الهيئة العامة للطيران المدني
GENERAL CIVIL AVIATION AUTHORITY

United Arab Emirates

Air Accident Investigation Sector

Serious Incident

- Final Report -

AAIS Case No. AIFN/0022/2012

Pilot Incapacitation

Operator: Etihad Airways
Type: Airbus A320-232
Registration: A6-EII
Location: Abu Dhabi
State of Occurrence: United Arab Emirates
Date of Occurrence: 16 November 2012

Incident Brief

GCAA AAI Report No.:	AIFN/0022/2012
Operator:	Etihad Airways
Aircraft Type and Registration:	Airbus A320-232, A6-EII
MSN	3713
No. and Type of Engines:	Two (2), IAE V2527-A5, Turbofan Engines
Date and Time (UTC):	16 November 2012, 2042 UTC
Location:	9.5 Nautical miles South East of Abu Dhabi International Airport
Type of Flight:	Passenger Transport
Persons Onboard:	76 persons (2 flight crewmembers, 4 cabin crew and 70 passengers)
Injuries:	None

Investigation Objective

This Investigation considers the aspects related to the incapacitated pilot and the related regulations.

This Investigation is performed pursuant to the UAE Federal Act No 20 of 1991, promulgating the Civil Aviation Law, Chapter VII, Aircraft Accidents, Article 48. The Investigation is in compliance with the UAE Civil Aviation Regulations, Part VI, Chapter 3, in conformity with *Annex 13 to the Convention on International Civil Aviation,* and in adherence to the *Air Accidents and Incidents Investigation Manual*.

The sole objective of this Investigation is to prevent aircraft accidents and incidents. It is not the purpose of this activity to apportion blame or liability.

Investigation Process

The occurrence involved an Airbus A320-232 passenger transport Aircraft, registration A6-EII, and was notified to the General Civil Aviation Authority (GCAA) Duty Investigator (DI) by phone call to the Hotline Number +971 50 641 4667. The notification call was on 17 November 2012 at 0100 Local Time.

After the Initial/On-Site Investigation phase, the occurrence was classified as a 'Serious Incident'.

An Investigation Team was formed in line with the International Civil Aviation Organization (ICAO) Annex 13 obligations of the United Arab Emirates (UAE) being the State of Occurrence.

ICAO, and the State of Design and Manufacture (France) Bureau d'Enquêtes et d'Analyses (BEA), were notified in line with the ICAO Annex 13 obligations. The BEA assigned Accredited Representatives to the Investigation.

The scope of this Investigation is limited to the events leading to the occurrence; no in-depth analysis of non-contributing factors was undertaken.

Notes:

1 Whenever the following words are mentioned in this Report with the first letter Capitalized, it shall mean:

- (Aircraft) - the aircraft involved in this Serious Incident.
- (Investigation) - the investigation into this Serious Incident
- (Incident) - this investigated Serious Incident
- (Report) - this Serious Incident Report

2 Unless otherwise mentioned, all times in this Report are Coordinated Universal Time (UTC), (UAE Local Time minus 4).

3 In this Report, the words:

- 'Cockpit' and 'Flight Deck' are synonymous.
- 'Captain' and 'Commander' are synonymous.

4 Photos used in the text of this Report are taken from different sources and are adjusted from the original for the sole purpose to improve 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 and Definitions

AAIS	Air Accident Investigation Sector
APS	Antiphospholipid Antibody Syndrome (*Medical term*)
ASDA	Accelerate-Stop Distance Available
ATC	Air Traffic Control
A/THR	Autothrust
ATPL	Air Transport Pilot License
BEA	Bureau d'Enquêtes et d'Analyses
CAA	Civil Aviation Authority
CAPS	Catastrophic Antiphospholipid Syndrome (*Medical term*)
CAR	UAE Civil Aviation Regulation
CAR-OPS	UAE Civil Aviation Regulation – Flight Operation
CAT	Category
CAT	Computerized Axial Topography (*Medical term*)
CAVOK	Cloud and Visibility Okay
CBC	Complete Blood Count (*Medical term*)
CG	Center of Gravity
CM	Cabin Manager
CoA	Certificate of Airworthiness
CoR	Certificate of Registration
CRM	Crew Resource Management
CT	Computerized Topography (*Medical term*)
CVR	Cockpit Voice Recorder
CWY	Clearway
DI	Duty Investigator
DVT	Deep Vein Thrombosis (*Medical term*)
ECG/EKG	Electrocardiogram (*Medical term*)
ELP	English Language Proficiency
FAA	United States Federal Aviation Administration
FD	Flight Director
FDR	Flight Data Recorder
GCAA	UAE General Civil Aviation Authority
GI	Gastrointestinal (*Medical term*)

HDG	Heading
ICAO	International Civil Aviation Organization
IAE	International Aero Engines
IFR	Instrument Flight Rules
ILS	Instrument Landing System
INR	International Normalised Ratio
JAR	Joint Aviation Requirements
KPI	Key Performance Indicator
KT	Knots
L	Left
LDA	Landing Distance Available
LH	Left hand
LOC	Loss of Consciousness (*Medical term*)
LT	Local Time
M	Meters
mb	millibars
M/E	Multi Engines
MHz	Mega Hertz
MOR	Mandatory Occurrence Reports
MRI	Magnetic Resonance Imaging (*Medical term*)
MSN	Manufacturer Serial Number
No.	Number
NOC	Network Operations Centre
NOSIG	No Significant Change
OK	all correct
P2	Co-pilot
PA	Passengers Address
PE	Pulmonary embolism (*Medical term*)
PF	Pilot Flying
PIC	Pilot in Command
PM	Pilot Monitoring
Q/QNH	Barometric pressure adjusted to sea level
R1	Right forward door
RH	Right hand

SARP	Standards and Recommended Practices
SEP	Safety & Emergency Procedures
SN	Serial Number
SSP	State Safety Programme
SWY	Stopway
SOP	Standard Operating Procedure(s)
TODA	Take-Off Distance Available
TORA	Take-Off Run Available
TSN	Time Since New
UAE	The United Arab Emirates
UK	The United Kingdom
U.S	The United States
UTC	Co-ordinated Universal Time
VFR	Visual Flight Rules
VHF	Very High Frequency
VOR	Very High Frequency Omnidirectional Range (Navigation System)

Synopsis

On 16 November 2012, at approximately 2042 UTC, the co-pilot of Airbus A320-232, registration mark A6-EII, operating a scheduled passenger flight, number ETD308, inbound from Kuwait International Airport, contacted Abu Dhabi International Airport Approach Controller requesting approach instructions. The captain was the pilot flying (PF) and the co-pilot was the pilot monitoring (PM).

While the Aircraft was approaching Abu Dhabi International Airport and maintaining 2,400 feet altitude at approximately 7.1 nautical miles south of the Airport, the captain said something to the co-pilot in an unusual tone of voice compared to the previous flight deck conversations. The captain continued attempting to speak but his speech was incoherent. Then the co-pilot observed that the captain was slumped in his seat and was leaning to his left. The co-pilot attempted to awaken the captain several times, but with no response. Consequently, he took over the control of the Aircraft.

The co-pilot informed Abu Dhabi Approach Controller about the incapacitation condition of the captain, and declared an emergency with the intention of landing the Aircraft as soon as possible. The co-pilot managed the cockpit efficiently after the captain's incapacitation and landed the Aircraft uneventfully.

After landing, the Aircraft was stopped on the runway since the pilot seated in the right hand seat was not authorized to taxi the Aircraft, as per the Operator's policy. The Aircraft was towed from the runway to the passenger terminal where the captain was the first person to disembark.

The captain was transported to the hospital for further checks and observation.

The GCAA preserved the cockpit voice recorder and the flight data recorder and they were brought to the Flight Recorder Laboratory at GCAA Headquarters in Abu Dhabi for playback and analysis.

The Investigation, conducted by the Air Accident Investigation Sector (AAIS) of the UAE General Civil Aviation Authority (GCAA), determines that the cause of the captain's incapacitation was an embolic event (stroke) that resulted in loss of consciousness.

The Investigation identifies the following contributory causal factors to the Serious Incident:

- The captain suffers from antiphospholipid (APS) syndrome disease which led to the embolic/stroke event;
- No additional information on the captain's medical history, except his hypertension, was made available to the medical examiner, so that no further medical treatment was prescribed to mitigate the possibility of an embolic event.
- The regulatory requirements current at the time of the incident did not enable the medical check to discover a specific syndrome or disease, and subsequently to reduce the possibility of a pilot incapacitation event by taking the necessary medication or therapy.

Six safety recommendations are included in this report. They are addressed to the Operator, and the GCAA.

CONTENTS

1. Factual Information

1.1 History of the Flight

On 16 November 2012, at approximately 2042 UTC, the co-pilot of Airbus A320-232, registration mark A6-EII, operating a scheduled passenger flight, number ETD308, inbound from Kuwait International Airport, contacted Abu Dhabi International Airport Approach Controller requesting approach instructions. The captain was the pilot flying (PF) and the co-pilot was the pilot monitoring (PM).

At 2042:14, while the Aircraft was approaching Abu Dhabi International Airport and maintaining 2,400 feet altitude at approximately 7.1 nautical miles south of the Airport, the captain said something to the co-pilot in an unusual tone of voice compared to the previous flight deck conversations recorded by the cockpit voice recorder (CVR).

Between 2042:52 and 2043:17, the captain attempted to speak but his speech was incoherent.

At 2043:32, the Approach Controller instructed ETD308 to turn left onto heading 040° and to continue descending to the Base Leg for runway 31L after the ASKIN waypoint[1]. The co-pilot read back the Controller's instruction correctly.

At 2043:37, the captain's side stick was touched momentarily.

Between 2043:38 and 2043:43, the co-pilot observed that the captain was slumped in his seat and was leaning to his left. The captain appeared to be making involuntary movements, was gasping for breath, and making unusual noises. The co-pilot attempted to awaken the captain several times but with no response.

At 2043:50, the autopilot was disengaged by the co-pilot who took over control of the Aircraft.

At 2044:04, the Approach Controller requested confirmation as to whether ETD308 was turning left onto heading 040° and the co-pilot replied: "Standby and still maintaining heading 125 due to pilot incapacitation."

At 2044:16, the co-pilot requested the cabin manager (CM) to come to the flight deck immediately.

At 2044:28, the Approach Controller instructed ETD308 to turn left heading 360°. At this time ETD308 declared a Mayday[2] due to pilot incapacitation.

At 2044:40, the CM entered the cockpit and she was told by the co-pilot that "*we have a pilot incapacitation*".

At 2044:41, the Approach Controller acknowledged the declared emergency, and requested ETD308 to turn left onto a heading of 360°. The Controller requested the emergency services to be on standby. The Controller asked the co-pilot for confirmation of the emergency and the co-pilot replied that the captain was incapacitated.

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[1] ASKIN is the last waypoint as RNAV Standard Arrival for AUH Runway 31L.

[2] Mayday is an expression, preferably spoken three times, used in the case of a distress: a condition of being threatened by serious and/or imminent danger and of requiring immediate assistance (as defined by Annex 10 to the Convention on International Civil Aviation, Volume II, Chapter 5, paragraph 5.3.1.1).

At 2045:09, the Controller contacted ETD308 to advise that there was no restriction on speed, and requesting ETD308 to continue turning left to heading 340°, and he provided clearance for an instrument landing system (ILS) approach to runway 31L. The co-pilot replied that he was not yet ready for the approach due to the possibility of an un-stabilized approach. The Controller proposed that ETD308 hold between 2,000 and 2,500 feet. The co-pilot acknowledged to the Controller that ETD308 was holding at 2,500 feet. Subsequently, the Controller cleared ETD308 to fly heading 360° and to route to the north of the airfield for holding until ready to commence the landing.

At 2045:46, the co-pilot contacted the Controller and informed him that the Aircraft was on heading 360° and was maintaining 2,500 feet. The co-pilot requested a long final for runway 31L which was approved by the Controller. The Controller requested to be advised on the distance to join the approach and he instructed ETD308 to make heading 040°. ETD308 read back the clearance correctly.

At 2046:40, the co-pilot contacted the Controller informing him that ETD308 was ready for the right turn. The message was not clearly received and the Controller asked ETD308 to repeat it. Later on, the Controller contacted ETD308 and asked "*You are not ready for the right turn?*". The co-pilot replied that ETD308 was ready for the right turn.

At 2046:55, the Controller contacted ETD308 asking whether the Aircraft was able to turn left into heading 280° for the intercept at about 8 miles and the co-pilot replied "*Negative*", indicating his preference to make a right turn onto a long final. The Controller approved the ETD308 request by advising direct to the SENSU waypoint and descent to 2,000 feet, which was read back by the co-pilot correctly.

At 2047:47, the co-pilot contacted the Controller to ask whether the Controller had copied the Mayday call and to request immediate assistance on landing due to pilot incapacitation. The Controller replied that the emergency situation was understood, the airport emergency service was on standby, and fire vehicles could be expected on landing. The Controller also informed ETD308 that traffic advice will be maintained throughout the ETD308 approach.

At 2048:14, the Controller contacted ETD308 requesting details on the incapacitated pilot: his age and his condition. The co-pilot replied that the incapacitated pilot was the captain and his condition was unknown. During that time, the CM and another cabin crewmember were taking care of the captain by supplying oxygen and ensuring the restraint on his seat.

At 2048:54, the co-pilot informed the Controller that the Aircraft was about to intercept the final approach to runway 31L, and the Controller cleared ETD308 for an immediate ILS approach. The co-pilot read back the clearance correctly, and informed the Controller that the Aircraft was established on the localizer.

At 2049:37, the Controller contacted ETD308 requesting information on persons onboard and fuel endurance. The co-pilot replied that the fuel onboard was 2,500 kilograms and asked to standby for the information pertinent to the persons onboard. The Controller acknowledged the information and confirmed the ILS approach. The Controller informed ETD308 that the Airport emergency services were on standby.

At 2050:33, the co-pilot requested one of the cabin crewmembers to ask through the passenger address if there was a doctor onboard the flight. Later on, the crewmember answered that there was no doctor onboard the flight.

At 2051:12, the co-pilot contacted the Controller to inform him that there were 76 persons onboard and to give the exact fuel onboard quantity. The Controller requested ETD308 to establish contact with Abu Dhabi Tower on 119.2 megahertz (MHz), and he again confirmed that the Airport emergency services were on standby. The co-pilot read back the frequency correctly.

At 2051:37, the co-pilot established contact with the Tower declaring a Mayday and that the Aircraft was on the localizer of runway 31L. The Tower informed ETD308 that the surface wind was 320°, 5 knots, and cleared ETD308 for landing. The co-pilot read back the clearance correctly.

At 2053:53, the co-pilot advised the Tower that the Aircraft could not be taxied after landing and would be stopped on the active runway[3], and that emergency assistance would be required. This was acknowledged by the Tower.

At 2055:49, the Aircraft landed uneventfully.

The flight path of the Aircraft is shown in Figure 1.

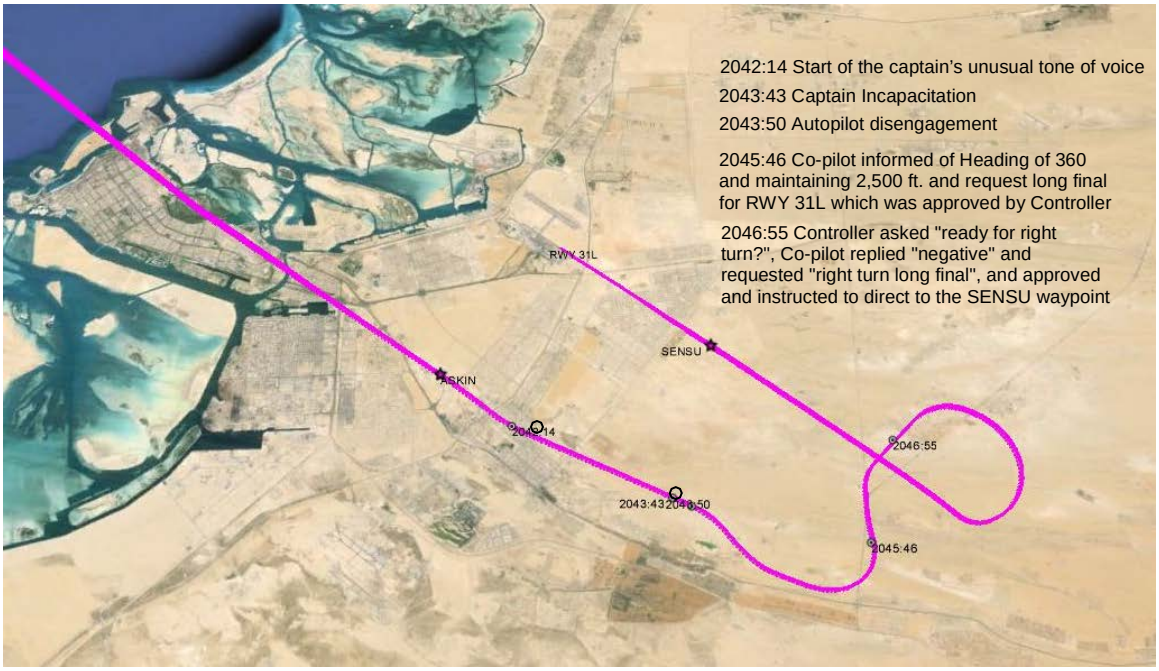

Figure 1. Flight Path

At 2056:10, the Tower requested confirmation as to whether the Aircraft had already completed the landing roll, and the co-pilot confirmed the landing roll completion and that the Aircraft had stopped on the runway.

At 2056:54, the Tower instructed ETD308 to establish contact with the Ground Controller (Ground) at 123.975 MHz which was read back correctly.

[3] As per the Operator's policy, the right hand seat pilot is not allowed to taxi the aircraft.

At 2057:09, the co-pilot established contact with Ground Control stating that the Aircraft was standing on the runway, advising of pilot incapacitation and requesting emergency assistance. Ground Control replied that the emergency services were notified and 5 vehicles were on their way to the Aircraft.

At 2057:26, the co-pilot informed Ground Control that the engines were shut down. Ground Control replied that arrangements were made to vacate the runway. ETD308 also requested a tow truck, and Ground Control replied that the request had already been processed.

At 2101:29, and while waiting for the emergency services, the co-pilot tried to talk to the captain by asking “Are you okay?”, at this time the captain had partially regained consciousness and appeared to be responsive and communicative.

Upon their arrival, about 30 minutes after the Aircraft landed, the paramedics arrived at the Aircraft and entered the flight deck in order to evaluate the captain’s condition. Thereafter at 2131:45, the Aircraft vacated the runway and was towed to the passenger terminal where the captain was the first person to disembark. The captain was transported to the hospital for further checks and observation.

1.2 Injuries to Persons

There were no injuries as a result of this incident (detailed in Table 1).

Table 1. Injuries to Persons

Injuries	Flight Crew	Cabin Crew	Other Crew Onboard	Passengers	Total Onboard	Others
Fatal	0	0	0	0	0	0
Serious	0	0	0	0	0	0
Minor	0	0	0	0	0	0
None	2	4	0	70	76	0
TOTAL	**2**	**4**	**0**	**70**	**76**	**0**

1.3 Damage to Aircraft

The Aircraft was undamaged.

1.4 Other Damage

There was no other damage to property or the environment.

1.5 Personnel Information

The flight crew was comprised of the captain and the co-pilot. Table 2 illustrates the qualifications of both.

Table 2. Qualifications of the flight crew

	Captain	Co-pilot
Gender	Male	Male

Date of Birth	29 August 1968	10 December 1954
UAE GCAA License Category and Rating	ATPL; M/E Land, A320, A330(P2), A340(P2)	ATPL; M/E Land, A320, A330(P2), A340(P2)
Class and Date of Last Medical	Class I (One); 12 July 2012	Class I (One); 30 November 2011
Flying Experience		
Total All Types	12,297.11 Hours	13,069.23 Hours
Total Command on All Types	4,930.57 Hours	2,500 Hours
Total on Type	332.57 Hours (as PIC)	84.55 Hours
Total last 28 Days	72.34 Hours	35.27 Hours
Total last 24 Hours	05.50 Hours	05.50 Hours
English Language Proficiency (ELP)	Level 6	Level 4

1.6 Aircraft Information

Table 3 shows general information about the Aircraft, and Figure 2 shows the 3-view drawing of the Aircraft.

Table 3. General Aircraft Information

Table 3. General Aircraft Information	
Make and Model:	Airbus A320-232
Manufacturer Serial Number (MSN):	3713
Manufacturing Year	November 2008
State of Registry:	United Arab Emirates
Registration:	A6-EII
Certificate of Airworthiness (CoA)	
Issuing Authority:	General Civil Aviation Authority (GCAA), United Arab Emirates
Issuance date:	12 December 2008
Valid until:	21 November 2012
Certificate of Registration (CoR)	
Issuing Authority:	General Civil Aviation Authority (GCAA), United Arab Emirates
Issue Date:	12 December 2008
Maximum Take Off Weight (MTOW):	77,000 Kg
Maximum Landing Weight (MLW):	66,000 Kg
Engines:	Two High-bypass Turbofan, International Aero Engines (IAE), V2527-A5

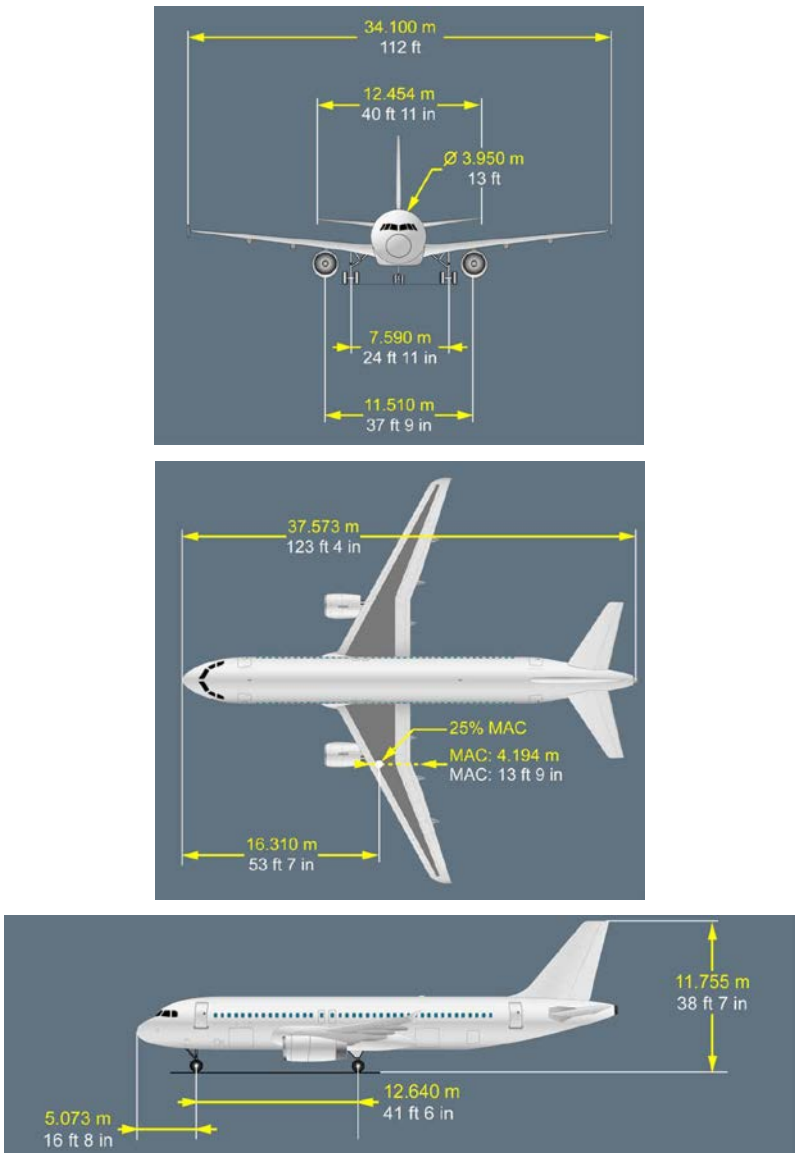

Figure 2. 3-View Drawing

No discrepancies were recorded on the Aircraft before the Incident.

1.7 Meteorological Information

Table 4 shows the METAR/actual weather for Abu Dhabi International Airport on 16 November 2012, over the period from 2000 to 2100 UTC.

Table 4. METAR for Abu Dhabi International Airport on 16 November 2012

METAR[4] OMAA 162100Z 30004KT CAVOK 25/20 Q1017 A3005[5] NOSIG=[6]
METAR OMAA 162000Z 31005KT 280V350 CAVOK 26/20 Q1018 A3006 NOSIG=

The above mentioned METAR description is as given in Table 5.

Table 5. Description of the METAR

	2000 UTC	2100 UTC
Wind	310°/05kts, direction varying between 280^0 and 350^0	300°/04kts
Visibility	More than 10 km	More than 10 km
Clouds	No Cloud	No Cloud
OAT	26°C	25°C
Dew Point	20°C	20°C
Pressure (Altimeter)	1018mb (30.06 inches Hg)	1017mb (30.05 inches Hg)
Condition	No Significant Weather	No Significant Weather

The prevailing meteorological conditions were not a factor in this Incident.

1.8 Aids to Navigation

Aids to navigation were not a factor in this Incident. The Aircraft performed Abu Dhabi Standard Approach for runway 31L and the ILS was functioning.

[4] METAR is a format for reporting weather information (Aviation Routine Weather Report)

[5] the altimeter setting is 30.05 inHg (1,017.6 hPa)

[6] NOSIG means that no significant change is expected to the reported conditions within the next 2 hours

1.9 Communications

All communications between the Aircraft and Abu Dhabi Approach on 124.400 MHz, Abu Dhabi Tower on 119.200 MHz, and Abu Dhabi Ground on 123.975 MHz, were clear.

1.10 Aerodrome Information

Abu Dhabi International Airport, ICAO code OMAA, coordinates 242559N 0543904E, is located 30.6 kilometers east of Abu Dhabi, the UAE. The airport elevation is 88 ft.

The airport has two asphalt runways: 13R/31L and 13L/31R, both with lengths of 4,100 meters.

RWY 31L is equipped with an ICAO CAT II/III[7] precision approach lighting system 900 M CL strobe and Flashing RTIL. The Runway centreline lighting is bi - directional with 15 meters spacing, white color coded in the first 3200 m, white/red ALTN for the next 600 m and red LIH for the last 300 m. The RWY edge lighting is bi-directional with LIL omni-directional component white LIH.

At the time of the Incident, the northern runway (31R/13L) was closed, and other aircraft had requested the use of runway 31R for landing. Abu Dhabi Approach informed the other aircraft that the northern runway was expected to be opened but there would be a short delay due to inspection of the runway.

1.11 Flight Recorders

The Aircraft was equipped with a flight data recorder (FDR) and cockpit voice recorder (CVR) as described below:

- **CVR**

  Type: Honeywell
  Part Number: 980-6022-001
  Serial Number: CVR120-05570

- **FDR**

  Type: L-3 Comm

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[7] *Category II (CAT II) operation* is a precision instrument approach and landing with:
a) a decision height lower than 60 m (200 ft), but not lower than 30 m (100 ft); and
b) a runway visual range not less than 300 m.

CAT III consists of:
- *Category IIIA (CAT IIIA) operation* is a precision instrument approach and landing with:
  a) a decision height lower than 30 m (100 ft) or no decision height; and
  b) a runway visual range not less than 175 m.
- *Category IIIB (CAT IIIB) operation* is a precision instrument approach and landing with:
  a) a decision height lower than 15 m (50 ft), or no decision height; and
  b) a runway visual range less than 175 m but not less than 50 m.
- *Category IIIC (CAT IIIC) operation* is a precision instrument approach and landing with no decision height and no runway visual range limitations.

Part Number: 2100-4043-02
Serial Number : 000620790

The CVR and FDR were removed to the Flight Recorder Laboratory at the GCAA Headquarters for downloading and readout. The Investigation retrieved useful information from both recorders.

The following read-out is the summary during the Incident, and the related parameters of the flight are shown in Figure 3.

The FDR parameters showed that the initial condition before the Incident as follows:

- Indicated Airspeed = 210 knots
- Gross Weight = 55,266 kgs
- Center of Gravity (CG) = 29.1%
- Autopilot 1 engaged in HDG mode, CAT 3 Single[8]
- Both Flight Directors (FDs) engaged
- Autothrust (A/THR) Engaged
- Slats / Flats configuration: Clean (00/00)

At 2043:37, the captain's side stick was touched momentarily.

At 2043:41, the left rudder pedal was momentarily pushed, and thereafter the right rudder pedal was pushed gradually up to approximately 14 degrees over the course of 8 seconds, then the right rudder pedal was maintained at about 14±1 degrees for about 18 seconds (until 2044:08). Subsequently, the Aircraft slipped to the right up to approximately 10 degrees.

At 2043:50, Autopilot 1 was disengaged by the co-pilot while the Aircraft was side slipping and he took over control of the Aircraft.

At 2043:56, Autopilot 2 was engaged and then disengaged again at 2044:03 by the co-pilot when the right rudder pedal input was still at approximately 14 degrees. The maximum lateral acceleration reached approximately 0.26 g during the side slip.

At 2044:08, the right rudder pedal input started to decrease, and returned to the neutral position at 2044:19.

At 2044:23, Autopilot 1 was engaged, but it disengaged automatically at 2044:33. At 2044:47, Autopilot 1 was re-engaged by the co-pilot.

At 2049:04, Autopilot 2 was engaged before the localizer was captured.

Thereafter, the co-pilot landed the Aircraft without any issue.

[8] When CAT 3 SINGLE is displayed, the Aircraft is able to perform a CAT III ILS approach and autoland with a minimum decision height of 50ft. as given in Limitations Section, Auto Flight System, Flight Guidance System, of the Aircraft Flight Manual (AFM).

Figure 3. Flight Parameters

1.12 Wreckage and Impact Information

The Aircraft was intact.

1.13 Medical and Pathological Information

Before the flight, the captain's observed demeanour was normal. During the flight, the captain did not indicate that he had physiological issues before he started uttering words in an unusual tone of voice.

The co-pilot noticed that the captain had suffered a sudden loss of consciousness. The co-pilot observed that the captain was slumped in his seat and leaning to his left. The captain made involuntary mild twitching movements, gasped for breath with his tongue out on one side, and made unusual noises. Subsequently, the co-pilot called the captain a few times and received no response.

The captain leant back towards his left shoulder. His eyes were closed, and both arms rested on his lap. His legs may have been in contact with his rudder pedals, since there was evidence of rudder pedal inputs.

The captain was in an unconsciousness state for about twenty minutes with no signs of crying, vocalizing, discoloured skin, tongue biting, urinary incontinence, or vomiting.

After regaining consciousness, the captain asked questions that indicated that he could not remember what had happened to him. He thought that he was in a sleep and he was wondering of why he was not woken up. At that time, the Aircraft was already on the runway and the captain offered to taxi the Aircraft, but the co-pilot preferred to tow the Aircraft.

Following the captain's recovery from unconsciousness he exhibited no abnormal indications, except headache and pain in the lower back, similar to muscular pain.

There was no evidence that the captain had experienced food poisoning.

Computerized topography (CT)[9] and magnetic resonance imaging (MRI)[10] scans were performed after the captain was transferred to the hospital. The result of the scans revealed that the left cerebellum[11] was intact, and the left occipital lobe[12] infracted.

Further tests including MRI angiogram[13] and MRI angiography[14] were performed. The result of the tests showed small infracts on cerebellum, and that the left occipital lobe was clear from occlusions.

The regions of the human brain are shown in Figure 4.

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[9] Computerized axial topography — also called CT or CAT scans, are special X-ray tests that produce cross-sectional images of the body using X-rays and a computer. A head or brain CT is used to evaluate the various structures of the brain to look for a mass, stroke, area of bleeding, or blood vessel abnormality. It is also sometimes used to look at the skull. (http://www.emedicinehealth.com/ct_scan/article_em.htm).

[10] An MRI is similar to a computerized topography (CT) scanner in that it produces cross-sectional images of the body. Looking at images of the body in cross section can be compared to looking at the inside of a loaf of bread by slicing it. Unlike a CT scan, MRI does not use X-rays. Instead, it uses a strong magnetic field and radio waves to produce very clear and detailed computerized images of the inside of the body. MRI is commonly used to examine the brain, spine, joints, abdomen, and pelvis (http://www.emedicinehealth.com/ct_scan/article_em.htm).

[11] The cerebellum processes input from other areas of the brain, spinal cord and sensory receptors to provide precise timing for coordinated, smooth movements of the skeletal muscular system. A stroke affecting the cerebellum may cause dizziness, nausea, balance and coordination problems. Ref: (http://www.nlm.nih.gov/medlineplus/ency/)

[12] The occipital lobe houses the primary visual cortices. These are the portions of the cerebrum that receive visual information from the eyes and the optic nerve and organize it into images that the brain can recognize. This includes the ability to determine spatial organization (like a 3-dimensional map) of the objects in the visual field. The primary cortex, then, is necessary for the interpretation of vision for the purposes of cognitive (mental) awareness. Since the brain is divided into halves, the left and right halves of the occipital lobe each have a primary visual cortex. (Ref: http://education-portal.com/academy/lesson/occipital-lobe-definition-location-function.html)

[13] A magnetic resonance angiogram (MRA) is a type of magnetic resonance imaging (MRI) scan that uses a magnetic field and pulses of radio wave energy to provide pictures of blood vessels inside the body.

[14] A special kind of MRI exam, called magnetic resonance angiography (MRA), examines the blood vessels. (Ref: http://www.emedicinehealth.com/ct_scan/article_em.htm).

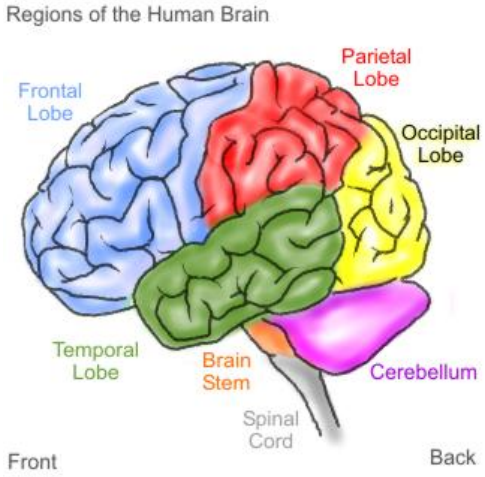

Figure 4. Human Brain

A doppler scan[15] was performed, and provided a negative result.

Cardiological evaluation, which consisted of Electrocardiogram (ECG)[16], stress test[17], echo evaluation[18], and transesophageal echodiagram evaluation[19], was performed. The results of these tests were all clear and normal.

Further extensive blood test was performed, and it showed an elevated complete blood count (CBC)[20].

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[15] This Doppler scan test uses ultrasound to look at the blood flow in the large arteries and veins. This test is done as the first step to look at arteries and veins, and to help diagnosing blood clot. (Ref: http://www.nlm.nih.gov/medlineplus/)

[16] An electrocardiogram (ECG or EKG) is a graphic record of the electrical activity of the heart as it contracts and rests. Electrodes attached to the skin of the legs, arms and chest record information about the body. It can be used to diagnose heart conditions such as valve disorders, arrhythmias and heart attack. (Ref: http://www.progresswest.org/Services/)

[17] A stress test can be used to test for heart disease. Stress tests are tests performed by a doctor and/or trained technician to determine the amount of stress that the heart can manage before developing either an abnormal rhythm or evidence of ischemia (not enough blood flow to the heart muscle). The most commonly performed stress test is the exercise stress test. The exercise stress test -- also called a stress test, exercise electrocardiogram, treadmill test, graded exercise test, or stress ECG -- is used to provide information about how the heart responds to exertion. It usually involves walking on a treadmill or pedaling a stationary bike at increasing levels of difficulty, while the electrocardiogram, heart rate, and blood pressure are monitored. (Ref: http://www.webmd.com/heart-disease/guide/stress-test)

[18] An echocardiogram is a test that uses sound waves to create pictures of the heart. The picture is more detailed than a standard x-ray image. An echocardiogram allows doctors to see the heart beating. It also shows the heart valves and other structures. (Ref: http://www.nlm.nih.gov/medlineplus/)

[19] A transesophageal echocardiogram (TEE) is a diagnostic procedure that uses echocardiography to assess the heart's function. Echocardiography is a procedure used to assess the heart's function and structures. During the procedure, a transducer (like a microphone) sends out ultrasonic sound waves at a frequency too high to be heard. When the transducer is placed at certain locations and angles, the ultrasonic sound waves move through the skin and other body tissues to the heart tissues, where the waves bounce or "echo" off of the heart structures. The transducer picks up the reflected waves and sends them to a computer. The computer displays the echoes as images of the heart walls and valves.

[20] A complete blood count (CBC) is a blood test used to evaluate a person overall health and detect a wide range of disorders, including anemia, infection and leukemia.

A complete blood count test measures several components and features of the blood, including:

- Red blood cells, which carry oxygen
- White blood cells, which fight infection

Keppra[21] was administered to the captain in order to inhibit the spread of seizure[22] activity in the brain.

Warfarin was given to him in order to prevent further blood clots. International Normalised Ratio (INR[23]) self-monitoring was given in order to adjust the warfarin doses.

Two years before the Incident, the captain was diagnosed with hypertension. Accordingly, hypertension medication was prescribed for him. He declared his medical history of hypertension, and that he had been prescribed medication to control the condition. He provided this information during his license renewal application in July 2012.

One year after the Incident, the captain had suffered no further episode, or loss of consciousness, or seizers. The continuous monitoring of blood clotting by using INR indicated that the captain's condition was stable.

The thorough medical investigation concluded that the captain was diagnosed with antiphospholipid syndrome (see Paragraph 1.18.4 for the details of the syndrome), which caused an embolic[24] event (stroke) that caused him to lose consciousness.

1.14 Fire

There was no evidence of fire.

1.15 Survival Aspects

When the cabin manager entered the flight deck, she noticed that the captain was immobile and unresponsive. Therefore, she moved his body to up-right position, pulled his seat fully aft, removed his hands from the controls, and called the R1 cabin crewmember[25] for assistance. Both cabin crewmembers tied the captain's arms, and kept his legs away from the controls and the flight instrument panel, and ascertained that the shoulder harness was fitted and locked.

The CM exited the flight deck, picked up the oxygen bottle located in business class, and returned to the flight deck. She fitted the oxygen mask over the captain's

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- Hemoglobin, the oxygen-carrying protein in red blood cells
- Hematocrit, the proportion of red blood cells to the fluid component, or plasma, in the blood
- Platelets, which help with blood clotting

Abnormal increases or decreases in cell counts as revealed in a complete blood count may indicate that the person has an underlying medical condition that calls for further evaluation. (Ref: http://www.mayoclinic.org/tests-procedures/complete-blood-count/basics/definition/prc-20014088)

[21] Keppra (levetiracetam) is an anti-epileptic drug, and is used to treat partial onset seizures in adults and children who are at least 1 month old. (Ref: http://www.drugs.com/keppra.html)

[22] A seizure is a sudden surge of electrical activity in the brain. A seizure usually affects how a person appears or acts for a short time. Many different things can occur during a seizure. Whatever the brain and body can do normally, can also occur during a seizure. (http://www.epilepsy.com/learn/epilepsy-101/what-epilepsy)

[23] The INR is a test of blood clotting, which is primarily used to monitor warfarin therapy, where the aim is to maintain an elevated INR in a certain range eg, 2.0 to 3.0. It is initially checked frequently, but as treatment is stabilized it may be done less often, eg fortnightly. Changes in the warfarin dose take several days to affect the INR result. (Ref: http://healthengine.com.au/info/INR_Test)

[24] An embolic stroke occurs when a blood clot that forms elsewhere in the body (embolus) breaks loose and travels to the brain via the bloodstream. Eventually, the clot lodges in a blood vessel and blocks the flow of blood, causing a stroke. (Ref: http://www.healthline.com/health-slideshow/embolic-stroke-symptoms)

[25] R1 cabin crew is the cabin crewmember who is allocated near the right side front door of the Aircraft.

mouth and nose and continued monitoring the captain's breath since he tried more than once time to remove the mask. It took two cabin crew members to manage the captain during his incapacitation, the CM for restraint and the R1 cabin crew member for providing oxygen.

The co-pilot requested one of the cabin crewmembers to ask through the passengers address (PA) if a doctor was onboard. The R1 cabin crewmember made a PA in Arabic and English, however, there was no doctor onboard.

During the landing, the CM and R1 cabin crewmembers remained in the cockpit monitoring the captain's condition.

The Airport Emergency Plan was activated once the Mayday was declared by the crew.

After the Aircraft landed and stopped on the runway, Abu Dhabi Airport Airfield Rescue and Fire Fighting Services responded immediately. The first aid emergency unit responded by providing onboard first aid to the incapacitated captain and thereafter brought the captain to the First Aid Emergency Medical Center at the Airport. Although no action was required from the rescue and firefighting services, they were continuously present to monitor and standby as a precaution until the Aircraft was towed off the runway. The captain was transported to the hospital for intensive medical checks.

1.16 Tests and Research

No testing or research was required to be conducted as a result of this Incident.

1.17 Organisational and Management Information

1.17.1 The Operator's *Operations Manual, Part A*

For a Pilot Incapacitation event, the Operator's *Operations Manual, Part A*, contains the following procedure:

> **"1.4.2.1 Duties and Responsibilities of Co-Pilot**
>
> Specific Responsibilities under point 6:
>
> Specifically the co-pilot is responsible for in the event of Commander Incapacitation, the highest ranking Co-pilot assigned to the flight shall assume command.
>
> **4.3 Flight Crew Incapacitation**
>
> Refer to Chain of Command (Chapter 1.3) for succession of command in the event of incapacitation of the Commander. In the event of incapacitation of the Commander, the other pilot assumes authority over all persons on board the aircraft until such time a normal chain of command can be re-established. In such event, NOC[26] shall be notified as soon as possible.
>
> The autopilot shall be used to its full capacity to reduce workload and to ensure the safe outcome of the flight.

[26] Network Operations Centre (NOC) is the 24hours designated control centre for Operator's global operations and is resourced to ensure the daily supervision and management of the flight operation, including aircrew.

8.3.15.1.3 Action to be Taken in Case of Incapacitation

Once a subtle or an obvious incapacitation is identified:

- Other pilot in control to immediately make Emergency Alert PA "Cabin Manger to the cockpit immediately"
- Take over control
- Engage the auto-pilot whenever practicable
- Check the position of essential controls and switches
- Concentrate on flying the aeroplane especially during critical phases of flight
- Inform ATC
- Declare emergency if required
- Give NITS[27] briefing to Cabin Manager or Deputy as per SEP manual
- Arrange a landing as soon as possible
- Summon help from cabin crew to take care of the incapacitated flight crew member
- Reorganize the flight deck work
- Distribute the workload among the remaining flight crew
- Do not press for a hasty approach
- Perform checklist earlier than normal
- Achieve landing configuration earlier than normal

Assisting cabin crew member(s) should:

- Pull the incapacitated pilot back to his seat and fit the shoulder harness
- Place hands across the chest through the shoulder harnesses
- Push the seat completely AFT and fully recline the seatback
- Pull the incapacitated pilot out, without touching any controls or switches, if not possible, remain in the cockpit and provide first aid/oxygen, if required
- Assist the other pilot as directed

Note: The shoulder harnesses should be locked if the incapacitated pilot has to be left unattended in his seat (e.g. assisting cabin crew seeking support).

The CM shall make a PA for a medically qualified passenger and after liaising with the remaining flight crew member will discreetly check if type qualified pilot is on board to replace the incapacitated crew."

1.17.2 The Operator's *Safety and Emergency Manual*

In case of pilot Incapacitation, the Operator's *Safety and Emergency Manual* contains the following procedures:

" 8.2.1 Pilot Incapacitation

In case of incapacitation of a flight crew member inflight, the other pilot in control will make an emergency PA "Cabin Manager to the Cockpit immediately" and give NITS briefing to the CM or deputy.

Assisting cabin crew to take care of the incapacitated flight crew member as follows:

[27] N : Nature of emergency
I: Intention of the captain (ground evacuation / ditching)
T: Time available to brief the passengers and prepare the cabin
S: Specific Instructions (if any)

	PILOT INCAPACITATION DRILL	
PULL	.....	PILOT BACK
FASTEN	.....	SHOULDER HARNESS
MOVE	.....	SEAT AFT AND RECLINE
PULL	.....	LEGS AWAY FROM CONTROLS
ADMINISTER	.....	FIRST AID*
ASSIST	.....	OTHER PILOT

*Ideally out of the flight deck without touching controls/switches

Note: Before fastening shoulder harness, the pilot's arms are to be folded across the chest to restrict movement

The CM shall make a PA for a medically qualified passenger and, after liaising with the remaining flight crew member, discreetly check if a type qualified pilot is onboard to replace the incapacitated crew member."

1.18 Additional Information

1.18.1 UAE National Standards of Licences and Ratings for Pilots

Part II of the UAE Civil Aviation Regulations – *Licensing Regulations*, prescribes the requirements for licensing and rating certification.

The requirements for issuing class and type ratings for pilots as given in the UAE *CAR Part II, Chapter 2 – Licences and Ratings-Pilots,* are as the following:

> **"2.1.5 Requirements for the Issue of Class and Type Ratings**
>
> When applying for a class or type rating, the holder of a pilot's licence shall meet the following requirements in a manner determined by the GCAA:
>
> (b) Type rating as required by paragraph 2.1.3.2 above, the applicant shall have:
>
> (1) gained under appropriate supervision, experience in the applicable type of aircraft and/or flight simulator in the following:
>
> - procedures for crew incapacitation and crew co-ordination including allocation of pilot tasks; crew co-ordination and use of checklist; and,
>
> (2) demonstrated the skill and knowledge required for the safe operation of the applicable type of aircraft, relevant to the duties of pilot-in command.

2.5.5 Skill

(a) The applicant shall have demonstrated the ability to perform, as pilot-in-command of an aircraft within the appropriate category required to be operated with a co-pilot, the following manoeuvres:

(5) procedures for crew incapacitation and crew co-ordination, including allocation of pilot tasks, crew co-operation and use of checklists.

(b) The applicant shall have demonstrated the ability to perform the procedures and manoeuvres described in sub-paragraph (a) above, with a degree of competency appropriate to the privileges granted to the holder of an airline transport pilot licence - aeroplane, and to:

(7) understand and apply crew co-ordination and incapacitation procedures;"

1.18.2 UAE National Standards of Medical Assessment and Fitness

At the time of the Incident, the physical and mental requirements for Class 1 medical assessment regarding the Electrocardiography as given in the UAE CAR Part II, Chapter 5 – *Medical Provisions for Licensing,* as following:

"5.4 Class 1 Medical Assessment

5.4.2 Physical and Mental Requirements

5.4.2.6 Electrocardiography[28] shall form part of the heart examination for the first issue of a Medical Assessment.

5.4.2.6.1 Electrocardiography shall be included in re-examinations of applicants every 5 years until age 30, every 2 years until age 40, annually until age 60, and every 6 months thereafter and on clinical indication."

Based on international best practice, revision in the Class 1 Medical Assessment regarding the Electrocardiography has been applied in February 2015, by adding following clauses:

"5.4.2 Physical and Mental Requirements

5.4.2.6.2 Extended cardiovascular assessment shall be required when clinically indicated.

5.4.2.6.3 For a Class 1 medical certificate, an extended cardiovascular assessment shall be completed at the first revalidation of renewal examination at the age 60 and every year thereafter.

5.4.2.6.4 For a Class 1 medical certificate, estimation of serum lipids, including cholesterol, shall be required at the examination for the first issue of

[28] Electrocardiography is a diagnostic method of examining the electrical impulses through the heart using electrodes attached to the chest and to a recording device to make an electrocardiogram. It is used to diagnose heart conditions such as valve disorders, arrhythmias and heart attack.

An arrhythmia or dysrhythmia is a problem with the rate or rhythm of the heartbeat. During an arrhythmia, the heart can beat too fast, too slow, or with an irregular rhythm. Most arrhythmias are harmless, but some can be serious or even life threatening. During an arrhythmia, the heart may not be able to pump enough blood to the body. Lack of blood flow can damage the brain, heart, and other organs. (Ref: http://www.nhlbi.nih.gov/health/health-topics/topics/arr)

a medical certificate, and at the first examination after having reached the age of 40."

On the medical assessment, the obligation of the applicant for disclosing his/her medical history is regulated, as given in the UAE CAR Part II, Chapter 5 – *Medical Provisions for Licensing,* and Chapter 1 – *Licences and Ratings Requirements*, as following:

"5.2 Medical Assessment General

5.2.1 Classes of Medical Assessment

5.2.1.1 The applicant for a Medical Assessment shall provide the medical examiner with a personally certified statement of medical facts concerning his/her personal, familial and hereditary history. The applicant shall be made aware of the necessity for giving a statement that is as complete and accurate as his/her knowledge permits, and any false statement shall be dealt with in accordance with paragraph (1.5.6.1).

1.5.6.1 Any false declaration to a medical examiner made by an applicant for a licence or rating shall be reported to the GCAA for such action as may be considered appropriate."

1.18.3 ICAO Annex 1- *Personnel Licensing*

The standards and recommended practices (SARP) of medical fitness, and the general rules concerning pilot licenses and ratings according to *ICAO Annex 1*, as following:

"1.2.4 Medical fitness

1.2.4.2 **Recommendation.—** From 18 November 2010 States should apply, as part of their State safety programme, basic safety management principles to the medical assessment process of licence holders, that as a minimum include:

a) routine analysis of in-flight incapacitation events and medical findings during medical assessments to identify areas of increased medical risk; and

b) continuous re-evaluation of the medical assessment process to concentrate on identified areas of increased medical risk.

2.1 General rules concerning pilot licences and ratings

2.1.5 Requirements for the issue of class and type ratings

2.1.5.2 Type rating as required by 2.1.3.2 a)

The applicant shall have:

a) gained, under appropriate supervision, experience in the applicable type of aircraft and/or flight simulator in the following:
- procedures for crew incapacitation and crew coordination including allocation of pilot tasks; crew cooperation and use of checklists;

2.5 Multi-crew pilot licence appropriate to the aeroplane category

2.5.1 General requirements for the issue of the licence

2.5.1.3 Skill

2.5.1.3.1 The applicant shall have demonstrated the skills required for fulfilling all the competency units specified in Appendix 3 as pilot flying and pilot not flying, to the level required to perform as a co-pilot of turbine-powered aeroplanes certificated for operation with a minimum crew of at least two pilots under VFR and IFR, and to:

e) communicate effectively with other flight crew members and demonstrate the ability to effectively perform procedures for crew incapacitation, crew coordination, including allocation of pilot tasks, crew cooperation, adherence to standard operating procedures (SOPs) and use of checklists."

1.18.4 Antiphospholipid Antibody Syndrome[29] [30]

Antiphospholipid Antibody Syndrome (APS), also known as Hughes Syndrome or Sticky Blood, is an autoimmune disorder or disease. Autoimmune disorders occur if the body's immune system makes antibodies that attack and damage tissues or cells.

Phospholipids are a type of fat found in all living cells and cell membranes, including blood cells and the lining of blood vessels.

Antibodies are a type of protein that helps the body to defend itself from infections.

However, in APS, the body makes antibodies that mistakenly attack phospholipids. When antibodies attack phospholipids, cells are damaged. This damage causes blood clots to form in the body's arteries and veins.

Two blood proteins that are major targets of antiphospholipid antibodies are b_2-glycoprotein I and prothrombin.

Usually, blood clotting is a normal body process that helps in sealing small cuts or breaks on blood vessel walls. However, in APS, too much blood clotting can block blood flow and damage the body's organs. In other words, APS causes unwanted blood clots to form in the body's arteries and veins.

What causes the immune system to make antibodies against phospholipids is not known. Researchers do not know why APS antibodies cause blood clots to form. Some believe that the antibodies damage or affect the inner lining of the blood vessels, which causes blood clots to form. Others believe that the immune system makes antibodies in response to blood clots damaging the blood vessels.

Some people have APS antibodies, but do not ever have signs or symptoms of the disorder. Having APS antibodies does not mean that the person has APS.

To be diagnosed with APS, a person must have APS antibodies and a history of health problems related to the disorder. However, people who have APS antibodies but no signs or symptoms are at risk of developing APS.

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[29] Ref: http://www.nhlbi.nih.gov/health/health-topics/topics/aps National Heart, Lung, and Blood Institute (NHLBI), Maryland, the United States

[30] Ref: http://www.apsfa.org/aps.htm APS Foundation of America, Inc. (APSFA), the United States

APS can lead to many health problems, such as stroke, heart attack, kidney damage, deep vein thrombosis (DVT)[31], and pulmonary embolism[32].

Very rarely, some people who suffer from APS develop many blood clots over weeks or months. This condition is called catastrophic antiphospholipid syndrome (CAPS).

APS can affect people of any age. However, it is more common in women and people who have other autoimmune or rheumatic disorders.

The Signs and Symptoms of APS

The signs and symptoms of APS are related to abnormal blood clotting. The outcome of a blood clot depends on its size and location.

Blood clots can form in, or travel to, the arteries or veins in the brain, heart, kidneys, lungs, and limbs. Clots can reduce or block blood flow, which can damage the body's organs and may cause death.

Major signs and symptoms of blood clots include:

- Chest pain and shortness of breath
- Pain, redness, warmth, and swelling in the limbs
- Ongoing headaches
- Speech changes
- Upper body discomfort in the arms, back, neck, and jaw
- Nausea

Other signs and symptoms of APS include chronic (ongoing) headaches, memory loss, and heart valve problems. Some people who have APS also get a lacy-looking red rash on their wrists and knees.

Diagnosing APS

Diagnosing APS is based on a combination of clinical signs and symptoms, as described above, and from the blood tests to diagnose APS. The common blood tests for antiphospholipid antibodies are as follows:

- Anticardiolipin antibodies (IgG, IgM, and IgA)[33]

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[31] Deep vein thrombosis (DVT) is usually the formation of a blood clot (thrombus) in the deep veins of the leg, although DVT may also occur in the veins of the upper extremities. DVT can occur spontaneously without a known underlying cause or after provoking events, such as trauma, surgery or acute illness. (Ref: http://www.thrombosisadviser.com/en/vte-treatment/deep-vein-thrombosis/)

[32] Pulmonary embolism (PE) is a potential cardiovascular emergency and occurs when a part of a blood clot (thrombus), usually dislodged from a DVT (and then called an embolus), passes into the pulmonary circulation, occluding the pulmonary arteries. Arteries are vessels that carry blood away from the heart. Pulmonary artery transports blood from the heart to the lungs. (Ref: http://www.thrombosisadviser.com/en/vte-treatment/pulmonary-embolism/)

[33] Anticardiolipin, or cardiolipin antibodies test measures the concentration of the antibodies IgG (immunoglobulin G), IgA (immunoglobulin A), and IgM (immunoglobulin M) as they relate to the amount of cardiolipins. Cardiolipin is a phospholipid, or lipid (fat) molecule, in the blood. The levels of these antibodies are often high in people with abnormal blood clotting, autoimmune diseases like lupus, or repeated miscarriages. (Ref: http://www.urmc.rochester.edu/encyclopedia/content.aspx?ContentTypeID=167&ContentID=cardiolipin_antibody)

- Lupus anticoagulant[34]
- Antibodies to b_2-glycoprotein I (IgG, IgM, IgA)[35]

If a person has APS and another autoimmune disorder, such as lupus[36], it is important to control the other disorder as well. When the other condition is controlled, APS may cause fewer problems.

Research is ongoing to find new ways to treat APS.

Medicines and Living with APS

There is no cure for APS, but there is treatment. The treatment of choice for patients with APS who have had a blood clot is anticoagulant therapy. This is usually successful in preventing further clots.

In general, patients who have had a blood clot (i.e., stroke, heart attack, DVT) and have persistently positive tests for antiphospholipid antibodies should be treated with anticoagulants indefinitely. Discontinuing treatment after a fixed period of time, such as six months, may be quite dangerous in such patients.

In some patients with a history of blood clots, antiphospholipid antibodies may disappear after a certain period of time. It is not known whether it is safe to stop anticoagulation in this situation.

Blood thinners do not prevent APS. They simply reduce the risk of further blood clotting. APS treatment is life-long.

APS Statistics

The statistics based on APS Foundation of America, is as following:

- 1-5% of the general population is believed to have APS.

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[34] Lupus Anticoagulant is a specialized blood test to determine whether your body is producing certain antibodies or proteins that cause you to have a blood-clotting disorder. It does not mean you have lupus, specific type of autoimmune disorder.
(Ref: http://www.urmc.rochester.edu/encyclopedia/content.aspx?ContentTypeID=167&ContentID=lupus_anticoagulant)

[35] Beta-2 glycoprotein 1 antibody tests are used along with cardiolipin antibody and lupus anticoagulant testing to help diagnose the cause of an unexplained blood clot (thrombotic episode) or recurrent miscarriages, to help diagnose antiphospholipid syndrome (APS), or to detect the autoantibodies in someone with another autoimmune disorder. Antiphospholipid antibodies, including beta-2 glycoprotein anitboides, are associated with excessive clotting. They interfere with the body's blood clotting process in a way that is not fully understood. Beta-2 glycoprotein 1 antibody is an autoantibody that is associated with inappropriate blood clotting. This test detects and measures one or more classes (IgG, IgM, or IgA) of beta-2 glycoprotein 1 antibodies. Beta-2 glycoprotein antibody is considered one of the primary autoantibodies called antiphospholipid antibodies that mistakenly target the body's own lipid-proteins (phospholipids) found in the outermost layer of cells (cell membranes) and platelets.
(Ref: http://labtestsonline.org/understanding/analytes/beta-2-glycoprotein-1-antibodies)

[36] Lupus is an autoimmune disease where the body's immune system becomes hyperactive and attacks normal, healthy tissue. This results in symptoms such as inflammation, swelling, and damage to joints, skin, kidneys, blood, the heart, and lungs. Under normal function, the immune system makes proteins called antibodies in order to protect and fight against antigens such as viruses and bacteria. Lupus makes the immune system unable to differentiate between antigens (a substance capable of inducing a specific immune response) and healthy tissue. This leads the immune system to direct antibodies against the healthy tissue - not just antigens - causing swelling, pain, and tissue damage.
(Ref: http://www.medicalnewstoday.com/info/lupus/)

- 15-20% of all cases of blood clots in large veins (deep vein thrombosis) including blood clots that go to the lungs (pulmonary embolism) are due to APS.
- 10-25% of women with recurrent miscarriages have APS.
- One third of strokes occurring in younger people (under the age of 50) are due to APS.
- APS is a major women's health issue: 75-90% of those affected by APS are women.
- 40-50% of patients with lupus also have APS.

1.18.5 Pilot Population

According to ICAO source, the pilot population in 2010 was 463,386 pilots, 93.3% male, and 6.7% female pilots.

According to 2010 statistics, the world population was about 6.89 billion, out of which about 0.0067% were pilots.

1.18.6 Pilot Incapacitation Study

In 2004, a study[37] was performed by the United Kingdom Civil Aviation Authority (UK CAA) to analyze all incapacitations occurring among United Kingdom commercial pilots, both in-flight and off-duty. The purpose of the study was to derive a baseline minimum annual incapacitation rate for UK commercial pilot community.

The study group encompassed professional pilots holding valid UK / Joint Aviation Requirements (JAR) Class 1 medical certificate and license issued as of 2004. Three data sources were used to identify episodes of incapacitation: the statutory notification of prolonged illness, personal injury, or pregnancy to the UK Civil Aviation Authority; Mandatory Occurrence Reports (MORs) for in-flight medical incidents; and death certificates. The total number of incapacitations was expressed as a proportion of the number of professional pilots to give an incapacitation rate.

Appendix A to this Report shows the detail of the study and the related statistics on commercial pilot incapacitation rate.

A study of in-flight medical incapacitations and impairments in U.S. airline pilots from 1993 through 1998 was performed by the FAA.

Appendix B to this Report shows the detail of the FAA study.

The definition of in-flight medical incapacitation is a condition in which a flight crewmember was unable to perform any flight duties, and impairment, as a condition in which a crewmember could perform limited flight duties, even though performance may have been degraded.

[37] The Annual Incapacitation Rate of Commercial Pilots" by Sally Evans, M.B.B.S., MFOM, and Sally-Ann Radcliffe, B.A.(Hons), Medical Department, UK Civil Aviation Authority. (http://www.ingentaconnect.com/content/asma/asem/2012/00000083/00000001/art00009?crawler=true)

1.19 Useful or Effective Investigation Techniques

No new investigation techniques were used during this investigation.

2. Analysis

2.1 Introduction

The Team collected data from various sources for the purpose of determining the causes and contributing factors.

This Analysis covers the issues of human factors, incapacitation and impairment of pilots, medical history, Antiphospholipid Antibody Syndrome, the UAE Regulations and ICAO SARPs, and taxiing of the Aircraft.

This Section of the Report explains the contribution of every investigation aspect 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 Human Factors

Both pilots were licensed and qualified for the flight in accordance with the existing requirements of the General Civil Aviation Authority of the United Arab Emirates.

During approach to Abu Dhabi International Airport, and while the Aircraft was maintaining 2,400 feet altitude and was approximately 9.5 nautical miles south east of the Airport, the captain said something to the co-pilot in an unusual tone of voice compared to his previous conversation. Within approximately one and a half minutes, the captain was attempting to verbalize unsuccessfully. This was associated with difficulty in breathing and incoherent verbal communication. The co-pilot noticed that the captain had suddenly become unconscious. Subsequently, the co-pilot took over the controls.

Approximately seven seconds after the captain's last attempt to communicate, autopilot 1 was disengaged by the co-pilot, at this time the travel of the captain's right rudder pedal reached approximately 13 degrees, and the Aircraft started to sideslip. The co-pilot disengaged autopilot 1 when he decided to take over control after realizing that the Aircraft was side-slipping. However, after the autopilot disengagement, the captain's right pedal was still being subject to pressure continuously while it maintained a position of 14±1 degrees for another 18 seconds.

Autopilot 2 was engaged by the co-pilot in order to reduce the workload, but after seven seconds, the co-pilot disengaged it due to, most probably, noticing the continuous input of the captain's right rudder pedal, which put the Aircraft into a 10 degree sideslip, and to lateral acceleration that reached approximately 0.26 g.

After the 18 second period of constant pressure on the right rudder pedal, the rudder input started to decrease and the pedal returned to the neutral position within 11 seconds. During the 29 seconds from the captain's full coma until the pedals returned to the neutral position, the co-pilot was making continuous attempts to recover the Aircraft to straight and level flight manually.

The duration of the continuous captain's right rudder pedal input was approximately 37 seconds. This long and excessive rudder input was, most probably, due to muscle spasms resulting from the captain's incapacitation.

Approximately four seconds after the rudder pedal had returned to the neutral position, the co-pilot re-engaged autopilot 1 in order to reduce his workload. However,

10 seconds after the engagement of autopilot 1, it disengaged automatically when the bank angle reached approximately 21 degrees.

After 14 seconds the co-pilot re-engaged autopilot 1. Thereafter, autopilot 2 was also engaged to enable CAT 3 DUAL[38]. Both autopilots remained engaged until 850 ft above ground level and then were disengaged by the co-pilot before the Aircraft landed.

There were some instructions from the Controller that could not be followed and performed by the co-pilot due to the condition and workload in the cockpit after the captain's incapacitation.

The co-pilot required time to manage the situation. He discontinued the approach and requested permission to perform an orbit in order to acquire more time to ensure that the cockpit was prepared for landing. The co-pilot was able to manage with the assistance of the CM who was present in the cockpit taking care of the incapacitated captain. The co-pilot requested one of the cabin crew to ask, through the PA, if there was a doctor onboard, and he was also in continuous communication with the Approach Controller. The co-pilot landed the Aircraft uneventfully.

The Investigation believes that the co-pilot managed the cockpit efficiently after the captain's incapacitation. Although he intended to carry out the landing as soon as possible, he did not put himself under stress to perform a hasty approach. The co-pilot's actions were in accordance with the Operator's *Operations Manual, Part A,* for pilot incapacitation and reflected good airmanship.

Although some instructions given by the Approach Controller could not be followed exactly, the Controller managed the requests from the Aircraft for the orbit and the landing, and controlled the traffic safely.

The CM assisted in managing the cockpit by restraining the captain's body in order to prevent any inadvertent inputs to the flight controls. The CM required assistance from another cabin crew member to ensure that the captain was supplied with oxygen by fixing the oxygen mask in place, as required.

The cabin crew members assisted the co-pilot and reacted as per the Operator's *Operations Manual, Part A*, and *Safety and Emergency Manual*.

The Investigation believes that crew resource management (CRM) was practiced well in taking appropriate actions at proper times without putting the flight into a situation of increased risk.

2.3 Incapacitation and Impairment of Pilots

One of the purposes of medical examinations, and the determination of medical fitness, is to evaluate the probability of a medical condition likely to cause in-flight incapacitation. As per ICAO Doc 8984, many States use the "1% rule"[39] per annum as a

[38] CAT 3 DUAL annunciations are displayed on the primary flight displays (PFDs) then the airplane's approach capability is fail operational and capable of a CAT IIIB autoland ILS approach. As an example, a head-up display (HUD) which allows the pilot to perform aircraft maneuvers rather than an automatic system is considered as fail-operational. A HUD allows the flight crew to fly the aircraft using the guidance cues from the ILS sensors such that if a safe landing is in doubt, the crew can respond in an appropriate and timely manner.

[39] From ICAO Doc 8984: The "1% rule" specifies a predicted annual medical incapacitation rate which, if exceeded, would exclude a pilot from flying in a multi-crew aircraft. This is widely regarded as an acceptable risk level and was adopted by the European Joint Aviation Authorities as the basis of aeromedical risk assessment. The "1% rule" cannot apply to

reference for assessing pilots' fitness, which develop in a medical condition.
The UAE GCAA also uses the “1% rule” per annum as the basis of aeromedical risk assessment. Based only on this criterion, the GCAA could objectively consider certification criteria compatible with internationally recognized flight safety standards.

Incapacitation can take many forms, ranging from a not-easily noticeable partial loss of appropriate perception and functioning, up to sudden death. This phenomenon may occur over with pilots of any age. From the study that was performed by the UK CAA, a positive trend was observed between incapacitation and age. The risk is smaller for pilots in their 40s, increases gradually over the age of 50, and rises steeply (about 5 times the level of the 40s), for the age of 60 and above. The factor most affecting pilots incapacitation is age, as also was evidenced by the study conducted on a target population of airline pilots in the United States.[40]

In multi-pilot cockpits, the consequences of a pilot incapacitation can be effectively mitigated because of the presence of another pilot, who can take over control. However, the risk of continuing a flight safely is increased, due to the increased workload, possible effects of distraction, and stressful conditions imposed on the pilot flying. In single-pilot cockpits, the mitigation of risks due to pilot incapacitation is not assured and, most likely, the result will be a fatal accident.

In order to reduce incidents caused by compromised pilot physical fitness, and to mitigate accidents in a single-pilot operation, definitive operators' safety investigations, through an efficient safety management system, should always be undertaken into each incapacitation event to identify the causes of incapacitation, and the appropriate remedial actions. It is important to consider all medical events affecting pilots, which occur inflight and also off duty. Incapacitation during off-duty periods should also be medically investigated as incapacitation can occur at any time. This will give more accurate results in the determination of causes of medical events which affect pilots.

The UK CAA study revealed that the annual rate of medical events affecting flight safety was 0.8% in 2004, while the annual incapacitation rate was 0.25%.

Although the periodic medical check establishment of regulatory assessments is in place, the medical events can indicate the risks that require attention and indicate possible changes to the medical requirements. Medical events, considered both as incapacitations and impairments, are relevant risk indicators for aviation medicine experts.

Medical data collection is a challenge when studying medical issues. Although the GCAA has its own reporting systems, the Reporting of Safety Incident 'ROSI' and the Voluntary Reporting of Safety Issue 'VORSI', the confidential nature of medical information may impede the collection of accurate data in a reasonable time. Medical condition data, especially for impairments, are rarely evaluated and categorized by a person who has adequate knowledge of medical implications.

Although there is no trend in the UAE operators' pilot impairment and incapacitation rate, the UAE GCAA is enhancing the reporting systems in order to acquire more data. The data can indicate the risks that require attention and possible

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a solo pilot flying in public transport operations, because it is derived from two pilot operations and the availability of a second pilot to take over in the event of one pilot becoming incapacitated.

[40] In-Flight Medical Incapacitation and Impairment of U.S. Airline Pilots: 1993 to 1998

need to change current medical requirements towards the UAE State Safety Program (SSP) requirements.

Therefore, in order to obtain data on the medical event and incapacitation rates, and to reduce events of pilot incapacitation, the GCAA should widen the sources of medical data collection, aiming to determine medical events and incapacitation rates in order to identify any required risk mitigations. The demonstrated annual incapacitation rate may provide a good indication to key factors to be monitored, particularly for single-pilot commercial operations.

2.4 Medical History

The risk determining factors of an incapacitation, or impairment, are the rate of onset and the severity of the presenting symptoms. As these vary for almost all medical diagnoses, some degree of judgment needs to be exercised based on the availability of clinical history.

High medical standards for a person, who is applying for a position as a pilot, require accurate and transparent information about the applicant's medical history. Transparent information may be understood by the applicant as being an intrusion into his/her privacy, and a threat to his/her career. This may cause the applicant to withhold important medical information from the medical examiner.

Normally, medical history gives more information than a medical examination on the condition of the applicant, but a beneficial review of the applicant's medical history requires his/her belief in receiving fair treatment, so that the applicant will have an incentive, and feel free, to self-disclose any particular medical problem.

The Investigation believes that the medical history of the captain, except for the history of his hypertension, was not captured before the Incident. The APS disorder only became apparent following the Incident.

The captain was diagnosed with hypertension two years before the Incident, and hypertension medication was prescribed. The captain reported to the medical examiner that he was suffering from hypertension one year and eight months after diagnosis, in his last medical renewal application before the Incident. The Investigation believes that the Operator's voluntary reporting system was not sufficiently open to encourage reporting of newly discovered syndromes in a proper time frame.

The symptoms and signs of his APS disorder, may or may not have been discernable at that time. With the exception of hypertension, no additional information on his medical condition was made available. No further medical examinations were undergone by the captain.

Disclosure of medical history is required by UAE *CAR Part II, Chapter 5, Paragraph 5.2.1.1.* and *Chapter 1, Paragraph 1.5.6.1*. However, to ensure the awareness of the applicant to disclosure his/her medical history, the GCAA should include a cautionary statement in the application form, stating the applicability of the related regulations, and the probable consequences of not divulging essential information.

In order to widen the sources of medical data collection, and to make it more effective in obtaining the medical history of a license holder, the GCAA should promote an appropriate just culture to collect the medical history of UAE license holders in cooperation with all stakeholders including the operators.

2.5 Antiphospholipid Antibody Syndrome

The Antiphospolipid Antibody Syndrome has no cure, and the only way to control the disorder, and to prevent its complications, is by using blood thinner medicines. Anticoagulants or "blood thinners" are used to prevent blood clotting.

A person can have APS antibodies, but never have any signs or symptoms of the disorder. Having APS antibodies, does not mean that the person has APS. However, this person is at risk of developing APS.

A person who does not notice the signs and symptoms of APS may experience other health problems first, such as a stroke, heart attack, kidney damage, deep vein thrombosis (DVT), or pulmonary embolism, before he or she is diagnosed with APS.

No APS statistical data, or results from studies on pilots with APS was available. Therefore, the Investigation could not obtain any data on pilot incapacitation due to APS disease.

The Investigation attempted to determine an estimate of the number of pilots with APS. The following assumption was made.

Based on Population Reference Bureau data, the world population at the end of 2011 was about 7 billion people, and it rose to approximately 7.06 billion at the end of 2012. This means that the yearly growth in world population was approximately 1.004% in the year 2012. Therefore, it can be estimated that the world population was about 7.05 in November 2012.

By using the same percentage of pilot population figure as in 2010, which was $6.723*10^{-3}$ %, then the following can be assumed for the period of November 2012:

Pilot Population	Male Pilot with APS	Female Pilot with APS
474,070 ($6.732*10^{-3}$ %)	2,322 ($3.2932*10^{-5}$ %)	786 ($1.1149*10^{-5}$ %)

Based on the above assumption, the estimation of the total population of pilots with APS was approximately 3,100 for November 2012, with a yearly growth of approximately 1%.

The only way to diagnose a person suffering from APS is by performing blood tests for antiphospholipid antibodies.

Medical certification should be considered on a case by case basis for pilots, who have APS already. In the medical re-examinations, the GCAA should ensure that pilots with APS have appropriate anticoagulant therapy, and are compliant with self-monitoring and management of the International Normalised Ratio for adjusting the anticoagulant therapy doses. This will help to ensure that the concerned pilot will function safely during the entire flight operation.

The Investigation believes that medical examination, or re-examination whenever required, on a case by case basis for pilots and/or first applicants, who already have the disease but which can be controlled with an appropriate therapy, need to be considered in order to ensure that the concerned pilots will function safely during the entire flight operation.

Therefore, the Investigation recommends that the GCAA conduct continuous testing of the medical assessment requirements, considering any newly arising medical risk.

2.6 The UAE Regulations and ICAO SARPs

The UAE *CAR Part II, Chapter 5- Medical Provisions for Licensing*, paragraph 5.4.2.6, requires electrocardiography as part of the heart examination for the first issue of a medical assessment. Electrocardiography is included in re-examinations of applicants every 5 years until the age of 30, every 2 years until 40, annually until 60, and every 6 months thereafter, and on clinical indication.

The high percentage of cardiovascular and cerebrovascular conditions, were the most common cause of pilot incapacitation. Based on the UK CAA study, these two conditions resulted in 50% of the incapacitations.

The regulatory requirements current at the time of the incident were limited in enabling the medical check to discover specific syndromes or diseases, in this case the APS syndrome, and subsequently to reduce the pilot incapacitation events by taking the necessary medication or therapy. In general, the UAE *CARs* current at the time of the incident were limited to reducing the probability of pilot incapacitation caused by cardiovascular and cerebrovascular conditions.

However, since February 2015, the UAE GCAA requirements for Class 1 medical certificate have been enhanced. Regulations that are more stringent were applied by adding the extended cardiovascular assessment when clinically indicated, and at the first revalidation of renewal examination at the age of 60, and every year thereafter. In addition, estimation of serum lipids, including cholesterol[41], is required at the examination for the first issue of a medical certificate, and at the first examination from the age of 40 and above. These additional assessments are intended to minimize cardiovascular and cerebrovascular risks.

One of the ICAO recommendations, contained in ICAO Annex 1 Paragraph 1.2.4, is the routine analysis of inflight incapacitation events and medical findings during medical assessments to identify areas of increased medical risk. This routine analysis is almost compatible with the UK study in determining the medical event rate and the incapacitation rate. The study is more comprehensive since it includes the impairment (medical event where the pilot is still capable of functioning), and off-duty pilot incapacitation.

Another ICAO recommendation, contained in ICAO Annex 1 Paragraph 1.2.4, is the continuous re-evaluation of the medical assessment process, to concentrate on identified areas of increased medical risk. This ICAO recommendation also covers, on a case-by-case basis, the applicant pilots who already suffer from syndromes that are controllable by prescribed medicine or therapy.

The Investigation believes that the GCAA should determine the data for medical event rate and the incapacitation rate. This is to ensure that the GCAA apply basic risk management principles to the medical assessment process of license holders, as part of the SSP, as recommended by ICAO Annex 1, Paragraph 1.2.4 for pilot medical fitness.

[41] Raised cholesterol levels can narrow the arteries and increase the risk of a blood clot, which may result in a cerebrovascular condition

2.7 Taxiing the Aircraft

The Aircraft was equipped with left and right nose wheel steering tillers. However, after landing, the Aircraft was stopped on the runway for about 34 minutes because the pilot seated in the right hand seat was not authorized to taxi the Aircraft as per the Operator's policy.

The Investigation believes that had the operator's policy allowed, the co-pilot could have taxied the Aircraft to the gate, and the runway could have been vacated immediately after the landing.

3. Conclusions

3.1 General

From the evidence available, the following findings, causes and contributing factors were determined with respect to this Incident. These shall not be read as apportioning blame or liability to any particular organisation 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 certified, equipped and maintained in accordance with the existing requirements of the General Civil Aviation Authority, United Arab Emirates.

(b) The Aircraft was certified as being airworthy when dispatched for the flight.

(c) There was no evidence of any defect or malfunction of the Aircraft that could have contributed to the Incident.

3.2.2 Findings relevant to the crew

(a) The flight crew and cabin crewmembers were licensed and qualified for the flight in accordance with the existing requirements of the General Civil Aviation Authority of the United Arab Emirates.

(b) Both flight crewmembers possessed valid Class 1 Medical Certificates.

(c) During the approach, the co-pilot noticed that the captain, as the pilot flying, had suffered a sudden loss of consciousness. Subsequently, the co-pilot took over the controls.

(d) Before the flight, the captain’s observed condition was normal, and during the flight, the captain did not express concern that he had experienced any adverse physiological issues before he started uttering words in an unusual tone of voice.

(e) The co-pilot managed the situation well after the captain's incapacitation. Although he intended to carry out the landing as soon as possible, the co-pilot did not put himself under stress to perform a hasty approach.

(f) The cabin crewmembers assisted the co-pilot and reacted as per the Operator's *Operations Manual, Part A*, and *Safety and Emergency Manual*.

(g) The captain was incapacitated for about 18 minutes.

(h) The captain was transported to the hospital for intensive medical checks and observation.

(i) The thorough medical investigation determined that the captain was suffering from antiphospholipid syndrome, which had caused an embolic event (stroke) that resulted in loss of consciousness.

(j) The captain reported to the medical examiner that he was suffering from hypertension one year and eight months after diagnosis, in his last medical renewal application before the Incident.

(k) One year after the Incident, the captain had suffered no further episodes or loss of consciousness, or seizers. The continuous monitoring of blood clotting by using INR indicated that the captain's symptoms were stable.

3.2.3 Findings relevant to the operation of the flight

(a) The co-pilot and cabin crew reactions were appropriate, and in accordance with the Operator's *Operations Manual, Part A*, in case of pilot incapacitation.

(b) Some of the Approach Controller's instructions could not be followed by the co-pilot due to the extra cockpit workload he experienced after the captain's incapacitation.

(c) More time was required by the co-pilot to manage the situation after the captain incapacitation. Therefore, the co-pilot discontinued the approach and requested permission to perform an orbit in order to ensure that the cockpit was safely prepared for landing.

(d) The co-pilot informed the Tower that the Aircraft could not be taxied after landing and would be stopped on the active runway, and would require assistance to tow the Aircraft to the stand. Also, medical personnel would be required to deal with the medical emergency for the incapacitated captain.

(e) The Aircraft landed uneventfully.

(f) The Aircraft stopped on the runway as the pilot seated in the right hand seat was not authorized to taxi the Aircraft, as per the Operator's policy.

(g) The Aircraft was stopped on the runway for approximately 34 minutes.

3.2.4 Findings relevant to the air traffic services and airport facilities

(a) There were some instructions from the Approach Controller that could not be followed by the Aircraft, however, the Controller did manage the

requests from the Aircraft for the orbit and the landing, and controlled the traffic safely.

(b) The airport emergency services were deployed appropriately.

(c) Although no action was required from the rescue and firefighting services, they were continuously present to monitor and standby as a precaution until the Aircraft had been towed from the runway,

(d) The medical personnel arrived at the Aircraft and entered the flight deck in order to evaluate the captain's condition 30 minutes after landing.

3.2.5 Findings relevant to Operator

(a) CRM was practiced appropriately.

(b) The Operator's policy allows taxiing the Aircraft only from the left hand seat.

3.3 Causes

The Air Accident Investigation Sector determines that the cause of the captain's incapacitation was the embolic event (stroke) that resulted in loss of consciousness.

3.4 Contributing Factors to the Incident

The Investigation identifies the following contributing factors to the Incident:

3.4.1 The captain suffers from antiphospholipid syndrome disease which led to the embolic/stroke event.

3.4.2 No additional information on the captain's medical history, except his hypertension, was made available to the medical examiner, such that no further medical treatment was prescribed to mitigate the possibility of an embolic event.

3.4.3 The regulatory requirements current at the time of the incident did not enable the medical check to discover a specific syndrome or disease, and subsequently to reduce the possibility of a pilot incapacitation event by taking the necessary medication or therapy.

4. Safety Recommendations

4.1 General

Safety actions taken after the Incident are described in paragraph 4.2.

The safety recommendations are proposed according to paragraph 6.8 of *Annex 13 to the Convention on International Civil Aviation*[42], and are based on the conclusions listed in heading 3 of this Report. The GCAA expects that all safety issues identified by the Investigation are addressed by the receiving States and organizations.

4.2 Safety Actions Taken

General Civil Aviation Authority of the United Arab Emirates

The medical regulations were improved by adding more efficient provisions for cardiovascular assessment, and this was for the purpose of reducing pilot incapacitation events, especially for cardiovascular conditions, as stated in *CAR Part II – Chapter 5- Medical Provisions for Licensing*, paragraph 5.4.2- *Physical and Mental Requirements*, states:

> *"5.4.2.6.2 Extended cardiovascular assessment shall be required when clinically indicated.*
>
> *5.4.2.6.3 For a Class 1 medical certificate, an extended cardiovascular assessment shall be completed at the first revalidation of renewal examination at the age 60 and every year thereafter.*
>
> *5.4.2.6.4 For a Class 1 medical certificate, estimation of serum lipids, including cholesterol, shall be required at the examination for the first issue of a medical certificate, and at the first examination after having reached the age of 40."*

4.3 Safety Recommendations

The Air Accident Investigation Sector recommends that:

4.3.1 The Operator should:

SR 59/2015

Review the policy, assisted by appropriate risk assessment that prohibits taxiing an aircraft from the right hand seat, especially in emergency or abnormal situations.

SR 60/2015

Ensure that its safety culture encourages voluntary disclosure of medical issues by the license holders.

[42] Paragraph 6.8 of *Annex 13 to the Convention on International Civil Aviation* states: 'At any stage of the investigation of an accident or incident, the accident or incident investigation authority of the State conducting the investigation shall recommend in a dated transmittal correspondence to the appropriate authorities, including those in other States, any preventive action that it considers necessary to be taken promptly to enhance aviation safety'.

4.3.2 The General Civil Aviation Authority of the United Arab Emirates should:

SR 61/2015

Consider enhancing medical data collection for medical events and pilot incapacitation, in order to identify any required risk mitigations.

SR 62/2015

Conduct continuous testing of the medical assessment requirements, considering any newly arising medical risk.

SR 63/2015

Include a cautionary statement in the license application form, which highlights the importance of disclosing an applicant's medical history to the medical examiner.

SR 64/2015

Promote an appropriate just culture across the aviation industry to widen the sources of medical data collection, including voluntary disclosures by applicant for the position of pilot.

This Report is issued by:

The Air Accident Investigation Sector
General Civil Aviation Authority
United Arab Emirates

Appendix A. Incapacitation Rates for UK Commercial Pilot Community, in 2004

A study was performed by the United Kingdom Civil Aviation Authority (UK CAA) to analyze all incapacitations occurring among United Kingdom commercial pilots, both in-flight and off-duty.

The statistics, as shown in Table A-1, were gathered during the study and form the overall numeric basis for the results:

Table A-1. Statistic of UK Pilots in 2004

	Number	Percentage	Remarks
Total number of UK/JAR Class 1 Medical Holders with valid UK/JAR professional pilot's license	**16,145**		
Male Pilot	15,528	96.2%	
Female Pilot	617	3.8%	
Episodes of temporary unfitness holding UK/JAR professional pilot's license	**720**	**4.46%**	658 ATPL, 56 CPL, 6 BCPL
Episode of unfitness			
- accidental injury	**131**	**0.81%**	
Male	124	0.77%	
Female	7	0.04%	
- pregnancy (female)	**24**	**0.15%**	
- medical condition	**565**	**3.50%**	
Male	539	3.34%	
Female	26	0.16%	

Episodes of unfitness were classified as being due to accidental injury, pregnancy, or a medical condition.

Table A-2. Causes of Episodes of Temporary Unfitness

System Category	Number	Percentage
Accidents	131	18
Pregnancy related	24	3
Cardiovascular	103	14
Cerebrovascular	8	1
Dermatologic	3	<1
Diabetes	8	1
Ear, Nose, and Throat	46	6
Endocrine	5	<1
Gastrointestinal	59	8
Genitourinary	30	4
Hematologic	2	<1
Infectious disease	9	1
Information not received	5	<1
Miscellaneous	12	2
Musculoskeletal	126	18
Neurologic	21	3
Neoplasms	25	3
Ophthalmologic	17	2
Psychiatric	71	10
Respiratory	15	2
Total	**720**	**100**

As given in table A-2, musculoskeletal disorders were the most common (18%). Of the remaining medical disorders cardiovascular illness predominated (14%), with psychiatric disorders the next most common (10%).

As the number of female pilots which is 3.8% of the total pilots, and episodes of female pilot unfitness were small (0.35% of the total pilots), with almost half being related to pregnancy (0.15%), further analysis of medical conditions was restricted to male pilots.

In this study the following definitions were used appertaining to flight crew medical condition:

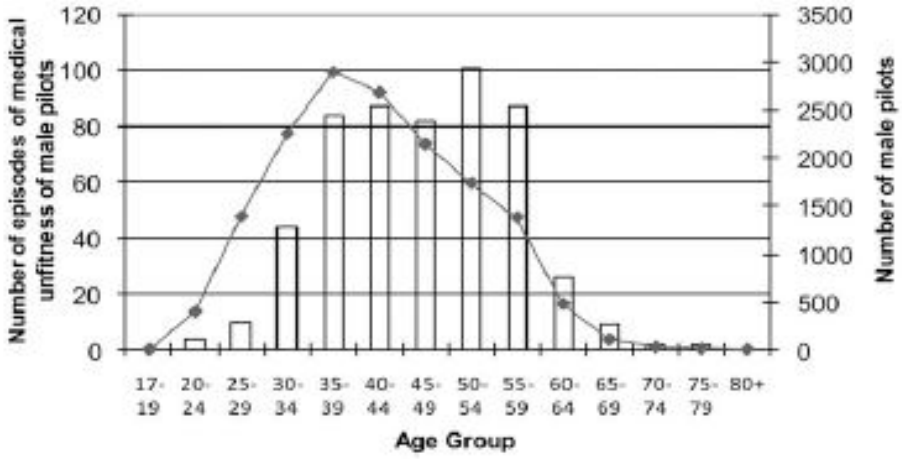
- *incapacitation:* a medical event that resulted, or would have had the propensity to result, in an inability to act as flight crew for at least 10 min;
- *impairment:* a partial incapacitation associated with symptoms that resulted, or would have had the propensity to result, in a reduction of function or distraction from the flight crew task, but would be unlikely to have caused loss of control of an aircraft.

The group was divided into 10-years age groups and the number of incapacitations, including sudden deaths, in each group was determined. The proportion of male pilots in each age group was compared with the proportion of male incapacitations within that group. Pilots between 50 and 69 years of age were further divided into 5-yr age groups and similar comparisons were made.

Comparing the 539 male pilots who experienced an episode of unfitness of medical cause with the total male professional pilot population, there was a definite skew toward the older age groups (Figure A-1). The number of episodes demonstrated a

plateau between the late thirties and late fifties with a marked drop after age 59 reflecting the usual retirement age of 60 for commercial pilots. The increased risk of experiencing an episode of unfitness with increasing age is clearly demonstrated.

Figure A-1. Comparison of medical causes of unfitness of male pilots by age with the male pilot age distribution



Note: Bars show number of unfit episodes; black diamonds show number of male pilots.

The 36 events that presented as incapacitations of professional pilots in 2004 are summarized in Table A-3.

There were 13 incapacitations as a consequence of a cardiovascular event, and 5 incapacitations from cerebrovascular event. Under cerebrovascular, there were 4 incapacitations due to stroke and 1 from a subarachnoid hemorrhage.

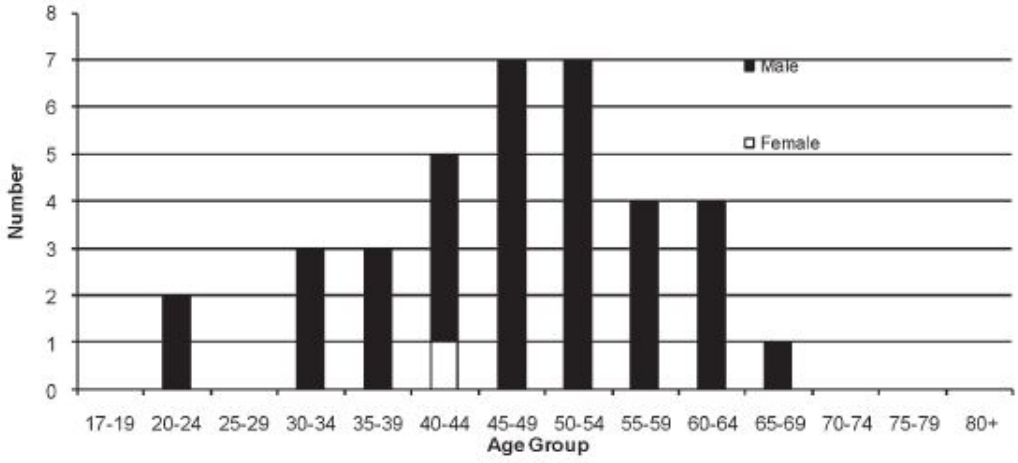
Table A-3. Cause of Incapacitation of Professional UK Pilot in 2004

Cause of Incapacitation	Number of events	Ages of pilots
Cardiovascular		
Acute myocardial infarction	6	39, 52, 54, 58, 59, 64
Chest pain	2	48, 60
Arrhythmia	3	42, 50, 66
Pulmonary embolus	2	45*, 49
Cerebrovascular		
Stroke	4	33, 42, 50, 59
Subarachnoid hemorrhage	1	48
Other		
Panic attack	3	34*, 35*, 64*
Spontaneous pneumothorax	4	30, 40, 44, 62
Gastric ulcer	1	47
Perforated appendix	1	24
Syncope	1	54
Bowel obstruction	1	48
Biliary colic	1	51*
Migraine	1	47
Prolapsed intervertebral disc	1	52
Epilepsy	2	24, 55
Vestibular disturbance	1	39*
Spontaneous abortion	1	40
Total	**36**	

* Occurred in flight or in the simulator.

Incapacitations (excluding sudden death) of all pilots by age are demonstrated in Figure A-2.

Figure A-2. Age distribution of professional UK pilot incapacitations in 2004



There were 14 deaths of commercial pilots with valid Class 1 medical certificates that were confirmed to have occurred in 2004, none were female. The four deaths likely

to have been sudden were two myocardial infarctions (heart attack)[43], a subarachnoid hemorrhage[44], and a gastro-intestinal hemorrhage[45].

Cardiovascular and cerebrovascular conditions led to 18 of the 36 incapacitations and 2 of the 4 sudden deaths. The cardiovascular conditions were acute myocardial infraction, chest pain, arrhythmia, and pulmonary embolus.

The number of incapacitations, including 4 sudden deaths, known to have occurred in 2004 was 40. The annual incapacitation rate was therefore 40/16,145 = 0.25%.

Cardiovascular and cerebrovascular conditions accounted for 20% (103+8/565) of the medical condition (excluding accidental injury and pregnancy), but 50% of the incapacitations (20/40). The tendency of these conditions to adversely affect flight safety highlights their importance for clinical aviation medicine practice.

The number of impairments known to have occurred in 2004 was 90.

The incapacitation rates of different age groups were compared and the age trend reviewed. A one-way analysis of variance test was applied to age groups over 19 and less than 70 years. The youngest and oldest pilots were excluded due to small numbers.

The annual incapacitation rates (including sudden deaths) for male pilots by age group are shown in Table A-4. Since females represented only 3.8% of all pilots and experienced only one pregnancy-related incapacitation, the age relationship of female incapacitations was not explored further.

Of the incapacitations, 15% were experienced by the 33% of male pilots who were in their 30s; 28% of incapacitations were experienced by the 31% of male pilots who were in their 40s; and 33% by the 20% of pilots in their 50s. Of all incapacitations, 18% affected the 3.7% of pilots in their 60s. The number of pilots over the age of 70 was too small for meaningful analysis.

Table A-4. Annual Male Incapacitation Rates by Age Group

Age group	17-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
Male incapacitations (%)	0 (0%)	2 (5%)	6 (15%)	11 (28%)	13 (33%)	7 (18%)	0 (0%)	0 (0%)
Male pilots (%)	3 (0.02%)	1788 (11.50%)	5158 (33.20%)	4835 (31.1%)	3123 (20.10%)	581 (3.70%)	38 (0.24%)	2 (0.01%)
Percent Incapacitation rate per annum	0.00%	0.11%	0.12%	0.23%	0.42%	1.20%	0.00%	0.00%

If the episodes are distributed evenly through all age group. Then the percentage incapacitation rate per annum is 2.08% (39/15,528).

[43] A heart attack (myocardial infarction) is usually caused by a blood clot, which stops the blood flowing to a part of your heart muscle. (Ref: http://www.patient.co.uk/health/myocardial-infarction-heart-attack)

[44] Subarachnoid hemorrhage is bleeding in the area between the brain and the thin tissues that cover the brain. This area is called the subarachnoid space. (Ref: http://www.nlm.nih.gov/medlineplus/ency/article/000701.htm)

[45] Gastrointestinal hemorrhage is bleeding within the gastrointestinal (GI) tract. (Ref: http://www.mdguidelines.com/gastrointestinal-hemorrhage)

Male pilots in their 20s and 30s have fewer incapacitations than would be expected if the episodes were distributed evenly through all age groups.

It is evident that pilots in their 40s have approximately the same number of incapacitations that would be expected with an even distribution of age.

Pilots in their 50s have a 2.0 fold increase compared with the number of expected incapacitations.

Pilots in their 60s account for 18% of all incapacitations but only 3.7% of all male pilots. A pilot in his 60s has 5 times the risk of incapacitation of a pilot in his 40s.

The trend in incapacitation rates between the five decade age groups between pilots in their 20s and 60s is given in Figure A-3.

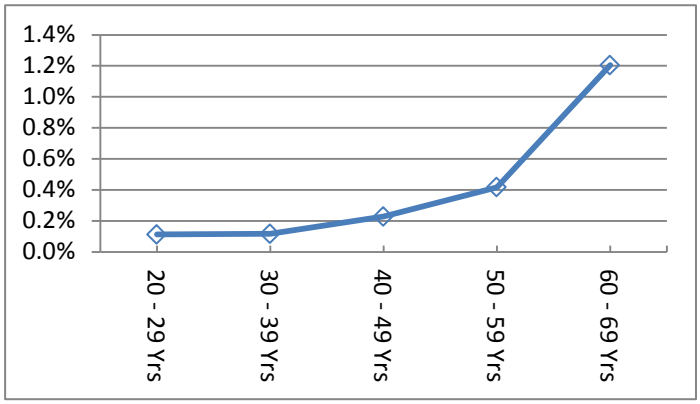


Figure A-3. Incapacitation Rates between the Five Decade Age Groups

The number of incapacitations plus of the impairments give a total of 130 as the overall number of medical events that had the potential to affect flight safety in a one-year period. The annual rate of a medical event with the potential to affect flight safety was therefore 130/16,145 = 0.8%.

Appendix B. The Percentage of US Airline Pilot In-flight Incapacitations and Impairments from 1993 to 1998

Based on the United States Federal Aviation Administration (FAA) Report number DOT/FAA/AM-04/16[46], the percentage of US airline pilot in-flight incapacitations and impairments as a function of age from 1993 to 1998, is presented in Figure B-1.

This technical report is about the study of in-flight medical incapacitations and impairments in U.S. airline pilots from 1993 through 1998. The definition of in-flight medical incapacitation is a condition in which a flight crewmember was unable to perform any flight duties and impairment as a condition in which a crewmember could perform limited flight duties, even though performance may have been degraded. From the study, it was found 39 incapacitations and 11 impairments aboard 47 aircraft during the six-year period, from 1993 to1998. All pilots who had an in-flight incapacitations and impairments were males. Table B-1 presents the categories of in-flight incapacitations of US airline pilots during the mentioned six-year period.

Figure B-1. Percent of U.S. airline pilot in-flight incapacitations and impairments as a function of age (1993 to 1998)

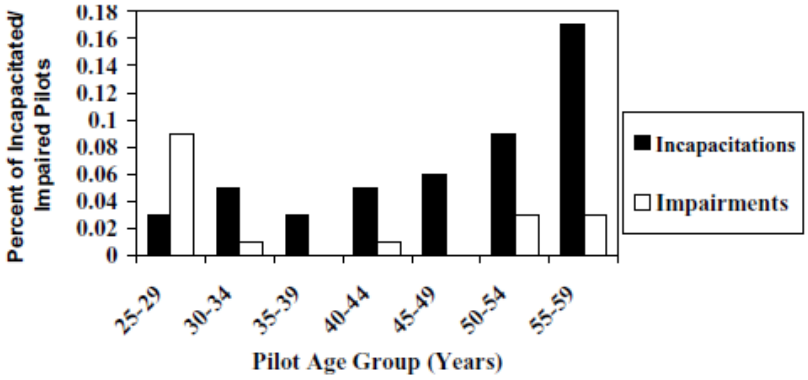


Table B-1. Categories of in-flight medical incapacitations of US Airline Pilots (1993 – 1998)

Cause of Incapacitation	Number	Percentage
Loss of Consciousness (LOC)	**9**	23.1%
Vasovagal syncope[47]	4	

[46] In-Flight Medical Incapacitation and Impairment of U.S. Airline Pilots: 1993 to 1998; by DeJohn CA, Wolbrink AM, Larcher JG; performed organization: FAA Civil Aerospace Medical Institute, American Airlines; Sponsoring Agency: Office of Aerospace Medicine, Federal Aviation Administration, October 2004.

[47] Vasovagal syncope is one of the most common causes of fainting. Vasovagal syncope occurs when your body overreacts to certain triggers, such as the sight of blood or extreme emotional distress. The vasovagal syncope trigger causes a sudden drop in your heart rate and blood pressure. That leads to reduced blood flow to your brain, which results in a brief loss of consciousness. (Ref: http://www.mayoclinic.org/diseases-conditions/vasovagal-syncope/basics/definition/con-20026900)

Neurogenic syncope[48] Duodenal bulb ulcer[49] Decompression sickness[50] Gastrointestinal	1 1 1 2	
Cardiac Myocardial infarctions Dysrhythmia Coronary spasm[51]	**5** 3 1 1	12.8%
Neurological Grand-mal seizures[52] Alcohol withdrawal seizure[53] Petit mal seizure[54]	**6** 4 1 1	15.4%
Gastrointestinal (GI) Cholelithiasis[55] Intestinal gas expansion with altitude Possible food poisoning	**6** 2 2 2	15.4%
Urological Renal lithiasis[56]	**3** 3	7.7%
hypoxia[57]	2	5.1%
diabetes	1	2.6%

[48] Neurogenic syncope encompasses a wide range of reflexogenic syncope that includes the vasovagal type, micturition syncope, carotid sinus hypersensitivity and post-prandial syncope.

[49] Duodenal ulcers may occur in the duodenal bulb. A number of mechanisms are placed throughout the digestive system to protect the mucosa from acid. When an alteration occurs in these protective factors, either due to intrinsic factors or extrinsic factors such as non-steroidal anti-inflammatory use, ulcers may result. The duodenal bulb is the first section of the duodenum, which is responsible for the breakdown of food and regulating the emptying of the stomach. (Ref: http://www.wisegeekhealth.com/what-is-the-duodenal-bulb.htm)

[50] Decompression sickness is caused by the formation of bubbles of gas that occur with changes in pressure. Ref: http://www.emedicinehealth.com/decompression_syndromes_the_bends/article_em.htm)

[51] Coronary artery spasm is a temporary, sudden narrowing of one of the coronary arteries (the arteries that supply blood to the heart). The spasm slows or stops blood flow through the artery and starves part of the heart of oxygen-rich blood. If the spasm lasts long enough, it may even cause a heart attack.

(Ref: http://www.nlm.nih.gov/medlineplus/ency/article/000159.htm)

[52] A grand mal seizure — also known as a generalized tonic-clonic seizure — features a loss of consciousness and violent muscle contractions. It's the type of seizure most people picture when they think about seizures in general. Grand mal seizure is caused by abnormal electrical activity throughout the brain. Most of the time grand mal seizure is caused by epilepsy. In some cases, however, this type of seizure is triggered by other health problems, such as extremely low blood sugar, high fever or a stroke. (Ref: http://www.mayoclinic.org/diseases-conditions/grand-mal-seizure/basics/definition/con-20021356)

[53] Alcohol withdrawal is the changes the body goes through when a person suddenly stops drinking after prolonged and heavy alcohol use. Symptoms include trembling (shakes), insomnia (inability to sleep), anxiety, and other physical and mental symptoms. Seizures may occur 6 to 48 hours after the last drink, and it is common for several seizures to occur over several hours. The risk peaks at 24 hours. (Ref: http://www.drugs.com/health-guide/alcohol-withdrawal.html)

[54] Petit mal seizure or absence seizure causes a short period of “blanking out” or staring into space. Like other kinds of seizures, they are caused by abnormal activity in a person’s brain. (Ref: http://www.epilepsy.com/learn/types-seizures/absence-seizures)

[55] Cholelithiasis is the presence of one or more calculi (gallstones) in the gallbladder. (Ref: http://www.merckmanuals.com/professional/hepatic-and-biliary-disorders/gallbladder-and-bile-duct-disorders/cholelithiasis)

[56] Kidney stones (renal lithiasis, nephrolithiasis) are small, hard mineral deposits that form inside your kidneys. The stones are made of mineral and acid salts. (Ref: http://www.mayoclinic.org/diseases-conditions/kidney-stones/basics/definition/con-20024829)

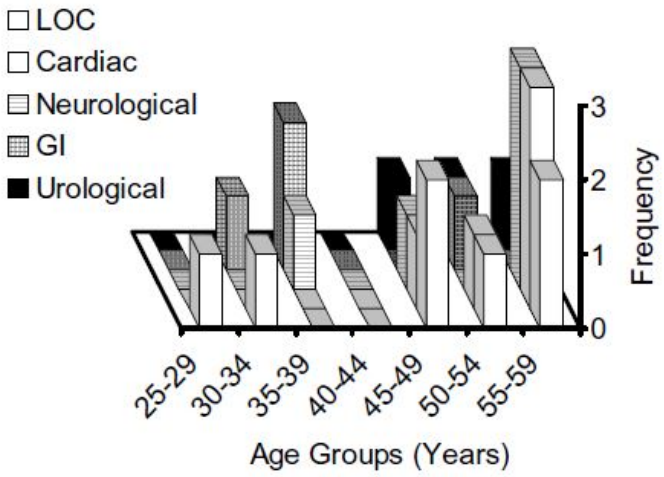
[57] Hypoxia, or altitude sickness, reduces the amount of oxygen in the brain causing such symptoms as dizziness, shortness of breath, and mental confusion. (Ref: http://medical-dictionary.thefreedictionary.com/hypoxia)

Decompression sickness	1	2.6%
vascular[58]	1	2.6%
reaction to medication[59]	1	2.6%
Traumatic injury[60]	1	2.6%
Miscellaneous	3	7.7%
Total	**39**	**100%**

The categories of in-flight medical impairment included respiratory (4), fatigue (2), vision (2), cardiac (1), gastrointestinal (1), and infectious disease (1).

As given in Figure B-2, it was found that the more serious categories, such as loss of consciousness secondary to ulcers, cardiac events like myocardial infarctions, and neurological seizures occurred more frequently in older pilots. The less serious medical categories, such as gastrointestinal events due to gas expansion and food poisoning and loss of consciousness due to vasovagal syncope, occurred more frequently in younger pilots.

Figure B-2. Most frequent categories of in-flight medical incapacitation by age of U.S. airline pilot



[58] Vascular means pertaining to blood vessels or indicative of a copious blood supply. (Ref: http://medical-dictionary.thefreedictionary.com/vascular)

[59] Adverse reactions to medications/drugs. Reactions range from irritating or mild side effects such as nausea and vomiting to life-threatening anaphylaxis. Anaphylaxis is a severe, whole-body allergic reaction to a chemical that has become an allergen. An allergen is a substance that can cause an allergic reaction. (Ref: http://www.nlm.nih.gov/medlineplus/ency/article/000819.htm)

[60] Traumatic injury is a term which refers to physical injuries of sudden onset and severity which require immediate medical attention. (Ref: https://ufhealth.org/traumatic-injury)