RNSA

Rannsóknarnefnd samgönguslysa

# Final report on aircraft serious incident

Case no.: **17-018F005**

Date: **23. February 2017**

Location: **During approach to Manchester Airport**

Description: **Declaration of an emergency due to low fuel**

## 1. FACTUAL INFORMATION

| Location and time | |
|---|---|
| **Location:** | At 4992 feet MSL[1], at location 53°30'4.27''N and 003°3'24.39''W |
| **Date:** | 23. February 2017 |
| **Time[2]:** | 11:14:26 |

| Aircraft | |
|---|---|
| **Type:** | Boeing 757-200 |
| **Register:** | TF-FIP |
| **Year of manufacture:** | 2000 |
| **Serial number:** | 30423 |
| **CoA:** | Valid |
| **Engines:** | Two Rolls-Royce RB211-535E4 |

| Other information | |
|---|---|
| **Type of flight:** | Commercial flight |
| **Persons on board:** | 174 (6 crew and 168 passengers) |
| **Injury:** | None |
| **Damage:** | None |
| **Short description:** | Fuel emergency declared after two attempted landings, one at Manchester Airport (EGCC) and one at Liverpool Airport (EGGP) |

| Commander (Pilot Flying) | |
|---|---|
| **Age:** | 47 years |
| **Certificate:** | ATPL/A |
| **Ratings:** | B757/767 |
| **Medical Certificate:** | Class 1, valid |

**Experience:**

| | |
|---|---|
| Total flight hours: | 9,072 hours |
| Total flight hours as Commander: | 1,964 hours |
| Total flight hours on type: | 6,930 hours |
| Last 90 days on type: | 97 hours |
| Last 24 hours on type: | 0 hours |

[1] Mean Sea Level
[2] All times in the report are UK local times (UTC+0), unless otherwise stated

| First Officer (Pilot Monitoring) | |
|---|---|
| **Age:** | 30 years |
| **Certificate:** | FCLS.A |
| **Ratings:** | B757/767 |
| **Medical Certificate:** | Class 1, valid |
| **Experience:** | Total flight hours: 1,952 hours<br>Total flight hours on type: 1,348 hours<br>Last 90 days on type: 139 hours<br>Last 24 hours on type: 0 hours |

### 1.1. History of the flight

Flight FI440 was scheduled for departure from Keflavik Airport (BIKF) at 08:00Z on February 23rd 2017, to Manchester Airport (EGCC).

At the time of the preparation of the flight plan for flight FI440, there were two Flight Operation Officers (FOO) on duty in the Dispatch department of the flight operator's Network Control Center (NCC). One of the Flight Operation Officers (FOO) issued the original flight plan for flight FI440 at 05:05:29Z.

The planned alternate airport in the flight plan was Liverpool Airport (EGGP).

The Commander initial review of the original operational flight plan package[3] was at home early in the morning. Due to winter operation at Keflavik Airport and high wind conditions at Manchester Airport the Commander decided to call the operator's Dispatch and request an additional 1000 kg to the originally planned fuel.

The pilots reported for duty 1 hour and 40 minutes before scheduled departure. According to the First Officer, in general in his experience, if the flight crew travelled on the same bus to the airport they usually used the bus trip to review the flight documents and discuss the flight. The Commander and the First Officer were however not on the same bus to Keflavik Airport.

An updated flight plan was issued at 06:24:19Z, due to the Commander's request for one ton of extra fuel. The scheduled departure in the updated flight plan was 08:00Z.

The aircraft was parked at a remote stand away from the terminal. The crew had to walk through the terminal to clear passport control before taking a bus to the remote stand. According to the Commander, he entered the cockpit just over 30 minutes before scheduled departure.

According to the Commander, he had not seen any Significant Meteorological Information (SIGMETs) before the flight, but he knew that it would be windy.

According to the First Officer, they reviewed the weather forecast once they were in the cockpit and they did not notice any Significant Meteorological Information (SIGMETs), but they knew it would be windy.

[3] Also called flight documents in the report, as it also includes weather, NOTAMS, airport information etc.

The take-off was delayed due to de-icing of the aircraft from the scheduled take-off at 08:00Z per the flight plan. The actual take-off was at 08:33Z.

The weather forecast for both Manchester Airport and Liverpool Airport were above weather minimums. However, SIGMETs were in effect that were forecasted to pass over the destination and the alternate airport at the estimated time of arrival.

The take-off from Keflavik Airport, the climb, as well as the en-route part of the flight were uneventful. The Commander was the Pilot Flying (PF) during the flight.

At 10:24:47, as the aircraft descended over Northern England, Manchester Radar[4] informed the flight crew of flight FI440 to expect a holding pattern at ROSUN at FL110, eventually to be vectored for the ILS RWY 23R [at Manchester Airport] with QNH 980. According to the FDR, flight FI440 had 6.1 tons of fuel remaining at 10:24:47.

Manchester Radar also informed the flight crew of flight FI440, that one aircraft had executed a go-around [at Manchester Airport]. That aircraft was about to be back on the frequency and Manchester Radar would inquire the flight crew of that aircraft about their intentions.

Manchester Radar then stated, that the flight crew of flight FI440 could then make a decision whether to make an approach themselves [to RWY 23R at Manchester Airport].

About a minute later, the aircraft that had just executed a go-around at Manchester Airport decided to divert due to having experienced severe wind shear on the approach to Manchester.

The flight crew of flight FI440 then informed Manchester Radar that they were entering a holding and would report their intentions within a few minutes (see Figure 1).

At 10:26:31, Manchester Radar instructed the flight crew to enter holding at FL110.

While FI440 was holding at ROSUN at FL110, the flight crew [and crews of other aircraft] were in communications with Manchester Radar regarding wind at different airports around Manchester.

[4] Air Traffic Control at 118.575 MHz frequency

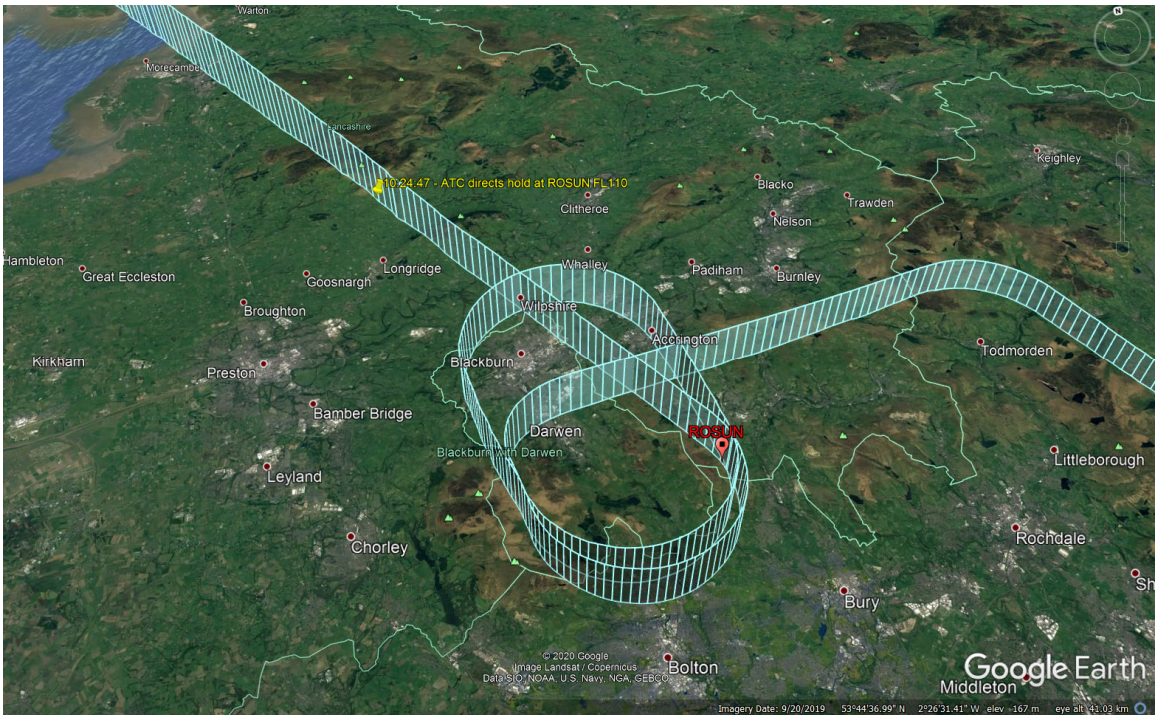



**Figure 1: Holding at ROSUN at FL110**

Manchester Radar reported the following wind conditions:

- East Midlands 260°/38 gusting 56 knots
- Liverpool 270°/40 gusting 52 knots
- Leeds 230°/15 knots

According to the Commander, he became aware of the actual severity of the weather conditions, resulting in multiple go-arounds at Manchester Airport, when instructed to hold at ROSUN FL 110.

The flight crew of flight FI440 completed one and a half holding pattern at ROSUN at FL110, discussing the situation and the option of diverting to Liverpool Airport (EGGP), before deciding to attempt an approach to Manchester Airport. The flight crew also decided that if they could not land at Manchester Airport due to the high wind condition, they would divert directly to Liverpool Airport. The flight crew informed Manchester Radar of their intentions.

At 10:37:37, Manchester Radar instructed the flight crew of flight FI440 to leave the holding and turn right heading 070°. According to the FDR, flight FI440 had just over 5.5 tons of fuel remaining at 10:37:37.

During the approach to Manchester Airport, the flight crew of flight FI440 and Manchester Radar discussed that in case of go-around, flight FI440 would be going directly to Liverpool.

At 10:47:59, Manchester Radar instructed the flight crew to contact Manchester tower at frequency 118.625 MHz. According to the FDR, flight FI440 had just below 5.2 tons of fuel remaining at 10:47:59.

During the approach, the aircraft encountered moderate icing. The aircraft was vectored to the ILS for RWY 23R at Manchester Airport.

At 10:48:13, the flight crew contacted Manchester tower and received clearance to land on RWY 23R.

The flight crew configured the aircraft for landing and selected FLAP 30.

During their final approach to RWY 23R, Manchester tower provided the following updates:

- At 10:49:10 instant wind update 280°/40 knots
- At 10:50:04 wind check 280°/37 knots
- At 10:50:31 updated QNH of 981HPa
- At 10:51:09 instant wind check 290°/34 knots

According to the Commander, the aircraft encountered severe turbulence on final approach (ILS to RWY 23R) and around 800 feet[5] it was clear that the approach could not be continued due to the turbulence.

According to the FDR, Go-Around mode was selected at 10:51:16, when the aircraft was at an altitude of 460 feet MSL[6] and 0.5 NM from Manchester Airport RWY 23R threshold.

At 10:51:39, the flight crew advised Manchester tower that they had executed a go-around. According to the FDR, flight FI440 had just below 4.9 tons of fuel remaining at 10:51:39.

The flight crew commenced a go-around on RWY heading, climbing to 3500 feet, and then diverted to Liverpool Airport.

[5] All altitudes are MSL in the report unless otherwise stated
[6] ALTITUDE_Uncorrected per the FDR was 1426 feet at 10:51:16. Corrected for atmospheric pressure: 1013.25 HPa – 981 HPa = 32.25 HPa. 1426 ft – 32.25 Hpa x 30 ft/HPa = 458.5 ft

At 10:54:16, the flight crew of flight FI440 contacted Liverpool Radar[7] while maintaining a heading of 290° and requested weather information. Liverpool Radar reported the following weather conditions:

- 280°/42 gusting 57 knots
- QNH 982 HPa

The flight crew inquired Liverpool Radar if aircraft had been landing or executing go-arounds at the airport. Liverpool Radar advised that there had both been landings and go-arounds.

At 10:56:13, Liverpool Radar instructed the flight crew to descend to 2000 feet altitude on heading 300 as well as clearing them for approach to RWY 27.

At 10:57:11, Liverpool Radar advised the flight crew that in case of a go-around they were to fly runway heading to an altitude of 2500 feet.

At 10:57:31, the flight crew requested to Liverpool Radar to be taken through the localizer for a 270° right turn to the approach, as they were a bit high and still setting up the approach. Liverpool Radar approved this request and instructed them to turn right heading 360°.


**Figure 2: Go-around at Manchester, through the Liverpool localizer and then a go-around**

At 10:58:44, the flight crew contacted Liverpool Radar and advised that they were ready to start the approach. Liverpool Radar then instructed the flight crew to turn right to heading

[7] Air Traffic Control at 119.850 MHz frequency

180°. According to the FDR, flight FI440 had just over 4.4 tons of fuel remaining at 10:58:44.

At 10:59:04, Liverpool Radar advised of a new QNH 983 HPa.

At 10:59:27, Liverpool Radar instructed the flight crew to turn right again to heading 230° and cleared them for approach to RWY 27.

At 11:01:30, the flight crew contacted Liverpool Radar to confirm in case of go-around instructions as well as requesting updated weather information from Leeds Airport.

At 11:02:12, Liverpool Radar informed the flight crew of the latest Leeds weather:

- Leeds 260°/18 gusting 30 knots

At 11:02:49, Liverpool Radar instructed the flight crew to contact Liverpool tower at frequency 126.350 MHz.

At 11:03:12 the flight crew of flight FI440 contacted Liverpool tower and notified that they were established on the localizer for RWY 27. Liverpool tower replied that flight FI440 was cleared to land.

The flight crew configured the aircraft for landing and selected FLAP 25.

Liverpool tower reported the following weather conditions during the final approach:

- At 11:03:22 surface winds 290°/49 knots minimum 25 gusting to 59
- At 11:03:50 two minute wind 280°/48 knots, min 25 max 59
- At 11:04:00 instant wind 270°/53 knots
- At 11:05:22 Surface winds 2 minutes average 280°/42 knots, minimum 25 gusting 59
- At 11:06:11 instant wind 290°/44 knots

According to the Commander, the aircraft encountered severe turbulence on final approach (ILS to RWY 27). Passing 1000 feet the wind was around 73 knots and around 800 feet a wind shear warning initiated.

Review of the FDR revealed wind shear to have occurred between 11:06:05 and 11:06:52.

According to the FDR, Go-Around mode was selected at 11:06:09, when the aircraft was at about 860 feet MSL[8] and at a distance of 2.5 NM from Liverpool Airport RWY 27 threshold.

At 11:06:36, the flight crew of flight FI440 advised Liverpool tower that they had executed a go-around due to wind shear. According to the FDR, flight FI440 had just over 3.9 tons of fuel remaining at 11:06:36.

According to the Commander, after go-around was initiated the flight experienced heavy turbulence in addition with a low-level altitude capture which resulted in both altitude and airspeed exceedances.

At 11:09:09, the flight crew of flight FI440 contacted Liverpool Radar, per instructions from Liverpool tower, and advised of their 3000 feet altitude and 260° heading. Liverpool Radar instructed flight crew of flight FI440 to turn right to 360° heading and inquired about their intentions [to attempt another landing or to divert].

The flight crew of flight FI440 noticed that they were reaching their minimum diversion fuel of 3664 kg at this time. They had 1950 kg to burn before reaching final reserve fuel 1714 kg.

At 11:09:35, the flight crew contacted Liverpool Radar and informed that they were becoming low on fuel and requested an alternate airport in the vicinity. According to the FDR, flight FI440 had just below 3.7 tons of fuel remaining at 11:09:35.

Around this time, the Commander called an experienced airline pilot, which he knew was travelling on the flight, to the cockpit. The Commander did this to have an additional trained pilot with a fresh mind in the cockpit, as well as to assist with locating airport charts in the library stowed under the jump seat, as ATC had been giving options on alternate airports such as Leeds that were not in the LIDO[9] database.

At 11:10:37, Liverpool Radar informed the flight crew that Leeds Airport could accept them. The flight crew of flight FI440 replied that they would like to go to Leeds.

At 11:11:12, Liverpool Radar instructed flight crew to climb to 5000 feet.

[8] ALTITUDE_Uncorrected per the FDR was 1770 feet at 11:06:09. Corrected for atmospheric pressure: 1013.25 HPa – 983 HPa = 30.25 HPa. 1770 ft – 30.25 Hpa x 30 ft/HPa = 862.5 ft
[9] Electronic Flight Bag (EFB) database containing, amongst other, approach and airport charts

At 11:11:30, Liverpool Radar informed the flight crew that the weather at Leeds was 270°/21 knots. The flight crew of flight FI440 confirmed their intentions to go to Leeds and Liverpool Radar instructed them to turn right to heading 060° as soon as they were through 4000 feet.

The flight crew did not find any data for Leeds Airport in the LIDO database, nor were they familiar with the airport.

At 11:12:28, Liverpool Radar instructed the flight crew to report to Scottish Control at 128.050 MHz.

At 11:12:51, the flight crew of flight FI440 contacted Scottish Control at 128.050 MHz and received instructions to turn left to heading of 340° with further climb shortly. The flight crew of flight FI440 read back the instructions and asked for confirmation that Leeds Airport was EGNM. Scottish Control confirmed that and advised that RWY 32 was in use at Leeds Airport.

At 11:13:23, the flight crew contacted Scottish Control and requested the ILS frequency for RWY 32 at Leeds Airport. Scottish Control told them to standby.

At 11:13:41, Scottish Control instructed the flight crew to climb to FL090.

At 11:13:47, the flight crew of flight FI440 advised Scottish Control that they were getting low on fuel and needed to land. According to the FDR, flight FI440 had just below 3.4 tons of fuel remaining at 11:13:47.

Scottish Control acknowledged this and informed the flight crew of flight FI440 that they would be turning them to Leeds very shortly. The flight crew of flight FI440 responded with a second request for the ILS frequency in Leeds. Scottish Control advised that they were working on that and would respond very shortly. The flight crew then requested permission to stay at an altitude of 5000 feet. Scottish Control told them to standby.

At 11:14:26, the flight crew of flight FI440 contacted Scottish Control, declaring fuel emergency. According to the FDR, flight FI440 had just over 3.3 tons of fuel remaining at 11:14:26. This allowed them about 1600 kg as trip fuel to the alternate to land with final reserve fuel as required by regulation. If a flight crew foresees that they cannot land with final reserve fuel they shall declare an emergency.

| | |
|---|---|
| Flight FI440: | From ICE Air 440, we are declaring fuel emergency. We need to.. we would like to either divert to Manchester or Liverpool. Could you give us a better choice? |
| Scottish Control: | ICE Air 440, that is understood. Squak 7700, turn right now, radar heading of 090° then on heading for Leeds. |
| Flight FI440: | Ok right heading 190° confirm..confirm for ICE Air 440, right turn 090°. |
| Scottish Control: | ICE Air 440 afirm will be heading for RWY 32 at Leeds. |
| Flight FI440: | Yes sir, we are unable Leeds now. We are down to.. below minimum fuel for Leeds. It will take us below the fuel, ICE Air 440. |

At 11:15:21, Scottish Control contacted the flight crew and advised of Warton in the range of 11 NM at their 12 O'clock position, as well as a second airport at their 6 O'clock position in the range of 15 NM. The flight crew of flight FI440 inquired if they had ILS there.

The flight crew reviewed their options. They were down below the minimum diversion fuel and Leeds Airport (which they were unfamiliar with) was now at a distance of 50 NM. They made the decision to commit to Manchester Airport, as they were familiar with that airport. It was very windy in the whole area, and Manchester was much closer than Leeds.

At 11:15:31, the flight crew contacted Scottish Control requesting to divert to Manchester with fuel emergency.

| | |
|---|---|
| Flight FI440: | Sir, we would like to divert to Manchester from present..with fuel emergency. |
| Scottish Control: | ICE Air 440, you like to divert to Manchester? There are still some go-arounds at Manchester. You have to be able to get on ground there? |
| Flight FI440: | Afirm. Are they still making go-arounds at Manchester? |
| Scottish Control: | ICE Air 440 there has been two recent go-arounds at Manchester. |
| Flight FI440: | Take us to the nearest one. |
| Scottish Control: | ICE Air 440, wind at Warton is 290°/25 knots, gusting 46 knots. |
| Flight FI440: | Ok, copy that. Standby. |

At 11:17:02, the flight crew contacted Scottish Control to inquire if Blackpool was available.

| | |
|---|---|
| Flight FI440: | and from ICE Air 440, was Blackpool available for us? |
| Scottish Control: | ICE Air 440, standby for Blackpool. Warton is available for you. I am speaking to Warton at the moment. Weather as previously mentioned 290°/25 knots, gusting 46 knots. We are currently speaking to Manchester to get their latest weather. |
| Flight FI440: | Ok. We prefer Manchester if available. |
| Scottish Control: | ICE Air 440 roger, your current heading is taking you towards [inaudiable] for Manchester. |
| Flight FI440: | Copy. |
| Scottish Control: | and ICE Air 440, winds at Manchester 33 knots gusting to 43 knots. Are you happy with that? |
| Flight FI440: | Yeah, we go to Manchester. |

Scottish Control then inquired the flight crew into the remaining on-board fuel. The flight crew of flight FI440 responded [at 11:18:28] that they had 3.1 tons [of fuel] remaining.

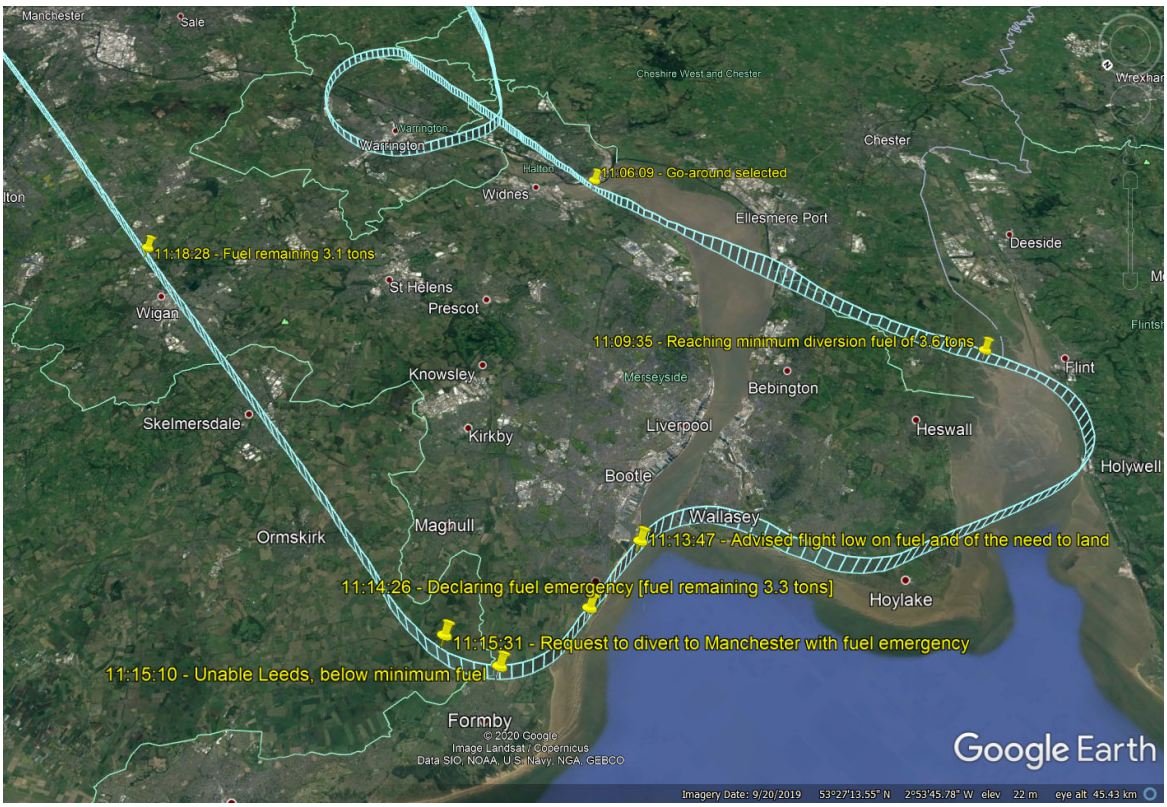



**Figure 3: Diversion to Liverpool, go-around at Liverpool and the fuel emergency thereafter**

Scottish Control then inquired the flight crew on the number of persons on board, which the flight crew responded with 174 total.

At 11:18:48, Scottish Control instructed the flight crew to report their heading to Manchester Radar on 118.575 [MHz].

At 11:19:06, the flight crew of flight FI440 contacted Manchester Radar at an altitude of 5000 feet and a heading of 090° with a fuel emergency and requested to land.

Manchester Radar instructed the flight crew of flight FI440 to continue on the heading with radar vectors to ILS RWY 23R, descend altitude 4000 feet QNH 982 HPa. The flight crew read back the information.

At 11:20:17, Manchester Radar contacted the flight crew, instructed them to descend to 3500 feet, and informed them that they had about 20 NM to the RWY. The flight crew read back the information.

At 11:20:31, Manchester Radar instructed the flight crew to contact Manchester Director at 121.350 [MHz].

At 11:20:45, the flight crew of flight FI440 contacted Manchester Director, notifying that they were descending 3500 feet on a heading of 090° with fuel emergency. Manchester Director confirmed their identity and advised that they had about 19 NM to the RWY.

At 11:21:21, Manchester Director contacted the flight crew of flight FI440 and instructed them to turn right to heading 125°. The flight crew read back the clearance.

At 11:21:54, Manchester Director contacted the flight crew and instructed them to descend to altitude of 2500 feet. The flight crew read back the clearance.

At 11:22:05, Manchester Director contacted the flight crew and instructed them to change their heading to 215° and report intercepting the glideslope for RWY 23R. The flight crew read back the clearance.

The aircraft overshot the glideslope path.

At 11:22:33, Manchester Director contacted the flight crew and instructed them to continue right turn to heading 280°. The flight crew read back the clearance and Manchester Director instructed them to report interception of the glideslope from the south.

At 11:23:24, Manchester Director advised the flight crew that they were closing in from the south and had about 8 NM to touchdown. Then, Manchester Director instructed the flight crew to continue down the glide path when established on the localizer. The flight crew read back this clearance.

At 11:24:01, the flight crew inquired about go-around instructions and Manchester Director asked them to confirm in case of missed approach, that they would be making a go-around. The flight crew confirmed this.

At 11:24:38, Manchester Director contacted the flight crew of flight FI440, notified them that they were 5 NM from touchdown and instructed them to contact Manchester Tower at 118.625 [MHz]. The flight crew read back this information.

At 11:24:49, the flight crew of flight FI440 contacted Manchester Tower and notified that they were on ILS for RWY 23R. Manchester Tower replied that they were cleared to land on RWY 23R.

Manchester Tower also informed the flight crew of the following wind:

- Two minute average wind of 290°/31 knots maximum 45
- Instant wind 280°/29 knots

At 11:25:12, Manchester Tower informed the flight crew of flight FI440 that a departing aircraft had reported positive wind shear, gain of 15 knots on departure 1000 feet.

According to the FDR, RUDDER RATIO SYS warning appeared on EICAS during the final approach to RWY 23R at 11:25:23. This warning stayed on until the end of the flight.

According to the Commander, the aircraft encountered severe turbulence on final approach (ILS to RWY 23R) and the autopilot had difficulties maintaining localizer and glideslope. The flight crew configured the aircraft for landing and selected FLAP 25.

During their final approach to RWY 23R, Manchester tower provided the following updates:

- At 11:25:38 instant wind of 280°/24 knots
- At 11:26:01 instant wind of 300°/31 knots
- At 11:26:14 instant wind of 280°/20 knots
- At 11:26:33 instant wind of 290°/29 knots
- At 11:27:01 instant wind of 280°/32 knots
- At 11:27:14 instant wind of 300°/25 knots

At 11:27:22, the aircraft landed[10] at Manchester Airport. According to the FDR, flight FI440 had 2.7 tons of fuel remaining at 11:27:22. This was 986 kg above final reserve fuel, or about 20 minutes of flying time before using final reserve fuel.

The last fuel measurement of the flight, according to the FDR, occurred at 11:33:12, when the aircraft was at the gate at Manchester Airport. According to the FDR, flight FI440 had just over 2.5 tons of fuel remaining at 11:33:12.

[10] touchdown

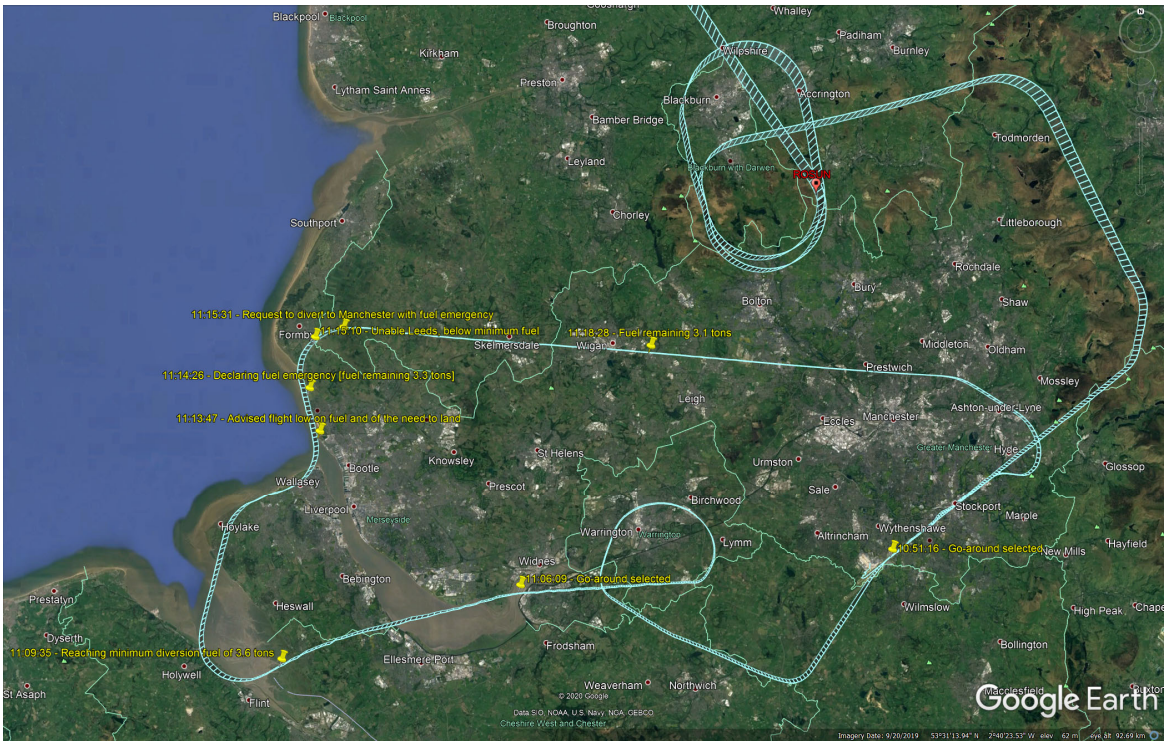



**Figure 4: The flight track of the two go-arounds, fuel emergency and then the landing**

### 1.2. Flight plan – Route, fuel and airports

Following is data from the flight plan issued at 06:24:19Z, after the original flight plan (issued at 05:05:29Z) had been revised.

The flight plan was revised, because the Commander decided to add an extra ton of fuel to the planned departure fuel. According to the Commander, he did this because of winter operations at Keflavik Airport (departure airport) as well as high wind conditions at Manchester Airport (arrival airport).

```
ICELANDAIR                      OPERATIONAL FLIGHT PLAN            CREATED 23-02-2017
                                 MASTER DOCUMENT/COPY                      06:24:19Z

RELEASE VALID UNTIL 6 HOURS AFTER STD: 08:00Z                              UWX 230000

FLIGHT   DATE           FROM     TO       TYPE          REG       ALTN        LOG NR:
ICE440   23/02-2017     KEF      MAN      B757-200W     TFFIP     LPL         1003
                        BIKF     EGCC                             EGGP

         STD: 08:00Z    EET:  2:10    STA: 10:35Z
```

```
LOAD SUMMARY: PAX 171 = 17100 KG  CGO&MAIL     0 KG     EZFW 80156   ETOW  92956

FUEL SUMMARY: COST INDEX  31          PLANNED RAMP  13100       EST LAND  5163
              BIAS IN %   4.2         MINIMUM RAMP  11983       MIN DIV   3664
```

```
REMARKS FROM OPERATIONS:


MAX TURBULENCE. SEVERITY/WAYPOINT:  5/VAMEB

ROUTE INFO
KEFMAN999

INITIAL: M079F370        CTOT: ....:....        DIST:   955

RWY/SID: RW01.PIXUM1A.PIXUM                      STAR/RWY:

PIXUM DCT PETUX DCT ORTAV/N0458F370 DCT ODPEX DCT STN UL612

LAKEY/N0364F190 UL612 CALDA DCT MCT
```

```
AIRPORT LIST:
SCHEDULED OUT: 08:00  ASSUMED OFF:  8:00
BIKF KEF A   169ft  7:00 -  9:00  DEP /ADEQ /
EGPF GLA B    26ft                ADEQ /
EGCC MAN A   257ft  9:10 - 11:10  DEST /ADEQ /
EGGP LPL B    81ft  9:21 - 11:21  ALT1 /

EGNX EMA A   306ft  9:24 - 11:24  ALT /
EGGW LTN A   526ft  9:36 - 11:36  ALT /
EGBB BHX A   339ft  9:27 - 11:27  ALT /
```

WEIGHT INFORMATION

TOTAL PAYLOAD 17100 KG (PAX 171 = 17100 KG CGO&MAIL 0 KG)

| | TOW | LW | ZFW |
|---|---|---|---|
| **MAX OPS WT** | **113398** | **95254** | **85910** |
| PLANNED WT | 92956 | 85319 | 80156 |

ACTUAL WT .....

FUEL CALCULATION:

| | |
|---|---|
| DEST/ALTN | MAN / LPL |
| TIME | 2:10/ 0:11 |
| DIST | 955/ 39 |
| AV WC TO DEST | 40 KTS TAIL |
| T/O ALTN: | |
| MINIMUM RAMP FUEL | :11983 |
| EST LAND FUEL AT DEST | : 5163 |
| (PLANNED RAMP-B/O DEST-TAXI) | |
| MINIMUM DIVERSION FUEL | : 3664 |
| (B/O ALTN+FINAL RESERVE) | |

FUEL BIAS IN %: 4.2

| | FUEL | TIME | |
|---|---|---|---|
| B/O DEST | 7637 | 2:10 | |
| CONTING 5% | 382 | 0:06 | |
| B/O ALTN (EGGP) | 1950 | 0:11 | FL 60 |
| FINAL RESERVE | 1714 | 0:30 | |
| ADDITIONAL | 0 | 0:00 | |
| COMPANY | 100 | 0:02 | |
| EXTRA | 1017 | 0:20 | |
| TAXI | 300 | - | |
| **PLANNED RAMP** | **13100** | 3:19 | |
| OTHER | ..... | ..... | |
| FUEL ON BOARD | ..... | ..... | |

FUEL BURN INCREASE PER 1000 KG WEIGHT 75 Kg
PER 10 KT HEADWIND 167 Kg

ALTITUDE PROFILE:
BIKF/FL370/LAKEY/FL190/

ALTITUDE COMPARISON TO DESTINATION (BASED ON PLANNED CI SPEED)

| | B/O DEST | TIME | WC | FL |
|---|---|---|---|---|
| ABOVE | 7701 | 2:10 | 42 | 390 |
| **PLAN** | **7651** | **2:10** | **40** | **370** |
| BELOW | 7697 | 2:10 | 39 | 350 |
| BELOW | 7793 | 2:12 | 38 | 330 |

SPEED COMPARISON TO DESTINATION

| COST INDEX | B/O DEST | TIME | FL |
|---|---|---|---|
| **31** | **7651** | **2:10** | **370** |
| 65 | 7687 | 2:09 | 370 |
| 200 | 7852 | 2:08 | 370 |

FLIGHT TIME CALCULATIONS

| AWY<br>FIR<br>GMORA | POS<br>FL<br>NAME | FREQ | LAT<br>LONG | TTR<br>MTR | ZD<br>DTG | ZT<br>TTM | ETO/ATO<br>RTO | OAT<br>WIND<br>COMP | TAS<br>GS<br>S | REM / TBO<br>ACT / ACT<br>MFR / |
|---|---|---|---|---|---|---|---|---|---|---|
| ... | | | | | | | | | | |
| UL612 | VAMEB | | N54:00.2 | 157 | 15 | 2 | ..../.. | -28 | 364 | 5553 7547 |
| EGTT | 190/... | | W002:48.5 | 159 | 76 | 1:55 | .... | 296/052 | 402 | ..../ .... |
| 40 | VAMEB | | | | | | | T 38 | 5 | 4055 |
| UL612 | -TOD- | | N53:59.2 | 157 | 1 | 0 | ..../.. | -28 | 364 | 5547 7553 |
| | 190/... | | W002:47.9 | 159 | 75 | 1:55 | .... | 296/052 | 402 | ..../ .... |
| 40 | | | | | | | | T 38 | 5 | 4048 |
| UL612 | OBUNI | | N53:54.7 | 157 | 5 | 1 | ..../.. | VAR | 189 | 5519 7581 |
| EGTT | DSC/... | | W002:44.5 | 159 | 70 | 1:56 | .... | 292/072 | 126 | ..../ .... |
| 35 | OBUNI | | | | | | | T 38 | 5 | 4020 |
| UL612 | CALDA | | N53:46.5 | 157 | 9 | 2 | ..../.. | VAR | 189 | 5473 7627 |
| EGTT | DSC/... | | W002:38.6 | 159 | 61 | 1:58 | .... | 292/072 | 126 | ..../ .... |
| 35 | CALDA | | | | | | | T 69 | 1 | 3975 |
| DCT | MCT | 113.55 | N53:21.4 | 151 | 29 | 6 | ..../.. | VAR | 189 | 5325 7774 |
| EGTT | DSC/... | | W002:15.7 | 153 | 32 | 2:04 | .... | 292/072 | 126 | ..../ .... |
| 35 | MANCHESTER | | | | | | | T 69 | 1 | 3827 |
| MCT | EGCC | 257ft | N53:21.2 | 248 | 32 | 6 | ..../.. | VAR | 189 | 5163 7937 |
| | /... | | W002:16.5 | 250 | 0 | 2:10 | .... | 292/072 | 126 | ..../ .... |
| 35 | | | | | | | | T 69 | | 3664 |

END

ROUTE TO ALTERNATE:

| AWY<br>FIR<br>GMORA | POS<br>FL<br>NAME | FREQ | LAT<br>LONG | TTR<br>MTR | ZD<br>DTG | ZT<br>TTM | ETO/ATO<br>RTO | OAT<br>WIND<br>COMP | TAS<br>GS<br>S | REM / TBO<br>ACT / ACT<br>MFR / |
|---|---|---|---|---|---|---|---|---|---|---|
| Alternate EGGP LISTO2S LISTO | | | | | | | | | | |
| DCT | LISTO | | N53:08.6 | 168 | 13 | 4 | | -5 | 288 | 4908 8192 |
| EGTT | 60 | | W002:12.0 | 170 | | 2:14 | | 300/070 | 330 | |
| 35 | LISTO | | | | | | | | 4 | 2224 |
| DCT | EGGP | | N53:20.0 | 296 | 26 | 7 | | -5 | 288 | 4399 8701 |
| | DSC | | W002:51.0 | 298 | | 2:21 | | 300/070 | 218 | |
| 35 | LIVERPOOL | | | | | | | | 4 | 1714 |

| ICAO | NAME | WIND | FL | NM | MT | TIME | FUEL | ---BLOCK--- | |
|---|---|---|---|---|---|---|---|---|---|
| EGNX | EMA DERBY/EAST MIDL | 312/ 70 | 110 | 46 | 134 | 0:14 | 1950 | 2:54 | 12083 |
| EGGW | LTN LONDON/LUTON | 296/ 76 | 230 | 113 | 143 | 0:26 | 1950 | 3:06 | 12083 |
| EGBB | BHX BIRMINGHAM | 302/ 68 | 130 | 57 | 162 | 0:17 | 1950 | 2:57 | 12083 |

Climb : 86 NM in 0:17 hrs 2527 Kg Descent: 75 NM in 0:15 hrs 384 Kg

### 1.3. Meteorological information

On the 23rd of February 2017 deep low-pressure system, named “storm Doris” moved across the United Kingdom.

Storm warnings had been issued by the UK MET Office on the 21st of February that transportation disruptions were to be expected on February 23rd, as the centre of “storm Doris” moved rapidly through Northern Ireland in the early hours, then across northern England, and out into the North Sea by the early afternoon. This had been followed up by the issue of SIGMETs.

#### 1.3.1. Meteorological data from the flight plan

```
REMARKS FROM OPERATIONS:


MAX TURBULENCE. SEVERITY/WAYPOINT:  5/VAMEB
```

ENROUTE WINDS AND TEMPERATURE

ENROUTE WINDS

| IDENT | FL 330 | | FL 350 | | FL 370 | | FL 390 | | FL 410 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | W/V | TMP | W/V | TMP | W/V | TMP | W/V | TMP | W/V | TMP |
| PIXUM | 276/035 | -49 | 276/040 | -49 | 278/041 | -50 | 280/044 | -48 | 282/046 | -49 |
| -TOC- | 276/035 | -49 | 276/040 | -49 | 278/041 | -50 | 280/044 | -48 | 282/046 | -49 |
| PETUX | 272/029 | -50 | 272/035 | -50 | 277/037 | -50 | 282/042 | -49 | 283/044 | -50 |
| ORTAV | 278/042 | -51 | 278/050 | -51 | 280/052 | -51 | 282/059 | -49 | 287/056 | -49 |
| ODPEX | 296/051 | -50 | 296/054 | -50 | 296/054 | -50 | 296/055 | -49 | 296/057 | -50 |
| STN | 294/051 | -49 | 294/054 | -49 | 294/054 | -50 | 294/055 | -48 | 293/055 | -50 |
| ORSUM | 290/041 | -51 | 290/047 | -50 | 290/048 | -50 | 290/050 | -49 | 288/052 | -50 |
| GOW | 298/058 | -49 | 298/055 | -49 | 295/054 | -50 | 292/052 | -49 | 290/056 | -50 |
| FENIK | 298/058 | -49 | 298/055 | -49 | 295/054 | -50 | 292/052 | -49 | 290/056 | -50 |
| LUSIV | 298/058 | -49 | 298/055 | -49 | 295/054 | -50 | 292/052 | -49 | 290/056 | -50 |
| NAVSO | 298/058 | -49 | 298/055 | -49 | 295/054 | -50 | 292/052 | -49 | 290/056 | -50 |
| BEBNI | 298/058 | -49 | 298/055 | -49 | 295/054 | -50 | 292/052 | -49 | 290/056 | -50 |
| DCS | 298/072 | -49 | 298/064 | -50 | 294/062 | -50 | 290/055 | -49 | 288/056 | -52 |
| LAKEY | 298/072 | -49 | 298/064 | -50 | 294/062 | -50 | 290/055 | -49 | 288/056 | -52 |
| VAMEB | 298/072 | -49 | 298/064 | -50 | 294/062 | -50 | 290/055 | -49 | 288/056 | -52 |
| -TOD- | 298/072 | -49 | 298/064 | -50 | 294/062 | -50 | 290/055 | -49 | 288/056 | -52 |
| OBUNI | 296/064 | -47 | 296/057 | -48 | 292/056 | -48 | 288/052 | -48 | 288/056 | -50 |
| CALDA | 296/064 | -47 | 296/057 | -48 | 292/056 | -48 | 288/052 | -48 | 288/056 | -50 |
| MCT | 296/077 | -48 | 296/066 | -49 | 291/063 | -50 | 286/054 | -49 | 288/054 | -52 |

DESCENT WINDS

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| FL300 | 296/087 | FL240 | 296/081 | FL180 | 292/067 | FL100 | 312/070 | FL050 | 300/070 |

Following is weather data from the original flight documents issued at 05:05:29Z. This is the weather information the flight crew had in its possession before the flight:

**WX** for flight **ICE440-BIKF-EGCC** (STD 230800)

(WX search performed 2017-02-23 05:47:56 Z, for METAR, TAF, LONG TAF and SIGMET.)

**Departure airport BIKF - KEF - KEFLAVIK RWY 01 11 19 29**

```
SA  230530Z  19009KT 9999 FEW020 BKN090 M01/M05 Q0990 R19/470071=
FT  230412Z  2306/2406 18012KT 9999 -SHSN SCT015 BKN025 TX01/2315Z TNM02/2308Z TEMPO
     2306/2406 2500 SHSN BKN007CB OVC012 BECMG 2401/2404 16018G28KT=
```

**Destination airport EGCC - MAN - MANCHESTER RWY 05L 05R 23L 23R**

```
SA  230520Z  COR AUTO 19013KT 150V220 9999 -RA FEW016 BKN030 OVC040 09/08 Q0987 TEMPO 3000
     +RA BKN009=
FT  230501Z  2306/2412 21015G25KT 9999 BKN015 BECMG 2306/2308 23020G35KT TEMPO 2306/2307
     3000 +RA BKN009 TEMPO 2307/2412 6000 SHRA BKN014 BECMG 2308/2311 28025G45KT PROB30
     TEMPO 2308/2315 29035G55KT 4000 +SHRA BKN009 BECMG 2315/2317 31015G25KT BECMG
     2317/2320 27012KT PROB30 TEMPO 2320/2412 29015G25KT=
```

**Alternate airport EGGP - LPL - LIVERPOOL RWY 09 27**

```
SA  230520Z  19012G22KT 150V210 9999 BKN022 10/08 Q0986=
FT  230501Z  2306/2406 22025G35KT 9999 SCT015 BECMG 2306/2308 24030G45KT TEMPO 2306/2307
     25040G55KT 3000 +RA BKN009 TEMPO 2307/2406 6000 SHRA BECMG 2308/2311 28035G50KT PROB30
     TEMPO 2308/2315 29040G60KT 4000 +SHRA BECMG 2311/2314 31030G45KT BECMG 2314/2317
     32018G28KT PROB30 TEMPO 2315/2406 4000 +SHRA BECMG 2403/2406 30010KT=
```

**Alternate airport EGNX - EMA - DERBY/EAST MIDLANDS RWY 09 27**

```
SA  230520Z  22017KT 9999 BKN017 BKN032 10/08 Q0990=
FT  230501Z  2306/2406 21015G25KT 9999 SCT015 BECMG 2306/2308 23025G40KT TEMPO 2306/2308
     3000 +RA BKN009 BECMG 2308/2311 27035G50KT TEMPO 2308/2406 6000 SHRA PROB30 TEMPO
     2308/2315 28040G60KT 4000 +SHRA BECMG 2315/2317 30025G40KT BECMG 2317/2320 31015G25KT
     BECMG 2320/2323 30012KT PROB30 TEMPO 2323/2406 31015G25KT=
```

**Alternate airport EGGW - LTN - LONDON/LUTON RWY 08 26**

```
SA  230520Z  AUTO 21017G28KT 9999 OVC010 09/09 Q0995=
FT  230502Z  2306/2406 22015KT 9999 BKN008 BECMG 2306/2309 23022G38KT FEW012 SCT025 TEMPO
     2306/2309 6000 RA PROB40 TEMPO 2307/2309 24030G48KT 3000 +RA BKN012 BECMG 2309/2312
     27030G45KT PROB30 TEMPO 2309/2406 8000 SHRA PROB40 TEMPO 2310/2319 28040G55KT BECMG
     2318/2321 30015KT=
```

**Alternate airport EGBB - BHX - BIRMINGHAM RWY 15 33**

```
SA  230520Z  20013G23KT 9999 BKN013 10/08 Q0991=
FT  230501Z  2306/2406 21015G25KT 9999 SCT015 BECMG 2306/2308 24025G40KT TEMPO 2306/2308
     3000 +RA BKN009 BECMG 2308/2311 27030G50KT TEMPO 2308/2406 6000 SHRA PROB30 TEMPO
     2308/2315 28040G60KT 4000 +SHRA BECMG 2313/2316 30025G40KT BECMG 2316/2319 31015G25KT
     BECMG 2319/2322 30012KT=
```

**Adequate airport EGPF - GLA - GLASGOW RWY 05 23**

```
SA  230520Z  AUTO 06017KT 3200 -RA OVC005/// //////CB 02/01 Q0981 RERA=
FT  230501Z  2306/2406 06015KT 9999 BKN008 TEMPO 2306/2311 1200 +RASN BKN003 PROB40 TEMPO
     2306/2310 0200 +SN VV/// BECMG 2309/2312 33012KT SCT012 PROB30 TEMPO 2312/2320 8000 -
     SHRA BKN014 BECMG 2315/2318 27005KT TEMPO 2320/2402 6000 SHRA BKN010 PROB30 TEMPO
     2320/2324 4000 SHRASN BKN008=
```

**SIGMET(s) for EGJJ FIR:**

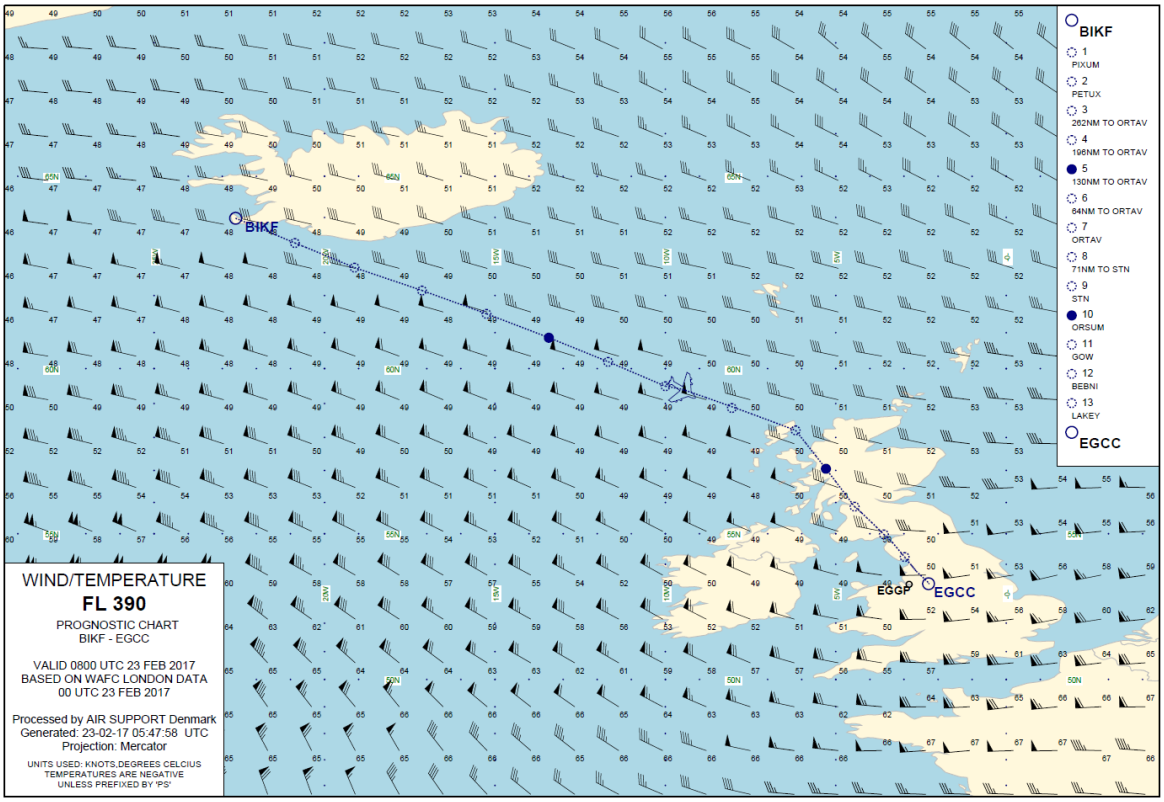
```
WSUK32 EGJJ 230531
EGJJ SIGMET 01 VALID 230600/231000 EGJJ-
EGJJ CHANNEL ISLANDS CTA LCA SEV TURB FCST SFC/3000FT INTSF=
```

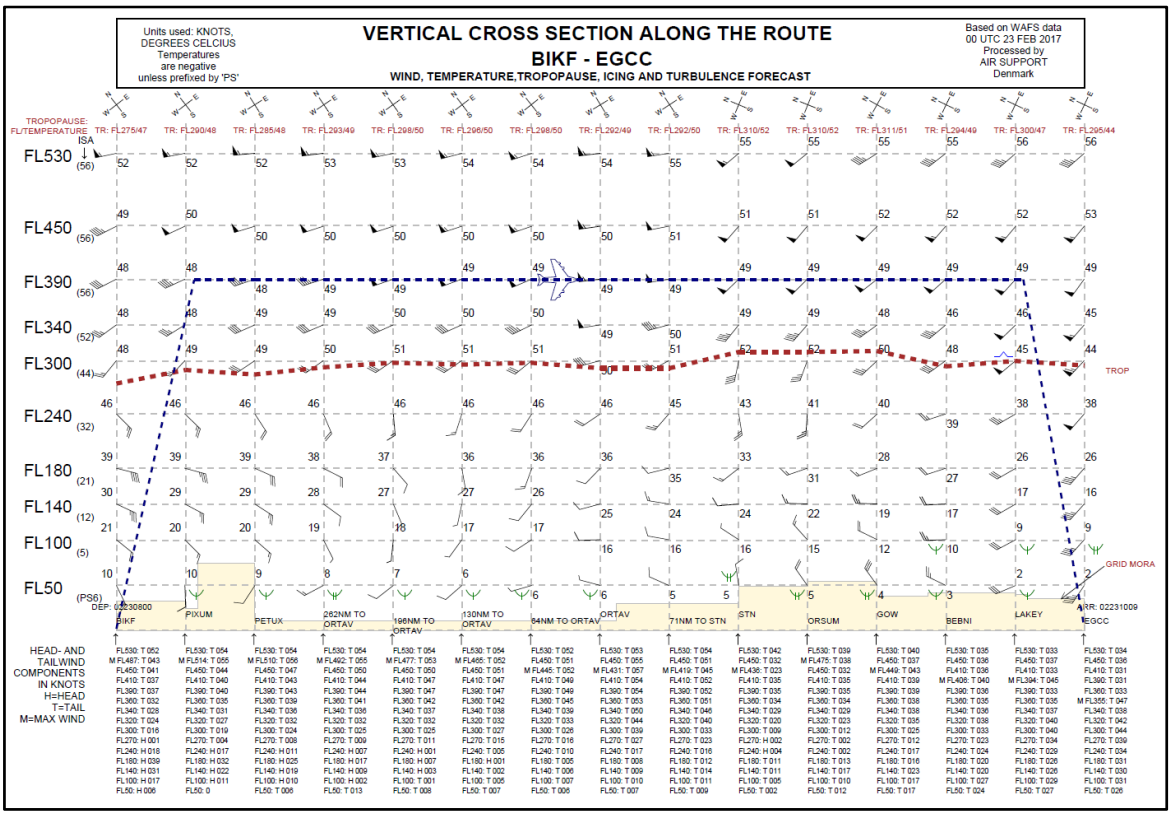
**SIGMET(s) for EGTT FIR:**

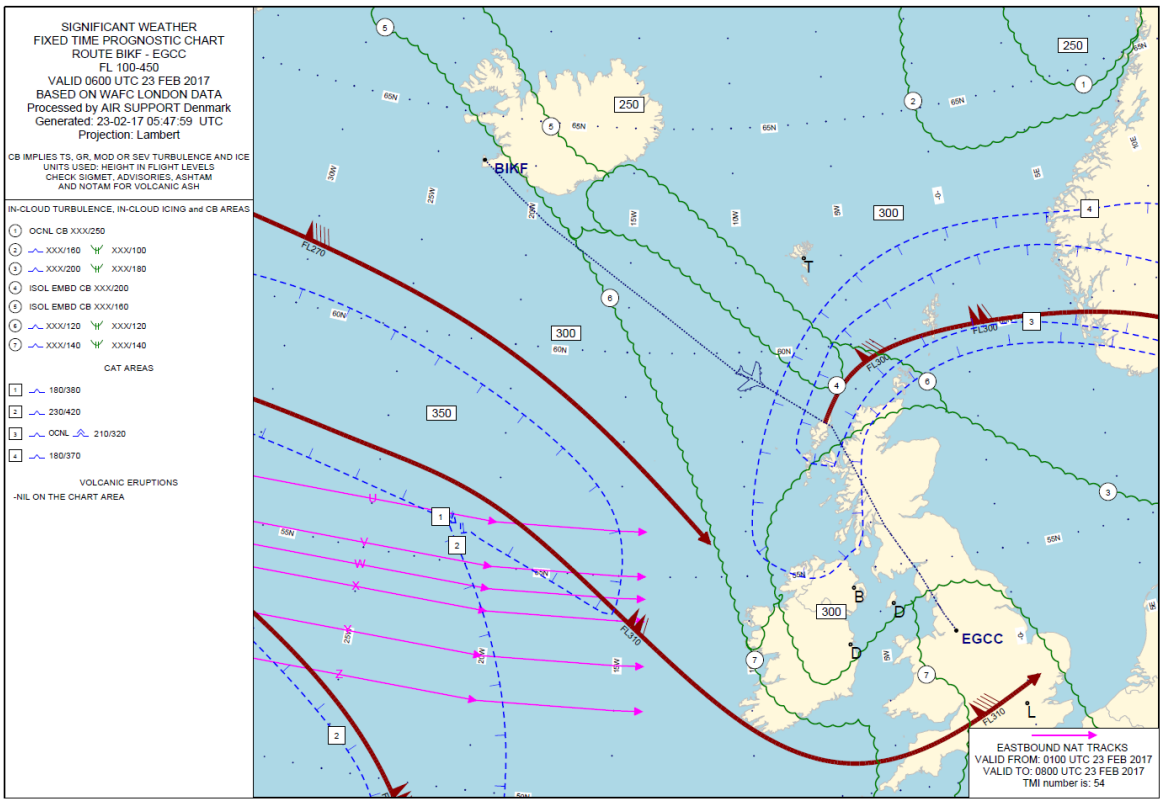
```
WSUK31 EGRR 230214
EGTT SIGMET 01 VALID 230300/230700 EGRR-
EGTT LONDON FIR SEV TURB FCST W OF LINE N5149 W00628 - N4907 W00633 SFC/FL060 MOV ENE 30KT
INTSF=

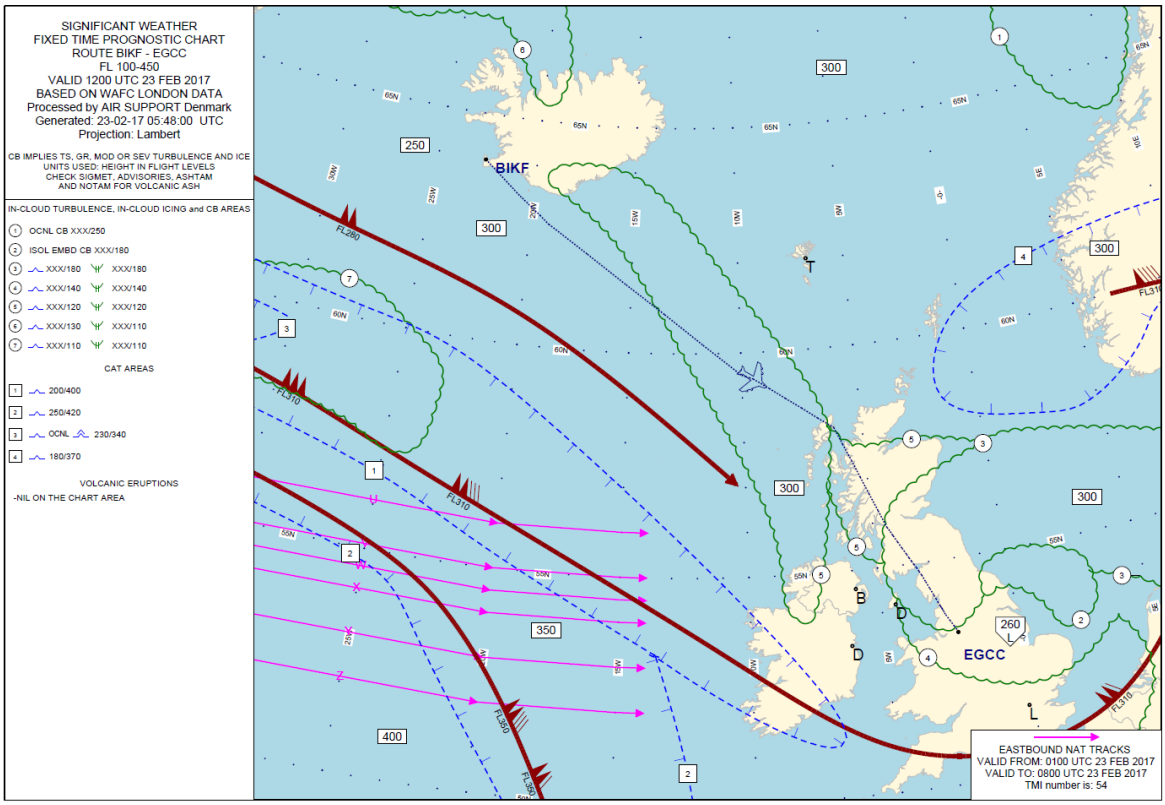
WSUK31 EGRR 230222
EGTT SIGMET 02 VALID 230300/230700 EGRR-
EGTT LONDON FIR SEV MTW FCST WI N5341 W00530 - N5044 E00106 - N5001 W00500 - N5229 W00530
- N5341 W00530 FL040/260 MOV ENE 10KT NC=
```

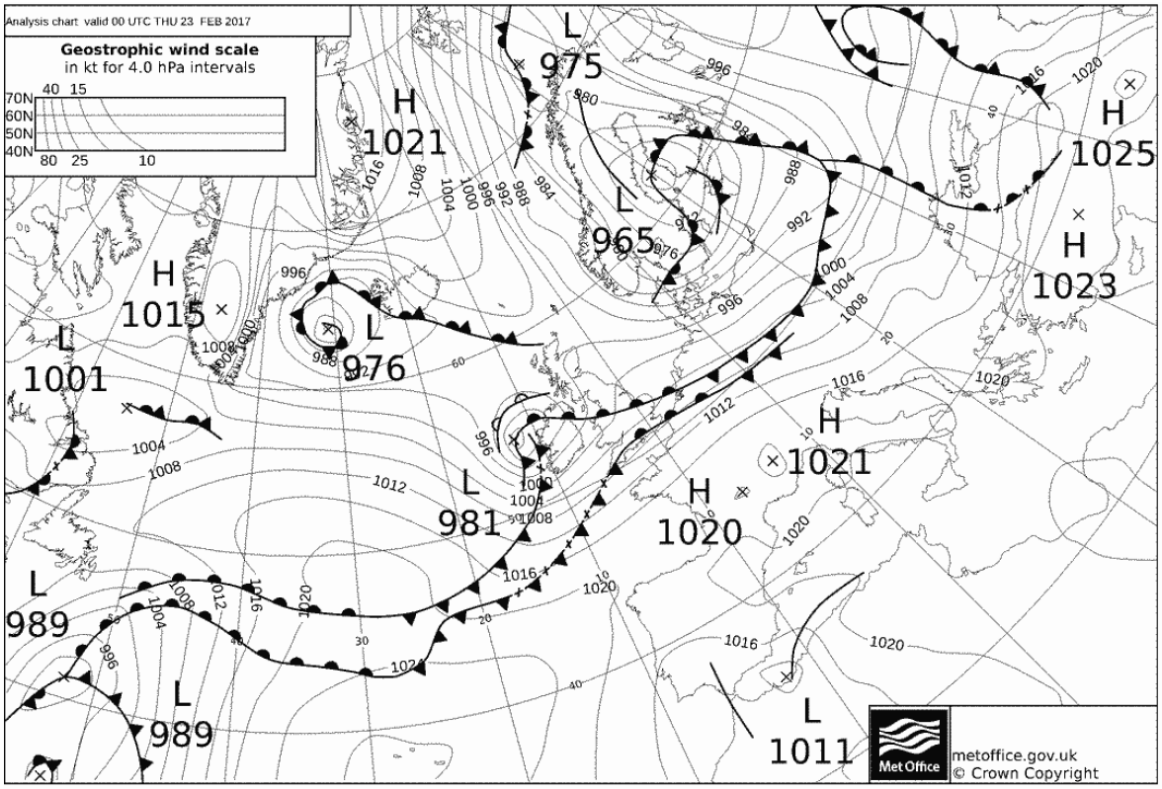
**End of WX information**


BIKF
1 PIXUM
2 PETUX
3 262NM TO ORTAV
4 196NM TO ORTAV
5 130NM TO ORTAV
6 64NM TO ORTAV
7 ORTAV
8 71NM TO STN
9 STN
10 ORSUM
11 GOW
12 BEBNI
13 LAKEY
EGCC
BIKF
EGGP
EGCC
WIND/TEMPERATURE
FL 390
PROGNOSTIC CHART
BIKF - EGCC
VALID 0800 UTC 23 FEB 2017
BASED ON WAFC LONDON DATA
00 UTC 23 FEB 2017
Processed by AIR SUPPORT Denmark
Generated: 23-02-17 05:47:58 UTC
Projection: Mercator
UNITS USED: KNOTS,DEGREES CELCIUS
TEMPERATURES ARE NEGATIVE
UNLESS PREFIXED BY 'PS'


Units used: KNOTS, DEGREES CELCIUS Temperatures are negative unless prefixed by 'PS'
VERTICAL CROSS SECTION ALONG THE ROUTE
BIKF - EGCC
WIND, TEMPERATURE,TROPOPAUSE, ICING AND TURBULENCE FORECAST
Based on WAFS data 00 UTC 23 FEB 2017 Processed by AIR SUPPORT Denmark
TROPOPAUSE: FL/TEMPERATURE
TR: FL275/47
TR: FL290/48
TR: FL285/48
TR: FL293/49
TR: FL298/50
TR: FL296/50
TR: FL298/50
TR: FL292/49
TR: FL292/50
TR: FL310/52
TR: FL310/52
TR: FL311/51
TR: FL294/49
TR: FL300/47
TR: FL295/44
ISA
FL530 (56)
FL450 (56)
FL390 (56)
FL340 (52)
FL300 (44)
FL240 (32)
FL180 (21)
FL140 (12)
FL100 (5)
FL50 (PS6)
TROP
GRID MORA
DEP: 02230800
ARR: 02231009
BIKF
PIXUM
PETUX
262NM TO ORTAV
196NM TO ORTAV
130NM TO ORTAV
64NM TO ORTAV
ORTAV
71NM TO STN
STN
ORSUM
GOW
BEBNI
LAKEY
EGCC
HEAD- AND TAILWIND COMPONENTS IN KNOTS H=HEAD T=TAIL M=MAX WIND


SIGNIFICANT WEATHER
FIXED TIME PROGNOSTIC CHART
ROUTE BIKF - EGCC
FL 100-450
VALID 0600 UTC 23 FEB 2017
BASED ON WAFC LONDON DATA
Processed by AIR SUPPORT Denmark
Generated: 23-02-17 05:47:59 UTC
Projection: Lambert
CB IMPLIES TS, GR, MOD OR SEV TURBULENCE AND ICE
UNITS USED: HEIGHT IN FLIGHT LEVELS
CHECK SIGMET, ADVISORIES, ASHTAM
AND NOTAM FOR VOLCANIC ASH
IN-CLOUD TURBULENCE, IN-CLOUD ICING and CB AREAS
1 OCNL CB XXX/250
2 XXX/160 XXX/100
3 XXX/200 XXX/180
4 ISOL EMBD CB XXX/200
5 ISOL EMBD CB XXX/160
6 XXX/120 XXX/120
7 XXX/140 XXX/140
CAT AREAS
1 180/380
2 230/420
3 OCNL 210/320
4 180/370
VOLCANIC ERUPTIONS
-NIL ON THE CHART AREA
BIKF
EGCC
EASTBOUND NAT TRACKS
VALID FROM: 0100 UTC 23 FEB 2017
VALID TO: 0800 UTC 23 FEB 2017
TMI number is: 54


SIGNIFICANT WEATHER
FIXED TIME PROGNOSTIC CHART
ROUTE BIKF - EGCC
FL 100-450
VALID 1200 UTC 23 FEB 2017
BASED ON WAFC LONDON DATA
Processed by AIR SUPPORT Denmark
Generated: 23-02-17 05:48:00 UTC
Projection: Lambert
CB IMPLIES TS, GR, MOD OR SEV TURBULENCE AND ICE
UNITS USED: HEIGHT IN FLIGHT LEVELS
CHECK SIGMET, ADVISORIES, ASHTAM
AND NOTAM FOR VOLCANIC ASH
IN-CLOUD TURBULENCE, IN-CLOUD ICING and CB AREAS
1 OCNL CB XXX/250
2 ISOL EMBD CB XXX/180
3 XXX/180 XXX/180
4 XXX/140 XXX/140
5 XXX/120 XXX/120
6 XXX/130 XXX/110
7 XXX/110 XXX/110
CAT AREAS
1 200/400
2 250/420
3 OCNL 230/340
4 180/370
VOLCANIC ERUPTIONS
-NIL ON THE CHART AREA
BIKF
EGCC
EASTBOUND NAT TRACKS
VALID FROM: 0100 UTC 23 FEB 2017
VALID TO: 0800 UTC 23 FEB 2017
TMI number is: 54


Analysis chart valid 00 UTC THU 23 FEB 2017
Geostrophic wind scale
in kt for 4.0 hPa intervals
40 15
70N
60N
50N
40N
80 25 10
L 975
H 1021
L 965
H 1025
H 1023
H 1015
L 976
L 1001
H 1021
L 981
H 1020
L 989
L 989
L 1011
Met Office
metoffice.gov.uk
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### 1.3.2. Meteorological data issued by the UK MET Office

The following weather report was compiled by the UK MET Office for the investigation:



Met Office

[redacted]

Air Accidents Investigation Branch
Farnborough House
Berkshire Copse Road
Aldershot
Hampshire
GU11 2HH

[redacted]

02.03.2017 Our ref: AAIB 15, 23.02.2017, Manchester.

**AAIB Aftercast: Icelandair Incident.**

Dear [redacted]

From the information provided, I understand that you require an aftercast for Manchester and Liverpool airports, between 10:00-13:00 UTC on the 23rd February 2017.

All figures are in Appendix 1.

**Review of Meteorological Data**

**Figure 1.** Surface analysis chart valid at 1200 UTC on 23rd February 2017. This shows a deep low pressure system (storm Doris) centred over North East England. Associated fronts circulate the low, and the tight isobars indicate a strong cyclonic flow around the low pressure system, with a NW flow over North Wes: England.

**Figure 2.** F215 Chart valid between 0800 UTC and 1700 UTC on 23rd February 2017. Zone C lies over the area of interest at this time, with area B approaching from the west. The chart suggests thick frontal cloud in zone C, with bases generally in the 500-1000FT range, but as low as 200FT on the fronts themselves. Occasional rain was forecast. The chart also indicates widespread moderate low level turbulence and isolated severe turbulence north of N4800, an area encompassing North West England. Zone B moving into the area suggests SCT/BKN amounts of convective cloud with higher bases than one C, with isolated showers of rain, but the risk of moderate/severe low level turbulence remains.

**Figures 3 and 4.** High resolution visible satellite imagery valid at 1200 UTC on 23rd February 2017. Satellite imagery shows storm Doris centred over Northern England with thick frontal cloud circulating around the low pressure system. Figure 4 shows some brighter, lumpier cloud over north west England, suggesting some convection embedded within the frontal band. The open cell convective cloud to the west of the storm, over Ireland at this time, is indicative of a strong flow.

**Figure. 5** Sigmets issued in the London FIR on 23rd February 2017. Sigmet 1 warned of intensifying severe low level turbulence across the southwest of the London FIR between 0700-1100UTC, moving east through the period to affect an area including EGCC and EGGP. Sigmet 2 was warning for severe mountain waves between 4000-26000FT for all but the far north of the London FIR, this SIGMET area also including EGCC and EGGP. Sigmet 3 valid 1100-1500UTC warns that severe low level turbulence has been observed in the London FIR, the area again including EGCC and EGGP.

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Devon, EX1 3PB
United Kingdom
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Met Office

**Figures 6 and 7.** TAF reports from EGCC and EGGP issued between 06:00-08:00UTC on 23rd February 2017.

The EGCC TAF valid from 06:00UTC had a BECMG group between 08:00UTC and 11:00UTC describing an increase in the winds to give mean speeds of 25KT and gusts of 45KT, from a WNW direction. There was also a PROB30 TEMPO between 08:00UTC and 15:00UTC of mean speeds of 35KT and gusts of 55KT, accompanied by heavy showers of rain and BKN cloud at 900FT.

The EGGP TAF valid from 06:00UTC had a BECMG group between 08:00UTC and 11:00UTC describing an increase in the winds to give mean speeds of 30KT and gusts of 50KT, from a WNW direction. There was also a PROB30 TEMPO between 08:00UTC and 15:00UTC of mean speeds of 40KT and gusts of 60KT, accompanied by heavy showers of rain.

**Figures 8 and 9.** METAR and SPECI reports from EGCC and EGGP issued between 10:00-13:00UTC on 23rd February 2017.

The observations from EGCC show heavy rain becoming moderate then light through the period. BKN stratus cloud bases start at 1100FT and lift to 1400FT, and visibility improves from 3500M at the start of the period to 6000M by the end of the period. WSW winds initially have mean speeds of 29-33KT with gusts in the range 42-45KT. Winds veer to a NW direction with mean speeds of 28-36KT with gusts of 41-49KT later in the period.

The observations from EGGP show visibilities in the range 3000-5000M with moderate rain, becoming light. BKN cloud bases of 1100FT increase to 2100FT. Westerly winds with mean speeds of 41KT and gusts of 52KT veer to a NW direction, peak speeds of 44KT and gusts of 63KT were recorded at 10:50UTC, before easing to mean speeds of 39KT and gusts of 52KT by the end of the period.

**Summary of findings**

The figures detailed above show that on 23rd February 2017 between 10:00-13:00 UTC a deep low pressure system, named storm Doris, was centred over Northern England, moving from west to east.

Thick frontal cloud with some embedded convection resulted in moderate to heavy rain over North West England at the start of the period, this easing towards the end of the period. Cloud bases were at their lowest at the start of the period, EGCC and EGGP both reported BKN stratus cloud bases at 1100FT initially.

Winds were from a southwest direction initially, but veered to a NW direction through the period. Winds were strong/gale force throughout with a maximum gust of 63KT at EGGP reported at 10:50UTC and a maximum gust of 49KT reported at EGCC at 11:29UTC.

Sigmets for severe low level turbulence and severe mountain waves had been issued, both covering the area concerned.

I hope that the information provided is useful. Please do not hesitate to get in contact if you would like any further information or clarification of the details included.

Yours Sincerely,

[redacted]

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Devon, EX1 3PB
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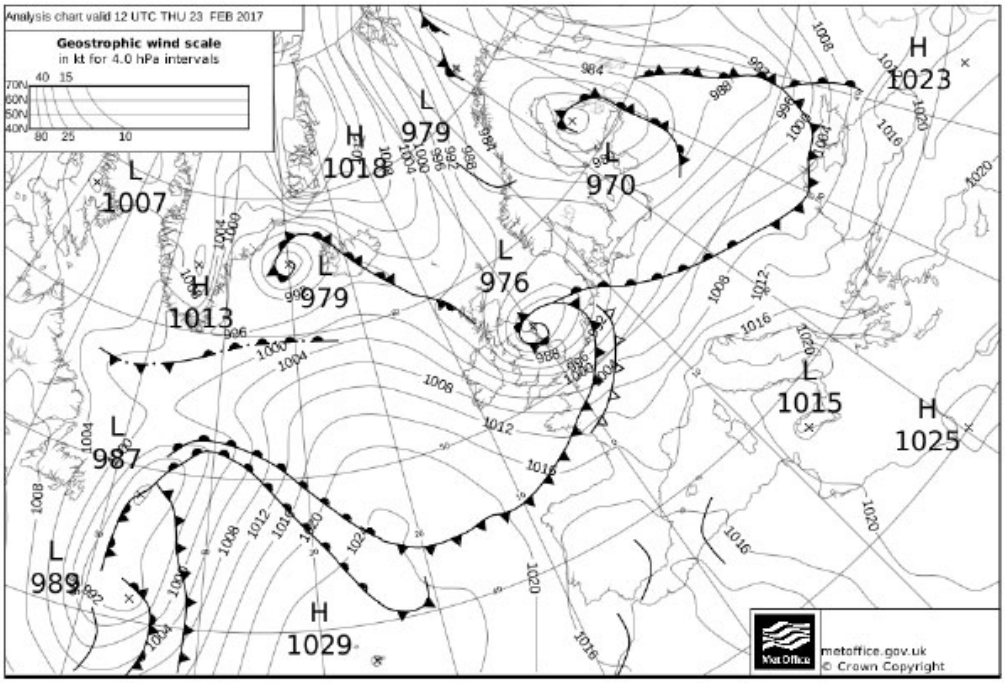
Met Office

Appendix 1.

**Figure 1.** Surface analysis chart valid at 1200UTC on 23rd February 2017.

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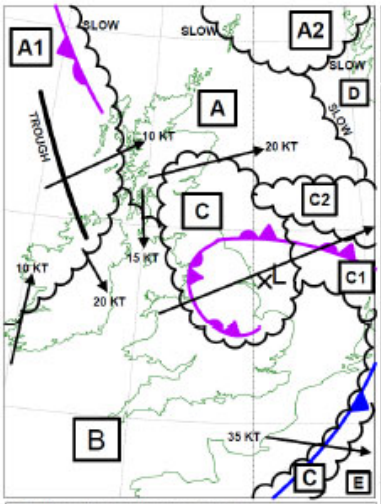
Met Office

**Figure 2.** F215 Chart Valid between 0800UTC and 1700UTC on 23rd February 2017.




All heights in 100s of feet above mean sea level

XXX means above chart upper limit
Speed of movement in KT
Hill FG implies VIS <200 M
Cloud amount (Oktas)
FEW: 1-2 SCT: 3-4
BKN: 5-7 OVC: 8
MOD / SEV ICE
MOD / SEV TURB
TS / CB implies OR
FZ precipitation implies

This forecast may be amended at any time.
Issued by Met Office Exeter at 230335 Z
Contact telephone 0370 900 0100 F 215
Forecaster: Duty Forecaster



## Forecast Weather below 10000 FT

Met Office Valid 230800 to 231700 Z FEB 17 Fronts/zones valid at 231200 Z

| AREA | SURFACE VIS AND WX | CLOUD | 0 C |
|---|---|---|---|
| A | 30 KM NIL<br>ISOL (OCNL **A1 A2**) 6 KM SHRA/SHGS<br>ISOL 3000 M +SHRASN/+TSGS **A1 A2**<br>ISOL 1200 M SHSN MON SCOTLAND<br>ISOL 300 M +SHSN **A2** AND MON **A1**<br>OCNL ⩓ **A1 A2**<br>ISOL HILL FG | BKN/OVC AC ⩓ 080 / XXX FRONT<br>SCT/BKN CU SC ⩓ ⩓ ...<br>... 015-030 / 070-( XXX **A1 A2**)<br>OCNL (EMBD FRONT) CB ...<br>... 015-020 / 090-XXX **A1 A2**<br>ISOL SCT/BKN ST 005-010 / 015 | 010 N<br>020 S |
| B | 25 KM NIL<br>ISOL 6 KM SHRA<br>ISOL 500 M SHSN MON<br>MTW MAX VSP 800 FPM AT 090<br>⩓/⩓ ...<br>ISOL HILL FG | SCT/BKN CU SC ⩓ 020-030 / 060-090<br>ISOL SCT/BKN ST 010-015 / 020 | 025-035 N<br>040-060 S |
| C | 15 KM NIL/-RA<br>OCNL 6 KM RA/-RADZ/BASN LAN N)<br>ISOL 3500 M +RA/+TSRA **C1**<br>ISOL 500 M SN LAN FAR NW ...<br>... (AND MON N OF 53 N)<br>MTW MAX VSP 500 FPM AT 060 SE OF ...<br>... COLD FRONT<br>WDSPR ⩓ (OCNL ⩓ N OF 48 N)<br>OCNL HILL FG | BKN/OVC AC AS ⩓ 080 / XXX<br>BKN/OVC (LCA SCT LEE MON) CU SC ...<br>... ⩓ (LCA 015-080 **C2**) ⩓ ...<br>... 015-025 / 080-(XXX FRONTS)<br>ISOL EMBD CB 015 / XXX **C1**<br>OCNL (WDSPR FRONTS) SCT/BKN ST ...<br>... 005-010 / 015 ( LCA BASE 002 ...<br>... FRONTS AND SN) | 005-015 ...<br>... LAN ...<br>... FAR NW<br>015-040 N<br>050-070 S |
| D | 30 KM NIL<br>ISOL HILL FG | ISOL SCT/BKN SC AC ⩓ 040-060 / 090 | 010-020 S |
| E | 30 KM NIL<br>ISOL 4000 M -RADZ UPSLOPES TL 11 Z<br>MTW MAX VSP 600 FPM AT 070<br>OCNL ⩓ (ISOL ⩓ N OF 50 N)<br>ISOL HILL FG | ISOL SCT/BKN AC ⩓ 080 / XXX<br>OCNL SCT/BKN CU SC ⩓ ⩓ ...<br>... 020-035 / 060<br>ISOL SCT/BKN ST SC 007-012 / 020 ...<br>... UPSLOPES TL 11 Z | 050-070 N |

Outlook Until 232400 Z: TURB BECMG MOD IN AREA B, OTHERWISE SIMILAR.

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Figure 3. High resolution MSG Visible satellite image valid at 1200UTC on 23rd December 2017.

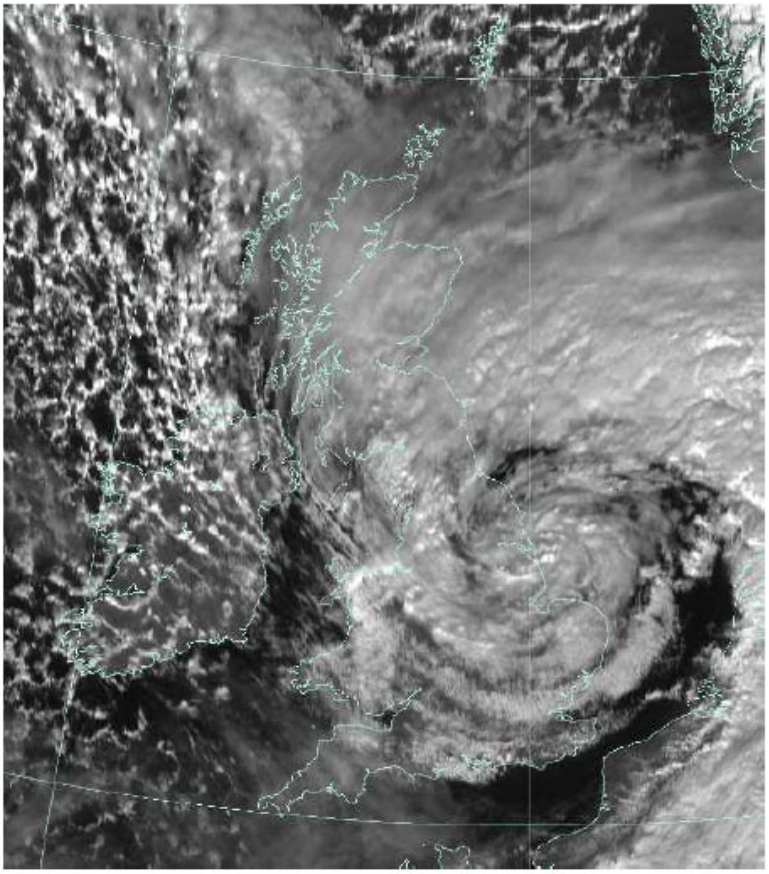

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**Figure 4.** High resolution MSG Visible satellite image valid at 1200UTC on 23rd December 2017, zoomed in on area of interest.

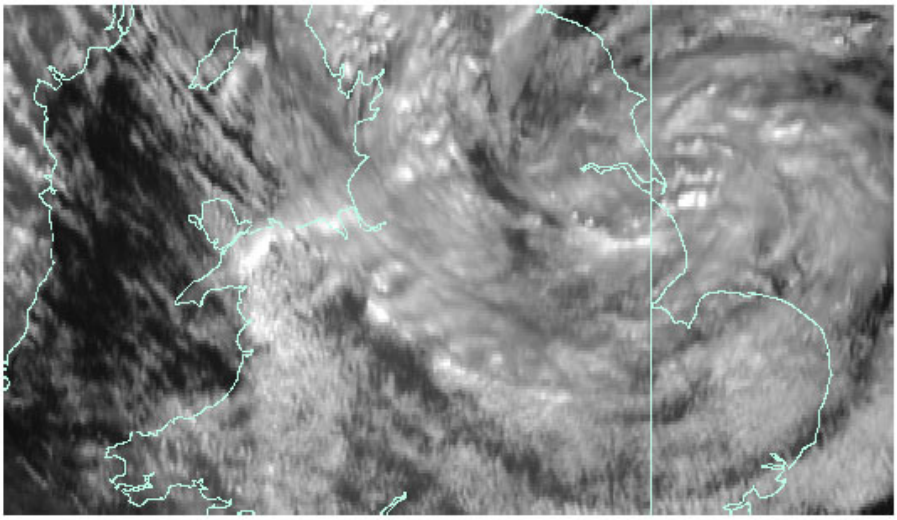

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**Figure.** 5 Sigmets issued in the London FIR on 23rd February 2017.

**Sigmet 1:**

WSUK31 EGRR 230617
EGTT SIGMET 03 VALID 230700/231100 EGRR-
EGTT LONDON FIR SEV TURB FCST SW OF LINE N5418 W00530 - N5036 E00119
SFC/FL060 MOV E 30KT INTSF

**Sigmet 2:**

WSUK31 EGRR 230623
EGTT SIGMET 04 VALID 230700/231100 EGRR-
EGTT LONDON FIR SEV MTW FCST S OF LINE N5349 W00530 - N5248 E00303
FL040/260 STNR NC

**Sigmet 3:**

WSUK31 EGRR 231054
EGTT SIGMET 05 VALID 231100/231500 EGRR-
EGTT LONDON FIR SEV TURB OBS WI N5400 E00410 - N5012 E00150 - N4930
W00440 - N5135 W00700 - N5220 W00530 - N5500 W00530 - N5500 W00340 -
N5350 W00120 - N5400 E00410 SFC/FL060 MOV E 20KT NC

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**Figure 6.** TAF report from EGCC issued between 06:00-08:00UTC on 23rd February 2017.

EGCC 230501Z 2306/2412 21015G25KT 9999 BKN015 BECMG 2306/2308 23020G35KT TEMPO 2306/2307 3000 +RA BKN009 TEMPO 2307/2412 6000 SHRA BKN014 BECMG 2308/2311 28025G45KT PROB30 TEMPO 2308/2315 29035G55KT 4000 +SHRA BKN009 BECMG 2315/2317 31015G25KT BECMG 2317/2320 27012KT PROB30 TEMPO 2320/2412 29015G25KT=

**Figure 7.** TAF report from EGGP issued between 06:00-08:00UTC on 23rd February 2017.

EGGP 230501Z 2306/2406 22025G35KT 9999 SCT015 BECMG 2306/2308 24030G45KT TEMPO 2306/2307 25040G55KT 3000 +RA BKN009 TEMPO 2307/2406 6000 SHRA BECMG 2308/2311 28035G50KT PROB30 TEMPO 2308/2315 29040G60KT 4000 +SHRA BECMG 2311/2314 31030G45KT BECMG 2314/2317 32018G28KT PROB30 TEMPO 2315/2406 4000 +SHRA BECMG 2403/2406 30010KT=

**Figure 8.** METAR and SPECI reports from EGCC issued between 10:00-13:00UTC on 23rd February 2017.

EGCC 231020Z 26032G45KT 3500 R23R/1000 +RA FEW007 BKN011 05/04 Q0980=
EGCC 231020Z 26031G45KT 3500 R23R/1000 +RA FEW007 BKN011 05/04 Q0980=
EGCC 231020Z 26032G45KT 3500 R23R/1000 +RA FEW007 BKN011 05/04 Q0980 TEMPO RA=
EGCC 231050Z 26033G43KT 4500 R23R/1000 RA SCT007 BKN014 05/04 Q0981 RERA TEMPO +RA BKN009=
EGCC 231050Z 26033G43KT 3500 R23R/1000 +RA FEW007 BKN011 05/04 Q0981=
EGCC 231112Z 27032G42KT 4500 R23R/1000 RA SCT007 BKN014 05/04 Q0982=
EGCC 231120Z 27029G46KT 4500 R23R/1100 RA SCT009 BKN016 05/04 Q0982 TEMPO +RA BKN009=
EGCC 231129Z 28036G49KT 4500 R23R/1000 RA SCT009 BKN016 05/04 Q0983=
EGCC 231145Z 28032G47KT 4500 R23R/1000 RA SCT009 BKN016 05/04 Q0984=
EGCC 231150Z AUTO 28030G42KT 5000 R23R/1000 -RA SCT010/// BKN014/// OVC027/// //////TCU 05/04 Q0984 RERA BECMG SCT010=
EGCC 231204Z 28032G46KT 5000 R23R/1000 -RA SCT010/// BKN014/// OVC027/// //////TCU 06/03 Q0985=
EGCC 231220Z AUTO 29028G41KT 6000 R23R/1100 -RA BKN014 OVC027 06/03 Q0986 BECMG SCT014=
EGCC 231250Z AUTO 29032G47KT 9999 R23R/1100 BKN020 OVC025 06/02 Q0987 NOSIG=
EGCC 231253Z 29032G47KT 6000 R23R/1100 -RA BKN014 OVC027 06/02 Q0987=

**Figure 9.** METAR and SPECI reports from EGGP issued between 10:00-13:00UTC on 23rd February 2017.

EGGP 231020Z 27041G52KT 4000 RA SCT009 BKN011 05/04 Q0981=
EGGP 231029Z 28040G53KT 4000 RA SCT009 BKN011 06/04 Q0981=
EGGP 231038Z 28040G58KT 4000 RA SCT009 BKN011 05/04 Q0982=
EGGP 231050Z 28044G63KT 3000 RA SCT009 BKN011 OVC019 06/04 Q0982=
EGGP 231058Z 28041G57KT 3000 RA SCT009 BKN011 OVC019 06/04 Q0983=
EGGP 231114Z 29040G60KT 3000 RA SCT009 BKN011 OVC019 06/04 Q0984=
EGGP 231120Z 29041G60KT 3000 RA SCT011 BKN015 OVC019 06/04 Q0984=
EGGP 231125Z 29040G61KT 3000 RA SCT011 BKN015 OVC019 06/03 Q0985=
EGGP 231140Z 28039G61KT 3000 RA SCT011 BKN015 OVC019 07/03 Q0986=
EGGP 231150Z 28038G61KT 3000 -RA SCT011 BKN021 OVC026 07/03 Q0986=
EGGP 231210Z 29037G52KT 3000 -RA SCT011 BKN021 OVC026 07/04 Q0987=
EGGP 231220Z 29035G49KT 3000 -RA BKN011 BKN027 OVC039 07/04 Q0987=
EGGP 231232Z 29036G57KT 3000 -RA BKN011 BKN027 OVC039 07/04 Q0988=
EGGP 231250Z 29039G52KT 5000 RA FEW016 BKN021 BKN027 06/04 Q0988=

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## 1.4. Organizational and management information

This serious incident was not reported to the UK AAIB[11] nor the ITSB[12] by the flight operator, but initial notification of a mandatory occurrence was issued to ICETRA[13].

The ITSB picked up the initial notification issued to ICETRA and notified the UK AAIB of the serious incident. At that time the aircraft was already en-route back to Iceland on its return leg. However, the Commander was in contact with the flight operator's Network Control Center regarding the serious incident after landing in Manchester.

The Cockpit Voice Recorder (CVR) recordings of the serious incident flight were therefore lost.

The Commander was not aware of his duty to notify the ITSB of the serious incident, per Icelandic regulation 763/2013 and Icelandic law 18/2013.

[11] United Kingdom Air Accident Investigation Branch
[12] Icelandic Transportation Safety Board, or Rannsóknarnefnd Samgönguslysa (RNSA) in Icelandic
[13] Icelandic Transport Authority, or Samgöngustofa in Icelandic

## 2. ANALYSIS

### 2.1. Planned fuel and departure fuel

The original planned fuel for the flight was 12,067 kg.

| | | | | | |
|---|---|---|---|---|---|
| FUEL CALCULATION: | | FUEL BIAS IN %: 4.2 | | | |
| | | | FUEL | TIME | |
| DEST/ALTN MAN / LPL | | B/O DEST | 7527 | 2:09 | |
| TIME 2:09/ 0:11 | | CONTING 5% | 376 | 0:06 | |
| DIST 955/ 39 | | B/O ALTN (EGGP) | 1950 | 0:11 | FL 60 |
| AV WC TO DEST 42 KTS TAIL | | FINAL RESERVE | 1714 | 0:30 | |
| | | ADDITIONAL | 0 | 0:00 | |
| T/O ALTN: | | COMPANY | 100 | 0:02 | |
| | | EXTRA | 100 | 0:02 | |
| | | TAXI | 300 | - | |
| MINIMUM RAMP FUEL :11867 | | **PLANNED RAMP** | **12067** | 3:00 | |
| EST LAND FUEL AT DEST : 4240 | | OTHER | ..... | ..... | |
| (PLANNED RAMP-B/O DEST-TAXI) | | FUEL ON BOARD | ..... | ..... | |
| MINIMUM DIVERSION FUEL : 3664 | | | | | |
| (B/O ALTN+FINAL RESERVE) | | | | | |

**Figure 5: Original planned fuel for the flight**

The Commander decided before the flight to add an extra ton of fuel to the planned departure fuel. According to the Commander, he decided to do this because of winter operations at Keflavik Airport (departure airport) as well as high wind conditions at Manchester Airport (arrival airport). The planned ramp fuel before the flight changed to 13,100 kg instead of 12,067 kg because of this.

| | | | | | |
|---|---|---|---|---|---|
| FUEL CALCULATION: | | FUEL BIAS IN %: 4.2 | | | |
| | | | FUEL | TIME | |
| DEST/ALTN MAN / LPL | | B/O DEST | 7637 | 2:10 | |
| TIME 2:10/ 0:11 | | CONTING 5% | 382 | 0:06 | |
| DIST 955/ 39 | | B/O ALTN (EGGP) | 1950 | 0:11 | FL 60 |
| AV WC TO DEST 40 KTS TAIL | | FINAL RESERVE | 1714 | 0:30 | |
| | | ADDITIONAL | 0 | 0:00 | |
| T/O ALTN: | | COMPANY | 100 | 0:02 | |
| | | EXTRA | 1017 | 0:20 | |
| | | TAXI | 300 | - | |
| MINIMUM RAMP FUEL :11983 | | **PLANNED RAMP** | **13100** | 3:19 | |
| EST LAND FUEL AT DEST : 5163 | | OTHER | ..... | ..... | |
| (PLANNED RAMP-B/O DEST-TAXI) | | FUEL ON BOARD | ..... | ..... | |
| MINIMUM DIVERSION FUEL : 3664 | | | | | |
| (B/O ALTN+FINAL RESERVE) | | | | | |

**Figure 6: Revised fuel plan after the Commander decided to take an additional ton of fuel**

According to the flight plan, the planned Take-Off Weight (TOW) for the flight was 92,956 kg. This was after the Taxi Fuel Weight of 300 kg had been burned, so the planned Gross

Weight (GW) of the aircraft prior to departure was 93,256 kg. The planned ramp fuel was 13,100 kg, so the planned Zero Fuel Weight (ZFW) was 80,156 kg.

```
Log Nr.: 1003 Page  2                                          BIKF-EGCC  ICE440

WEIGHT INFORMATION

TOTAL PAYLOAD  17100 KG (PAX 171 = 17100 KG   CGO&MAIL     0 KG)

               TOW            LW             ZFW
MAX OPS WT     113398         95254          85910
PLANNED WT      92956         85319          80156

ACTUAL  WT     ......

FUEL CALCULATION:                  FUEL BIAS IN %: 4.2
                                                    FUEL   TIME
DEST/ALTN  MAN / LPL               B/O DEST         7637   2:10
TIME       2:10/ 0:11              CONTING 5%        382   0:06
DIST        955/ 39                B/O ALTN (EGGP) 1950   0:11 FL 60
AV WC TO DEST   40 KTS TAIL        FINAL RESERVE   1714   0:30
                                   ADDITIONAL         0   0:00
T/O ALTN:                          COMPANY          100   0:02
                                   EXTRA           1017   0:20
                                   TAXI             300    -
MINIMUM RAMP FUEL       :11983     PLANNED RAMP   13100   3:19

EST LAND FUEL AT DEST   : 5163     OTHER          .....  .....
(PLANNED RAMP-B/O DEST-TAXI)       FUEL ON BOARD  .....  .....

MINIMUM DIVERSION FUEL  : 3664
(B/O ALTN+FINAL RESERVE)
```

**Figure 7: Planned TOW, LW and ZFW**

According to the FDR, the actual Gross Weight of the aircraft at 08:16:56 (before flight) was 92,605 kg. With 13,100 kg of fuel on board, the actual Zero Fuel Weight of the aircraft was 79,505 kg.

## 2.2. Flight preparation

The bus pickup was 1 hour and 40 minutes before scheduled departure. The scheduled departure was at 08:00Z, so the bus pickup should have been around 06:20Z. The travel time between the Commander's home and the bus pickup at the flight operator's pickup facility in Hafnarfjörður is about 15 minutes, so at the latest he should have left his home at 06:05Z. The Commander stated that his initial review of the original operational flight documents was at home early in the morning. The flight plan was issued at 05:05:29Z.

An updated flight plan was issued at 06:24:19Z, due to the Commander's request for one ton of extra fuel. The scheduled departure in the updated flight plan was 08:00Z.

At the day of the serious incident, the flight operator's flight crew had to go through the Keflavik Airport terminal on their way to the aircraft.

According to the Commander, he entered the cockpit just over 30 minutes before scheduled departure.

Based on the FDR, the aircraft was located at a remote stand, requiring additional time for the flight crew to reach the aircraft compared with if it had been at the terminal.

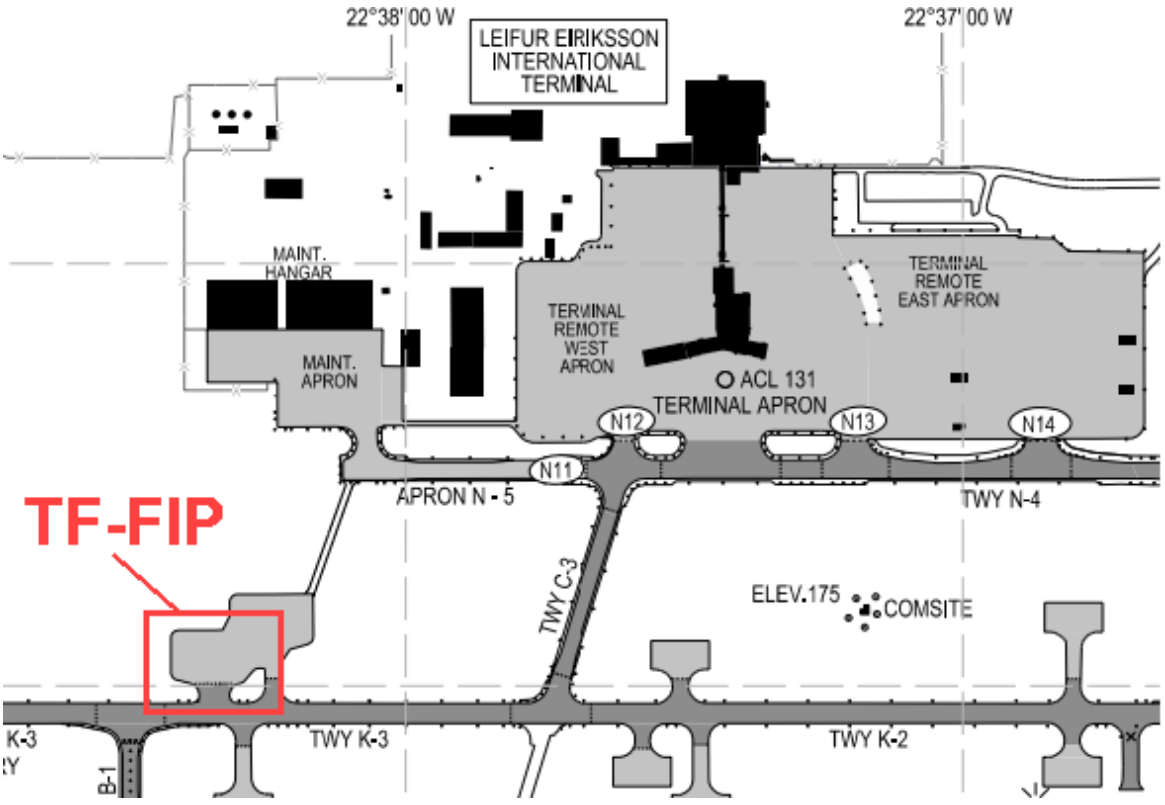


**Figure 8: Location of aircraft TF-FIP at Keflavik Airport before the flight**

According to the First Officer, they reviewed the flight plan, including the weather forecast, once they were in the cockpit.

According to the FDR, the initial movement of the aircraft on the ramp was at 08:19:56Z.

According to the Commander, he had not seen any Significant Meteorological Information (SIGMET) before the flight, but he knew that it would be windy.

According to the First Officer, they reviewed the flight plan, including the weather forecast once they were in the cockpit. They did not notice any Significant Meteorological Information (SIGMET), but they knew it would be windy.

There were three SIGMETs in the weather section of the flight documents. Why the flight crew did not notice the three SIGMETs in the flight documents could not be determined.

The flight plan did not include any graphical data regarding the issued SIGMETs, neither the boundaries of the SIGMETs nor the SIGMETs information.

The actual take-off was delayed by 33 minutes from the scheduled take-off at 08:00Z per the original and the revised flight plans.

According to the delay code for the flight, the delayed take-off occurred due to de-icing at Keflavik Airport.

## 2.3. Weather

The UK MET Office had issued severe weather warnings over the UK for the 23rd of February, two days prior to the serious incident. This had been followed up by the issue of SIGMETs.

The following three issued SIGMETs had been part of the original flight documents at 05:05:29Z:

- EGJJ SIGMET 01
- EGTT SIGMET 01
- EGTT SIGMET 02

EGJJ SIGMET 01, issued for EGJJ (Channel Islands), was valid from 06:00Z to 10:00Z on the day of the serious incident. It forecasted severe turbulence from the surface and up to 3000 feet. It also stated that the severe turbulence was intensifying.

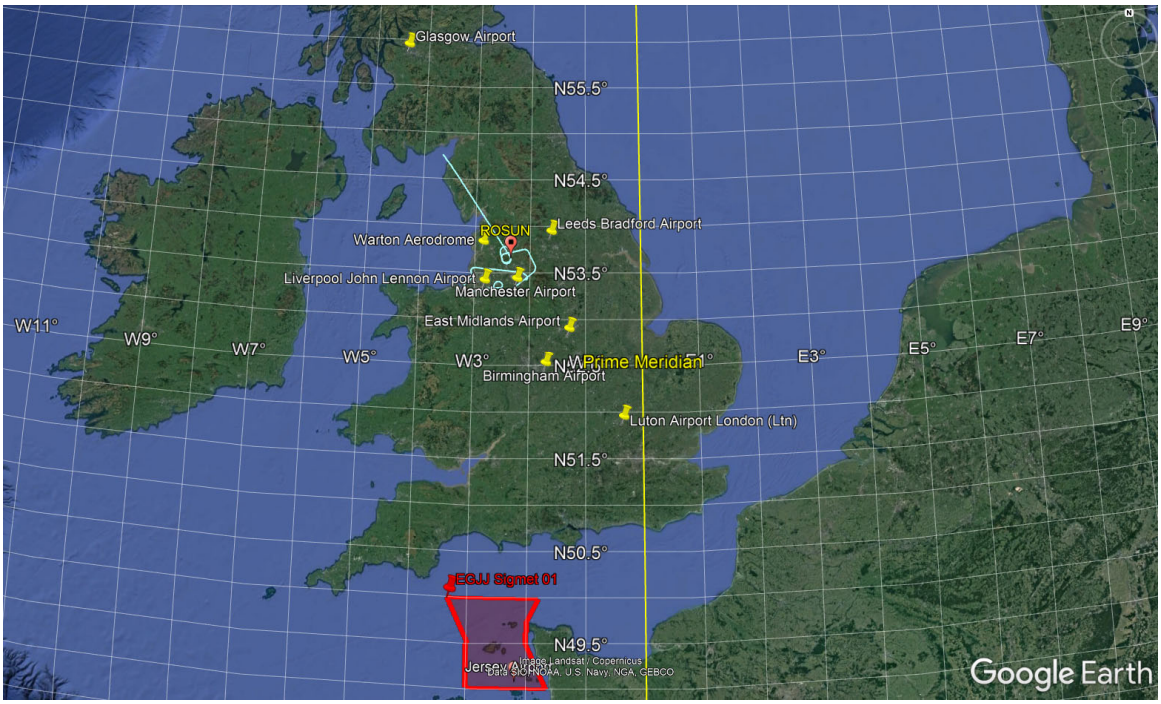


**Figure 9: EGJJ SIGMET 01 – Severe turbulence forecasted within the (red) area**

EGTT SIGMET 01, issued for EGTT (London Area Control), was valid from 03:00Z to 07:00Z on the day of the serious incident. It forecasted severe turbulence west of the line (see red line in Figure 10), from the surface and up to FL060. It also stated that the severe turbulence was moving east-north-east at a speed of 30 knots and it was intensifying.

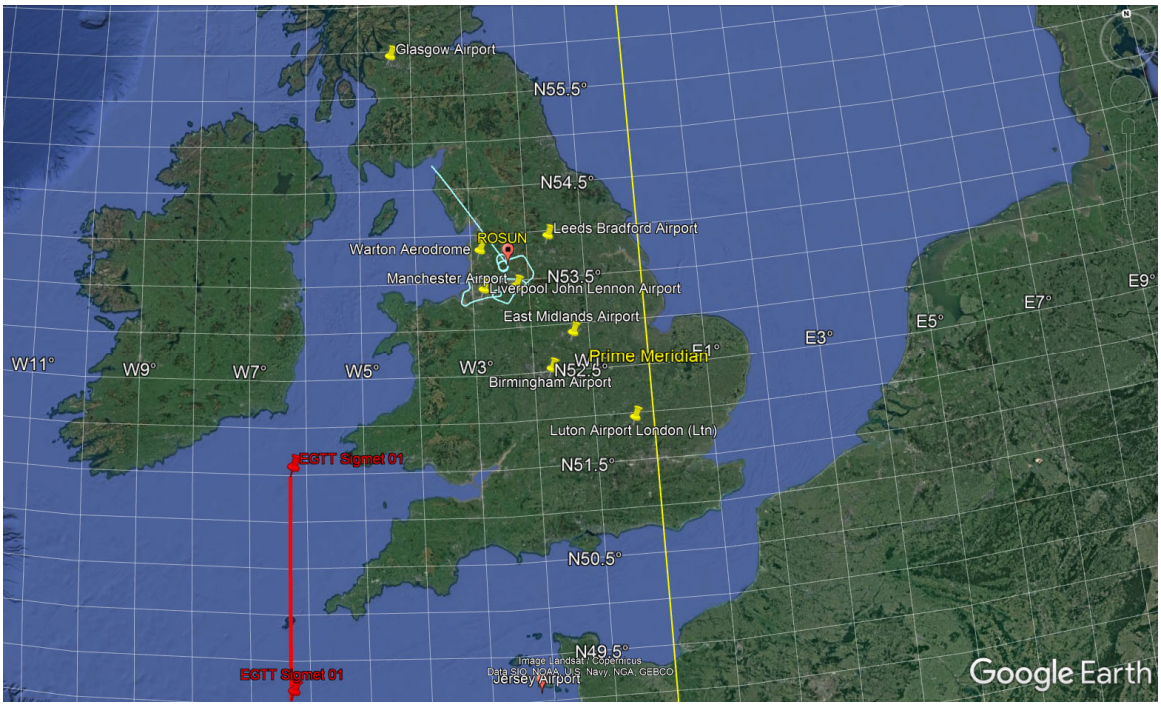


**Figure 10: EGTT SIGMET 01 – Severe turbulence forecasted west of the (red) line**

EGTT SIGMET 02, issued for EGTT (London Area Control), was valid from 03:00Z to 07:00Z on the day of the serious incident. It forecasted severe mountain waves within the area between FL040 to FL260. It also stated that the effective area was moving east-north-east at a speed of 10 knots.

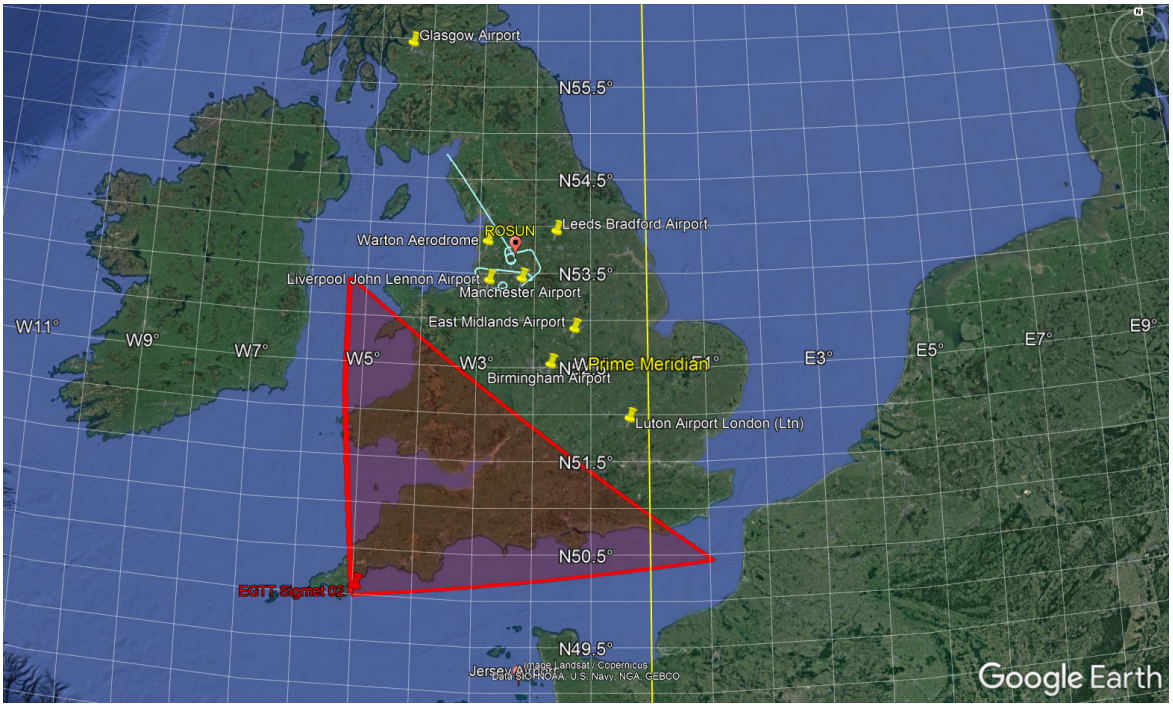


**Figure 11: EGTT SIGMET 02 – Severe mountain waves forcasted within the (red) area**

The three SIGMETs in the flight plan, particularly EGTT SIGMET 01 as it was intensifying and moving east-north-east towards the destination airport, warranted a close scrutiny at both the fuel planning as well as the selection of an alternate airport.

This should also have warranted regular updates of SIGMETs to be sought by the crew or issued by flight operations during the flight.

Neither the Commander nor the First Officer, were however aware of the three SIGMETs in the flight documents package.

The investigation revealed that there were three valid SIGMET(s) in effect at the time of the flight and around the time of the serious incident, in the area of or in part of the area of EGTT (London Area Control). They were:

- EGJJ SIGMET 03
- EGTT SIGMET 04
- EGTT SIGMET 05

EGTT SIGMET 03, issued for EGTT (London Area Control), was valid from 07:00Z to 11:00Z on the day of the serious incident. It forecasted severe turbulence southwest of the line from the surface and up to FL060. It also stated that the severe turbulence was moving east at a speed of 30 knots and it was intensifying.

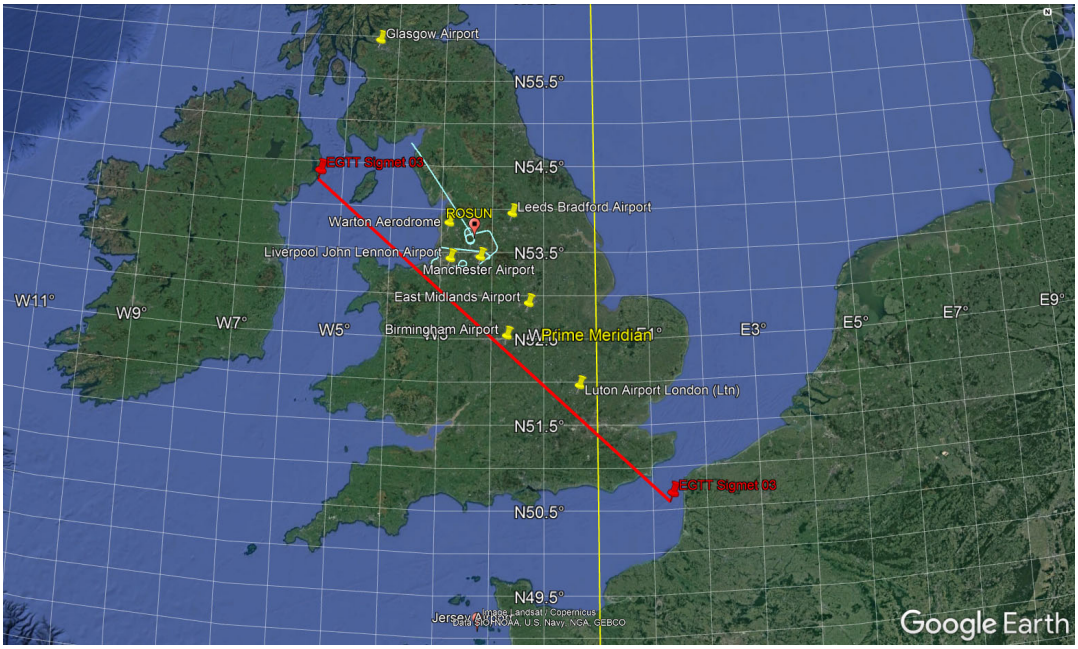


**Figure 12: EGTT SIGMET 03 – Severe turbulence forecasted southwest of the (red) line**

EGTT SIGMET 04, issued for EGTT (London Area Control), was valid from 07:00Z to 11:00Z on the day of the serious incident. It forecasted severe mountain waves south of the line between FL040 to FL260.

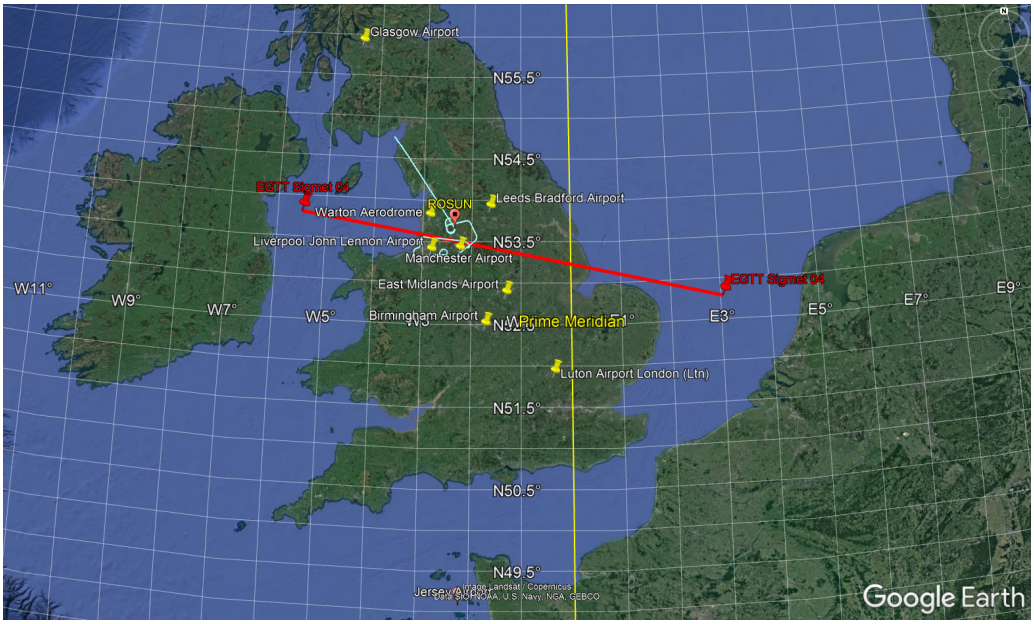


**Figure 13: EGTT SIGMET 04 – Severe mountain waves forecasted south of the (red) line**

EGTT SIGMET 05, issued for EGTT (London Area Control), was valid from 11:00Z to 15:00Z on the day of the serious incident. It forecasted severe turbulence within the area from the surface and up to FL060. It also stated that the severe turbulence was moving east at a speed of 20 knots.

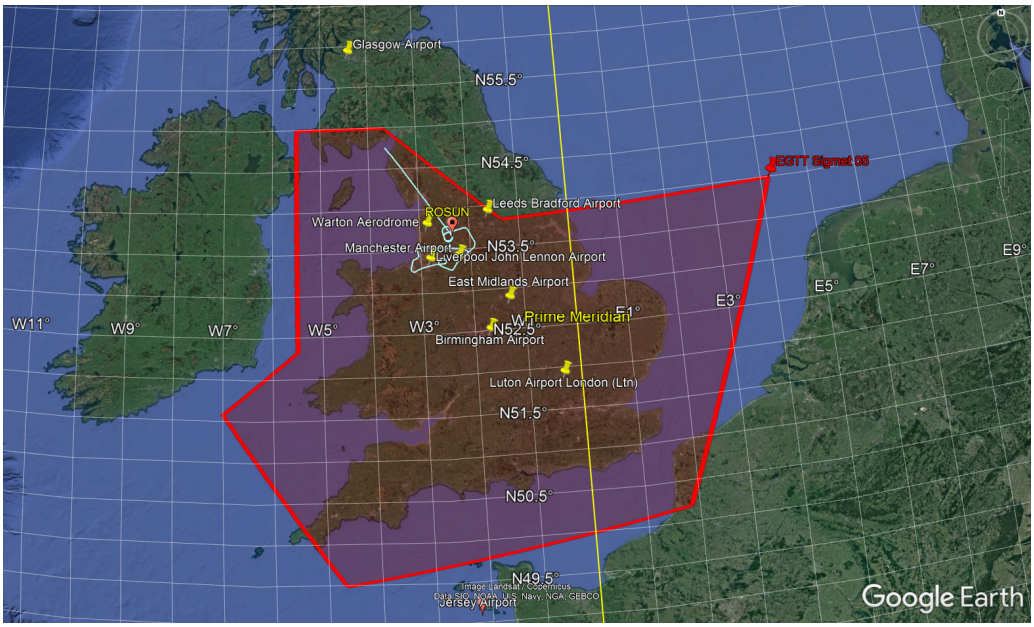


**Figure 14: EGTT SIGMET 05 – Severe turbulence forecasted within the (red) area**

UK MET Office Chart F215 (see Figure 15) was valid between 0800 UTC and 1700 UTC on 23rd February 2017. Zone C was located over the area of Northern England, where the fuel emergency occurred, with area B approaching from the west.

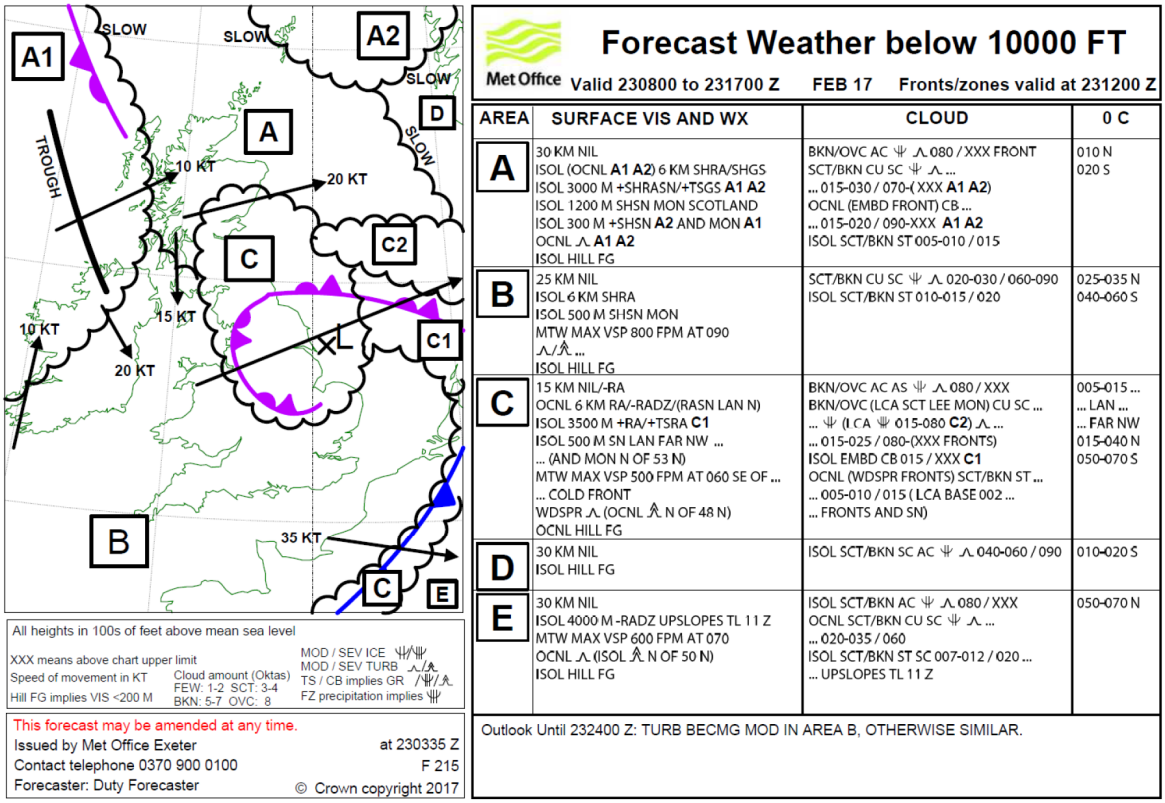


**Figure 15: UK MET Office Chart F215 valid between 0800 and 1700 UTC on Feb 23rd 2017**

The chart suggested thick frontal clouds in zone C, with bases generally in the 500-1000FT range, but as low as 200FT on the fronts themselves. Occasional rain was forecasted in the area as well.

The chart also indicated a widespread, moderate, low level, turbulence as well as isolated severe turbulence north of N4800, an area encompassing North West England.

Zone B moving into the area suggested SCT/BKN amounts of convective cloud with higher bases than zone C, with isolated showers of rain, but the risk of moderate/severe low level turbulence remained.

## 2.4. Operations

The investigation did not find any indication that the flight operator considered cancelling flight FI440 due to the weather.

During the investigation, the ITSB noted that there is a warning in the AIP[14] for RWY 23R at Manchester Airport that states the following:

> *Pilots are warned, when landing on Runway 23R in strong north westerly winds, of the possibility of turbulence and large windshear effects.*

The warning stated in AIP was displayed on the Airport Operation Information (AOI) page along with all charts for EGCC in the EFB.

According to the Commander, he did not become aware of the actual severity of the weather conditions, resulting in multiple go-arounds at Manchester Airport, until getting directions to hold at ROSUN at FL 110, at 10:24. This indicates that the flight crew did not get updates regarding the weather at the destination during the flight. This could not be confirmed through the Cockpit Voice Recorder (CVR) as it was not available for the investigation.

The three SIGMETs that were in the flight plan package, particularly EGTT SIGMET 01 as it was intensifying and moving east-north-east towards the destination airport, warranted a close scrutiny at both the selection of an alternate airport as well as the fuel planning. This should also have warranted regular updates of SIGMETs to be sought after by the flight crew or offered by Dispatch during the flight.

[14] AIP EG-AD-2, EGCC AD 2.20 Local Aerodrome Regulations, 4. Warnings, d.

## 2.5. Selection of alternate airport

Liverpool Airport was planned as the alternate Airport for the flight to Manchester. Liverpool Airport is located about 20 NM from Manchester Airport. Both airports are located well inside the severe weather warning area, valid at the time of the flight, and issued in EGTT SIGMET 04 and EGTT SIGMET 05 by the UK MET Office.

With regards to meteorological conditions, the usability of alternate airport is based on ceiling and visibility. The ITSB believes this needs to include Significant Meteorological Information (SIGMET).

The ITSB believes the alternate airport selection for the flight, by the Flight Operation Officers (FOO) on duty in the Dispatch department, was inappropriate in light of the severe meteorological conditions.

The selection of an alternate airport for the flight was also not challenged by the Commander of the flight. The Commander of the flight had the authority to change the alternate airport selection.

EGTT SIGMET 04, which was in effect between 7:00Z and 11:00Z, included both the destination (Manchester Airport) as well as the planned alternate (Liverpool Airport). It also included East Midlands, Birmingham and Luton airports, which were also all possible alternate airports per the flight plan.

EGTT SIGMET 05, which was in effect between 11:00Z and 15:00Z, included all the possible airports that were discussed with ATC, or planned as possible alternative airports.

By selecting an alternate airport outside the SIGMET area, the pilots would have had better options following the first missed approach.

## 2.6. Flight Dispatch

The flight operator's flight dispatch is part of the operator's Network Control Center (NCC). The purpose of the NCC is to support and coordinate the daily flight operations activities.

In case of operational disruptions the NCC Duty Manager will coordinate the activities within the NCC as required to restore normal operation. The NCC accommodates personnel with different expertise working under the discipline of the applicable Operations Departments of the flight operator.

- Duty Manager
- Crew Planning
- Dispatch
- Ground Operation
- Maintenance Control

At the time of the preparation of the flight plan for the serious incident flight, there were two Flight Operation Officers (FOO) on duty in the Dispatch department of the NCC. Their functions consisted of the following two entities:

- Support NCC with flight planning
- Flight watch

The Flight Operation Officers shall hold an approved ICETRA Flight Operations Officer License and are required to undergo extensive training and re-current training.

Both Flight Operation Officers on duty at the time of the preparation of the flight plan for the serious incident flight were qualified flight dispatchers.

According to the flight operator, the duties and responsibilities of the Flight Operation Officers, amongst other, include the following:

- Study the full details of weather forecasts, actual weather reports, SIGMETs and NOTAMs along the planned routes and at aerodromes in and adjacent to his area of responsibility

When preparing the flight plan, the FOO, amongst other, had the following responsibility with regards to reviewing, analysing, highlighting and providing the weather data to the flight crew:

- Thoroughly analyze the full details of weather maps, terminal forecasts, actual weather reports, SNOWTAMs and NOTAMs for the planned routes, destination and alternate aerodromes
- Provide the Commander with all available current reports or information on aerodrome conditions that may affect the safety of the flight
- Provide the Commander with all available weather reports and forecasts of weather phenomena that may affect the safety of flight, including adverse weather phenomena, such as clear air turbulence, thunderstorms, and low altitude wind shear
- Have readily available the latest meteorological data and runway conditions
- Bring to the attention of the Commander any information that may affect the safe conduct of the flight
- Monitor NOTAM and SNOWTAM to ensure a flight will not be commenced unless that conditions and ground facilities required for the flight are adequate for the type of operation

The operational flight documents package for the flight was 23 pages long. The only remark from the flight dispatch to the flight crew, was the following remark on page 3 of the 23 page long flight plan:

```
REMARKS FROM OPERATIONS:

MAX TURBULENCE. SEVERITY/WAYPOINT:  5/VAMEB
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The ITSB believes that the Flight Operation Officer that compiled the flight documents did not bring to the attention of the Commander the SIGMETs that were applicable for the flight, as they could affect the safe conduct of the flight.

The two Flight Operation Officers on duty planned a total of 28 flights during their whole shift. The investigation did not reveal that the flight dispatchers were overloaded.

The investigation revealed that at the time of the serious incident the flight operator utilized pre-described company routes flight plans. This has been changed and today the flight

plans are compiled from scratch. Part of this has been the implementation of the LIDO Flight Planning system which has certain automatics to assist the Flight Operation Officer to determine the usability of airports.

The investigation also revealed that flight plans are updated if any changes are made and the Commander is contacted via telephone if the changes to the flight plans occur less than one hour before flight.

At the time of the serious incident, as well as today, the Flight Operation Officer was responsible for reviewing and selecting the alternate airport(s).

The procedures in the Flight Operation Officer Handbook, amongst other, include the following:

- An airport shall only be selected as a destination alternate airport when the appropriate weather reports and/or forecasts indicate that, during a period commencing one hour before and ending one hour after the estimated time of arrival at the airport, the weather conditions will be at or above the planning minima
- Two separate runways are available and usable at the destination aerodrome and the appropriate weather reports and/or forecasts for the destination aerodrome indicate that, for the period from 1 hour before until 1 hour after the expected time of arrival at the destination aerodrome, the ceiling will be at least 2000 ft or circling height +500 ft, whichever is greater, and the ground visibility will be at least 5 km
- The flight operator shall select two destination alternate aerodromes when, the appropriate weather reports and/or forecasts for the destination aerodrome indicate that during a period commencing 1 hour before and ending 1 hour after the estimated time of arrival, the weather conditions will be below the applicable planning minima

Nothing in the procedures states what to do in case of severe meteorological conditions that do not include ceiling and visibility, such as severe turbulence.

If SIGMET(s) are in effect or extreme weather is forecasted the alternate airport should not be located within the same weather area as the destination airport.

## 2.7. Organizational pressure

The investigation revealed that the management of the flight operator actively incorporated and monitored fuel saving program for the following four fuel parameters:

- Reduced Acceleration Altitude (RAAL)
- Engine Out Taxi In (EOTI)
- Continuous Descent Approach (CDA)
- Extra Fuel (XTRAF)

In July of 2017, the flight operator stated that during the period of January 1st 2017 to June 30th 2017, the fuel saving program had resulted in an average improvement in fuel saving of 127 kg per flight. The flight operator broke this down per the four parameters, indicating how much fuel had been saved:

- RAAL fuel saved 52 kg/flight
- EOTI fuel saved 10 kg/flight
- CDA fuel saved 57 kg/flight
- XTRAF fuel saved 8 kg/flight

By the end of 2017, the 5th fuel saving parameter, APU Monitoring (APU) was to be added to the fuel saving program.

## 2.8. Fuel bonuses

The investigation revealed that the flight operator paid its pilots fuel bonuses, based on the fuel saving program. These bonuses were paid twice a year, based on the fuel savings for the 6 preceding months.

These fuel bonuses were part of the salary contract between the flight operator and the Airline Pilots' Association.

The fuel bonuses were paid out twice a year, based on how well the whole group has been performing with conserving fuel[15] as well as by utilizing minimum extra fuel [XTRAF parameter].

The XTRAF parameter was calculated based on the extra cost that occurs when carrying extra fuel in the excess of 200 kg. In other words, if flights were flown with an excess of 200 kg of extra fuel, it would have had negative effect on the fuel bonus.

As comparison, the originally planned extra fuel for this flight was 100 kg, but after the Commander requested an additional one ton of fuel, the extra fuel for the flight became 1017 kg. Therefore it can be concluded that the fuel bonus did not affect the amount of fuel taken on this flight

In flight time, that decision changed the extra fuel for the flight from 2 minutes to 20 minutes. In comparison, the time between the first go-around at Manchester (10:51:16) and the landing at Manchester (11:27:22) was just over 36 minutes.

The ITSB inquired if the flight operator had performed any risk assessment with regards to the implementation of the fuel bonuses.

- According to the flight operator, no risk assessment of the fuel bonuses had been performed prior to the implementation of the system, nor during its use

The ITSB inquired if the flight operator's Quality department had performed audits into occurrences that were found to have relation(s) to the fuel bonus system.

[15] by utilizing Reduced Acceleration Altitude (RAAL), Engine Out Taxi In (EOTI) and Continous Descent Approach (CDA)

- According to the flight operator, the operator's Quality department had not performed any audits into occurrences involving the fuel bonus system

The ITSB inquired if the flight operator's Safety department had performed internal investigations into occurrences that were found to have relation(s) to the fuel bonus system.

- According to the flight operator, the operator's Safety department had not performed any internal investigations into occurrences involving the fuel bonus system

The investigation revealed that the Commander did not let the extra fuel (XTRAF) affect his judgement in this flight, as he did request an extra ton of fuel for the flight.

## 2.9. Safety actions already implemented by the flight operator

The flight operator and the Airline Pilot Association removed the fuel bonuses from the pilot's salary contract in May 2020.

At the time of the serious incident the flight operator utilized pre-described company routes flight plans. Today, the flight plans are compiled from scratch and with the implementation of the LIDO Flight Planning system, certain automations have been implemented to assist the Flight Operation Officer to determine the usability of airports.

At the time of the incident, the flight crew often did not meet until at the aircraft, as they did not necessarily travel on the same bus to Keflavik Airport and then had to go through the terminal on their way to the aircraft. Today the whole crew meets in a new flight operator's facility (Heimavöllur) at Keflavik Airport, where they conduct crew briefings, before travelling together to the aircraft.

In Notice of Proposed Amendment 2016-06 (A), EASA[16] introduced a performance based approach for fuel planning, selection of aerodromes and in-flight fuel management. This has since then been highlighted and clarified by EASA through the work under RMT.0573 'Fuel/energy planning and management' which is planned to be completed in the 4th quarter of 2021.

According to EASA, effective implementation of RMT.0573 'Fuel/energy planning and management' should ensure that Significant Meteorological Information (SIGMET) are considered when selecting an alternate airport.

The investigation revealed that the flight operator is already well under its way of implementing its own fuel policy system, based on information in EASA NPA 2016-06 (A), utilizing fuel efficiency project and the LIDO flight planning system for the implementation.

The investigation revealed the need for the flight operator to ensure that Significant Meteorological Information (SIGMET) are considered when selecting an alternate airport.

[16] European Union Aviation Safety Agency

## 3. CONCLUSIONS

**Causes:**

- Inappropriate selection of an alternate airport considering the meteorological conditions
- Flight plan did not highlight SIGMET information included in the flight documents
- The flight crew did not notice the SIGMETs

**Contributing factors:**

- Limited time and facility for crew briefing

## 4. SAFETY RECOMMENDATIONS

The ITSB recommends to Icelandair, to:

**17-018F005 T01**

Update flight planning procedure, in such a way that Significant Meteorological Information (SIGMET) that affect the flight are given higher priority in the flight documents.

**17-018F005 T02**

Update its flight documents to include graphical data showing the boundaries of active SIGMETs to make it easier for flight crews to visualize.


This final report was approved by following ITSB board members:

- Bryndís Lára Torfadóttir, board member
- Gestur Gunnarsson, board member
- Hörður Arilíusson, deputy board member
- Tómas Davíð Þorsteinsson, deputy board member

Reykjavik 15. March 2021

On behalf of the Icelandic Transportation Safety Board

*Ragnar Guðmundsson*
*Investigator-In-Charge (IIC)*