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COMISIÓN DE
INVESTIGACIÓN
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AVIACIÓN **C**IVIL

Report
EXT A-006/2014

Accident involving a BOEING B-737-800, registration EI-ENB, operated by RYANAIR, in the vicinity of Toulouse (France) on 23 June 2014

GOBIERNO DE ESPAÑA
MINISTERIO DE FOMENTO

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COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

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Foreword

This report is a technical document that reflects the point of view of the Civil Aviation Accident and Incident Investigation Commission (CIAIAC) regarding the circumstances of the accident object of the investigation, and its probable causes and consequences.

In accordance with the provisions in Article 5.4.1 of Annex 13 of the International Civil Aviation Convention; and with articles 5.5 of Regulation (UE) nº 996/2010, of the European Parliament and the Council, of 20 October 2010; Article 15 of Law 21/2003 on Air Safety and articles 1.4 and 21.2 of Regulation 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future civil aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent from their reoccurrence. The investigation is not pointed to establish blame or liability whatsoever, and it's not prejudging the possible decision taken by the judicial authorities. Therefore, and according to above norms and regulations, the investigation was carried out using procedures not necessarily subject to the guarantees and rights usually used for the evidences in a judicial process.

Consequently, any use of this report for purposes other than that of preventing future accidents may lead to erroneous conclusions or interpretations.

This report was originally issued in Spanish. This English translation is provided for information purposes only.

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Abbreviations

° ' "	Sexagesimal degrees, minutes and seconds
°C	Degrees Centigrade
AAIU	Air Accident Investigation Unit (Ireland)
AENA	Spanish Airports and Air Navigation
AIRMET	Information on weather phenomena en route that could affect the safety of low-altitude aircraft operations
AMM	Aircraft Maintenance Manual
ATC	Air Traffic Control
ATPL	Air transport pilot license
ATS	Air Traffic Service
BEA	Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (France)
CB	Cumulonimbus
CIAIAC	Civil Aviation Accident and Incident Investigation Commission (Spain)
CPL	Commercial pilot license
CRM	Crew Resources Management
CSA	Cabin service attendant
CSS	Cabin service supervisor
CVR	Cockpit voice recorder
CWS	Control Wheel Steering
FA	Flight attendant
FCOM	Flight Crew Operations Manual
FDR	Flight data recorder
FIR	Flight information region
FL	Flight level
FMC	Flight Management Computer
ft	feet
g	Acceleration due to gravity
GMC	Ground movement control
HDG	Heading
hPa	Hectopascals
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organization
ILS	Instrument landing system
IMC	Instrumental Meteorological Conditions
IR	Infrared
IR(A)	Instrument rating
hr	Hour(s)
Kt	Knots
lb	Pounds
LFBB	ICAO site designator for the Bordeaux FIR
LFBF	ICAO site designator for Toulouse-Francazal Air Base
LFBO	ICAO site designator for the Toulouse Airport
m	Meters
M	Mach number
MAP	Millibars
ME	Multi-engine
MEL	Minimum equipment list
METAR	Aerodrome weather report
MHz	Megahertz
MPA	Multi-pilot airplane rating
NAV	Navigation
N	North
ND	Navigation display
NM	Nautical miles
OFP	Operational Flight Plan

OM	Operations Manual
PA	Passengers address
PF	Pilot flying
PM	Pilot monitoring
PTT	Push to talk
QNH	Altimer sub-scale setting to obtain the elevation on the ground
Rpm	Revolutions per minute
S	South
s	Seconds
S/N	Serial number
SIGMET	Information on weather phenomena en route that could affect the safety of aircraft operations
SP	Special Procedure
TAFOR	Aerodrome forecast
TLB	Technical log book
TMA	Terminal control area
TOC	Top of cruise
TOD	Top of descent
TWR	Control tower
UIR	Upper Information Region
UTC	Coordinated universal time
VHF	Very High Frequency
VMO/MMO	Maximum operating speed / Maximum operating Mach no.
W	West

Synopsis

Operator:	Ryanair
Aircraft:	Boeing B-737-800, EI-ENB
Date and time of accident:	Monday, 23 June 2014 at 16:35 UTC
Site of accident:	Vicinity of Toulouse (France)
Persons onboard:	169 (163 passengers of which 1 seriously injured and 6 crew)
Type of flight:	Air transport – Scheduled – International - Passenger
Date of approval:	23 June 2014

Summary of the event

On 23 June 2014, a Boeing B-737-800, registration EI-ENB, operated by Ryanair, was making a flight with callsign RYR4398 between the Dublin (Ireland) and Reus (Spain) airports.

When the aircraft was some 42 NM away from the city of Toulouse and on heading 138º, it made a right turn to heading 165º, direct to point PUMAL[1], which is near the border between France and Spain. On this segment the aircraft had to fly over the city of Toulouse.

At 16:37:19, some 7 NM before reaching Toulouse, the crew initiated a turn to the right to try to avoid a storm cell that was developing over Toulouse. When they began the turn, the aircraft was at FL370 and flying at a speed of Mach 0.766. Its weight was 133,400 lb and the autopilot was engaged in lateral navigation (NAV) mode. The autothrottle was also engaged.

The crew were unable to keep the aircraft from crossing the edge of the storm, which resulted in its being affected by the turbulent motions typical of these atmospheric phenomena. The turbulence lasted 29 s, starting at 16:38:11 and finishing at 16:38:40.

As a result of the aircraft's sudden movements, two passengers were hurt, one of them seriously,. Besides three cabin crew suffered minor injuries.

The rest of the flight was uneventful and the aircraft landed at its destination airport normally.

[1] PUMAL is the transition point between the Bordeaux and Barcelona Flight Information Regions.

The five people who were injured during the turbulence were evacuated on two ambulances and taken to a hospital for treatment.

The investigation determined that the accident occurred because the flight crew were unable to detect a developing convective cloud, the severe turbulence from which affected the aircraft, causing injuries to several passengers and crew who had not been alerted to the presence of this phenomenon.

1. FACTUAL INFORMATION

1.1. History of the flight

1.1.1. Notification

The CIAIAC was notified of this accident by Ireland's Air Accident Investigation Unit (AAIU) on 24 June 2014. The notification included a report from the crew on the event.

Based on the information contained in this report, it was noted that the event had taken place during the approach to the destination airport, Reus. Two requests were sent out, one to the operator to save the aircraft's flight recorders, and another to the air traffic services provider, AENA – Air Navigation (now ENAIRE), to save both the flight's radar data and the recordings of any communications maintained during the flight.

The accident was reported to the following States: Ireland, as the State of registration and of the operator; the United States of America, as the State of the aircraft's design and manufacture; and France, as the State of the engines' design and manufacture. All of them appointed accredited representatives.

The ensuing investigation revealed that the event had not taken place during the approach to the Reus airport, but prior to commencing the descent, while the aircraft was over the French city of Toulouse.

This fact was made known to all of the accredited representatives since according to international law, the investigation of an accident or serious incident corresponds to the country in which it takes place, which in this case would be France.

The Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation civile (BEA), which is the French accident investigation authority, agreed to delegate the investigation of this event to the CIAIAC.

After this, the CIAIAC resumed its investigation and requested flight radar and communications data from French authorities.

Pursuant to applicable laws in France, these data are kept for one month, after which they are deleted. Since by the time the request was made one month had already elapsed since the event, it was not possible to recover the data from the accident flight.

1.1.2. History of the flight

The aircraft was on flight RYR4398 between the airports of Dublin (Ireland) and Reus (Spain). There were 163 passengers and 6 crew onboard.

The first officer was the pilot flying (PF) and the captain was the pilot monitoring (PM).

When the aircraft was some 42 NM north of the city of Toulouse, flying on heading 138º, the crew turned right to heading 165º, direct to point PUMAL, which is near the border between France and Spain. On this segment, the aircraft would fly over the city of Toulouse.

At 16:37:19, some 7 NM before reaching Toulouse, the crew started a turn to the right to try to avoid a storm cell that was developing over Toulouse. When they started the turn, the aircraft was at FL370 and flying at a speed of Mach .766. Its weight was 133,400 lb and the autopilot was engaged in lateral navigation (NAV) mode. The autothrottle was also engaged.

The captain's navigation display (ND) was showing the weather radar with the range set to 80 NM.

The first officer's ND was selected to ground mode with the range set to 160 NM.

The crew were making the before descent briefing, meaning that as per the operator's requirements, the PF at that time was the captain and the first officer was acting as the PM.

The evasive maneuver was unable to keep the aircraft from crossing the edge of the storm, as a result of which it was subjected to the turbulence typical of these atmospheric phenomena. The turbulence lasted 29 s, starting at 16:38:11 and finishing at 16:38:40.

The vertical and lateral accelerations recorded during this time period reached the following maximum values:

- Vertical acceleration: between -0.575092 and 1.89515 g.

- Lateral acceleration: between -0.23 and 0.244 g.

The captain turned on the seatbelt sign just before the airplane entered the cumulus cloud, but without notifying the cabin crew to take their seats.

There were two flight attendants in the aft galley region, as well as a passenger who was buying some of the items available for purchase onboard. As a result of the sudden movements that affected the aircraft, these individuals struck the ceiling and floor of the cabin, as well as one of the service carts. Several other passengers and one flight attendant also suffered bruises caused by the turbulence.

After crossing the area of turbulence, the flight continued normally.

The crew tried to establish radio contact with their handling agent at the Reus Airport but were unable to do so.

As a result, the captain called ground control at the Reus airport and made contact with the duty controller. During this exchange, the crew informed ATC that they had experienced severe turbulence, which had resulted in injuries to two passengers who would require medical assistance and an ambulance upon landing.

The aircraft landed at the Reus airport at 17:12:30 UTC, after which it proceeded to position 2 in the parking stand.

Two of the injured passengers were evacuated immediately by an ambulance and taken to a hospital.

The three flight attendants were then evacuated by a second ambulance, which also took them to a hospital.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Other
Fatal				
Serious		1		
Minor	3	1		N/A
None	3	161		N/A
TOTAL	6	163		

1.3. Damage to aircraft

After landing at the destination airport in Reus, the aircraft underwent a severe turbulence inspection, as per the Aircraft Maintenance Manual (AMM 05-51-04-210-801 Rev. 54), which revealed no damage.

1.4. Other damage

Not applicable.

1.5. Personnel information

1.5.1. Captain

- Age: 48
- Nationality: British
- License: ATPL (airplane)
- Ratings:
  - B737 300-900 valid until 30/11/2014
  - ME IR (MPA)[2] valid until 30/11/2014
- Language level: English level 6
- Medical certificate: class 1, valid until 19/02/2015
- Total flight hours: 8500
- Flight hours on the type: 7400
- Activity in the:
  - Previous 90 days: 250 hr
  - Previous 28 days: 85 hr
  - Rest before the flight: 14:00 hr

1.5.2. First officer

- Age: 25
- Nationality: British
- License: CPL (airplane), valid until 9/07/2017
- Ratings:

[2] Instrument rating restricted to multi-pilot aircraft.

  - B737 300-900, valid until 31/12/2014
  - IR (A) valid until 31/12/2014
- Language level: English level 6
- Medical certificate: class 1 valid until 1/07/2014
- Total flight hours: 1500
- Flight hours on the type: 1300
- Activity in the:
  - Previous 90 days 270 hr
  - Previous 28 days: 86 hr
  - Rest before the flight: 14:00 hr

1.5.3. Cabin Service Supervisor (CSS1)

- Age: 22
- Nationality: Spanish
- License: B737
- Activity in the 7 days before the event: 08:50 hr
- Duty start time: 14:45 UTC
- Experience: since 30/06/2011

1.5.4. Cabin Service Attendant 2 (CSA2)

- Age: 28
- Nationality: Slovakian
- License: B737

- Activity in the 7 days before the event: 11:12 hr
- Duty start time: 14:45 UTC
- Experience: since 10/12/2010

1.5.5. Cabin Service Attendant 3 (CSA3)

- Age: 25
- Nationality: Bulgarian
- License: B737
- Activity in the 7 days before the event: 20:33 hr
- Duty start time: 14:45 UTC
- Experience: since 14/04/2014

1.5.6. Cabin Service Attendant 4 (CSA4)

- Age: 19
- Nationality: Latvian
- License: B737
- Activity in the 7 days before the event: 20:41 hr
- Duty start time: 14:45 UTC
- Experience: since 23/05/2014

1.6. Aircraft information

1.6.1. General information

- Marca: Boeing

- Manufacturer: Boeing
- Model: B737-800
- Serial number: 40289
- Year of manufacture: 2010
- Airworthiness review certificate: valid until 27/09/2014
- Engines, number, manufacturer and model: two (2)/CFM,56-7B/3
- Weights
  - Maximum takeoff weight: 174,200 lb
  - Maximum landing weight: 146,300 lb
- Dimensions
  - Wingspan (with winglets): 35.8 m
  - Length: 39.5 m
  - Height: 12.5 m
- Hours: 12092
- Cycles: 6892
- Maintenance status:

Last inspections of the aircraft		
Inspection type	Total hours	Date
Daily[3]	12090	23/06/2014
A_S07	12058	20/06/2014

- Deferred

[3] Performed in Dublin before the first flight of the day.

The aircraft's Technical Log Book (TLB) contained an entry from 20/06/2014 involving the autopilot which stated that autopilot B was inoperative. The aircraft had been dispatched as per point 22-1 of the minimum equipment list (MEL), and was restricted to category I approaches.

1.7. Meteorological information

1.7.1. Meteorological information available to the crew

Annex I shows the weather information of relevance to the investigation, and was taken from the information that had been provided to the crew prior to the flight. This information includes:

- AirMet
- Sigmet
- METAR
- TAFOR
- Significant weather chart. FL100-450. Valid: 18:00 UTC
- Wind map FL370.

According to this information, in the area of the event the forecast called for moderate icing between FL110 and FL220, and moderate turbulence from levels below FL100 to FL220.

The entire Pyrenean mountain range, the southeast of France and the north of the Iberian Peninsula were included in another area for which embedded cumulonimbus clouds were forecast, with bases below FL100 and tops at FL370.

The forecasts indicated that the most critical point for windshear would be at point KO-RER, which is in the area of Brittany, in the northwest of France, and that its intensity level would be 3 (out of 9).

1.7.2. Actual meteorological information

The weather information was provided by MeteoFrance.

According to this information, the general weather situation aloft was dictated by a flow from the southwest. On the surface there was a large mass of hot, humid air. There were occasional storm cells developing along the Cantabrian mountains and in the Pyrenees, with isolated cells in the south of France.

Based on the weather data, the conditions at the time and place of the event were estimated to have been as follows:

- Cloud cover: overcast with cumulonimbus clouds at FL380 moving north at 15 kt.
- Significant phenomena: storms, rain and hail.
- Ice formation: light or none outside the CB, high inside the CB.
- Temperature: -55º C.
- Pressure: QNH 1016 hPa.
- Turbulence: light outside the CB, severe inside the CB.
- Location of the tropopause: FL370, temperature -55º C.
- 0º isotherm: FL110.

The METARs for the Toulouse Airport for the time interval between 15:00 and 17:00 UTC are as follows:

LFBO 231500Z AUTO VRB03KT 9999 BKN048 BKN056 28/16 Q1016=

LFBO 231530Z AUTO 02004KT 320V110 9999 BKN047 BKN060 27/17 Q1016=

LFBO 231600Z AUTO 04005KT 340V090 9999 BKN043/// BKN049/// BKN070/// ///CB 27/17 Q1016=

LFBO 231630Z AUTO 02007KT 340V060 9999 TS FEW042/// BKN052/// BKN074/// ///CB 26/18 Q1016=

LFBO 231700Z AUTO 22018KT 180V260 0400 0250 R14R/1000D R32L/0650D R14L/0600D R32R/1000N TSRA FG FEW015/// SCT028/// OVC041/// ///CB 19/16 Q1017=

The 16:00 UTC information indicated the presence of cumulonimbus (CB) over the airport.

The no. 5 SIGMET issued on the day of the event, valid for the Bordeaux FIR from 15:45 UTC until 18:00 UTC, was as follows:

LFBB SIGMET 5 VALID 231545/231800 LFPWLFBB

BORDEAUX FIR/UIR EMBD TS OBS WI N4215 E00230 - N4300 W00145 - N4330 W00145 - N4330 E00000 - N4245 E00230 TOP FL380 MOV N 15KT NC=

The SIGMET messages contain information indicating the actual or forecast presence of weather phenomena en route that could affect the safety of aircraft operations, as well as the progression of those phenomena in time and location.

SIGMET 5 above reports that embedded storms were observed inside the coordinates provided in the message, with a ceiling at FL380 and moving north at 15 kt.

The area specified in the message spanned practically all of the Pyrenees except for the eastern end.

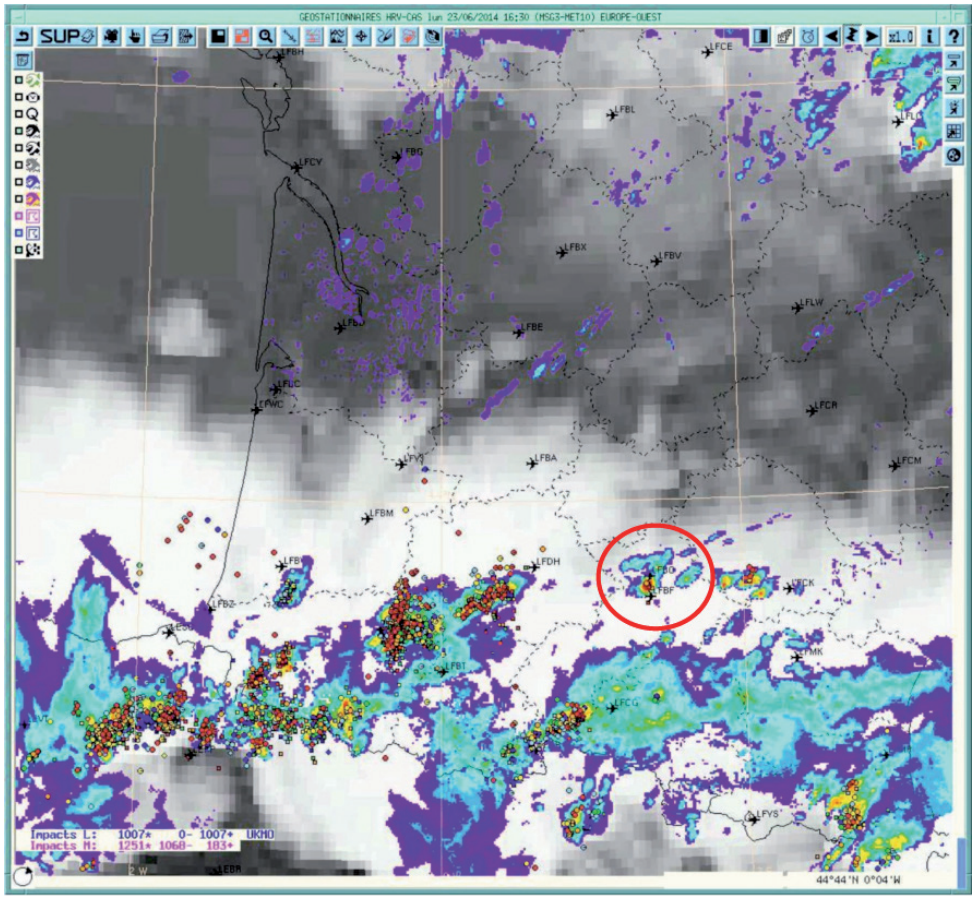

Figure 1. Satellite (IR) and radar images, and lightning map for 16:30 UTC. The area of the event is circled in red

Figure 1 shows the satellite (IR) and radar images for 16:30 UTC. As we can see, the Pyrenean mountains were affected by developing storms, especially along their Western half. The figure also shows several isolated storm cells north of the Pyrenees, which include the one that affected the accident flight.

The radar image from minutes earlier (16:20 UTC) shows that the storm cell in the Toulouse area was growing. The dark blue colors shown in the image indicate that activity in the cells was light.

The image from 16:25 UTC shows that the size of the storm grew. The area between the Toulouse-Blagnac Airport (LFBO) and the Toulouse-Francazal Air Base (LFBF) appears entirely covered in yellow/orange, indicating increased storm activity.

The image from 16:30 UTC does not show a significant increase in the size of the storm cell, but it does show a change in the colors for the area between the two airports, with red patches appearing.

The image from 16:35 UTC (figure 2) shows an increase in the surface area colored in yellow, orange and red.

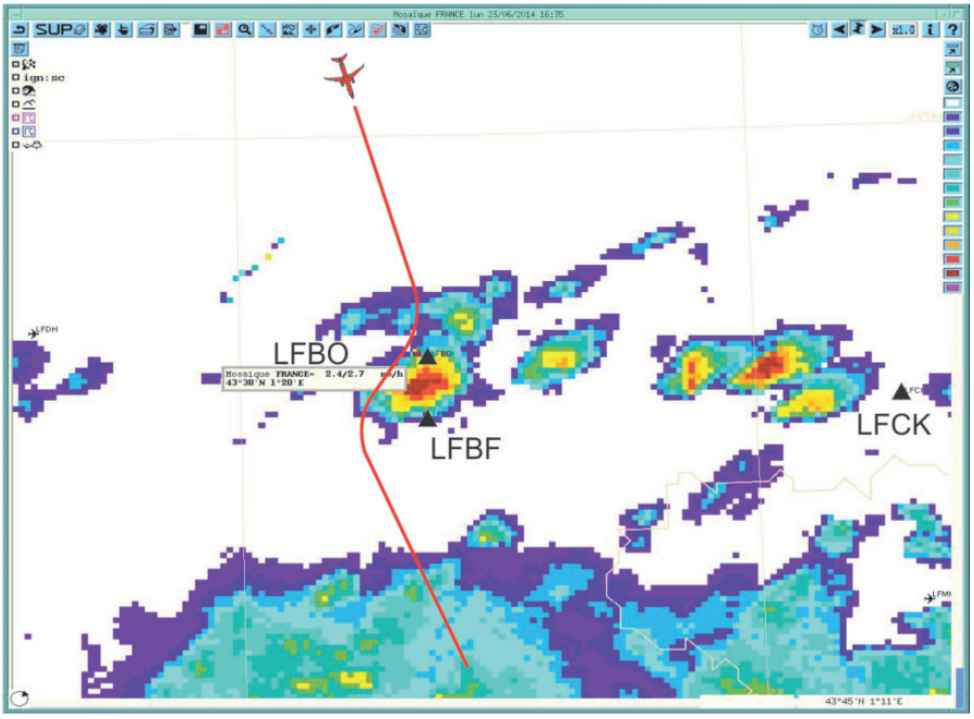

Figure 2. Weather radar image from 16:35 UTC,
with the aircraft's trajectory superimposed on it

1.8. Aids to navigation

Not applicable.

1.9. Communications

As noted in point 1.1.1, the communications between the crew and French ATC facilities were not available to investigators.

The communications between the crew and Spanish ATC, however, were available.

The crew contacted sectors T1 and T4 of the Barcelona TMA, as well as the control tower (TWR) and ground control (GMC) at the Reus airport.

The crew's communications with sector T1 were standard and made no reference to the event.

At 16:55:42 the crew made initial contact with sector T4, stating they were descending to FL130. The controller confirmed radar contact and instructed them to maintain FL130, which the crew acknowledged.

At 16:55:57 the crew called GMC at the Reus airport to report they would be landing in about 15 minutes, that they had attempted to contact their handling company in Reus but had not been able to, and that they required the presence of an ambulance and medical assistance upon landing. The controller asked the crew if they could describe what had happened, to which the crew replied that they had encountered turbulence and that two passengers were injured, one with a cut to the head and another with a nose bleed, and would require medical assistance. The controller informed them that he would relay their message to the operations office.

At 16:59:30 the T4 sector controller called the aircraft, stating that it was on regard with the crew's request to have medical services standing by upon their arrival at Reus. The crew replied that they anticipated landing in 15 minutes, and confirmed their need for medical assistance and an ambulance since there were two injured passengers onboard.

At 17:01:47 the controller called the crew to inform them they were cleared for the ILS Z approach to runway 25.

At 17:05:10 the controller again called the crew to instruct them to call the Reus control tower on 118.15 MHz, which the crew acknowledged.

1.10. Aerodrome information

Not applicable.

1.11. Flight recorders

1.11.1. Flight data recorders (FDR)

The aircraft was equipped with a solid-state flight data recorder (FDR) made by Honeywell, part number 980-4700-042 and serial number 18626, which recorded 1221 parameters.

The recorder was preserved by the operator and provided to CIAIAC to be downloaded at its laboratory and verified to contain valid information on the accident flight.

Based on the information on the FDR, at 16:32:43, some 6 minutes before encountering the turbulence, the aircraft had just completed a right turn, changing its heading from 165º to 202º. This course took it directly to point PUMAL.

In the seconds before they ran into turbulence, the aircraft was established on FL370 at Mach 0.768 and weighed 133480 lb. The autopilot and autothrust were engaged. The recorded wind was from 250º at between 35 and 40 kt.

The captain's navigation display (ND) was in MAP mode, showing the weather radar on an 80-NM range.

The first officer's ND was in MAP mode, showing the TERRAIN on a 160-NM range.

Figure 3 contains a graph which shows the values recorded for several parameters in the minutes preceding the turbulence.

The graph reveals that at 16:37:16 UTC, the aircraft, which was on heading 165º, started a turn to the right to change course to 202º. This turn was made with the autopilot in HDG (heading) mode.

Figure 4 shows a graph of several parameters recorded between 16:33:47 and 16:42:04 UTC, which includes the encounter with the turbulence.

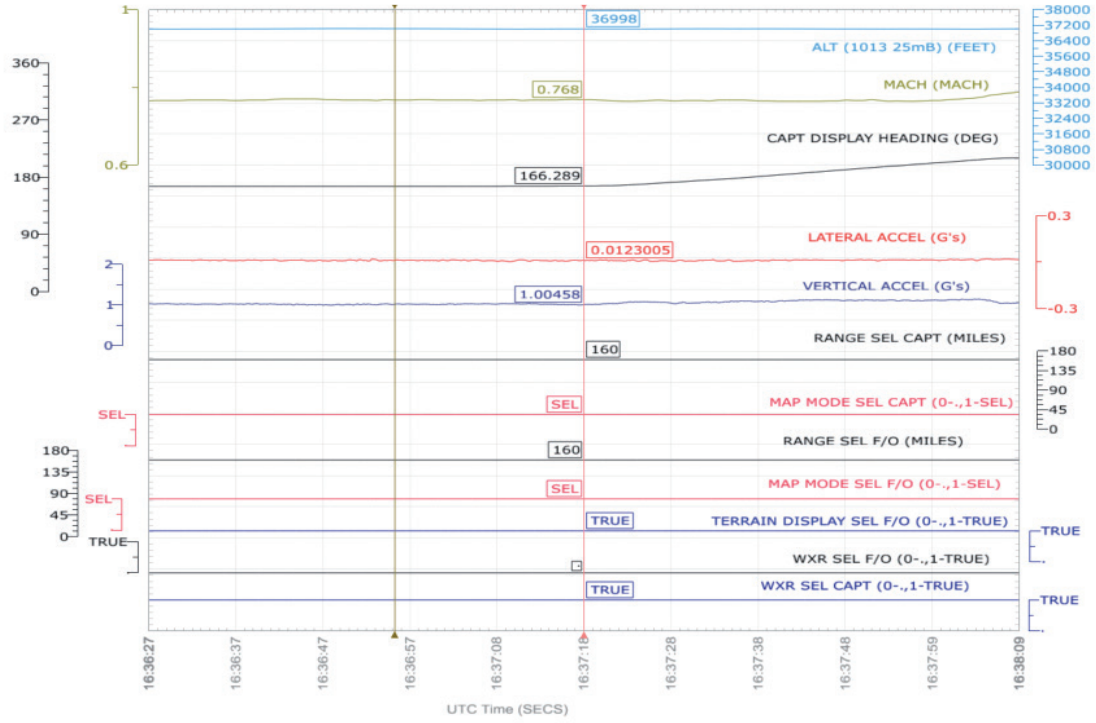

Figure 3. Graph of certain flight data in the two minutes preceding the turbulence

This graph, like the one in Figure 3, shows the heading change made by the crew at 16:37:16 UTC using the HDG mode selector.

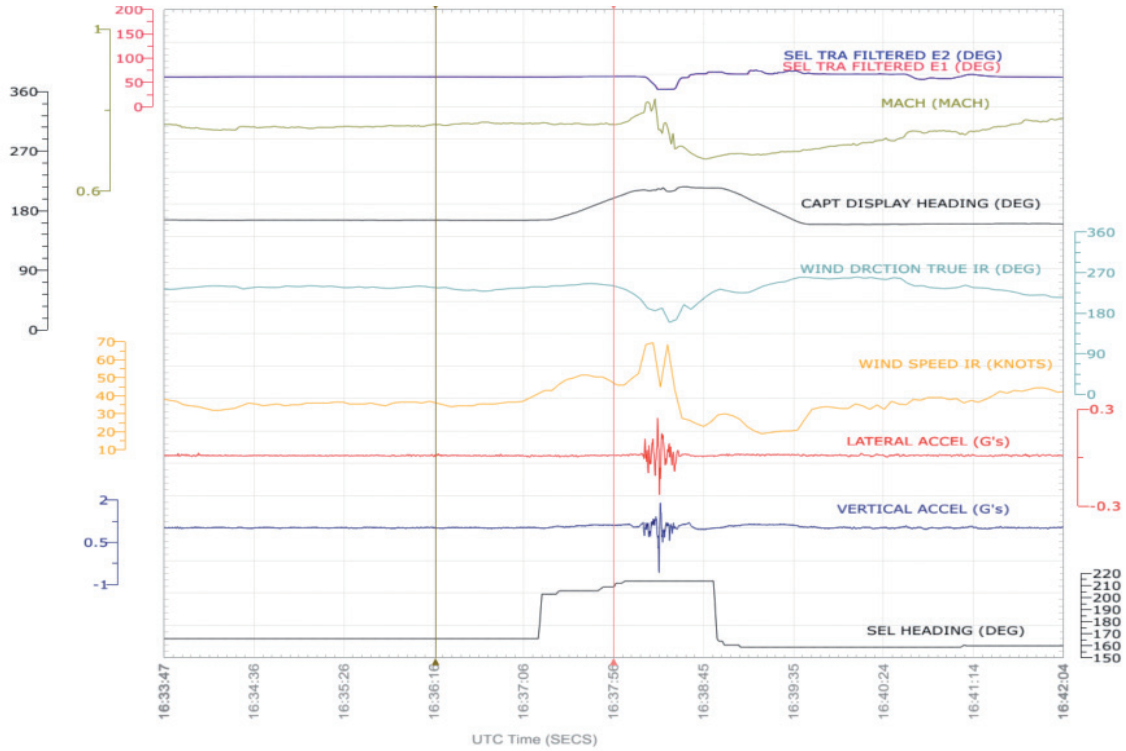

Figure 4. Graph of flight parameters recorded between 16:33:47 UTC and 16:42:04 UTC

Also evident is the fact that the action to change the aircraft's heading was taken about 10 s after the wind speed recorded by the aircraft started to increase. Until that moment, the values of the remaining parameters recorded by the FDR were within normal ranges.

During the turn, some of the parameter values changed significantly:

- The wind speed recorded by the aircraft continued to increase, with slight fluctuations, reaching a maximum value of 69.5 kt.

- The wind direction also changed, veering left until reaching 180º.

- The aircraft's speed increased to a maximum value of 0.82 M, which is above the maximum VMO/MMO of 0.82 M. This value was exceeded for no more than one second. The parameter that records the overspeed warning activation did not record any such activation.

- The engine throttles, labeled "SEL TRA FILTERED E1 (DEG)" and "SEL TRA FILTERED E2 (DEG)" in Figure 4, were retarded (to decrease power).

- The aircraft's speed started to decrease after the throttle levers were pulled back.

- At 16:37:42 UTC, the values for the vertical and lateral accelerations started to increase slightly before holding steady for about 30 s, until 16:38:12 UTC, after which the values rose sharply for 28 s. The maximum acceleration values recorded during this interval were:

    - Vertical acceleration: 0.575092 and 1.89515 g.

    - Lateral acceleration: between -0.23 and 0.244 g.

At the conclusion of this interval, 16:38:40 UTC, the acceleration values returned to normal.

- The throttle levers were advanced at 16:38:36 UTC.

- The altitude, which is not shown on the graph, varied between 36872 and 37118 ft during the turbulence.

- The heading selected was increased to 215º.

Figure 5 shows a graph of several parameters from 16:38:00 UTC, which is immediately preceding the period of severe turbulence, until 16:46:23 UTC.

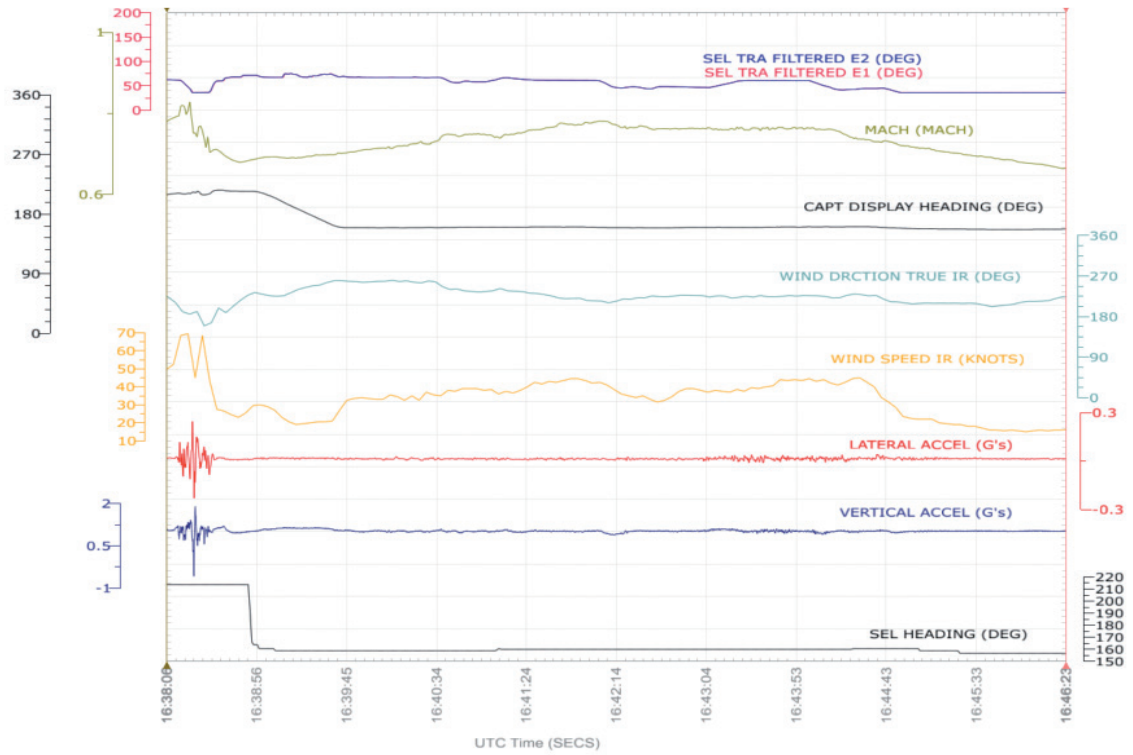

Figure 5. Graph of flight parameters recorded between 16:38:00 UTC and 16:46:23 UTC

As the graph clearly shows, the period of severe turbulence occurred during the aircraft's right turn. In fact, the turn continued after the period of intense acceleration, which took place at 16:38:40, ceased.

At 16:38:51 UTC the heading selected was changed to 160°. The aircraft started turning to the left and reached the selected heading at 16:39:43 UTC.

Although both the wind speed and direction were more stable than during the period of severe turbulence, they still varied between 19 and 42.5 kt in speed and between 202 and 260° in direction.

There was a slight increase in the vertical and lateral acceleration values between 16:43:00 and 16:44:00.

The aircraft's speed shows a certain instability with a clear upward trend.

The throttle levers were moved in the opposite direction of the aircraft's speed: if the speed increased, the levers were retarded (to lower thrust), and if the speed dropped, they were shifted forward.

The parameters remained stable within normal values for the rest of the flight.

1.11.2. Cockpit voice recorder (CVR)

The aircraft was equipped with a four-channel, solid-state cockpit voice recorder (CVR) made by Honeywell, part number 980-6022-001 and serial number (S/N) CVR120-14239. On channels 1 and 2 it recorded the signals from the crewmembers' communications microphones, and on channel 3 messages to the passengers. These three channels lasted 30 minutes. The fourth channel recorded the sounds captured by the cockpit area microphone and lasted two hours.

The CVR was preserved by the operator and provided to CIAIAC to be downloaded at its laboratory. All four channels were verified to contain audible information of high quality on channels 1, 2 and 3, and of medium-low quality on channel 4.

Channels 1, 2 and 3 only contained information after the time of the accident, since the CVR continued recording for the rest of the flight, as expected. Since this time period exceeded the 30-minute recording duration time, the information pertaining to the accident was recorded over.

Channel 4, which lasts the longest (2 hours), did contain information from before and after the event. Due to the poor quality of the sound and to the low volume of the pilots' voices, it was not possible to fully transcribe the conversations held in the cockpit. The parts of the recording that could be understood, however, were used to identify the subject matter involved in the conversations.

The recorders were synchronized using the communications held with ATC facilities, the audio for which was recorded on the CVR, while the moment at which the crewmember pressed the PTT (push to talk) button to talk on the radio was recorded on the FDR (VHF KEY parameter). The overspeed warning, which was recorded on the CVR, was also used. Although the parameter that records this warning on the FDR did not register its activation, the acoustic warning is assumed to have taken place when the maximum VMO/MMO value was exceeded. The table below shows a summary of these events and the times when they were recorded.

Event	CVR time (hh:min:ss)	FDR time (hh:min:ss)	ATC time (hh:min:ss)	Time difference FDR/CVR
Overspeed warning	00:34:26	16:38:20	-	16:03:54
First call to Barcelona ATC	00:42:15	16:46:11	16:46:11	16:03:56
Second call to Barcelona ATC	00:42:31[4]	16:46:25	16:46:26	16:03:54

[4] Although the call to ATC was almost drowned out by a conversation between the captain and a FA, it is possible to hear the first officer's voice in the background, possibly corresponding to the call placed to ATC.

As the data in the table show, the FDR time coincides with the time of the ATC facility.

The differences between the CVR and the FDR for the three events shown are practically the same, with this value being regarded as valid. Thus, to obtain UTC time from the CVR time, it is necessary to add 16:03:54 to the latter.

The recordings were reviewed from 5 minutes before the aircraft started to turn right to head direct to PUMAL, until the event. The reference time is UTC.

During this interval, the recordings reveal how after contacting ATC, the captain took control of the aircraft so the first officer could do the cockpit check in preparation for arriving in Reus. The first officer then conducted the approach briefing.

This task was interrupted when the captain indicated he was starting a turn to the right, presumably to avoid a developing cloud formation. He started the turn at 16:37:30.

After a period of silence that lasted until 16:38:27, both the captain and the first officer uttered expressions that manifested their surprise at an unexpected event, which was identified as the shaking caused by strong turbulence.

Over an 11-second interval, an alert sound is heard corresponding to the overspeed acoustic warning.

Following that, the maneuver stabilized and the flight crew noted their surprise and the effects of the shaking.

The captain established communications with the cabin crew to learn of the effects of the turbulence on the passenger cabin and to deal with any possible injuries sustained by passengers and crew.

1.12. Wreckage and impact information

Not applicable.

1.13. Medical and pathological information

One of the passengers suffered a back injury that required admission to and treatment in a hospital. This passenger also sustained broken bones in one foot and damage to the ligaments in the other foot.

The other passenger and three crew who were thrown about during the turbulence sustained minor injuries.

1.14. Fire

Not applicable.

1.15. Survival aspects

Not applicable.

1.16. Tests and research

1.16.1. Statements from the crew

1.16.1.1. Flight crew

The crew met in the crew room 45 minutes before their scheduled 14:00 departure time, where they held the relevant briefing. It was their first time flying together.

The aircraft's maintenance records noted that autopilot B was inoperative. According to the MEL, the airplane can be dispatched in this condition as long as autopilot A is operative.

The weather forecast for the flight was normal and no significant weather was forecast along their route. Both pilots were sure they had checked all the weather reports.

Their planned flight level was FL370. They did not consider changing the planned route in terms of the flight level, deviations or taking on extra fuel, since their analysis of the pre-flight information did not require any such changes.

The flight was uneventful until the time of the accident. They did not notice any significant changes in wind speed or direction during the flight, and they did not experience any turbulence either before or after the event.

The crew stated that areas of enroute weather had been visually identified but no track deviation had been necessary due to their lateral navigation track keeping them clear of any build ups.

Both pilots heard on the frequency how some crews were requesting weather-related deviations, but they did not receive any indication from ATC that alerted them to the presence of adverse weather conditions on their route.

The first officer was the PF in this sector, but the captain was the pilot flying at the time of the accident. Control had been transferred as per company procedures to facilitate the job of the pilot flying while doing the approach briefing.

The display on the weather radar was as per their operating procedures, with the captain's navigation display (ND) selected to show said radar display, while the first officer's ND was set to show the elevation of the terrain (TERRAIN mode).

They noted that they knew that the company manual recommended avoiding convective clouds by at least 20 NM, but due to the presence of several of these clouds in the vicinity of their route in this area, it was not possible to alter their trajectory and avoid them all by that margin of distance.

They turned on the seatbelt sign just before the airplane entered the cumulus cloud, but they did not notify the cabin crew to take their seats.

The turbulence was sudden and strong, but it lasted no more than 30 seconds. They reduced thrust in an effort to clear the overspeed.

After the event, the light for the L2 door turned on, indicating it was open. The crew checked the door and the light turned off. They were informed by the cabin supervisor that the crew and some of the passengers had been thrown around, but that the situation was calm.

They were notified that two passengers had been injured, one with a nose bleed and the other with a blow to the head, but that their injuries did not appear serious. They asked the cabin supervisor if there was anyone onboard with medical knowledge, and they asked ATC to have medical services standing by. They also made an announcement to the passengers to remain calm.

The captain stated that he was aware that the injured had been moved to the back of the airplane, but he did not know they were lying down in the aisle.

He received the "cabin secure" report from the cabin supervisor before landing. They did not report a medical emergency (PAN PAN MEDICAL), nor did they initially report the turbulence to ATC, since their primary concern was to ascertain the condition of the airplane and of the passengers.

The medical assistance and ambulance they requested were awaiting them upon arrival.

They decided to continue to Reus, since the event occurred very close to the top of descent and they had already conducted the approach briefing.

The approach and landing were normal. Both pilots were familiar with operations at the airport.

The passengers disembarked via the front door, which allowed medical personnel to board at the rear. The captain went out to talk to the passengers and recommended to all who had been affected that they ask for a medical evaluation.

A maintenance team checked the airplane and cleared it for dispatch for the next flight. Three cabin crew from Barcelona boarded the airplane for the return flight to Dublin.

1.16.1.2. Cabin Service Supervisor (CSS1)

The cabin supervisor stated that the pre-flight briefing was standard. The flight crew told them that everything was normal and that no significant weather phenomena were forecast.

When the event occurred, she was in the aft galley with two other flight attendants and a passenger who wanted to buy perfume. All four were standing. The fourth flight attendant was seated nearby. The remaining passengers were seated with the exception of a girl of about 8 who was in the lavatory.

When she felt the first sudden movement, she quickly instructed the attendants and the passenger to sit down, but before they were able to move, there was a sudden shaking that was much more severe, and which propelled them toward the ceiling.

She then hit the floor and the sale cart fell on top of her. She saw blood stains on her hands and thought it was her blood. She was unable to stand due to the weight of the cart she had on top of her.

One of the flight attendants managed to take the cart off her. She stood up and noticed that the blood was not hers, but from the female passenger who was bleeding profusely from her head. She told the other attendants to take their seats in case there was more turbulence, and she stayed to tend to the passenger. She took off her apron and used it to try to stop the bleeding.

The girl tried to exit the lavatory but she asked her to remain inside and hold on as well as she could.

The captain called to ask about the situation in the cabin. She told him that there were several injured and that they would need medical assistance at their destination. The captain told her they had a warning that one of the aft doors was open. She looked and saw that the handle had been moved slightly from its position. She returned it to its proper position.

The passenger was complaining about her neck and was unable to move her legs.

She called on the passenger address (PA) to request a doctor, but no one came forward. She thought it might have been because the passengers were still affected by the turbulence.

When the situation seemed to return to normal, she told the girl to come out of the lavatory and took her to her seat. She then continued forward to see if there were more injured. She saw that two other passengers had been hurt, one with a small cut to the hand and the other with back pain.

She addressed the passengers again to inform them that everything was normal and that they would land in about 20 minutes. She again asked for a doctor, but received no reply.

She returned to the aft of the cabin. The passenger was lying down in the middle of the galley and the cart was broken on the floor.

She made another appeal for medical personnel on the PA, and this time two people came forward, a nurse and a medical technician.

The nurse attended to the more seriously injured passenger and the technician to the other passenger.

In light of the female passenger's condition, they decided not to move her from the floor so as not to aggravate her injuries.

Since the passenger was in the galley, the cart could not be re-stowed. Moreover, since it was broken, it would probably not have stayed still by itself, so they decided that they would hold the passenger and the cart still during landing.

The landing was normal. Once the aircraft stopped, she announced over the PA that the passengers would disembark via the front doors so as to leave the aft doors available for the medical personnel to board.

The passengers disembarked via the front doors normally and medical personnel boarded via the aft doors.

As for her injuries, she stated that her neck had been injured and that she was on medical leave for two weeks. She then returned to work though she had to go back to the doctor, who gave her an additional month of leave, which was later extended an additional 10 days.

When asked if the flight crew knew that the passenger had remained on the floor, she said she did not know. She added that by the time they decided not to move her it was too late and she did not have time to inform the captain.

When asked if there are any procedures applicable if, as happened in this case, an exit is blocked, she said no, but that it would be similar to a ditching, in which the evacuation is conducted via the front doors.

1.17. Organizational and management information

1.17.1. Information in the operator's Operations Manual, Part A.

Point 8.3.0.2.6 of the Operations Manual, Part A (OM A), on managing the cruise flight phase, states that the sweep of the weather radar will be used to identify and avoid developing cumulonimbus clouds and storm activity. The captain must select the WXR display during takeoff, climb, cruise and descent/approach in IMC and at night. This does not mean that the first officer, when acting as the pilot flying, cannot also use the weather radar for this purpose. Permission must be requested from ATC to deviate from the route, and the storm is to be avoided to windward if possible. If the storm activity is particularly severe and there is no apparent way to avoid the developing clouds associated with it, the crew must consider diverting to an alternate airport.

In point 8.3.8.1.3, the operator provides an ample explanation on storm cloud prediction, formation and development.

This point deals with the presence of turbulence in and around storm clouds, stating that these clouds can be detected by the weather radar by using the feature to display the outline of the cumulonimbus and its active cells. It also warns of the potential danger posed by turbulence as a possible cause of structural failure.

In point 8.3.8.1.4 of the OM A, the operator provides guidelines for the proper use of the weather radar, as well as its limitations. It notes that radar information on storm activity must be used to avoid the areas affected by said activity, which must never be entered.

In the first section, which deals with detection, it states that the hazardous turbulence can extend up to 20 NM away from the radar echo shown. As a result, crews are instructed to avoid strong returns by at least 30 NM. Two adjacent echoes must be at least 40 NM away from each other in order to fly between them.

In the second section, on radar types, frequency bands used, controls and operation, and in the third, on limitations, it provides instructions on using the system and recommends that whenever possible, the information detected by the radar should be verified visually.

It suggests that, initially and periodically, the highest range should be used to detect areas of storm activity from as far away as possible so as to allow for sufficient lead time to be able to plan a route around them. The shortest ranges should be used to provide a more

detailed picture of the storm clouds detected. The return signals are less attenuated in the short and medium ranges, making it possible for activity that was not initially visible to be detected as the aircraft approaches it.

In point 8.3.8.1.5 the operator describes the procedures for operating the aircraft in a stormy environment.

As a general policy, flying into active storms should be avoided. Under no circumstances should aircraft be flown through an area that is ¾ covered by active storms.

Crews should never rely on a cloud's outward appearance as an indicator of the presence of turbulence inside storms. The height of the tops of cumulonimbus clouds is indicative of their severity, and tops in excess of 35000 feet should be regarded as extremely risky.

Clouds to windward should be cleared by a distance of at least 20 NM if their altitudes are in excess of 30000 ft. The idea behind this range is to avoid the associated turbulence that may exist beyond the confines of severe storms detected by high-intensity echoes. If the cloud is to be overflown, it should be done with a vertical separation of at least 5000 ft.

If flying through a storm cannot be avoided, the following procedure is recommended:

a. Instruct the cabin crew to secure the passenger compartment and alert the passengers.

b. Secure all loose equipment.

c. Tighten the safety harness.

d. Turn engine anti-ice ON.

e. Plan the altitude so as to avoid severe icing conditions.

f. Plan and maintain the optimum penetration route while continuously monitoring the weather radar.

g. Do not backtrack after entering the developing cloud.

h. Adjust the cabin lighting to maximum.

i. Keep your eyes on the instruments to minimize the risk of being blinded by lightning strikes.

Point 8.3.8.3.1 is devoted specifically to turbulence, which the operator indicates can be associated with the presence of developing convective storm clouds.

Turbulence is categorized as light, moderate and severe, depending on its effects.

The seatbelt light must be ON for light to moderate turbulence and higher categories. All passengers will be required to take their seats and fasten their seatbelts. The cabin service must be terminated during conditions of moderate or higher turbulence. For severe turbulence, the flight crew is required to use the full harness.

Variations in the load factor produced by severe turbulence make it difficult to read the instruments and to control the aircraft. It can also toss loose objects around. Flying in conditions of severe turbulence can lead to a loss of control and to potentially catastrophic structural failure, and must therefore be avoided not only out of passenger comfort concerns, but for safety reasons.

Flight crews must report turbulent conditions to ATC.

Point 8.3.11 concerns the policy on seatbelt use, with the presence of turbulence being one of the conditions that requires the flight crew to use the full harness. It also requires a flight crew member seating in one of the pilots' seats to use the seatbelt. As for the cabin crew and passengers, the use of seatbelts is left to the captain's discretion during phases other than takeoff and landing, when seatbelts must always be used.

1.17.2. Information from the manufacturer in the Flight Crew Operations Manual (FCOM)

The manufacturer gives some specific considerations on flying in turbulent conditions as part of a special procedure (SP).

The maximum turbulence experienced by the aircraft during its certification flights was classified as moderate.

Flying through severe turbulence must be avoided if possible. When the flight level is 30000 feet or higher, the area of turbulence should not be avoided by trying to climb above it, unless clear information is available indicating that it can be overflown without any problems. For a given turbulence intensity, the buffet margins increase if flying at the recommended speeds at lower altitudes.

1.17.2.1. Flying in light and moderate turbulence

The autopilot and autothrust can remain engaged when flying in conditions of light to moderate turbulence. Crews should expect increased movement of the throttle control levers when flying in changing wind, temperature and atmospheric pressure conditions. Variations in the indicated airspeed of 10 to 15 knots can be expected.

Seatbelt sign……..ON

Instruct passengers to keep their seatbelts fastened before entering areas where turbulence has been reported, and have the cabin crew verify it.

1.17.2.2. Flying in severe turbulence

The use of control wheel steering (CWS) is recommended in conditions of severe turbulence. Do not use the Altitude Hold (ALT HLD) mode.

The recommended procedures for flying in severe turbulence are:

- The target speed should be close to an IAS of 280 or 0.76 Mach, whichever is lower. Severe turbulence will cause fast, large swings in the indicated airspeed. Do not chase the speed indication.

- Engage the yaw damper.

- Use of the autopilot is optional. If engaged, use CWS mode, never ALT HLD mode.

- Disengage the autothrottle.

- Maintain the wings level and the desired pitch angle. Use the attitude indicator as the primary instrument. Extreme wind gusts can cause large changes in attitude. Do not make any sudden control inputs. Once the trim setting is adjusted for the penetration speed, do not change it.

- Allow altitude variations. In severe turbulence, large altitude swings are possible. Sacrifice altitude in favor of maintaining the attitude and the speed. Do not chase the altitude.

- Set engine ignition ON. Make an initial power adjustment to maintain the target speed and do not change it unless there is an extreme swing in speed. The recommended value for the N1 low-pressure compressor RPMs is shown on the cruise page on the Flight Management Computer (FMC).

- If the approach must be made through an area of severe turbulence, delay extending the flaps as long as possible. The aircraft can withstand a higher load factor when in a clean configuration.

1.17.3. Descent briefing

The Flight Crew Operations Manual (FCOM) contains guidelines for holding the descent briefing.

It states that about 100 NM before the calculated top of descent (TOD[5]), the pilot flying will hand control of the aircraft to the pilot monitoring to commence preparing the briefing.

The briefing is to include the remaining phases of the flight (descent, approach, landing, taxi and parking on the apron) and the FMC is to be updated with the latest weather and navigational information available for the various phases.

The manual states that the captain will select the weather radar on his navigation display and confirm that there is no adverse weather on the planned arrival route by monitoring for storm activity on the approach and go-around routes. The first officer will select the terrain (TERR) display on his ND and ensure that the arrival route avoids obstacles on the ground.

1.18. Additional information

1.18.1. Flight path

1.18.1.1. Programmed flight path

The operational flight plan (OFP) anticipated entering the France UIR through airway UN26 at FL370.

The flight would continue on that route to point KORER, where it would take airway UN616 to point TUPAR, linking there to UM184 and taking that to point COGNAC. There it would continue on airway UN863 to AGEN-GAUDON. Before reaching that point, the OFP included a climb to FL390, which would be the highest point on the route (TOC[6]).

After AGEN-GAUDON, the flight would continue on UN727 to point LOMRA, where it would switch to UN859.

The point where they would begin the descent (TOD) was located to the southeast of LOMRA.

They would enter the Barcelona UIR via UN859, which would take the aircraft to BERGA, where the crew would make the BERGA2Q standard arrival.

1.18.1.2. Flight path flown

The actual and planned flight paths coincided until point VELIN, which was located shortly before the TOC.

[5] Top of descent.
[6] Top of climb.

Figure 6. The flight path as per the operational flight path is shown in red and the actual path taken in green

At that point the aircraft deviated slightly left from its planned trajectory (see Figure 7). The aircraft remained at FL370 despite reaching the point in the flight plan where in theory it was supposed to climb to FL390. Some 66 NM past VELIN, the aircraft turned right onto heading 160°, which took it directly to Toulouse.

Just as it was reaching this city, the aircraft made a turn to the right that took it to heading 215°.

The event occurred as soon as this turn was completed.

The aircraft continued flying an additional 5 NM on the same heading as before the event and then turned left to heading 155°, which took it direct to point PUMAL.

From that point on, the aircraft followed the programmed flight plan.

1.19. Useful or effective investigation techniques

Not applicable.

2. ANALYSIS

2.1. Flight preparation. Assessment of weather forecasts

The crew carried out an assessment of the flight at their departure airport, Dublin, based on the weather information provided by the operator.

Based on this information, the forecast for the area where the event took place called for moderate icing between FL110 and FL220 and moderate turbulence from below FL100 to FL220. There was no information on significant phenomena on the route at the flight level planned.

The area of the Pyrenean mountain range, the southeast of France and the northern part of the Iberian Peninsula were inside another zone for which the presence of embedded cumulonimbus clouds was forecast, with bases below FL100 and tops at FL370.

The weather information did not mention the presence of any significant turbulence along the route, especially in the area where the accident occurred.

With this information, then, the flight crew concluded that they would not encounter any significant phenomena along the route, and mentioned as much to the cabin crew during their departure briefing.

They anticipated flying at FL370. They did not regard it necessary to modify the parameters planned for the route in terms of flight levels, deviations in the route or taking on extra fuel, as their analysis of the pre-flight information did not call for any such changes.

Images from weather satellites detected the presence of a convective cumulonimbus cloud developing above the city of Toulouse. Although their planned route did not pass over that position, subsequent instructions from ATC resulted in a deviation from their route that led them to fly over the storm cell.

Although they heard other crews on the frequency requesting to divert due to storm activity, they did not receive any information in this regard from ATC informing them of the presence of similar phenomena along their route.

2.2. Adherence to company procedures on the use of weather radar and flying in stormy conditions

The company's procedures require the captain to have the radar weather on his navigation display, and this was in fact the mode that was active, selected to a range of 80 NM at the time of the accident.

The operator recommends a long range at first to monitor areas where convective activity is anticipated. Then, as the aircraft approaches the cumulonimbus cloud, the range is lowered to improve the definition and the display scale so the most problematic areas can be detected. The fact that the captain had such a long range selected could indicate that their monitoring and surveillance of the weather situation was improper, since with such a long range and the cloud scale displayed it is impossible to see in detail how the situation is evolving and where the areas of greatest risk are.

The first officer had the terrain mode selected on his navigation display, set to a range of 160 NM, as required by the company's procedures. The company also permits, at the captain's discretion and depending on the situation, for both pilots to select the weather display so as to make it easier to study it and analyze a possible course change to avoid flying through storms. The mode and range that were active on the first officer's display did not provide information that they could use to avoid the stormy area. The use of this mode indicates that the crew were not concerned about the possibility of being affected by the adverse phenomena associated with developing cloud formations.

The crew adhered to the requirements of the operations manual regarding holding the relevant briefing far enough ahead of the calculated descent point (TOD). The piloting functions were swapped so the first officer could prepare and present the briefing. This activity could have distracted the crew, preventing them from detecting the presence of the convective cloud. The operator recommends cross checking the radar display with visual observations to better assess the conditions.

Ten seconds before the course change to the southwest was recorded, the recorded wind data started to change. This indicates the proximity of a turbulent region. From this we can conclude that the maneuver to avoid the active cell was started late, with the aircraft already close to the cloud, instead of clearing the cloud formation by 20 NM, as recommended by the operator.

Since the cumulonimbus was not detected ahead of time, the seatbelt sign was not turned on until the evasive maneuver was started.

The decision to turn off the seatbelt sign after the takeoff and/or landing phases and to bring out the service cart is always the captain's to make, regardless of whether he is the pilot flying or not. This decision is made based on the weather conditions that exist during the flight.

In the event of turbulence and in the absence of instructions from the flight crew, the Cabin Supervisor can decide to interrupt any activity not related to safety and inform the captain of the level of turbulence being experienced, and recommend turning on the seatbelt sign.

It was during the turning maneuver that they experienced the most severe turbulence, causing the speed to increase in excess of the MMO. Although the crew made a corrective input to the throttles, they did not disengage the autothrottle, contrary to the manufacturer's recommendations for flying in severe turbulence.

The aircraft experienced an increase in vertical acceleration (maximum value of 1.89515 g) and lateral acceleration (maximum value of 0.244 g). The turbulent movements typical of these atmospheric phenomena that affected the aircraft lasted about 29 s. Due to its effects, the turbulence is believed to have been severe.

2.3. CRM and crew coordination

The encounter with this turbulence was not reported to ATC, contrary to the requirements of the operator's Operations Manual. The crew explained this omission by arguing that they were busy evaluating the injuries sustained in the passenger cabin.

The captain established contact with the flight attendants, who informed him of the injuries sustained by the FAs themselves and by the passengers. Although he was told about the injuries, he did not report the need for medical assistance until he was in contact with controllers at the Reus Airport. He also did not think it necessary to declare a medical emergency (PAN PAN Medical) to ATS.

The statements by the cabin supervisor and the flight crew seem to indicate that communications between them were not good, since the former stated that when the captain called to ask about the situation in the cabin, she told him there were several injuries that would require medical attention. In contrast, the flight crew stated that it was their understanding that there were two injured passengers whose condition did not seem serious. In any event, the flight crew were aware that two injured individuals were being treated by two passengers who were healthcare professionals. Had the captain been better informed of the situation in the cockpit, that should have prompted him to request help from ATS by declaring a medical emergency. This would have given them a certain priority and minimized the length of time the injured were left unattended.

The Cabin Supervisor did not tell the flight crew that she was unable to move the more seriously injured passenger, and of her decision to land with a passenger blocking access to the aft doors. This information is essential to the captain, as it affects how a potential evacuation will be conducted. Likewise, the Cabin Supervisor must take into account any obstacles (injured passenger and damaged service cart) that could affect the availability of an emergency exit and give instructions to the rest of the crew so that, in the event of an evacuation, the obstruction can be avoided. This investigation has thus detected a fault involving crew resource management (CRM); in particular, faulty communications and threat assessment. A safety recommendation was considered to be issued to the operator in this regard.

Nevertheless, during the investigation term, the operator showed that they had improved its training regarding the detected deficiency by:

- Generation of new presentations and exercises about measures to be taken and communication coordination with the cabin crew in case of turbulence forecast and encountering, during the flight crew recurrent training.

- Generation of new presentations and exercises about measures to be taken and communication coordination with the flight crew in case of turbulence forecast and encountering, during the cabin crew recurrent training.

- Analysis and discussion of present incident case with the crews as a negative example of crew coordination and threat assessment.

This measure is deemed efficient to solve the deficiency and, as a consequence, no safety recommendation is issued in this report.

3. CONCLUSIONS

3.1. Findings

- The flight and cabin crews had valid and in force licenses and ratings and were in proper medical condition to carry out the tasks assigned to them.

- The aircraft was airworthy and its documentation was valid and in force.

- The crew received weather and operational information at the departure airport.

- The crew did not detect any significant phenomena that required them to take any precautions or exceptional measures.

- The variations in the planned route, in keeping with ATC's instructions, led the aircraft over the city of Toulouse, where a convective storm cell had developed.

- The display modes and ranges selected on the navigation displays were not useful in detecting and evaluating the risk associated with flying through the storm.

- The crew did not take any evasive maneuvers sufficiently far in advance to avoid the weather phenomena associated with the storm.

- The captain, due to the unanticipated and unforecasted extent of the storm cell, did not turn on the seatbelt sign until they were in the turbulence, which resulted in the passengers and crew being unrestrained.

- Two passengers and three cabin crew were affected by the severe turbulence and injured to varying extents.

- The flight crew did not report the turbulence to ATC.

- The captain did not declare a medical emergency to ATC as he was not aware of the extent of the injuries.

- The Cabin Supervisor did not report that a passenger had been immobilized and was blocking the operation of one of the emergency doors.

- The affected passengers and crew were evacuated to receive medical assistance.

- The aircraft was checked at Reus Airport by the operator's maintenance personnel, who returned it to service. No damage was found during their inspection.

3.2. Causes/Contributing factors

The accident was caused when the aircraft entered a developing convective cloud that had not been detected by the crew. The severe turbulence associated with the cloud affected the aircraft, causing injuries to several passengers and crew who had not been alerted to the turbulence.

4. SAFETY RECOMMENDATIONS

The communications between the flight and cabin crews were ineffective since the captain was unaware of the seriousness of the injuries caused by the turbulence. The Cabin Service Supervisor also did not alert the captain to the presence of a passenger who had to be immobilized in place, blocking an emergency exit. She also made no comments or organized the flight attendants to specify their tasks in the event of an evacuation.

The investigation considered to issue a safety recommendation to the operator to reinforce its training on Crew Resource Management, specifically as it relates to communications, organization and threat detection, among its cabin crews and between cabin crews and flight crews.

During the investigation term the operator showed that they had improved its training regarding the detected deficiency by:

- Generation of new presentations and exercises about measures to be taken and communication coordination with the cabin crew in case of turbulence forecast and encountering, during the flight crew recurrent training.

- Generation of new presentations and exercises about measures to be taken and communication coordination with the flight crew in case of turbulence forecast and encountering, during the cabin crew recurrent training.

- Analysis and discussion of present incident case with the crews as a negative example of crew coordination and threat assessment.

This measure is deemed efficient to solve the deficiency and, as a consequence, no safety recommendation is issued in this report.

5. APPENDICES

ANNEX I

ANNEX I

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[ Airport WX List ]
-------------------------------------------------------------------
AIRMETs:
  No Wx data available

SIGMETs:
LECM  MADRID UIR
  WS  SIGMET 1 VALID 231330/231600 LEMM- LECM MADRID FIR/UIR
             FRQ TS N43 W008 - N42 W008 - N42 W00630 - N43 W00630
             TOP FL420 MOV E SLW NC=

Tropical Cyclone SIGMETs:
  No Wx data available

Volcanic Ash  SIGMETs:
  No Wx data available

Departure/Destination:
EIDW/DUB  DUBLIN INTL
  SA  231330 VRB03KT 9999 FEW023 SCT050 20/09 Q1025 WS RWY10 NOSIG=
  FT  231100 2312/2412 36009KT 9999 FEW022 SCT030
             BECMG 2312/2314 08008KT
             BECMG 2320/2322 VRB03KT
             BECMG 2410/2412 09009KT=
LERS/REU  REUS
  SA  231330 13004KT 080V200 9999 FEW017 SCT025 26/20 Q1017=
  FT  230800 2309/2409 VRB03KT 9999 FEW020 TX27/2313Z TN20/2405Z
             TEMPO 2309/2318 10010KT
             PROB30 TEMPO 2406/2409 4000 TSRA FEW020CB BKN030=

Destination Alternates:
LEGE/GRO  GIRONA
  SA  231330 16009KT 120V210 9999 SCT030 FEW035TCU 27/20 Q1017=
  FT  231100 2312/2412 VRB03KT 9999 SCT020 TX27/2314Z TN18/2406Z
             TEMPO 2312/2316 12010KT
             PROB30 TEMPO 2312/2320 FEW030CB
             TEMPO 2410/2412 FEW030CB=
LEVC/VLC  VALENCIA/MANISES
  SA  231330 09004KT 040V110 9999 FEW030 25/20 Q1016 NOSIG=
  FT  231100 2312/2412 11010KT 9999 SCT030 TX28/2313Z TN20/2406Z
             PROB30 TEMPO 2314/2322 FEW020CB
             BECMG 2318/2321 26005KT
             PROB30 2402/2409 3000 SHRA FEW020CB BKN028=
LEBL/BCN  BARCELONA/EL PRAT
  SA  231330 11009KT 070V150 9999 SCT013 26/20 Q1017 NOSIG=
  FT  231100 2312/2412 10010KT 9999 SCT010 TX27/2313Z TN21/2406Z
             PROB30 TEMPO 2315/2319 FEW030CB
             BECMG 2318/2321 32005KT
             TEMPO 2409/2412 2000 TSRA SCT020CB BKN030=
LFMP/PGF  PERPIGNAN/RIVESALTES
  SA  231330 09009KT 9999 BKN018 SCT022CB 23/20 Q1017 NOSIG=
  FT  231100 2312/2412 09010KT 9999 BKN013 BKN050
             TEMPO 2315/2323 2000 TSRA BKN010 SCT040CB
             TEMPO 2323/2412 RA=
EGGP/LPL  LIVERPOOL
  SA  231320 28014KT 9999 FEW040 20/13 Q1023=
  FT  231101 2312/2412 30008KT 9999 FEW035
             PROB40 2400/2408 7000 BKN008=
EINN/SNN  SHANNON
  SA  231330 VRB03KT 9999 FEW030 BKN050 21/10 Q1025 NOSIG=
  FT  231100 2312/2412 36007KT 9999 SCT020 BKN040
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              BECMG 2407/2410 32006KT=
EGPK/PIK  PRESTWICK
  SA  231320 25005KT 220V280 9999 SCT020 18/13 Q1024=
  FT  231100 2312/2412 28010KT 9999 FEW015 SCT030
             PROB30 TEMPO 2400/2406 BKN012=
EICK/ORK  CORK
  SA  231330 34007KT 9999 SCT038 BKN050 19/10 Q1025 NOSIG=
  FT  231100 2312/2412 03008KT 9999 FEW020 BKN040
             BECMG 2314/2316 21008KT
             BECMG 2316/2319 VRB03KT=

Enroute Alternates:
LFRS/NTE  NANTES ATLANTIQUE
  FT  231100 2312/2418 05005KT CAVOK=
LFBO/TLS  TOULOUSE/BLAGNAC
  FT  231100 2312/2418 VRB02KT 9999 SCT030
             BECMG 2314/2316 35005KT
             TEMPO 2316/2322 2000 TSRA BKN025 BKN040CB
             BECMG 2322/2324 24005KT CAVOK
             BECMG 2403/2405 BKN012
             BECMG 2410/2412 SCT035 SCT060TCU
             BECMG 2411/2413 31005KT
             PROB40 TEMPO 2415/2418 4000 TSRA SCT025 BKN040CB=
LFBH/LRH  LA ROCHELLE/ILE DE RE
  FT  231100 2312/2412 03008KT 9999 BKN030
             TEMPO 2312/2316 5000 RA BKN040TCU
             BECMG 2316/2318 CAVOK
             PROB30 TEMPO 2403/2406 5000 BR=
EGTE/EXT  EXETER
  FC  231100 2312/2321 VRB03KT 9999 FEW040
             PROB30 2312/2318 15010KT=
EGGD/BRS  BRISTOL
  FT  231059 2312/2412 VRB05KT 9999 FEW040
             PROB30 TEMPO 2315/2319 8000 -SHRA=
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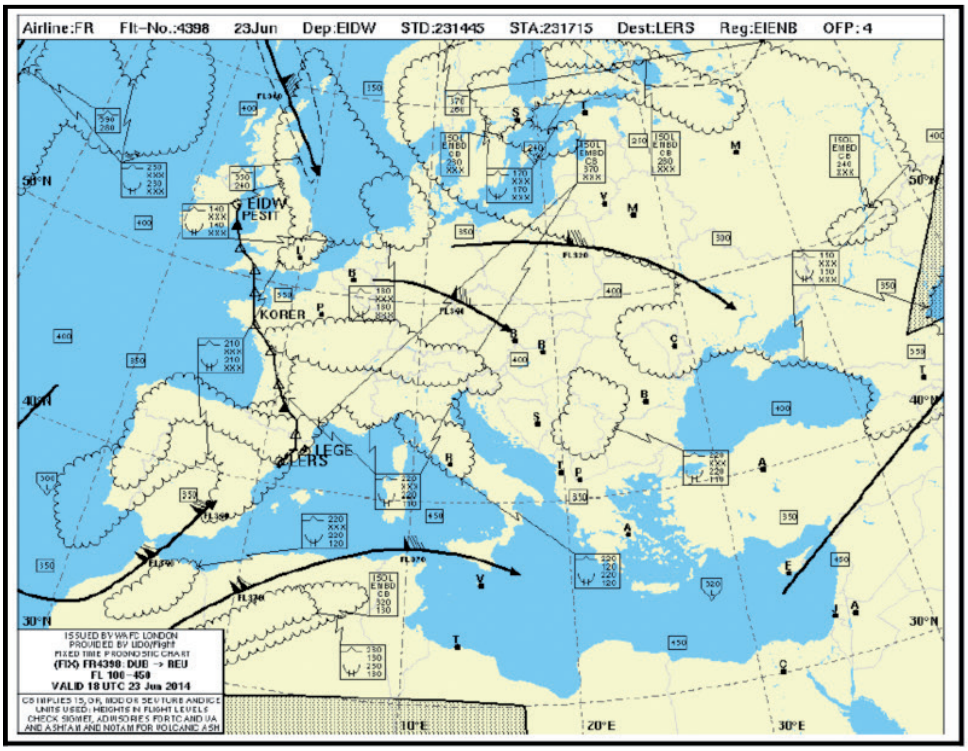
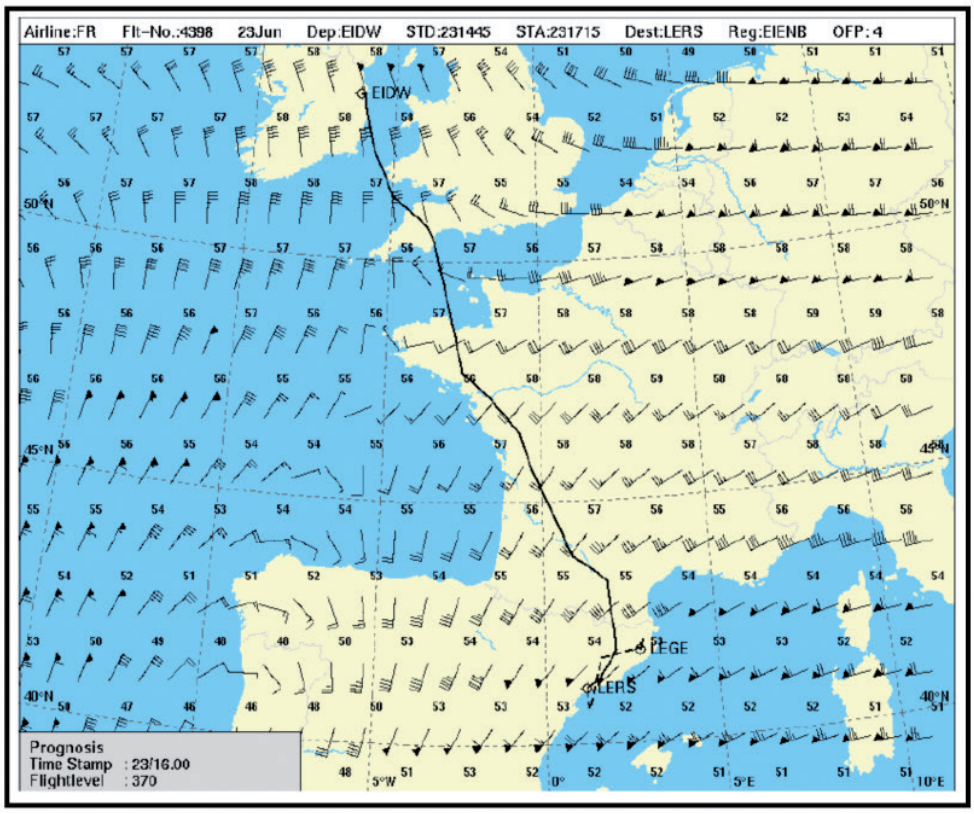
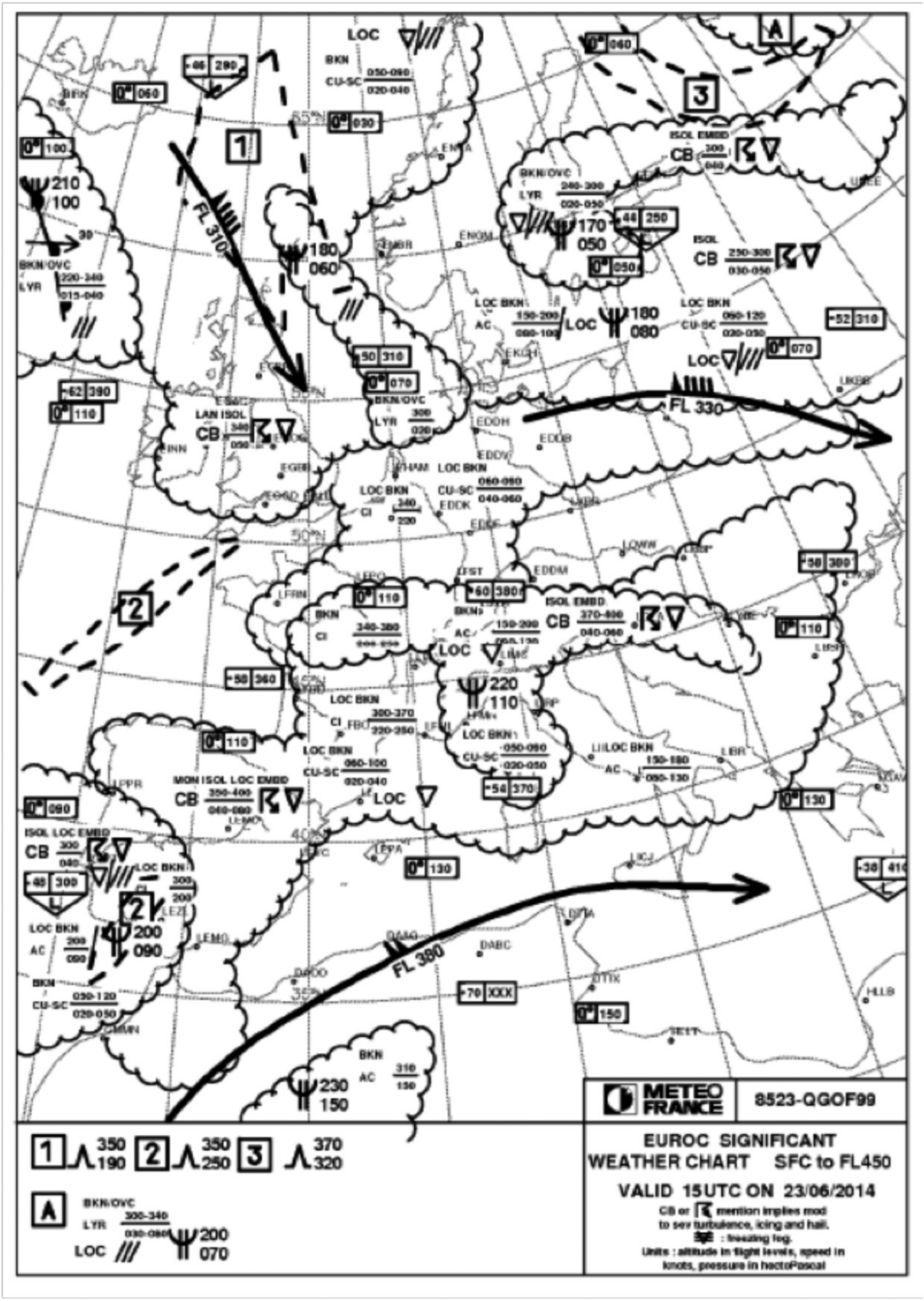
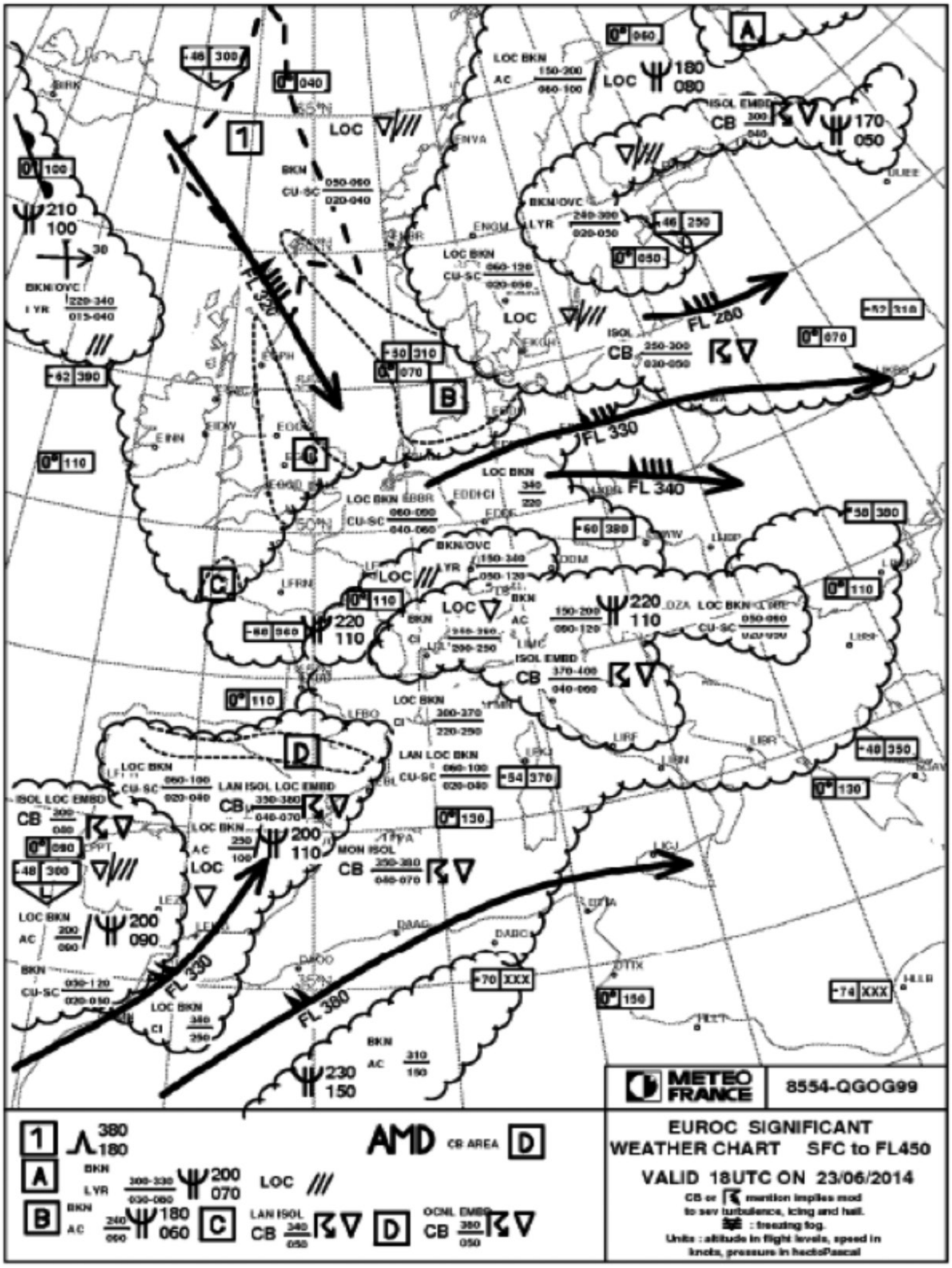


Significant weather chart, FL100-450



Wind map, FL370.


METEO FRANCE
8523-QGOF99
EUROC SIGNIFICANT WEATHER CHART SFC to FL450
VALID 15UTC ON 23/06/2014
CB or mention implies mod to sev turbulence, icing and hail.
: freezing fog.
Units : altitude in flight levels, speed in knots, pressure in hectoPascal
FL 310
FL 330
FL 380
1 350 190
2 350 250
3 370 320
A BKN/OVC LYR 300-340 030-080 LOC 200 070


METEO FRANCE
8554-QGOG99
EUROC SIGNIFICANT WEATHER CHART SFC to FL450
VALID 18UTC ON 23/06/2014
CB or TS mention implies mod to sev turbulence, icing and hail.
: freezing fog.
Units : altitude in flight levels, speed in knots, pressure in hectoPascal
AMD
CB AREA
FL 320
FL 330
FL 340
FL 380
FL 200
LOC BKN
ISOL CB
LAN ISOL CB
OCNL CB
MON ISOL CB