*. Journal of Aviation/Aerospace Education & Research, 11(2). The article can be downloaded from the following link <http://commons.erau.edu/jaer/vol11/iss2/8>.

voucher. Not surprisingly, flight attendants are most likely to be hurt, primarily because they are not buckled into seats when the jet hits turbulence. Also vulnerable, are the few passengers who are not seated, for whatever reason, and the passengers who insist on not having their seat belts fastened even though they are seated. It should be apparent that seatbelts are not the total answer.

A successful program to prevent turbulence-related mishaps must also apply sensor technology to the problem. First, the dynamics of turbulence must be better understood and models improved to provide better forecasts. The benefit will be to assist pilots in preflight planning and inflight strategies for avoiding turbulence. However, forecasts will never be perfect. Second, new sensor technologies capable of detecting various types of turbulence must continue to be explored. Third, prototype multi-sensor turbulence detection systems must integrate onboard radar for convective activity and lidar for clear air turbulence with data link for weather forecasts and pilot reports to warn pilots of the location and severity of turbulence. Fourth, the operational requirements necessary to fully realize the benefits of the turbulence sensor on the aircraft must be examined. The goal is to integrate turbulence sensor data with the cockpit display so that the pilot can refer to it and understand it instantly.

A successful program to prevent turbulence-related mishaps also must be approved by FAA. Two laws spell potential delay for installation of turbulence detection systems by our airlines. The FAA is required by law to balance safety against the financial burden to airlines and manufacturers whenever it considers changes in safety and equipment regulations. Cost could cause delay by adversely impacting the smaller airlines in a significant way. The lidar unit alone is expected to be about \$100,000 with a market as much as \$1 billion (Leib, 1998). Also FAA is required by law to justify the cost of implementing proposed safety measures by showing that enough lives will be saved (Brazil, 1994). This potentially could result in delay. Statistics reveal that from 1981 through December 1997, only three passengers died due to turbulence mishaps affecting major air carriers (FAA, 1997). Therefore, a realistic time frame that the lidar units can win FAA certification and be placed in cockpits of commercial jets is probably between 3 and 10 years (Leib, 1998).

Technology will eventually prevail in preventing turbulence mishaps by producing sensors to provide adequate warning. In the interim the commercial airlines industry should adopt the Turbulence Plot System used by Northwest Airlines and hire in-house meteorologists to monitor, forecast, and relay the latest turbulence information to the carrier's flight crews around the clock. This interim solution would certainly lead to a reduction in turbulence-related mishaps.

Finally, turbulence remains a major threat to flight safety and is a paramount concern to the aviation industry. I believe it's time to translate research into action!

6.3 Life Cycle of a Thunderstorm

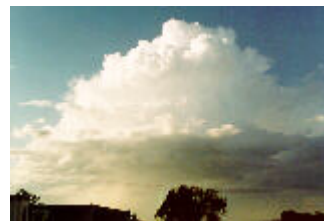
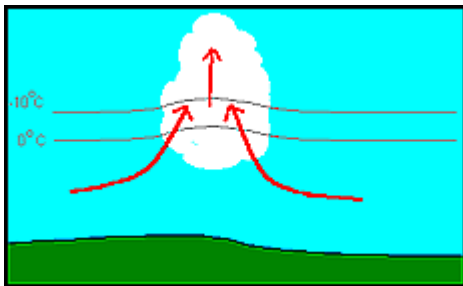
Taken from <http://climate.ncsu.edu/climate/tstorms/lifecycle.php>

Many thunderstorms undergo a three-stage life cycle:

Cumulus Stage (a)

Warm, moist air rises in a buoyant plume or in a series of convective updrafts. As this

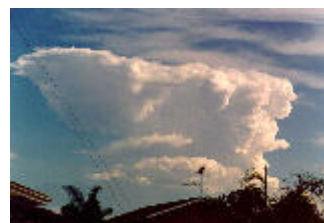
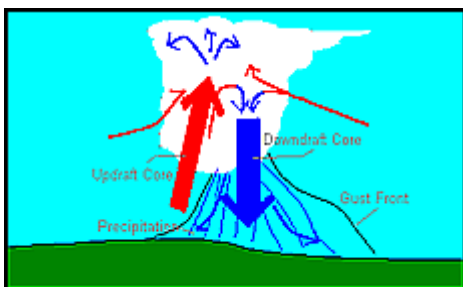
occurs the air begins to condense into a cumulus cloud. The interactions between the rising and cooling air result in the development of a positive feedback mechanism. As the warm air within the cloud continues to rise, it eventually cools and condenses. The condensation releases heat into the cloud, warming the air. This, in turn, causes it to rise adiabatically. The cloud edges during this stage are sharp and distinct, indicating that the cloud is composed primarily of water droplets. The process continues and works to form a towering cumulus cloud. The convective cloud continues to grow upward, eventually growing above the freezing level where supercooled water droplets and ice crystals coexist. Precipitation begins to form via the Bergeron process once the air rises above the freezing level. Falling precipitation and cool air entrainment from the environment start the initiation of cool downdrafts, which leads to the second stage.



Cumulus stage diagram and actual picture

Mature Stage (b)

Characterized by the presence of both updrafts and downdrafts within the cloud. The downdrafts are initiated by the downward drag of falling precipitation. The downdraft is strengthened by evaporative cooling, as the rain falling with the downdraft enters drier air below the cloud base and evaporates. This cold descending air in the downdraft will often reach the ground before the precipitation. As the mature-stage thunderstorm develops, the cumulus cloud continues to increase in size, height and width. Cloud to ground lightning usually begins when the precipitation first falls from the cloud base. During this phase of the life cycle, the top of the resulting cumulonimbus cloud will start to flatten out, forming an anvil shape often at the top of the troposphere.



Mature stage diagram and actual picture with anvil

Decaying Stage (c)

Characterized by downdrafts throughout the entire cloud. Decay often begins when the supercooled cloud droplets freeze and the cloud becomes glaciated, which means that it contains ice crystals. Glaciation typically first appears in the anvil, which becomes more pronounced in this stage. The glaciated cloud appears filmy, or diffuse, with

indistinct cloud edges. The cloud begins to collapse because no additional latent heat is released after the cloud droplets freeze, and because the shadow of the cloud and rain cooled downdrafts reduce the temperature below the cloud. The decay of a thunderstorm can also be initiated when the precipitation within the storm becomes too heavy for the updrafts to support, when the source of moisture is cut off, or when lifting ceases.

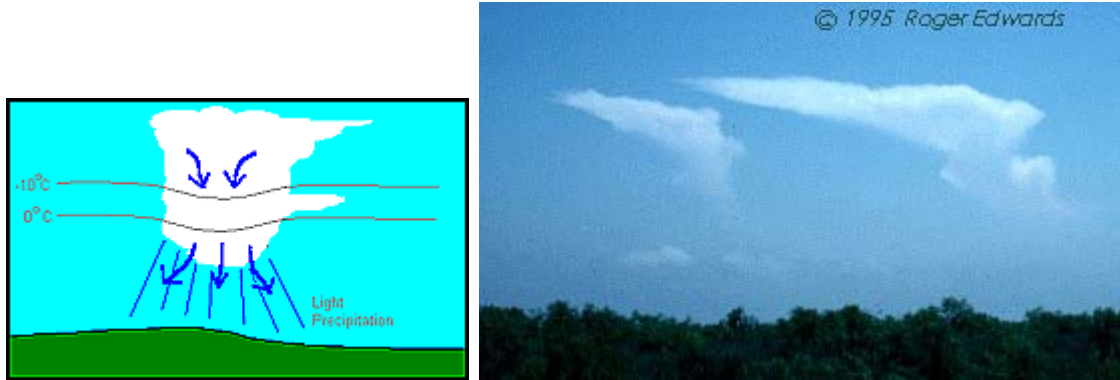
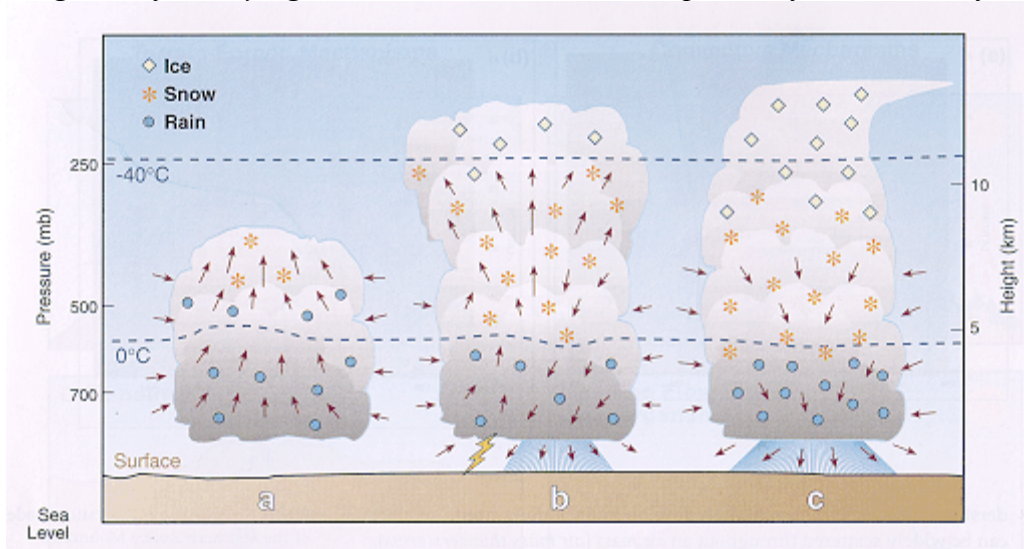


Diagram of decaying thunderstorm and actual photo of remnants of the anvil



The three stages of the life cycle of air mass thunderstorms: (a) cumulus stage, (b) mature stage, and (c) decaying stage. Arrows indicate wind directions. (Adapted from Byers and Braham, 1949)

6.4 GCAA AAIS and Etihad Airways Comments

| No | Report Section | Concerns from the Report | GCAA AAIS/Etihad Airways Comments and References | GCAA AAIS/Etihad Airways Request | KNKT Response |
|----|--------------------------|---|--|--|--|
| 1. | Front page and Figure 1. | Pictures of the aircraft in the report. | Refer to Annex 13 and ICAO Doc 9756 Part IV – Reporting. We prefer not to show any picture of the aircraft in the report as it does not add value to the investigation. | UAE request to remove all pictures of aircraft from the report. | Accepted |
| 2. | Preamble | <i>The preliminary report consists of factual information collected until the preliminary report published. This report will not include analysis and conclusion.</i> | As this statement is referring to the preliminary report, I guess it shall be removed for the final report? | UAE request to remove/amend 3 rd paragraph | Rejected <i>This report was not included with such statement</i> |
| 3. | Abbreviations | <i>FCOM</i> | Incorrect abbreviation | Change <i>Flight Control Operating Manual</i> to “ <i>Flight Crew Operating Manual</i> ” | Accepted |
| 4. | Abbreviations | FOM | Incorrect abbreviation | Change <i>Flight Operating Message</i> to “ <i>Flight Operations Message</i> ” | Accepted |
| 5. | Abbreviations | GCAA | Missing “The” in front of United Arab Emirates | Add the word “ <i>The</i> ” in front of United Arab Emirates | Accepted |
| 6. | Abbreviations | AAIS | Not mentioned in the abbreviations | Add “AAIS – Air Accident Investigation Sector of the United Arab Emirates” | Accepted |

| No | Report Section | Concerns from the Report | GCAA AAIS/Etihad Airways Comments and References | GCAA AAIS/Etihad Airways Request | KNKT Response |
|----|------------------------------------|--|--|--|---|
| 7. | Synopsis | <i>At 0640:10 UTC, the aircraft was on cruising at FL 390 and flying less than 20 Nm beside of cumulonimbus clouds formation, the aircraft encountered in severe turbulence for 22 seconds.</i> | The lateral flying distance from the cumulonimbus has not been established, besides the crews' interview statement. | UAE request to replace "less than 20NM beside" with the words "within the vicinity". | Accepted |
| 8. | 1, 2 and 3 | <ul style="list-style-type: none"> • 1.1, pg 2: <i>The pilot stated that the aircraft flew within 10 to 15 Nm from cumulus cloud formations.</i> • 2.1., pg 45: <i>The pilot stated that the aircraft flew within 10 to 15 Nm from cumulus cloud formations while cruising at 39,000 feet.</i> • 2.4, pg 49: <i>At 0640 UTC, the aircraft was cruising at FL 390 within 10 to 15 Nm side of cumulus clouds formation with the fasten seat belt sign OFF.</i> • 3.1.5, pg 51: <i>At about 15 minutes before top of descent, the aircraft flew within 10 to 15 Nm beside of cumulonimbus clouds formation with the fasten seat belt sign OFF and encountered severe turbulence at 06:40:10 UTC. The pilot switched on the seatbelt sign.</i> | We believe that the statement 10 to 15 Nm was taken from an interview testimony. Has KNKT determined that the CB mentioned by the Captain was the one that generated the turbulence? | UAE request to kindly ensure that that these statements are verified and supported in the final report. | Accepted |
| 9. | Examples are 1.1; 1.11; 1.16; etc. | <p>1.1, pg 3: <i>At 06:40:32 UTC, the pilot voluntary disengaged the autopilot and at 06:40:35 UTC, the pilot re-engaged the autopilot with no success.</i></p> <p>The above statement is only a sample of where the word "voluntary" is used in the report.</p> | <p>Based on Airbus test and research, the autopilot disconnection at 06:40:32 UTC was immediately followed by an attempt by the pilot to re-engage the autopilot 3 seconds later.</p> <p>The immediacy of the attempt to re-engage the autopilot suggests that the disconnection was not done intentionally.</p> | UAE request to replace the word <i>voluntary</i> with <i>accidentally</i> or <i>inadvertently</i> , wherever it is used in the report. | Delete voluntary and changed with "disengage" amended |

| No | Report Section | Concerns from the Report | GCAA AAIS/Etihad Airways Comments and References | GCAA AAIS/Etihad Airways Request | KNKT Response | | | | | | |
|-------------|--|---------------------------------|--|----------------------------------|---------------|-----------|---|-----------|--|--|-----------------|
| | | | <p>Based on the Merriam-Webster Dictionary, Voluntary has the same meaning as intentionally:</p> <ol style="list-style-type: none"> 1. Proceeding from the will or from one's own choice or consent 2. Unconstrained by interference 3. Done by design or intention 4. Of, relating to, subject to, or regulated by the will 5. Having power of free choice 6. Provided or supported by voluntary action 7. Acting or done of one's free will with our valuable consideration or legal obligation. | | | | | | | | |
| 10. | 1.2 | 1.2, pg. 4: Injuries to Persons | <p>Etihad records indicate 1 cabin crew and 6 passengers sustained serious injuries. Etihad records also indicate 3 cabin crew and 14 passengers with minor injuries.</p> <table border="1" data-bbox="797 1018 1339 1345"> <thead> <tr> <th data-bbox="797 1018 936 1098">Patient No.</th> <th data-bbox="940 1018 1339 1098">Comments</th> </tr> </thead> <tbody> <tr> <td data-bbox="797 1101 936 1206">Patient 1</td> <td data-bbox="940 1101 1339 1206">One closed fracture of distal tibia and fibula. Spent one night in hospital. No surgery required.</td> </tr> <tr> <td data-bbox="797 1209 936 1345">Patient 2</td> <td data-bbox="940 1209 1339 1345">Swelling to her neck and spine causing numbness to her arms and legs. Spent over 48 hours in hospital.</td> </tr> </tbody> </table> | Patient No. | Comments | Patient 1 | One closed fracture of distal tibia and fibula. Spent one night in hospital. No surgery required. | Patient 2 | Swelling to her neck and spine causing numbness to her arms and legs. Spent over 48 hours in hospital. | As there is a difference with the records of injured crew and passengers, UAE request to replace the numbers in table 1.2 according to the what has been confirmed. This is mentioned in the table below item #11. | Accepted |
| Patient No. | Comments | | | | | | | | | | |
| Patient 1 | One closed fracture of distal tibia and fibula. Spent one night in hospital. No surgery required. | | | | | | | | | | |
| Patient 2 | Swelling to her neck and spine causing numbness to her arms and legs. Spent over 48 hours in hospital. | | | | | | | | | | |

| No | Report Section | Concerns from the Report | GCAA AAIS/Etihad Airways Comments and References | | GCAA AAIS/Etihad Airways Request | KNKT Response |
|----|----------------|--------------------------|---|---|----------------------------------|---------------|
| | | | Patient 3 | A lot of swelling to his neck and spine causing significant numbness to his arms and legs. Spent over 48 hours in hospital. | | |
| | | | Patient 4 | Closed/stable fractures in her spine, long duration in hospital (over 48 hours) and after discharge will require a lot of follow up and home care/assistance. Due to other existing medical conditions she was not a candidate for surgery. | | |
| | | | Patient 5 | A lot of swelling to her neck and spine causing significant numbness to her arms and legs. Spent over 48 hours in hospital. | | |
| | | | Patient 6 | Falls under major category as she spent over 48 hours in hospital, this patient developed blood pressure/heart complications due to the trauma of her chest area hitting the seat in front, she then developed complications such as pneumonia as she was bed bound and unable to breath properly (due to injury). She had extensive bruising to her neck, back and left shoulder | | |
| | | | As for the passengers with minor injuries, all experienced soft tissue injuries, minor lacerations, bruising and loss of teeth. Out of the 14 passengers sent to hospital with injuries that fall under the minor | | | |

| No | Report Section | Concerns from the Report | GCAA AAIS/Etihad Airways Comments and References | GCAA AAIS/Etihad Airways Request | KNKT Response | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|------------|----------------|--|--|---|-----------------|------------|-------------------|--------|-------|---|---|---|---|---------|---|---|---|---|------------|---|----|----|---|------|---|-----|-----|---|-------|----|-----|-----|---|---|-----------------|
| | | | <p>category, ten were discharged from the Emergency Room (so not technically hospital admissions), four were admitted but length of stay was less than 48 hours.</p> <p>One cabin crew sustained serious injuries which included a fracture to her spine and bruising. Three other cabin crew sustained minor head injuries and bruising.</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11. | 1.2 | 1.2, pg 4: Injuries to Persons | <p>The numbers under category None is currently blank</p> <table border="1" data-bbox="795 606 1355 957"> <thead> <tr> <th>Injuries</th> <th>Flight Crew</th> <th>Passengers</th> <th>Total in Aircraft</th> <th>Others</th> </tr> </thead> <tbody> <tr> <td>Fatal</td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> </tr> <tr> <td>Serious</td> <td>1</td> <td>6</td> <td>7</td> <td>-</td> </tr> <tr> <td>Minor/none</td> <td>3</td> <td>14</td> <td>17</td> <td>-</td> </tr> <tr> <td>None</td> <td>8</td> <td>242</td> <td>250</td> <td>-</td> </tr> <tr> <td>Total</td> <td>12</td> <td>262</td> <td>274</td> <td>-</td> </tr> </tbody> </table> | Injuries | Flight Crew | Passengers | Total in Aircraft | Others | Fatal | - | - | - | - | Serious | 1 | 6 | 7 | - | Minor/none | 3 | 14 | 17 | - | None | 8 | 242 | 250 | - | Total | 12 | 262 | 274 | - | <p>UAE request:</p> <p>Row for ‘None’: Add 8 to Flight Crew; 242 to Passengers; and 250 in Total in Aircraft.</p> <p>Row for “Total”: Flight Crew 12; Passengers 262; and Total in Aircraft Total 274.</p> <p>Alternatively, remove the row for None.</p> | Accepted |
| Injuries | Flight Crew | Passengers | Total in Aircraft | Others | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fatal | - | - | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Serious | 1 | 6 | 7 | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Minor/none | 3 | 14 | 17 | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| None | 8 | 242 | 250 | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total | 12 | 262 | 274 | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12. | 1.5. | 1.5.1; 1.5.2; 1.5.3; pages 4, 5 and 6: Personnel Information | <p>Refer to Annex 13 and ICAO Doc 9756 Part IV – There is no significance to include gender, age, nationality, marital status, and date of joining company as the Investigation did not confirm if these were a factor in the occurrence.</p> | <p>UAE request to remove gender, age, nationality, marital status, and date of joining company from all pilots’ personnel information</p> | Accepted | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13. | 1.5. | 1.5.1; 1.5.2; 1.5.3; pages 4, 5 and 6: Personnel Information | <p>Even though with reference to Annex 13 and ICAO Doc 9756 Part IV it is mentioned to have a brief description of each flight crew personnel information, we would like to suggest for the report to show this information in a table format.</p> | <p>UAE request to combine the three flight crewmembers personnel information into a single table</p> | Rejected | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| No | Report Section | Concerns from the Report | GCAA AAIS/Etihad Airways Comments and References | GCAA AAIS/Etihad Airways Request | KNKT Response |
|-----|----------------|--|--|--|--|
| 14. | 1.7, and 3.1 | <ul style="list-style-type: none"> • 1.7; pg 8: <i>The forecasted weather on the chart highlighted development of cumulonimbus clouds up to FL470 (47,000 feet) near the aircraft flight plan track (figure 3).</i> • 3.1.3; pg 51: <i>The forecasted weather on the chart highlighted thunderstorms and development of cumulonimbus clouds above FL470 near the aircraft flight plan track.</i> | <p>Choice of the word “near” is ambiguous and is subjective. A distance of 40 to 50 Nm away from forecasted turbulence is measurable and thus can be considered far.</p> <p>From the Flight Plan package: In the Jakarta FIR/UIR, the aircraft's flight plan route paralleled the forecasted CB cloud. From the boundary to PKP VORDME, the aircraft was not planned any closer than 50Nm. At the location of turbulence, the area of forecasted turbulence was not less than 40Nm for the event location.</p> | <p>UAE request that the KNKT quantify the meaning of “near” as it can mislead the reader.</p> | <p>Accepted</p> <p>The word “near” 1.7 & 3.1.3 amended.</p> |
| 15. | 1.7 | <p>1.7; pg 8 and 9: <i>The satellite weather image around Sumatera and Bangka islands area issued by Meteo France on 4 April 2016 at 0640 UTC indicated development of cumulonimbus clouds near the area when the aircraft encountered turbulence (yellow circle in figure 4).</i></p> | <p>Satellite imagery at 06:37UTC (3 minutes) prior to the turbulence did not indicate any cumulonimbus activity in the vicinity of the event area. This would preclude the weather radar system from picking up returns on the aircraft system. The image at 06:47UTC does indicate strong convective activity at the location. See satellite imagery for 04/05/2016 06:37UTC on page 2 and page 3 of the attached report by WxFUSION.</p> | <p>As the KNKT did not have a satellite image in the report prior to the one shown at 0640 UTC, the UAE request to mention in the report that the cumulonimbus cloud may have developed rapidly, which was therefore missed by the aircraft systems.</p> | <p>Accepted</p> |
| 16. | 1.11. | <p>1.11.1; pg 11: <i>06:40:35 UTC, the AP re-engaged and voluntary disengaged one second later.</i></p> | <p>At 06:40:35, the pilot attempted to re-engage the autopilot but the autopilot system did not allow re-engagement</p> <p>Refer to Airbus report, section 5.3 on page 22</p> <p><i>Around 3 sec after AP disconnection, the flight crew attempted to reengage the AP with no success. This is likely due to an internal logic that prevents AP re-engagement during 3 sec after a voluntary AP</i></p> | <p>On page 11, at bullet point 06:40:35, UAE request to replace <i>re-engaged and voluntary disengaged one second later</i> with <i>re-engagement was attempted but not successful.</i></p> | <p>Accepted</p> |

| No | Report Section | Concerns from the Report | GCAA AAIS/Etihad Airways Comments and References | GCAA AAIS/Etihad Airways Request | KNKT Response |
|-----|----------------|--|--|--|---|
| | | | <i>disconnection.</i> | | |
| 17. | 1.11. | 1.11.2; pg 11 & 12: <i>6:40:32 Sound similar with autopilot disengage.</i> <i>6:40:34 Cavalry charge, sound similar with autopilot disengage</i> | Is this sound at 6:40:32 the same as the Cavalry charge as described 2 seconds later? Are you referring to the click sound with the button being pressed? | If it is a button clicking sound at 6:40:32, UAE request to please amend report to indicate this. | The CVR time had been verified and confirm it was the same. |
| 18. | 1.12 | 1.12; pages 12 & 13: Wreckage and Impact Information | Section 1.12 as the name suggests, relates to an aircraft that has experienced an accident resulting in wreckage or impact. A6-EYN does not fall into this category involving wreckage or impact as there was only interior cabin panel damages. | Even though Annex 13 and Doc 9756 mentions that section 1.3 (Damage to aircraft) should be a brief statement of the damage sustained to the aircraft, the UAE request that the information contained in section 1.12 to be amended and moved to section 1.3 of the report. | Accepted |
| 19. | 1.14 | 1.14; pg 14: <i>There was no evidence of fire in-flight or after the aircraft impacted terrain</i> | The aircraft performed a normal landing. Impact with terrain makes it sound like the aircraft crashed. See last paragraph in section 1.1 “At 0724 UTC, the aircraft landed safely in Jakarta...” | UAE request to reword the statement to reflect that there was no aircraft impact. | Rejected |
| 20. | 1.15 | 1.15; pg 14: <i>The cabin crew and a passenger qualified as medical doctor checked the injured occupants and administer first aid requirement.</i> | The cabin crew did perform first aid on passengers based on the training given to them by Etihad. | UAE request to add an additional paragraph to the end of section 1.15 to read, “ <i>The first aid performed by the cabin crew was</i> | Rejected |

| No | Report Section | Concerns from the Report | GCAA AAIS/Etihad Airways Comments and References | GCAA AAIS/Etihad Airways Request | KNKT Response |
|-----|----------------|---|--|--|---|
| | | | | <i>consistent with their training.”</i> | |
| 21. | 1.16 | 1.16; pg 15: <i>On the longitudinal axis of the runway,</i> - <i>On the lateral axis of the runway,</i> - <i>On the vertical axis of the runway</i> | See Figure 10 on page 16, Acceleration axes are based on aircraft axes not runway. | UAE request to replace <i>runway</i> with <i>aircraft</i> for the three axes. | Accepted |
| 22. | 1.16 and 2.2 | <ul style="list-style-type: none"> • 1.16; pg 19 point 3: <i>At 06:40:30 UTC, the flight control reverted from Normal to Alternate Law most likely due to the change of the speed above the MMO as resulted in the change of wind during the turbulence.</i> • 2.2; pg 47: <i>This momentary speed exceedance caused the CAS was rejected by FCPC and the flight control reverted to Alternate Law for 10 seconds.</i> • 2.2; pg 48: <i>At 06:40:30 UTC, the flight control reverted to alternate law most likely due to the exceedance of aircraft speed (above the MMO).</i> | <p>Exceeding MMO is not a criteria for reversion to alternate law. See DSC-27-20-20-10. Loss of autopilot during reversion to Alternate Law occurs when:</p> <ul style="list-style-type: none"> • THS JAM • THS POS FAULT • ONE ELEV FAULT • YAW DAMPER ACT LOST • ALL ENG OUT • DOUBLE IR FAULT • DOUBLE ADR FAULT <p>Moreover, Figure 14 on pg 18 of the report, indicates that at 06:40:30, a “<i>Sharp CAS evolution-> 3 CAS rejected by the FCPCs caused a reversion to ALTN Law for 10 seconds.</i>”</p> | <p>The UAE request to revisit the applicable statements referring to reversion to alternate law and state the reasons why the aircraft systems would allow reversion to alternate law. Alternatively, the KNKT is requested to strike out the incorrect information from the report as mentioned</p> | Accepted |
| 23. | 1.17 and 1.18 | <ul style="list-style-type: none"> • 1.17; Organizational and Management Information; from pages 22 to 36; Referenced and copied text • 1.18; Additional Information from pages 37 to 44: Referenced and copied text. | There is a lot of verbatim copying of information from other manuals and publications. Some of the copied text, including sections 1.18.2 and 1.18.3, has conclusions which is the opinion of the author and not the conclusion or opinion of the Investigation. Even though the information in these sections is of value in terms of general knowledge, it is reading material that | The UAE believes that copying of text that is not relevant to the occurrence can mislead the readers and does not add value to the Investigation. | The Turbulence article has been removed to appendix |

| No | Report Section | Concerns from the Report | GCAA AAIS/Etihad Airways Comments and References | GCAA AAIS/Etihad Airways Request | KNKT Response |
|-----|----------------|---|---|--|-----------------|
| | | | is available on the internet. | KNKT is kindly requested to review the copied information from pages 22 to 44 and keep only what has been used to develop the Analysis in section 2 of the report. In addition, the UAE request that if the Investigation still believes that non-analytical copied text is required, that this information to be attached as an appendix to the report. | |
| 24. | 1.17 | 1.17.1; pg 23: <i>Meteorological Information during Flight Operation.</i> | During the pre-departure phase of this flight, the most current meteorological information was available and provided to the operating crew. There is no evidence to prove otherwise. Refer to OFP package. | On page 23, the UAE request to add a sentence to indicate that there was no evidence to indicate that out of date meteorological information was given to the operating crew at the preflight/dispatch phase of the flight. | Accepted |

| No | Report Section | Concerns from the Report | GCAA AAIS/Etihad Airways Comments and References | GCAA AAIS/Etihad Airways Request | KNKT Response |
|-----|-------------------|---|---|---|-----------------|
| 25. | 1.17; 2; 3; and 5 | <p>1.17.3; pages 25 to 27. <i>Safety & Emergency Procedure Manual</i> 2.3; pg 49: <i>However, the investigation did not find any indication that the NITS briefing had been conducted by the crewmember prior to and after the aircraft landed</i></p> <p>3.1.19; pg 52: 19. <i>The Safety & Emergency Procedure manual subchapter 8.1.2 described, when abnormal event occurred the PIC should call the Cabin Manager to the cockpit to provide the Nature, Intentions, Time Special Instructions (NITS) briefing. The CVR did not record that the NITS briefing was conducted.</i></p> <p>5.1; Safety Recommendation (bullet point 4): <i>The Safety Emergency & Procedure manual subchapter 8.1.2 described, when abnormal flight event occurred, the PIC should give the NITS (Nature, Intentions, Time Special Instructions) briefing to cabin crew. However, the investigation did not find such briefing to the cabin crew after turbulence.</i></p> | <p>The NITS briefing is discretionary and not mandatory. In this event, there is no evidence that the absence of a NITS briefing adversely affected the outcome of the event. A NITS briefing would actually be redundant as the Cabin Manager was aware of the nature of the event and was aware of the time left before landing, based on pre-turbulence entry into the cockpit. The cabin and occupants were secured before landing and cabin crew were able to coordinate themselves even without receiving a NITS briefing.</p> <p>Moreover, as the PIC did not declare an emergency, in his mind it was not an emergency. Therefore, in SEPM 8.1.1, it would fall under the category of an abnormal event. A “should” also means that the action is recommended and not mandatory.</p> <p>Refer to SEPM section 8.1.2:</p> <p><i>NITS briefing is a structured method of communication between the flight crew and cabin crew and at the Commander’s discretion, it may be used to brief cabin crew in a non-emergency situation, abnormal event or emergency situation. It does not always mean that an emergency situation has arisen.</i></p> <p>SEPM 8.1.1:</p> <p><i>Should an abnormal event arise on the ground or on in-flight, the Commander should alert the cabin crew using to Flight Crew and Cabin Crew Standard Emergency Calls/Communication.</i></p> <p>SEPM 0.2.7</p> <p><i>“Should” means that the application of a procedure or provision is recommended.</i></p> | <p>The UAE request to:</p> <p>a. Review and summarize relevant information for section 1.17.3.</p> <p>b. Strike out the entirety of section 2.3.</p> <p>c. Strike out all of Finding 19 in section 3.1</p> <p>d. Strike out recommendation 4 in section 5.1</p> | Rejected |
| 26. | 1.17 | 1.17.4; page 30 to 33: <i>WEATHER</i> | At the time of the incident, A6-EYN was fitted with a | On pages 30-33, the | Accepted |

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| | | <p><i>RADAR (DSC-34-60)</i> <i>DESCRIPTION (DSC-34-60-10 P 1/6)</i></p> | <p>Honeywell RDR-4000 weather radar system. The FCOM MSN effectivity had not been updated to match the correctly installed system. The correct page for system description is supposed to be DSC-34-60-10 P5/6, DSC-34-60-15 P1/6-P6/6. The picture of the control panel is on DSC 34-60-30 P2/22.</p> | <p>UAE request to change the weather radar description to match the one installed on the aircraft at the time of the occurrence.</p> | |
| 27. | 2 | <p>2.1; pg45: <i>The good management of the radar tilt is essential, in order to accurately assess and evaluate the vertical development of CBs, the gain should be left in Auto.</i></p> | <p>There was no tilt function on the weather radar system. Therefore tilt management could not be performed.</p> | <p>UAE request to change the statement to reflect what was fitted on the Aircraft.</p> | Accepted |
| 28. | 2 | <p>2.1; pg 46: <i>The prognosis chart was part of the pre-departure briefing material that should have been given and known by the pilots prior to departure.</i></p> | <p>The prognostic charts were given to the crew members prior to departure. Refer to OFP package.</p> | <p>On page 46, replace <i>should have been to was</i></p> | Accepted |
| 29. | 2 | <p>2.1; pg 46: <i>The prognosis chart highlighted the thunderstorms and development of cumulonimbus clouds up to FL 470 (47,000 feet) with the edge of the cumulonimbus was approximately 50 Nm from the aircraft flight path near the west of Bangka Island.</i> <i>Therefore, the pilots should have been aware and took special precaution to anticipate for the safety of the flight especially when the aircraft flying over predicted turbulence areas.</i></p> | <p>On page 46, the report mentions that the pilots should have taken special precautions. However, in the paragraph above in the report, it is stated that the prognostic charts indicated the area of forecasted cumulonimbus clouds was 50Nm away from the aircraft flight path. Therefore, the aircraft was not planned to fly over an area of predicted turbulence. Refer to OFP package.</p> | <p>As the statements mentioned in the report do not support each other, the UAE believes that there was no need for the crew to take special precautions hence the requirement to take special precautions is mute. Kindly rephrase or delete the statements from the report.</p> | Accepted |

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| 30. | 2 and 3 | <p>2.2; pg 47: <i>A few minutes after turbulence the cabin manager called the PIC through interphone to inform him the damages to the cabin interior and the injured occupants. This was acknowledged by the PIC, however since there was no call of "PAN PAN" from the pilot to the air traffic controller caused no special attention and priority to shorten the time to land.</i></p> <p>3.1.18; pg 52: <i>A few minutes after turbulence the cabin manager called the PIC through interphone to inform him the damages to the cabin interior and the injured occupants. This was acknowledged by the PIC, however since there was no call of "PAN PAN" from the pilot to the air traffic controller caused no special attention and priority to shorten the time to land.</i></p> | <p>With all the information available to the pilots including the feedback from the cabin manager and based on OM-A 12.12.1&2, the flight crew decided that the declaration of a distress or urgency was not required. This is a PIC's prerogative. In addition, KNKT has not determined how much time to land could have been reduced, and therefore, it is only a conjecture as to how much the time could have been shortened.</p> | <p>The UAE believes that as there were no passengers with life threatening injuries, the decision to proceed with a normal landing and not declaring an emergency was a valid decision. Thus, the UAE would like this section of the report to be amended accordingly or to be removed from the report.</p> | Accepted |
| 31. | 2 and 3 | <p>2.2; pg 48: <i>The disengagement of autopilot during turbulence resulted in loss of turbulence damping system which made the turbulence more severe.</i></p> <p>3.1.12; pg 52: <i>The autopilot voluntary disengaged while encountering turbulence resulted in loss of turbulence damping system which made the turbulence more severe. It was not in accordance with the FCOM.</i></p> | <p>The most severe turbulence occurred between 06:40:10 and 06:40:32 with the autopilot still engaged. Therefore, the autopilot and the turbulence damping feature were available during the period of severe turbulence. The autopilot was switched off at 06:40:32 and therefore the statement that the autopilot disconnection caused the turbulence to be more severe is incorrect.</p> <p>Refer to analysis section 2.2 on page 47: <i>"The FDR data showed, few minutes prior to encounter the severe turbulence, the aircraft was stable with auto pilot engaged and was cruising at altitude of 39,000 feet. Thereafter, at 06:40:00 UTC,</i></p> | <p>As the statements are not supported, the UAE request to strikeout the first paragraph on page 48 and finding 3.1.12.</p> | Accepted |

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| | | | <i>the aircraft encountered a light turbulence and then become severe at 06:40:10 UTC for about 22 seconds...</i> | | |
| 32. | 2 | 2.4; pg 49: <i>This indicated that the flight crew did not aware of possible turbulence.</i> | The UAE is not sure what is intended by this statement. However, it is true that the flight crew were not aware of possible turbulence. | The UAE request that to change the wording of the statement to <i>“This indicated that the flight crews were not aware of possible turbulence.”</i> | Accepted |
| 33. | 2 | 2.4; pg 49: <i>The cabin crew shall recommend the passenger to keep the seat belt fastened during seated.</i> | The statement is incomplete. | The UAE request to add the following continuation to the sentence, <i>“which is achieved through a standardized public address conducted after take-off.”</i> | Rejected |
| 34. | 2; 3 and 5. | 2.4; pg 50: <i>The past 5 hours flying in clear weather and the cabin crews activities for arrival likely degraded the cabin crew attention to identify the passengers who did not fasten the seat belt. The condition was consistent with most of the injured passengers did not wear the seat belt during the severe turbulence.</i> <i>This might indicate that the policy for passenger to fasten the seat belt during</i> | The statements behind each passenger seat are there to remind passengers to keep their seatbelts fastened while they are seated regardless of the seatbelt signs. It serves as a warning control barrier. As research data has shown, these warnings can be disregarded or overlooked by passengers. It is not Etihad cabin crew procedure to check on each seated passenger to ensure that their seatbelts are fastened when the seatbelt signs are switched off. In the current Finding 22 in section 3.1, the wording of the finding assumes that the procedure is to | The UAE request: a. Remove the first sentence on page 50 as KNKT has not supported the statement. b. Remove the last paragraph on page 50 as KNKT has not supported the statement. | Accepted |

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| | | <p><i>seated was not effectively implemented in this flight.</i></p> <p>3.1.21; pg 53: <i>Seat belt policy available in the operator manuals and on the passenger seats, however the policy for passenger to fasten the seat belt during seated was not effectively implemented in this flight.</i></p> <p>3.1.22; pg 53: <i>Golding (2000), in his research of Turbulence and its Impact on Commercial Aviation stated that the policy to fasten the seatbelts whenever passenger seated was not strictly enforced in United States of America. This research likely also applicable for most of the commercial aviation in the world.</i></p> <p>5.1; bullet point 2, pg 55: <i>The Etihad Airways had policies which advises passenger to have their seat belts fastened even when the seat belt signs are switched off. However, the most injured passengers did not wear the seat belt during the severe turbulence.</i></p> <p><i>The KNKT recommends the Etihad Airways to review the effectiveness of the use of seatbelt policies to ensure passenger fastened their seatbelt when seated.</i></p> | <p>continuously monitor the cabin to check for passengers while they are seated. This is not the intent of Etihad’s procedure.</p> <p>Refer to the standard in-flight announcement after take-off in SEPM section 5.4.2.1: <i>Ladies and Gentlemen, Please remain seated and continue to observe the seatbelt sign until it has been switched off.</i></p> <p><i>We also recommend that you keep your seatbelt fastened whenever you are seated and when the seat belt sign is on....</i></p> <p>Even though the Golding research in the year 2000 has good information, from that time to current, the aviation industry has gone through many safety enhancements. However, the culture and norms of people is a factor that many airlines has to contend with. As KNKT has made reference to this study, the UAE request that KNKT also refer to TSB Aviation Investigation Report A15F0165 published February 2017. http://www.tsb.gc.ca/eng/rappports-reports/aviation/2015/a15f0165/a15f0165.pdf</p> | <p>c. Remove the following of Finding 21: <i>”...however the policy for passenger to fasten the seat belt during seated was not effectively implemented in this flight.”</i></p> <p>d. Remove Finding 3.1.22 as this is a reference study and not related to the occurrence. See footnote 8 on page 51.</p> <p>e. Remove Recommendation 5.1 bullet point 4 of the recommendations to Etihad Airways.</p> | |

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