

FINAL REPORT

on
investigation of an aviation occurrence with BOEING 737-500, registered
LZ-BOQ, operated by Bulgaria Air on 28.12.2005 during scheduled
passenger flight FB-472 from Madrid to Sofia (MAD/SOF)



2005

The materials have been classified under state file number 10/28.12.2005 in the archives of the Air Accident Investigation Unit (AAIU)

Operator: Bulgaria Air Sole-Owner JSC, with main office at Sofia, 1 Brussels boulevard, Sofia Airport, Air Operator License issued by the CAA on 01.11.2002 and period of validity till 20.02.2007.

Aircraft Manufacturer: Boeing , USA

National and Registration Marks: LZ-BOQ, according Certificate for Registration No1999, I issued on 10.06.2005 by the CAA.

Place and Date of Air Occurrence: in flight, at FL 350 (35000 ft), in the airspace of Republic of Italy and 25 minutes later in the airspace of Republic of Croatia on 28.12.2005.

Brief Description: The aircraft came upon a zone of severe turbulence. The autopilot was self-switched-off. For short period of time the airplane was out of control. The crew reported to Brindisi Control about severe turbulence at the flight level and asked permission for descent to FL290. Twenty minutes later the aircraft came upon a zone with severe turbulence once again. After aircraft stabilizing the senior cabin attendant reported to the commander captain that a female passenger complained she had suffered an injury of the left hand and a cabin attendant had broken his leg.

The crew informed Sofia Approach about on-board situation and asked an ambulance for rendering of qualified help for the injured persons.

Notified: Aircraft Accident Investigation Unit, Civil Aviation Authority (CAA), International Civil Aviation Organization (ICAO) and Italian Aeronautic Safety Agency (ANSV).

For investigation of the aviation occurrence a Commission was appointed with the Order RD-08-9/06.01.2006 of the Minister of Transport of the Republic of Bulgaria.

Type of the Flight: Scheduled passenger flight No FB-472 from Madrid to Sofia (MAD/SOF).

In accordance with Para.3, Item 2, Letter (a) of the Additional Provisions of the Civil Aviation Law, Para.3, item 1, Letter (a) & Point 15, Letter (b) of the Additional Provisions of the Regulation 13 of the Ministry of Transportation about aircraft accident investigation and on the ground of the Article 9 of the same Regulation, the air occurrence has been classified as an Accident.

1. Factual Information

1.1 History of the Flight

The flight assignment was given by the airline operator to a crew consisting of: commander, first officer, three female cabin attendants and a male cabin attendant.

1.1.1 Flight Number: FB-472.

1.1.2 Flight Preparation and Description

Preflight briefing for the flight from Madrid to Sofia was done in Madrid Airport.

The slot for flight Madrid – Sofia was set for 16:00 UTC, but the real take-off was performed in 16:24:44.

The commander was appointed as a flying pilot for the Madrid-Sofia segment .

At Madrid Airport the commander and the first officer have performed preflight check of the airplane without any remarks.

The boarding of eighty five passengers was executed under first officer supervising.

The airplane BOEING-737-500, reg. No LZ-BOQ took off for the scheduled flight at 16:24:44 UTC on 28.12.2005.

After climbing to FL350 (altitude 35000 ft) at 18:03:35 the aircraft came upon a zone with severe turbulence, the autopilot was self-switched-off and the aircraft for a short time was out of control, descending unintentionally about 1000 ft, what could be seen from the analyze of the flight data recorders. The crew reported to Brindisi Control and after receiving permission changed the flight level from FL350 to FL290.

At this flight level at 18:27:35 in Zagreb area the aircraft came upon a zone with severe turbulence again and the aircraft descent spontaneously about 500 ft.

At 19:00:53 at an altitude about 5000 ft during approach descent to Sofia Airport the aircraft came upon a zone with moderate turbulence.

The severe turbulence surprised a female passenger, who felt on the aisle in the aft passenger cabin. As a result of falling her left hand was injured.

During the coming upon the second severe turbulence zone a male cabin attendant, who was standing in the aft passenger cabin, failed to stay on and fell on the floor and as result he was seriously injured and suffered a fracture of the left leg.

The approach and landing at Sofia Airport were uneventful for the aircraft, crew and passengers.

1.1.3 Location of the Occurrence

The accident occurred after aircraft coming upon zones with severe turbulence: at 18:03:35 with geographic coordinates: 42° 17' 20" N & 013° 39' 31" E and at 18:27:35 with geographic coordinates: 43° 25' 14" N & 017° 57' 35" E on 28.12.2005 during horizontal flight in the airspace of Republic of Italy and Republic of Croatia at an altitude of 35000 ft (FL350) and 29000 ft (FL290).

1.2 Injures to Persons

Injures	Crew	Passengers	Others
fatal	0	0	0

serious	1	1	0
minor/none	5	84	0

- a serious injure of female passenger, who suffered a left hand fracture.
- a serious injure of crew member - a cabin attendant, who suffered a fracture and luxation of the left leg.

1.3 Damage to Aircraft

No damages were found on the aircraft.

1.4 Other Damages

No other damages.

1.5 Personnel Information

1.5.1 Commander – male, aged 41, with valid ATPL license and medical certificate.

1.5.2 First Officer – male, aged 33, with valid ATPL license and medical certificate.

1.5.3. Chief Cabin Attendant - female, aged 42, with valid C/AL license and medical certificate.

1.5.4 Cabin Attendant - female, aged 40, with valid C/AL license and medical certificate.

1.5.5 Cabin Attendant - female, aged 21, with valid C/AL license and medical certificate.

1.5.6. Cabin Attendant - male, aged 29, with valid C/AL license and medical certificate.

License: C/AL No BG CA – 00663-30591, first issued on 13.06.2005, valid till 13.06.2010. Medical certificate No MED BG 50765-30591-3, Class 4, issued on 13.06.2005 and valid till 28.03.2006.

1.6. Aircraft information

1.6.1. Airworthiness information

Boeing B 737-500, registered LZ-BOQ, manufacturer serial number (MSN) 26687, Certificate of Airworthiness No 1999, issued on 10.06.2005 by CAA and valid until 06.06.2006.

As on 29.12.2005 (the day of air occurrence) the aircraft has accumulated 35221 hrs total time since new and 21760 cycles since new.

The aircraft has undergone respective A Check and C check according the schedule, given in the Maintenance Program approved by the CAA.

According the aircraft technical logbook No 000363 at 8:00 UTC on 28.12.2005 a daily check was performed at Sofia Airport and according the aircraft technical logbook No 000364 at 17:30 UTC a walk-around check was performed at Madrid Airport. No failures have been reported. The aircraft was fully airworthy for the flight.

1.6.2. Airplane performance

The maximum take-off weight of the airplane in accordance with the Certificate of Airworthiness is 55566 kg. The actual take-off weight of the aircraft for the flight FB 472 according to the loadsheet is 49500 kg. The balance was within the operational limits and did not influence the occurrence.

The aircraft is equipped with ACAS-TCAS II Version 7 Airborne Collision Avoidance System and EGPWS with improved additional function for terrain assessment along the flight direction.

1.6.3. Fuel

According page No L 000364 of the aircraft technical logbook of the aircraft LZ-BOQ before the flight from Madrid to Sofia the first officer certified refueling of the aircraft with 8330kg of fuel JET A1 and as result the total fuel quantity on board was 12130 kg and it was enough for execution of the flight from Madrid to Sofia.

1.7. Meteorological information

According the enclosed to the deed analysis, prepared by the duty air meteorologist on the synoptic charts for 12, 15 & 18 hrs on 28.12.2005 the weather conditions were as follows:

- at 12.00 UTC there was a local centre of low pressure over Milan. An area of low pressure was connected with this centre and a cold front was situated to the East from the Italian shore of Adriatic Sea, passing over Brindisi;
- at 15.00 UTC there was local centre of low pressure over Zagreb, which was expanding in all directions;
- upper air prognostic charts for wind and temperature at FL 340 & FL390 together with the significant weather chart for 18 hrs UTC showed a frontal system in upper airspace, consisting of warm, cold and occlusion fronts, which determined zones with moderate to severe turbulence.

Terminal weather for landing in Sofia Airport was as follows: wind from 060°; speed 6 m/s; visibility greater than 10 000 m; temperature 6°C, dew point 3°; QNH = 1008 hPa.

1.8. Aids to navigation

Standard aids for B 737-500 aircraft.

1.9. Communications

Standard communication equipment for B 737-500 aircraft.

1.10. Airport

The air occurrence occurred at FL350 and FL290 in the airspace of Republic of Italy and Republic of Croatia.

The aircraft took off from Madrid Airport RWY 01 and landed at Sofia Airport on RWY 09. The reference point of Sofia Airport is with coordinates N 42^o 41,7, E 023^o 24,5.

Airport elevation is 531 m.

The airport is equipped with ILS Instrumental Landing System, Cat. II.

1.11. Flight data recorders

After landing at Sofia Airport the information from the flight data recorder has been read-out from FDR in absence of AAIU representative. The full data from the read-out are attached in Attachment No 1.

After read-out and analysis of the flight data from on-board recorders the following was established:

- LZ-BOQ aircraft took off from Madrid (MAD RWY01) at 16:24:44 UTC;
- after take-off the aircraft climbed to FL340, where the bigger part of the flight was performed;
- at 18:00:19 the aircraft started to climb to FL350, what level was reached at 18:02:08, all flight parameters were normal;
- at 18:03:57 the aircraft entered in turbulent zone.

The severe turbulence went on for one minute ten seconds, the recorded loads and banks are given in the attachment.

Seven g-loads of 1.5 g were registered, the maximal was 1.57g and minimal was 0.128g, the maximal bank was 14.1°.

The aircraft self-descended down to ALT 34700 ft in 15 s and this altitude was supported till 18:05:07 hrs.

At 18:05:08 a new descend start was registered down to FL290.

At 18:28:05 the aircraft again came upon a zone of turbulence and vertical loads were registered: $G_{vert} = -0.51g$, $G_{vert} = -0.322$, g-loads about 1.5g, and the maximum was 2.025g.

The turbulence lasted thirteen seconds.

At 18:47:46 the aircraft began to descend from FL290 and at 19:00:54 passed through a zone of moderate turbulence, where four normal loadings were registered with values between 1.49g and 0.709g.

At 19:04:55 the aircraft landed at Sofia Airport.

1.12. Wreckage and impact information

No impact and no destructions on the aircraft and engines were found.

1.13. Medical and pathological information

The occurrence emerged in flight and led up to a fracture of the passenger left hand and a fracture of the cabin attendant left leg.

1.14. Fire

No fire appeared in the aircraft and engines.

1.15. Survival aspects

The serious injured passenger and crew member during the first and second severe turbulence were without safety belts, were not in their seats and were standing in the aft part of the passenger cabin.

No injured passengers and crew members, who were sitting in their seats with fastened belts.

1.16. Tests and research

For the purpose of the technical investigation the following tests and research have been conducted:

- Read-out, decoding and analyses of the flight data records;
- Aircraft documentation for organization and executing of the flight;
- Crew documentation for organization and executing of the flight;
- Documentation related with aircraft airworthiness;
- An interview with the crew was carried out and written explanations were taken in connection with the aviation occurrence;
- Written description of weather conditions on 28.12.2005 from Air Weather Office (AWO) –Sofia;
- An interview was carried out and the opinion of the doctor in charge was taken;
- An interview was carried out and written explanations were taken from the injured passenger and crew member.
- Analysis was conducted about the possible causes for the occurrence;

2. Analysis

The commission, appointed in order to investigate the aviation occurrence, analyzed the documents related with the preparation and execution of the flight, performed an analysis of the FDR records, analyzed all activities performed in order to maintain the aircraft airworthiness before and after the aviation occurrence, the crew preparation and activities.

During the check of the data in aircraft technical logbook and flight data recorders no records about faults and repairs on such faults of the aircraft structure, engines and systems were found after the aviation occurrence. The preparation of the aircraft for the Flight 471/472 Sofia - Madrid – Sofia, including Daily and Transit checks, is recorded in the aircraft technical logbook on 28.12.2005. There are no faults and corrective actions for them recorded in this logbook.

In the commander's report after landing, in accordance with the Flight Operation Manual (FOM, page 8.3-32), the occurrence was classified as "severe turbulence".

The reasons for such classification are given in the report: "rapid change of altitude of 1000ft, autopilot self-shutting-off in the two channels: pitch and bank, activation of Over-speed signalization and for a short time the aircraft was out of control".

In FAR/AIM Aeronautical Information Manual, Chapter 7 Safety of Flight, Section 1 Meteorology a classification of the turbulence intensity is given; in Table 1-3 it is classified as light, moderate, severe and extreme.

The definition of severe turbulence is: “Turbulence, which cause big, abrupt and sudden changes in altitude and/or the attitude of the aircraft. Usually it causes large variations in indicated airspeed. Aircraft may be momentarily out of control”.

The researches and experience have shown that the reasons for turbulence may be different depending on altitude range of meteorological phenomenon and the altitude of the flight.

At low and middle altitudes the reasons may include; clouds, thunderstorms, mountain wind, abruptly change of the relief or different levels of ground/sea surface heating.

At high altitudes it may be well vertically developed active clouds, jet streams with a high speed of movement of the air masses, abrupt temperature changes.

The turbulent movement of the air masses in clear weather or above the clouds at high altitude of flight over 15 000 – 20 000 ft is defined as “Clear Air Turbulence” (CAT).

The analyses and the data from flight data recorders have shown, that the most of the time of the flight 472 is at FL340 and FL350 (34 000 – 35 000 ft) over the clouds.

During the preflight preparation the crew has received in the flight documents set a meteorological bulletin and has familiarized with the weather conditions for the flight.

The meteorological bulletin received from AWO – Sofia and contains:

- Prognostic chart of significant weather in upper air for FL100-450 with validity from 12:00 UTC;
- Upper air wind charts for FL 180;240;340 and 390 respectively;
- METAR & TAF messages for take-off and landing airports and for alternate airports;
- SIGMET message from Meteorological Information Stations in Brindisi, Zagreb and Belgrade.

The significant weather prognostic chart in upper air and the wind and temperature charts in upper air were of 6 hours validity – from 12.00 UTC till 18.00 UTC on 28.12.2005.

The validity of SIGMET is also 6 hours, taking into account, that the warning is issued no earlier than 6 hours before expected time of beginning of the meteorological phenomena in question.

A SIGMET message received from Brindisi station (LIBB) warns about moderate turbulence in serviced airspace over FL360.

A SIGMET message received from Zagreb station (LDZO) warns about “embedded thunderstorm clouds in the total cloud mass” up to FL300.

A SIGMET message received from Belgrade station (LYBA) also warns about “embedded thunderstorm clouds in the total cloud mass”.

The analyses of significant weather in upper air and the three SIGMET messages determined a complex and dynamic meteorological prognosis en-route.

The existence of SIGMET message in the meteorological bulletin already shows “existing and expected meteorological phenomena, which exert influence on the flight safety en-route”

(Regulation No 3/03.01.2006 of the Ministry of Transport about the Meteorological Services for Civil Aeronautics, Chapter VI, Section I, SIGMET Information).

The analyses of flight data recorders and crew information have shown, that during the first segment of the flight Sofia – Madrid, performed at FL 340 there weren't any problems related to the meteorology.

During the second segment of the flight Madrid – Sofia in accordance the flight plan the flight level should be changed in the Brindisi serviced airspace from FL340 to FL350.

The analyses of the significant weather chart in this area has shown, that in the vicinity of the flight path there was a jet stream with a speed about 200 km/h, which change its direction in this area from South to East under the influence of the general air mass movement of a powerful low pressure centre in Northern Italy.

The abrupt change of the air mass movement direction and speed most likely was the reason for the severe turbulence, influenced upon the aircraft during the period from 18:03:35 till 18:05:35 in the area with coordinates: N 42°20" and E 13° 39' 31".

The turning on of the Over-speed signalization is a result of abrupt increase of the aircraft speed because of the jet stream in vicinity of the flight path in that area.

The sudden, unexpected and abrupt changes of the aircraft attitude in the space during the first turbulence caused a serious injury (hand fracture) of a female passenger, who was standing on the aisle between the seats of the next to last row of the passenger cabin.

The time of severe turbulence influence was 1.10 minutes according the flight data records.

Until the moment of entering the severe turbulence area the crew was not informed by ATC about the existence of such probability.

The analyses has shown, that both pilots were at their working stations in the cockpit with shoulder and torso harness, the auto seat belts switch was on auto and the signalization in the passenger cabin for using of personal safety belts by passengers was switched off.

The following activities of the flying pilot (aircraft commander) and the servicing pilot were adequate to the situation and the requirements of the Flight Operation Manual of the airline operator: The signalization for fastening belts in the passenger cabin was switched on, the aircraft control after self-switch-off of the autopilot was recovered, Brindisi Control was informed about severe turbulence at FL350 and FL290 was requested, the aircraft commander was informed about the passengers' condition and immediate information for taking the seats and fastening the belts was given.

At 18:27:35 UTC in the Zagreb area the aircraft again came upon a zone with severe turbulence, which lasted about two minutes, belts signalization was switched on, the two pilots, three female board attendants and passengers were in their seats with belts fastened, what saved them from injuries.

The unregulated, abrupt and sudden aircraft movement coincided in time with the position of the male cabin attendant, who in violation of the aircraft commander's instruction and Cabin

Attendant Manual (CAM), p. 3.5 – Turbulence, p.3.5..1.2 Expected Turbulence, was standing on the aisle in the aft part of the aircraft.

The board attendant suffered a serious injury – a fracture of the left leg. He was rendered assistance by the two senior cabin attendants, who immobilized the leg, gave pain relieving remedies and informed the aircraft commander. The commander informed immediately Sofia and asked for qualified medical personnel and an ambulance.

At 19:00:53 during descend for landing at Sofia Airport and during the approach the aircraft was under moderate turbulence influence without any further consequences for the passengers and the crew.

The analysis of the commission has shown, that CAT is one of the most frequent reasons for serious injuries of passengers and crew members during the flight.

Taking into account the peculiarities of the Clear Air Turbulence, namely that:

- The flight is in clear weather (over clouds) conditions;
- There is no possibility for visual identification;
- There is no possibility for identification by ground or on-board radars;
- It starts suddenly and unexpected,

and in view of above mentioned in the analyses circumstances, the commission has done the following

3. Conclusions

The technical investigation gives the grounds for the conclusion, that the air occurrence is a result from the following

Main cause

Inadvertent and sudden aircraft coming upon zones with severe turbulence and as result of it a passenger and a crew member have suffered a serious injure.

During investigation the **following deficiencies** were established:

1. Although the flight was performed during the period of validity of the documents in the meteorological bulletin, received in Sofia, the crew hadn't fulfilled the requirement of Art. 20, Para 2, p.5 of Regulation No 6 of the Ministry of Transport and Communications from 14.06.2001 for operation of aircraft and it hadn't received a new one before the flight at Madrid Airport.

2. In the Flight Operation Manual of AO – Part A, in point 8.3.8 Adverse and potentially hazardous atmospheric conditions – Turbulence, the way of reporting for severe turbulence influence on the aircraft by the personnel in charge for the airworthiness is not defined concretely. The commission considers this as a possible reason that the aviation occurrence was not reported in the aircraft technical logbook.

3. The Safety Program of the AO is not updated and not brought to conformity with the requirements of Regulation No 13 from 27.01.1999 for aircraft accident investigation of the Ministry of Transport. In the Safety Program there are classifications, which are inadequate with the Regulation requirements.

4. AAIU was not timely informed about the air occurrence by AO.

5. The time of aircraft preflight check at Madrid Airport was recorded incorrectly in the aircraft technical logbook.

Having in view the above described, the commission proposes the following

Safety recommendations:

1. CAA to execute a single revision of AO on organization, refueling, actualization and the order of use of first aid kits and emergency medical kits, equipped with medicines and medical means for rendering first aid in accordance with the requirements of Art.118, Para 2 and Art.119, Para.3 and Para.4 of Regulation No 6/14.06.2001 of the Ministry of Transport and Communications about the aeronautical means.

Time: 20 days after the day of handing in of the report. Person responsible: Executive Director of CAA.

2. The Airline Operator to perform inspection according AMM 05-51-31/201 after severe turbulence encounter.

Time: 15 days after the day of handing in of the report. Person responsible: Director of Technical Operation of the Airline Operator.

3. The Aviation Operator should create a system for control and analyses of the flight documents after the end of the flight in order to ensure mutual information and cooperation between the Flight Operation Directorate and Technical Servicing Directorate.

Time: 20 days after the day of handing in of the report. Person responsible: Executive Director of Airline Operator.

4. Flight Operation Manual of the AO – Part A, point 8.3.8 Adverse and potentially hazardous atmospheric conditions – Turbulence on page 8.3-33, paragraph 3 should be defined concretely, adding the following sentence: “The report to the Maintenance Staff should be done by an entry in the aircraft technical logbook”.

Time: 10 days after the day of handing in of the report. Person responsible: Flight Operations Director.

5. In the Safety Program of AO a procedure should be developed for timely notification of AAIU in case of air occurrence in accordance with the requirements of Regulation No 13/27.01.1999 of MT for air occurrences investigation.

Time: 15 days after the day of handing in of the report. Person responsible: Flight Operations Director.