Air Accident Investigation Unit Ireland

SYNOPTIC REPORT

ACCIDENT

Boeing 737-8AS, EI-DWF
Near Perugia, Italy
18 July 2013

An Roinn Iompair Turasóireachta agus Spóirt

Department of Transport, Tourism and Sport

Foreword

This safety investigation is exclusively of a technical nature and the Final Report reflects the determination of the AAIU regarding the circumstances of this occurrence and its probable causes.

In accordance with the provisions of Annex 13[1] to the Convention on International Civil Aviation, Regulation (EU) No 996/2010[2] of the European Parliament and the Council, and Statutory Instrument No. 460 of 2009[3], safety investigations are in no case concerned with apportioning blame or liability. They are independent of, separate from and without prejudice to any judicial or administrative proceedings to apportion blame or liability. The sole objective of this safety investigation and Final Report is the prevention of accidents and incidents.

Accordingly, it is inappropriate that AAIU Reports should be used to assign fault or blame or determine liability, since neither the safety investigation nor the reporting process has been undertaken for that purpose.

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[1] **ICAO Annex 13**: International Civil Aviation Organization, Annex 13 to the Convention on International Civil Aviation, Aircraft Accident and Incident Investigation.
[2] **Regulation (EU) No 996/2010** of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation.
[3] **S.I. No. 460 of 2009**: Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulations 2009.

AAIU Report No: 2014-010
State File No: IRL00913059
Report Format: Synoptic Report
Published: 31 July 2014

In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No. 996/2010 and the provisions of S.I. No. 460 of 2009, the Chief Inspector of Air Accidents, on 19 July 2013, appointed Mr Thomas Moloney as the Investigator-in-Charge to carry out an Investigation into this Accident and prepare a Report. Mr John Owens, an Inspector of Air Accidents, was appointed to assist with the Investigation.

Aircraft Type and Registration:	Boeing 737-8AS, EI-DWF
No. and Type of Engines:	2 x CFM 56-7B26
Aircraft Serial Number:	33619
Year of Manufacture:	2007
Date and Time (UTC)[4]:	18 July 2013 @ 13.47 hrs
Location:	48 km south of Perugia, Italy N42°40'47.3'' E12°25'02.3''
Type of Operation:	Commercial Air Transport, Scheduled Passenger
Persons on Board:	Crew - 6 Passengers - 129
Injuries:	Crew - 1 Passengers - Nil
Nature of Damage:	None
Commander's Licence:	JAA ATPL(A)[5] issued by the Irish Aviation Authority (IAA)
Commander's Details:	Male, aged 39 years
Commander's Flying Experience:	3,880 hours of which 3,650 were on type
Notification Source:	Mandatory Occurrence Report from Operator
Information Source:	AAIU Accident Report Form AAIU Field Investigation

[4] **UTC**: Co-ordinated Universal Time. All timings in this report are quoted in UTC; to obtain the local time, add two hours.
[5] **JAA ATPL(A)**: Joint Aviation Authorities Airline Transport Pilot Licence (Aeroplanes)

SYNOPSIS

The aircraft was on a scheduled passenger flight from Rome Ciampino (LIRA), Italy to Leipzig (EDDP), Germany. While climbing in Instrument Meteorological Conditions (IMC)[6], it encountered sudden and unexpected severe turbulence in an area to the south of Perugia, Italy. At the time, the Cabin Crew were preparing for the in-flight service. One Cabin Crew Member (CCM) who was working in the rear galley was thrown into the air due to the severity of the event, struck the ceiling and fell heavily to the floor, sustaining a serious injury. The three other CCMs who were in the forward galley at the time were uninjured. All passengers were seated with their seat belts on and none were injured. No aircraft damage was reported.

NOTIFICATION

The Operator submitted a Mandatory Occurrence Report (MOR) which was notified by the AAIU to the Italian Aviation Safety Investigation Authority, ANSV[7]. The ANSV decided to delegate the Investigation to Ireland as the State of Registry.

1. FACTUAL INFORMATION

1.1 History of the flight

The aircraft departed from LIRA at approximately 13.33 hrs. The First Officer (FO) was the Pilot Flying (PF) and the Commander was the Pilot Monitoring (PM). The weather reports, which were reviewed by the Flight Crew prior to departure, did not indicate the presence of any turbulent weather conditions. As a result, no special instructions were relayed to the Cabin Crew by the Flight Crew.

During the early stages of the climb, the Commander released the Cabin Crew from their seated positions using the cabin call chime, to allow them to prepare for the in-flight service. Later in the climb, the Flight Crew became aware of some isolated cumulonimbus clouds (Cbs)[8] of considerable size to the north of Rome; the Cbs began to appear on the weather radar and they heard other aircraft on the same Air Traffic Control (ATC) frequency requesting heading deviations to avoid the Cbs. The Flight Crew decided to leave the passenger fasten seatbelt sign ON because of concern over possible associated turbulence. The Cabin Crew continued to work in the aircraft galleys.

From the weather radar returns, the Flight Crew noted that one particular Cb was on their intended routing. The Commander stated that they requested a heading deviation from ATC to avoid the Cb. This was granted and the Flight Crew circumnavigated the cloud formation.

[6] **Instrument Meteorological Conditions (IMC):** Weather conditions that require pilots to fly primarily by reference to instruments, and therefore under Instrument Flight Rules (IFR).

[7] **ANSV:** *Agenzia Nazionale per la Sicurezza del Volo*.

[8] **Cumulonimbus Clouds (Cbs):** Dense towering vertical clouds associated with thunderstorms and atmospheric instability.

When clear of the weather, they reported this to ATC and were given a clearance on a direct routing to their next waypoint[9]. Based on a review of the weather radar information, which indicated that the routing would not take the aircraft close to any Cbs, this clearance was accepted.

The Commander stated that when the aircraft was approaching Perugia (**Figure No. 1**), climbing from FL230[10] to FL340 in IMC, unexpected severe turbulence was encountered. Recorded data showed that GITOD was the closest Operational Flight Plan (OFP) waypoint to the encounter. Up to this point during the climb, the aircraft had reportedly experienced periods of intermittent and continuous light turbulence but the Commander stated that there was nothing on the weather radar to suggest that severe turbulence might occur. Following the turbulence, the autopilot disengaged and the Commander noticed a high rate of climb. He took over control and reduced the rate of climb. He then re-engaged the autopilot and the aircraft continued to climb to its cleared level. At this point, the aircraft became clear of cloud and continued climbing in Visual Meteorological Conditions (VMC) [11]. There were no higher cloud layers and consequently, the Flight Crew suspected that they had been approaching the cloud tops when the severe turbulence event occurred.

Figure No. 1: Location of Occurrence (*Google Maps*)

When the aircraft levelled off, the Commander handed back control to the FO and contacted the No. 1, the most senior CCM, to check if everybody was okay. The CCM advised that that one of the CCMs (the No. 2), who was working on her own in the rear galley at the time, had been badly hurt during the turbulence. The Commander advised the No. 1 that they could return to LIRA if necessary or make an unscheduled landing for emergency medical reasons.

[9] **Waypoint:** A specified geographical location, used for navigation purposes.

[10] **FL230**: Flight Level 230, a three digit representation of aircraft altitude (23,000 ft in this case) referenced to standard pressure (1013.25 hPa).

[11] **Visual Meteorological Conditions (VMC):** Conditions in which pilots have sufficient visibility to fly the aircraft maintaining visual separation from terrain and other aircraft.

The No. 1 informed the Commander that the No. 2 was in pain, but was fully conscious and had been made as comfortable as possible in a row of seats at the rear of the cabin and that she was content to continue to the intended destination.

In the descent to EDDP, the Commander made a request to ATC for medical services to meet the aircraft on arrival. On the ground at EDDP, the Commander spoke with the No. 2, who explained to him that during the event, she was lifted into the air, hit her head on the ceiling and had then fallen back to the floor, resulting in pain down one side of her body. She also advised that she could not walk. It was clear to the Commander that she was in severe discomfort. However, the CCM was insistent that she did not want to be left in EDDP, but wanted to seek medical attention on her return to LIRA, as she was living in Rome.

Following consultation with the Operator's Operations department and because there were less than 150 passengers on the return flight, it was agreed that the aircraft could operate back with three CCMs. The injured CCM travelled back to LIRA lying across three seats at the rear of the passenger cabin. The aircraft departed EDDP and during the descent to LIRA, the Flight Crew made a request to ATC to arrange for medical services to meet the aircraft. On arrival in LIRA, the injured CCM was lifted from the aircraft. When she subsequently attended hospital the following day, she was diagnosed with a fractured pelvis.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Serious	1	0	0
Minor /None	5	129	

1.3 Damage to Aircraft

No damage to the aircraft was reported.

1.4 Interviews

The Flight Crew and Cabin Crew were interviewed by the Investigation. In addition the Commander submitted a detailed written report.

1.4.1 Flight Crew

The Commander said that he reviewed the weather charts contained in his briefing pack in LIRA when preparing for the flight. He stated that his interpretation was that *"the weather was pretty good"*. The FO confirmed this by stating that: "*Even looking at it now, if I had something like this today, I would make the same consideration – weather is good*".

The Commander reported that during the climb, he became aware of some Cbs: "*It soon became apparent that there were aircraft requesting radar headings to avoid and then on the weather radar, there was certainly one Cb that appeared on our intended routing…..with consent from ATC, we negotiated a heading to take us around*". He said that there was no mention of turbulence in the ATC communications and confirmed that the Cbs they saw were "*mature, big Cbs*" that were "*beginning to dissipate*".

There was no thermal variation noticed. In the written report submitted earlier by the Commander, he stated that he decided to leave the passengers seated "*owing to the concern of possible associated turbulence*".

The Commander said that, after they bypassed the Cb, they reported clear of weather to ATC and were given clearance to FER[12] waypoint. He reported that while climbing and routing towards that point, the aircraft entered IMC and was in IMC when they encountered the severe turbulence. He confirmed to the Investigation that there was "*light buffeting*" before the severe turbulence and that "*it went from light buffeting to suddenly, a sharp downwards motion and then up again… and that might have happened at least one more time, but it was very sudden…it lasted for around five seconds and possibly a maximum of ten*". When asked how far clear of the Cb he was at the time, he said that it was "*at least ten miles*". He confirmed that nothing was detected on the weather radar when the severe turbulence was encountered. The FO said that aircraft speed was approximately Mach[13] 0.76 "*the recommended turbulence penetration speed".* When the aircraft reached FL340, conditions were VMC again, "*with nothing of concern being indicated on the weather radar*".

The Commander said that he did not inform ATC of the occurrence, as he was busy dealing with what had happened. However, he said that he did advise the passengers that the aircraft had experienced some bad turbulence and to remain in their seats when the seatbelt sign was on. He stated that the seatbelt sign was on throughout the entire climb and that none of the passengers was injured.

Having been made aware that a CCM was injured, the Commander said that he wanted to ascertain whether a diversion or a return to LIRA was necessary. He said that he was "*trying to gauge whether she was in a condition whereby time was of the essence and we needed to get her on the ground as soon as possible*" and he was "*relying on effective communication through the No. 1*". He confirmed that neither he nor the FO left the flight deck during the flight, but that the No. 1 informed him that the injured CCM was okay to continue to the destination.

The Commander confirmed that he liaised with ATC in relation to obtaining medical attention on arrival in EDDP. He said that he didn't speak to the doctor in person in EDDP, but that the dispatcher told him that the doctor had seen the CCM and advised that she was fit to fly back to LIRA. The Commander said that he wanted the CCM to go to hospital in Leipzig, but that the she wanted to return to LIRA.

The Commander advised that, while he had spoken to Operations about the event, he did not communicate with the Operator's Maintenance Control. No entry was made in the Technical Log.

[12] **FER:** A waypoint near Ferrara in northern Italy with latitude N44°48'52" and longitude E11°36'59".
[13] **Mach (Number):** The ratio of the aircraft's speed to the speed of sound in the same atmospheric conditions.

1.4.2 Injured Cabin Crew Member

The Investigation spoke by telephone with the injured CCM who was at her residence in Rome. The CCM stated that she was operating as the No. 2 and was seated in the rear of the cabin for take-off. She said that shortly after take-off, the Commander released the Cabin Crew from their seated positions to prepare for the in-flight service. She said that the No. 3 CCM went to the front of the aircraft to assist with the preparations and that the No. 1 requested her (the No. 2) to check something in a trolley, which was open, but still stowed in the rear galley. She said "*It was bumpy so I was seated. It felt to be really, really bumpy, so I closed the trolley and I was trying to fasten my harness but I didn't manage*". The CCM said "*I was sitting next to R2 door* [the rear R/H door] *and then I was taken up to the ceiling and I fell down all the way next to L2 door. I fell down on the side of my hip. I had no feeling at all in my hip*". The CCM confirmed that the severe turbulence occurred suddenly.

She said that the other CCMs then placed her in a row of seats. She stated that the No. 1 had asked her if she wanted him to tell the Commander to divert and she had replied, *"I'm the casualty, I won't decide about diversion of the plane."* The No. 2 explained to the Investigation that, as she was in shock and a lot of pain, she felt that she was the last one who should be making such a decision. On arrival in EDDP she asked the Commander not to offload her because she didn't want "*to be alone in Germany*".

She said that on return to LIRA, an ambulance attended the aircraft which took her to the airport first-aid centre. She was examined there and was advised to attend a hospital. She said that because it was late when she left the first-aid centre, she went to the hospital the following day. When she was x-rayed, there was no specialist on duty who could review her results. Consequently, she stayed in hospital overnight and was informed on the following day that she had sustained a fracture to her pelvis. She was then discharged and was told that no special treatment was required but she was advised to remain in bed for 30 days.

When asked if she was surprised that the Cabin Crew had been released for their duties, she replied that it was "*More or less as usual… ...It is really often that we are working with the turbulence. I didn't notice anything unusual*".

1.4.3 Other Cabin Crew Members

The other CCMs outlined the normal working positions for each CCM during a flight. They advised that the No. 1 and No. 4 normally work in the forward galley and the No. 2 and No. 3 work in the rear. The No. 1 is usually most experienced, followed by the No. 2 and so on.

The CCMs were asked about their pre-flight briefing with the Commander. They said that "*We spoke about the weather… and he said that around the area there were a few storms…but the forecast was saying that there was nothing to be worried about, no turbulence expected".* The No. 1 confirmed that the weather conditions were normal for LIRA and had "*no particular concern about the weather before the flight*".

The No. 1 said that the Cabin Crew were released as normal during the climb and said: "*it was a sunny day….in a few seconds,….everything became dark….so I understood that maybe it was going to be really bumpy, so I just had the time to grab the latches ….of the stowage, so I grabbed them"*. He stated that the severe turbulence occurred four to five minutes after they were released, which was 10 to 13 minutes after take-off. He confirmed that the severe turbulence lasted for "*a few seconds…five, six seconds*".

When the No. 1 thought it was safe to move, he said that he looked into the cabin and could see that the passengers were okay as they were all seated. He noticed some portable electronic devices belonging to passengers lying on the cabin floor and that a passenger in one of the most aft rows was trying to get his attention. When he then went to the rear of the cabin, he saw the injured CCM. He said that he ensured that she could speak properly and that she could move her limbs. He requested some passengers to move and he put the injured CCM into a row of three seats and strapped her in. He said that he then advised the Commander about what had happened. When asked by the Commander if a diversion or a return to LIRA was required, the No. 1 said that he informed the Commander that that the injured CCM said she was okay to travel to EDDP. The No. 1 stated that he didn't make an announcement to establish if a doctor or nurse was on board who may have been able to provide assistance, because at the time, the aircraft was still moving a lot and he didn't want to risk any further injuries.

He confirmed to the Investigation that even though the Commander releases the Cabin Crew to perform their duties, the No. 1 can request that the Cabin Crew remain seated. He added that "*when he released us….the condition was smooth*" and that the turbulence occurred suddenly**.** He stated that "*the front of the cabin moved less than the tail of the aircraft….at the back, I think it was much stronger than in the front*".

1.5 Personnel Information

1.5.1. Aircraft Commander

Personal Details:	Male, aged 39 years
Licence:	JAA ATPL - Valid
Total all Types	3,880 hours
Total on Type	3,650 hours
Total P1 on Type:	2,275 hours
Last 90 Days:	176 hours
Last 28 Days:	45 hours
Last 24 Hours:	6 hours

1.5.2 First Officer

Personal Details:	Male, aged 28 years
Licence:	JAA CPL[14] - Valid
Total all Types	1,050 hours
Total on Type	840 hours

[14] **CPL:** Commercial Pilot Licence

1.6 Aircraft Information

The Certificate of Airworthiness for the aircraft was issued by the IAA on 3 October 2007. The Airworthiness Review Certificate in force at the time of the occurrence was issued on 3 October 2012 and was valid until 2 October 2013. The in-flight manoeuvring load acceleration limits (flaps up) of the Boeing 737-800 are +2.5 g[15] to -1.0 g.

1.7 Flight Recorders

The Operator provided the Investigation with Flight Data obtained from the aircraft's Quick Access Recorder (QAR). **Figure No. 2** includes a graphical representation of the following parameters: Altitude (blue), vertical acceleration (green), longitudinal acceleration (magenta), lateral acceleration (grey) and autopilot (orange).

The QAR data shows that the aircraft took off at 13.33:30 hrs from RWY 15 in LIRA and climbed initially on a southerly heading. It then turned right onto a heading of 240° which was followed by a left turn onto a heading of 360°. After approximately one minute on this heading, the aircraft turned left onto 340° at 13.38:40 hrs and it remained on this heading until several minutes after the turbulence encounter.

It can be seen from the vertical acceleration parameter in **Figure No. 2** that the severe turbulence was encountered suddenly at 13.47:05 hrs at an altitude of approximately 31,000 ft (FL 310). After approximately four seconds, a maximum positive acceleration of 1.95 g was recorded. Five seconds later, the maximum negative value of -0.46 g occurred, quickly followed by a positive acceleration of 1.52 g. Four seconds after this, the turbulence had effectively ceased. Lateral and longitudinal disturbance coincided with the vertical acceleration. The autopilot disengagement is shown by the step in the orange line. The data indicates that no significant turbulence preceded the event.

Since the aircraft continued in service after the occurrence and the Flight Crew did not pull the Cockpit Voice Recorder (CVR) Circuit Breaker, the CVR, which has a nominal recording duration of two hours, was over-written.

[15] **g:** A measurement of acceleration due to gravity, which is normally felt as weight. At 2g, the human body feels a gravitational force equal to twice its normal weight.

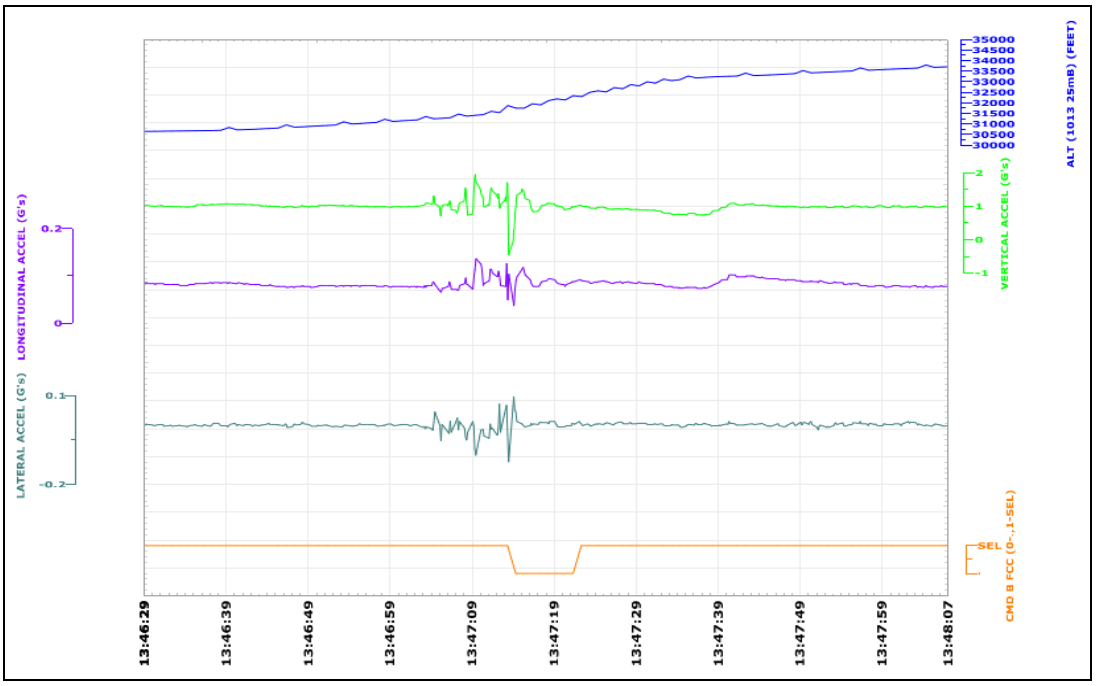

Figure No. 2: Graphical representation of Flight Data extract

1.8 Meteorological Information

1.8.1 Forecasts and Operator Guidance Material

The meteorological data provided to the Flight Crew by the Operator, as part of the briefing pack for the flight, included prognostic weather charts for 12.00 hrs and 18.00 hrs, (**Appendix A**). Neither chart indicated any Cb activity over the Italian peninsula. On the chart for 12.00 hrs, occasional embedded Cbs were forecast over northern Italy for FL370. The forecast for 18.00 hrs indicated that these would expand in northerly, easterly and westerly directions and would be present at FL340. The charts note that the presence of Cb implies thunderstorms, hail, moderate or severe turbulence and ice.

An OFP is generated by the Operator for each flight. Section 8.1.10.1 of the Operator's Operations Manual contains guidance on the "Shear Values" included on the OFP. It states that: "*Theoretically there is no upper limit to the value, but generally it will appear as a single digit. The wind shear value is calculated from wind speed and direction samples taken from 2,000 ft above and 2,000 ft below the datum level. The lower the number, the less chance of turbulence. Moderate turbulence can be expected whenever the shear value is equal to or greater than three. Severe turbulence can be anticipated whenever the shear value is equal to or greater than five*".

The shear value contained on the OFP for the waypoint GITOD, which was in the vicinity of the turbulence encounter, was '2'. All other shear values on the OFP were '2' or less, (**Appendix B**).

1.8.2 Additional Information

The ANSV was requested to obtain details of the actual weather conditions that existed in the area at the time of the event. They provided a High Resolution Visible (HRV) satellite image showing the cloud activity over Italy at the time of the occurrence. The SIGMET[16] and AIRMET[17] messages that were issued on the day of the occurrence were also provided.

In addition, the ANSV confirmed that other aircraft in the area were making route deviations to avoid weather and that none of these reported experiencing turbulence.

The AIRMET message for the Milan Flight Information Region (FIR) for 12.50 hrs to 16.50 hrs restricts the thunderstorm activity to the Alpine and the Liguria[18] areas. However, the AIRMET issued for the Rome FIR at this time, referred to isolated thunderstorms, Cbs and Towering Cumulus[19] clouds in the north and central Apennine area. This includes the area where the severe turbulence was encountered. The SIGMETs for the Milan and Rome FIRs valid for 12.50 hrs to 16.50 hrs did not indicate the presence of any Cbs in this area. However, the SIGMETs issued later for both FIRs referred to embedded thunderstorms in this area **(Appendix C).** The HRV satellite image of the Italian peninsula indicates the presence of Cb activity adjacent to the incident area (**Appendix D**). This was not forecast on the weather charts obtained by the Flight Crew as part of their pre-flight briefing pack.

1.9 Standard Operating Procedures (SOPs)

The Operator provided the Investigation with extracts from their Operations Manual.

1.9.1 Turbulence

Regarding pre-flight briefings in relation to turbulence, Section 2.29.3, "*Flight Crew notification to Cabin Crew*", states that: "*Pre-flight, the Captain shall advise the No. 1 of the expected levels of turbulence en route*".

A table in Section 2.29.4 "*Actions to be taken by Cabin Crew*" contains definitions and specific instructions for each level of turbulence. Extracts from the table are included below (**Table No. 1**).

[16] **SIGMET:** (Significant Meteorological Information): is a weather advisory that contains meteorological information concerning the safety of all aircraft. This information is usually broadcast on the ATIS (Automatic Terminal Information Service) at ATC facilities.

[17] **AIRMET** (Airmen's Meteorological Information): An AIRMET is a concise description of weather phenomena that are occurring or may occur along an air route that may affect aircraft safety. Compared to SIGMETs, AIRMETs cover less severe weather: including moderate turbulence and icing, sustained surface winds of 30 knots or more, or widespread restricted visibility. AIRMETs are broadcast on the ATIS at ATC facilities, and are referred to as Weather Advisories.

[18] **Liguria:** North-west coastal region of Italy, bordering France.

[19] **Towering Cumulus clouds** (TCUs) are also known as Cumulus congestus clouds and are characteristic of unstable areas of the atmosphere. They may develop into cumulonimbus under conditions of sufficient instability.

Levels of Turbulence			
	Light	**Moderate**	**Severe**
Conditions inside of aircraft	• Liquids are shaking, but not splashing out of cups. • Trolleys can be manoeuvred with little difficulty. • Passengers may feel a slight strain against seat belts.	• Liquids are splashing out of cups. Trolleys are difficult to manoeuvre. • Difficult to walk. Difficult to stand without balancing or holding onto something. • Passengers feel definite strain against seat belts.	• Items are falling over or lifting off floor. • Unsecured objects are tossed about. • Drinks, duty free and food services and walking are impossible. • Passengers are forced violently against seat belts.
Cabin Service	Continue with caution	Discontinue	Discontinue immediately
Other relevant points		Cabin Crew take their seats once duties are complete	Take the nearest available seat (Passenger seats and floor included).

Table No. 1: Cabin Crew Procedures during turbulence

A warning is included in this Section stating: *"If unexpected moderate or severe turbulence is encountered, the No. 1 shall instruct CC* [Cabin Crew] *to take their seats. No. 1 can make a PA*[20] *from the jump seat advising passengers to fasten their seat belts and remain seated".*

This section also contains the actions to be taken by CC during turbulence. It states: "*Do not risk injury by continuing service during unsafe conditions*" and "*The No. 1 shall immediately advise all CC of any turbulence information received from the Captain pre-flight".* It also states*: "Do not wait for Flight Crew advice to be seated if the conditions in the cabin warrant you to do so".*

The following note is also included: *"In the absence of any instruction from the Flight Crew, the senior CC shall be entitled to discontinue non-safety related duties and advise the Flight Crew of the level of turbulence being experienced and the need for the fasten seatbelt signs to be switched on. This shall be followed by the CC securing the passenger cabin and other applicable areas".*

[20] **PA**: Passenger Address

Section 8.3.10 of the Operations Manual Part A, "*Crew at their stations",* states that the "*The minimum altitude for releasing the CCMs from their seats shall be 3,000 ft AGL* [Above Ground Level]. *This is achieved by pressing the Cabin Crew call bell once. When releasing the cabin, crews are reminded that the safety of the operation must take precedence over passenger service requirements. If the Commander considers that the departure routing could be affected by adverse weather, he should delay releasing the Cabin Crew from their seats. Where weather forecasts indicate the possibility of adverse weather, the Cabin Crew should be briefed prior to departure*".

Several sections contain guidance on turbulence. Section 8.3.8.3.1 states that turbulence is categorised as: "*Light*", "*Moderate*" or "*Severe*" and that "*Seat belts are usually switched ON for light to moderate and higher categories of turbulence. It is a requirement for all passengers to be seated with seat belts fastened and for all cabin service to be terminated for moderate or higher categories of turbulence. For severe turbulence, Flight Crew and cabin must be strapped in using the full harness".*

It also states that *"Flight Crew members encountering turbulence should report the conditions to ATC".*

Section 8.3.8.1.7.4 deals with avoidance of thunderstorms and hail. It states, *inter alia*, *"The following procedures should be adopted if a Flight Crew member has to fly through a storm area:*

- *…Avoid any storm with sharp shear and heavy turbulence;*
- *Fly at least five miles from storms below freezing level and at least 10 miles from storms above freezing level;*
- *Avoid by at least 10 miles any storm which is changing shape rapidly:*
- *Fly well clear of rapidly developing storm echoes"…*

1.9.2 Safety Alert Initial Reports

Section 11.3.4 of the Operations Manual contains information on Safety Alert Initial Reports (SAIRs) used for reporting incidents and accidents. It states in this section that where incidents involve a "*System failure, damage to the aircraft, birdstrike, lightning strike, severe turbulence and/or airframe exceedances, a corresponding tech log entry shall be made".*

1.9.3 Flight Recorders

Section 1.4.2 of the Operations Manual Part A describes the authority and responsibility of the Commander. It states that the Commander shall "*not permit a flight recorder to be disabled, switched off or erased during flight nor permit recorded data to be erased after flight in the event of an accident or an incident subject to mandatory reporting*".

Section 8.9.5.4.6 contains the requirements regarding the preservation of CVR data: "*It is a mandatory requirement to preserve CVR data after an incident/accident and it is the responsibility of the aircraft commander to ensure that the yellow collared CVR circuit breaker is pulled at the earliest opportunity on the ground following any of the following serious incidents*".

Injuries due to turbulence are not specifically mentioned in the list. However, one of the items included is for "*any other incident where the Commander believes that CVR data would be useful in any subsequent investigation*".

Related to this Operations Manual section, the Operator issued a Flight Crew Instruction (FCI) on 4 April 2013 to clarify the incidents that require flight crews to preserve CVR data (Document reference: Gen 13.08). An additional note was included in the procedure to state that, following a listed incident, the Commander shall pull the CVR circuit breaker and advise Operations Dublin of the incident and CVR action. The note also states that the decision to retain the CVR data or to dispatch after such an incident occurs can only be made following consultation with specific operational management personnel as listed in the FCI.

1.10 Aircraft Maintenance Manual (AMM)

AMM TASK 05-51-04-210-801 refers to the maintenance inspections required following "*Severe or Unusual Turbulence, Excessive Maneuver, Buffet, or Speeds More than the Design Limits*".

Severe or unusual turbulence is defined within this AMM section. The requirements for when a maintenance inspection is required are also included.

This section states that: "*Severe turbulence is identified as turbulence which causes large, abrupt changes in the altitude and/or attitude. The airplane could be out of control for short periods. It usually causes large variations in airspeed. Passengers and crew are moved violently against their seat belts and loose objects are moved around the airplane*".

It is also stated that: "*An inspection is required when the aircraft has encountered severe turbulence. The pilot must report the suspected encounter of this event. If the pilot reports that the aircraft has encountered severe turbulence, refer to 'Examine Airplane Structure and Wing Areas' and 'Cabin Inspections' in this section*".

2. ANALYSIS

2.1 Pre-Flight Briefings and Release of Cabin Crew

As part of their normal pre-flight preparation, the Flight Crew reviewed the weather charts included in the flight pack. The prognostic charts for 12.00 and 18.00 hrs showed localised areas of occasional embedded Cb over the north of Italy. The presence of Cb implies thunderstorms, hail, moderate or severe turbulence and ice, **Appendix A**. However the charts did not indicate any areas of potential difficulty over peninsular Italy. Additionally, the Shear Values included on the OFP associated with each navigational waypoint on the intended routing were '2' or less. The Operator's SOPs state that moderate turbulence can be expected whenever the shear value is equal to or greater than three and severe turbulence can be anticipated whenever the shear value is equal to or greater than five. Consequently, the Flight Crew had no particular cause for concern about the weather conditions and therefore no pre-flight warnings were issued to the Cabin Crew.

The Operator's procedures allow the release of Cabin Crew at altitudes above 3,000 ft and state that *"If the Commander considers that the departure routing could be affected by adverse weather, he should delay releasing the Cabin Crew from their seats".* In this case, no adverse weather was forecast and *t*he Commander released the Cabin Crew from their seated positions early in the climb as permitted. The No. 1 confirmed that conditions were smooth when they were released.

2.2 Cabin Crew Injury

During the climb, the Commander became aware of some isolated Cbs to the north of Rome and decided to leave the passengers seated "*owing to the concern of possible associated turbulence*". He then noticed, both visually and by the indications on the aircraft's weather radar, that one particular Cb was on his intended heading. He requested clearance from ATC to navigate around this Cb. This is likely to have been the 20° deviation to the left made at 13.38:40 hrs as shown on the QAR data. Flight crews from other aircraft in the area were requesting similar clearances, but turbulence was not mentioned in the associated communications.

When the aircraft became clear of the Cb and with no significant returns showing on the weather radar, the climb was continued in IMC conditions, in what was described by the Commander to be "*light buffeting*". Severe turbulence was then encountered which only lasted for a few seconds. Because it occurred suddenly, as verified by the QAR data, a warning was not issued by either the Flight Crew or the No. 1 CCM.

The Operator's procedures permit the Cabin Crew to continue the cabin service with caution during light turbulence. For moderate turbulence they must take their seats once duties are complete, but for severe turbulence they are required to take their seats immediately or use the nearest available passenger seat. At the time, the No. 2 CCM was working on her own in the rear galley. She said that it was "*bumpy*" so she was seated. However, when the severe turbulence occurred, she did not have sufficient time to fasten her harness. She was thrown out of her seat, struck the ceiling and fell back down, sustaining a fractured pelvis.

Negative vertical acceleration, such as the value of -0.46 g recorded in this event, will cause an effect of reduced weight which will result in an unsecured person or object moving towards the aircraft ceiling. The person or object will then drop to the floor when positive 'g' is restored. In this case, the negative acceleration was immediately followed by a positive acceleration of 1.52 g, which would have the effect of a much heavier fall than at the normal 1g.

Having been informed that the No. 2 CCM was injured, the Commander asked the No. 1 to establish if a diversion or a return to LIRA was necessary. The No. 1 advised the Commander that the No. 2 said she was okay to continue to the planned destination and the flight continued to EDDP. The injured No. 2 informed the Investigation that, as the casualty, she would not make a decision about diverting the aircraft and that she considered that she was the last person who should be making such a decision. Had the true extent of her injuries been known, a diversion or return to LIRA would have been prudent.

On arrival in EDDP, the injured CCM was spoken to by the Commander and was seen by a doctor. It was clear to the Commander that the No. 2 was in considerable discomfort and as a result, he wanted her to go to hospital. However, the CCM was anxious to return to LIRA, as she lived in Rome. With the doctor's permission, and following consultation with his Operations department, the Commander agreed to bring her back. Again, had the exact nature of her injuries been known, it may have been appropriate for her to remain in EDDP and attend a hospital there, rather than risk additional complications during the return flight to LIRA.

2.3 Injury Prevention

In circumstances such as those encountered on this flight, it is often difficult for flight crews to predict the onset of severe turbulence and to provide timely warnings to cabin crew working in the cabin to return to their seats to avoid the possibility of injury. However, the Operator's SOPs contain a requirement to advise ATC if turbulence is encountered. Following this event, the Flight Crew stated that they were busy trying to establish the nature of the CCM's injuries and as a result, ATC were not informed of the turbulence. It should be noted that prompt notification to ATC could help other aircraft in the area avoid similar encounters and possibly prevent further injuries. Accordingly, a Safety Recommendation is issued to the Operator to remind flight crews of this requirement:

Safety Recommendation No. 1
It is recommended that Ryanair Limited should remind flight crews of the requirement to inform ATC whenever turbulence is encountered, as contained in their Operations Manual, Section 8.3.8.3.1. (IRLD2014023)

The Operator has informed the Investigation that a memo will be issued reminding flight crews of their responsibility to inform ATC whenever turbulence is encountered.

2.4 Weather Forecasts

The weather prognostic charts received by the Flight Crew as part of their flight briefing pack did not indicate the presence of Cb activity over the Italian peninsula. Additionally, the SIGMETs valid at the time of the occurrence did not highlight Cbs or thunderstorms in the Apennine area, which includes the area where the turbulence was encountered. However, such activity was referred to in the AIRMET issued at 12.50 hrs for the Rome FIR.

The Flight Crew were aware of Cb activity on their flight path and, like other aircraft in the area, they requested and received ATC clearance to bypass this. Nevertheless, this event highlights the importance of accurate weather forecasting and its role in flight planning and associated pre-flight briefings.

2.5 Cockpit Voice Recorder

A CVR recording was unavailable to the Investigation since the aircraft continued in service after the occurrence and the CVR was over-written. An injury due to turbulence is not specifically mentioned in the Operator's list of serious incidents requiring the preservation of CVR data. However, the list includes "*Any other incident where the Commander believes the CVR data would be useful in any subsequent investigation*".

When the aircraft landed in EDDP, the Flight Crew members were busy dealing with the injured CCM and consulting with their operations department concerning the situation. This was in addition to their normal pre-flight duties. Furthermore, the extent of the CCM's injuries was unknown. Thus, the preservation of the CVR may not have been considered.

2.6 Aircraft Inspection

In its definition of severe turbulence, the AMM includes the sentence "*Passengers and crew are moved violently against their seat belts and loose objects are moved around the airplane"*. In the circumstances, the Investigation considers that this event may be characterised as a short encounter with severe turbulence. The Commander informed the Investigation that he did not inform Maintenance Control following the event and a maintenance inspection as required by the AMM following an encounter with severe turbulence was not performed. Consequently, a Safety Recommendation is made to the Operator to remind flight crews of this requirement:

Safety Recommendation No. 2
It is recommended that Ryanair Limited should remind flight crews of the AMM requirement for a maintenance inspection following an encounter with severe turbulence and of the requirement to make a corresponding Technical Logbook entry as contained in their Operations Manual, Section 11.3.4. (IRLD2014024)

The Operator has informed the Investigation that a memo will be issued reminding flight crews of their responsibility to complete a Technical Log entry whenever severe turbulence is encountered.

3. CONCLUSIONS

(a) Findings

1. Both Pilots were properly licensed and held valid medical certificates.

2. The airworthiness certification for the aircraft was valid.

3. The weather data contained in the Flight Crew's briefing pack did not indicate any Cb activity in the vicinity of Perugia.

4. The Shear Values included in the Operational Flight Plan for each navigational waypoint were all '2' or less, indicating that only light turbulence could be expected.

5. Prior to departure, the Flight Crew understood that en route weather conditions were good and consequently no specific instructions were relayed to the Cabin Crew in relation to the weather conditions.

6. The Cabin Crew were permitted to leave their crew seats shortly after departure from LIRA, in accordance with SOPs.

7. The "Fasten seat belt" sign remained on and as a result all passengers were seated.

8. The Flight Crew became aware of a Cb on their intended routing and requested clearance from ATC to navigate around it.

9. Shortly after they had advised ATC that they were clear of the Cb, the aircraft encountered sudden and unexpected turbulence.

10. Due to the sudden and unexpected nature of the turbulence, no prior warning was issued by the Flight Crew to advise the Cabin Crew of potential turbulence.

11. During the turbulence, the aircraft experienced a maximum positive vertical acceleration of 1.95 g and a maximum negative vertical acceleration of -0.46 g.

12. A CCM who was working in the rear galley sustained a serious injury (later diagnosed as a fractured pelvis) as a result of the turbulence encounter.

13. The Flight Crew did not advise ATC that severe turbulence had been encountered.

14. The aircraft continued to its scheduled destination with the injured CCM lying down in a seat row at the rear of the cabin. The injured CCM, at her request and with medical permission, returned to LIRA in the same position.

15. A Technical Logbook entry, indicating that the aircraft had encountered severe turbulence, was not made. As a consequence, a maintenance inspection was not immediately carried out.

(b) Probable Cause

Unrestrained movement of the No. 2 CCM during sudden and unexpected severe turbulence.

(c) Contributory Factors

Cb activity and turbulence was not forecast over peninsular Italy in the prognostic weather charts included in the Flight Crew's briefing pack.

4. SAFETY RECOMMENDATIONS

No.	It is Recommended that:	Recommendation Ref.
1.	Ryanair Limited should remind flight crews of the requirement to inform ATC whenever turbulence is encountered as contained in their Operations Manual, Section 8.3.8.3.1.	IRLD2014023
2.	Ryanair Limited should remind flight crews of the AMM requirement for a maintenance inspection following an encounter with severe turbulence and of the requirement to make a corresponding Technical Logbook entry as contained in their Operations Manual, Section 11.3.4.	IRLD2014024

View Safety Recommendations for Report 2014-010

Appendix A

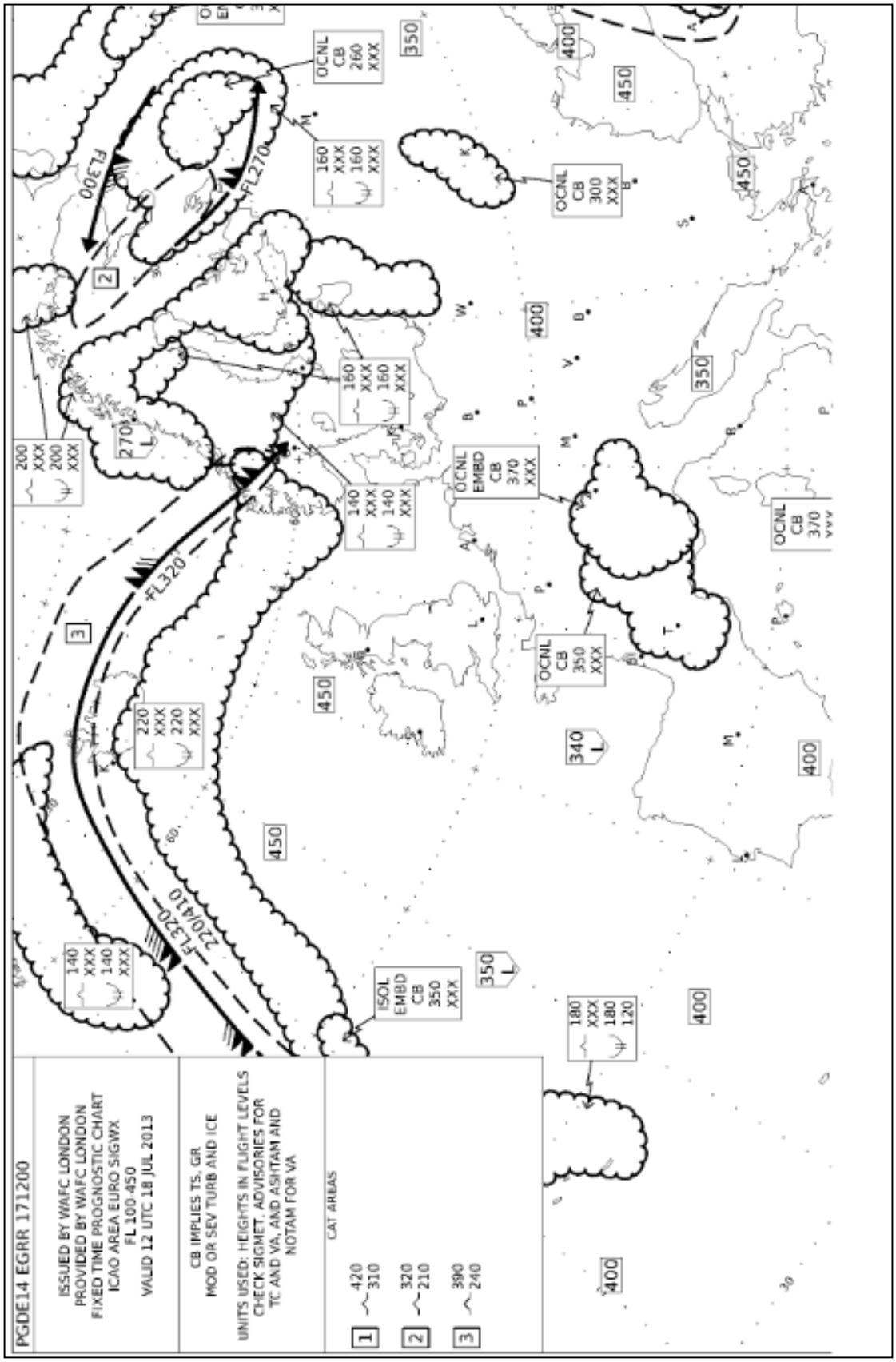

Figure No. 3: Prognostic Chart for 12.00 hrs issued to the Flight Crew.

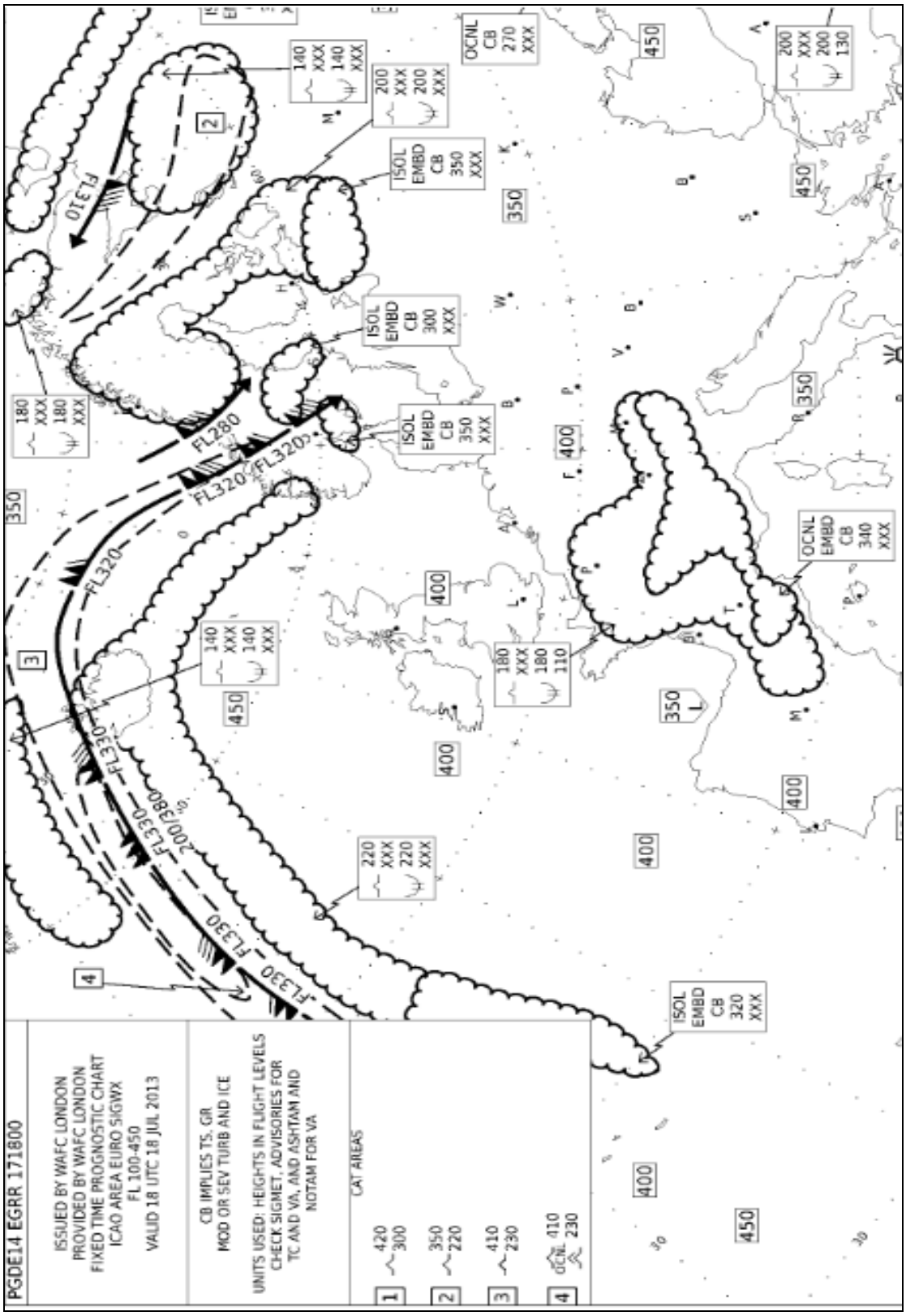

Figure No. 4: Prognostic Chart for 18.00 hrs issued to the Flight Crew.

Appendix B

DREM	FREM	AREM	G/S	W/V	S.H	STAGE	S	FREQ	MTK	DIS	TM	ETA	ATA	FL
759	7088					TAXI								
705	6160				12.0	PEMAR			044	54	10	:	:	
675	5680				12.0	T-O-C			328	30	6	:	:	
651	5553		420	25020	12.0	GITOD	2		327	24	3	:	:	
617	5377		419	25020	9.7	VERUN	2		328	34	5	:	:	
603	5305		425	25020	8.1	DENAL	2		351	14	2	:	:	
589	5233		425	25020	8.1	VERNA	2		350	14	2	:	:	
580	5187		425	25020	8.1	BAGNO	2		351	9	1	:	:	
559	5080		425	25020	8.1	PELEG	2		350	21	3	:	:	
539	4978		423	26020	5.8	SUKOM	2		350	20	3	:	:	
523	4896		423	26020	10.2	FER	2	343.00	350	16	2	:	:	
486	4708		423	25015	10.2	ALBET	1		351	37	5	:	:	
473	4642		422	25011	10.2	VADIK	1		352	13	2	:	:	
449	4520		422	25011	14.0	DIKEM	1		351	24	3	:	:	
440	4474		420	25011	14.0	KODUV	1		350	9	1	:	:	
436	4454		420	25011	14.0	SUMIR	1		351	4	1	:	:	
424	4393		420	25011	14.0	BZO	1	362.00	352	12	2	:	:	
405	4297		422	25011	14.0	OGEPI	1		002	19	3	:	:	
393	4237		422	25011	14.0	BRENO	1		003	12	2	:	:	
378	4162		422	25011	14.0	INN	1	420.00	003	15	2	:	:	
369	4117		421	25011	13.8	NORIN	1		358	9	1	:	:	
355	4047		425	21011	13.8	KOGOL	1		358	14	2	:	:	
341	3978		427	17011	13.8	KONIN	1		353	14	2	:	:	
316	3855		427	17011	13.8	MAH	1	D115.20	352	25	4	:	:	

Figure No. 5: Extract from the Operational Flight Plan received by Flight Crew showing Shear Values of '2' or less.

Appendix C

Extracts from weather information supplied by the ANSV (Relevant sections highlighted in blue and outlined with a border).

AIRMET

WAIY31 LIIB 181240

LIMM AIRMET 04 VALID 181250/181650 LIMM-
LIMM MILANO FIR SFC VIS 3000/5000 M TSRA RA FCST W AND S PART MAINLY LIGURIAN AREA STNR NC.
LIMM MILANO FIR EMBD CB/TCU OBS SW PART AND CENTRAL ALPS STNR NC.
LIMM MILANO FIR MT OBSC OBS W AND CENTRAL ALPS AND N APPENNINI STNR NC=

WAIY32 LIIB 181045

LIRR AIRMET 01 VALID 181050/181250 LIMM-
LIRR ROMA FIR ISOL TS AND CB/TCU OBS N PART MAINLY N TYRRHENIAN SEA STNR NC=

WAIY32 LIIB 181250

LIRR AIRMET 02 VALID 181250/181650 LIMM-
LIRR ROMA FIR ISOL TS AND CB/TCU OBS N AND CENTRAL APPENNINI AND TUSCANY AND LAZIO AND SARDINIA AREAS STNR NC.
LIRR ROMA FIR EMBD CB/TCU OBS N TYRRHENIAN SEA STNR NC.
LIRR ROMA FIR MT OBSC ISOL N AND CENTRAL APPENNINI STNR NC=

SIGMET

WSIY31 LIIB 181235

LIMM SIGMET 04 VALID 181250/181650 LIMM-
LIMM MILANO FIR EMBD TS OBS SW PART MAINLY LIGURIAN AREA AND CENTRAL ALPS TOP FL390 STNR NC=

WSIY31 LIIB 181630

LIMM SIGMET 05 VALID 181650/182050 LIMM-
LIMM MILANO FIR EMBD TS OBS CENTRAL AND E ALPS AND APPENNINI TOP FL300 STNR NC=

WSIY32 LIIB 181250

LIRR SIGMET 01 VALID 181250/181650 LIMM-
LIRR ROMA FIR EMBD TS OBS N TYRRHENIAN SEA TOP FL330 STNR NC=

WSIY32 LIIB 181445

LIRR SIGMET 02 VALID 181450/181650 LIMM-
LIRR ROMA FIR EMBD TS OBS N TYRRHENIAN SEA AND N AND CENTRAL APPENNINI TOP FL390 STNR NC=

Appendix D

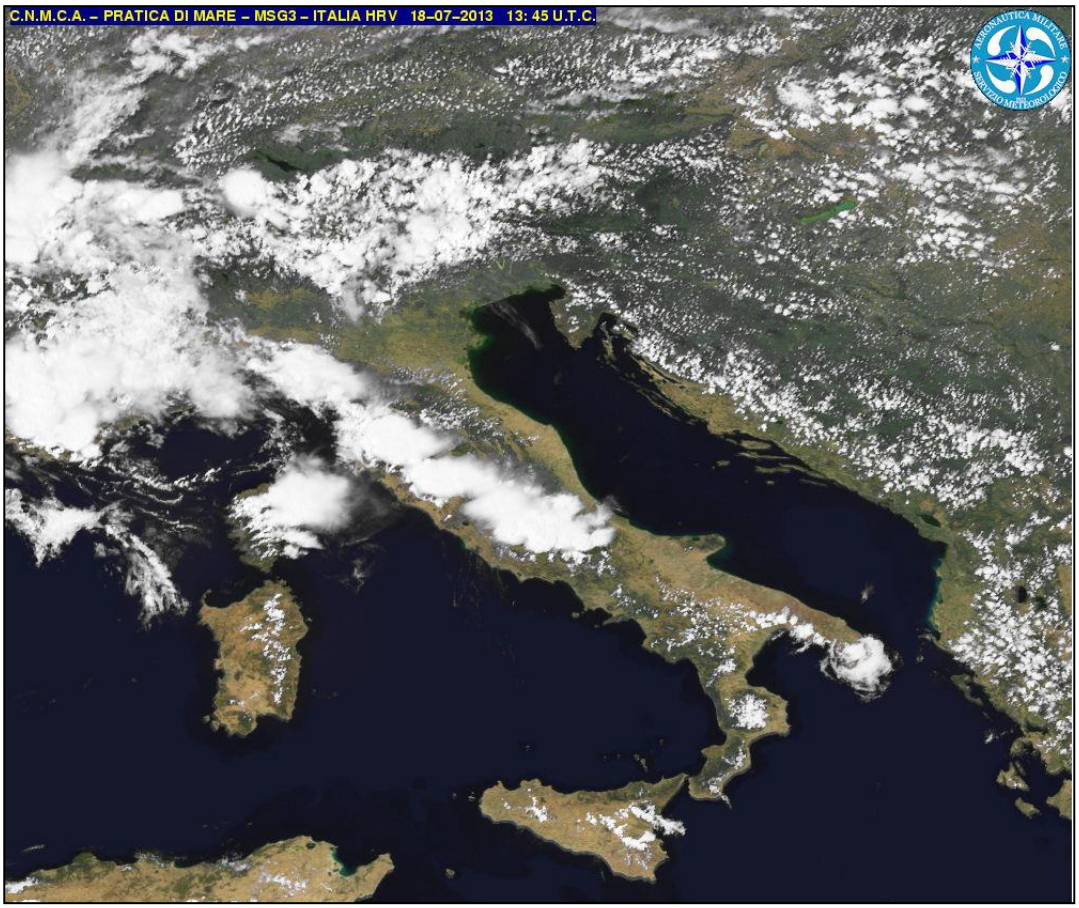

Figure No. 6: High Resolution Visible image of actual weather conditions at 13.45 hrs

- END -

In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No. 996/2010, and Statutory Instrument No. 460 of 2009, Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulation, 2009, the sole purpose of this investigation is to prevent aviation accidents and serious incidents. It is not the purpose of any such investigation and the associated investigation report to apportion blame or liability.

A safety recommendation shall in no case create a presumption of blame or liability for an occurrence.

Produced by the Air Accident Investigation Unit

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