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pour la sécurité de l'aviation civile

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INVESTIGATION REPORT

Serious incident to the Boeing 737-800 registered **F-GZHM** on 13 February 2019 en route off the coast of Montenegro[(1)]

Time	13:30[(2)]
Operator	Transavia
Type of flight	Commercial air transport (passengers)
Persons on board	Captain (PM then PF); first officer (PF then PM); 4 cabin crew; 156 passengers
Consequences and damage	Eight passengers and two cabin crew slightly injured
This is a courtesy translation by the BEA of the Final Report on the Safety Investigation published in January 2020. As accurate as the translation may be, the original text in French is the work of reference.	

Severe turbulence en route

1 - HISTORY OF THE FLIGHT

Note: the following information is principally taken from the flight data recorder (FDR) and the crew's statements. The CVR[(3)] recording, of a duration of 3 h 11 min, started approximately 10 minutes after the episode of turbulence[(4)].

The crew met in the lobby of their hotel before the flight that they were to make between Lyon Saint-Exupéry and Tel Aviv airports (Israel). During the briefing, the captain mentioned in particular, a risk of slight to moderate turbulence forecast approximately 1 hour 30 minutes after take-off.

The take-off time was recorded at 12:01. The cabin crew carried out the regulatory safety demonstrations and gave the instructions concerning the use of seatbelts. After climbing, they carried out the cabin service. Once this was completed, the purser went to the cockpit. At this point, at 13:27:15, the air traffic controller told the crew that they were going to enter a zone where severe turbulence had been reported between FL380 and FL400. The aeroplane was cruising at FL370. The captain told the purser that there was going to be turbulence in two to three minutes. The latter left the cockpit and joined her two colleagues stationed at the rear of the aeroplane. When she arrived at the rear, the Fasten Seatbelt signs were illuminated. Cabin crew member 2[(5)] then announced a zone of turbulence over the PA system while cabin crew member 3 started to go through the cabin to check whether the passengers had fastened their seatbelts. The purser returned to the front of the aeroplane and passed in the aisle, cabin crew member 4 who had started checking the cabin from the front. In the meantime, the first officer reduced speed from Mach 0.79 to Mach 0.77 at 13:29:06. Approximately one minute after the illumination of the signs, the first turbulence was felt.

(1)Close to VAKSU at FL370.

(2)Except where otherwise indicated, the times in this report are in Coordinated Universal Time (UTC). The local time at the departure airport is obtained by adding one hour to the UTC time.

(3)Cockpit Voice Recorder.

(4)The CVR has a limited recording capacity. During the flight, newly recorded data continuously overwrites the oldest data. For this reason, the CVR data at the time of the turbulence was not available.

(5)The cabin crew stations are designated as follows: Cabin crew members 1 (purser) and 4 at the front of the aeroplane, cabin crew members 2 and 3 at the rear.

From 13:30:20, the aeroplane was subject to moderate turbulence for ten seconds. The longitudinal wind component changed from a tailwind of 35 kt to a headwind of 11 kt and the left crosswind component with respect to the aeroplane's heading went from 77 kt to 50 kt in approximately ten seconds. The normal load factor, measured close to the centre of gravity of the aeroplane, varied between 0.52 g and 1.70 g. The crew observed that the indicated airspeed was rapidly increasing and the overspeed warning was activated. The first officer extended the air brakes and left the auto-thrust engaged.

The turbulence then increased in severity for six seconds. The normal load factor went from -0.70 g to 1.71 g then -0.32 g, while the aeroplane rolled up to 37° to the left with a rate reaching 38°/s. The captain took control to level the wings and the CWS[6] mode of the autopilot was engaged. He began descending and asked the first officer to inform the air traffic controller of this. After first refusing, the controller accepted the descent to FL350 after the first officer had told him that they were descending because of severe turbulence.

[6] Control Wheel Steering. An autopilot mode which is engaged, in particular, when the crew make a control input and override the autopilot.

In the cabin, when the severe turbulence started, the purser managed to sit down on a front galley seat and pull on the harness and cabin crew member 4 was able to sit down in an unoccupied passenger seat. Cabin crew member 3 who was in the aisle at row 27 and cabin crew member 2 who was in the rear galley did not have time to sit down and were thrown against the ceiling twice. Passengers who had not fastened their seatbelts, sat at the rear of the cabin, were also thrown upwards and struck the overhead compartments. Other passengers who had fastened their seatbelts sustained minor injuries.

Once the turbulence was over, the purser called her colleagues at the rear of the cabin via the interphone to find out if they were well. Cabin crew members 2 and 3 took a few minutes to recover their senses while the purser and cabin crew member 4 went through the cabin to help passengers who were injured or in shock. There was no division of tasks between the cabin crew and each one went through the cabin without coordinating with the others. After having seen all the passengers, the purser went to the cockpit to inform the captain of the situation in the cabin. A request for a doctor was made and the cabin crew provided first aid care to the injured passengers in coordination with the doctor and student doctor who came forward.

The crew checked that the aeroplane had no technical problem. The doctor informed the captain that the health of the passengers did not require a diversion. Believing that there was no further risk of turbulence, the crew decided to continue the flight. The captain called Transavia operations and asked for medical assistance on arrival. The cabin crew spent the rest of the flight looking after and reassuring the passengers. The end of the flight and the disembarkation took place without any particular difficulties.

2 - ADDITIONAL INFORMATION

2.1 Crew information

The captain holds an Airline Transport Pilot License (ATPL(A)) along with TRI[7] and TRE[8] qualifications. The day of the event, he had logged around 15,000 flight hours of which 11,200 as captain and 6,800 on type.

[7] Type Rating Instructor.

[8] Type Rating Examiner.

The first officer holds a Commercial Pilot Licence/aeroplanes (CPL(A)). The day of the event, he had logged more than 3,000 flight hours of which around 900 on type.

2.2 Meteorological information

2.2.1 Observed situation

The analysis of the weather data provided by Météo-France shows that an anticyclone centred over Europe led to a north-easterly flow marked by a jet stream running perpendicular to the terrain of the Dinaric Alps[9], towards Italy. This jet stream was behind the clear air turbulence (CAT) and the mountain waves breaking at high altitude over the Adriatic. These phenomena are fairly common in this area and more generally downwind of a mountain range when a jet stream runs perpendicular to the terrain.

[9] Balkans.

2.2.2 Data available before the flight

The Euroc SIGWX charts valid for 9:00 and for 12:00 both mentioned the probable presence of moderate turbulence in the area and at the altitude where the incident occurred. Furthermore, the 12:00 chart mentioned severe local turbulence between FL300 and FL420.

The charts produced by the London and Washington World Area Forecast Centres (WAFC) for 12:00 forecast the probability of moderate turbulence and occasionally severe turbulence in the area of the incident, limited to below FL340.

A SIGMET[10], published at 11:49, mentioned severe turbulence observed in the south area of the Zagreb FIR between FL190 and FL400:
LDZO SIGMET 1 VALID 131149/131400 LDZALDZO
ZAGREB FIR SEV TURB OBS S OF LINE N4234 E01600 - N4226 E01829 FL190/400 STNR NC=

[10] SIGnificant METeorological Phenomena.

The incident occurred in the area described by this SIGMET.

The eWas PILOT application was also available on the operator's EFB[11] as a decision support tool. It provides forecasts and weather reports from various sources in the form of an interactive chart. The morning of the incident, the application indicated the presence of a small zone of moderate turbulence over the Adriatic between FL350 and FL374 and a larger zone of moderate to severe turbulence between FL374 and FL399.

[11] Electronic Flight Bag.

2.2.3 Turbulence forecast

The turbulence forecasts shown on the SIGWX charts are based on a forecaster's analysis of the results of several turbulence indices. The turbulence forecasts given by the eWas PILOT application are the direct result of a single turbulence index.

2.3 Flight preparation

2.3.1 Compiling flight file

The operator's flight files are compiled as follows:

- the flight plans are automatically created by a software 12 hours before the planned departure of the flight;
- around three hours before the departure of the flight, a dispatcher checks Eurocontrol has accepted the flight plan as well as the scheduled fuel load and weight and balance;
- the weather data (charts, METAR and TAF, SIGMET, etc.), the NOTAMs and the AIP supplements are automatically included in the flight file when a pilot downloads it onto his EFB.

2.3.2 Flight preparation by crew

The captain downloaded the flight file onto his EFB at 07:29 while the first officer downloaded it at 08:04. The SIGWX chart valid for 12:00 was published at 08:06, the crew therefore only had the SIGWX valid for 9:00 and the London and Washington WAFC charts. The operator's documentation does not specify at what stage pilots can download the flight file. While studying the weather conditions, the captain and first officer also used the eWas PILOT application available on their EFBs. They noted the presence of moderate turbulence indicated by the SIGWX chart and they saw only moderate turbulence forecast above their flight level on the eWas PILOT application. In retrospect, they think that they did not notice the severe turbulence as they were not familiar with the colour code used by the application[12] (light green for moderate turbulence, dark green for severe turbulence). They added that when eWas PILOT was introduced by the operator, the pilots simply received the associated documentation and did not get any classroom training.

At 11:22, the first officer downloaded the flight file again to check that there were no changes and to look at the latest TAF and METAR. He did not, however, look to see if the SIGWX chart had been updated. The crew were not aware of the SIGMET published ten minutes before the departure of the flight indicating the presence of severe turbulence on their path in the Zagreb FIR[13].

[12] The operator's crews follow an e-learning training course for the use of the eWas PILOT application.

[13] Flight Information Region.

2.4 Management of event

2.4.1 By the flight crew

In the event of unforeseen severe turbulence, the operator's safety manual asks the pilots to illuminate the "Fasten seatbelt" signs and to tell the cabin crew that due to turbulence, they must sit down and fasten their seatbelt. The crew explained that they did not have time to do this.

When the aeroplane started rolling to the left with a roll rate of 38° per second, the captain took control and overrode the autopilot in order to level the wings. He said that he was convinced that the aeroplane would have exceeded 90° in roll if he had not acted on the controls.

The Transavia Operations Manual states that the autopilot must be the primary means of controlling the aeroplane when entering turbulence. The Boeing 737 FCOM[14] includes instructions for the crew to disengage the auto-thrust and to engage the CWS mode of the autopilot during severe turbulence. During this event, the autopilot and auto-thrust initially acted on the controls and reduced the thrust to counter the effects of the atmospheric disturbances, then the CWS mode was automatically engaged due to the captain's input on the controls.

[14] Flight Crew Operating Manual.

2.4.2 By the cabin crew

The operator's safety manual stipulates that each time the "Fasten seatbelt" signs are illuminated, the cabin crew make a passenger announcement with respect to the turbulence and check that the passengers have fastened their seatbelts. The cabin crew stationed in the rear of the aeroplane explained that despite the illumination of the "Fasten seatbelt" signs and despite them passing through the cabin to check that seatbelts were fastened, certain passengers did not comply with instructions. The cabin crew said that some passengers on this flight were relatively undisciplined and paid little attention to the crew's directions.

As the flight crew had not had time to make the turbulence announcement, the purser took the initiative of asking the cabin crew to sit down and fasten their seatbelts.

Once the turbulence was over, the cabin crew started passing through the cabin in order to help passengers. Tasks were not shared between the cabin crew, each cabin crew member checking the passengers in all of the cabin. All of the passengers received the necessary help.

2.5 Cabin crew recurrent training

Each year, the Transavia cabin crews must follow a three-day training course in which, every three years, the turbulence procedures are addressed. During this course, practical exercises in an aeroplane mockup are carried out, but none of these exercises concern the actions to be performed in the cabin after severe turbulence. However, similar emergency descent exercises are proposed. All of the cabin crew on this flight had been working for Transavia for several years and had followed these training courses several times.

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2.5.1 Forecasting and detecting Clear Air Turbulence (CAT) projects

In the scope of the IATA's[15] Turbulence Aware project, certain operators have equipped their aeroplanes with a system to measure the strength of turbulence[16] during flights. The purpose of this project is to collect data about the turbulence actually encountered in order to check in retrospect, the pertinence of the forecasts and thus improve their reliability. In France, Météo-France is part of this project and should use this data in an operational way in the near future, but the number of equipped aeroplanes is small for the moment.

Parallel to this, several projects are studying the feasibility of CAT detection with LIDAR[17] systems. Boeing carried out a test flight in 2018 in partnership with JAXA[18] which showed the initial technical feasibility of this type of system. The publication of a feasibility report is planned for March 2020[19]. In Europe, the DELICAT project, coordinated by Thalès[20] was also designed to study the feasibility of detecting CAT with a LIDAR system. The final report of this project mentioned the need to carry out additional test flights in order to draw reliable conclusions as to the capability of the LIDAR to detect CATs. The BEA is not aware of any follow-ups to this project.

(15) International Air Transport Association.

(16) This system measures the EDR (Energy Dissipation Rate), a turbulence strength indicator.

(17) Laser Detection And Ranging.

(18) Japan Aerospace Exploration Agency.

(19) This feasibility report will be written by a working group from the RTCA (Radio Technical Commission for Aeronautics, an American non-profit making association) in which Boeing participates.

(20) This project was carried out between 2009 and 2014 in the scope of a European Union call for projects. The project website can be consulted at the following address: http://www.delicat.inoe.ro/. The project final report is available on this website.

3 - LESSONS LEARNED AND CONCLUSION

The aeroplane entered a zone of clear air turbulence (CAT) without passengers and members of the cabin crew having their seatbelts fastened. The accelerations experienced by the aeroplane threw certain passengers and crew members against the ceiling causing injuries to them.

The air traffic controller informed the crew that a previous aeroplane had reported severe turbulence between FL380 and FL400. This information was taken into account and transmitted to the purser. The pilots switched on the seatbelt signs less than a minute later. The cabin crew were checking that the passengers had their seatbelts fastened when the severe turbulence started. A few passengers, including some who had been asked by the cabin crew to fasten their seatbelts, did not have their seatbelts fastened at this point and were injured. The cabin crew stationed at the rear of the cabin did not have time to fasten their seatbelts and were also injured.

The morning of the flight, the crew had downloaded the flight file more than four hours before the scheduled take-off time. As the flight file was not automatically updated, when they studied the weather conditions to prepare the flight, they only had the SIGWX chart valid for 9:00. The latter did not forecast severe turbulence whereas the chart valid for 12:00 which had just been published, indicated severe turbulence on the planned route. The preparation of the flight at the hotel may have contributed to the very early downloading of the flight file. In addition, the crew had not noticed that the turbulence shown on the eWas PILOT application slightly above the planned flight level was "severe" as they were not familiar with the colour code used by the application. Lastly, as SIGMETs are not transmitted in real time, the crew were not informed about the severe turbulence observed in the area of the event. The crew were not therefore aware of the severe turbulence forecasts and reports; this was not conducive to the immediate illumination of the seatbelt signs.

In the event of unforeseen severe turbulence, the Operations Manual requires the crew to tell the cabin crew that due to turbulence, they must sit down and fasten their seatbelt. The crew were concentrated on controlling the aeroplane. Furthermore, the very short lapse of time between the illumination of the seatbelt signs followed by the passenger announcement and the occurrence of the severe turbulence did not allow the cabin crew to check all of the cabin and to fasten their seatbelts. It is common to have light turbulence and it was not possible for the cabin crew to know the magnitude of the turbulence to come and to assess the urgency of fastening their seatbelts.

These observations bring to light the intrinsic limitation of the procedures concerning unforeseen turbulence: the unpredictability both in terms of the time of the occurrence and strength of the turbulence means that these procedures cannot be applied in a timely or correct manner.

The turbulence forecast by the weather services can only supply probabilities and the detection of CAT is not possible with the technology currently installed on aeroplanes. This event and the anticipated increase in the frequency of CAT over the North Atlantic due to climate change[(21)] underline the need to improve the forecasting and detection of CAT. The development of onboard turbulence detection systems and the transmission of updated weather information to the aeroplane are two safety improvement measures which would meet this need. The BEA report on the serious incident to the Airbus A330 registered F-GZCG in 2012[(22)] illustrates the fact that this need also exists for the management of some convective turbulence.

The only way of limiting the risk of injury at this time is for passengers to comply with the instructions to keep their seatbelt fastened when they are seated. Since 2000, the BEA has carried out or participated in 74 investigations into accidents in which 107 persons were seriously injured following severe turbulence. In 1996 and 1997, two accidents caused by turbulence each gave rise to fatal injuries to a passenger. In all the cases where there was information available concerning the use of seatbelts[(23)], and in particular for the two fatal accidents, the victims did not have their seatbelts fastened.

[(21)] A study published in the Nature review concludes that the climatic change increases windshear and CAT over the North Atlantic. The abstract of this study is available at the following address: https://www.nature.com/articles/s41586-019-1465-z

[(22)] https://www.bea.aero/fileadmin/documents/docspa/2012/f-cg120227.en/pdf/f-cg120227.en.pdf

[(23)] For 36 of the 74 accidents mentioned here, the BEA did not have information about the use of seatbelts by the victims.