Technical report

IN-024/2023

Incident on 27 August 2023 involving a Boeing 737-800 aircraft operated by Jet2.com, registration G-DRTW, at Palma de Mallorca Airport (Balearic Islands, Spain)

Please note that this report is not presented in its final layout and therefore it could include minor errors or need type corrections, but not related to its content. The final layout with its NIPO included (Identification Number for Official Publications) will substitute the present report when available.

GOBIERNO DE ESPAÑA
MINISTERIO DE TRANSPORTES Y MOVILIDAD SOSTENIBLE
SUBSECRETARÍA
COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

NOTICE

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

In accordance with the provisions of Article 5.4.1 of Annex 13 of the International Civil Aviation Convention, Article 5.6 of Regulation (EU) No 996/2010 of the European Parliament and of the Council of 20 October 2010; Article 15 of Law 21/2003 on Air Safety; and Articles 1 and 21.2 of RD 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent their recurrence. The investigation is not intended to attribute any blame or liability, nor to prejudge any decisions that may be taken by the judicial authorities. Therefore, and according to the laws specified above, the investigation was carried out using procedures not necessarily subject to the guarantees and rights by which evidence should be governed in a judicial process.

As a result, the use of this report for any purpose other than the prevention of 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.

CONTENTS

ABBREVIATIONS

APP ..... Approach control office

ATC ..... Air traffic control

ATPL(A) ..... Airline transport pilot licence

CPL(A) ..... Commercial pilot licence

FL ..... Flight level

ft ..... Feet

IATA ..... International Air Transport Association

IFR ..... Instrument flight rules

IR ..... Instrument flight rating

kg ..... Kilogrames

kt ..... Knots

L ..... Left

LEMH ..... ICAO code for Menorca Aerodrome (Spain)

LEML ..... ICAO code for Badajoz Aerodrome (Spain)

LEPA ..... ICAO code for Palma de Mallorca Aerodrome (Spain)

LFML ..... ICAO code for Marseille Aerodrome (France)

METAR ..... Meteorological aerodrome report

NM ..... Nautical mile

OFP ..... Operational flight plan

PDM ..... Mass diversion plan

R ..... Right

s/n ..... Series number

SIGMET ..... Area forecast

TACC ..... Terminal Area Control Centre

TAFOR ..... Terminal aerodrome forecast

TWR ..... Control tower

UTC ..... Coordinated universal time

Technical Report IN-024/2023

Owner and operator:	Jet2.com
Aircraft:	Boeing 737-800, G- DRTW (UK)
Date and time of incident:	Sunday 27 August 2023; 11:12 UTC[1]
Site of incident:	Palma de Mallorca Airport (Balearic Islands)
Persons on board:	6 crew members +187 passengers (unharmed)
Type of flight:	Commercial air transport - international - passengers
Phase of flight:	Approach
Flight rules:	IFR
Date of approval:	18 December 2024

Synopsis

Summary:

On the morning of Sunday, 27 August 2023, the Boeing 737-800 G-DRTW aircraft operated by Jet2.com and arriving from Glasgow Airport (UK), landed at Palma de Mallorca Airport with 1115 kg of final reserve fuel ,which is 44 kg short of the final reserve fuel established by the regulations. The flight had been delayed on departure due to adverse weather, and the crew had loaded additional fuel in case of further delays for this reason.

The area around the Balearic Islands was affected by particularly poor weather conditions that affected all three of the archipelago's airports at the same time, making impossible the operation in all of them and resulted in the establishment of rate 0 around 09:00 h, by which time the aircraft was already in French airspace. The situation in the Balearic Islands had a knock-on effect on the Barcelona ACC airspace, where aircraft began to accumulate and where the G-DRTW aircraft flew four holding patterns over the Pyrenees. The aircraft was finally routed to Palma de Mallorca, which was beginning to accept aircraft again, and after a further 53 minutes of additional flight time, landed after declaring MAYDAY for fuel 20 NM from touchdown.

The investigation focused on the planning and management of the flight by the aircraft, the meteorology, the traffic control measures taken and, lastly, the operation of the ATC services.

The investigation has established that the probable cause of the incident involving the G-DRTW aircraft was an excessive workload in the CCC sector of the ACC Barcelona and in the collateral sectors of the ACC Bordeaux as a consequence of the weather conditions in the Balearic Islands, as well as an error in the alternate airport entered in the aircraft's flight plan while in French airspace.

[1] All times used in this report are UTC.

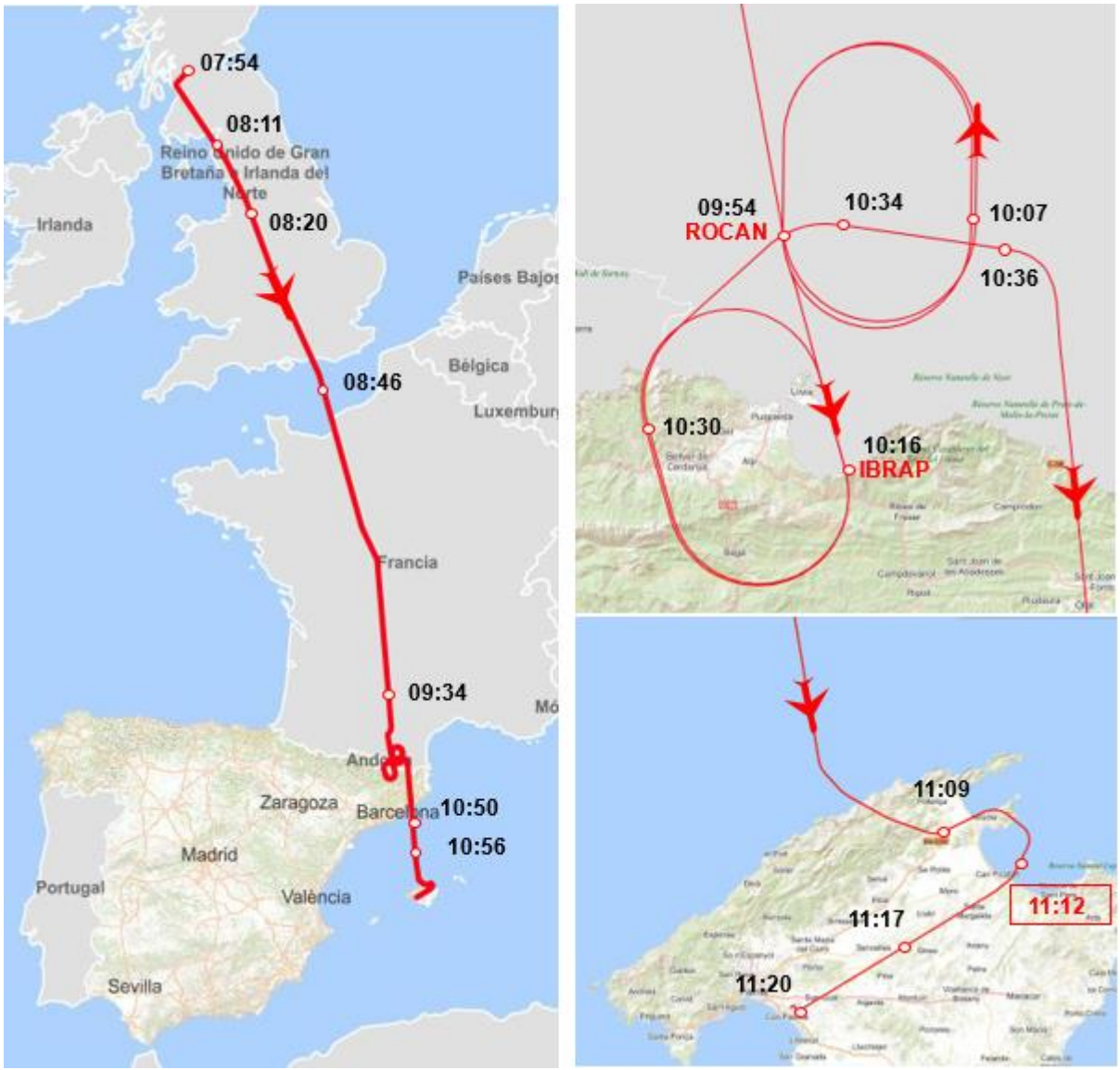
It is considered as probable contributory factors the overload of the air traffic controllers and the inefficiency of the ATFM measures implemented on the tactical phase, and the complexity of the management of huge deviation when two dependencies are affected.

The report does not contain any safety recommendations.

1. FACTUAL INFORMATION

1.1. Summary of the incident

On the morning of Sunday, 27 August 2023, the Boeing 737-800 G-DRTW aircraft operated by Jet2.com was due to make two scheduled return flights between Glasgow (UK) and Palma de Mallorca (Spain). Take-off from Glasgow was planned for 06:00, and the duration was to be 2 hours 33 minutes, with Menorca Airport (LEMH) being the alternate for the first sector. Both sectors were to be carried out by the same crew, who initiated their activity for the day with these flights. The callsign for the first flight was EXS5AB.



07:54 take-off
08:11 FL330
08:20 FL330
08:46 FL350 aircraft with ATC France
09:34 Palma not accepting traffic and activation of PDM
09:54 holding patterns to the left over ROCAN
10:07 destination change to Menorca
10:16 aircraft to LECB and holding patterns to the right over IBRAP
10:30 aircraft to LFBB
10:34 aircraft to LECB and Palma open
10:36 clearance to LORES
10:50 start of descent
10:56 aircraft with TACC Palma
11:09 aircraft with APP Palma
11:12 MAYDAY FUEL
11:17 aircraft with TWR Palma
11:20 touchdown in Palma

Figure 1. Full flight path of flight EXSAB

The sequence of events on the day was as follows.

Flight preparation:

- 00:58: the aircraft landed with the preceding crew, arriving from Tenerife South with 2850 kg of fuel.
- 01:14: the aircraft was refuelled in a standard pre-fuelling process set by the operator to 8050 kg of fuel.
- 04:10: issuance of the third revision[2] of the operational flight plan (hereinafter OFP) two hours before the planned take-off time. The fuel stated in the OFP was 9097 kg.
- 04:30: the crew arrives to sign on for duty and prepare for the flight 90 minutes before the planned take-off time because it was a training flight for the first officer.[3]
- 05:11: after reviewing the flight readiness documentation, the crew decided that the aircraft should be refuelled to 10100 kg.

This amount of fuel ensured the aircraft was ready for the flight.

The OFP's fuel calculations were based on take-off from runway 23, which was the runway it used, and landing on runway 24L which was the runway the aircraft landed on.

Delay in the scheduled take-off time:

The take-off, scheduled for 06:00, was delayed by 1 hour 41 minutes because of an ATFM restriction due to weather at the destination airport (IATA code 84).

Take-off:

At 07:41, the aircraft commenced the taxi from its parking position, and at 07:54, it initiated its take-off run on runway 23 at Glasgow Airport, as per the OFP. At 08:00, the aircraft was on a southeasterly heading as it continued to climb.

Flight on a southeasterly heading:

At 08:11, the aircraft reached FL310. At 08:20 FL330 and finally at 08:46 FL350 after entering French airspace. The flight followed the planned route in terms of the heading but not in terms of the flight level, remaining at FL350 instead of FL370. This en-route phase of the flight was uneventful and carried out with the first officer as the pilot flying.

At 09:00[4], the crew checked the fuel and noted that they had 6100 kg on board, indicating they had used 100 kg more than planned.

[2] According to the OM, three versions of the OFP are issued: 12 hours before, 6 hours before, and 2 hours before.
[3] Crews normally arrive to sign on for duty 60 minutes before the take-off time.
[4] According to the OM, fuel checks should be made every hour during flights lasting more than one hour.

Rate 0[5] in Palma de Mallorca and holding patterns over the Pyrenees:

At 09:26, the Mass Diversion Plan (PDM) was activated in Palma and a few minutes later it was stablished rate 0, being impossible the operation at the airport due to bad weather. The Spanish (LECB) and French (LFBB) control centres began to make arrangements to hold traffic in French airspace and not transfer it to Spain due to congestion. The no acceptance of aircraft at Palma airport was notified by the French control centre to the aircraft at 09:43.

At 09:54, the aircraft, still under French control, approached the Pyrenees and began a sequence of four holding patterns that lasted 38 minutes:

- From 09:54 to 10:15: Two holding patterns over ROCAN at FL350 with a selected IAS of 239 kt. At 10:07, during the second holding pattern, the crew informed LFBB that they were changing their destination airport to Menorca, their alternate.
- From 10:15 to 10:32: Two holding patterns over IBRAP at FL350 with a selected IAS of 228 kt. During the third hold, at 10:16, the aircraft was transferred to Spain (LECB), which, at the end of the fourth hold (10:30), returned the aircraft to French control (LFBB).

During these holding patterns, the fuel level decreased from 3882 kg to 2526 kg.

Opening of Palma de Mallorca and flight to the Balearic Islands:

At 10:32 the aircraft was completing the fourth hold and flying on an easterly heading. At 10:33, Palma re-opened, and at 10:34, the aircraft was transferred back to Spain (LECB). At 10:36 the aircraft was notified that Palma had re-opened and was cleared to proceed on a southerly heading direct to LORES.

One minute later, the aircraft turned to a southerly heading, and at 10:46 and 10:47, the low fuel warnings were triggered for both tanks.

Start of descent and low fuel warnings

At 10:50, the aircraft began its descent while still under LECB control. It was then transferred six minutes later (10:56) to the TACC unit in Palma. The aircraft continued its descent following ATC instructions and without notifying ATC of the low fuel situation[6]. At 11:09, with the aircraft already over the island of Mallorca, it was transferred to Palma APP.

MAYDAY due to fuel:

At 11:12, the crew declared an emergency using the term "MAYDAY MAYDAY MAYDAY FUEL". At that time, the aircraft was 25 NM from runway 24L and descending, at 5800 ft altitude and

[5] The term rate refers to an airspace regulation measure, by which, in this case Palma, does not accept traffic during a certain period of time. In this case, rate 0 means that the aerodrome does not accept any traffic and, consequently, takeoff operations from any origin that have this destination are not allowed. This regulation affects traffic that has not taken off, but does not affect those that are already in flight to that destination. For these aircraft, other measures have to be adopted such as keeping them on hold or redirecting them to alternative aerodromes.

[6] ICAO introduced the term MINIMUM FUEL in 2012, and in March 2023, the UK Civil Aviation Authority issued the third version of safety notice SN-2019-002 to recommend that operators use it in advance of declaring MAYDAY.

about to intercept the 24L localiser. At 11:17, the aircraft was transferred to the Palma TWR frequency.

Landing in Palma de Mallorca:

At 11:20, the aircraft touched down on runway 24L after a flight time extension of 53 minutes. At the time of touchdown, the total fuel was 1115 kg, 44 kg below the final reserve fuel. At 11:26, the aircraft reached the parking stand, and the block time was recorded. The passengers disembarked normally, and none of the occupants were injured.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatalities				
Serious				
Minor				
Unharmed	6	187	193	---
TOTAL	6	187	193	---

1.3. Damage to the aircraft

None.

1.4. Other damages

None.

1.5. Information about the personnel

Captain

The 51-year-old captain held an ATPL(A) licence issued by the UK Civil Aviation Authority. His B737 300-900/IR rating had been renewed on 06/08/2023, his medical certificate had been renewed on 17/08/2023, and therefore, both were valid. He had worked for the operator for 11 years. His recent activity was as follows:

- The three previous days had been days off.
- He had made his last flight 5 days before.
- He had flown 60:08 h in the last month and 188:54 h in the last 3 months.

On the day of the event, he arrived 90 minutes before the planned take-off time at 04:30 UTC due to the fact that it was an instructional flight[7]. He was in the left seat and was the pilot flying for the last part of the flight.

[7] For all other flights, signing on time is 60 minutes prior to departure.

First officer

The 29-year-old first officer held a CPL(A) licence issued by the UK Civil Aviation Authority. His B737 300-900/IR rating had been renewed on 27/05/2023, his medical certificate had been renewed on 19/01/2023, and therefore, both were valid. He had worked for the operator for 6 months and was in training. He had 252 hours of experience, of which 92 hours were in type. His recent activity was as follows:

- He had not flown at the two weeks prior to the incident flight.
- He had flown 25:32 h in the last month and 91:39 h in the last 3 months.

He was in the right seat and was the pilot flying until the holding patterns over the Pyrenees.

1.6. Information about the aircraft

The Boeing 737-86N, registration G-DRTW, s/n 28618, has been owned by the operator since 2019. It had an airworthiness review certificate issued by the operator's CAMO on 12/06/2023, making it valid at the time of the incident.

It had accumulated a total of 66299:07 hours. A review of the flight logs showed no defects relevant to this to this event.

1.7. Meteorological information

Storm Betty was expected to affect the whole of the western Mediterranean region, concentrating principally on the Balearic Islands. From 08:55 onwards, the area experienced highly intense and virulent convective phenomena that brought very heavy rain, extremely strong winds and continuous changes of wind direction that caused the first missed approaches to Palma de Mallorca Airport.

1.7.1 Area forecasts: significant maps

Figures 2 and 3 show the EUMETNET significant maps which were issued the day before and on the day of the incident and which predicted strong cumulonimbus over the Mediterranean area moving E/NE with their maximum height at level 450 and local precipitation associated with large hail and strong gusts of wind.

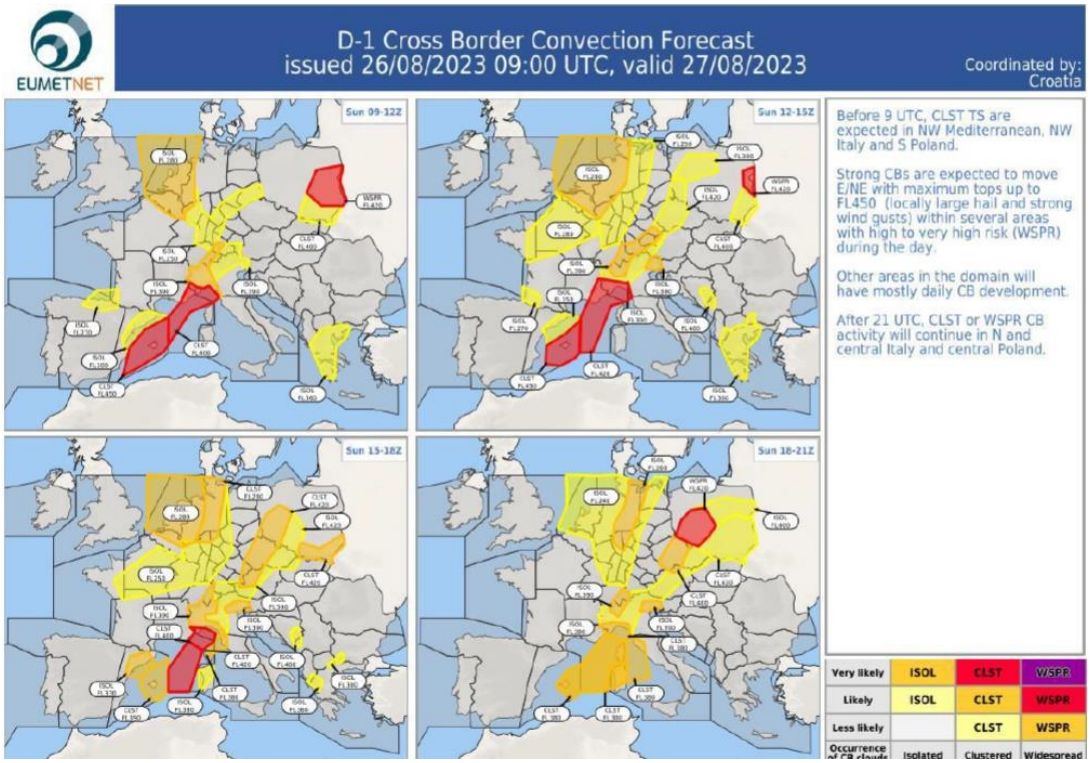


Figure 2. Significant maps issued the day before (EUMETNET)

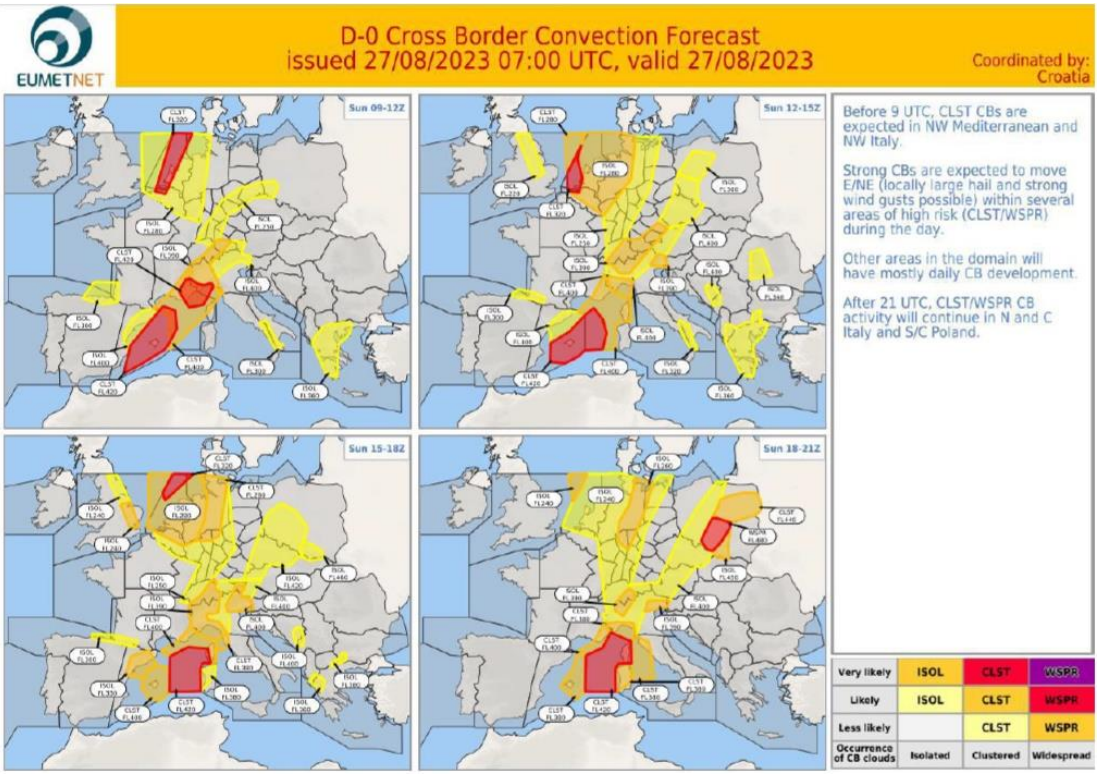


Figure 3. Significant maps issued on the day of the incident (EUMETNET)

WSSP32 LEMM 270755
LECB SIGMET 8 VALID 270800/271000 LEVA-
LECB BARCELONA FIR/UIR EMBD TS FCST WI N4157 E00229 - N4002 E00417 - N3812 E00003 - N3822 W00124 - N3946 W00102 - N4157

E00229 TOP FL430 MOV NE 30KT NC=

The SIGMET published by the Valencia Meteorological Surveillance Office at 07:55 on the day of the incident, which was valid between 08:00 and 10:00 for the Barcelona FIR/UIR, forecast thunderstorms up to FL430 moving northeast at 30 knots, without variation.

WSSP32 LEMM 270947
LECB SIGMET 9 VALID 271000/271200 LEVA-
LECB BARCELONA FIR/UIR EMBD TS FCST WI N4229 E00055 - N4120
E00434 - N3937 E00412 - N3728 W00001 - N3832 W00041 - N4054
E00038 - N4229 E00055 TOP FL430 MOV NE 30KT NC=

The SIGMET published by the Valencia Meteorological Surveillance Office at 09:47 on the day of the incident, which was valid between 10:00 and 12:00 for the Barcelona FIR/UIR, forecast thunderstorms up to FL430 moving northeast at 30 knots, without variation.

1.7.2 Aerodrome forecasts: TAF

The aerodrome forecasts (TAF) for Palma Airport issued between 23:00 on the day before the event and 11:00 on the day of the event included an amendment, which warned of worsening conditions from 09:00 onwards.

TAF LEPA 262300Z 2700/2724 06006KT 9999 FEW020 TX27/2712Z TN18/2706Z PROB40 TEMPO 2703/2707 TSRA FEW030CB BECMG 2704/2706 33009KT TEMPO 2707/2718 VRB20G35KT 2000 SHRA TSGR SCT030CB

The forecast for the next 24 hours issued at 23:00 the day before the incident predicted wind at 6 knots from a direction of 060º. Visibility was 10 km or more, with few clouds at 2000 ft. The forecast maximum temperature at 12:00 was 27ºC and the forecast minimum at 06:00 was 18ºC with a 40% probability. Between 03:00 and 07:00 the forecast was for thunderstorms with rain, few clouds at 3000 with cumulonimbus. Changing between 04:00 and 06:00 the wind was forecast to be 9 knots from a direction of 330º. Between 07:00 and 18:00 the forecast was for variable winds of 20 knots with gusts of 35 knots, visibility of 2 km with showers, thunderstorms with hail and scattered clouds at 3000 ft with cumulonimbus.

TAF LEPA 270500Z 2706/2806 06005KT 9999 FEW020 TX27/2712Z TN18/2706Z PROB40 TEMPO 2706/2707 TSRA FEW040CB TEMPO 2707/2720 VRB20G30KT 2000 SHRA TSGR SCT030CB BECMG 2720/2722 30008KT

The forecast for the next 24 hours issued at 05:00 on the day of the incident was wind of 5 knots from a direction of 060º. Visibility was 10 km or more, with few clouds at 2000 ft. The forecast maximum temperature at 12:00 was 27ºC and the forecast minimum at 06:00 was 18ºC with a 40% probability. Between 06:00 and 07:00 the forecast was for rain with few clouds at 4000 with cumulonimbus. Between 07:00 and 20:00 the forecast was for variable winds of 20 knots with gusts of 30 knots, visibility of 2 km with showers and thunderstorms with hail, scattered clouds at 3000 ft with cumulonimbus. Changing between 20:00 and 22:00 the wind was forecast to be 8 knots from a direction of 300º.

TAF AMD LEPA 270926Z 2709/2806 31012KT 9999 SCT010 TX27/2712Z TN19/2806Z PROB40 TEMPO 2709/2714 27020G50KT TEMPO 2709/2720 30015G27KT 2000 SHRA TSGR SCT030CB

At 09:26 on the day of the event, the forecast for between 09:00 and 06:00 the next day was for wind at 12 knots from 310º. Visibility was 10 km or more, with scattered clouds at 1000 ft. The forecast maximum temperature at 12:00 was 27ºC and the forecast minimum at 06:00 was 19ºC with a 40% probability. Between 09:00 and 14:00 wind from a direction of 270º with a speed of 20 knots and gusts of 50 knots was forecast. Between 09:00 and 20:00 wind from a direction of 300º with a speed of 15 knots and gusts of 27 knots was forecast with visibility of 2 km, showers and thunderstorms with hail and scattered clouds at 3000 ft with cumulonimbus.

This updated forecast, which coincides with the establishment of rate 0 at Palma Airport, was the one that most accurately reflected the weather conditions being experienced at the time.

TAF LEPA 271100Z 2712/2812 31012KT 9999 SCT010 TX28/2712Z TN19/2806Z PROB40 TEMPO 2712/2714 27020G50KT SHRA TS SCT030CB TEMPO 2714/2720 30015G27KT 2000 SHRA TSGR SCT030CB

At 11:00 on the day of the event, the forecast for between 12:00 and 12:00 the next day was for wind at 12 knots from 310º. Visibility was 10 km or more, with scattered clouds at 1000 ft. The forecast maximum temperature at 12:00 was 28ºC and the forecast minimum at 06:00 was 19ºC with a 40% probability. Between 12:00 and 14:00 wind from a direction of 270º with a speed of 20 knots and gusts of 50 knots was forecast, with showers, thunderstorms and scattered clouds at 3000 ft with cumulonimbus. Between 14:00 and 20:00 wind from a direction of 300º with a speed of 15 knots and gusts of 27 knots was forecast with visibility of 2 km, showers, thunderstorms with hail and scattered clouds at 3000 ft with cumulonimbus.

1.7.3 Actual observations: METAR and SPECI

The ordinary and special weather reports for Palma Airport between 08:30 and 12:00, which correspond to the period in which the aircraft involved was initially scheduled to arrive until the actual time of landing at the airport, are shown below. From 09:04 on the day of the event, 14 special aerodrome weather reports were issued, reflecting the disruptive nature of the weather conditions at Palma Airport.

METAR LEPA 270830Z 06013KT 020V080 9999 FEW018 FEW030TCU SCT065 26/21 Q1005 NOSIG

At 08:30, the wind speed was 13 knots and the wind direction was 060º, variable between 020º and 080º. Visibility was 10 km or more, with few clouds at 1800 ft and 3000 ft with towering cumulus and scattered clouds at 6500 ft. The temperature was 26ºC, and the dew point was 21ºC. The QNH was 1005 hPa. No significant changes were forecast for the two hours following the observation time.

METAR LEPA 270900Z 08014KT 050V110 9999 FEW018 FEW030CB SCT065 26/21 Q1005 NOSIG

At 09:00, the wind speed was 14 knots and the wind direction was 080º and variable between 050º and 110º. Visibility was 10 km or more, with few clouds at 1800 ft and 3000 ft with cumulonimbus and scattered clouds at 6500 ft. The temperature was 26ºC, and the dew point was 21ºC. The QNH was 1005 hPa. No significant changes were forecast for the two hours following the observation time.

From this moment onwards, special reports were issued repeatedly, reflecting the fact that storm Betty was affecting both Palma Airport and the other two airports in the Balearic Islands, which were also experiencing this highly adverse convective meteorological phenomenon.

SPECI LEPA 270904Z 25021G51KT 1000 R24L/P2000 R24R/P2000 +TSRA FEW018 FEW030CB SCT065 23/18 Q1009 NOSIG

At 09:04, the wind speed was 21 knots with gusts of 51 knots, and the wind direction was 250°. Visibility was 1000 m, with the runway visual range forecast for both runways at 2000 m, with heavy rain, few clouds at 1800 ft and 3000 ft with cumulonimbus and scattered cloud at 6500 ft. The temperature was 23ºC, and the dew point was 18ºC. The QNH was 1009 hPa. No significant changes were forecast for the two hours following the observation time.

SPECI LEPA 270916Z 29019G35KT 250V340 1600 R06L/1700U R06R/0900U +TSRA SCT011 FEW030CB SCT065 19/19 Q1009 NOSIG

At 09:16, the wind speed was 19 knots with gusts of 35 knots and the wind direction was 290º, variable between 250º and 340º. The visibility was 1600 m, with the runway visual range for runway 06L at 1700 m and increasing, while for runway 06R it was 900 m and increasing, with heavy rain, scattered clouds at 1100 ft and 6500 ft and few clouds at 3000 ft with cumulonimbus. The temperature was 19ºC, and the dew point was 19ºC. The QNH was 1009 hPa. No significant changes were forecast for the two hours following the observation time.

METAR LEPA 270930Z 31022G35KT 280V340 1600 TSRA SCT011 FEW027CB SCT066 20/17 Q1010 NOSIG

At 09:30, the wind speed was 22 knots with gusts of 35 knots and the wind direction was 310º, variable between 280º and 340º. The visibility was 1600 m, with rain, scattered clouds at 1100 ft and 6600 ft and few clouds at 2700 ft with cumulonimbus. The temperature was 20ºC, and the dew point was 17ºC. The QNH was 1010 hPa. No significant changes were forecast for the two hours following the observation time.

SPECI LEPA 270942Z 33016KT 4000 –TSRA SCT011 FEW027CB SCT066 19/18 Q1008 RETSRA NOSIG

At 09:42, the wind speed was 16 knots and the wind direction was 330°. The visibility was 4 km, with light rain, scattered clouds at 1100 ft and 6600 ft and few clouds at 2700 ft with cumulonimbus. The temperature was 19ºC, and the dew point was 18ºC. The QNH was

1008 hPa. Precipitation from recent rainfall. No significant changes were forecast for the two hours following the observation time.

METAR LEPA 271000Z 34014G25KT 300V010 4000 RA VCTS SCT014 FEW027CB SCT066 21/18 Q1007 RETSRA NOSIG

At 10:00, the wind speed was 14 knots with gusts of 25 knots and the wind direction was 340º, variable between 300º and 010º. The visibility was 4 km, with rain and storms in the vicinity, scattered clouds at 1400 ft and 6600 ft and few clouds at 2700 ft with cumulonimbus. The temperature was 21ºC, and the dew point was 18ºC. The QNH was 1007 hPa. Precipitation from recent rainfall. No significant changes were forecast for the two hours following the observation time.

SPECI LEPA 271021Z 34015G29KT 300V010 6000 RA VCTS SCT014 FEW027CB SCT066 20/17 Q1007 NOSIG

At 10:21, the wind speed was 15 knots with gusts of 29 knots and the wind direction was 340º, variable between 300º and 010º. The visibility was 6 km, with rain and storms in the vicinity, scattered clouds at 1400 ft and 6600 ft and few clouds at 2700 ft with cumulonimbus. The temperature was 20ºC, and the dew point was 17ºC. The QNH was 1007 hPa. No significant changes were forecast for the two hours following the observation time.

METAR LEPA 271030Z 35013KT 320V020 3000 RA VCTS SCT014 FEW027CB SCT066 20/17 Q1008 NOSIG

At 10:30, the wind speed was 13 knots and the wind direction was 350º and variable between 320º and 020º. The visibility was 3 km, with rain and storms in the vicinity, scattered clouds at 1400 ft and 6600 ft and few clouds at 2700 ft with cumulonimbus. The temperature was 20ºC, and the dew point was 17ºC. The QNH was 1008 hPa. No significant changes were forecast for the two hours following the observation time.

SPECI LEPA 271051Z 01007KT 330V060 1600 +RA VCTS SCT014 FEW027CB SCT060 20/17 Q1009 NOSIG

At 10:51, the wind speed was 7 knots and the wind direction was 010º and variable between 330º and 060º. The visibility was 1600 m, with heavy rain and storms in the vicinity, scattered clouds at 1400 ft and 6000 ft and few clouds at 2700 ft with cumulonimbus. The temperature was 20ºC, and the dew point was 17ºC. The QNH was 1009 hPa. No significant changes were forecast for the two hours following the observation time.

METAR LEPA 271100Z 03005KT 330V070 1600 R24L/P2000 R24R/1400U +RA VCTS SCT014 FEW027CB SCT060 19/18 Q1009 NOSIG

At 11:00, the wind speed was 5 knots and the wind direction was 030º and variable between 330º and 070º. The visibility was 1600 m, the expected runway visual range was 2000 m for runway 24L and 1400 m and increasing for runway 24R, with heavy rain and storms in the vicinity, scattered clouds at 1400 ft and 6000 ft and few clouds at 2700 ft with cumulonimbus. The temperature was 19ºC, and the dew point was 18ºC. The QNH was 1009 hPa. No significant changes were forecast for the two hours following the observation time.

SPECI LEPA 271115Z 03005KT 350V100 6000 -RA FEW014 FEW027CB SCT060 19/17 Q1008 RERA NOSIG

At 11:15, the wind speed was 5 knots and the wind direction was 030º and variable between 350º and 100º. The visibility was 6 km, with light rain, scattered clouds at 6000 ft and few clouds at 1400 ft and 2700 ft with cumulonimbus. The temperature was 19ºC, and the dew point was 17ºC. The QNH was 1008 hPa. No significant changes were forecast for the two hours following the observation time.

METAR LEPA 271130Z 07010KT 050V120 6000 -RA FEW012 FEW027CB SCT060 20/18 Q1008 RERA TEMPO 30020KT 2000 TSRA

At 11:30, the wind speed was 10 knots and the wind direction was 070º and variable between 050º and 120º. The visibility was 6 km, with light rain, scattered clouds at 6000 ft and few clouds at 1200 ft and 2700 ft with cumulonimbus. The temperature was 20ºC, and the dew point was 18ºC. The QNH was 1008 hPa. Recent rainfall. Temporarily wind 300º and 20 knots, visibility 2 km with rain.

METAR LEPA 271200Z 07014KT 040V100 6000 -RA VCTS FEW008 FEW027CB SCT060 20/18 Q1008 TEMPO 30020KT 2000 TSRA

At 12:00, the wind speed was 14 knots and the wind direction was 070º and variable between 040º and 100º. The visibility was 6 km, with light rain, storms in the vicinity, scattered clouds at 6000 ft and few clouds at 800 ft and 2700 ft with cumulonimbus. The temperature was 20ºC, and the dew point was 18ºC. The QNH was 1008 hPa. Temporarily wind 300º and 20 knots, visibility 2 km with rain.

1.8. Aids to navigation

The relevant information on the aids to navigation used by the aircraft is included in section 1.9.

1.9. Communications

This section details the oral communications between the ATC personnel in the different ATC units (Bordeaux ACC, Barcelona ACC, Palma TACC and, finally, Palma TWR) and the aircraft involved. The radar data from ENAIRE's Palestra system and some additional information from the flight plan processing system were also obtained. In an effort to provide a better understanding of the event, it has been integrated and included all of this information in this section.

- At 09:19:52, the planning controller for the CCC sector (a unified sector consisting of the CCU and CCL sectors) in the Barcelona ACC initiated a coordination with his Bordeaux ACC counterpart, N3 sector, instructing him to inform the crews of all aircraft bound for Palma Airport to reduce their speed due to traffic congestion, as there were multiple aircraft already orbiting the airport.

- At 09:24:48, the EXS5AB aircraft made initial contact with the corresponding N3 sector of the Bordeaux ACC at FL350. The controller instructed it to fly direct to the IBRAP waypoint. The crew read back correctly and asked ATC if there was reported turbulence. The controller replied in the negative. The crew reported turbulence at FL350, and ATC informed them that

it would improve after the NARAK point. A controller, in turn, informed his control centre room chief that an aircraft had reported severe turbulence.

- At 09:31:07, there was a coordination between the Bordeaux ACC room chief and the Meteorological Office on the formation of storm activity to the north of the Pyrenees. No SIGMET had been published for the area.

- At 09:34:20, the en-route supervisor at Barcelona ACC informed the Bordeaux ACC room chief that Palma Airport was not accepting aircraft due to severe weather conditions. He asked him not to send any aircraft bound for Palma or Ibiza, via PUMAL, instead requesting him to keep the aircraft in his airspace and that he would advise him when the situation improved.

- At 09:35:55, the EXS5AB aircraft made initial contact with the N3 sector of Bordeaux ACC while at FL350 on course for the Gaillac VOR. The controller identified it. The flight was active and correlated in the SACTA system, appearing with a diamond on the screen and the destination LEPA on its label.

- At 09:36:33, sector N3 of Bordeaux ACC reported to his room chief that the aircraft were leaving FL380 due to severe turbulence. During this conversation, the room chief informed him that Barcelona ACC was not accepting aircraft bound for Palma and Ibiza.

- At 09:36:52, the crew of the EXS5AB aircraft asked ATC if there was turbulence reported at FL330. The controller indicated that he had no information in this regard.

- At 09:37:45, the planning controller of the CCC sector informed his Bordeaux ACC counterpart that Palma Airport had applied rate 0[8], was not admitting any aircraft, and that, therefore, a lot of aircraft were being diverted to their alternate airports.

- Between 09:42:30 and 09:43.53, Bordeaux ACC attempted to contact the crew of the EXS5AB aircraft three times. After the last call, the crew responded.

- At 09:43:56, Bordeaux ACC sector N3 informed the EXS5AB aircraft that Palma Airport was not accepting aircraft and instructed it to circle the LOMRA waypoint at FL 350. The crew read back correctly.

- At 09:44:49, the crew of the EXS5AB aircraft asked to circle over the Gaillac VOR. ATC asked them if they could continue straight and, in two minutes, circle with right turns. The crew chose to hold at the LOMRA waypoint.

- At 09:47:32, sector N3 asked the crew of the EXS5AB aircraft if they could hold over the ROCAN waypoint. The crew agreed. ATC informed them that the holding pattern would be flown with left turns and this was acknowledged by the crew.

- At 09:54:45, several uninvolved aircraft reported that they had to leave FL350 south of Limoges due to turbulence. Three minutes later (09:57:50), aircraft EXS5AB can be seen on

[8] Rate 0 affects aircraft that have not yet taken off, but not aircraft that are already in flight and have to be managed.

the radar entering the first holding pattern over ROCAN at FL350 at the same time as another aircraft. In total, there were four aircraft in this holding pattern.

- At 09:57:58, the CCC sector instructed its Bordeaux collateral to send the first of these aircraft (RYR88KL), which was not involved in the incident, to the LORES waypoint. This aircraft had been holding the longest over ROCAN. At the same time, the en-route supervisor at Barcelona ACC informed the Bordeaux ACC room chief that, although Palma was still closed, they were going to request that the aircraft be transferred to them one by one, as they had some free levels in the holding patterns.

- At 10:00:06, the crew of the EXS5AB aircraft asked Bordeaux ACC if they knew how long Palma would be closed for. ATC replied that the closure was due to weather. A fifth aircraft joined the hold over ROCAN.

- At 10:06:00, the crew of the EXS5AB aircraft called Bordeaux ACC twice. The controller responded 1 minute and 18 seconds later, and the crew requested their destination be changed from Palma to Menorca.

- At 10:07:24, sector N3 asked the EXS5AB aircraft to confirm its intention to divert to Menorca. The crew of the aircraft confirmed. The controller couldn't remember the last two letters of the ICAO code for Menorca Airport. The crew informed him that the letters were MH.

- As a result of this request, at 10:09, the EXS5AB's initial flight plan was cancelled, and a new one was created with the new destination using the wrong code: LEML (Badajoz) instead of LEMH. At this point, the visual on the screen changed to non-correlated (a circle), and the destination disappeared from the label.

- At 10:10:36, the CCC sector instructed its collateral sector to transfer three more aircraft: aircrafts EXS34PX and EFW78F to the LORES waypoint and aircraft EFW3HY, which was heading to Ibiza, to the CORDA waypoint.

- At 10:13:16, the N3 sector instructed aircraft EXS5AB to fly direct to the IBRAP waypoint. The crew read back correctly.

- At 10:13:27, the N3 sector asked the EXS5AB aircraft for its estimated time of arrival at LEML. The crew advised that they estimated LEMH at 10:56. The controller corrected the ICAO code verbally but did not enter the correction into the system. The controller again asked for the estimated time of arrival. The crew confirmed ETA at 10:56. The controller read back the information and again instructed the crew to fly to the IBRAP waypoint. The crew read back correctly.

- At 10:14:10, the CCC sector instructed its collateral to transfer the EXS7GY aircraft to the LORES waypoint. Half a minute later there was another communication between them in which the first controller again asked the second to transfer another 3 aircraft to the LORES waypoint, as Palma Airport was accepting some aircraft.

- At 10:15:34, the N3 sector transferred the EXS5AB aircraft to the CCC sector without it being correlated in the system. The crew read back correctly. 17 seconds later, the trace shows the EXS5AB aircraft proceeding to the IBRAP waypoint at FL350.

- At 10:16:14, an inter-unit communication took place in which Barcelona accepted the transfer of 5 aircraft bound for Palma, none of which was the EXS5AB.

- At 10:16:28, the EXS5AB aircraft made initial contact with the CCC sector and reported that they were approaching IBRAP. There was no response.

- At 10:17:34, the EXS5AB aircraft called the CCC sector again and reported that they were circling IBRAP at FL 350 (2nd call). There was no response.

- At 10:19:22, the CCC sector instructed Bordeaux to transfer the RYR4SN aircraft to the LORES waypoint, and less than 1 minute later, they arranged for the RYR88GU aircraft to go to the LORES waypoint.

- At 10:19:54, the EXS5AB aircraft called the CCC sector again and reported that they were holding IBRAP at FL 350 (3rd call). ATC responded, asking them to stand by.

- At 10:20:00, the CCC sector informed an uninvolved aircraft that Palma Airport was not accepting aircraft, so it would have to proceed to an alternate aerodrome, offering it Barcelona, Valencia, Alicante, Gerona or Reus. Forty-one seconds later, it informed another uninvolved aircraft operated by Jet2 of the same thing.

- At 10:20:49, the crew of uninvolved aircraft acknowledged receipt and informed the CCC sector that they had a aircraft from their company (the EXS5AB) over the IBRAP point, holding at FL 350. ATC responded, asking them to stand by.

- At 10:21:13, the CCC sector informed an uninvolved aircraft that it would have to proceed to an alternate and subsequently offered it the airports of Barcelona, Valencia, Alicante, Gerona or Reus. The crew asked if Palma wasn't accepting them. ATC confirmed that it was not accepting any more aircraft. The crew told him to stand by.

- At 10:21:44, the CCC sector again informed the same uninvolved aircraft that Palma airport was not accepting aircraft and offered Barcelona, Valencia, Alicante, Gerona or Reus. The crew decided to divert to Barcelona.

- At 10:22:18, the EXS5AB aircraft called the CCC sector of Barcelona ACC again and reported that they were holding IBRAP at FL 350 (4th call). ATC responded by asking all aircraft to stand by. Around that time, a new, still uncorrelated flight plan appears for the aircraft with incorrect time information.

- At 10:22:45 and 10:23:38, the CCC sector advised all aircraft to stand by.

- At 10:23:54, the CCC sector invited the aircraft that had previously called to transmit, but another aircraft replied.

- At 10:24:44, the CCC sector once again offered the same uninvolved aircraft the choice of Barcelona or Reus.

- At 10:25:38, aircraft EXS5AB called the CCC sector again (5th call). The controller identified it and manually activated the flight plan to correlate it, changing the transit times through PUMAL. On the radar display, the radar echo symbol changed from a circle to a diamond, and the associated label showed LEML as the destination. A new SSR code was assigned to the aircraft and was read back correctly by the crew.

- At 10:26:16, Bordeaux ACC called the CCC sector to ask if they could transfer the EWG6U aircraft. The CCC sector accepted the transfer.

- At 10:27:06, the CCC sector informed an uninvolved aircraft that Palma Airport was accepting aircraft again, after which its crew requested to proceed to Palma. Forty-eight seconds later, the trace shows the EXS5AB aircraft completing its 3rd holding over the IBRAP waypoint at FL350.

- At 10:29:46, the CCC sector transferred the EXS5AB aircraft to the GO2 sector of Barcelona ACC. The crew read back correctly. Shortly after that, there was a handover of the CCC sector executive controller position.

- At 10:30:04, the EXS5AB aircraft made initial contact with the GO2 sector and reported that it was holding IBRAP at FL350. The controller responded and the aircraft was transferred back to the N3 sector of Bordeaux ACC. The crew read back the frequency.

- At 10:30:28, the EXS5AB aircraft made contact again, this time on the Bordeaux N3 sector frequency, and reported that it was holding over the IBRAP waypoint at FL350. The controller asked what their intentions were, and the crew indicated that they were waiting to land at Palma. The controller asked why they had returned to the Bordeaux ACC frequency. The crew replied that they were trying to proceed to Menorca. ATC replied LEMH and instructed it to holding the ROCAN waypoint twice. The crew read back correctly.

- At 10:31:36, ACC Sector N3 at Bordeaux called the CCC sector to clarify why the EXS5AB aircraft was back on their frequency, as it had been transferred to LECB 10 minutes earlier. The CCC sector thought it was going to Marseille (whose flight code was LFML) and instructed Bordeaux to transfer it back to them. At 10:32:27, the same parties coordinated in regard to this flight again, and the CCC sector requested it be transferred on a heading of 110°.

- At 10:32:09, the weather centre informed Bordeaux ACC of localised turbulence on TSA43 between FL 350 and FL 360 to the west of Limoges. ATC instructed the EXS5AB aircraft to fly on a heading of 110º at the request of Barcelona ACC.

- At 10:33:24, the Barcelona ACC en-route supervisor informed the Bordeaux ACC room chief that Palma Airport had re-opened and, therefore, all aircraft could be transferred to it normally. In this context, the controllers in the two control centres coordinated the transfer of the EXS5AB aircraft bound for Palma.

- At 10:34:16, the N3 sector transferred the EXS5AB aircraft back to the CCC sector and informed it that the latter was aware of its request. The crew read back the frequency.

- At 10:34:51, the EXS5AB aircraft contacted the CCC sector again and reported that they were on a heading of 110º at FL350. ATC asked them to repeat their callsign, and the crew repeated the information. The controller then identified the aircraft and instructed it to fly direct to LORES. The crew read back correctly.

- At 10:36:29, the EXS5AB aircraft confirmed to control that its destination was Menorca. The controller asked for its original destination. The crew asked him to repeat, and ATC informed them that Palma was open. The crew asked if there was any delay in proceeding to Palma. The controller again informed them that Palma was open and if that was their destination. The crew confirmed that it was, and ATC re-instructed them to fly to the LORES waypoint. The crew read back correctly.

- At 10:50:33, the EXS5AB aircraft twice asked to descend. ATC instructed the aircraft to descend to FL250. The crew read back correctly.

- At 10:54:24, the CCC sector instructed the EXS5AB aircraft to descend to FL200. The crew read back correctly.

- At 10:55:05, the CCC sector transferred the EXS5AB aircraft to the Palma TACC frequency, sector L1W. There was no readback, so ATC called the aircraft 4 times. After establishing contact, he again transferred it to the Palma TACC frequency, sector L1W, on two occasions.

- At 10:56:41, the EXS5AB aircraft contacted sector L1W and reported that it was descending at FL200, on course for LORES. ATC identified it and instructed it to continue its descent to FL150 on a southerly heading. The crew read back correctly.

- At 10:58:46, the L1W sector instructed aircraft EXS5AB to descend to FL110. The crew read back correctly.

- At 10:59:59, the L1W sector instructed aircraft EXS5AB to fly on a heading of 175º. The crew read back correctly.

- At 11:05:18, the L1W sector instructed aircraft EXS5AB to descend to FL90. The crew read back correctly.

- At 11:06:21, the EXS5AB aircraft asked ATC for permission to fly left on heading 140º and was cleared to do so by the L1W sector. The crew read back correctly.

- At 11:06:59, the L1W sector instructed aircraft EXS5AB to descend to FL80. The crew read back correctly.

- At 11:07:12, the EXS5AB aircraft asked ATC for permission to fly left on heading 120º and was cleared to do so by the L1W sector. The crew read back correctly.

- At 11:07:23, the L1W sector instructed the EXS5AB aircraft to fly at the minimum clean speed. The crew read back correctly.

- At 11:07:32, the L1W sector asked the EXS5AB aircraft what that speed was. The aircraft replied 210 kt.

- At 11:08:19, the EXS5AB aircraft asked ATC for permission to fly left on heading 110º and was cleared to do so by the L1W sector. The crew read back correctly.

- At 11:09:16, the L1W sector instructed aircraft EXS5AB to fly to the left on a heading of 060º. The crew read back correctly.

- At 11:09:44, the L1W sector transferred the EXS5AB aircraft to the Palma frequency. The crew read back correctly.

- At 11:10:09, Palma called the EXS5AB aircraft, identified it and instructed it to descend to 6000 ft with QNH 1009. It did not respond, and they had to call twice more. When they got a response from the crew, ATC instructed it again to descend to 6000 ft with QNH 1009, speed 200 kt, and turn right, heading 130º. The crew read back correctly.

- At 11:11:00, Palma arrivals instructed the EXS5AB aircraft to descend to 3000 ft. The crew read back correctly.

- At 11:11:39, Palma arrivals instructed the EXS5AB aircraft to turn right to a heading of 210° to intercept the localiser and cleared it for the ILS approach to runway 24L. The crew read back correctly.

- At 11:12:43, the EXS5AB aircraft issued a distress call due to a fuel emergency. Thirteen seconds later, the controller acknowledged receipt. Twenty seconds afterwards, the radar trace shows the aircraft on long final for runway 24L (less than 20 NM), through 5700 ft.

- At 11:13:07 h, ATC interrupted the approach of an uninvolved aircraft as the EXS5AB aircraft was behind it.

- At 11:13:48 h, Palma arrivals asked the EXS5AB aircraft for remaining fuel, persons on board and the presence of dangerous goods. The crew indicated 196 people and 1.2 tonnes.

- At 11:16:47 h, Palma arrivals transferred the EXS5AB aircraft to Palma TWR. The crew read back correctly.

- At 11:17:08 h, the aircraft made contact on the TWR Palma frequency when it was 10 miles from the runway, and ATC instructed it to continue its approach. One minute later, at the controller's request, the aircraft confirmed that the MAYDAY was for fuel.

- At 11:17:46 h, the TWR controller cleared the EXS5AB aircraft to land on runway 24L. The crew read back correctly.

- At 11:20:28, the aircraft touched down on runway 24L at Palma without incident.

1.10. Information about the aerodrome

N/A.

1.11. Flight recorders

The flight data recorder information was retrieved, but the cockpit communications were unavailable as they were recorded over after the event. The relevant information has been incorporated in section 1.9.

1.12. Aircraft wreckage and impact information

N/A.

1.13. Medical and pathological information

N/A.

1.14. Fire

There was no evidence of fire during the flight.

1.15. Survival aspects

N/A.

1.16. Tests and research

1.16.1 Relevant information: ACC Barcelona

It's clear from the description provided by the Barcelona ACC room chief that weather problems had been foreseen the previous day. He arrived at about 08:45 local time, and his outgoing counterpart told him that from 03:00 local time, he had been setting up restrictions and in contact with the Valencia Meteorological Office. From 05:00 h, the Verso and Central sectors (comprising CCL+CCU) were already under restrictions.

The meteorologists in the room (a staff of 5) play a fundamental role by being in situ. They arrive earlier and immediately gave a briefing on the situation and indicated that it was going to affect the Palma TMA and Palma Airport. Arrivals at Palma Airport were highly restricted (rate 20).

At one point, the Palma TACC room chief told him that no more aircraft was coming in and that they were initiating the mass diversion procedure (PDM). Most of the diverted aircraft went to the LERS (Reus, 42 NM west from Barcelona airport) and LEGE (Gerona, 48 NM noreast from Barcelona airport). He told him that they would try to fill their holding patterns but that as soon as they were full, they would have to use the holds in the Barcelona ACC airspace, which happened

about 30 minutes later. They could not use holding patterns in the vicinity of Ibiza due to the adverse weather.

Then, at around 09:00, aircraft from Bordeaux ACC stopped being accepted, and the central sector controller (comprising CCL and CCU) and the en-route supervisor were informed of the measure. His impression is that no aircraft was cleared to enter Palma.

Subsequently, some aircraft began to enter Palma, but in dribs and drabs, and as soon as he could, he began to accept aircraft from the Bordeaux ACC.

At these times, there is usually a lack of personnel, so the 2 controllers in the Palma departure sector were used to remedy the situation. As there were no departures, they acted as supervisors. He believes the restrictions were applied correctly.

As for the mass deviation procedure (PDM), it is extremely complex when two units are involved. A tool is being developed to improve this procedure, as the current process involves telephoning and asking each airport about its availability, which does not accurately reflect the status of available parking stands.

1.16.2 Relevant information: TACC Palma

According to the description of the room chief at Palma's TACC, on the day of the incident he arrived a little before 9 o'clock local time. The staffing was sufficient, with 3 controllers per sector to allow for handovers. It was an extremely complicated day from the outset, and the weather had been predicted to be extremely bad, with uncertainty as to its exact location given that these types of storms tend to move from west to east. It was noted that this storm was particularly severe and had the unique characteristic of being stuck over the 3 Balearic Islands, thus affecting all 3 airports.

All en-route and APP sectors were affected by the storm, unlike on other occasions when there was a less affected area to which aircraft could be moved to holding.

Unlike the ACCs in Madrid and Barcelona, the Palma Terminal Control Centre does not have its own meteorologist. They get the information from the Valencia Meteorological Office and at 10:00 local time every day they have an online meeting with the ACC meteorologist in Barcelona, which, that day, lasted for about 30 minutes, during which he told them that there was a "very pronounced trough, a kind of DANA[9], which would affect the eastern third of the peninsula". They also relied on the Meteorological Office at Palma Airport, which provided them with both TAF and METAR. Storms in the Balearic Islands tend to be fiercer because they are laden with sea water due to the difference in temperature between the upper and lower layers of the atmosphere. The METAR at 09:00 Z indicated a wind speed of 12 kt, and the SPECI at 09:04 increased it to 50 Kt. These weather conditions led to several runway configuration changes during the day due to the wind. As far as the restrictions were concerned, the night shift room chief applied rate 24 and then

[9] A DANA is an Isolated Depression at High Levels. It is a phenomenon in which a mass of very cold polar air is isolated and begins to circulate at very high altitudes, isolated from the general circulation of the atmosphere. These situations are potentially dangerous at the end of summer and autumn in the Mediterranean area when the water surface temperature is high.

adjusted it to rate 20, realising that it could also affect the alternates on the islands and on the eastern coast of the peninsula. Rate 0 was applied to all three airports:

- In Palma, it was implemented at 09:11, initially until 10:20. It was then extended to 11:00 and then until 12:00. At 09:26, the mass diversion procedure (PDM) was activated, which had been coordinated with COM/AIS so that it had updated lists of available arrivals and parking spaces. Thanks to this pre-prepared measure, time was saved. There were 42 diversions to alternates, which, over the course of the day, rose to 50.
- In Ibiza rate 0 was implemented at 09:17.
- In Menorca rate 0 was implemented at 11:09.

The first missed approaches, involving three aircraft at Palma, took place at around 08:50 due to severe turbulence and shear, and this was the deciding factor in preventing other aircraft from entering. As there was so much aircraft holding and the 1000 ft vertical separation could not be guaranteed, they had no choice but to use holding patterns at other waypoints. He then spoke to the Barcelona ACC chief to tell him that they were not admitting any more aircraft into the Palma TMA. Before 11:00, they brought a few aircraft in to alleviate the holding patterns, and between 11:00 and 12:00, 8 more aircraft were brought in sporadically. As for the PDM, they believe it could be substantially improved.

1.16.3 Relevant information: CCU/CCL sector of the Barcelona ACC

The executive controller of the CCU/CCL sector of Barcelona ACC stated that it was forecast to be a challenging day due to the weather conditions, the fact that it was the end of August and also that it was a public holiday. He was instructing that day and carried out the first session between 07:45 and 08:45 local time. After a break, he was supposed to give the second session in this sector, but the decision was made to interrupt the sessions as the conditions were less than ideal. The room chief told him to support the controllers in the sector, as the weather conditions were deteriorating. At one point, he relieved the executive controller.

Neither the unit's procedures nor its Operating Manual contain any provisions for handling such a complex situation[10]. The night shift room chief had been setting restrictions from as early as 03:00 h due to the expected adverse conditions.

After he arrived, the room chief for the morning shift continued to make further adjustments. As a rule, all flights to the Balearic Islands airports are channelled through the central sector (made up of the CCU and CCL airspace). However, on that day, due to the meteorological conditions, the aircraft climbing towards Europe and the United Kingdom was also diverted through the sector, which doesn't normally happen and increased the complexity because it meant that the sector contained both aircraft climbing and aircraft descending. He had experienced complex situations before, but nothing like the scenario that day.

[10] This comment made by the controller has to be understood in the context of the event. The air navigation service provider, in Annex Z of its Operations Manual, has defined the Procedure for action in the event of severe weather (section 3.1). This comment refers to highly complex situations, with numerous flights involved, detours, delays, impact on all airports and impact on airspace collateral to the origin of the problem.

At one point he received the information that Palma Airport was no longer accepting any more aircraft due to the application of rate 0; this made things worse as they had quite a few flights holding at LORES and LUNIK waypoints in opposing directions (with no published holding patterns at these points), which increased the complexity.

As soon as Palma Airport applied rate 0, the room chief took swift action, and they informed Bordeaux ACC that they were not admitting any more aircraft.

He was told that the aircraft should proceed to alternate airports such as Valencia, Alicante, Reus and Gerona, and the crews of the affected aircraft were informed accordingly. They weren't accepting aircraft to Ibiza either, to the extent that at one point Palma TACC accepted only 2 flights. Subsequently, it was agreed that aircraft would be sent via the CORDA waypoint rather than the LORES waypoint.

The pilots were asking for information, and he recalled that the fact that there were no expected approach times (EATs) made it difficult for the aircraft to make decisions. There was a lot of communication between the room chief, the route supervisor and the controllers supporting both of them. The staffing level was sufficient. At one point, the supervisor informed him that Palma Airport had opened.

1.16.4 Relevant information: GO2 sector of the Barcelona ACC

According to the interview with the executive controller of the Barcelona ACC GO2 sector, the bad weather had been predicted several days before the event, and the fact that it was going to be a tough day had been announced. Initially, he was supposed to be in the central sector, but in the end, he was put in GO2, which covers from FL 350 to FL 370 for aircraft on the E-W route and ongoing climbs from Palma Airport. The central sector and GO2 aren't adjacent to one another in the control room, so coordination has to be carried out using hotlines. He couldn’t remember anything about that day. It's not normal for flights over the IBRAP waypoint to be with Barcelona ACC, as it's in French airspace. When Palma Airport applied rate 0, they didn't provide EATs (estimated approach times) or an estimated opening time. These situations are not without precedent; they occur 2 or 3 times every summer, and there are no established procedures for dealing with them.

1.16.5 Relevant information: captain

The interview with the captain of the EXS5AB aircraft confirmed the delay at origin due to the weather-related restrictions on the flight to Palma and the fact that they decided to load 20 minutes of additional fuel on top of the planned amount for the alternate destination aerodrome (LEMH). The weather forecast for Menorca was windy but within the limits. When they approached the Toulouse area, ATC informed them that Palma Airport was not accepting aircraft, and afterwards, they were transferred to Barcelona ACC. When they were on the frequency of this ATC unit, they called several times without receiving an answer. As they had no clearance beyond the authorised waypoint, they decided to maintain FL350. Every time they called the Barcelona ACC, they received a "stand by" response. Another aircraft from their company informed control that the EXS5AB aircraft was trying to contact ATC. The frequency was extremely busy, and the controller was overloaded. The captain decided to divert to Menorca Airport. During the descent, ATC

informed them that Palma Airport was now open and accepting aircraft. Palma Airport was relatively close to that point, with 2 runways, so they decided to continue to Palma Airport. The anticipated fuel on landing was 1.3 or 1.4 tonnes, which was above the final reserve fuel.

During the vector guidance they were given to the final approach, they had to add a few miles due to the aircraft at the time and to avoid the weather. This meant they had to reduce the predicted amount of fuel on landing to 1.1 tonnes. It was at this point that the captain instructed the F/O to declare mayday for fuel. The preceding aircraft was taken out of the approach sequence to give them priority. The landing was completed without incident with 1120 kg, 40 kg below the legal final reserve fuel. The first officer under supervision was flying to Palma for the first time.

1.16.5 Relevant information: first officer

The interview with the first officer of the EXS5AB aircraft indicates that the weather forecast for Palma was PROB40 TEMPO, which is why they decided to increase by 800 kg to cover a 20-minute hold and the extra APU expenditure on the ground due to the one-hour delay in the initial slot. They added more fuel (900 kg), which allowed them to extend to just under 2h, with a 20-minute holding margin. The aircraft pushed back and departed just under 2 hours after the initial departure time. The first officer was acting as PF, and when they were 1 h from the destination, they carried out the arrival briefing and were informed that Palma was not accepting traffic. The captain took over from this point due to the inexperience of the F/O, as multiple decisions and preparations had to be made. They were subsequently instructed to holding over ROCAN waypoint at FL350.

They tried to notify their intention to divert to Menorca Airport, but ATC told them to stand by. Bordeaux asked them for the code of the alternate destination airport (LEMH), and the captain had to confirm the code. Again, ATC told them to stand by. They were then instructed to fly to the IBRAP waypoint and were transferred to Barcelona ACC. This ATC instructed all aircraft to stand by. They tried several times to communicate their position and altitude, and another aircraft from their company heard them and notified ATC of their position. The frequency was pretty busy. ATC transferred them back to the initial frequency. They were subsequently informed that Palma had opened and asked about their intentions, so they checked the fuel they needed to get to Palma, which was between 1.3 or 1.4 tonnes, the final legal reserve (FRF) fuel being 1.15 tonnes, and agreed to proceed to Palma with the weather update. They were cleared to proceed to ROCAN and then to the LORES STAR. The total time was 35 to 40 minutes.

On the descent through FL 100, the captain requested course adjustments to proceed to a wide base due to turbulence and the weather. When they calculated the fuel in the FMC, it had reduced to 1.1 tonnes, which meant that it was below the final legal reserve (FRF). They updated the fuel, and the captain asked him to declare "MAYDAY FUEL". Palma APP requested the number of people on board and the reasons for the distress call, and he stated that it was due to fuel. They eventually landed with 1.12 tonnes, with the final legal reserve (FRF) being 1.15.

1.16.6 Consequences on the traffic

There were 54 total diversions that had their arrival at the airports of the Balearic Islands; these flights had to be coordinated and rerouted to other alternative aerodromes in the area. Of that total, 45 flights were destined for Palma airport, another 7 initially proceeded to Ibiza airport and 2 to Menorca.

1.17. Organisational and management information

N/A.

1.18. Additional information

N/A.

1.19. Special investigation techniques

N/A.

2. ANALYSIS

On the morning of Sunday, 27 August 2023, the Boeing 737-800 G-DRTW aircraft operated by Jet2.com landed 44 kg short of the final reserve fuel established by the regulations. The flight's destination was in a geographical area that was affected by highly adverse meteorological conditions that impacted all of the Balearic Islands at the same time. The situation had repercussions in Barcelona's ACC, where aircraft were waiting in holding patterns.

The investigation focused on the planning and management of the flight by the aircraft, the meteorology, the traffic control measures taken and, lastly, the operation of the ATC services.

2.1. Management of the flight by the crew

The investigation has ruled out any possibility that the crew's fuel planning contributed to the event, as they decided to load extra fuel precisely to account for the deteriorating weather conditions. Since the regulations apply to flights that are not yet airborne, once the flight was under way, it was up to the crew to make decisions concerning the situation in which they were involved.

The overload on the control services was compounded by the erroneous entry of the alternate airport in the flight plan by ATC France, which resulted in the CCC sector controller thinking the flight was heading for Marseille (the last two letters corresponded to the ICAO code for that airport but the mistaken destination entered “LEML” didn't make sense). This meant that the aircraft was returned to French airspace and not handled like the other aircraft in the same circumstances.

The crew satisfactorily managed the situation and the ATC overload that was transferred to the aircraft (difficulty in contacting, obtaining information, return to France, etc.), making the decision to head towards their alternative airport at a given time. The fact that ATC eventually offered the aircraft the possibility of reaching its initial destination probably induced the crew to choose that option, instead of going to its alternative airport, as decided previously. As a reference, 13 of the operator's aircraft were destined for Palma de Mallorca that day and affected by the same situation. Of those 13, 8 decided to change their destination airport in view of the magnitude of the unfolding situation.

2.2. Meteorology

The meteorology that developed over the Balearic Islands was due to a highly adverse and virulent convective phenomenon that significantly and simultaneously affected the three airports on the islands. Specifically, the airport of Palma, where the G-DRTW aircraft was scheduled to land, did not accept any traffic at all from 09:11 UTC for more than an hour.

It had been forecast since the day before the incident that the phenomenon would be concentrated in the Mediterranean region, where intense cumulonimbus clouds were expected to develop and move towards the east/northeast, extending upwards to flight level 450 and bringing locally heavy rainfall with severe hail and very strong gusts of wind. The aerodrome forecasts (TAF) published in the hours leading up to the event predicted the same conditions.

As a result of the conditions described above, a total of 54 flights bound for airports in the Balearic Islands had to be diverted, all of which had to be coordinated and rerouted to alternate aerodromes on the eastern coast of the Spanish peninsula. Of these, 45 were bound for Palma Airport, another 7 were initially bound for Ibiza Airport, and 2 were heading to Menorca.

2.3. Traffic flow management measures

During the pre-tactical phase, the day before the incident, the decision was taken not to adopt any measures in advance and instead to react tactically as the weather evolved. Therefore, all the measures implemented were decided upon during the tactical phase. As the sector that channels all aircraft to the three airports in the Balearic Islands, the CCC sector of Barcelona ACC was directly implicated in this event, and its capacity was reduced by 23% from 05:20 to 16:00.

Palma TACC also adopted congestion measures, initially reducing its traffic by 60% and later increasing that reduction to 67%.

With regard to the CCC sector, the measures adopted were not particularly effective because many of the flights were already en route to the airports in the Balearic Islands, and their crews were forced to request deviations from their planned and now unfeasible routes due to the prevailing weather conditions. Furthermore, the controllers of the adjacent sectors were forced to transfer, in the best of cases, their aircraft to the sector, resulting in a peak of 55 aircraft between 08:20 and 08:40, i.e. 67% over the regulatory capacity. Specifically, at 08:57, the controllers in the CCC sector had 15 aircraft on the frequency when the maximum should be 14.

This situation was made worse when, at 08:55, three aircraft on approach to Palma missed their approach, and Palma tower had to declare rate 0 for its airport, with the same decision taken at Ibiza airport at almost exactly the same time. Palma TACC then had to instruct its aircraft to circle in its airspace, which gradually reached full capacity, so they had to arrange for subsequent incoming aircraft to circle in Barcelona ACC's airspace. Later, they had to ask the adjacent French ACCs of Bordeaux and Marseille to delay and circle aircraft bound for the airports in the Balearic Islands in their airspaces.

2.4. Operation of the ATC services

The G-DRTW aircraft, whose callsign was EXS5AB, was originally scheduled to depart for Palma Airport at 06:00, but due to the implemented restrictions, they had to delay their departure by 1 h 41 min. Consequently, its actual take-off time from Glasgow was 07:41, the scheduled flight time was 2 h 33 min, and it was scheduled to land in Palma at 10:14.

While the aircraft was still with French ATC, the CCC sector in Barcelona coordinated with its French counterpart to reduce the speed of inbound aircraft as they already had several aircraft in holding patterns. This was because Balearic airports were not accepting aircraft due to the adverse weather, the holding points were accumulating aircraft and rate 0 had eventually to be stablished around 9 minutes earlier.

About 24 minutes after the rate 0 at Palma, the en-route supervisor at Barcelona ACC contacted Bordeaux ACC and informed them that Palma Airport was not accepting aircraft and, therefore, that they shouldn't send any aircraft destined for Palma and Ibiza airports via the PUMAL point.

Shortly afterwards, the EXS5AB aircraft was transferred to the frequency of another Bordeaux ACC sector, sector N3.

The CCC sector then coordinated with its French collateral, indicating that Palma had applied rate 0 and that a lot of aircraft had to be diverted to alternate aerodromes. The French controller notified the crew of this situation and initially instructed them to holding over the LOMRA waypoint at FL350. This instruction was then changed to specify the ROCAN waypoint, where they completed two circles.

Later, both the CCC sector and the en-route supervisor at Barcelona ACC coordinated to transfer the aircraft that were still in French airspace one by one. The first aircraft to be transferred was an uninvolved aircraft that was over the ROCAN waypoint holding at FL340, and this was followed by the transfer of a further 8 aircraft, half of which didn't even need to hold; they simply followed their airway and were transferred directly to Barcelona ACC. The EXS5AB aircraft was eventually coordinated and transferred 35 minutes after the first aircraft.

In the meantime, its crew asked Bordeaux ACC if it knew how long Palma Airport would be affected. ATC replied that it was due to adverse weather but that they didn't know for how long. After this, the crew decided to change to the alternate destination aerodrome to Menorca. At this point, the Bordeaux ACC controller made a mistake, entering LEML into the flight plan system instead of LEMH, which is the correct code for Menorca Airport.

Bordeaux ACC then instructed the G-DRTW aircraft to fly direct to the IBRAP waypoint. Subsequently, the controller requested the estimated landing time at LEML, and the crew corrected him again, giving an ETA of 10:56 at LEMH.

The aircraft was then transferred to the CCC sector after the controller indicated that Palma was accepting aircraft again. The crew made 3 unsuccessful attempts to communicate with the CCC sector. Despite this, the controller continued to inform other aircraft that Palma wasn’t accepting aircraft and offered them various airports on the east coast of the peninsula. One of uninvolved aircraft alerted the sector to the fact that the G-DRTW aircraft had called them about its IBRAP hold at FL 350. The controller responded, "Stand by", and then continued to inform other flights of the incident at Palma. Afterwards, the crew of the aircraft involved called for the fourth time, receiving a similar response. Finally, after contacting the CCC sector for the fifth time, the crew of the EXS5AB aircraft were assigned a new SSR code.

The additional workload placed on the controllers of the CCC sector was due to several factors: the increase in the number of required coordinations (they had to inform the aircraft of the non-acceptance of aircraft on affected airports, have the crews notify their new alternate aerodrome and then re-route them to it), the large number of diversions generated by the situation after the activation of the mass diversion procedure, the congestion on the frequencies, and the fact that aircraft were departing from their original routes and entering adjacent sectors. A similar situation was occurring at both Palma TACC and Palma tower.

Due to this high workload, and without any justification, when it was circling over the IBRAP waypoint at FL 350, the G-DRTW aircraft was erroneously transferred both to the GO2 sector of

the same ACC and, subsequently, to Bordeaux ACC. The Bordeaux ACC controller, somewhat in disbelief, asked the crew what their intentions were. They initially indicated that they wanted to proceed to Palma, although, in their second response, they stated that they wanted to proceed to Menorca. After this, the French controller coordinated with the CCC sector, and after further coordination, the aircraft left the IBRAP holding pattern on a heading of 110º and was transferred back to the CCC sector.

When the situation started to improve, there was a handover of the executive controller position in the CCC sector. After this handover, both the en-route supervisor at Barcelona ACC and the CCC sector informed Bordeaux ACC that Palma Airport was once again accepting aircraft.

At the same time, the G-DRTW aircraft contacted the CCC sector again, and the controller instructed it to proceed directly to the LORES point. The crew then reported that their destination would be Menorca, and after an exchange of communications in which the crew's queries went unanswered, the crew were advised that their original destination of Palma was accepting aircraft again. The crew then decided that they would proceed to Palma. Later, the aircraft was descended and finally transferred to Palma TACC, which provided vectors to the runway 24L localiser.

When the aircraft was approximately 20 miles away on final for the aforementioned runway, it made a distress call due to a fuel emergency, as it expected to land with less fuel than the final reserve. The controllers provided all the necessary assistance and the aircraft landed at 11:20, with a delay of 56 minutes.

It should be noted that since rate 0 had been implemented at 09:11, no other aircraft had been able to land at Palma. Ibiza was in a similar situation from 09:10, and Menorca was also closed from 11:09. As a result, the Palma and Ibiza approach sectors gradually filled up with circling aircraft, and subsequently, the Palma TACC holding patterns also reached maximum capacity. This meant that other aircraft had to join the published holding patterns within the Barcelona ACC airspace and then at other unpublished waypoints, and eventually, the collateral ACCs of Marseille and Bordeaux were asked to keep aircraft within their airspace. The length of time during which the weather phenomenon would affect the aforementioned airports was unknown, and consequently, expected approach times could not be given to the crews. It should be noted that the aircraft in the holding patterns were experiencing problems maintaining the 1000 ft vertical separation between them due to turbulence.

Given the overall scenario, the head of Barcelona ACC asked the controllers who were not in operational positions at the time to assist the other controllers with their coordination tasks.

In regard to the mass diversion procedure, it proved somewhat inefficient due to the management required when there are several ACCs involved, as each one has to reserve, assign and note the parking stands in the event of a diversion for every aircraft that requests it, and given that there is no shared tool available to manage the process, duplications could easily arise.

Lastly, although it didn't affect the outcome of the incident, the crew of the EXS5AB aircraft should have anticipated their situation and made a minimum fuel call to warn Palma TACC of their status.

3. CONCLUSION

3.1. Findings

- The crew planned for extra fuel due to the adverse weather conditions in the destination area.
- Tactical ATFM measures were adopted. No pre-tactical measures were adopted.
- The meteorological conditions evolved to the point that all three Balearic airports were affected at the same time.
- The crew did not declare MINIMUM FUEL.
- The crew declared MAYDAY for fuel.

3.2. Causes/contributing factors

The probable cause of the incident involving the G-DRTW aircraft was an excessive workload in the CCC sector of the ACC Barcelona and in the collateral sectors of the ACC Bordeaux as a consequence of the weather conditions in the Balearic Islands, as well as an error in the alternate airport entered in the aircraft's flight plan while in French airspace.

It is considered as probable contributory factors the overload of the air traffic controllers and the inefficiency of the ATFM measures implemented on the tactical phase, and the complexity of the management of huge deviation when two dependencies are affected.

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4. RECOMMENDATIONS

No recommendations are issued.