

الهيئة العامة للطيران المدني  
GENERAL CIVIL AVIATION AUTHORITY



# Air Accident Investigation Sector

Serious Incident

- Final Report -

AAIS Case N°: AIFN/0007/2020

## Descent below Vertical Profile during Approach

Operator:	Etihad Airways
Make and Model:	Boeing B787-10
Nationality and Registration:	The United Arab Emirates, A6-BMD
Place of Occurrence:	Abu Dhabi International Airport (OMAA)
State of Occurrence:	United Arab Emirates
Date of Occurrence:	6 June 2020



This Investigation was conducted by the Air Accident Investigation Sector of the United Arab Emirates pursuant to Civil Aviation Law No. 20 of 1991, in compliance with Air Accident and Incident Investigation Regulation, and in conformance with the requirements of Annex 13 to the Convention on International Civil Aviation.

This Investigation was conducted independently and without prejudice. The sole objective of the investigation is to prevent future aircraft accidents and incidents. It is not the purpose of this activity to apportion blame or liability.

The Air Accident Investigation Sector issued this Final Report in accordance with the national and international standards and practices. Consultation with applicable stakeholders, and consideration of their comments, took place prior to the publication of this Report.

The Final Report is publicly available at:

<http://www.gcaa.gov.ae/en/epublication/pages/investigationReport.aspx>

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## Occurrence Brief

<b>AAIS Case N°:</b>	AIFN/0007/2020
<b>Operator:</b>	Etihad Airways
<b>Aircraft make and model:</b>	Boeing B787-10
<b>Registration mark:</b>	A6-BMD
<b>Manufacturer serial number:</b>	60758
<b>Number and type of engines:</b>	Two, GENx-1B 74/75P2 high-bypass turbofan engines
<b>Date and time (UTC):</b>	6 June 2020, at 1001 UTC
<b>Place:</b>	Abu Dhabi International Airport, the United Arab Emirates
<b>Category:</b>	Transport (Cargo)
<b>Persons on-board:</b>	3
<b>Injuries:</b>	Nil

## Investigation Process

The occurrence involved a Boeing B787-10 aircraft, registration A6-BMD, and was notified by the operator to the Air Accident Investigation Sector (AAIS) by phone call to the Duty Investigator Hotline Number +971 50 641 4667.

The AAIS opened an investigation in line with State's obligations in accordance with Annex 13 as the United Arab Emirates being the State of Occurrence, Registry, and the Operator, and appointed an investigator-in-charge from the AAIS for the various investigation areas.

The occurrence was classified as a 'serious incident' after the initial investigation phase.

The AAIS notified the National Transportation Safety Board (NTSB) of the United States being the State of Manufacture and Design.

The scope of the investigation into this serious incident is limited to the events leading up to the occurrence; no in-depth analysis of non-contributing factors or non-safety-related issues was undertaken.

### Notes:

- <sup>1</sup> Whenever the following words are mentioned in this Final Report with the first letter capitalized, they shall mean the following:
- (Aircraft) – the aircraft involved in this serious incident
  - (Commander) – the commander of the serious incident flight
  - (Operating Copilot) – the operating copilot of the serious incident flight
  - (Additional Copilot) – the copilot of the serious incident flight seated on the jump seat
  - (Incident) – this investigated serious incident referred to on the title page of this Report
  - (Investigation) – the investigation into this serious incident
  - (Operator) – Etihad Airways (operator of the aircraft)



- (Report) – this serious incident investigation Final Report.
- <sup>2</sup> Unless otherwise mentioned, all times in this Report are 24-hour clock in Coordinated Universal Time (UTC), United Arab Emirates local time minus 4).
- <sup>3</sup> Photos and figures used in this Report are taken from different sources and are adjusted from the original for the sole purpose to improve the clarity of the Report. Modifications to images used in this Report are limited to cropping, magnification, file compression, or enhancement of color, brightness, contrast, or insertion of text boxes, arrows, or lines.



## Abbreviations

<b>AAE</b>	Above aerodrome elevation
<b>AAIS</b>	The Air Accident Investigation Sector of the United Arab Emirates
<b>AAL</b>	Above airfield level
<b>ACARS</b>	Aircraft communications addressing and reporting system
<b>AFDS</b>	Autopilot flight director system
<b>ALT</b>	Altitude
<b>ANS</b>	Air navigation services
<b>AOC</b>	Air operator certificate
<b>APCH</b>	Approach
<b>AR</b>	Authorization required
<b>ARC</b>	Airworthiness review certificate
<b>ASR</b>	Air safety report
<b>ATC</b>	Air traffic control
<b>ATCO</b>	Air traffic control officer
<b>ATIS</b>	Automatic terminal information service
<b>ATM</b>	Air traffic management
<b>ATS</b>	Air traffic services
<b>ATSOM</b>	<i>Air traffic services operating manual</i>
<b>ATPL</b>	Air transport pilot license
<b>CAR</b>	<i>Civil Aviation Regulations</i> of the United Arab Emirates
<b>CAT</b>	Category
<b>CFIT</b>	Controlled flight into terrain
<b>COA</b>	Certificate of airworthiness
<b>COR</b>	Certificate of registration
<b>CTA</b>	Control area
<b>CVR</b>	Cockpit voice recorder
<b>DES</b>	Descent
<b>DA</b>	Decision altitude
<b>DN</b>	Down
<b>EAFR</b>	Enhanced airborne flight recorder
<b>EBT</b>	Evidence-based training
<b>ECON</b>	Economy
<b>ELP</b>	English language proficiency
<b>ERP</b>	Emergency response plan
<b>FAF</b>	Final approach fix



<b>FCOM</b>	<i>Flight crew operating manual</i>
<b>FDR</b>	Flight data recorder
<b>FL</b>	Flight level
<b>FLCH</b>	Flight level change
<b>FMA</b>	Flight mode annunciation
<b>FMC</b>	Flight management computer
<b>FMS</b>	Flight management system
<b>FSM</b>	Flight safety message
<b>ft</b>	Feet
<b>GCAA</b>	The General Civil Aviation Authority of the United Arab Emirates
<b>hPa</b>	Hectopascal
<b>IAF</b>	Initial approach fix
<b>IAS</b>	Indicated airspeed
<b>ICAO</b>	International Civil Aviation Organization
<b>IF</b>	Intermediate fix
<b>ILS</b>	Instrument landing system
<b>KIAS</b>	Knots indicated airspeed
<b>km</b>	Kilometers
<b>kts (KT)</b>	Knots
<b>L</b>	Left
<b>LFUS</b>	Line flying under supervision
<b>LNAV</b>	Lateral navigation
<b>LSK</b>	Line select key
<b>MAP</b>	Missed approach point
<b>MCP</b>	Mode control panel
<b>MHz</b>	Megahertz
<b>MSAW</b>	Minimum safe altitude warning
<b>No.</b>	Number
<b>ND</b>	Navigation display
<b>Nm</b>	Nautical mile
<b>OAT</b>	Outside air temperature
<b>OB</b>	Operations bulletin
<b>OM</b>	<i>Operations manual</i>
<b>OMAA</b>	Abu Dhabi International Airport
<b>OPC</b>	Operator proficiency check
<b>OPS</b>	Operations



<b>PAPI</b>	Precision approach path indicator
<b>PBN</b>	Performance-based navigation
<b>PF</b>	Pilot flying
<b>PFD</b>	Primary flight display
<b>PIC</b>	Pilot in command
<b>PM</b>	Pilot monitoring
<b>PTH</b>	Path
<b>RA</b>	Radio altitude
<b>REF</b>	Reference
<b>RNAV</b>	Area navigation
<b>RNP</b>	Required navigation performance
<b>ROD</b>	Rate of descent
<b>RWY</b>	Runway
<b>SEM</b>	Semester
<b>SEP</b>	<i>Safety and emergency procedures</i>
<b>SMS</b>	Safety management system
<b>SOP</b>	Standard operating procedures
<b>SPD</b>	Speed
<b>SPS</b>	Samn-Perelli (seven-point fatigue) scale
<b>STAR</b>	Standard arrival
<b>TO</b>	Takeoff
<b>TO/GA (TOGA)</b>	Takeoff/go-around
<b>TERR</b>	Terrain
<b>TI</b>	<i>Temporary instruction</i>
<b>TPC</b>	Threat based briefing
<b>UAE</b>	The United Arab Emirates
<b>UAS</b>	Undesirable aircraft state
<b>UTC</b>	Coordinated Universal Time
<b>VNAV</b>	Vertical navigation
<b>VREF</b>	Reference speed
<b>VSD</b>	Vertical situation display
<b>WLM</b>	Workload management
<b>WXR</b>	Weather radar
<b>ZFW</b>	Zero fuel weight

## Synopsis

On 6 June 2020, an Etihad Airways Boeing B787-10, registration mark A6-BMD, operated cargo flight EY9878 from Beijing Capital International Airport, China, to Abu Dhabi International Airport, the United Arab Emirates, with three persons on-board comprising a Commander and two Copilots.

During an RNP AR approach (RNAV (RNP) Y) to runway 31L at Abu Dhabi International Airport, when the Aircraft was on final approach at a distance of approximately 1.3 nautical miles from the threshold of runway 31L and approximately 210 feet radio altitude, the flight crew initiated a go-around. The go-around initiation was decided by the Commander after sighting four reds of the precision approach path indicator (PAPI) and subsequently carried out by the Copilot as pilot flying.

The Air Accident Investigation Sector of the United Arab Emirates (AAIS) determines that the cause of the Aircraft flying below the vertical profile during approach was the incorrect local pressure (QNH) altimeter setting.

The AAIS identifies the following contributing factors to the Incident:

- The operating flight crew omitted to preset local Abu Dhabi International QNH value after receiving automatic terminal information service (ATIS) information.
- Prior to and at transition level, the flight crew were fixated on the high-energy management for the descent, such that selecting the barometric setting from the standard pressure of 1013 hectopascal (hPa) to the local QNH value was carried out incorrectly.
- The Approach Controller did not provide local QNH information along with the initial descent clearance from a flight level to an altitude, nor when issued the clearance of RNAV Y runway 31L approach.
- The vertical situation display (VSD) and its cues were not used or considered of their vertical profile assessment during approach by the flight crew for monitoring.
- Air traffic control did not provide instruction to check the QNH setting and the level of the Aircraft when the activation of the minimum safe altitude warning was triggered on its radar screen.
- At higher altitudes, the forward visibility was less than reported, due to the presence of haze layer(s) of which are commonly associated with temperature inversions in the Middle Eastern region.

The AAIS issued six safety recommendations as a result of the Investigation, which consist of four recommendations to the Aircraft Operator, one to the GAL Air Navigation Services provider (GAL ANS), and one to the General Civil Aviation Authority (GCAA). The recommendations were for a reinforcement of the implementation of QNH barometric preselecting, a reinforcement of additional monitoring by the additional flight crew in the flight deck, addressing to amend baro-VNAV approach procedures with more detailed information on the VSD, a review of the effectiveness of the Aircraft Operator's safety actions taken after the Incident, a consideration to include Supplementary Instructions in the *Air Traffic Services Operating Manual*, and a consideration to implement the requirements of 25 hours CVR recording capability.





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# 1. Factual Information

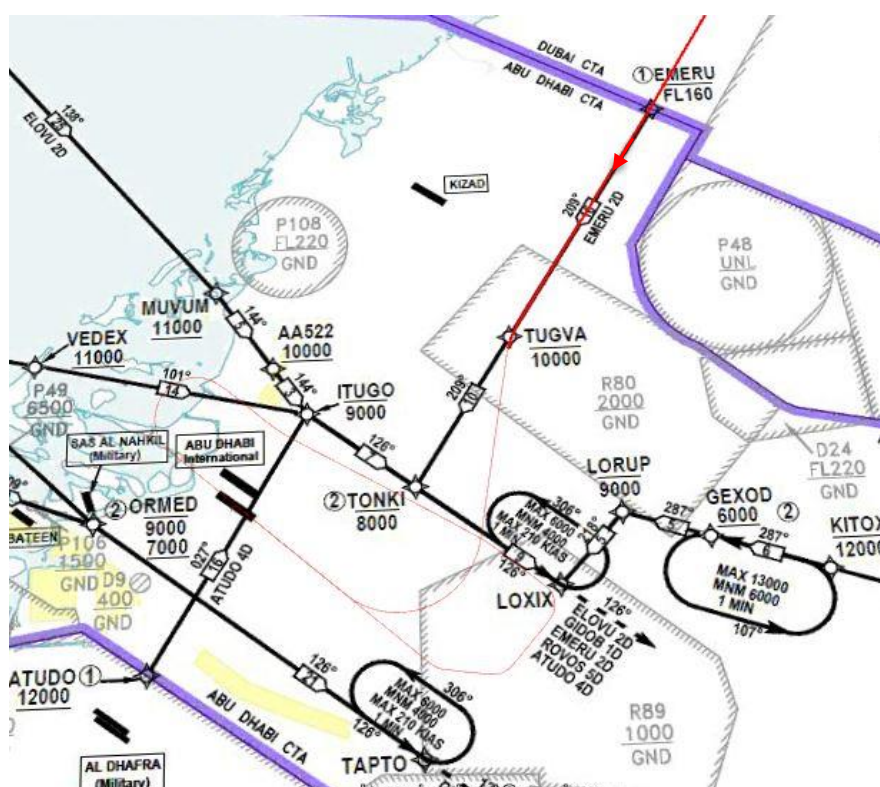
## 1.1 History of Flight

On 6 June 2020, an Etihad Airways Boeing B787-10, registration mark A6-BMD, operated cargo flight EY9878 from Beijing Capital International Airport (ZBAA<sup>1</sup>), China, to Abu Dhabi International Airport (OMAA<sup>2</sup>), the United Arab Emirates, with three persons on-board comprising a Commander and two Copilots.

The Commander was the pilot monitoring (PM). One of the two Copilots in the cockpit was the pilot flying (PF). The other Copilot seated on the jump seat was an additional flight crew in this flight.

The Aircraft took off from runway 01 at 0219. After takeoff and climb, the Aircraft cruised at flight level (FL) 360 for around 2 hours 40 minutes. The Aircraft then climbed, and cruised at FL380 for approximately 3 hours 56 minutes, as the flight proceeded uneventfully.

At 0937, the Aircraft commenced its descent, subsequently followed standard arrival EMERU 2D (figure 1), and continued to proceed for an RNP AR approach (RNAV (RNP) Y) to runway 31L at OMAA (figure 2).

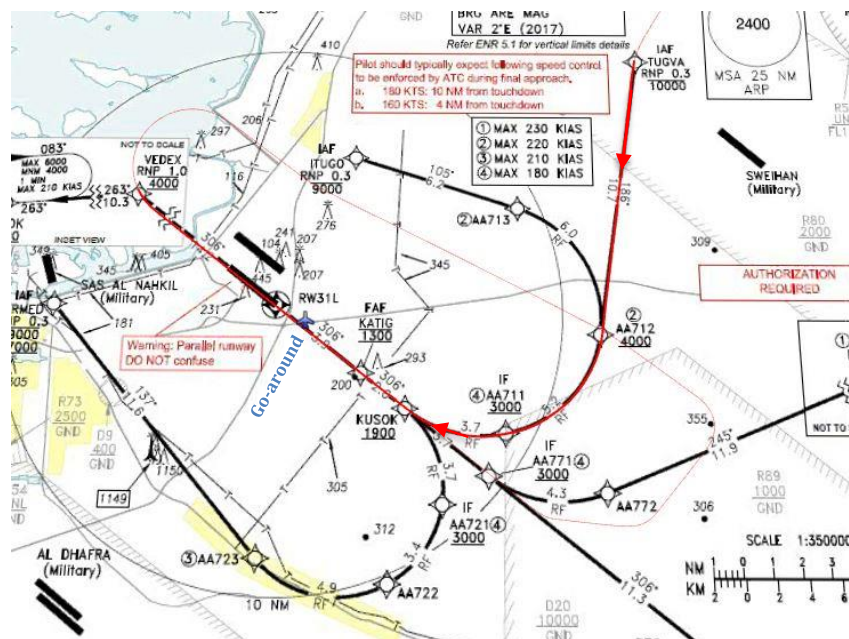


**Figure 1.** EY9878 flight path on arrival (red thick-line) following OMAA STAR RNAV 1 runway 31L/R chart

At 1001:06, when the Aircraft was on final approach at a distance of approximately 1.3 nautical miles from the threshold of runway 31L and approximately 210 feet radio altitude (RA), the flight crew initiated a go-around. The go-around initiation was decided by the Commander after sighting four reds of the precision approach path indicator (PAPI) and subsequently carried out by the Copilot as PF.

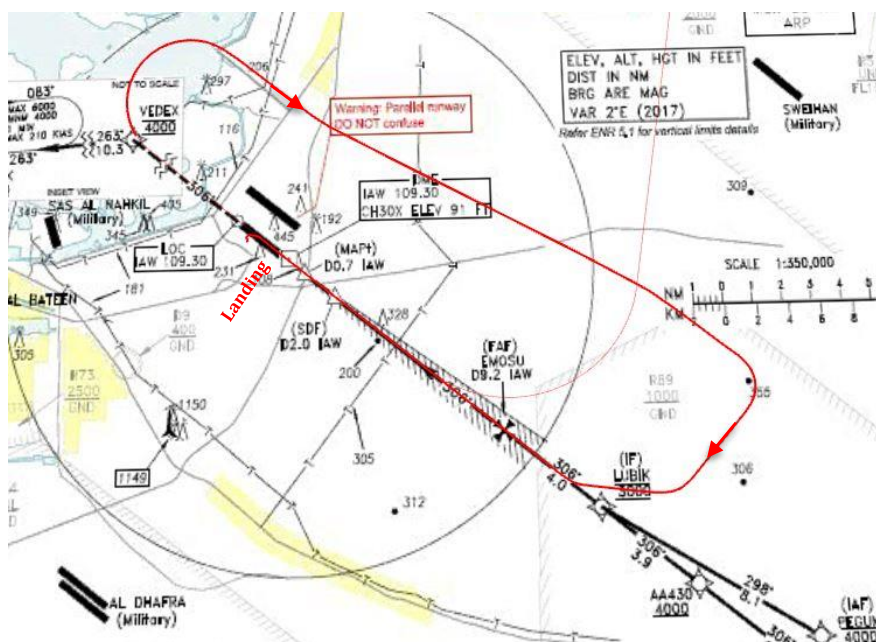
<sup>1</sup> ZBAA is the ICAO four letter airport code for Beijing Capital International Airport, China

<sup>2</sup> OMAA is the ICAO four letter airport code for Abu Dhabi International Airport, United Arab Emirates



**Figure 2.** EY9878 flight path of first approach and go-around (red thick-line) following instrument approach chart of OMAA RNAV(RNP) Y Runway 31L

After the go-around, the flight crew informed air traffic control (ATC) that they were ready for a second approach to the same runway (31L). While the ATC provided vectors for the second approach on instrument landing system (ILS) approach to the runway, the Aircraft leveled off at 4,000 feet indicated altitude.



**Figure 3.** EY9878 flight path of second approach and landing (red thick-line) following instrument approach chart of OMAA ILS Runway 31L

At 1004:19, ATC asked for confirmation to EY9878 regarding the QNH setting in the cockpit and its current altitude. The ATC Radar System (Eurocat-X) indicated the correct altitude of 3,700 feet that was calculated based on the QNH setting of 998 hPa, which was then informed to the flight crew by the Controller. The flight crew then realized that they had set the wrong QNH setting and needed to climb further to 4,000 feet to the correct missed



approach altitude. The Aircraft experienced a level bust around 300 feet below the missed approach altitude. The Aircraft then climbed to the missed approach altitude after the flight crew had changed their QNH setting from 1009 to 998 hPa, and continued an ILS approach to runway 31L as per the vectors provided by the ATC.

Figure 3 shows the Aircraft flight path of its ILS approach on runway 31L. The Aircraft landed uneventfully at 1017, vacated the runway via taxiway Echo 8, and continued taxiing through taxiway Echo 6 to parking stand 308. The engines were shut down at 1022:14.

## 1.2 Injuries to Persons

There were no injuries to persons because of the Incident.

Table 1. Injuries to persons					
Injuries	Flight crew	Cabin crew	Passengers	Total onboard	Others
Fatal	0	0	0	0	0
Serious	0	0	0	0	0
Minor	0	0	0	0	0
None	3	0	0	3	0
<b>TOTAL</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>0</b>

## 1.3 Damage to Aircraft

There was no damage to the Aircraft.

## 1.4 Other Damage

There was no damage to property or the environment.

## 1.5 Personnel Information

The qualifications and experience of the Commander and two Copilots at the time of the Incident were as shown in table 2.

Table 2. Flight crewmembers data			
	Commander (Pilot Monitoring)	Operational Copilot (Pilot Flying)	Additional Copilot (Jumpseat)
Age	54	35	50
Type of license	ATPL-A <sup>3</sup>	ATPL-A	ATPL-A
Valid to	18 October 2022	13 July 2023	25 August 2023
Rating	MEP <sup>4</sup> Land, IR/MPA <sup>5</sup> , B777, B787	MEP Land, IR/MPA, B777, B787	IR/MPA, B787
Total flying time (hours)	20,536.38	8,818.73	7,965.38
Total Command on all types (hours)	15,074.38	230	2,121
Total on this type (hours)	2,117.5	1751.45	3,350.57
Total Command on this type (hours)	2,117.5	0	0

<sup>3</sup> ATPL: Air transport pilot license

<sup>4</sup> MEP: Multi engine piston

<sup>5</sup> MPA: Multi-pilot aircraft



Total twelve months (hours)	749.67	768.53	680.97
Total on type the last 28 days	64.48	60.93	77.38
Total on type the last 14 days	43.33	45.02	46.77
Total last 7 days (hours)	27.88	29.35	27.88
Total on type last 7 days (hours)	27.88	29.35	27.88
Total last 24 hours (hours)	8.42	8.42	8.42
Last safety and emergency procedures (SEP)	8 May 2020	12 March 2020	8 July 2019
Last Operator proficiency check (OPC)	9 May 2020	17 May 2020	15 January 2020
Last annual line check	27 May 2020	3 October 2019	5 November 2019
Medical class	Class 1	Class 1	Class 1
Valid to	28 May 2021	20 April 2021	22 March 2021
Medical limitation	VNL <sup>6</sup>	VDL <sup>7</sup>	NIL
English language proficiency (ELP)	Level 6	Level 6	Level 6

Based on the flight crew records provided to the Investigation, the flight crew qualifications and experience were not factors in the Incident.

## 1.6 Aircraft Information

### 1.6.1 Aircraft data

Table 3 illustrates general information related to the Aircraft on the date of the Incident.

**Table 3. Aircraft data**

Manufacturer:	Boeing
Model:	B787-10
Manufacturer serial number:	60758
Nationality and registration mark:	United Arab Emirates, A6-BMD
Name of the Operator:	Etihad Airways
Certificate of airworthiness	
Number:	UAE-COA-0576
Original issue date:	21 December 2018
Re-issue date:	Not applicable
Valid to:	<i>Airworthiness Review Certificate ARC-EY-BMD-2</i> 20 December 2020
Certificate of registration	
Number:	UAE-COR-1095
Original issue date:	21 December 2018

<sup>6</sup> VNL is a medical limitation code of correction for defective near vision, which means that the licence holder should have readily available spectacles that correct for defective near vision as examined and approved by the aero-medical centre or aero-medical examiners.

<sup>7</sup> VDL is a medical limitation code of correction for defective distant vision, which means that the licence holder should have readily available spectacles that correct for defective distant vision as examined and approved by the aero-medical centre or aero-medical examiners.



Date of production/delivery:	December 2018 / 23 December 2018
Time since new (flight hours):	5,540.23
Cycles since new:	1,021
Last major inspection, type, date and hours/cycle:	29 February 2020 (A-03 Check), 4,841.22 hours, 904 cycles
Time since last major inspection (flight hours):	699.01
Cycles since last major inspection:	117
Last inspection, type, date and hours/cycle:	6 June 2020 (Daily-Check), 5,540.23 hours, 1,021 cycles
Maximum take-off weight:	250,836 kg
Maximum landing weight:	201,848 kg
Maximum zero fuel weight:	192,776 kg

### 1.6.2 Engine data

Table 4 illustrates general information related to the engines on the date of the Incident.

**Table 4. Engine data**

Manufacturer:	General Electric	
	No. 1 engine	No. 2 engine
Model:	GEEx-1B 74/75P2	GEEx-1B 74/75P2
Manufacturer serial number:	958217	958220
Date installed on Aircraft:	08 November 2018	08 November 2018
Time since new (hours):	5,548.2	5,548.2
Cycles since new:	1,022	1,022
Time since last overhaul/inspection (hours):	5,548.2	5,548.2
Cycles since last overhaul/inspection:	1,022	1,022

### 1.6.3 Post-Incident inspection

Based on the technical logs after the flight, there were no defects recorded.

### 1.6.4 Maintenance records

No defect was recorded on 6 June 2020 prior to the flight based on the Aircraft's maintenance records.

## 1.7 Meteorological Information

Table 5 shows the METAR for OMAA on 6 June 2020, during the period from 0900 to 1000.

**Table 5. METAR, 6 June 2020, 0900 to 1000 UTC**

METAR OMAA 060900Z 30006KT 260V340 CAVOK 41/23 Q0999 NOSIG  
METAR OMAA 061000Z 30010KT CAVOK 42/21 Q0998 NOSIG





Table 6 describes the above-mentioned METAR.

Table 6. Description of the METAR		
0900 UTC		1000 UTC
<b>Wind</b>	Direction 300 degrees / speed 06 kts Variation in wind direction between 260 and 340 degrees	Direction 300 degrees / speed 6 kts
<b>Visibility</b>	10 km or more	10 km or more
<b>Clouds</b>	No clouds below 5,000 ft	No clouds below 5,000 ft
<b>OAT</b>	41 °C	42 °C
<b>Dew point</b>	23 °C	21 °C
<b>Pressure (Altimeter)</b>	999 hPa	998 hPa
<b>Condition</b>	No significant change within the next 2 hours	No significant change within the next 2 hours

## 1.8 Aids to Navigation

There were no reported defects related to onboard navigation aids or their serviceability. The navigations aids were functioning normally.

### 1.8.1 On-board vertical situation display

A vertical situation display (VSD) was incorporated in the Aircraft. The VSD displays a profile view of the Aircraft and its environment. It was located on the bottom of the navigation display (ND).

This VSD incorporated a vertical flight path vector, which indicated the current flight path angle as a function of Aircraft vertical speed and groundspeed. The VSD incorporated a runway and scaled runway length. In combination, these provided an approximate indication of the predicted point the Aircraft will intercept the runway (or otherwise) based on this vector.

## 1.9 Communications

All communications between the flight crew and Abu Dhabi ATC were generally clear and normal and were recorded by the ground-based voice recording equipment. The transcript of these communications was made available to the Investigation.

During the approach, from 0948:24 to 0958:55, the Aircraft was in communication with Approach Control (Abu Dhabi Radar Central) on (primary) frequency 124.400 megahertz (Mhz). Subsequently, EY9878 was in communication with Tower Control (Abu Dhabi Tower South) on (primary) frequency 119.200 Mhz from 0959:21 to 1002:17.

During the go-around and the second approach, the Aircraft was in communication with Approach Control (Abu Dhabi Radar West) from 1002:30 to 1014:32. Subsequently, the Aircraft was in communication with Tower Control on frequency 119.200 Mhz started from 1014:37 until it landed.

### 1.10 Aerodrome Information

Abu Dhabi International Airport (OMAA), coordinates 24°25'59"N 54°39'04"E, is the mid-point of runway 13R/31L on the centerline, and located 16.5 kilometers east of Abu Dhabi city. The airport elevation is 83 feet.



OMAA is equipped with two asphalt runways: 13R/31L; and 13L/31R. Runway 31L has a landing distance available of 4,106 meters. The distance between both runways' centerlines is 2,000 meters.

Runway 31L is equipped with an Instrument Landing System International Civil Aviation Organization Category (ILS ICAO CAT) II/III precision approach lighting system and PAPI lights for a 3.0 degrees glide path.

### 1.11 Flight Recorders

The Aircraft was equipped with one forward and one aft enhanced airborne flight recorders (EAFR). The EAFR had the capabilities of both flight data recorder and cockpit voice recorder (combined flight recorders). However, since the occurrence was notified late, the data of the cockpit voice recorder was overwritten by the next flight.

The ATC transcript was provided to the Investigation. The data of the flight data recorder and ATC transcript were examined, and prior to that, the time between the two data was synchronized.

The following detail of the flight is based on the mentioned data after time synchronization.

The flight crew commenced contacting Abu Dhabi Approach Control and provided confirmation of receiving ATIS information India (see Appendix 1), conducting RNAV 1 instrument standard arrival through EMERU 2D and approaching FL160, while the Aircraft was descending passing 17,080 feet pressure altitude at a distance of approximately 19.8 nautical miles from EMERU<sup>8</sup>.

Approach Control informed the flight crew to expect RNAV Y approach runway 31L and instructed them to descend to FL160 and to maintain that level. The Abu Dhabi Approach Controller could not issue a clearance to descend below FL160 earlier due to the enforcement of the aircraft transfer agreement provisions between the Dubai and Abu Dhabi ATC units. At this time, the Aircraft was descending through 16,700 feet pressure altitude, at a distance of approximately 12 nautical miles south-south-west of OMDB. Additionally, the flight crew were informed that the Controller would come back and provide information of when the Aircraft would be able for further descent. The QNH information was not verbally provided by the ATC. The flight crew confirmed receiving ATIS information India that contained the QNH value of 999 hPa on the first contact with Abu Dhabi Approach Control. The flight crew read back correctly to maintain FL160.

The Aircraft leveled off at FL160 at 0949:19 in Dubai control area (CTA) with a distance of approximately 15.6 nautical miles northeast of EMERU waypoint, and the airspeed was 280 knots.

At 0950:13, while maintaining FL160 at a distance of approximately 10 nautical miles northeast of EMERU waypoint, the flight crew requested a confirmation from the ATC that after TUGVA waypoint to proceed to AA712 waypoint, and the ATC confirmed that.

At 0951:19, at approximately 3.1 nautical miles before EMERU waypoint, the ATC instructed the flight crew to descend to 7,000 feet, and cleared the Aircraft for RNAV Y approach runway 31L from TUGVA, as the initial approach fix (IAF). The flight crew read back correctly.

The Aircraft crossed EMERU waypoint at around 0951:51, while descending through 15,880 feet indicated altitude (QNH 1009), and followed EMERU 2D STAR.

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<sup>8</sup> EMERU is a waypoint on the border line between Dubai control area (CTA) and Abu Dhabi CTA (see also figure 1).



At 0952:36, when the Aircraft was passing FL146, the Commander's altimeter pressure setting was changed from the standard pressure (1013 hPa) to QNH 1009 hPa, which resulted in changing of the indicated altitude from 14,610 feet to 14,500 feet. One second later, the Copilot changed his altimeter setting from the standard pressure to QNH setting.

At 0953:25, the Aircraft was descending through 13,130 feet indicated altitude, the vertical mode was changed from vertical navigation (VNAV) to flight level change (FLCH). At this point, the indicated airspeed (IAS) was 269 knots, and the Aircraft was approximately 32 track nautical miles to touchdown. One second later, the speedbrakes were deployed to 2/3<sup>rd</sup> of full position.

At 0953:35, the Aircraft was descending through 13,000 feet indicated altitude, the target speed was set to 240 knots. At this point, the indicated airspeed was 269 knots, and the Aircraft was approximately 31 track nautical miles to touchdown. Two seconds later, the speedbrakes were deployed to a full position.

At 0954:36, the Aircraft crossed TUGVA waypoint (the IAF), while descending through 10,920 feet indicated altitude and 240 knots IAS. There was a constraint requirement at TUGVA of 10,000 feet or below.

At 0954:42, the speedbrakes were brought to half of the full position.

At 0954:57, ATC informed that the Aircraft was at 23 nautical miles prior to touchdown, and requested confirmation whether the flight crew were able to lose the altitude of the Aircraft. In the meantime, the target speed was set to 220 knots, while the Aircraft was turning to the left and descending through 10,170 feet indicated altitude at distance around 1.7 nautical miles after TUGVA waypoint. The flight crew subsequently, affirmed the ATC request.

At 0955:03, the speedbrakes were again deployed to the full position.

At 0955:12, the Aircraft was descending through 9,835 feet indicated altitude, the vertical mode was changed from FLCH to VNAV. Subsequently, the target altitude was set to 470 feet, at 0955:19.

At 0955:35, the flap lever was moved from UP to position 1 detent (slats moved to the middle position, and the flaps remained retracted) when the Aircraft was descending through 9,350 feet indicated altitude.

At 0956:56, VNAV PTH (vertical navigation – path) briefly annunciated approximately two seconds, followed by a change to FLCH vertical mode when the Aircraft was descending through 6,570 feet indicated altitude.

At 0957:00, the Aircraft crossed AA712 waypoint while descending passing 6,500 feet indicated altitude, and the airspeed was 220 knots.

At 0957:38, the landing lever was moved from UP to DN (down) position when the Aircraft was descending through 5,200 feet indicated altitude.

At 0957:46, the flap lever was moved from 1 to 5 detent (flaps moved to 5-degree position, and the slats remained in the middle position) when the Aircraft was descending through 4,905 feet indicated altitude.

At 0957:57, all gears were in extension position when the Aircraft was descending through 4,500 feet indicated altitude.

At 0958:13, the flap lever was moved from 5 to 15 detent (flaps moved to 15-degree position, and the slats remained in the middle position) when the Aircraft was descending through 3,750 feet indicated altitude.



At 0958:17, the Aircraft crossed AA711 (intermediate fix “IF”) while descending passing 3,600 feet indicated altitude, and the airspeed was 206 knots.

At 0958:34, the flap lever was moved from 15 to 20 detent (flaps moved to 20-degree position, and the slats remained in the middle position) when the Aircraft was descending through 3,065 feet indicated altitude.

At 0958:44, the Aircraft was descending through 2,670 feet indicated altitude, the radio altitude showed 2,500 feet. The auto voice callout “2500” annunciated.

At 0958:46, the ATC instructed the flight crew to contact Tower Control on 119.200 Mhz. The flight crew read back of the frequency mistakenly. Hence, the ATC repeated Tower frequency, which the flight crew then correctly read back.

At 0958:58, the Aircraft was descending through 2,150 feet indicated altitude (1900 feet radio altitude) with an airspeed of 182 knots (groundspeed of 195 knots) and at around 1.2 nautical miles prior to position KUSOK, FLCH mode deactivated, while VNAV PTH mode re-activated.

Between 0959:05 and 0959:35, the speedbrakes were retracted from full position to positions between 14 and 20 degrees (about half to 2/3 of the full position).

At 0959:08, the target speed of 148 knots was selected, as the Vref + 5 knots.

At 0959:20, the Aircraft crossed KUSOK while descending passing 1,790 feet indicated altitude (1,470 feet radio altitude), with an airspeed of 175 knots and groundspeed of 185 knots that continued decreasing. At the same time, the flap lever was moved from 20 to 25 detent (slats moved to the fully extended position, and the flaps did not move), which made the Aircraft fully configured for landing.

The flight crew commenced contacting Tower Control at 0959:21. The ATC instructed the flight crew to continue the approach runway 31L.

At 0959:36, the speedbrakes were retracted, while the Aircraft was descending through 1,630 feet indicated altitude. The airspeed reached 154 knots, and the Aircraft was on the profile (with incorrect QNH setting).

At 0959:43, ATC informed the surface wind information of 320-degrees direction and 10-knots speed and cleared EY9878 to land. After few seconds, since the flight crew had not yet read back the ATC broadcast, the ATC repeated the surface wind information and the landing clearance. The flight crew read back correctly the landing clearance at 0959:57.

At 1000:01, the Aircraft descended passing 1,000 feet radio altitude, while the indicated altitude showed 1,350 feet.

At 1000:04, the Aircraft crossed KATIG (final approach fix “FAF”) while descending passing 1,300 feet indicated altitude (950 feet radio altitude). The airspeed was 151 knots. At the same time, the selected altitude was commenced to be changed, and at 1000:08, it was set at 4,000 feet as the target altitude.

At 1000:38, the Aircraft descended passing 500 feet radio altitude, while the indicated altitude showed 860 feet.

At 1000:55, the autopilot was disengaged when the Aircraft passed 660 feet indicated altitude (280 feet radio altitude).

At 1001:06, the takeoff/go-around (TO/GA) switches were pushed, and TOGA mode became engaged when the Aircraft was at a distance of approximately 1.3 nautical miles from the threshold of runway 31L. The indicated altitude was 570 feet and the radio altitude was around 210 feet.



At 1001:18, the flap lever was moved from 25 to 20 detent when the Aircraft was climbing through 850 feet indicated altitude (480 feet radio altitude).

At 1001:21, the flight crew informed the ATC that EY9878 performed a go-around. At this time, the Aircraft was climbing through 960 feet indicated altitude (600 feet radio altitude).

At 1001:28, the ATC instructed the flight crew to follow the go-around procedure of runway 31L and to climb to 4,000 feet.

At 1001:48, since the flight crew had not yet read back ATC instructions, the ATC repeated the instruction. The flight crew then replied "Roger Etihad Niner Eight Seven Eight" at 1001:52.

At 1002:00, the Tower Controller called Approach Controller by phone and told that EY9878 was performing a go-around for an unknown reason. The Tower Controller also mentioned that EY9878 would call Approach Control after this.

At 1002:09, the Tower Controller instructed the flight crew to contact Approach Control (Abu Dhabi Radar West) on (primary) frequency 128.100 Mhz.

The flight crew commenced contacting Approach Control at 1002:30 and informed that the Aircraft was on a missed approach and climbing to 4,000 feet. The ATC informed that the QNH was 998 and requested to confirm the ATC when the flight crew were ready for vectors for an ILS approach runway 31L. The flight crew replied that they were ready, however, the flight crew did not read back the provided QNH.

At 1002:54, ATC provided vectors for the next approach by instructing to turn to the right to heading 060 for ILS runway 31L. The flight crew read back correctly. In the meantime, the Aircraft leveled off at 4,000 feet indicated altitude.

At 1003:08, ATC requested an explanation of the reason for the go-around. The flight crew replied that the Aircraft was on profile below 600 feet, but they saw four red lights on PAPI, and that was the reason they carried out the missed approach.

While vectors for ILS approach runway 31L were continued provided, the ATC informed a QNH confirmation of 998, and requested a confirmation of the present Aircraft altitude, at 1004:20.

At 1004:27, the flight crew commenced changing their pressure altimeter setting. The flight crew affirmed the QNH of 998 to the ATC, at 1004:29.

However, at 1004:34, the ATC again requested a confirmation of the present altitude. At this time, the indicated altitude showed 3,700 feet on both sides.

At 1004:36, the flight crew replied that the Aircraft was climbing to 4,000 feet (however, the Aircraft was still flying level), and also apologized that the Aircraft was below 4,000 feet.

At 1004:39, the flight crew were informed that ATC just to make sure that EY9878 had the proper QNH since 3,700 feet of Aircraft altitude was shown on the ATC screen.

At 1004:45, the thrust was increased from 55% N1 to 73% N1 for about eight seconds.

At 1004:47, the flight crew replied to ATC informing that the Aircraft was climbing to 4,000 feet.

At 1004:48, the Aircraft started to climb. The indicated altitude showed around 3,700 feet at the climb initiation.





At 1005:10, the Aircraft commenced to level off at 4,000 feet pressure altitude (QNH 998).

At 1005:16, the ATC requested a confirmation from the flight crew whether EY9878 was set for ILS approach runway 31L. The flight crew replied that the Aircraft was set for ILS approach runway 31L. The ATC continued providing vectors for the ILS approach, including instruction to descend to 2,000 feet.

When the Aircraft was on downwind leg while descending through 3,680 feet indicated altitude, the flight crew requested confirmation of the QNH. However, the ATC requested the flight crew to repeat the broadcast. The flight crew repeated requesting the QNH, and the ATC then informed that the QNH was 998.

Thereafter, there was communication by phone between Approach Control (Abu Dhabi Radar West) and Tower Control (Abu Dhabi Tower South) taken place. The Tower Control asked Approach Control about the Aircraft missed approach. Based on the received terms used by the flight crew, Approach Control explained that the Aircraft was on profile but at 600 feet the flight crew saw four red lights of the PAPI, and that was the reason the flight crew carried out the go-around.

Tower Control then requested Approach Control whether the Aircraft could be dragged further a bit on downwind, such that Tower Control could ask Ground Control to check the PAPI lights on runway 31L. Approach Control agreed and informed Tower Control that the Aircraft was coming for an ILS approach. Tower Control then contacted Ground Control (South) on (primary) frequency 123.975 Mhz and requested Ground to check urgently PAPI lights of runway 31L, which was then agreed by the Ground Control. The Tower Control informed Ground Control that the preceding landing of an aircraft had reported four red PAPI lights at 500 feet height.

At 1009:44, Approach Control contacted Tower Control by phone and asked whether Approach Control could instruct the Aircraft to turn into the base leg, and Tower Control thereafter agreed on it. Approach Control provided further vectors to the Aircraft and instructed the flight crew to contact Tower Control.

The flight crew commenced contacting Tower Control (Abu Dhabi Tower South) on (primary) frequency 119.200 Mhz, at 1014:37, and informed that EY9878 was at an inbound position for an ILS approach runway 31L. The Tower Control instructed the flight crew to continue the approach. The ATC asked the flight crew whether four red PAPI lights were seen on the previous approach. The flight crew affirmed it, and the ATC then instructed the flight crew to continue the approach. At this time the Aircraft was descending through 1,920 feet pressure altitude approximately 6.1 nautical miles

At 1015:14, the Ground personnel contacted Tower Control (Abu Dhabi Tower South) using Ground Control (South) primary frequency of 123.975 Mhz and requested permission to enter runway 31L for checking the PAPI lights. Tower Controller informed the Ground personnel that an aircraft was coming in at five nautical miles, hence, permission to enter runway 31L was not given. However, the Ground personnel was asked to stand by. The Ground personnel replied that they were standing by, which was then acknowledged by the Tower Control. At this time, the Aircraft was descending through 1,540 feet pressure altitude on the final approach leg with a distance of approximately 4.9 nautical miles.

At 1015:41, the Aircraft was at a distance of 4.4 nautical miles, and the Tower Control asked the flight crew whether they were able to see the PAPI light at this time. The flight crew replied that they could not see yet the PAPI lights, but they would inform when the Aircraft came closer to the runway. The ATC informed the surface wind information of 290-degrees direction and 10-knots speed and cleared the Aircraft to land.



The Aircraft landed at 1017:32. At the end of the landing roll, prior to the Aircraft started turning to the left for vacating the runway, the Tower Controller asked confirmation to the flight crew whether the PAPI lights were observed correctly (when the Aircraft was on short final). The flight crew affirmed it. Tower Controller instructed the flight crew to taxi via Echo 6 and to park on stand 308, and the PM correctly read back.

At 1022:14, the engines were shut down.

## **1.12 Wreckage and Impact Information**

The Aircraft was intact.

## **1.13 Medical and Pathological Information**

No medical tests were made.

## **1.14 Fire**

There was no sign of fire.

## **1.15 Survival Aspects**

None of the persons on-board sustained any injury.

## **1.16 Tests and Research**

No tests or research were required to be conducted for the Investigation.

## **1.17 Organizational and Management Information**

### **1.17.1 General information**

The Operator commenced operations in November 2003 in compliance with an air operator certificate (AOC) issued by the General Civil Aviation Authority of the United Arab Emirates (GCAA).

### **1.17.2 Training**

All required training for the Operator's pilots was described in the *Operations Manual Part D (OM Part D)*.

The training of required navigation performance (RNP), basic area navigation (B-RNAV), and precision radio navigation (P-RNAV) operations was provided by the Operator to the pilots. Recurrent training was also provided, as appropriate, in the same areas.

The training related to RNP/RNAV covered the applicable systems, policies, and operational procedures applicable to RNP / B-RNAV / P-RNAV operations. The Operator provided RNP training in three main training programs: Part 1 Ground Training; Part 2 Flight Simulation Training Devices (FSTD) Training; and Part 3 Recurrent Training.

FSTD training and checks conducted during a conversion course routinely covered the following requirements:

1. Pre-flight and in-flight procedures applicable to operations in RNP/RNAV airspace;
2. Flying en-route, arrival, and departure RNAV procedures;
3. Application of contingency procedures in RNP/RNAV airspace; and
4. Post-flight procedures (as applicable)

During line flying under supervision (LFUS), training related to RNP/RNAV



operations was provided according to the required items, and routine operation in terminal areas and on routes where RNP/RNAV procedures and requirements applied.

The training of RNP Approach (RNP APCH) procedures provided by the Operator covered the applicable systems, policies, and operational procedures applicable to RNP APCH operations, with or without vertical guidance. The training was incorporated in initial and recurrent training programs.

The Operator's *Operations Manual* specified the operational policies and procedures applicable to RNP APCH operations, including normal and abnormal operations. The training requirements were fully satisfied by the Operator's conversion training courses.

The training of RNP–Authorization Required Approach (RNP-AR APCH) procedures provided by the Operator covered applicable systems, policies, and operational procedures applicable to RNP-AR APCH operations. The training was incorporated in initial and recurrent training programs. The Operator's *Operations Manual* specified the operational policies and procedures applicable to RNP-AR APCH operations, including normal and abnormal operations. Pilots already qualified to conduct RNP APCH procedures shall complete differences training in order to qualify for conducting RNP-AR APCH operations.

The Operator ensured that each flight crew member's knowledge of RNP-AR approach procedures is evaluated prior to conducting these approaches during line operations. This evaluation was conducted by an Operator instructor or examiner during the RNP-AR approach simulator training or during LFUS or line checks.

The Operator incorporated recurrent RNP-AR approach training that covers the unique characteristics of the approved procedures as part of the overall recurrent training program. A minimum of two RNP-AR APCH must be flown by each pilot for each duty position (pilot flying and pilot monitoring) during each 3-year recurrent training cycle. One approach culminated in a landing, and one in a missed approach, and might be substituted for any required "precision" approach.

All three EY9878 pilots were provided with the required training and checking of RNAV/RNP operations including RNP APCH and RNP-AR APCH operations. They were qualified to carry out RNP-AR approaches as per the Operator's requirements specified in Part D of the *Operations Manual*.

### 1.17.3 Fatigue measurement

The Operator incorporated SAFE12 software to measure pilot fatigue, which included a well-established subjective measuring system using the Samn-Perelli seven-point fatigue scale (SPS). The predicted level of fatigue around the time at top of descent was around SPS 4.20 which can be considered as "a little tired, less than fresh" for the three flight crewmembers since the predicted SPS was slightly more than SPS 4.0<sup>9</sup>.

### 1.17.4 Procedures

#### 1.17.4.1 Procedures of the third flight crew in the cockpit

The Operator, as accepted by the GCAA, included an additional current type-rated pilot to the crew for the sole purpose of extending the FDP, and this is not an augmented flight, as per the *Operations Manual – Part A (OM-A)*, section 7.11.2 – *Flight Time Limitations, Maximum FDP, Operations with three (3) flight crew with no in flight relief*.

According to the *OM-A*, the role of an additional flight crew member was as following:

<sup>9</sup> The Samn-Perelli scale is a seven-point scale that indicates levels of fatigue, as follows:  
1. Fully alert, wide awake; 2. Very lively, responsive, but not at peak; 3. Okay, somewhat fresh; 4. A little tired, less than fresh; 5. Moderately tired, let down; 6. Extremely tired, finding it very difficult to concentrate; and 7. Completely exhausted, unable to function effectively.





#### “8.3.11.1.1. Role of Augmented/Additional Flight Crew Members

For the purpose of this section an augmented/additional flight crew member is any EY pilot, occupying a flightdeck jumpseat during any phase of flight but, in particular during the takeoff and landing phases.

The augmented/additional flight crew member(s) will provide additional monitoring of the flight during ground operations and critical phases of flight. Augmented/additional flight crew member(s) will be alert for any threats and/or errors that have not been trapped by the operating crew. Monitoring is conducted silently.

Such threats or errors will be pointed out to the operating crew with due regard to any high workload situation, so that the operating crew can take the necessary steps to manage the threat effectively. The additional crew shall not diminish the synergy of the two-pilot basic crew operation.

Interrupting the operating crew is only warranted when it is clear that a potentially undesirable aircraft state (UAS) exists. When all attempts to alert the crew of an impending UAS have failed, or verbal intervention is time critical use of key words, such as “GO-AROUND” shall be used.....“

#### 1.17.4.2 Descent procedure

According to the *flight crew operating manual (FCOM)*, the descent procedure was as following:

##### “Descent Procedure

No later than ten minutes prior to the Top of Descent, the PF (or as designated by the PIC [pilot in command]) shall make a PA to passengers as per company OM-A policy (contents in Company owned iPad – Flight Deck PA Handbook)

FMC [flight management computer ] setup .....Complete PF

**Note:** PF shall handover control of the aircraft for the CDU set up and Approach Brief.

Enter desired speed in the VNAV DES page

- Recommended: ECON [economy] MACH/280 KIAS [knots indicated airspeed]

**Note:** Use recommended speed unless assigned by ATC

Enter VREF on the APPROACH REF page:

- Use actual ZFW [zero fuel weight] plus predicted arrival fuel at destination or current gross weight minus predicted fuel burn to destination
- Enter resulting weight onto LSK [line select key] 1L
- Enter FLAP/SPEED for landing flaps

Flaps 25 or 30 will be the standard landing configuration.

The following factors must be considered:

Use of speed brakes is allowed in any flaps configuration above 1,000 ft AAE [above aerodrome elevation].

Enter/review RWY/STAR procedure and any constraints.

Verify or enter the correct RNP for the arrival.

Set the NAV RADIO page for the approach.

After receiving ATIS at the destination airport, preselect the barometric setting value.....“

#### 1.17.4.3 Approach procedure

According to the *FCOM*, the approach procedure was as following:

##### “Approach Procedure

The Approach Procedure is normally started when the altimeters setting is changed to a local QNH. Complete the Approach Procedure before:



- The initial approach fix, or
- The start of radar vectors to the final approach course, or
- The start of a visual approach

Pilot Flying	Pilot Monitoring
Call "APPROACH CHECKLIST".	Do the APPROACH checklist.
Select Speed Intervention	At 10,000 ft AAE: LANDING, RWY TURNOFF and TAXI switches - ON WING lights- as required
WXR [Weather radar] or TERR [terrain] display on ND as required	
At transition level, set the altimeters.	
Update changes to the arrival and approach procedures as needed. Update changes to the RNP as needed.	
Update the approach briefing as needed.	
	PA: "CABIN CREW 10 MINUTES TO ARRIVAL" SEAT BELT Selector ON

**Note:** Do not manually build the approach or add waypoints to the selected FMC approach procedure. Add cold temperature corrections to waypoint altitude constraints as appropriate."

#### 1.17.4.4 Standard callouts – altimeter setting

According to the *FCOM*, the standard callouts for altimeter setting was as following:

##### "Altimeter setting

When there is a scheduled change in the altimeter reference, the reference setting (i.e. Standard or QNH) and the altitude/flight level indication shall be verified.

Event	Pilot Flying	Pilot Monitoring
Descent — Passing Through Transition Level	"SET QNH"  "CHECKED"	"QNH__ SET, CROSS CHECKED, PASSING ALT__FEET; NOW"

"

#### 1.17.4.5 Intercept VNAV PATH from above

According to the *FCOM*, the *Intercept VNAV PATH from Above* procedure was as following:

##### "Intercept VNAV PATH from Above

1. Set an altitude of 1000ft AFE [above field elevation] on the MCP [mode control panel]. Engage VNAV (A/C [aircraft] will descend towards VNAV calculated path in VNAV SPD).
2. Continue to configure for landing (Gear down, flaps 20, arm speedbrakes, then flaps 25 or 30).
3. Use Speedbrake if required (to increase the rate of descent to capture the Flight Management Computer (FMC) calculated approach path – using judicious Speedbrake to maintain within the OM-A Maximum rate of Descent criteria).



4. Once the approach path is captured (VNAV PATH displayed and minimums set) and the aircraft is 300 ft. below the Missed Approach altitude, set the Missed Approach altitude.
5. If descent profile (VNAV PTH) is not captured by 1000' AFE, perform a missed approach...

#### 1.17.4.6 Standard callouts – altitude awareness

According to the *FCOM*, the standard callouts for altitude awareness was as following:

##### “Altitude Awareness

Event	Pilot Flying	Pilot Monitoring
RA alive	“CHECKED”	“ <b>RADIO ALTIMETER ALIVE</b> ” (See Notes 1 and 2)
<p><b>Note: 1.</b> Checked confirms Pressure Altimeter reads approximate 2500ft AAL [above airfield level] and crew should now keep RA in scan to landing.</p> <p><b>Note: 2.</b> PM monitors auto callout “2500” or makes the appropriate callout “<b>RADIO ALTIMETER ALIVE</b>” if auto callout function is inoperative.</p>		

#### 1.17.4.6 Standard callouts for Non-ILS approach

According to the *FCOM*, the standard callouts for non-ILS approach regarding the “1,000” auto callout was as following:

##### “Altitude Awareness

Event	Pilot Flying	Pilot Monitoring
...	...	...
“1,000” (auto callout)	“ON PROFILE”	“xx MILES TO TOUCHDOWN”
	“GO-AROUND” Announce FMA e.g “THRUST, TOGA, TOGA” “FLAPS 20”	“GO-AROUND”  “THRUST SET, FLAPS 20”
...	...	...

#### 1.17.4.7 Go-around and missed approach procedure

According to the *FCOM*, the go-around and missed approach procedure was as following:

##### “Go-around and Missed Approach Procedure

All Engine Acceleration Height .....800 ft  
AGL

For Engine-out Go-Around, or an engine failure during a Go-Around accelerate at 800 ft AGL or as stipulated in the OPT EOMAP if higher.

Pilot Flying	Pilot Monitoring
<p>Call “GO-AROUND”</p> <p>At the same time:</p> <ul style="list-style-type: none"> <li>• Push the TO/GA switch, observe that the autothrottles apply go-around thrust or manually apply go-around</li> </ul>	



<p>thrust as the airplane rotates to the go-around attitude.</p> <p>Verify thrust increases</p> <p><b>Note:</b> The PF shall manually follow the advancing Thrust Levers until G/A [go-around] thrust is set</p> <p>Announce FMA e.g. <i>"THRUST TOGA TOGA"</i></p> <p>Call <i>"FLAPS 20"</i></p> <p><b>Note:</b> With second push of either TO/GA switch call FMA <i>"THRUST REF"</i>.</p>	<p>Verify that the thrust is sufficient for the go-around or adjust as needed.</p> <p><i>"THRUST SET, FLAPS 20"</i></p> <p>Position the flap lever to 20.</p>
Verify the rotation to go-around attitude	
	Verify a positive rate of climb on the altimeter and call <i>"POSITIVE CLIMB."</i>
Verify a positive climb and call <i>"GEAR UP"</i>	
	Set the landing gear lever to UP.
Limit bank angle to 15 degrees if airspeed is below minimum maneuver speed	
Above 400 feet radio altitude, verify LNAV [lateral navigation] or select the appropriate roll mode.	Verify /announce that the missed approach altitude is set.
Verify that the missed approach route is tracked.	
<p>If an LNAV path is available, LNAV automatically arms and engages:</p> <ul style="list-style-type: none"> <li>• Above 50 feet radio altitude when autopilot is not engaged, or</li> <li>• Above 200 feet radio altitude when autopilot is engaged</li> </ul> <p><b>Note:</b> Route discontinuities after the missed approach will prevent LNAV from engaging.</p> <p><b>Note:</b> If FD's have been cycled (for visual approach) ensure both are switched back on</p>	
At acceleration height, set speed to the maneuver speed for the planned flap setting.	
Call <i>"FLAPS___"</i> according to the flap retraction schedule.	Set the flap lever as directed.
After flap retraction to the planned flap setting, select FLCH or VNAV as needed.	
Verify That climb thrust is set.	
Verify that the missed approach altitude is captured.	
Call <i>"AFTER TAKEOFF CHECKLIST"</i> .	Do the AFTER TAKEOFF checklist.

“

#### 1.17.4.8 RNAV (RNP) / RNP AR

The standard operating procedures for RNAV (RNP) approaches as per the Operator's *Quick Reference Handbook (QRH) Supplementary* are as following:



## “PBN [Performance-based navigation] APPROACH QUICK REFERENCES

...

VOR/DME NAV on POS REF

page..... OFF

CHART MIN TEMP vs. REPORTED

TEMP..... CHECK

CHART MAX WIND vs. REPORTED WIND (if

applicable)..... CHECK

MAX IAS for RF LEGS (if applicable) ..... REVIEW

Refer to Appendix A -Maximum TAS function of the turn radius R.

CHART G/P vs FMC G/P ..... VERIFY

**Note:** Note: For more details, refer to FCOM SP.4.5 Chapter "Instrument Approach – RNAV (RNP) AR".

**Note:** Direct-To modifications are not permitted when: - the fix is the beginning of an RF leg. - the fix is the Final Approach Fix (FAF) for the procedure.

---

### AT OR BEFORE IAF

GPS on ND (FMC position update status) .....  
CHECK

Both GPS on POS 4/4 page

..... CHECK

LRNP 0.3 or charted RNP for RNAV (RNP) procedure.....  
VERIFY

Ensure LRNP 0.3 is displayed on ND (Do not manually insert).

VSD

.....  
ON

“

A note for these SOPs was that “RNAV (RNP) / RNP AR Approaches are ONLY approved at AUH on ETIHAD B787”.

### 1.17.4.9 Flight level change (FLCH) mode and vertical navigation (VNAV) mode

FLCH mode is one of the autopilot flight director system (AFDS) pitch modes.

When FLCH mode is desired, FLCH switch on the mode control panel (MCP) should be pushed, and a white light will illuminate which means the flight level change mode is active. When it is active, it displays ‘FLCH SPD’ (flight level change - speed) on the flight mode annunciation (FMA) in the pitch mode annunciator. The active FLCH SPD means that the pitch commands maintain IAS/MACH window airspeed or MACH.

Altitude hold (ALT) mode will be activated when FLCH mode during climb or descent is captured.

Vertical Navigation (VNAV) mode is one of the AFDS pitch modes. The VNAV mode consists of VNAV SPD (VNAV - Speed), VNAV - ALT (VNAV -Altitude), and VNAV PTH (VNAV - Path).

When VNAV mode is desired, the VNAV switch on the MCP should be pushed, and a white light will illuminate that means the VNAV mode is armed or active.

VNAV SPD, VNAV PTH, or VNAV ALT pitch mode displays in green (active) on the primary flight display (PFD) and HUD pitch flight mode annunciation.

In the VNAV SPD pitch mode, the AFDS commands pitch to hold the target airspeed. The autothrottle operates in the thrust reference mode (THR REF), thrust mode (THR), idle (IDLE), or hold (HOLD) mode, as required by the phase of flight.

In the VNAV PTH pitch mode, the AFDS commands pitch to maintain FMC target altitude or the VNAV path. The autothrottle maintains speed.

In the VNAV ALT pitch mode, the AFDS commands pitch to maintain the MCP selected altitude when that altitude is lower than the VNAV commanded altitude in climb, or higher than the VNAV commanded altitude in descent

#### 1.17.4.10 *Operations Manual – Part A* for serious incident reporting policy

The *Operation manual – Part A* contained the following policies regarding serious incident reporting:

##### **“11.6.1 Responsibility to Report Serious Incidents / Accidents**

After any serious incident or accident, it is the responsibility of the Commander involved, the Duty Manager NOC, the Airport Manager or the most senior staff member on site and the contracted service providers, to ensure that the appropriate notification and reporting procedures are followed without delay. “

;

##### **“11.6.2 Serious Incidents / Accident Notification Procedures**

Typical examples of incidents that are likely to be serious incidents include, but are not limited to:

- ...
- Controlled flight into terrain only marginally avoided.
- ...

“

; and

##### **“11.6.4 Aircraft Serious Incident / Accident Reporting Policy**

The Commander or his nominated delegate is responsible for notifying, the nearest Authority, by the quickest available means, (either in person or by telephone in the first instance to the police, ATC or local Aviation Authority), of any accident or serious incident resulting in injury, death, or substantial aircraft damage. Following an accident or incident the commander shall complete the ETIHAD Air Safety Report (ASR), in addition to complying with the laws and regulations of the country of which the accident or incident occurred upon receiving instructions from the company or Local Authorities.

Aircraft serious incidents/accidents are classified by ETIHAD, for reporting purposes, in accordance with the definitions as detailed in the ETIHAD Emergency Response Plan (ERP). ”

#### 1.17.4.11 *Operations Manual – Part A* for flight data and cockpit voice recorders after incident or accident

The *Operations Manual – Part A* contained the following procedures regarding flight recorders after incident or accident:

##### **“11.6.5 Flight Data and Cockpit Voice Recorders after Incident or Accident**

Flight Data and Cockpit Voice Recorders and Flight Data Recorder records shall be preserved and retained in safe custody for the duration of the investigation. For accidents the National Aviation Authority or independent investigation body will retain the Flight Data and Cockpit Voice Recorders for the purpose of the investigation. For incidents the ETIHAD Airways Safety and Quality Department will be responsible to



retrieve and archive and protect the downloaded records for internal investigation.....”

#### 1.17.4.12 Safety management system

In order to continuously maintain safe, secure, and compliant operations, the Operator had established an integrated Corporate Safety, Security and Quality (CSSQ) Department to oversee its operations and ensure compliance with Safety Management System (SMS), as one of the established systems.

Corporate Safety Group under CSSQ is the group that responsible for the implementation, maintenance, and day-to-day administration of the safety management system throughout the organization. This group carries out hazard identification and risk analysis, primarily driven by investigations of its safety events.

The reactive method of hazard identification is to analyze hazards that have been identified or have already contributed to a mishap, which includes the conduct of investigations into accidents, incidents, occurrences, employee reports, and regulatory violations. The proactive method of hazard identification is to attempt identifying and analyzing hazards before they have resulted in an incident or accident.

Safety risk management is a formal process that is used to identify hazards associated with its operations, analyze and assess the risks associated with those hazards, and implement controls, when necessary, to prevent future accidents and incidents.

Safety assurance processes are employed for autonomous monitoring of the effectiveness of safety risk controls and corrective actions implemented across different operations departments.

Following the Incident, the Operator Corporate Safety & Quality Department conducted its internal safety investigation with the objective of enhancing safety by reducing safety-related risks. Central to this investigation of safety matters was the early identification of safety issues in the operational environment.

Risk mitigation actions were taken by the Operator, which could be considered as safety actions (see section 4.2.1 in this Report).

### 1.17.5 Air Traffic Management

#### 1.17.5.1 Air traffic services

GAL Air Navigation Services (GAL ANS) is a limited liability company based in Abu Dhabi, the United Arab Emirates.

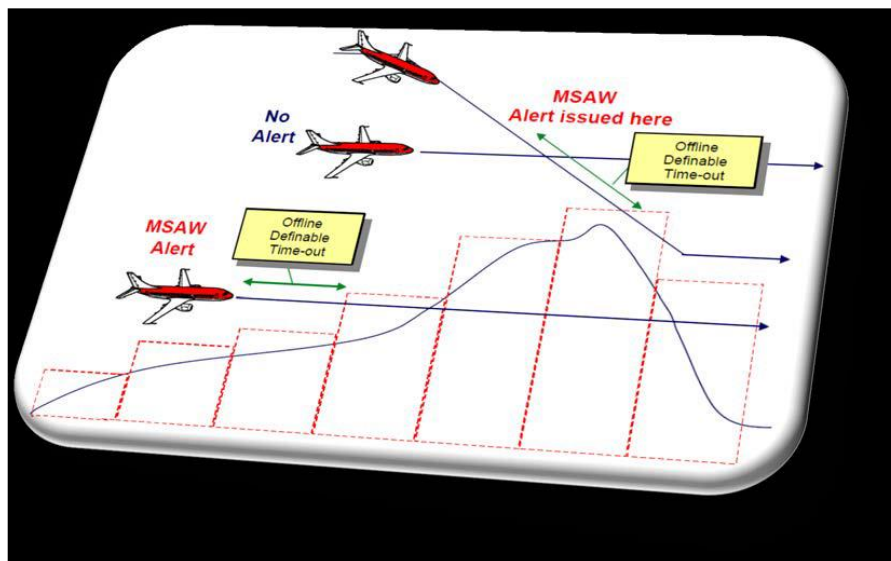
GAL ANS is certified by the GCAA for providing approach and tower air traffic services from many airports to private and government customers including Abu Dhabi International Airport.

#### 1.17.5.2 ATM system capability

Abu Dhabi air traffic management (ATM) system had the capability to predict, detect and alert flights below the required vertical profile by using a Eurocat-X ATM system. The system provides, among other alerts, minimum safe altitude warning (MSAW) and approach path monitoring warning (APMW).

The MSAW function was available for aircraft under radar coverage to inform the responsible controller if an aircraft is predicted to infringe on one of the predefined MSAW areas within a predefined time interval. In the MSAW function, the reported levels from aircraft with pressure-altitude reporting capability are monitored against defined minimum safe altitudes. When the level of an aircraft is detected or predicted to be less than the applicable minimum safe altitude, a visual warning will be generated in a yellow label on the radar screen

to the controller and an acoustic alarm will be heard. The MSAW will be generated 30 seconds before the aircraft is predicted to be below minimum safe altitude (figure 4).



**Figure 4.** Minimum safe altitude warning (MSAW) - [Source: GAL ANS]

The APMW function generally informs the controller when an aircraft is detected to be outside the three-dimensional approach path profile. The APMW function was available for aircraft under radar coverage and performs specific MSAW processing ensuring that the approach path of an aircraft is consistent with the descent profile and the runway axis while the aircraft is in the defined approach path. If the function detects an aircraft, deviating from the optimum descent profile or deviating from the runway axis, the warning (MS warning in a yellow label) will be displayed on the radar screen and an acoustic alarm will be heard.

The Eurocat-X ATM system does not differentiate between the two warnings, MSAW and APMW, hence the APMW will display as an MSAW (MS on the display).

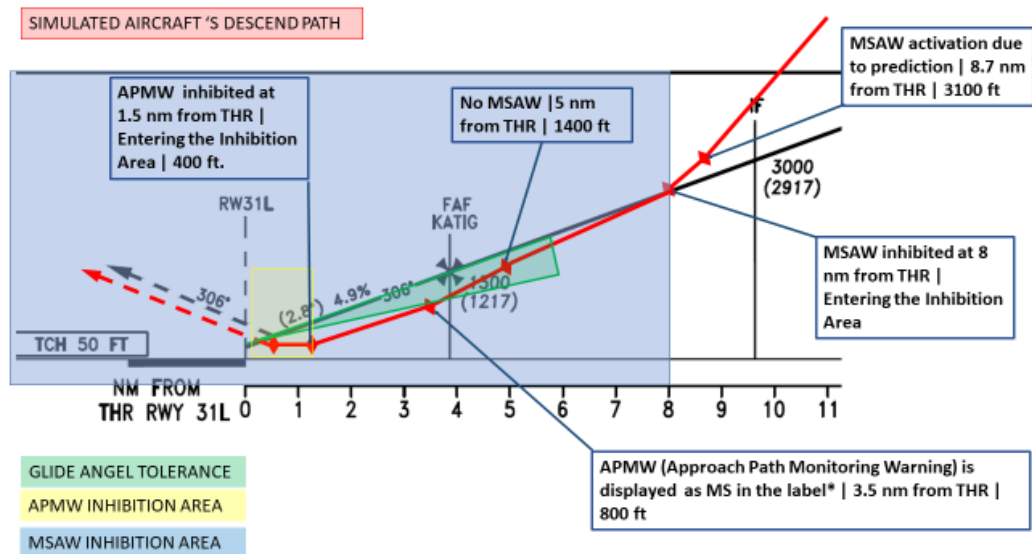
The approach path monitoring (APM) of the system adds independent alerting in order to avoid controlled flight into terrain (CFIT) accidents by generating alerts in a timely manner of aircraft proximity to terrain or obstacles, which required attention/action.

Simulation of the flight EY9878 was conducted by GAL ANS with the configured OMAA APMW inhibition area and MSAW inhibition area, glide angle tolerance of runway 31L, and the relevant AIP published ATC Surveillance Minimum Altitude chart (OMAA-AD-2-51) for Abu Dhabi. Prior to that, verification and analysis of the data of flight EY9878 were carried out to ensure the validity of the dataset configuration for the simulation. Tests were also carried out with different altitudes and the same airspeed of flight EY9878 to verify the presence of APM warning, which resulted in all alerts and their deactivation were obtained in an expected and predicted manner (as per design).

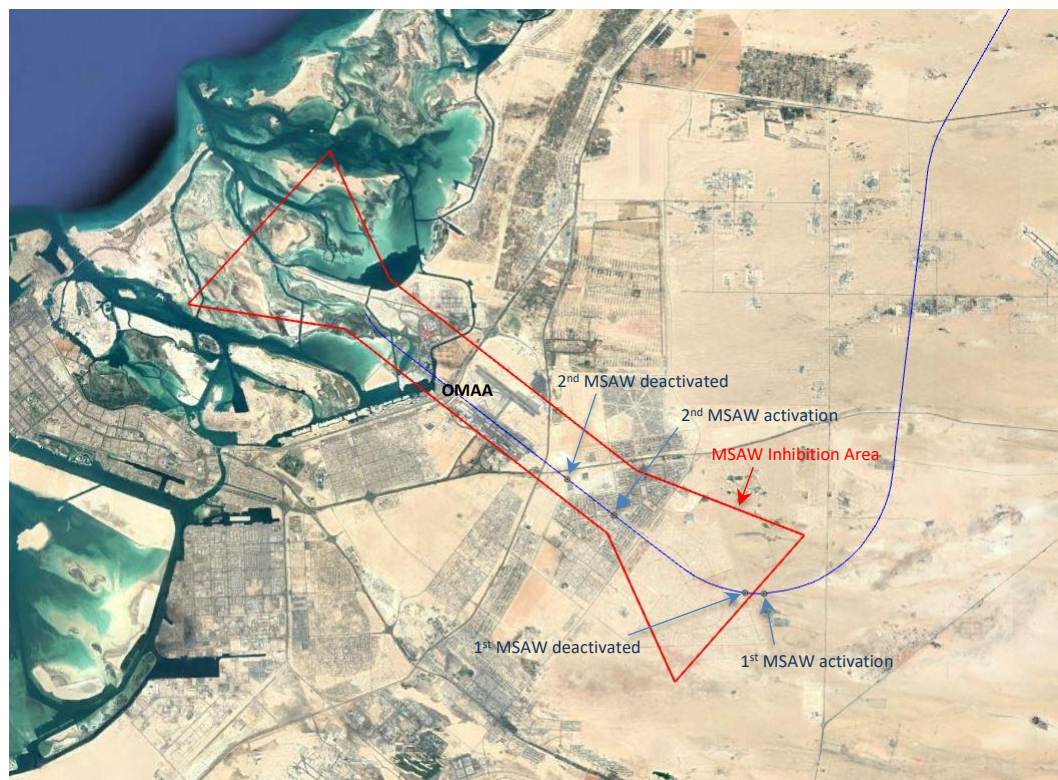
In EY9878 flight, the MSAW was triggered on two occasions.

Based on the simulation conducted by GAL ANS and time synchronization with the flight data, the first MSAW activation in the Incident flight occurred at 0958:27 when the Aircraft was at approximately 8.7 nautical miles from the runway 31L threshold, crossing 3,100 feet as shown on the ATC display. The duration of the MSAW activation was ten seconds. The Aircraft was at around eight nautical miles from the threshold upon entering the "MSAW Inhibition Area" when the warning was de-activated (figures 5 and 6). The warning activation corresponded to a prediction by the system, which calculated that the Aircraft was descending with a high rate of descent close to the configured minimum safe altitude.





**Figure 5.** Vertical section of the Aircraft descent trajectory and the warning alerts  
[Source: GAL ANS]



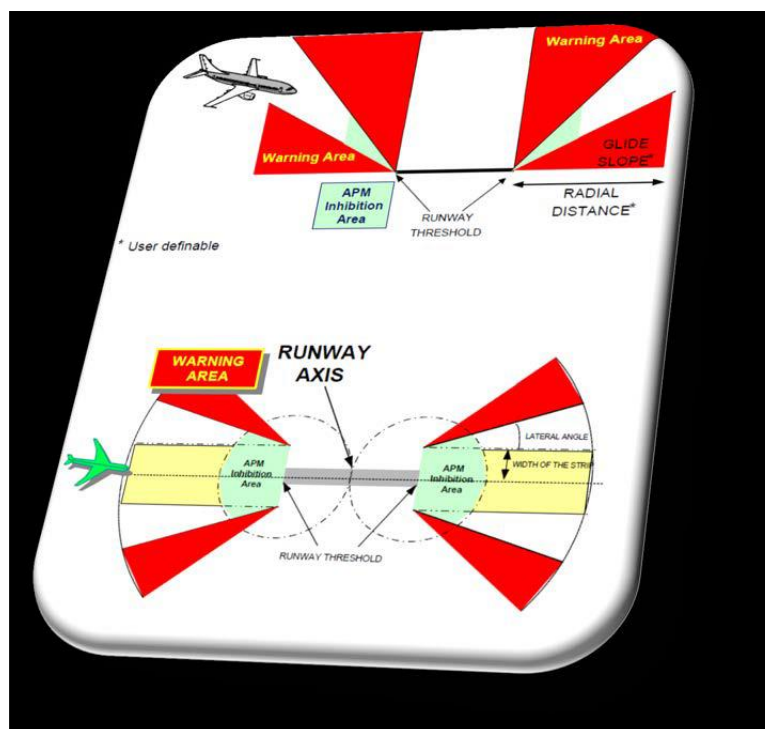
**Figure 6.** Aircraft positions when MSAW were activated and deactivated

The second MSAW was activated at 1000:16 when the Aircraft was at approximately 3.5 nautical miles from the threshold and passing 800 feet as displayed on the ATC radar. The duration of this warning was 45 seconds. The Aircraft was at around 1.5 nautical miles from the threshold and passing 400 feet on the ATC radar display when the warning was deactivated. This second MSAW was actually an approach path monitor warning (APMW) with an MS in a yellow label on the radar display.

The APMW was activated when the Aircraft was descending below the tolerance angle of the Glide Path (GP). Subsequently, the warning was deactivated when the Aircraft entered the APMW inhibition area and crossed the Glide Path angle during the go-around (figures 5 and 6).

Figure 7 shows the vertical and horizontal views of the APMW. The APMW was inhibited at 1.5 nautical miles from the threshold.

Figure 8 shows the radar screenshot indicating that the Aircraft was at two nautical miles from the threshold of runway 31L, at an altitude of 300 feet, which correlated to approximately 200 feet below the required vertical profile. As per the logic and alerting description of the warning system, the MS (minimum safe, in a yellow label) was displayed, and an acoustic alarm was activated.



**Figure 7.** Approach path monitor warning (APMW) – vertical and horizontal views [Source: GAL ANS]



**Figure 8.** Radar screenshot - Aircraft at two nautical miles on final approach, indicated altitude 300 feet (corrected), and activation of minimum safe altitude warning [Source: GAL ANS]



#### 1.17.5.3 Providing QNH information

According to the *air traffic services operating manual (ATSOM)*, the destination QNH information should be provided by air traffic controllers when issuing the initial clearance to an altitude to aircraft.

A *Supplementary Instruction (SI) 027/20* for RNAV YANKEE or ZULU Approach for OMAA had been issued by the air traffic services (ATS) operator on 10 May 2020. This *SI* requires the controllers to provide QNH information when issuing approach clearance

#### 1.17.5.4 Minimum safe altitude warning (MSAW) requirement

According to the *ATSOM Part 2, Chapter 7, Section 2 – Abu Dhabi Radar, section 3.5.2*, the requirement of when an MSAW is triggered, as following:

“In other cases, the flight crew shall immediately be advised that a minimum safe altitude warning has been generated and be instructed to check QNH and the level of the aircraft.”

### 1.18 Additional Information

#### 1.18.1 Serious incident reporting requirement in the *Civil Aviation Regulations*

The United Arab Emirates *Civil Aviation Regulations (CAR)* part IV – *Operations Regulations, CAR-OPS 1 – Commercial & Private Air Transportation (Aeroplanes)*, prescribes the requirements for the operations of aeroplanes as commercial and private air transportation.

The requirements for notifying or reporting regarding a serious incident as given in the *CAR-OPS 1.420 (c)* are as follows:

##### “CAR-OPS 1.420 Occurrence reporting

...

##### (c) *Accident and Serious Incident Reporting*

An operator shall establish procedures for reporting accidents and serious incidents taking into account responsibilities described below and circumstances described in sub-paragraph (d) below.

(1) A commander shall notify the operator of any accident or serious incident occurring while he was responsible for the flight. In the event that the commander is incapable of providing such notification, this task shall be undertaken by any other member of the crew if they are able to do so, note being taken of the succession of command specified by the operator.

(2) An operator shall ensure that the Authority in the State of the operator, the nearest appropriate Authority (if not the Authority in the State of the operator), and any other organisation required by the State of the operator to be informed, are notified by the quickest means available of any accident or serious incident and - in the case of accidents only - at least before the aeroplane is moved unless exceptional circumstances prevent this.... “

The *CAR* part VI, chapter 3 – *Air Accidents and Incidents Investigation*, prescribes the requirements for the air accidents and incidents investigation.

The requirements for notifying or reporting a serious incident as given in the *CAR* Part VI, Chapter 3, sub-section 4.2 are as follows:

##### “4.2 IMMEDIATE NOTIFICATION TO THE GCAA

4.2.1 Any person who has knowledge of the occurrence of accident or serious incident shall immediately notify the GCAA.....“

### 1.18.2 Flight recorders preservation requirement in the *Civil Aviation Regulations*

CAR part IV – *Operations Regulations*, CAR-OPS 1 – *Commercial & Private Air Transportation (Aeroplanes)* prescribes the requirements for the operations of aeroplanes as commercial and private air transportation.

The requirements for flight recorders preservation following a serious incident as given in the *CAR-OPS 1.160 (a)(2)* are as follows:

**“CAR-OPS 1.160 Preservation, production and use of flight recorder recordings**

(a) *Preservation of recordings*

(2) Unless prior permission has been granted by the Authority, following an incident that is subject to mandatory reporting, the operator of an aeroplane on which a flight recorder is carried shall, to the extent possible, preserve the original recorded data pertaining to that incident, as retained by the recorder for a period of 60 days unless otherwise directed by the investigating authority....“

The GCAA is drafting regulations *CAR-AIR OPS*, which is being planned for the final implementation on 16 May 2023. Among the regulations drafted, there are regulations related to cockpit voice recorder, which are mentioned in *CAR-AIR OPS - Part - CAT.IDE.A.185*, and in subsection (c) it states as follows:

**“CAR-AIR OPS – PART - CAT.IDE.185 Cockpit voice recorder**

...

(c) The CVR [cockpit voice recorder] shall be capable of retaining the data recorded during at least:

(1) The preceding 25 hours for aeroplanes with an MCTOM of more than 27,000 kg and first issued with an individual CofA on or after 1 January 2022; or

(2) The preceding 2 hours in all other cases....”

### 1.19 Useful or Effective Investigation Techniques

This Investigation was conducted in accordance with Air Accident and Incident Investigation Regulation of the United Arab Emirates, and the AAIS approved policies and procedures, and in conformity with the Standards and Recommended Practices of *Annex 13 to the Chicago Convention*.





## 2. Analysis

### 2.1 General

The Investigation collected data from various sources for the purpose of determining the causes and contributing factors that led to the Incident.

This analysis covers the flying technique, the weather conditions, the relevant Operator's procedures, flight operations, flight crew performance, and air traffic control.

This part of the Report explains the contribution of the relevant aspects to the Incident. The analysis also contains safety issues that may not be contributory to the Incident but are significant in adversely affecting safety.

### 2.2 The First Approach and Go-around

The flight crewmembers stated that the flight was uneventful during the climb and cruise phases. Based on the flight data, there were no technical anomalies detected in regards to Aircraft systems and equipment. The Operating Copilot was the pilot flying.

During the Aircraft flying in Tehran airspace, before starting to descend from FL380 as the top of descent, the flight crew carried out descent preparations and the approach briefing for Abu Dhabi International Airport (OMAA), including the threat based briefing (called TPC by the Operator).

According to the *flight crew operations manual (FCOM)*, as a part of the descent procedure, after receiving the automatic terminal information service (ATIS) information of the destination airport, the barometric setting needs to be preselected. Based on the ATIS information for OMAA uplinked at 0902, the QNH was 999 hectopascal (hPa), the weather condition was CAVOK, and an RNAV Yankee Approach to runway 31L was expected (refer to Appendix 1).

The Commander, as the pilot monitoring, stated in his interview that there was a possibility that both operating flight crewmembers had overlooked the preselection OMAA QNH setting after they had received the ATIS. Since the recorded cockpit voice recorder (CVR) data was not available to the Investigation, it could not be determined why the preselection action was overlooked when the ATIS information was received. The Investigation recommends that the Operator reinforce among its pilots the requirement for preselecting the QNH setting after receiving the ATIS information of the destination airport as per the *FCOM*.

When the Aircraft was descending through FL164, the vertical mode changed from VNAV SPD to VNAV ALT mode.

At a distance of around three nautical miles prior to reaching EMERU waypoint while the Aircraft was flying straight and level at FL160, Abu Dhabi Approach Control instructed the flight crew to descend to 7,000 feet and cleared RNAV Y approach runway 31L from TUGVA (initial approach fix "IAF"). The Abu Dhabi Approach Controller could not issue a clearance to descend below FL160 earlier due to the enforcement of the aircraft transfer agreement provisions between Dubai and Abu Dhabi air traffic control (ATC) units. The QNH information was not provided by Approach Control along with the initial descent clearance to an altitude, which was not as per the standard operating procedures.

Few seconds prior to the Aircraft started to descend to 7,000 feet, the vertical mode changed from VNAV ALT to VNAV SPD mode.

When the Aircraft was descending through FL146 about 4 nautical miles after crossing EMERU, the altimeter pressure setting was changed from the standard pressure (1013 hPa) to QNH 1009 hPa.



The QNH setting for Beijing Capital International Airport (ZBAA), as per the data, was 1009 hPa. The ZBAA QNH was stored as a pre-setting of the pressure altimeter when the flight crew changed the setting from ZBAA QNH to the standard pressure (1013) when climbing through the transition level after the takeoff from Beijing. Therefore, the Investigation believes that the pre-setting of the QNH had never been changed after the takeoff from Beijing.

The flight crew commenced descent from FL160 when the Aircraft was at a distance of 0.6 nautical miles prior to reaching EMERU waypoint, and the airspeed was 265 knots. From that position, following the tracking via position TUGVA and the procedural track for RNAV Y approach to runway 31L, the Aircraft was at about 43 track nautical miles to touchdown. The Aircraft crossed EMERU waypoint, while descending through 15,880 feet indicated altitude (QNH 1009), and followed EMERU 2D route.

The transition level of standard arrival RNAV 1 runway 31L/R was FL150, which means that the Aircraft had a slot of 1,000 feet to descend from when the Aircraft was flying level at FL160, to the transition level. Hence, the flight crew, probably, started to adapt their mindset to the flight path management as the highest priority, especially the high energy situation that needed to be managed, which commenced after the descent instruction to 7,000 feet had been received.

The Commander stated that the flight crew accomplished the approach checklist when passing the transition level. The standard operating procedure (SOP) required to confirm the correct QNH is set on the altimeter (sections 1.17.4.3 and 1.17.4.4 of this Report). The QNH is always required to be set prior to the completion of the checklist. In this case, the QNH was set but not the correct value. Due to the lack of CVR data, the Investigation could not determine whether the altimeter setting standard callouts were implemented by the pilot flying (PF) and pilot monitoring (PM) as per the *FCOM*. However, based on the same incorrect QNH setting of 1009 hPa on the left and right sides, the flight crew, most probably, performed the scan and callout the incorrect value, as per the approach checklist. Hence, the Investigation believes that the checklist was not correctly performed.

Task management, prioritization, shared mental model and good communication between the flight crewmembers were required to have effective and efficient monitoring functions of everything relating to the flight. The B787 flight management system (FMS) descent profile assumed that there was a continuous descent from the top of descent to landing, taking into consideration any height/speed restrictions during the descent. The descent was stopped at FL160 during the handover between Dubai Approach and Abu Dhabi Approach Controls. This condition of leveling off at FL160 by airspace/controlling unit design, most likely, made the flight crew fixated on the high profile and how to manage the high energy of the Aircraft prior to descent from FL160. Based on the flight crew statements, the PF and PM shared their mental model of managing the high energy of the descent during the approach. However, this fixation condition distracted their attention and task management, which resulted further in an ineffective monitoring function. Additionally, the condition was compounded when the ATC lapsed providing OMAA QNH when first clearance to an altitude and clearance for the RNAV Y approach runway 31 L from IAF were issued.

The additional copilot who was seated on the jump seat was also unaware of the incorrect QNH setting that had not been trapped by the operating flight crew. Additional monitoring of the flight needs to be provided by the additional flight crew as per the *FCOM*, which was ineffective in this case. Hence, the Investigation recommends that the Operator reinforce among its pilots the requirement of additional monitoring by the additional flight crew in the flight deck as per the *FCOM*.

Since the QNH was incorrectly set, as it should have been (999 hPa), the true altitude was 300 feet lower than the indicated one for the remainder of the descent and approach.



When the Aircraft was descending through 13,130 feet indicated altitude, the vertical mode was changed from VNAV SPD to FLCH (FLCH SPD). At this point, the indicated airspeed (IAS) was 272 knots, and the Aircraft was at approximately 32 track nautical miles to touchdown. One second later, the speedbrakes were deployed to 2/3<sup>rd</sup> of full position.

When the Aircraft reached 13,000 feet indicated altitude, the target speed was set to 240 knots.

When the Aircraft reached 12,770 feet indicated altitude, the speedbrakes were deployed to the full position, and this was 12 seconds later after the speedbrakes had been deployed to two-third of the full position. This revealed that the flight crew attempted to recover the FMS vertical profile from above.

The Aircraft crossed TUGVA waypoint, the IAF while descending through 10,920 feet indicated altitude, and the indicated airspeed was 240 knots. TUGVA waypoint had an altitude limitation of 10,000 feet maximum and was at approximately 25.5 track nautical miles from touchdown.

This higher indicated altitude (10,920 feet) at TUGVA made the flight crew still concern about the Aircraft being high and continued focusing on the energy management for the descent. Request confirmation of QNH to the ATC by the flight crew was not a standard operating procedure. However, should the flight crew have requested confirmation of the OMAA QNH either when given their first clearance to an altitude or when given clearance for the approach, the flight crew would have a high likelihood of realizing that they had selected the wrong QNH. After the Incident, the Operator amended the SOP for RNP AR operations for confirming the QNH prior to the IAF (see section 4.2.1 of this Report).

The Aircraft was programmed to fly an RNP AR (Required Navigation Performance – Authorization Required), and the navigation trajectory was based on the altimeter barometric setting value. Since the altimeter barometric setting was incorrectly set, the Aircraft flew an inappropriate (lower) vertical path during the RNP AR intermediate and final approach segments.

After TUGVA, the Aircraft turned left onto a heading of 186 degrees and headed to AA712 waypoint, and followed the route/track as per RNAV/RNP Y approach runway 31L chart. When the Aircraft was descending through 10,720 feet indicated altitude, the speedbrakes were commenced retracting to around half of the full position.

The target speed was set to 220 knots when the Aircraft was descending through 10,170 feet indicated altitude, and a few seconds later the speedbrakes were again deployed to the full position. This is an indication that the flight crew were still attempting to manage the high energy of the Aircraft. At the same time, the Controller advised the flight crew that the remaining distance to touchdown was 23 nautical miles, and requested confirmation whether the flight crew would be able to lose altitude. The PM replied affirmative.

When the Aircraft was descending through 9,835 feet indicated altitude, the vertical mode was changed from FLCH to VNAV SPD. Subsequently, few seconds later, the target altitude was set to 470 feet, as the decision altitude (DA). At this point, the Aircraft was approximately three nautical miles after passing the initial approach fix (TUGVA) and still far (18.6 nautical miles) before reaching the final approach fix (KATIG). The SOPs required the DA to be set approximately two nautical miles before the final approach fix and after ALT, VNAV PTH, or VNAV ALT is annunciated. This means that the timing of setting the DA was not as per the SOPs.

The flap lever was moved from UP to 1 detent when the Aircraft was descending through 9,350 feet indicated altitude.



When the Aircraft was descending through 6,700 feet indicated altitude, VNAV PTH briefly annunciated for less than 2 seconds, followed by a change to FLCH vertical mode when the Aircraft descended passing 6,570 feet indicated altitude.

Since the Copilot (PF) chose the FLCH vertical mode with the combination of the DA setting, the AFDS allowed the Aircraft to descend to the DA (470 feet), without adherence to any altitude constraints that had been set in the FMS. The Copilot, most likely, changed the vertical mode from VNAV to FLCH to attempt the recovery of the nominal vertical profile from above, the same as what he also did previously.

According to the *FCOM*, in a situation of being high, the 'Intercept VNAV PATH from Above' procedure should have been used that required the use of VNAV mode, which provided altitude constraint protection. In this case, the FLCH vertical mode activation was carried out until the Aircraft reached 2,150 feet indicated altitude, which was not as per the *FCOM*. Since the FLCH mode was used twice as the Aircraft being high, it is believed that the Copilot as the PF was unaware of using the correct 'Intercept VNAV PATH from Above' procedures. There was no indication found by the Investigation that the Commander as the PM detected the incorrect FLCH vertical mode used with the combination of the DA setting, and/or alerted the PF about it.

As mitigation action, after this Incident, the Operator devised a training briefing for RNP AR approaches at Abu Dhabi further highlighting the requirement to use VNAV mode for these approaches to ensure altitude protection. The mode control panel (MCP) altitude setting techniques using VNAV for RNP AR operations at OMAA were also refined, in coordination with the Aircraft manufacturer (see section 4.2.1 of this Report).

When the Aircraft was descending through 2,670 feet indicated altitude, the radio altitude showed 2,500 feet, and the auto callout "2500" was annunciated. The flight data revealed the annunciation of the auto voice "2500" callout, which means that the radio altimeter was alive.

Normally, the difference between the pressure altitude with a correct QNH setting and the radio altitude at OMAA is less than 100 feet. Had the flight crew checked the indicated pressure altitude when the Aircraft passed 2,500 feet radio altitude, the unusual difference would have been observed provided appropriate cockpit scanning had been accomplished. During the remainder approach after this point, the pressure altitude indicated higher than the radio altitude with a variance of 150 to 380 feet which was not noticed by the PM. This was most probably due to a lack of cockpit scanning or awareness of the unusual variance as required by *FCOM* altitude awareness (see section 1.17.4.6 in this Report).

When the Aircraft was descending through 2,150 feet indicated altitude (1,900 feet radio altitude) with an airspeed of 182 knots (groundspeed of 195 knots) and at around 1.2 nautical miles prior to position KUSOK, the FLCH mode was deactivated, while VNAV PTH mode was re-activated, which indicated the interception of the FMS-derived vertical profile.

### **Changing vertical mode twice from VNAV to FLCH**

The Copilot stated that the change of the vertical mode from VNAV to FLCH was intentional in order to attempt the recovery of the nominal flight management system (FMS) vertical profile from above.

Few seconds prior to the Aircraft started to descend from FL160 to 7,000 feet, the vertical mode changed from VNAV ALT to VNAV SPD mode.

During the approach, the Copilot used the FLCH mode twice. The first activation of FLCH mode was used when the Aircraft descended at 13,130 feet.





Based on the approach speed categorization, the B787 aircraft is a category (CAT) D aircraft. According to *ICAO Doc 8168 – PANS OPS*, the maximum permissible descent gradient for CAT D aircraft is 370 feet per nautical mile.

The EMERU 2D STAR was designed with a maximum flight level of FL160 at EMERU and a maximum altitude of 10,000 feet at TUGVA. For a standard atmosphere of ISA+0 condition, if due to airspace allocation design, an aircraft could not descend below FL160 prior to EMERU, a descent gradient of 375 feet per nautical mile is at least required in order to achieve the altitude restriction (10,000 feet) at TUGVA (see table 7). This means that the space for descent from EMERU to TUGVA was designed slightly above the maximum permissible descent gradient for CAT D aircraft as per the *ICAO Doc 8168 – PANS OPS* (comparing between 375 ft/nm and 370 ft/nm). In a condition of an aircraft cannot descend below FL160 prior to EMERU, there is almost no room for pilots to have a glitch in complying with the maximum permissible descent gradient.

If the atmosphere condition is higher than ISA+0 standard atmosphere condition, it requires less descent gradient than 375 feet per nautical mile from EMERU to TUGVA (IAF) waypoint. In this Incident flight, the atmosphere condition around OMAA was ISA+27. Therefore, in general, the design of the OMAA RNAV 1 STAR RWY 31L/R chart is considered in accordance with *ICAO Doc 8168 – PANS OPS* requirements, also for the Instrument Approach RNAV(RNP) Y RWY 31L chart, as shown in table 7.

In this flight, the distance made by the Aircraft from EMERU (15,880 feet indicated altitude) until the point when the altimeter setting was changed from the standard to a QNH setting (14,610 feet indicated altitude at 1013 hPa setting) was 4.32 nautical miles. Therefore, the descent gradient was 294 ft/nm ( $\approx 1,270$  feet / 4.32 nm).

The distance made by the Aircraft from the point when the altimeter setting was changed from the standard to a QNH setting (14,500 feet indicated altitude at QNH setting of 1009 hPa) until the initiation point of FLCH mode (13,130 feet indicated altitude) was 4.79 nautical miles. Therefore, the descent gradient was 286 ft/nm ( $\approx 1,370$  feet / 4.79 nm).

Therefore, by using VNAV SPD mode, the average descent gradient from EMERU to the point when the vertical mode was changed from VNAV SPD to FLCH was 290 ft/nm.

The distance made by the Aircraft from the point when FLCH mode was initiated until the point when passing TUGVA (10,920 feet indicated altitude) was 6.44 nautical miles. Therefore, the descent gradient was 343 ft/nm ( $\approx 2,210$  feet / 6.44 nm).

Hence, the average descent gradient from EMERU to TUGVA in this flight was approximately 317 ft/nm.

The required descent gradient from the altitude of the Aircraft at EMERU (15,880 feet indicated altitude at standard 1013 hPa setting) to the altitude restriction (maximum 10,000 feet indicated altitude at 1009 hPa setting) at TUGVA should have been approximately 375 ft/nm. Should a descent gradient of 360 feet per nautical mile have been applied by the flight crew, the Aircraft could have reached 10,000 feet at TUGVA.

The activation of FLCH mode was used from when the Aircraft descended at 13,130 feet until reaching 9,835 feet indicated altitude. This was the first changing vertical mode from VNAV to FLCH. The distance taken using this mode was 9.35 nautical miles. Therefore, the average descent profile gradient using the FLCH mode was approximately 352 feet per nautical mile.

The VNAV SPD mode was activated when FLCH mode was deactivated (9,835 feet indicated altitude). This VNAV mode activation was used until the Aircraft reached 6,570 feet indicated altitude and the distance made was 7.63 nautical miles. Therefore, the average descent profile gradient using the VNAV SPD mode was approximately 428 feet per nautical mile.

The second FLCH mode was used from when the Aircraft descended at 6,570 feet indicated altitude, just before reaching AA712 waypoint. This FLCH mode was used until the Aircraft reached 2,150 feet indicated altitude. The distance taken using this mode was 7.87 nautical miles. Therefore, the average descent profile gradient using the FLCH mode was approximately 562 feet per nautical mile.

Table 7 shows the summary of the descent profile gradients of the requirements, the design of the related Approach chart, and what happened in the Incident flight.

<b>Table 7. Descent profile gradient and rate of descent</b>			
	Vertical Mode	Descent Profile Gradient (ft/nm)	Average Rate of Descent (ft/min)
ICAO Doc 8168 – PANS OPS, CAT D Aircraft	---	370	
Chart Design from EMERU (max alt) to TUGVA (max alt)	---	375	
Chart Design from TUGVA to AA712		(Max) 561	
Chart Design from AA712 (min alt) to AA771 / intermediate fix (min alt)		192	
Chart Design from AA771 (min alt) to KUSOK (min alt)		297	
Chart Design from KUSOK to KATIG		(Min) 300	
<b>Incident flight – from Point to Point</b>			
EMERU -> Changing Altimeter setting from Standard to QNH	VNAV SPD	294	1,693
Changing Altimeter setting from Standard to QNH -> FLCH initiation	VNAV SPD	286	1,678
EMERU -> FLCH initiation	VNAV SPD	(average) 290	1,685
FLCH initiation -> TUGVA	FLCH (FLCH SPD)	343	1,842
EMERU -> TUGVA	Mixed (VNAV SPD & FLCH)	(average) 317	1,764
First FLCH Activation (13,130 ft -> 9,835 ft)	FLCH	352	1,848
VNAV Activation (9,835 ft -> 6,570 ft)	VNAV SPD	428	1,848
Second FLCH Activation (6,570 ft -> 2,150 ft)	FLCH	562	2,210

Comparing the Aircraft's descent profile gradients between the VNAV (VNAV SPD) mode (from the point EMERU to the point when FLCH mode was engaged at 13,130 feet indicated altitude) and the first FLCH (FLCH SPD) mode activation (from 13,130 feet to 9,835 feet indicated altitude), the last resulted in higher descent profile gradient (352 ft/nm > 290 ft/nm). However, the speedbrakes were only applied for the FLCH mode. Therefore, this comparison is considered not valid.

Comparing the Aircraft's descent profile gradients between the first FLCH mode activation and the VNAV (VNAV SPD) mode (from the point when the Aircraft was at 9,835 feet to 6,570 feet indicated altitude), the last resulted in higher descent profile gradient (428 ft/nm > 352 ft/nm). This comparison can be considered valid since the speedbrakes were applied on both modes, even though there was a small difference in the Aircraft configuration which was the deployment of flaps 1 when VNAV mode was being used that can be considered negligible.

Comparing the Aircraft's descent profile gradients between the second FLCH activation (from 6,570 feet to 2,150 feet indicated altitude) and VNAV mode (9,835 feet to 6,570 feet indicated altitude) cannot be done since there was a huge difference in the Aircraft configuration.



With the available comparison of the Aircraft's descent profile gradients between the VNAV (VNAV SPD) mode and FLCH mode, it can be concluded that the FLCH mode was ineffective since FLCH mode provided a lower descent gradient compared with the VNAV mode. As also mentioned before, by using the FLCH mode, there were no any altitude constraints as set in the FMS as a barrier, which was not according to the SOPs for intercepting the vertical profile from above.

With the above conclusion made, the Investigation believes that should the flight crew have applied (especially a full position) speedbrakes starting when the Aircraft descended through EMERU without changing VNAV SPD mode to FLCH mode, the Aircraft would have reached 10,000 feet indicated altitude when crossing TUGVA waypoint.

According to the Operator's OM-A, the criteria of sink rate for CAT D aircraft is not more than 1,200 feet per minute. However, if a higher rate of descent is required by approach procedure, it shall be briefed during approach preparations. As shown in Table 7, the Aircraft's rates of descent were more than 1,200 feet per minute starting from the waypoint EMERU until the activation of VNAV PTH mode when the Aircraft reached 2,150 feet indicated altitude. Since the CVR data was unavailable, the Investigation could not determine whether, during approach preparations, the flight crew discussed the higher rate of descent to be used for the approach manoeuvre.

#### **Back to VNAV vertical mode**

As mentioned before, VNAV PTH was activated when the Aircraft was descending crossing 2,150 feet indicated altitude.

Prior to passing KUSOK, the flight crew ended the communication with Approach Control as instructed to contact Tower Control. Up to this point, the QNH information had never been provided by the Approach Control.

The Aircraft crossed KUSOK while descending passing 1,790 feet indicated altitude (1,470 feet radio altitude), with an airspeed of 175 knots and groundspeed of 185 knots that continued decreasing. At the same time, the flap lever was moved from 20 to 25 detent, which made the Aircraft fully configured for landing. According to the RNAV(RNP) Y Runway 31 L Approach Chart, the minimum altitude at KUSOK was 1,900 feet. At this point, the Aircraft was below the indicated vertical profile approximately 110 feet. In addition, due to the incorrect QNH setting, the indicated vertical profile was also incorrect. Hence, the Aircraft was below the nominal profile approximately 410 feet. In the meantime, the flight crew commenced contacting Tower Control.

The Aircraft was configured for landing (after crossing KUSOK) with VNAV PTH mode, and the flight crew still managed the airspeed which was in a correct (reducing) trend. That was why the speedbrakes were used, which reduced the airspeed from 175 knots. The wind condition was stable with an average speed of 7.4 knots, and an average direction of 297 degrees.

The Controller instructed the flight crew to continue the approach runway 31L, which the PM read back correctly. The target speed of 148 knots was then selected as the Vref for flaps 25 plus 5 knots.

When the Aircraft was descending through 1,610 feet indicated altitude, the speedbrakes were retracted. The airspeed reached 151 knots, and the Aircraft was on the indicated profile. Since a baro-VNAV approach was being flown with an incorrect QNH setting, the Aircraft flew below the nominal profile. The flight crew perceived the indicated profile as the correct vertical profile, and were, most probably, released from their concern of being high, with a correct airspeed.



Subsequently, the Controller informed the flight crew of 320-degrees, 10-knots surface wind, and cleared the Aircraft to land. At this time, the Aircraft was descending through 1,590 feet indicated altitude and the airspeed reached 151 knots.

After few seconds, the Controller repeated the surface wind information and the landing clearance, since the flight crew had not yet read back the previous ATC instruction. Subsequently, the flight crew read back correctly the landing clearance. The Aircraft was descending through 1,390 feet indicated altitude. The outside air temperature was approximately 39 degrees Celsius, or in a standard atmosphere, the actual atmosphere was at ISA+27 condition.

The Commander stated that he checked the altimeter immediately when the auto callout of 1,000 feet was annunciated, however, he could not recollect the precise number of the indicated altitude. At 1,000 feet radio altitude, the indicated altitude showed around 1,350 feet, and the distance was approximately four nautical miles as per the flight data. The Copilot also stated that he heard the “1,000” auto callout. The SOP required the pilot monitoring to crosscheck the distance to touchdown in response to “1,000” radio callout. The Copilot as the pilot flying might have crosschecked that the Aircraft was on profile (with the incorrect QNH setting).

Since the flight crew perceived the indicated profile as the correct vertical profile, hence, the Commander as the PM, most probably, did not consider the need to crosscheck further the vertical situation of the Aircraft for the remainder approach. Should the Commander have crosschecked correctly the distance to the runway threshold that indicated approximately four nautical miles, in response to the “1,000” auto callout, he would have probably realized that the Aircraft was below the nominal vertical profile. And in that case, he might have commanded the Copilot to perform an earlier go-around and could have prevented the occurrence as the last barrier. Therefore, the Investigation believes that pilot’s response after the “1,000” auto callout was not effectively managed as per the SOP. However, the Investigation could not determine whether the required callouts in response to “1,000” auto callout was made by both flight crew since the CVR data was unavailable.

Approximately three seconds later after the “1,000” auto callout, the Aircraft crossed KATIG (final approach fix “FAF”) while descending passing 1,300 feet indicated altitude (950 feet radio altitude), which was in line with the mandatory altitude as per the Approach Chart. However, due to the incorrect altimeter pressure setting, the Aircraft was around 300 feet below the nominal vertical profile while flying a barometric VNAV profile, flying an unstable approach.

The airspeed had already been reduced and was 152 knots at this point. In the meantime, the target altitude was changed from 470 feet to 4,000 feet as the missed approach altitude as per the chart.

The flight crew stated that shortly after crossing KATIG (3.9 nm from the threshold), they could see the precision approach path indicator (PAPI). However, it was a bit hazy, such that they were not able to determine what color of the PAPI lights definitely.

The Aircraft descended passing 500 feet radio altitude while the indicated altitude showed 865 feet. The autopilot was disengaged when the Aircraft passed 660 feet indicated altitude (280 feet radio altitude), at which point manual flight was first applied.

The takeoff/go-around (TOGA) mode was engaged with the simultaneous engagement of the autopilot when the Aircraft was at a distance of approximately 1.3 nautical miles from the threshold of runway 31L. The indicated altitude was 570 feet and the radio altitude was around 210 feet.

The Copilot, as the PF, did not call for a go-around when he became aware of the vertical profile anomaly as he saw the four red PAPI lights.





The Commander, as the PM, stated that he saw the four red PAPI lights, and realized that something was not right, hence, he instructed the Copilot to go around. The PF then initiated the go-around by pressing the TO/GA switches.

The Investigation could not determine the precise time when the go-around order was made by the Commander since the CVR data was unavailable. However, based on all three flight crewmembers, none of them raised a concern that there was a delay between the time the Commander ordered the go-around and the commencement of the go-around. Therefore, it can be considered that the go-around was performed immediately after the order to go-around was made. The TO/GA switch was pressed when the Aircraft was approximately 1.3 nautical miles. Hence, it can be considered that the Commander saw the four red PAPI lights, and instructed the Copilot to go around when the Aircraft was approximately 1.5 nautical miles from the threshold.

In order to confirm the PAPI system functionality, Tower Control requested Aerodrome ground staff to inspect the system. The inspection was then conducted approximately 18 minutes after the first approach and found that the PAPI system was functioning correctly.

As per the flight data, the time between the callout of “1,000” and the go-around initiation (TO/GA mode activation) was one minute five seconds. The Aircraft had already been configured for landing and was following the profile.

Additionally, the vertical situation display (VSD) on the bottom of the navigation display (ND) was available to indicate the current flight path angle as a function of the Aircraft vertical speed and groundspeed, and incorporated the runway and scaled runway length. In combination with these, an estimated indication of the point the Aircraft would intercept the runway would be available.

The Investigation believes that this display would have enhanced the vertical situational awareness of the flight crew. However, the VSD and its cues were never described by the flight crew as being monitored during the approach, or considered for their vertical assessment. For RNP AR approaches, the VSD should be selected ON as per the SOP. However, there was no detailed provided guidance regarding specific reference or crosscheck of the VSD during approach. As per the *Flight Crew Training Manual (FCTM)*, VSD use was encouraged as much as possible during all approaches, however, it was not an obligatory reference for flight crew on approach. Therefore, the Investigation recommends that the Operator address amendment of the approach SOPs with more detailed information on specific referencing or crosschecking of the VSD on all baro-VNAV approach operations.

The lowest recorded radio altitude was 202 feet, at which the Aircraft commenced to climb. Three seconds later, the landing gear lever was positioned to UP. The flap lever was moved from 25 to 20 detent when the Aircraft was climbing through 480 feet radio altitude, at approximately seven seconds after the landing gear lever was positioned to UP. The Copilot, acting as the PF, stated that he initially commanded for the landing gear retraction.

The CVR data was unavailable to the Investigation, however, it is believed that at the go-around initiation, the FMA announcement of thrust setting, and the callout of flaps 20 were not pronounced by the PF, prior to the callout for the landing gear to up position, which was not as per the sequence of the Operator’s published procedures. However, this did not affect the flight safety of the remainder go-around.

Subsequently, approximately three seconds after setting the flap lever to 20 detent position, the PM reported to ATC that the Aircraft performed a go-around when the Aircraft was climbing through 604 feet radio altitude.



The flaps were retracted per the schedule above 1,000 feet radio altitude which was according to SOP. Subsequently, as per the go-around procedure for runway 31L, the Aircraft proceeded to climb to VEDEX at 4,000 feet.

While the Aircraft was climbing through 3,600 feet indicated altitude, the Approach Controller informed the QNH of 998 and requested the flight crew to confirm when they would be ready for vectors for an instrument landing system (ILS) approach to runway 31L. The PM replied that they were ready for another approach, at which this time, it was an ILS approach on the same runway 31L. However, he did not read back regarding the QNH of 998 hPa, and the flight crew did not change the altimeter setting with the provided QNH. The Investigation could not determine why the flight crew did not read back the provided QNH. However, the flight crew were probably negatively impacted by the high internal workload experienced during the go-around maneuver.

The interviews with the Investigation were the first time for the flight crew to know that the go-around was initiated while the Aircraft was only about 200 feet above the ground.

### **2.3 Level Bust, Second Approach, and Landing**

While the Aircraft was turning right from crosswind leg to downwind leg at a level of 4,000 feet indicated altitude as per the vectors provided, the Approach Controller requested confirmation that the flight crew had established the QNH setting of 998, and queried the flight crew about the present altitude, which was not a standard ATC request addressed to the flight crew. This indicates that the Controller was not certain of the QNH setting in the Aircraft since 3,700 feet was shown on the ATC's display.

Consequently, the flight crew realized that they had the incorrect QNH setting on their primary flight displays (PFD). The true altitude was 300 feet below the indicated altitude in the flight deck, and it was identical to the ATC display. Subsequently, the flight crew adjusted the altimeter settings to 998 hPa and informed the Controller that the Aircraft would climb to 4,000 feet. The Aircraft had experienced a level bust of around 300 feet as the Aircraft had leveled off below the correct missed approach altitude of 4,000 feet prior to the QNH setting adjustment from 1009 to 998 hPa was made. After the QNH setting had been changed to the correct one (998 hPa), the Aircraft climbed to 4,000 feet and maintained that level, which was accomplished uneventfully.

The approach below the profile in the first landing attempt, and level-off at 300 feet below the standard missed approach altitude after the go-around, indicate that the flight crew were unaware of the correct vertical profile during the approach and go-around. The Investigation believes that the flight crew only became aware of the root cause of the vertical profile discrepancy after being directed by ATC to change to the correct QNH after the completion of the go-around.

While the Aircraft was maintaining 4,000 feet on downwind, the Controller requested a confirmation from the flight crew that the ILS approach runway 31L was set. This requested confirmation indicated that the Controller wished to ensure that the flight crew set the ILS approach instead of RNAV (RNP) approach to runway 31L. The flight crew confirmed, and the Controller continued providing vectors for the ILS approach including instruction to descend to 2,000 feet.

When the Aircraft was maintaining 2,000 feet at 7.5 nautical miles on the final approach, the PM contacted Tower Control and informed that the Aircraft was at an inbound position for an ILS approach to runway 31L. Subsequently, Tower Control issued clearance to the flight crew to continue the approach. The flight crew were asked whether they were able to sight the PAPI lights at the time when the Aircraft was on the glideslope, around 4.4 nautical miles from the threshold. At this time, the flight crew could see the PAPI lights, however, the





colors definition was not yet clearly visible. The Aircraft continued an uneventful approach to runway 31L and touched down at 1017.

During the landing roll just prior to turning left for vacating the runway, the Tower Controller requested the flight crew for confirmation whether the PAPI lights were observed correctly functioning during the second approach, and the PM confirmed their functionality. This indicates that the PAPI lights had no discrepancies. The flight crew were able to see the definitive color of the PAPI lights on short final in spite of haze.

Subsequently, the Aircraft vacated the runway via taxiway Echo 8 and continued taxiing through taxiway Echo 6 to parking stand 308, as instructed by the Tower Controller. The engines were shut down at 1022.

## 2.4 Meteorological Condition

The flight crew described that during their first approach, they were not able to see the PAPI clearly when passing KATIG, due to hazy conditions (see section 2.2 of this Report).

The Commander, as the PM, stated that when following the profile, normally three whites and one red of PAPI lights would be sighted. When he saw the definitive four red PAPI lights, he decided to perform the go-around and commanded the PF to perform. At this point, the Aircraft was about 1.5 nautical miles ( $\approx$  2.8 kilometers) from the threshold.

Therefore, the Investigation concludes that the visibility was less than 2.8 kilometers.

Additionally, during the second approach when the Aircraft was at 4.4 nautical miles ( $\approx$  8.1 kilometers) from the threshold, and 1,380 feet indicated altitude (with correct QNH setting), the flight crew were not able to determine the PAPI lights color definitively as requested by ATC. As requested by the ATC when the Aircraft was rolling after touchdown, the flight crew reported that they did not have an issue with the functioning of the PAPI lights when the Aircraft had been on the short final before reaching the threshold. Although the Investigation could not determine when the flight crew were able to see definitively the PAPI (two red and two white) lights color, however, the Investigation concludes that the visibility was less than 8.1 kilometers.

In a fog or mist condition, the airfield might have been visible from directly overhead, however, in both approaches, the intensity levels of the fog or mist precluded the sighting of the runway, especially the PAPI lights, when the Aircraft aligned for landing.

Accordingly, the Investigation believes that despite the reported visibility of being more than 10 kilometers, the forward visibility was less in both approaches, at higher altitudes. This condition supported the presence of haze layer(s) of which is commonly associated with temperature inversions in the Middle Eastern region.

Should the visibility had been the same as reported during the first approach, the flight crew might have seen the definite PAPI lights from a longer distance and realized that the Aircraft was below profile earlier compared to what happened in this Incident.

## 2.5 Flight Crew Performance

The flight crew arrived at Beijing one day prior to the Incident flight and completed a layover with an allocated rest period of 23 hours 15 minutes. All three flight crewmembers were well-rested and reported fit for duty. They did not feel fatigued at the time of the Incident.

The total duty time of the flight, the operating flight time, and the scheduled rest period of all three flight crewmembers were in compliance with the flight and duty limitations and rest requirements of the *Civil Aviation Regulations CAR-OPS1*, and the *Operator's Operations Manual - Part A*.



Based on the SAFE12 software that was incorporated by the Operator, the predicted fatigue level of the flight crew at about the top of descent was approximately SPS 4.20, which can be considered as “a little tired, less than fresh” for the three flight crewmembers, since the predicted SPS was slightly more than SPS 4.0. This SAFE prediction was considered to be in line with the flight crew's feedback regarding their level of alertness. Therefore, the Investigation believes that the flight crewmembers' fatigue level was not a factor in this Incident.

Based on the flight crew records including their training records provided to the Investigation, the flight crew qualifications and experience were not factors in the Incident.

As described in section 2.2 in this Report, the flight crew priority and mental awareness were most likely on the flight path management (Aircraft being high and managing high energy during descent), and this created more workload than the usual one. This, probably, disturbed the flight crew's attention and task management, and the communication between them, which affected the functioning of their cockpit resource management and resulted in ineffective monitoring functions of the flight. This condition contributed to the omission to set and crosscheck the correct QNH value setting by the PF and PM. The Investigation believes that the flight crew cross-monitoring performance significantly degraded during the first approach.

Based on the Operator's OM-A, the additional Copilot on the jump seat should have verified the correct QNH setting as per the ATIS report as he was not actively flying the Aircraft during the descent phase and probably would not have the same (flight path management) mindset as the operating flight crew. Should he have acted in his proper role as per OM-A, the incorrect QNH setting could have been avoided.

## 2.6 Air Traffic Control

As described previously, when the Aircraft was at a distance of approximately three nautical miles prior to reaching EMERU waypoint, Abu Dhabi Approach Control instructed the flight crew to descend to 7,000 feet and cleared for an RNAV Y approach to runway 31L from TUGVA (IAF). The instruction ‘to descend to 7,000 feet’ was an initial descent clearance to an altitude without providing the local QNH information, which was not in accordance with the *air traffic services operating manual (ATSOM)*.

Also, when the RNAV Y approach to runway 31L from TUGVA clearance was provided, the Controller did not provide the local QNH information, which was not in accordance with the *Supplementary Instruction (SI) 027/20 that had been issued* by the air traffic services (ATS) unit on 10 May 2020. This SI 027/20 required the controller, for OMAA arrivals, to provide the QNH information in the clearance of ‘RNAV YANKEE Approach’.

The Controller did not provide verbally the local QNH when the initial descent clearance to an altitude of 7,000 feet, and RNAV Y approach to runway 31L from TUGVA clearance were provided, since the flight crew had confirmed receiving ATIS information India that contained the QNH value of 999 hPa on the first contact with Abu Dhabi Approach Control.

Corrective safety actions regarding providing QNH information were undertaken after the Incident by GAL Air Navigation Services (ANS) as given in section 4.2.2 of this Report. During the first approach and go-around, there was a difference between the flight deck indicated altitude and the actual altitude of the independent ATC radar monitor. Abu Dhabi air traffic management (ATM) system had the capability to detect and warn the flight crew below the required vertical profile as mentioned in section 1.17.5.2 of this Report.

In this Incident, the minimum safe altitude warning (MSAW) was triggered on two occasions: The first trigger was when the Aircraft was at 8.7 nautical miles from the threshold runway 3L where the flight deck indicated altitude was 3,300 feet and lasted for 10 seconds;

the second was at 3.5 nautical miles when the flight deck indicated altitude was 1,110 feet and lasted 45 seconds,

When the first MSAW alert (“MS” displayed) occurred, the Aircraft was under the control of OMAA Approach Control (APP). The Controller did not advise the flight crew of this warning since he was aware that the alert had been triggered as a result of the Aircraft’s close proximity to an area with a minimum vectoring altitude (MVA). The MS alert was activated due to a high rate of descent and system calculation that predicted the Aircraft might have penetrated the area with an MVA of 1,800 feet. The alert was deactivated when the Aircraft continued its right turn while being established on final for runway 31L and entered the MSAW inhibition area.

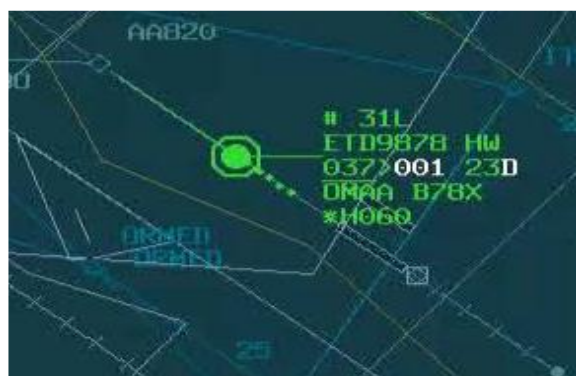
The no-reaction on the MSAW alert by the OMAA Approach Controller was not in accordance with the ATS standard operating procedures as given in the *OMAA ATISOM*, which required immediate advice to the flight crew when an MSAW has been triggered with an instruction to check the QNH and the level of the aircraft.

The second MSAW alert occurred when the Aircraft was descending below the tolerance angle of the glide path, and the Aircraft was under the control of OMAA Tower Control (TWR). The OMAA Approach Controller did not react to the alert since the Aircraft was not on the OMAA APP frequency. The Controller had previously transferred the Aircraft to the OMAA Tower Control frequency.

The available procedures of an MS warning event at the time of the Incident were only applicable to OMAA APP. However, there were no procedures or instructions available that OMAA Approach Control to notify OMAA Tower Control while an aircraft is under the control of OMAA TWR for an MS warning event. There were no procedures or instructions available that OMAA Tower Control to advise the pilot of an MS warning event when an aircraft was under the control of OMAA TWR.

After the Commander had informed Tower Control of performing the go-around, the Tower Controller called Approach Controller by phone and told that EY9878 was performing a go-around with unknown reason. This revealed that the Tower Controller was unaware of the MS warning event, even though no procedures were available for OMAA TWR to advise the pilot of an MS warning event when an aircraft is under its control.

In response to this Incident, OMAA Operations Management of GAL ANS – OMAA Operations (OPS) issued a Supplementary Instruction (SI) 029-21 applicable to OMAA Tower Control, and SI 027-21 applicable to OMAA Approach Control. Both SIs contained instructions on how to deal with instances in which an “MS” is activated while an aircraft is executing an approach into OMAA and established on final (see section 4.2.2 of this Report).



**Figure 9.** Radar screenshot - Aircraft leveled off after missed approach, indicated altitude 3,700 feet (corrected) [Source: GAL]

Figure 9 shows a radar screenshot indicating the Aircraft was maintaining an altitude of 3,700 feet instead of the required 4,000 feet when leveling off after the missed approach. Hence, the Controller advised the flight crew about the correct QNH setting (see section 2.3 of this Report).

## 2.7 Notification of the Incident and Flight Recorders Preservation

The Incident was notified to the Air Accident Investigation Sector of the United Arab Emirates (AAIS) about 23 hours after its occurrence. Before the notification, the Aircraft was being operated as per the flight schedule. The AAIS Duty Investigator requested the Operator to remove and preserve one of the recorders. The Operator had translated the requirements of notifying or reporting a serious incident in its OM-A (see section 1.17.4.10 of this Report). The requirements mentioned that the commanders involved must take action to notify when they believe a potentially serious incident has been involved. In this Incident, the Commander did not start the communication procedure required.

As discussed in section 2.2 of this Report, the flight crew were not aware that the Aircraft was about 200 feet above the ground level when the go-around was performed. The flight crew did not appreciate the severity of the event of seeing the four red PAPI lights. The seriousness of the event was only appreciated after the Commander's air safety report (ASR) and flight data monitoring (FDM) information was reviewed. Since the Aircraft did not experience any airworthiness issues after the Incident flight, therefore it was used on its next scheduled service. The flight crews' lack of appreciation of the occurrence severity, precluded them from reporting this to the necessary personal in the Operator's organization, and therefore, the Operator could not take the necessary steps to secure the CVR earlier. Since the CVR had only two hours of recording capability, the recorded data from the Incident flight had been overwritten.

The flight data recorder (FDR) had a recording capability of 72 hours. Therefore, the flight data for the Incident flight was available and was useful to the Investigation.

The CVR is one of the most essential tools used for safety (accident, serious incident, and incident) investigation. When CVR information is available, the investigators could comprehensively assess factors of safety events, such as flight crews' procedural compliance, workload, distraction, decision-making, situational awareness, and fatigue.

With the current standard of two hours CVR recording capability, the AAIS has ongoing experience with overwritten recordings. Most of the time, the overwritten recordings were due to:

- failure to immediately deactivate the CVR on arrival after a safety occurrence happened;
- the flight time remaining after a safety occurrence that exceeded the duration of the CVR two hours recording; and
- delay in reporting of a safety occurrence that was not immediately recognized as having a serious nature until further data review.

Having unavailable CVR information, an investigation may not identify issues that play a role in a safety occurrence, and hence, effective safety recommendation(s) could not be addressed. Consequently, no lesson learnt and safety defense(s) taken from the previous safety occurrence, which could result in a similar or worse safety occurrence in the future.

Regulations regarding CVR are being drafted by the General Civil Aviation Authority of the United Arab Emirates (GCAA), which will require a recording capability of 25 hours for aircraft with a maximum certificated take-off mass (MCTOM) of more than 27,000 kg and its certificate of airworthiness (CoA) issuance on or after 1 January 2022. For other cases, it will require the two hours recording capability.



Therefore, the AAIS recommends that GCAA consider the practicability to implement the requirement of 25 hours CVR recording capability for new aircraft with maximum certificated take-off mass (MCTOM) of more than 27,000 kg with its CoA issuance on or after 1 January 2022. It is further recommended to consider having a retrofit program within a certain period that mandating to upgrade to a 25 hour CVR recording capability for UAE registered aircraft with an MCTOM of more than 27,000 kg with the CoA issuance date before 1 January 2022.



## 3. Conclusions

### 3.1 General

From the evidence available, the following findings, causes, and contributing factors were made with respect to this Incident. These shall not be read as apportioning blame or liability to any particular organization or individual.

To serve the objective of this Investigation, the following sections are included in the Conclusions heading:

- **Findings.** Are statements of all significant conditions, events, or circumstances in this Incident. The findings are significant steps in this Incident sequence but they are not always causal or indicate deficiencies.
- **Causes.** Are actions, omissions, events, conditions, or a combination thereof, which led to this Incident.
- **Contributing factors.** Are actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided, or absent, would have reduced the probability of the Incident occurring, or mitigated the severity of the consequences of the Incident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil, or criminal liability.

### 3.2 Findings

#### 3.2.1 Findings relevant to the Aircraft

- (a) The Aircraft was certificated, equipped, and maintained in accordance with the requirements of the *Civil Aviation Regulations* of the United Arab Emirates.
- (b) No defects or technical anomalies were recorded for the Aircraft systems and equipment before or during the flight.

#### 3.2.2 Findings relevant to the flight crewmembers

- (a) The flight crewmembers were licensed and qualified for the flight in accordance with the existing requirements of the *Civil Aviation Regulations* of the United Arab Emirates.
- (b) The pilot flying and pilot monitoring did not change the QNH pre-set value to 999 hectopascal (hPa) as per automatic terminal information service (ATIS) information as per the descent procedure before the top of descent. The pre-set barometer setting value was 1009 hPa, which was the same as the QNH that had been set at the departure airport (Beijing).
- (c) The Commander, Copilot and the third flight crewmember were unaware of the incorrect Abu Dhabi International Airport (OMAA) QNH setting value, even though the Commander had confirmed to ATC that EY9878 had received ATIS Information India in which contained QNH 999 hPa.
- (d) The flight crew were concerned about being high when the Aircraft was at three nautical miles from EMERU (a waypoint on the border between Dubai CTA and Abu Dhabi CTA).
- (e) The flight crew were fixated on the energy management preparation for the descent when ATC issued the initial descent clearance from flight level FL160, to altitude 7,000 feet.





- (f) The fixation on the energy management caused inadequate monitoring functions that resulted in an incorrect QNH setting to the Abu Dhabi International Airport at the time of switching from the standard pressure to the QNH setting.
- (g) After switching from the standard pressure to the QNH setting during the approach, all three flight crewmembers were unaware of the incorrect OMAA QNH setting.
- (h) When the Aircraft passed the initial approach fix (IAF), the indicated altitude was 920 feet more than the altitude limitation of 10,000 feet, which concerned the flight crew of being high. They continued focusing on the energy management for the approach.
- (i) The vertical situation display (VSD) was not appropriately monitored by the flight crew or considered for their vertical assessment during the approach.
- (j) The flight crew did not cross check the vertical situation of the Aircraft for the remainder of the approach since the Aircraft was on the (perceived) profile with correct airspeed while descending through 1,610 feet indicated altitude.
- (k) The go-around was decided and initiated when the flight crew sighted the precision approach path indicator (PAPI) lights indicating four red lights.
- (l) On the last phase of the go-around, QNH information was provided by ATC, however, the flight crew were unaware of it and therefore did not change the altimeter setting to the provided QNH.

### 3.2.3 Findings relevant to flight operations

- (a) The departure airport (ZBAA) QNH of 1009 hPa was stored as a pre-setting of the barometer when the flight crew switched the ZBAA QNH to the standard pressure (1013 hPa), after the takeoff from Beijing. This pre-set value was not changed to the correct destination airport (OMAA) QNH of 999 hPa as per the ATIS information.
- (b) The barometric setting was switched from the standard pressure to the QNH setting for OMAA RNAV (RNP) runway 31L approach when the Aircraft was descending through FL146.
- (c) Since the QNH pre-set value of 1009 hPa had not been changed to 999 hPa, it resulted in an incorrect OMAA QNH setting for the approach.
- (d) The incorrect QNH settings on both pilots' sides caused the Aircraft to fly on a lower vertical path of 300 feet during the approach.
- (e) Flight level change (FLCH) vertical mode was selected few seconds before setting the decision altitude (DA), at which point the autopilot flight director system (AFDS) allowed the Aircraft to descend to this altitude without adherence to any altitude constraints that had been set in the flight management system.
- (f) The flight crew did not confirm the pressure altitude when the Aircraft passed through 2,500 feet radio altitude and were not aware of the unusual difference between the pressure altitude and the radio altitude for the remainder of the approach, as per the SOP.
- (g) The flight crews' response after the "1,000" auto callout was not effectively managed as per the SOP of crosschecking the distance to touchdown.



- (h) Despite the reported visibility of being more than 10 kilometers, the forward visibility was less in both approaches, at higher altitudes, due to the presence of haze layer(s) commonly associated with temperature inversions in the Middle Eastern region.
- (i) The PAPI lights were functioning normally.
- (j) The go-around was initiated at approximately 210 feet radio altitude.
- (k) During the go-around, the flight crew did not follow the standard go-around and missed approach procedure as per the Flight crew operating manual (FCOM). However, there was no consequent risk along with the remainder of the go-around.
- (l) Because of the incorrect QNH setting, the Aircraft experienced a level bust of around 300 feet below the missed approach altitude after the go-around while leveling off at 4,000 feet flight deck indicated altitude.
- (m) The flight crew changed the QNH setting to the correct value when they were advised by ATC to check their altimeters and set the correct QNH. Subsequently, the Aircraft climbed to the correct 4,000 feet missed approach altitude and maintained level.

#### 3.2.4 Findings relevant to Air Traffic Control

- (a) Approach Control did not provide information about the local OMAA QNH when issued initial descent clearance from a flight level to an altitude, which was not in accordance with the *air traffic services operating manual (ATSOM)*.
- (b) Approach Control did not provide local QNH information when issued clearance for RNAV Y approach to runway 31L from the IAF, which was not as per the air traffic services (ATS) unit *Supplementary Instruction 027/20*.
- (c) Minimum safe altitude warning (MSAW) was triggered on two occasions.
- (d) On the first MSAW activation on the EUROCAT radar screen, the flight crew were not advised by Approach Control as per the SOP because the Controller was aware that the alert had been triggered as a result of the Aircraft's close proximity to an area with a minimum vectoring altitude.
- (e) On the second MSAW activation, the Approach Controller did not react to the warning because the Aircraft was not on the frequency of OMAA Approach and there were no procedures or instructions available that OMAA Approach Control to notify OMAA Tower Control while an aircraft is under the control of OMAA Tower for an MSAW event ("MS" displayed).
- (f) There were no procedures or instructions available that OMAA Tower Control to advise the pilot of an MS warning event when an aircraft was under the control of OMAA Tower.
- (g) When the Aircraft leveled off at 4,000 feet indicated altitude, 3,700 feet was shown on the EUROCAT radar screen.

#### 3.2.5 Findings relevant to Aircraft Operator

- (a) No detailed guidance was provided in the SOP for scanning and crosschecking the VSD on RNP AR APCH operations.
- (b) The Operator notified the Incident late to the Air Accident Investigation Sector of the United Arab Emirates (AAIS) and the cockpit voice recorder (CVR) data

had consequently been overwritten by the next flight after the Incident. Therefore, the CVR data was not available to the Investigation.

- (c) The Operator did not preserve the flight data and information recordings as per the *CAR-OPS1* and the *Operations Manual*. However, the recorded flight data was still available to the Investigation since the flight data recorder (FDR) had a recording capability of 72 hours.

### 3.3 Cause

The Air Accident Investigation Sector determines that the cause of the Aircraft flying below the vertical profile during approach was the incorrect local pressure (QNH) altimeter setting. A Go-around was carried out when the Aircraft was at a distance of 1.3 nautical miles from the threshold of runway 31L after the flight crew had definitely seen four red precision approach path indicator (PAPI) lights.

### 3.4 Contributing Factors to the Incident

The Air Accident Investigation Sector identifies the following contributing factors to the Incident:

- The operating flight crew omitted to preset QNH value after receiving automatic terminal information service (ATIS) information, even though the Commander had confirmed to ATC that EY9878 had received ATIS Information India which contained OMAA QNH 999 hPa.
- Prior to and at transition level, the flight crew were fixated on the high-energy management for the descent, such that selecting the barometric setting from the standard pressure of 1013 hPa to the local QNH value was carried out incorrectly.
- ATC did not provide the OMAA QNH information along with the initial descent clearance from a flight level to an altitude, nor when issued the clearance of RNAV Y runway 31L approach from IAF.
- The VSD and its cues were not used or considered of their vertical profile assessment during approach by the flight crew for monitoring.
- ATC did not provide instruction to check the QNH setting and the level of the Aircraft when the activation of the minimum safe altitude warning was triggered on its radar screen.
- At higher altitudes, the forward visibility was less than reported, due to the presence of haze layer(s) of which are commonly associated with temperature inversions in the Middle Eastern region.



## 4. Safety Recommendations

### 4.1 General

The safety recommendations listed in this Report are proposed according to paragraph 6.8 of *Annex 13 to the Convention on International Civil Aviation*, and are based on the conclusions listed in Part 3 of this Report; the Air Accident Investigation Sector expects that all safety issues identified by the Investigation are addressed by the concerned organizations.

### 4.2 Safety Actions Taken

#### 4.2.1 Safety actions taken by the Operator

Based on the Operator's safety management system (SMS) assessment, the Operator took the following safety actions as described in the Operator's internal investigation report:

1. The Operator highlighted the importance of the correct altimeter setting for RNP AR approaches, as included in the publication of the Operator's *Flight Safety Message (FSM) 009/20*.
2. A requirement to confirm the QNH prior to the initial approach fix (IAF) has been incorporated in fleet-wide SOPs for all RNP AR approaches, as shown in Appendix 2.
3. Separate (Boeing and Airbus) 'Abu Dhabi RNAV (RNP) Approach Guides' were issued to highlight to crews:
  - the required procedures;
  - approach preparation;
  - altitude setting requirements;
  - effects of altimeter setting errors;
  - effect of high outside air temperature (OAT);
  - flight path monitoring requirements;
  - transition to visual references;
  - 1,000 feet RA distance crosscheck;
  - important considerations; and
  - common errors.

These courses were categorized as mandatory as was the completion of a compulsory 'AUH RNAV (RNP) Approach Questionnaire' by all crews.

Other training programs were implemented or planned relating to the Incident. The implemented ones are as shown in Appendix 3.

4. A publication 'Incorrect QNH Setting when conducting baro-VNAV approaches' was issued by Crew Training, aimed "to draw attention to the risk of controlled flight into terrain (CFIT) when flying instrument approach operations with the pressure altimeter sub-scale set to an incorrect pressure setting (QNH)".
5. The Aircraft manufacturer (Boeing) was approached to clarify the acceptability and endorsement of updated 'MCP Altitude Setting Techniques Using VNAV' for



RNP AR Approaches. These were incorporated into version 2 of the (Boeing) AUH RNAV (RNP) Approach Guide.

6. The Incident, especially the sequence of crew errors that were contributory, was incorporated for demonstration and explanation to all Operator's pilots during the Semester 'A' (Oct 2020-Mar 2021) Operator Proficiency Check syllabus.

Since the above-mentioned safety actions were taken by the Operator after this Incident, the Investigation does not address safety recommendations for the same aspects. However, one safety recommendation is addressed to the Operator in order to ensure the effectiveness of the safety actions taken (see section 4.3.1 in this Report).

#### 4.2.2 Safety actions taken by GAL Air Navigation Services (GAL ANS)

GAL ANS undertook the following corrective safety actions following the Incident and in response to its internal safety investigation into the Incident:

1. The ANS Operations provided the involved OMAA Approach Controller with a post-investigation debrief on the outcomes of the internal investigation that as a minimum should cover the following elements:
  - (a) Situational awareness – constant monitoring of the radar screen for potential warning signals.
  - (b) Safety Nets – Minimum Safety Altitude Warning 'MS' requirements.
  - (c) Adherence to standard phraseology.
2. The ANS Training and Standards Department starting from July 2020, conducted three tape reviews for the period of three months, where the involved Approach Controllers performance was reviewed. The tape reviews were focused on the correct use of phraseology especially during EMERU Arrivals and RNP-AR Approaches.
3. The ANS Safety Department shared the outcomes of its internal investigation with Etihad Safety Department for Etihad's internal review and remedial actions as necessary.
4. The ANS Safety Department produced a Safety Publication LL03/20 in a form of a "Lessons Learned (LL)" that was on the topic of "Incorrect QNH Setting".
5. In order to reiterate the requirements for the provision of QNH by air traffic controllers, *Operations Bulletin (OB) 007/20* was published on 24 June 2020 by GAL ANS Operations Management with the intention to raise staff awareness and reinforce the Unit regarding RNAV Procedures and Regulatory requirements (ICAO Doc 4444, section 6.6) in relation to the provision of "Information to Arriving Aircraft" i.e. QNH issuance.
6. Supplementary Instruction (SI) 027/20 was incorporated into *OMAA air traffic services operating manual (ATSOM)*.
7. Based on the request from Etihad's Operations, Temporary Instruction (TI) 349/20, titled *RNAV YANKEE PRIMARY APPROACH OMAA*, published on 29 September 2020, was cancelled on 5 October 2020 by ANS Operations Management. Etihad Operations had requested that instrument landing system (ILS) Approaches would be preferred as primary approaches into OMAA.
8. GAL ANS utilized regular meetings with Etihad Airways representatives to discuss the application of minimum safe altitude warning (MSAW) warnings and action to be taken by ATC and flight crews during these events. Subsequently, a



workshop was organized between GAL ANS and Etihad Airways on the topic of MSAW warnings.

9. A Supplementary Instruction (SI) 027/21 was issued by OMAA Operations (OPS), which applied to OMAA Approach Control (APP) containing instructions as following:
  - (a) In the event an alert is generated in respect of a controlled flight, the controller shall immediately assess the situation.
  - (b) If the traffic is outside the MSAW inhibition area, then refer to *ATSOM* procedure for MSAW.
  - (c) If inside the MSAW inhibition area, advise the pilot using the following radio transmission: “*Callsign – Check Altitude – QNHxxxx*”.
  - (d) If the alert is observed whilst the traffic is under the control of OMAA Tower Control (TWR) – in the interest of safety, Approach (APP) air traffic controller officers (ATCOs) will notify the OMAA TWR ATCO accordingly.
10. A Supplementary Instruction (SI) 029/21 was issued by OMAA OPS, which applied to OMAA Tower Control (TWR) containing instructions as follows:
  - (a) In the event of an MS warning is generated and observed within the lateral boundaries of the control zone (CTR or controlled traffic region) for aircraft in contact with one of the Abu Dhabi Tower frequencies, ATCOs shall advise the pilot using the following radio transmission: “*Callsign – Check Altitude – QNHxxxx*”.
  - (b) In the event of an MS warning is generated and observed within the lateral boundaries of the CTR for aircraft **not** in contact with one of the Abu Dhabi Tower frequencies, ATCOs shall notify APP accordingly and without delay.

### 4.3 Final Report Safety Recommendations

#### 4.3.1 Etihad Airways

##### SR48/2021

The flight crew did not change the pre-set QNH value to the correct Abu Dhabi International Airport (OMAA) QNH after they had received the automatic terminal information service (ATIS) information, as per the descent procedure.

Therefore, the Air Accident Investigation recommends that Etihad Airways reinforce among pilots the requirement to pre-select the QNH barometric setting after receiving ATIS information for the destination airport.

##### SR49/2021

After the Incident, in relation to incorrect altimeter setting for RNP AR approaches, the Operator took safety actions in order to reinforce the available required procedures and requirements, and re-iterate the effects of the altimeter setting errors and high outside air temperature (OAT). Additional required training was planned and some implemented, including distraction management, workload management, escalation of communication strategies, and glideslope from above/VNAV from above.

The Air Accident Investigation Sector recommends that Etihad Airways ensure the effectiveness of the safety actions taken as a part of its SMS program.

#### SR50/2021

For RNP AR approaches, there was no detailed guidance provided regarding specific referencing or crosschecking of the vertical situation display (VSD).

Therefore, the Air Accident Investigation Sector recommends that Etihad Airways address the amendment of the approach SOPs with more detailed information on specific referencing or crosschecking of the VSD on all baro-VNAV approach operations.

#### SR51/2021

Additional flight crew seated on the jump seat does have a role to provide additional monitoring of the flight during critical phases of flight. In this Incident flight, the additional flight crew was unaware of the incorrect QNH setting, which means that additional monitoring of the flight was carried out ineffectively.

Therefore, the Air Accident Investigation Sector recommends that Etihad Airways reinforce among pilots the requirement of additional monitoring role to be assumed by the additional flight crew in the flight deck as per the Flight crew operating manual (FCOM).

### 4.3.2 GAL Air Navigation Services (GAL ANS)

#### SR52/2021

With regards to the no-reaction of MS warning events by the air traffic controllers, safety actions were taken by GAL ANS – OMAA Operations by issuing Supplementary Instruction (SI) 029-21 applicable to OMAA Tower Control, and SI 027-21 applicable to OMAA Approach Control. Both Supplement Instructions contained instructions on how to deal with instances in which an “MS” is activated while an aircraft is executing an approach into OMAA and established on final.

However, in order to have a standard and solid system of an MS warning event, it is recommended that GAL ANS consider the practicability to include the contents of both Supplementary Instructions in the *Air Traffic Services Operating Manual* as SOPs for its air traffic controllers.

### 4.3.3 The General Civil Aviation Authority of the United Arab Emirates (GCAA)

#### SR53/2021

The flight crews' lack of appreciation of the occurrence severity, precluded them from reporting this to the necessary personnel in the Operator's organization, and therefore, the Operator could not take the necessary steps to secure the cockpit voice recorder (CVR) earlier. This precluded the capturing of the CVR data prior to being overwritten.

Therefore, the AAIS recommends that GCAA consider the practicability to implement the requirement of 25 hours CVR recording capability for new aircraft with maximum certificated take-off mass (MCTOM) of more than 27,000 kg with its certificate of airworthiness issuance on or after 1 January 2022. It is further recommended to consider having a retrofit program within a certain period for upgrading to a 25 hour CVR recording capability for aircraft registered in the United Arab Emirates with MCTOM of more than 27,000 kg with the certificate of airworthiness issuance date before 1 January 2022.



## Appendix 1. OMAA D-ATIS 'I' (Aircraft Communications Addressing and Reporting System (ACARS) Uplink)

The flight crew sourced a digital ATIS information for OMAA that was uplinked at 0902 as shown below:

0902Z	D-ATIS uplinked	/AUHABYA.TI2/OMAA ARR ATIS I 0858Z / LDG 31L WIND 300 06 KT / WIND DIR 260 V 340 CAVOK T 41 / DP 23 QNH 0999 NOSIG MINIMIZE RWY OCCUPANCY TIMES ACFT OPERATORS SHOULD ENSURE THAT MODE S TRANSPONDERS ARE ABLE TO OPERATE WHEN THE ACFT IS ON GND EXP ARNAV YANKEE APCH PILOTS UNABLE TO COMPLY SHALL ADZ ATC ON FIRST CONTACT AND CAN EXP ILS APCH ON FIRST CONTACT STATE AC TYPE RECEIVING INFO I 5D14
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## Appendix 2. Operator's Procedure Revision

The Operator amended the SOPs for RNP AR operations of B787 aircraft, as shown in a red highlighted block.

RNAV APPROACH GUIDE	Boeing 787 QRH Supplementary
VOR/DME NAV on POS REF page 3 .....	OFF
CHART MIN TEMP vs. REPORTED TEMP .....	CHECK
CHART MAX WIND vs. REPORTED WIND (if applicable) .....	CHECK
MAX IAS for RF LEGS (if applicable) .....	REVIEW
Refer to Appendix A -Maximum TAS function of the turn radius R.	
CHART G/P vs FMC G/P .....	VERIFY
<b>Note: Crew to confirm QNH by IAF.</b>	
<b>Note:</b> Note: For more details, refer to FCOM SP.4.5 Chapter "Instrument Approach – RNAV (RNP) AR".	
<b>Note:</b> Direct-To modifications are not permitted when:	
- the fix is the beginning of an RF leg.	
- the fix is the Final Approach Fix (FAF) for the procedure.	
<b>AT OR BEFORE IAF</b>	
GPS on ND (FMC position update status) .....	CHECK
Both GPS on POS 4/4 page .....	CHECK
LRNP 0.3 or charted RNP for RNAV (RNP) procedure .....	VERIFY
Ensure LRNP 0.3 is displayed on ND (Do not manually insert).	
VSD .....	ON
<b>PRIOR TO FAF OR RADAR VECTOR TO FINAL APPROACH COURSE</b>	
VRNP 125 .....	VERIFY
Verify vertical RNP 125 is displayed on ND before reaching FAF.	
<b>Note:</b> The use of VRNP 125 will cause the NPS amber deviation exceedance alert to occur at 75 feet or slightly less.	
XTK and VTK ERROR .....	MONITOR
Monitor flight path. Appropriate callout is required if either error exceeds ½ RNP.	

## Appendix 3. Training Programs Implemented After the Occurrence

The Operator has completed training programs relating to the event, as follows:

1. Incorrect altimeter setting events:
  - a. Identification of correct QNH and associated mitigations (presetting of QNH, 'Transition Level by ATC' threat, independent QNH sourcing)
    - i. AUH RNAV (RNP) Approach Guide Airbus & Boeing
    - ii. AUH RNAV (RNP) Approach Questionnaire
  - b. Distraction management e.g. high on profile, heading change/weather deviation approaching Transition Level (Workload Management "WLM")
    - i. Random exercises included in evidence-based training semester (EBT [Evidence-based training] SEM) B 2020 and SEM A 2020-2021
  - c. Escalation of communication strategies
    - i. Reviewed during 2020 H1 INMT's
2. Glideslope from above / VNAV from above:
  - a. Correct setting of MCP/FCU altitudes
    - i. Currently addressed in SRT for Airbus & Boeing
    - ii. Currently addressed AUH RNAV (RNP) Briefing Airbus & Boeing
    - iii. Currently addressed AUH RNAV (RNP) Questionnaire Airbus & Boeing
  - b. Observance of maximum rate of descents (RODs) per company policy
    - i. Currently addressed AUH RNAV (RNP) Briefing Airbus & Boeing
  - c. Setting of missed approach point (MAP) altitude for go-around (G/A) (Boeing)
    - i. Currently addressed AUH RNAV (RNP) Briefing Airbus & Boeing
    - ii. EBT SEM B 2020 – April 2020