United Arab Emirates

GCAA
دولة الإمارات العربية المتحدة
الهيئة العامة للطيران المدني
UAE General Civil Aviation Authority

AAIS Case Reference: 11/2011

AIR ACCIDENT INVESTIGATION SECTOR

FINAL

ACCIDENT INVESTIGATION REPORT

SEVERE TURBULENCE ENCOUNTER

Boeing 777-300
Registration: A6-ETC
Enroute from the Philippines to Abu Dhabi
October 18 2011

General Civil Aviation Authority of the
United Arab Emirates

United Arab Emirates

AIR ACCIDENT INVESTIGATION SECTOR STATEMENT

THIS INVESTIGATION HAS BEEN CARRIED OUT IN ACCORDANCE WITH UAE GENERAL CIVIL AVIATION AUTHORITIES CAR PART VI AND ANNEX 13 TO THE ICAO CONVENTION ON INTERNATIONAL CIVIL AVIATION.

THE SOLE OBJECTIVE OF THE INVESTIGATION OF AN ACCIDENTS OR INCIDENTS IS THE PREVENTION OFACCIDENTS AND INCIDENTS.

IT IS NOT THE PURPOSE OF AN INVESTIGATION TO APPORTION BLAME OR LIABILITY.

TABLE OF CONTENTS

[1] Reader information: The categories contained in this report are based on the ICAO Annex 13 Factual Information classifications numbered 1.1 to 1.19. Categories not relevant to this investigation are not included in the factual information

INDEX OF DIAGRAMS/MAPS/PHOTOS (Chronological Order)

ABBREVIATIONS/PHRASES USED IN THIS REPORT

ACARS	Aircraft Communications Addressing and Reporting System
ADAS	Abu Dhabi Airport Services
ADS	Automatic Dependent Surveillance
ASR	Air Safety Report
ATC	Air Traffic Control
ATL	Aircraft Technical Log
ATPL	Airline Transport Pilots License
AUH	Abu Dhabi International Airport, Abu Dhabi
BKK	Suvarnabhumi International Airport, Bangkok
CB	Cumulonimbus
CGK	Soekarno-Hatta International Airport, Jakarta
CM	Cabin Manager
CPDLC	Controller-Pilot Data Link Communication
CRP	Cruise Relief Pilot
CVR	Cockpit Voice Recorder
DDL	Deferred Defects List
DFDR	Digital Flight Data Recorder
ERP	Emergency Response Plan
F/O	First Officer
FCOM	Flight Crew Operating Manual
FCTM	Flight Crew Training Manual
FDM	Flight Data Monitoring
FIR	Flight Information Region
FL	Flight Level
GCAA	General Civil Aviation Authority
HCC	Hub Control Center
HF	High Frequency
ICAO	International Civil Aviation Organization
ITCZ	Inter-tropical Convergence Zone
LHS	Left Hand Operating Seat
LSU	Lavatory Service Unit
MCC	Maintenance Control Centre
MCP	Mode Control Panel
MNL	Ninoy Aquino International Airport, Manila
NOC	Network Operations Center
ND	Navigation Display
OMAA	Abu Dhabi Intl Airport [ICAO]
PF	Pilot Flying
PNF	Pilot Non Flying
PSU	Passenger Service Unit
QAR	Quick Access Recorder
RHS	Right Hand Operating Seat
SAFE	System for Aircrew Fatigue Evaluation
TAS	Turn Around Supervisor
UCRC	Upper Crew Rest Compartment
UTC	Universal Time Coordinate
VHF	Very High Frequency

1. FACTUAL INFORMATION

1.1. HISTORY OF THE FLIGHT

On 18-Oct-11, a Boeing 777-300, registration A6-ETC, operating a scheduled passenger flight from Manila, Philippines [MNL] to Abu Dhabi (United Arab Emirates) [AUH] . At 21:00 Coordinated Universal Time (UTC2), the flight encountered a region of severe turbulence enroute from MNL to AUH.

The crew complement consisted of three flight crew, one Captain and two First Officers [F/O], and 12 cabin crew members.

The flight was approximately 194 nautical miles south south west of Yangon, Myanmar, at FL340 over the Bay of Bengal having just passed waypoint RINDA while transiting from the boundary of the Yangon Flight Information Region [FIR] and Kolkata FIR

The Captain had left the flight deck to take a comfort break. The F/O was the Pilot Flying [PF] and the third crewman, also an F/O, was in the supernumerary seat[3] who was assisting the PF with the radio communication with Yangoon and Kolkata Air Traffic Control (ATC). The second F/O was sitting on the jump seat as he was not CRP[4] qualified, assisting the PF with managing the ATC communications.

The crew stated that the enroute weather was CAVOK prior to the event. However, the crew observed on the weather radar an isolated cumulonimbus (Cb) buildup directly on the flight path, ahead of the flight at about 20nm, or approximately 2 minutes track distance to run from the point it was observed.

During the Captains absence from the flight deck, the remaining crew received confusing and contradictory information on the Yangon frequency during the hand over from the Yangon Flight Information Region [FIR] to Kolkota FIR, with a contributory CPDLC uplink delay distracting the PF and supernumerary crew member .

The crew altered track to 315°, laterally off set to the right from the airway to avoid the Cb, the flight passed the Cb and when abeam the cell approximately 7 nm laterally off set, the airplane encountered severe turbulence for approximately 45 seconds.

During the severe turbulence encounter, the autopilot disconnected, the aircraft climbed approximately 600 feet and the stick shaker activated.

Following the turbulence the autopilot was re-engaged and the crew used the Mode Control Panel [MCP] to recover to the assigned flight level.

During the turbulence encounter, several cabin crew and passengers were injured.

The vertical acceleration(g) maximum loads were +1.98 and -0.68[5]

The Captain was not on the flight deck when the event occurred, the Captain was in the business class cabin and occupied one of the vacant business class seats and remained there for the duration of the severe turbulence encounter. Following the severe turbulence encounter the captain returned to the flight deck .

[2] Universal Time Coordinate [GMT/Zulu]
[3] Third pilot assigned due to flight crew limitation regulations
[4] Cruise Relief Pilot
[5] Refer to Section 2/Analysis for further information on the flight profile.

1.2. INJURIES TO PERSONS.

1.2.1.Injury to passengers/cabin crew seating location

INJURIES	CREW	PASSENGERS	OTHERS
FATAL	0	0	0
SERIOUS	1	1	0
MINOR/NONE	7	5	

Table 1: Injuries To Persons

1.2.1.1. Passengers

Most of the injured passengers were seated with seat restraints fastened. The seriously injured passenger was in the amenities/lavatory during the severe turbulence encounter.

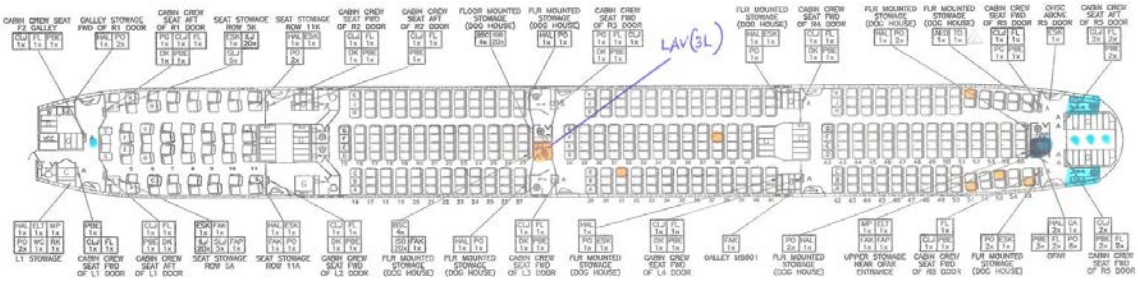

Figure 1:Cabin Configuration Diagram – Passenger seating, Lavatories and Galley Locations

- Injured Cabin Crew
- Injured Passengers

1.2.1.2. Cabin Crew

Various members of the cabin crew where in the bunks on rest or in the galleys performing routine duties mid-flight. Several sustained injuries, one serious; all injured cabin crew required post flight medical supervision.

1.3. DAMAGE TO AIRCRAFT.

There was no external aircraft damage to the aircraft. Damage to the internal passenger cabin were damaged Passenger Service Units (PSUs) and the activation of one of the passenger oxygen generators by the dropping of the overhead masks.

1.3.1.Damage to the Cabin

During the turbulence event several passengers contacted the passenger cabin overhead panel Passenger Service Units(PSU's), resulting in injury and significant damage to the tertiary structure cabin panels.

See Picture 1 and Picture 2 below

Figure 2 PSU Damage

Figure 3 PSU Damage

1.4. OTHER DAMAGE/ Not Applicable To This Investigation

1.5. PERSONNEL INFORMATION

	Captain	1st First Officer	2nd First Officer
Hours Flown in Last 90 Days	127:21	102:05	234:12
Hours Flown in Last 28 Days	55:28	59:09	62:47
Hours Flown in Last 7 Days	32.20	29.20	24.23
Hours Flown in Last 24 Hours	0:00	0:00	0:00

Table 2: Crew Duty Hours[6]

1.5.1. Crew License Validity

The Captain held a valid UAE ATPL with a P1 rating for the B777. The F/O's held valid UAE ATPLs with a P2 rating for the B777. All pilots held valid Class 1 medical certificates with the Captain and the 2nd First Officer having a limitation to wear corrective lenses while exercising their privileges of their respective licenses. All the cabin crew were certified and qualified to conduct the flight.

All the crewmembers were on three day duty pairing, leaving AUH on 17-Oct-11 and arriving back in AUH on the morning of 19-Oct-11. The crew earned a 24 hour 21 minute rest period in MNL prior to operating back to AUH. The planned flight duty for the day was for a one sector, 10 hour 30 minute flight duty from MNL to AUH.

Analyzing the crews' rosters through SAFE[7], the Samn-Perelli[8] score did not indicate that the crew would be suffering from the effects of fatigue.

1.5.2. Captain

The Captain joined in January 2008 as an F/O on the B777. Prior to joining he was an F/O on the B747. He started his command upgrade course in April 2011, completing the training on 28-Jul-11

The Captain was experienced in flying through the Bay of Bengal. The Captain had flown to MNL 12 times, BKK 13 times, and CGK six times in the 12-months prior to the accident flight. These flights usually traverse the Bay of Bengal.

1.5.3. First Officer

The 1st First Officer joined in May 2011 as an F/O on the B777. Prior to that he flew the B737 and no prior experience of flying the B777 prior to joining the operator. The F/O had completed his conversion course to the B777 on 05-Oct-11 and operated on his first unsupervised flight on 10-Oct-11. The accident flight was his fourth unsupervised flight on the B777.

During his line training the F/O had flown eight flights over the Indian Ocean and twice after his training. Prior to joining the F/O had limited experience of HF communications and ADS/CPDLC[9] communications

[6] Flight hours and duty time up until the departure of the accident flight

[7] SAFE is a software application which can analyze the fatigue levels of crewmembers by inserting their flying and rest schedules into the application. It uses sleep/wake schedules to determine fatigue but does not have the ability to include dietary habits or use of medication.

[8] The Samn-Perelli scale is a 7-point fatigue scale, a score of 1 is described as being fully alert and wide-awake, and a score of 7 is described as being completely exhausted and unable to function effectively.

1.5.4. Supernumerary First Officer

The 2nd First Officer joined in May 2010 as an F/O on the B777. Prior to joining had also flown the B777 as an F/O and was experienced with flying over the Indian Ocean. The Supernumerary F/O had flown over the Bay of Bengal 27 times.

1.6. AIRCRAFT INFORMATION

Manufacturer	The Boeing Commercial Airplanes
Type:	B777-300ER
Registration:	A6-ETC
MSN	34599
Engine Type:	GE90-115BL

Table 3: Aircraft Information

Prior to the start of the flight there were open DDL[10] items in the ATL but none had an impact on the flight.

1.7. METEOROLOGICAL INFORMATION

1.7.1. Weather Enroute

The dispatch documents provided to the crew included a Fixed Time Prognostic Chart for the Indian Ocean valid for 00:00 UTC, 19 October 2011 from FL 250 to FL 630. This chart indicated an area of isolated embedded cumulonimbus clouds from FL 250 up to FL 450 in the Bay of Bengal which stretched longitudinally from the Andaman Islands up until the east coast of India and latitudinal from approximately 10°N to southern coast of India, Bangladesh and Myanmar. Within this area was an area of occasional embedded cumulonimbus clouds from FL 250 up to FL 500. This weather is typical of the end of the monsoon season in southern Bangladesh and western Myanmar and corresponds with the southward movement of the ITCZ[11].

Based on DFDR data for the GPS plot of the track flown, the pilots deviated once in the South China Sea, prior to the turbulence event. The next weather deviation was immediately before the turbulence event.

During this deviation from track to avoid adverse meteorological conditions, the aircraft deviated approximately 7 nm laterally off track from the 285° heading to 315° when the turbulence occurred. After this event, the aircraft returned to the flight plan track (285°) and did not make any more weather deviations for the rest of the flight.

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[9] ADS/CPDLC allows pilots to communicate with air traffic controllers through a data link service. Air traffic control clearances can be sent and received through text messages instead of voice communications.

[10] Deferred Defects List

[11] The ITCZ is an area of increased thunderstorms and convective cloud activity which encircles the globe. It moves in a generally North-South seasonal direction based on the annual movement of the sun; further north during the Northern Hemisphere summer and south during the Southern Hemisphere summer.

A colour satellite image of the Bay of Bengal taken at 14:00 UTC was also provided in the dispatch package (see Fig 2 below).

The image indicated an area of intense convective activity in the Bay of Bengal from approximately 15°N up to the southern coast of Bangladesh.
See following page for composite of the briefed enroute briefing prognostic charts and a Google Map overlay.

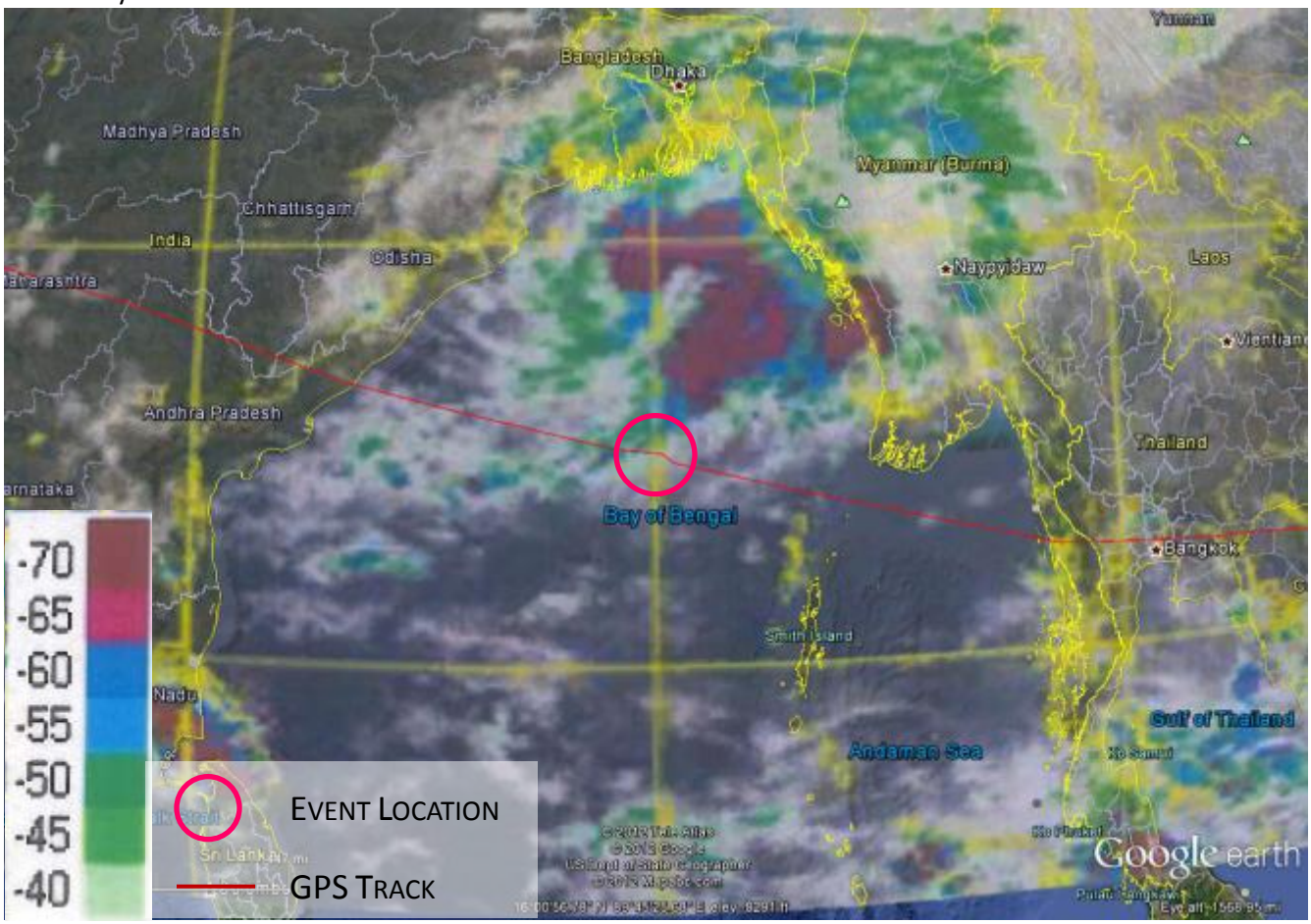

Figure 4: Enroute Briefing Prognostic Charts: Bay of Bengal – 14:00 UTC Prognostic Chart

1.7.2. Natural Light Conditions/Visibility

The turbulence occurred during the hours of darkness. According to the Astronomical Applications Department, U.S. Naval Observatory, moonrise occurred at 16:22 UTC and moonset at 04:46 UTC. The moon was in the last quarter on October 20, two days after the flight.

At the time of the turbulence, the moon was at an elevation of 63° in the East, behind the aircraft. This is consistent with the crew's observations that they could neither see the moon nor was there any additional ambient illumination on that heading and elevation

1.7.3. Sunrise/Sunset and Twilight Table

1.7.3.1. Sunrise/Sunset and Twilight table for the GPS location of the event.

FOR TUE, OCT 18 2011 GMT+6:30	
LOCAL TIME (ABOVE TZ)	23:33
MIDDAY AT	11:15
LENGTH OF DAY	11:44
ASTRO TWILIGHT START	16:11
NAUT TWILIGHT START	16:36
CIVIL TWILIGHT START	17:01
SUNRISE	17:23
SUNSET	5:07
CIVIL TWILIGHT END	5:29
NAUT TWILIGHT END	5:54
ASTRO TWILIGHT END	6:19

Table 4**:** Times, Rise and Set, Tuesday October 18, 2011 [GMT: +06-30]

1.7.4. Destination Weather

The meteorological forecast valid at the time of arrival in AUH forecasted wind variable at two knots, a visibility of 3000m in haze and between 4:00 Local Time [LT] and 9:00 LT there was forecast a temporary condition lasting not more than one hour in which the visibility would drop to 100m in fog, with an undetermined vertical visibility and winds from the south south-west at five knots.

The recorded meteorological conditions at 05:30 LT, 9 minutes prior to landing, indicated a Runway Visual Range [RVR] of 325 in fog, a cloud ceiling of 100ft, temperature of 25°C and a dew point of 24°C. The overall visibility was 300m.

AUH airport was observing low visibility procedures at the time of landing and the crew flew an automatic landing.

1.8. AIDS TO NAVIGATION

1.8.1. Weather Radar

The aircraft is equipped with a Honeywell Weather Radar Model RTA 4B Part No: 066-5008-0408.
The weather radar system consists of receiver- transmitter unit, antenna and control panel.
Radar returns are displayed on the Navigation Display [ND].
The radar display range automatically adjusts to the ND range selected on the EFIS Control panel.

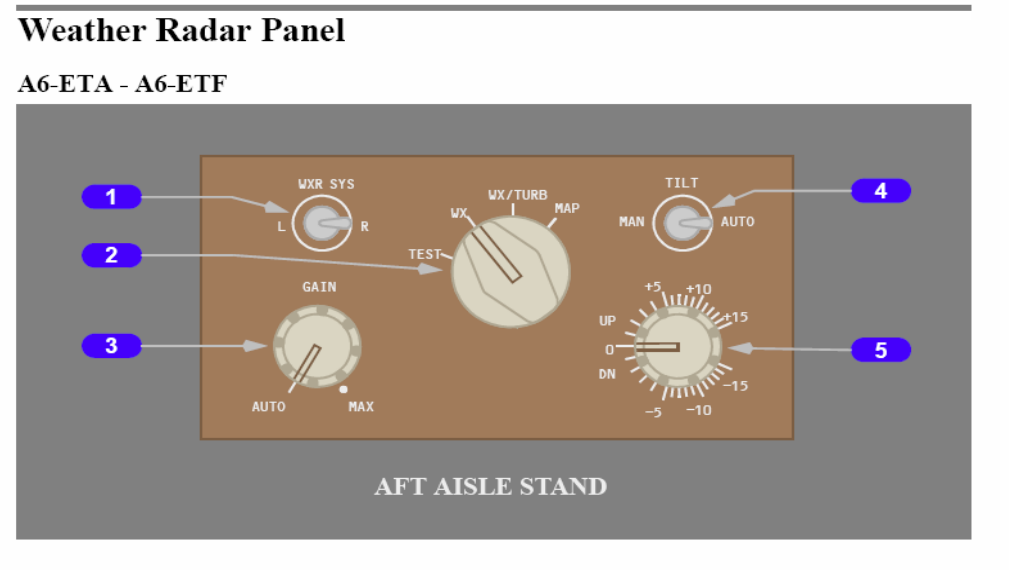

Figure 5 : Weather Radar Panel A6-ETC

The TILT Mode switch (shown as 4 above) has the two positions as defined below:

1. **MAN** :
   Disables auto-tilt function, allows the pilot to set the radar tilt with TILT Control (shown as 5 above)

2. **AUTO** :
   Optimizes antenna tilt to avoid over or under scanning weather

The TILT selection remained in the AUTO mode throughout the flight. The PF stated that it is advised by the operators training establishment to keep the TILT switch to AUTO. According to the crew statements, the crew did not consider putting the TILT to MAN.

1.9. COMMUNICATIONS

1.9.1. The Controller Pilot Data Link Communications (CPDLC)[12] was serviceable on board the aircraft but neither the crew attempted to logon to the Kolkata Data Link service prior to crossing the FIR boundary. The PF only attempted to contact Kolkata on CPDLC, and was successful, after passing the FIR boundary. The PF stated that no controller had asked him to logon to Kolkata Data Link and that his initiative to contact Kolkata Data Link was a non-standard procedure.

The aircraft crossed waypoint RINDA, the boundary between the Yangon and Kolkata FIRs, approximately 14 minutes prior to the turbulence. In the Yangon FIR, the pilots were in contact with the ATC on VHF. The pilots described the communication to be garbled and very hard to understand. While making the position report at position RINDA, the pilots were confused by the response given by the controller.

[12] Controller pilot data link communication (CPDLC) is a means of communication between controller and pilot, using data link for ATC communication

The crew stated that they interpreted the instructions to contact Kolkata on HF and to make another position report to Yangon ATC at RINDA again. In an attempt to confirm the clearance, the F/O sitting in the jump seat moved to the LHS and offered to communicate to the Yangon controllers while the F/O sitting in the RHS could continue to contact the Kolkata controllers on HF. Communication with Kolkata Radio on HF was also full of static and hard to comprehend.

The crew decided to deviate due to the weather radar indication, the PF initially asked the Pilot Non Flying [PNF] to request ATC clearance for a weather deviation with Kolkata on HF. Due to the proximity of the cell the crew decided to deviate without getting clearance. The maximum deviation was not more than 10 nautical miles.

1.10. AERODROME INFORMATION/Not Applicable To This Investigation

1.11. FLIGHT RECORDERS

1.11.1. Digital Flight Data Recorder (DFDR)

The DFDR on the aircraft records data automatically when the first aircraft engine is started up until when the engines are shutdown. The DFDR was retrieved after the flight and dispatched to the GCAA for analysis. The GCAA were able to retrieve useful information from the DFDR.

1.11.2. Cockpit Voice Recorder (CVR)

The type of CVR installed on the aircraft is energized and records cockpit voices and noises when the aircraft's A/C electrical system is powered and records the last 120 minutes. In the case of this event, after the aircraft landed, the A/C electrical system continued to be powered and the CVR circuit breaker was not pulled. This resulted in the CVR continuing to record information up until the CVR was physically removed from the aircraft. The removal of the CVR occurred more than two hours after the aircraft landed, therefore information pertaining to the flight was not captured.

Following the CVR download, it also became apparent to the investigators that the CVR installed [an L3 Communications/Model FA 2100/PNR FA2100] was not recording on four channels separately.

The current requirement in CAR Part IV, CAR Ops 1.700(b) is that the CVR shall record for 2 hrs.
Following investigation it was determined that the CVR installed recorded 30 minutes only of separate channel recording with 120 minutes of mixed/combined recording.

This recording standard was for a specific modification standard which was determined for the manufacturer as MOD #5.

The operators CVR Line Replaceable Units (LRU's) are managed by an MRO , taken from a pool of CVRs of various modification standards. The operator complies with this 2 hrs requirement, but the recording is limited to 30 mins per channel for each channel (1,2,3,4)

The required modification standard for this CVR type to be compliant with the 2 hour, 4 separate channels recording is for the CVR to be at MOD #7 or above. The LRU modification is a hardware modification which can be embodied during a maintenance check.[13]

1.11.3. Quick Access Recorder (QAR)

QAR information was also retrieved from the MO-disk and the data provided valid information from the FDM system.

1.12. WRECKAGE AND IMPACT INFORMATION/Not Applicable To This Investigation

1.13. MEDICAL AND PATHOLOGICAL INFORMATION/Not Applicable To This Investigation

1.14. FIRE/Not Applicable To This Investigation

1.15. SURVIVAL ASPECTS

As a result of the severe turbulence, one passenger and one cabin crew sustained serious injuries and seven cabin crewmembers and five passengers sustained minor injuries.

1.15.1. Flight deck crew

At the onset of the initial minor turbulence the Captain was in lavatory 1L. The Captain then walked around the cabin and when the severe turbulence hit was in the business class cabin and managed to secure one of the vacant business class seats. The Captain remained there until the turbulence subsided.

The two F/Os were in the cockpit. The 2nd F/O was initially in the center supernumerary seat but sat in the LHS to assist the PF with the communications with ATC. None of the flight deck crewmembers were injured.

[13] Further details are contained in Section 2. Analysis

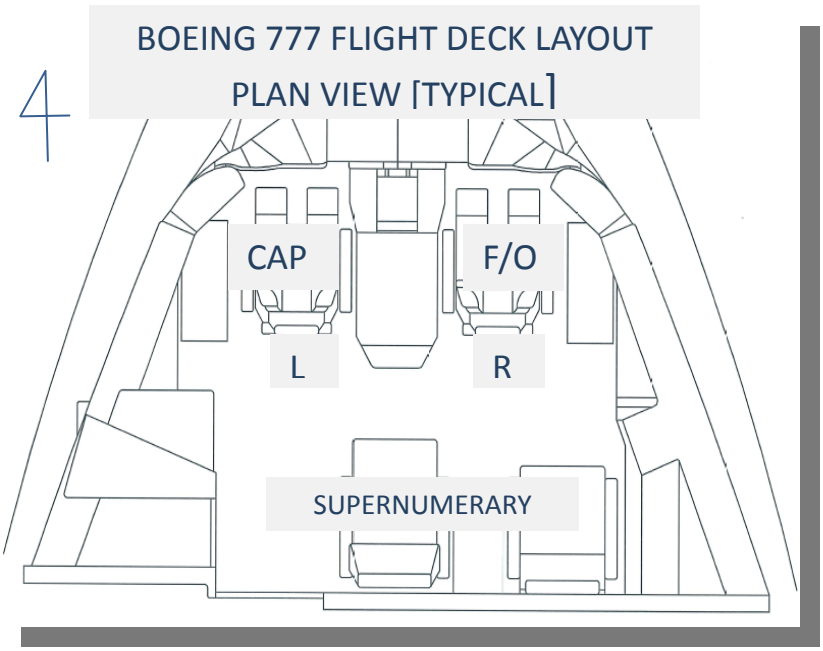

Figure 6: B777 Flight deck Seating

Table 5 Cabin Crew Positions

Crew Positions	**Location at the time of event**
L4/R2A/R3/L3/R4/L1A/L2	Galley
L5/R5	Lavatory
R1/R2	Upper Crew Rest Compartment
L1	Cabin Jump Seat

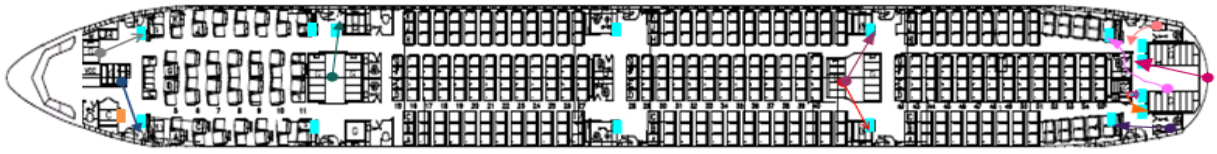

Figure 7 Cabin crew location during turbulence. Those not already at their jump seats, their movements are depicted with arrows.

1.15.1.1. Galley

During the severe turbulence six crewmembers who were present in the galley (forward, mid and aft area) experienced minor injuries, one sustained serious injury. The severity of the turbulence loads was higher in the aft section of the aircraft, compared to the mid or forward section. The crewmembers in

the aft galley were displaced along with the movement experienced by the aircraft as they were unable to secure themselves in the galley as there are no jump seats available.

The impact of the injuries was more on the crewmembers present in the aft area due to hitting the roof and galley floor. Out of the seven crewmembers present in the galley area, two crewmembers were able to sit immediately on the closest jump seat while five crew members were able to reach the jump seats after falling and hitting the galley fixtures and bulkheads.

During the turbulence, no cabin services were being conducted and subsequently all the carts and containers were stowed in their original stowage which remained intact due to the presence of latches in the locked position.

1.15.1.2. Lavatory

Two crewmembers were injured in separate aft lavatories. The crewmember in lavatory 5L was unable to get up and move out of the lavatory immediately. The LSU[14] was also damaged due to the impact and oxygen mask was deployed.

Another crewmember in lavatory 5R was also injured.
Both crewmembers initially had difficulty to get out of the lavatories due to the turbulence but eventually managed to secure themselves on to the nearest available jump seats.

1.15.1.3. Upper Crew Rest Compartment (UCRC)

The UCRC is located above the passenger cabin between doors L4 and L5. It can be accessed through step located near door L5. Two crewmembers were in the UCRC at the time of the incident . The crewmembers were thrown upwards from the crew rest bunks and hit the ceiling. Since the ceiling of the UCRC is low the crewmembers fell back down on the bed mattresses minimizing the impact and seriousness of the injuries.

1.15.1.4. Cabin Jump Seat

At the time of the event the CM was seated unsecured at the L1 jump seat. During the turbulence, she was thrown from the jump seat and fell on to the floor. The CM regained the seating position and managed to secure herself with the seatbelt and shoulder harness.

1.15.2. Passengers

Passenger Seat no.	**Location at the time of event**	**Condition of the seat belt**
31C	Lavatory 3LC	Not applicable
38F	Exiting Lavatory 3R	Not applicable

[14] The LSU houses, amongst other items, the emergency oxygen system, no smoking and return to seats signs and a speaker.

51AK/53C/55A	In seats	Loosely fastened

Figure 8 Passenger movement during turbulence is indicated by the arrows.

During the episode of severe turbulence, the majority of the passengers were in their seats.

Based on the witness statements, the seatbelt sign was switched on approximately 10 minutes prior to the incident during some minor turbulence/chop. An announcement was made in Arabic and English advising passengers to fasten their seatbelts.

According to the operators SOP, the cabin crewmembers would have visually secured the cabin and galleys and passed the cabin secure message to the flight deck.

According to the crew statements, the crew then got involved in galley activities.

Sometime after securing the cabin two passengers went to the lavatory situated at the Door 3 area. When the turbulence started, one of the passengers (pax sitting at seat position 31C) was present in lavatory 3LC. This passenger contacted the lavatory ceiling and then fell down on to the floor lavatory. The injured passenger was immobilized and the cabin crew secured the passenger on the floor of the galley.

The other passenger had just exited lavatory 3R. During the return back to the allocated seat, the turbulence started in the passenger was injured by hitting cabin fixtures. The passenger managed to reach the allocated seat 38F.

During turbulence, four other passengers who were seated in between the seat rows 51-55 at the aft section of the aircraft hit the PSU's[15] above their seats in the cabin. According to the cabin crew statements, the passengers had their seatbelts loosely fastened at the time of an event. Several masks were deployed and the PSUs were damaged due to the impact with the passengers.

One passenger near to the R3 Door, sustained injuries having been ejected from the seat and contacting the R3 door handle.

1.16. TESTS AND RESEARCH/Not Applicable To This Investigation

1.17. ORGANIZATIONAL AND MANAGEMENT INFORMATION

1.17.1. Operators Network Operations Center and Hub Control Center

After the encounter with the turbulence, the CAPT together with the CM called Medlink. During this telephone call, the Medlink personnel told the crew that he would inform the company of the situation, including a request for an ambulance for the seriously injured passenger.

[15] PSUs are the compartments above the passenger seats which house the emergency oxygen system, personnel lighting and passenger service call lights.

Medlink contacted NOC which included an attachment stating that the passenger was injured due to turbulence.

As fog was forecasted in AUH during the morning of 19-Oct-11, the NOC focused on managing the possible delays due to the reduced traffic flow associated with low visibility procedures. The NOC Duty Manager confirmed that he received the Medlink message but overlooked the fact that the injury was due to turbulence. Injuries due to turbulence should have warranted a callout but in the height of activity, this was overlooked.

Medlink also telephoned HCC with information regarding the injury and the need for the ambulance. The HCC personnel receiving this call then sent out a message to the various departments informing them the event.

When the aircraft was approaching the end of the cruise, the 2nd F/O contacted the HCC on the VHF radio to confirm the ambulance readiness on their arrival. The HCC personnel wanted to confirm if the passenger really needed an ambulance or if she could walk off the aircraft. The F/O confirmed that an ambulance was needed.

1.17.2. Activation of the Operators Emergency Response Plan [ERP]

Due to the fog/RVR restrictions at AUH, flights had been delayed due to the adverse weather.

Although the operator was aware there was damage to the aircraft, the focus was with the disruption caused by the destination weather.

The ASR was emailed to the Safety Department around 11 am, approximately six hours after the event.

The Safety Department then started the follow-up which included, coordinating with the GCAA AAI, MCC and the fleet office, locating the injured passengers and informing guest services. As the Emergency Response Plan was not activated, all the relevant departments were working independently, relying on information transfer from departments throughout the Abu Dhabi area.

The iSaturn system[16] was activated to collect information on the passengers but the work was done from locations away from the Emergency Response Centre.

1.18. ADDITIONAL INFORMATION

1.18.1. Preservation of Evidence

The operator did not inform the GCAA immediately that the event had been notified through the operators NOC, subsequently, due to the operators maintenance procedures with their maintenance provider MRO , the CVR/DFDR data was not recovered from the event.

This was compounded by the maintenance process which with aircraft power on and the cockpit voice recorder (CVR) circuit breaker closed, the CVR will operate continuously.

According to GCAA CAR Part VI/Chapter 3 the following applies regarding protection of evidence:

[16] iSaturn automates incident management, interfacing directly with reservations systems, passenger manifests and frequent flyer systems to get full information on affected passengers and crew. Communications between emergency team members, and with external parties, are streamlined so that information flows freely.

3.3.2 Protection of Evidence

3.3.2.1 When a reportable accident occurs in or over the UAE, no person other than an authorised person, shall have access to the aircraft involved in the accident and neither the aircraft nor its contents shall, except under the authority of the GCAA, be removed or otherwise interfered with.

3.3.2.4 The operator of an aircraft involved in an accident or incident for which notification must be given is responsible for preserving, to the extent possible, any aircraft wreckage and cargo aboard the aircraft and all records, including all recording mediums of flight, maintenance, and voice recorders pertaining to the operation and maintenance of the aircraft and to the airmen, until the GCAA takes custody thereof and a release is granted.

1.19. USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES

Not Applicable To This Investigation.

2. ANALYSIS

2.1. Digital Flight Data Factual Analysis - Flight Profile/Event Sequence

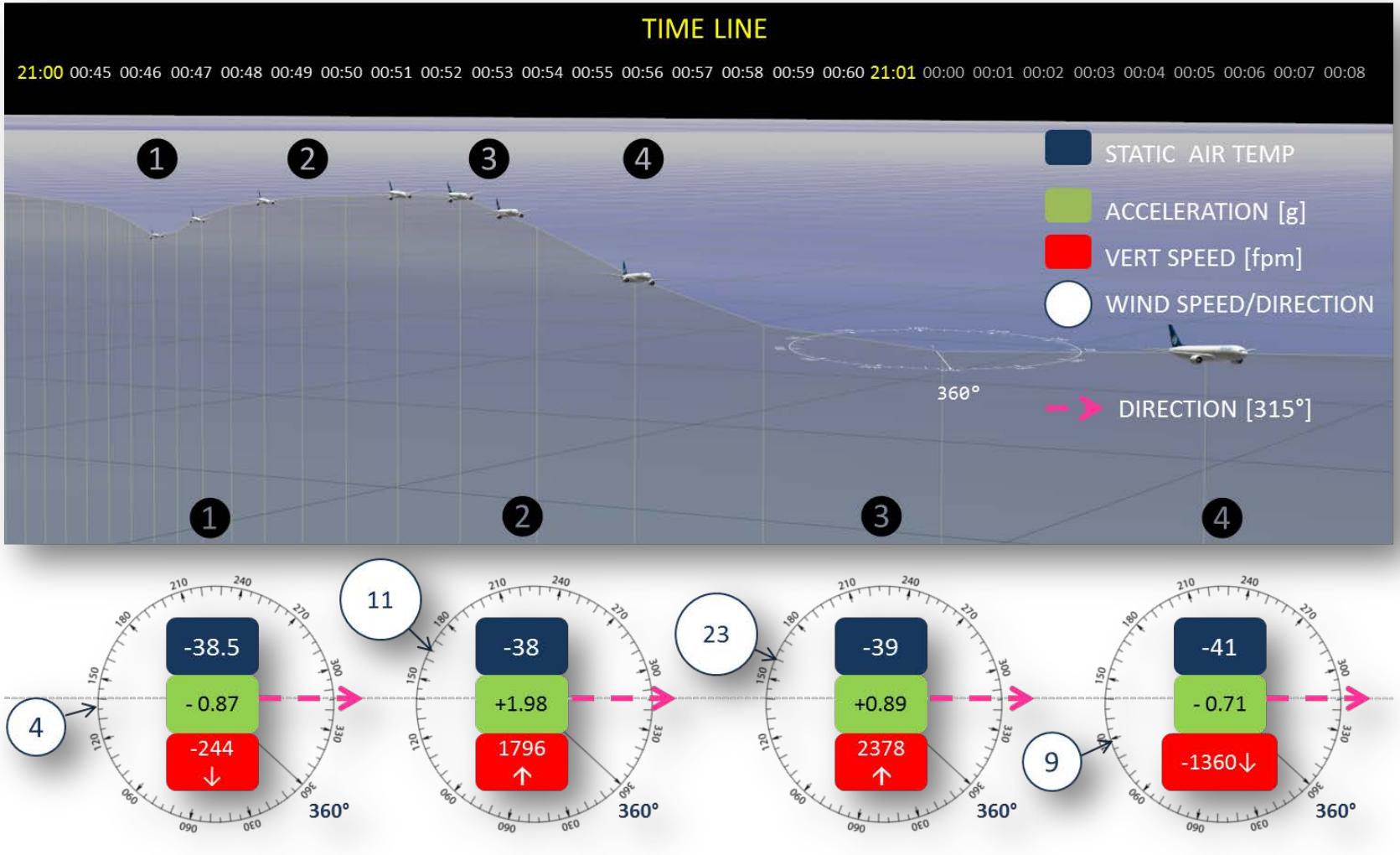

Figure 9 SEVERE TURBULENCE DATA –EVENT SEQUENCE

2.2. Use of the Weather Radar

A review of the B777 FCOM and FCTM indicated that there is no recommendation either by the manufacturer or the operator to use the MAN Tilt mode in adverse weather conditions. Therefore the decision of the crew to operate the weather radar in AUTO was in line with the SOPs.

It cannot be clearly established if the MAN mode have provided a clearer, consistent image resolution for the crew in this given scenario.

2.3. Use of CPDLC/Datalink

It is concluded that the aircraft was able to communicate with Kolkata ATC[17] and all necessary requests/clearances for route changes, weather deviations, speed could have been established electronically without the establishing HF communications, which is generally task specific. HF radio communication increases the workload and the transmission clarity on HF can be low. The SELCAL[18] check was delayed due to the communications problems experienced.

The crew statement indicates that the crew did not consider logging on to Kolkata FIR through CPDLC at least 10 minutes prior to the FIR boundary (near waypoint RINDA) as described in the State Rules and Procedures-Middle East, Jeppesen Airways Manual [19]

This was also recommended in B777 Supplementary Operations Manual (SOM) 4.1.19.1 (the SOM was valid at the time of the incident) and was the SOP used during line training. Earlier logging on through CPDLC would have enabled them to communicate weather deviations earlier. The crew eventually logged on to the CPDLC; however by that time the aircraft had already encountered severe turbulence and the crew had initiated a track deviation. The delay in logging on to CPDLC is a contributory safety factor in this investigation.

2.4. Functional Operability of the CVR

The investigation analysed the data to determine the function of the installed CVR and the technical explanation for the CVR data over ride.

The manufacture of the airplane details in the airplane maintenance manual that the functional description of the voice recorder system in the Boeing B777 Maintenance Manual Part I states that, "With power on the airplane and the cockpit voice recorder (CVR) circuit breaker closed, the CVR operates continuously." This would mean that if A/C electrical power remains connected to the aircraft after arrival or if the circuit breaker is not pulled the recorded information will be over-written .

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[17] The participating ATC unit

[18] SELCAL is a signaling method which can alert an individual aircraft that a ground station wishes to communicate with it. SELCAL signals can be transmitted over either HF or VHF RTF.

[19] Jeppesen Airways Manual – General, 15.2.3.3 "*Actions to be Taken if a Revised ATC Clearance Cannot be Obtained*" the aircraft can deviate up to 10 NM away from the airways at the same level, if a revised ATC clearance cannot be obtained.

In this instance, information regarding this event arrived at approximately 11:00am Abu Dhabi local time, five hours after the aircraft landed. By this time, voice data pertaining to the flight had been over-written.

After the aircraft had landed and the maintenance personnel started to work on the aircraft, the damage was not reported to the MCC. An engineer took photographs of the cabin damage and these are the only photographic evidence of the damage while the parts still attached to the aircraft. The operators MCC's instructions to repair the aircraft and download data from the DFDR were made in order to be able to dispatch the aircraft as soon as possible. Due to the heightened activity in the NOC due to the fog disruption, there was a delay of information transfer to the Safety Department which in turn delayed the transmission of the event to the GCAA AAI.

Once the operators Safety Department made contact with the GCAA Duty Investigator, the operator was instructed to remove the DFDR and CVR and quarantine the LRU's, as well as to make the aircraft available for the investigators to take photographs for the purposes of their investigation. By the time the Safety Department conveyed this information, the DFDR had already had the data downloaded and the CVR had been running for over 2 hours - all useful information had already been overwritten.

2.5. Two Hour Independent Four Channel CVR Recorded Data

Following access to the CVR when delivered to the GCAA from the operators MRO, the CVR was download.

The CVR read out was unsuccessful. However, following further investigation, it became apparent that the CVR installed was not recording on four channels separately for 120 minutes as per the requirements in the GCAA CAR's.

A cross check was made with similar CVR's installed and it was found that the operators CVR's are supplied by the MRO from a pool of CVR's which have a mixed modification embodiment across the CVR's installed throughout the operators fleets.

There are two modifications embodied on the fleet for the L3 Com CVR's, MOD #5 and MOD #7.

The modification status required to be compliant with the current GCAA CAR Part IV is the either Modification, #5 or #7.

The CVR installed on the accident aircraft was MOD #5.

Although MOD #5 does record all 4 channels independently for 2 hours, the channels are mixed after 30minutes of recording.

The preferred modification status is MOD#7. This modification status will be reflected in GCAA CAR Part IV to clarify the requirement for large passenger aircraft operators.

Two Hour Independent Four Channel CVR Recorded requirement is as follows:

(i) GCAA Civil Aviation Regulations (CAR) Part IV, CAR-OPS 1.700 (b)] requires 2 hours CVR recording for this type of aircraft, with four separate channel recording.

(ii) Cockpit Voice Recorder - ICAO Annex 6/Part 1

(a) The CVR shall have the capability to record two hours of voice data on each of the channels without combining the audio channels.
(b) The required recording time is 120 minutes for channels one (1) to four (4), with each channel to be recorded separately.

(c) See Table below – channels 1 – 4 and 120 minute recording times

CVR Cockpit Audio Inputs				
Channel	**1**	**2**	**3**	**4**
Recording time (minutes)	**120**	**120**	**120**	**120**

Table 6 CVR Cockpit Audio Inputs

2.6. Emergency Response Plan/Organizational Communication

Appropriate emergency response relies on effective communications and subsequent action commensurate to the information received. Effective communication in this context relates to timely, unambiguous information received by the operators NOC Duty Manager.

In Section 3 of the Operator's ERP Manual, a Category B event is defined as "An accident resulting in substantial damage to the aircraft and/or serious and/or fatal injury to one or more persons, and/or substantial damage to property caused by the aircraft". It goes on to give an example of, "Violent and extreme air turbulence (with theabove criteria)."

Based on these criteria, the event should have been categorized by the NOC Duty Manager as a Category B event.

This categorization would have activated the Emergency Response Centre with all the necessary resources involved in the assistance to the passengers, coordination with the investigative authorities and recovery of the operations. As the activation did not happen, the stakeholders had to perform their tasks individually in a desynchronized manner. As a consequence of this, immediate passenger support was limited to the hospitalized passenger and the immediate notification to the GCAA was delayed.

The investigation established that the scope of the injury level was not effectively categorized at the operations base. This coupled with the increased operation tempo related to the fog and possible disruption to the network diverted the NOC's attention to resolving the escalating aerodrome issues.

When the aircraft landed, two further sources of information could have conveyed the injury level message:

- The TAS officer
- The engineers who attended the aircraft.

The TAS officer was unable to properly assess the situation due to restrictions at the aircraft exit door.

The engineer's concern was focused on the repairs and return to service requirements.

2.7. Cabin Safety

Following an investigation into the cabin safety and cabin security following the event, it was identified that the definition of an incapacitated cabin crew is not specific to injury where the cabin crew is conscious and cognisant but unable to function - for example a fractured limb causing disability or severe concussion or trauma causing disorientation. The current SEP, section 8.2.2. instructs the following:

> *8.2.2. Cabin Crew Incapacitation (OM-A 8.3.15.2)*
> *If one or more cabin crew on board should become incapacitated during flight, CM shall inform the Commander immediately. If the number of remaining cabin crew is less than the minimum number required to operate the type, the following actions are necessary:*
> *Able-Bodied Person (ABP) selected to occupy vacant cabin crew seat.*

Based on case studies of passenger evacuation and emergency procedure handling, a further definition of Cabin Crew Incapacitation [CCI] relating to the ability to carry out the defined cabin crew safety functions with several CC injured should be reassessed by the operators.

2.8. Damage to the Aircraft

The affected panels were replaced in the hanger with all other associated post-accident inspections.
The OEM after receiving the flight data confirmed that the flight loads were within limits and no further inspections were required.

2.9. Loads and Allowable Limits

The OEM reviewed the flight data confirming that the high acceleration and associated flight loads were within allowable limits and no further inspections were required.

2.10. Deviation From Track [to avoid adverse meteorological conditions]

The delayed deviation from track is a contributory factor. The compound difficulty of the absence of the Captain, the CRM decision making delay associated with the communication problems experienced are factors in this event.

The crew should have considered weather deviation procedures in RVSM airspace as published in Jepp Airways Manual- General 15.2.3.3 – Actions to be taken if revised ATC clearance cannot be obtained.

Based on the following reference:

ICAO Doc 4444

15.2.3.3 ACTIONS TO BE TAKEN IF A REVISED ATC CLEARANCE CANNOT BE OBTAINED
Note.— The provisions of this section apply to situations where a pilot needs to exercise the authority of a pilot-in command under the provisions of Annex 2, 2.3.1

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If the aircraft is required to deviate from track to avoid adverse meteorological conditions and prior clearance cannot be obtained, an ATC clearance shall be obtained at the earliest

possible time. Until an ATC clearance is received, the pilot shall take the following actions:

a) if possible, deviate away from an organized track or route system;

b) establish communications with and alert nearby aircraft by broadcasting, at suitable intervals: aircraft identification, flight level, position (including ATS route designator or the track code) and intentions, on the frequency in use and on 121.5 MHz (or, as a back-up, on the inter-pilot air-to-air frequency 123.45 MHz);

c) watch for conflicting traffic both visually and by reference to ACAS (if equipped);

Note.— If, as a result of actions taken under the provisions of 15.2.3.3.1 b) and c), the pilot determines that there is another aircraft at or near the same flight level with which a conflict may occur, then the pilot is expected to adjust the path of the aircraft, as necessary, to avoid conflict.
d) turn on all aircraft exterior lights (commensurate with appropriate operating limitations)

SEVERE TURBULANCE ENCOUNTER – GPS TRACK/LATERAL OFF SET-UPSET RECOVERY/DISTANCE AND TIMES

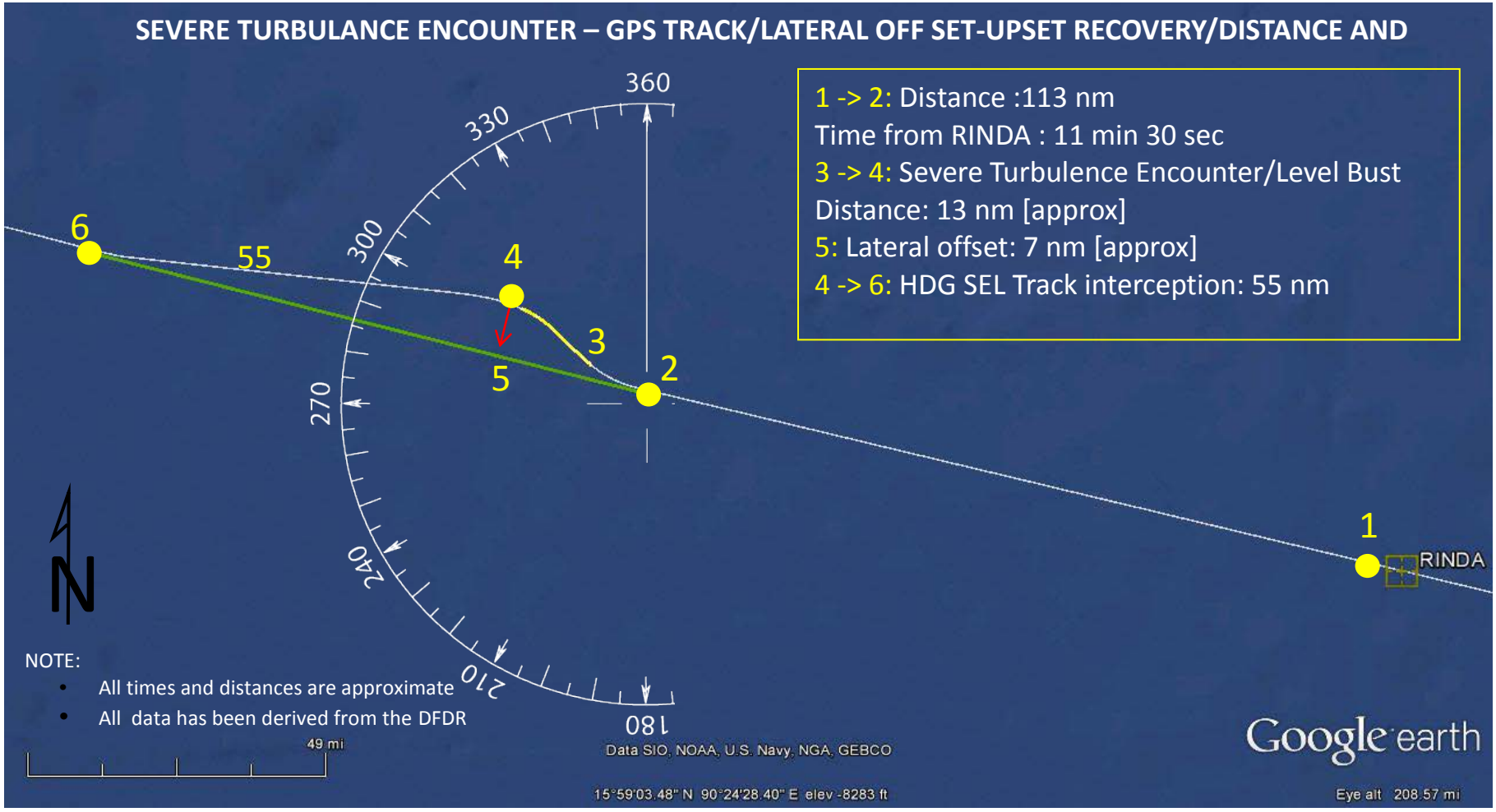
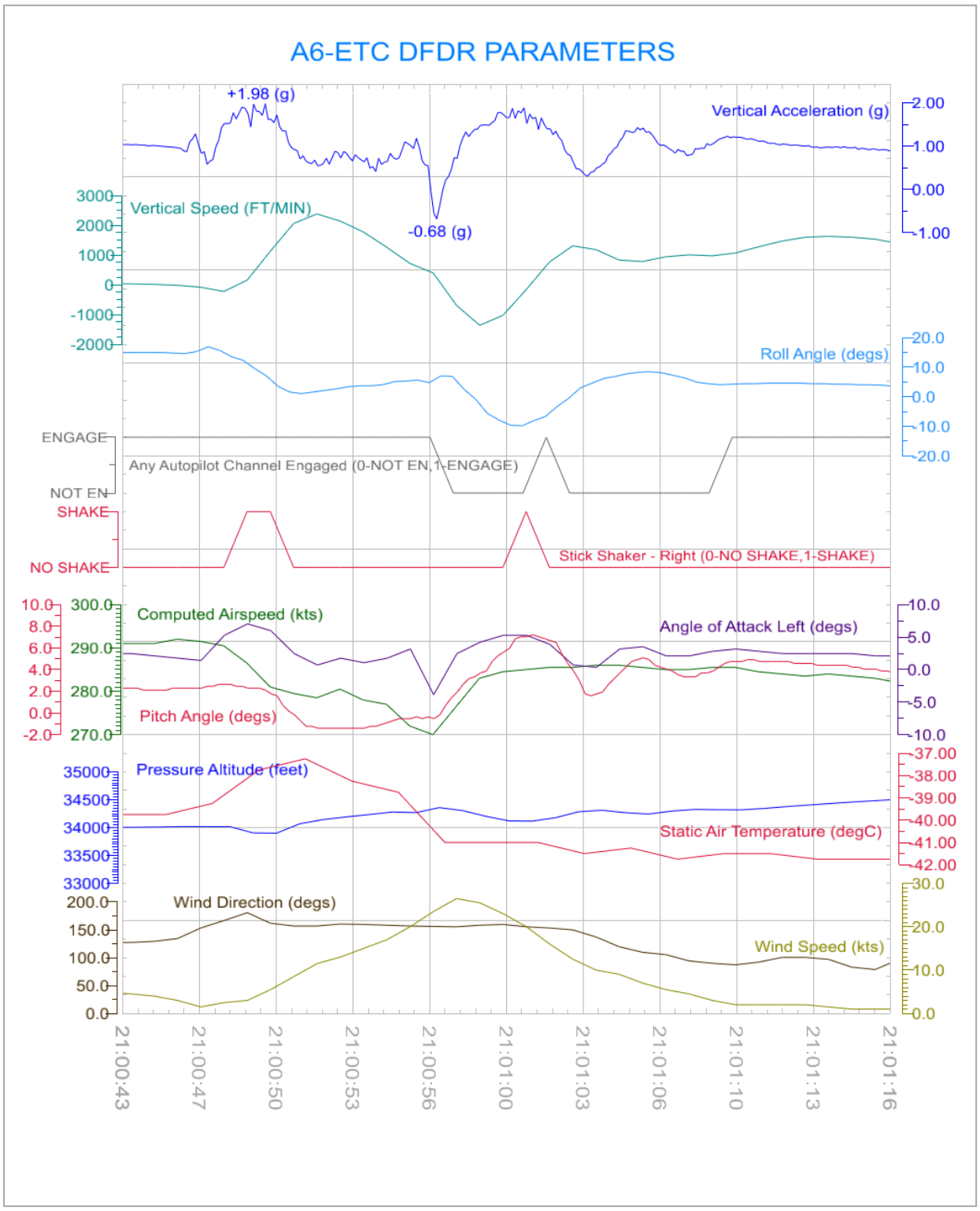


Figure 10 Track Deviation Overview [DFDR derived track data]

DIGITAL FLIGHT DATA PARAMETERS/TIME STAMP - UTC 21:00:43 TO 21:01:16



Analysis - DFDR Data Derived Event Sequence Parameters

3. CONCLUSIONS: FINDINGS, CAUSAL AND CONTRIBUTING FACTORS

3.1. FINDINGS

3.1.1. Preservation of Evidence

The operator did not inform the GCAA immediately that the event had been notified through the operators NOC, subsequently, due to the operators maintenance procedures with their maintenance provider MRO , the CVR/DFDR data was not recovered from the event. This was compounded by the maintenance process which with aircraft power on and the cockpit voice recorder (CVR) circuit breaker closed, the CVR will operate continuously recording over previous two hours of recording.

3.1.2. Two Hour Independent Four Channel CVR Recorded Data

3.1.2.1. Following the CVR download, it became apparent that the CVR installed was not recording on four channels separately for 120 minutes without combining the audio.

3.1.2.2. GCAA Civil Aviation Regulations (CAR) Part IV, CAR-OPS 1.700 (b)] requires 2 hours CVR recording for this type of aircraft, with four separate channel recording.

CVR – ICAO Annex 6/Part 1:

(a) The CVR shall have the capability to record two hours of voice data on each of the channels without combining the audio channels.
(b) The required recording time is 120 minutes for channels one (1) to four (4), with each channel to be recorded separately. See figure (i) below

CVR Cockpit Audio Inputs				
Channel	**1**	**2**	**3**	**4**
Recording time (minutes)	**120**	**120**	**120**	**120**

3.1.3. Investigation analysis indicates the all operators with pooled CVR procedures, i.e. where the LRU's are supplied from an MRO's central depot with mixed modification standards, in particular with LRU CVR units identified as: L3 Com FA2100, then all CVR's installed should be MOD-DOT #7 compliant[20]

[20] MOD-DOT #7 is an LRU specific hardware/software upgrade

See below for Aviation Recorders/Component Maintenance Manual Table 1/ATA 23-70-04

Model FA2100 CVR Recording Specifications

Model FA2100 Part Number	Cockpit Audio Inputs				Combined Channels	
	Channel 1	Channel 2	Channel 3	Channel 4	Combined Audio SQ	CAM–SQ
	3rd Crew Member/- Spare Audio Input for High Quality Recording	Co-Pilot Audio Input for High Quality Recording	Pilot Audio Input for High Quality Recording	Cockpit Area Microphone (CAM) Input for High Quality Recording	Summation of CH 1, 2, & 3 audio inputs for Standard Quality Recording	Standard Quality Recording of Cockpit Area Microphone (CAM) (CH 4) Input
2100–1010–XX	30 minutes	30 minutes	30 minutes	30 minutes	Not available	Not available
2100–1020–XX pre **MOD-DOT #7**	30 minutes	30 minutes	30 minutes	30 minutes	120 minutes	120 minutes
2100–1020–XX **MOD-DOT # 7**	120 minutes	120 minutes	120 minutes	120 minutes	Not available	Not available
2100–1025–XX 2100–1026–XX	120 minutes	120 minutes	120 minutes	120 minutes	Not available	Not available

NOTE: All of the times indicated in the above chart are minimum recording times.

3.1.4. Flight Crew

- Unfamiliarity with the Weather Radar use
- The 2 F/O's were unfamiliar with the CPDLC and Datalink procedures
- Non standard procedure for turbulence cabin security communication
- The crew were not familiar with the requirements for SLOP or weather deviation procedures in RVSM airspace as published in ICAO Doc 4444/ATM 501 and Jeppesen Airways Manual-General 15.2.3.3 – Actions to be taken if revised ATC clearance cannot be obtained.

3.1.5. Cabin Crew

- None adherence to Cabin crew Turbulence Safety and Emergency Procedures Manual Chap7, para 7.4.6
- None adherence to use of safety belts for cabin crew and passengers to secure themselves during turbulence as per CCM SEP 7.3.5 Manual/OM-A 8.3.12

3.1.6. Airline/Operator

- The operators NOC/Maintenance function failed to follow the GCAA CAR Ops requiring that the CVR is isolated and removed following an incident or accident.
- The CVR LRU circuit breaker was not isolated and the CVR and DFDR LRU's were not quarantined immediately.
- Passenger use of the toilets during turbulence encounters was not restricted when the seat belt signs were on in accordance with SEP

3.2. CAUSAL AND CONTRIBUTING FACTORS

3.2.1.Flight Crew

The following have been identified as contributing factors .

This combination of factors contributed to the late track deviation:

- Crew coordination
- Crew Resource Management
- HF Communications difficulties
- The absence of the Captain from the flight deck during the FIR transition and subsequent radio communication problems.
- The late recognition of the adverse weather on the weather radar
- The Captains delayed return to the flight deck immediately after the severe turbulence encounter effected the normalisation of the CRM environment.

3.2.2. Cabin Crew [CC]

- Not effectively monitoring the passenger use of the lavatories when the seat belt sign has been switch on.
- Performing routine CC organisational duties when the seat belt sign is on in the galley and associated areas.

4. SAFETY RECOMMENDATIONS

4.1. The operator shall review their internal procedures for the immediate notification of Accidents/Serious Incidents to the GCAA Duty Investigator [DI].

4.2. GCAA to revise CAR Part IV, CAR-OPS 1.700 (b) for large passenger aircraft operators to specifically mandate the requirement for 4 channel uncombined/non mixing CVR LRU's.

4.3. For operators with pooled CVR procedures involving the L3 FA2100 CVR: All CVR's should be MOD-DOT #7 modification compliant pending a revision of GCAA CAR Part IV, CAR-OPS 1.700 (b).

4.4. The operator shall develop procedures which prevent maintenance engineering or the maintenance provider from tampering with flight data recorders either inadvertently or otherwise. This procedure shall be robust and form part of the notification to the GCAA DI as in Recommendation 4.1 above.

4.5. The operator to review the policy for activation of the Emergency Response Plan [ERP] where there are passenger and crew injuries requiring medical intervention.

4.6. The number of injured cabin crew from a single event that effects the safety of the flight is not specifically determined in the SEP. The operator shall determine an emergency procedure to manage several injured cabin crew following a major severe turbulence event and develop an acceptable contingency policy to mitigate the risks.

4.7. The operators Training & Standards Department are to review the training and re-currency requirements for the following:

4.7.1. Review the training syllabus for the use of weather radar.

4.7.2. Review the training syllabus for the operational use of CPDLC and other Data link communications.

4.7.3. Provide user guide material to pilots on weather radar and CPDLC operational usage.

4.7.4. Provide user guide material to pilots for weather deviation procedures in RVSM airspace.

4.7.5. Review the Human Factors Training policy and the Crew Resource Management dynamic management and decision making procedures when the Captain is not on the flight deck.

4.7.6. Review current cabin security procedures during turbulence for service level 1,2 and 3

4.7.7. Managing Interruptions and Distractions [Coping with unexpected distraction, disturbance and contingency in the cockpit requires the use of techniques to lessen the effects of any disruption in the flow of on-going cockpit activities.]

4.7.8. Threat and Error Management (TEM) Techniques specific to adverse weather.

4.8. The operator shall introduce a procedure for managing reduced mobility/injured cabin crew as result of an in-flight safety events which effect the cabin crew fitness to operate if the cabin crew numbers are less than the minimum required for the aircraft type.

4.9. The operator shall adhere to the turbulence procedures for cabin crew to secure themselves and the passengers as CCM SEP 7.3.5 Manual/OM-A 8.3.12.

4.10. The operator shall reemphasis the turbulence procedures for passenger safety concerning the use of lavatories and the use of seatbelts during turbulence events.

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