

FINAL REPORT

on
investigation of a serious incident that occurred on the 16.12.2007 during
the landing at Varna Airport of British Aerospace BAe 146-300 aircraft,
registration No LZ-HBE, operated by Hemus Air EAD air operator,
conducting domestic flight for Bulgaria Air Airline FB977 on route Sofia -
Varna - Bourgas



CONTENTS

LIST OF ABBREVIATIONS 3

Introduction 4

1. Factual Information 4

 1.1 History of Flight 4

 1.1.1 Flight Number: 4

 1.1.2. Preparation and Description of the Flight 5

 1.1.3. Location of the Aviation Occurrence 5

 1.2 Injuries to Persons 5

 1.3. Damage to Aircraft 5

 1.4. Other Damages 5

 1.5 Personnel Information 6

 1.5.1 Information about the crew 6

 1.5.2. Air Traffic Controller - Approach 7

 1.5.3. Air Traffic Controller - Tower at Varna Airport 7

 1.6. Aircraft information 7

 1.6.1. Airworthiness information 7

 1.6.2. Airplane performance 8

 1.6.3 Fuel 8

 1.7. Meteorological information 9

 1.8. Aids to navigation 10

 1.9. Communications 10

 1.10. Airport 11

 1.11 Flight data recorders 12

 1.12 Wreckage and impact information 14

 1.13 Medical and pathological information 14

 1.14 Fire 14

 1.15 Survival aspects 14

 1.16 Tests and research 14

2. Analysis 15

3. Conclusions 23

4. Violations and irregularities established 23

5. Safety recommendations 25

LIST OF ABBREVIATIONS

AO	- Air operator;
AC	- Aircraft;
MD CAA	- Main Directorate of Civil Aviation Authority;
дс	- Decimal system;
ACr	- Aircraft crew;
CAA	- Civil Aviation Act;
ACC	- Aircraft commander;
ARP	- Airport reference point;
ACT	- Airport Control Tower;
AMS	- Airport Meteorological Service;
AC	- Airdrome control of air traffic;
MT	- Ministry of Transport;
MO	- Maintenance organization;
RWY	- Runway;
TWY	- Taxi way;
SM	- Scheduled maintenance;
ATC	- Air Traffic Control;
AOM	- Aircraft Operation Manual;
FCO	- Flight control officer;
AMOM	- Airport Management and Operation Manual;
AAIU	- Air Accident Investigation Unit
ATC	- Air Traffic Control;
ATIS	- Automatic terminal information service;
CAVOK	- Ceiling and visibility OK
CRM	- Crew recourses management;
CVR	- Cockpit voice recorder;
DME	- Distance measuring equipment;
ILS	- Instrument landing system;
FDR	- Flight data recorder;
FOM	- Aircraft Operation Manual;
G/S	- Glide path;
KIAS	- Knots indicated airspeed;
LOC	- Course;
METAR	- Information on regular weather observation;
NOSIG	- No significant changes of weather;
NOTAM	- Notice to airmen.
RA	- Radio height;
SNOWTAM	- Information about snowfalls to the crews;
SOP	- Standard Operating Procedures;
SG	- Snow grains;
SN	- Snow;
SPECI	- Special weather information;
TAF	- Terminal aerodrome forecast;
TEMPO	- Indicator for temporary meteorological phenomenon;
VOR	- VHF omnidirectional radio range.

Introduction

On the 16.12.2007 the crew of BAe 146-300 aircraft, reg. No LZ-HBE of Hemus Air AO was conducting a domestic en-route passenger flight Sofia - Varna - Bourgas under flight number FB977 of Bulgaria Air. After landing on RWY 09 at Varna Airport in snowfall conditions the aircraft could not manage to stop on the runway and went out from taxiway A and got stuck in the ground. No consequences for the crew and aircraft.

Notified: Air Accident Investigation Unit (AAIU) and Directorate General of Civil Aviation Authority (CAA) at the Ministry of Transport of Republic of Bulgaria, Air Accident Investigation Board (AAIB) of Great Britain and International Civil Aviation Organization (ICAO).

On the base of Article 9, Para. 1. Rev. - SG, No 83 of 2004, addition, No 77 of 2005) and in accordance with Para.3, p. 1 (6) of additional provisions of Regulation No 13 (last rev. and additions 16.01.2007) of 27.01.1999 of the MT, the aviation occurrence is classified by AAIU as a serious incident. The materials on the aviation occurrence are classified under state file number No 10/16.12.2007 in the archives of AAIU.

On the base of Article 142, Para. 2, of Civil Aviation Act of Republic of Bulgaria of 01.12.1972 (last revisions and additions SG No 10 of 30.01.2007) and Art. 10, Para.1 (Rev. - SG No 83 of 2004), in relation with Art. 2, Para. 1 of Regulation No13 of MT of 27.01.1999 with an order No RD-08-606/ 28.12.2007 of the Minister of Transport, as an authorized body for conducting of the investigation, a commission for investigation was appointed.

No authorized representative of Great Britain was presented.

The commission visited the aviation occurrence scene, conducted an inspection of the aircraft, made interviews and took written explanations from the aircraft crew members. The radio exchange between the aircraft and Air Traffic Controller - Varna Tower and Varna Approach Control was listened through, as well as all the internal communication between the work stations at Air Traffic Control body and Information and Coordination Center at Varna Airport. Written explanations were taken and interviews were conducted with the officials, related with the serious incident. Interviews were conducted with the witnesses of the aviation occurrence.

The difference between the local time and Universal Coordinated Time (UTC) is + 2 hours.

1. Factual Information

1.1 History of Flight

1.1.1 Flight Number:

The crew conducted the flight under flight number FB977/978 of Bulgaria Air.

Type of Flight:

Passenger transport flight on scheduled domestic line Sofia - Varna - Bourgas.

Last departure point: Sofia Airport.

Departure time: 20:27 h local time.

Last arrival point: Varna Airport.

1.1.2. Preparation and Description of the Flight

For the execution of flight FB977, by an order of the Hemus Air Manager a crew was appointed, consisting of: commander, co-pilot and three cabin attendants. At the day of flight the appointed aircraft commander got ill and he was replaced by reserve aircraft commander.

The crew arrived at Sofia Airport 1 h15 min before the start of the flight for preflight preparation. According to the communicated information for Varna Airport as for the time of the preflight preparation the wind was from 360⁰ with a speed of 8 kt and there was light snowfall. The cabin crew conducted the briefing separately from the cockpit crew.

The LZ-HBE aircraft was late on schedule from the previous flight and for this reason the aircraft refueling and the boarding of 85 passengers for FB977 was delayed and the take-off was conducted at 20:27 instead of 19:30 h. According to the flight plan the flight should have been with route LBSF – GOL2A – GOL – B27 - TOTKA – TOTKA1B – LBWN, but after the GOL3E take-off the aircraft got vectored directly to Varna.

According to the preliminary distribution of obligations between the flight crew for Sofia - Varna piloting pilot (including landing at Varna Airport) was appointed the aircraft commander.

The flight went without any peculiarities till the final approach for Varna Airport.

The crew conducted ILS approach to RWY09 at Varna Airport in conditions of north-west wind and snowfall with variable intensity. After landing during the roll out run the aircraft commander failed to reduce enough the speed and because of the possibility to go out of RWY in landing direction he attempted a left-hand turn to A taxiway, but the aircraft left TWY A at right-hand side and stopped stucked in the ground at about 85m from RWY27 threshold.

The aircraft commander made several unsuccessful attempts to move the aircraft back to TWY A by changing the engine regime and after eventually he stopped the engines.

Local emergency readiness alarm was declared at the airport. The passengers were brought out by an airport ladder and leaded to the terminal building.

The aviation occurrence didn't lead to any consequences for the passengers, crew, aircraft and airport equipment.

1.1.3. Location of the Aviation Occurrence

The aircraft got stucked in the ground at 85m north from RWY27 threshold of Varna Airport, to the right-hand side of right-hand end line of TWY A. The occurrence occurred at 21:02 h local time on the 16.12.2007.

1.2 Injuries to Persons

No injuries to crew members, passengers and third party persons as a result of the aviation occurrence.

1.3. Damage to Aircraft

During the assessment conducted on the aircraft's technical condition after the occurrence no damages and deviations from technical requirements were established.

In Enclosure 1 from Fig. 1 to Fig. 6 the aircraft is shown at the place of stopping on the ground, on Fig. 7 the aircraft is shown at the apron after been pulled out, on Fig. 8, 9 & 10 the nose and both main landing gear struts are shown.

1.4. Other Damages

No other damages.

1.5 Personnel Information

1.5.1 Information about the crew

1.5.1.1. Aircraft commander – 46 years old, in possession of a valid pilot license and medical certificate.

The aircraft commander is permitted to operational flights at following minima:

Take-off	Cloud base		0 m
	Visibility/Runway Range- RVR/	Visual	250 m
ILS landing	Cloud base		60 m
	Visibility/Runway Range- RVR/	Visual	800/550 m

1.5.1.2. Co-pilot - 41 years old, in possession of a valid pilot license and medical certificate.

The co-pilot is permitted to operational flights at following minima:

Take-off	Cloud base		0 m
	Visibility/Runway Range- RVR/	Visual	250 m
ILS landing	Cloud base		60 m
	Visibility/Runway Range- RVR/	Visual	800/550 m

From the described data about the flight personnel background the commission made the conclusion that the crew was with relatively little experience for the type of aircraft in relation with the weather conditions, given in item 1.7 of this report, especially regarding the level of training of the co-pilot, as it was his first operational flight. The last fact presumes raised work loading for the aircraft commander and in the specific fast changing weather conditions it might have lead to an increased possibility for errors. The precondition is increasing also in view of the little flight experience of the aircraft commander on BAe 146 aircraft.

1.5.1.3. Senior cabin attendant – 31 years old, in possession a valid pilot license and medical certificate.

1.5.1.4. Cabin attendant – 35 years old, in possession a valid pilot license and medical certificate.

1.5.1.5. Cabin attendant – 21 years old, in possession a valid pilot license and medical certificate.

From the gathered data about cabin staff the commission has concluded that the cabin staff possesses the required level of training for conducting of the flight.

1.5.2. Air Traffic Controller – Approach – 57 **46 years old, in possession a valid ATC license and medical certificate.**

1.5.3. Air Traffic Controller - Tower at Varna Airport – **55 years old, in possession a valid ATC license and medical certificate.**

1.6. Aircraft information

1.6.1. Airworthiness information

BAe 146-300 aircraft, reg. No LZ-HBE, serial No E3131 has been manufactured on the 25.05.1989 by British Aerospace (Regional Aircraft) Ltd, U. K. The aircraft has Certificate of Registration. The aircraft is owned by ANZEF LIMITED, with address at Minerva House, Montague Close, London SE1 9DH, U. K. of Great Britain. The air operator is Hemus Air EAD. The Certificate for Airworthiness was issued on the 09.02.2007. The Certificate for inspection of airworthiness was validated on 05.05.2007 and is valid till 05.05.2008. Since new till the 16.12.2007 (the day of occurring of the serious incident) the aircraft has flown 24362:45 hrs and 28913 cycles. In accordance with the approved Maintenance Program, before the implementation of Life Time Extension Program, there were limitations of 40000 cycles and 20 years of operation. As to the moment of the occurrence the residual life time is 11087 cycles and 1 year 5 months 10 days calendar life time.

Four bypass gas turbine engines ALF502R-5-103A model are installed on the aircraft.

The engine at No 1 position is serial number LF05644AC and it has been installed on 17.11.2002.

The engine at No 2 position is serial number LF05789AC and it has been installed on 29.05.2006.

The engine at No 3 position is serial number LF05025SC and it has been installed on 06.11.2003.

The engine at No 4 position is serial number LF05666AC and it has been installed on 12.11.2003s.

The aircraft maintenance is performed on the ground of an approved by CAA Maintenance Program for BAe 146-200/300 aircraft of AO Hemus Air. The program is based on the obligatory requirements of Maintenance Planning Document MPD146.01 Revision 41 and on the activities conducted in aircraft maintenance by Aer Lingus (previous aircraft operator). The program conforms to the requirement of JAR-OPS 1.910 and is in accordance with the provisions in Enclosure 1 to AMC M.A.302 of Part-M of Maintenance Schedule No 2042/2003 of EC.

In implementation of this program on the 21.03.2007 a scheduled maintenance of the aircraft 1A, 2A, 1AC, 2AC, 3AC, OP 1000C, OP 48 MON and OP 15 MON was scheduled, when the aircraft has accrued 22900:49 hrs and 28047 cycles. For execution of this maintenance a Release to Operation Certificate No 0000701 by Hemus Air Maintenance Organization, approved according Regulation No 145 under the license No BG CAA - 0011 was issued. A copy of this certificate was present on board of the aircraft.

In accordance with the Maintenance Program the following line maintenance has been conducted on the day of aviation occurrence:

- Daily Check, registered in Technical Logbook No 0014986, certified at 10:30 h on 16.12.2007 at Sofia Airport before execution of a flight to Zurich Airport. No malfunctions have been revealed and eliminated during the check; there are no comments from the crew from the flight to Zurich.

- Transit Check, two such inspection have been conducted on the aircraft. The first one at Zurich Airport, before the flight to Sofia, is registered in Technical Logbook No 0014987, certified at 13:30 h on 16.12.2007. No malfunctions have been revealed and eliminated during the check, there are no comments from the crew from the flight to Sofia. The second one at

Sofia, before the flight to Varna, is registered in Technical Logbook No 0014988, certified at 17:15 h on 16.12.2007. No malfunctions have been revealed and eliminated during check, there are no comments from the crew from the flight to Varna. There is no record about the going out to the ground of the aircraft.

Having in mind the aforesaid, a conclusion could be made that as to the moment of conducting of the flight Sofia - Varna when the serious incident occurred, the aircraft has been airworthy.

During the inspection the following faults have been established, which haven't endangered the flight safety:

1. In the Maintenance Program on page INT - 6 the first column about the engines of operated aircraft is designated as "serial number", but the type of engines is written in it. No serial numbers are given in the table.

2. Para1.8.1. Reporting of defects, page 1-25 of Exposition of Organization of the Control of Continuous Airworthiness, does not include the requirements of Directive 2003/42 of EC, reflected in Article 22 of Regulation No13 of 27.01.1999 about air accident investigation, issued by the Minister of Transport.

3. In Para 4.1.1.1. Assessment of an Inspector of Airworthiness Inspection, page 4-2 of Exposition of Organization of the Control of Continuous Airworthiness, in the requirement about the education is written "air navigation degree" instead of higher education in the field of aeronautics, which follows from M.A.707(a) of Part-M of Directive No 2042/2003/EC.

4. In the LOADSHEET for the flight FB0977/16 Sofia - Varna the maximum take-off mass of the aircraft is given as 43091 kg, but in the reference of Engineering Department of Organization of the Control of Continuous Airworthiness the aircraft maximum take-off mass is shown as 41750 kg. In Operators Manual Part B of Hemus Air AO for BAe 146 this mass is given as 42184 kg. In the Noiseworthiness Certificate No 2084 of the aircraft, issued by CAA on 17.05.2007, the maximum take-off mass is 43090 kg.

5. In the LOADSHEET of the aircraft for the flight FB0977/16 Sofia - Varna the maximum take-off mass of the aircraft at landing is given as 37648 kg. In Operators Manual Part B of Hemus Air AO for BAe 146 this mass is given as 36740 kg. In the Noiseworthiness Certificate No 2084 of the aircraft, issued by CAA on 17.05.2007, the maximum landing mass is take-off mass is 37650 kg.

1.6.2. Airplane performance

In accordance with the aircraft LOADSHEET for the flight FB0977 Sofia - Varna the actual take-off mass is 36953 kg, dry operating mass is 24974 kg, total transported mass 7979 kg, fuel at take-off 4000 kg, actual landing mass 35253 kg. The maximum take-off mass is given as 43091 kg and maximum landing mass is 37648 kg. The Center-of-Gravity for this loading is in the admissible limits. The aircraft loading and center-of-gravity has not influenced the aviation occurrence realized.

Maximum operational speed V_{MO} - 295 KIAS.

Maximum operational Mach number is M_{MO} - 0,72.

Maximum speed for landing gear extension is 205 KIAS.

Maximum speed for landing gear retraction is 205 KIAS.

Maximum speed with flaps at 18° - 210 KIAS.

Maximum speed with flaps at 24° - 180 KIAS.

Maximum speed with flaps at 30° - 170 KIAS.

Maximum speed with flaps at 33° - 145 KIAS.

1.6.3 Fuel

In accordance with the record in Technical Logbook the aircraft was refueled with 4200 kg of fuel JET-A1, and 2300 kg of it was left from previous flight and 1900 kg were refueled at Sofia Airport. At landing at Varna Airport the residual fuel, written in the

Technical Logbook, is 2400 kg. After arrival at Varna Airport the commission established by fuel gauges readings that present fuel was 1850 kg (1100 kg in the right-hand tank and 750 kg in the left-hand tank). The difference between the registered and actual fuel quantity probably is a result of the fuel spent for movement of the aircraft from the ground, realized by own thrust.

Independently of discrepancies of the fuel quantity, the fuel available was enough for the flight and its quantity had no influence on the course of the flight.

1.7. Meteorological information

1. General weather information:

Combined influence of large anti-cyclone from north/north-west and depression from south. At high altitude - south-west air transfer under a high cyclone with a nucleus of cold. Cold, humid air mass. Conditions for snowfall with variable intensity have been created.

2. The snowfall started at about 10:00 UTC and initially it was slight and consisting of snow grains.

(-SG), with a pause between 12:30 и 14:00 UTC.

The crew received the following weather bulletin from the flight dispatcher at the operational center of the airline:

WEATHER FROM Sunday, December 16, 2007 16:07 UTC

LBBG/BOJ/BURGAS

METAR:161600Z 36006MPS 9999 -SN OVC014 00/M01 Q1029 NOSIG=
TAF:161601Z 02004MPS 8000 BKN013 OVC030 TEMPO 2001 4000 -SN BR=
LONG TAF:

LBGO/GOZ/GORNA ORYAHOVITSA

METAR:161600Z 31003MPS 7000 BKN013 OVC025 M02/M03 Q1031 NOSIG 99491593=
TAF:161601Z VRB02MPS 4000 BR SCT017 OVC030 TEMPO 1620 1500 SN BKN010 OVC023=
LONG TAF:

LBDP/PDV/PLOVDIV

METAR:161600Z 08002MPS 6000 SCT025 BKN050 M00/M02 Q1028 NOSIG=
TAF:161601Z VRB02MPS 6000 SCT020 BKN040 TEMPO 1901 3000 BR BKN020=
LONG TAF:

LBSF/SOF/SOFIA

METAR:161600Z 28004MPS 8000 BKN030 M01/M05 Q1027 0929//95 NOSIG=
TAF:161430Z 161601 30003MPS 4000 BR BKN030 TEMPO 1801 2000 BR SCT010=
LONG TAF:161149Z 161818 05003MPS 5000 BR BKN030 TEMPO 0207 1500 SN SCT010=

LBWN/VAR/VARNA

METAR:161600Z 35004MPS 5000 -SG BKN018 OVC023 M01/M03 Q1029 NOSIG 991//95=
TAF:161601Z 35005MPS 7000 SCT010 BKN020 TEMPO 1623 4000 -SN OVC015=
LONG TAF:161818Z 35006MPS 7000 SCT010 BKN030 BECMG 0709 CAVOK=

DATA PROVIDED BY WXSsupport. WWW.WXSUPPORT.COM
For updated weather, send ICAO CODE as SMS to +45 4060 6361

At 16:50 UTC "SPECI" had been broadcasted with moderate precipitation of snow grains and sharp decreasing of visibility from 5 000 to 1 500m. Ten minutes later, at 17:00 UTC a METAR was broadcasted with a visibility of 1 000 m and an hour later the visibility was communicated as 1 300 m with moderate snowfall yet.

According to the witnesses' information in the period of one hour before the occurrence (\approx 18:00 UTC) and during the occurrence itself (\approx 19:00 UTC) the snowfall was heavy, which was confirmed by the RVR. 1 300 \rightarrow 1 900 \rightarrow 2 200 \rightarrow 1 700 \rightarrow 1 200m. During the period from 17:00 till 19:30 local time Varna communicated the following regular and special weather information and TREND forecasts:

LBWN	2007-12-16 17:00	2007-12-16 17:00	SA	METAR LBWN 161700Z 34003MPS 300V010 1000 R09/P1500N R27/P1500N SG BR FEW003 SCT014 OVC023 M01/M03 Q1030 TEMPO 3000 991///95=
LBWN	2007-12-16 17:18	2007-12-16 17:18	SP	SFECI LBWN 161718Z 34003MPS 290V010 3500 -SG BR BKN018 OVC034 M02/M02 Q1030 RESN NOSIG 991///95=
LBWN	2007-12-16 17:30	2007-12-16 17:30	SA	METAR LBWN 161730Z 32003MPS 260V010 5000 -SN BKN018 OVC034 M02/M02 Q1030 NOSIG 991///95=
LBWN	2007-12-16 18:00	2007-12-16 18:00	SA	METAR LBWN 161800Z 33003MPS 290V010 1300 R09/P1500N R27/P1500N SN BKN022 OVC030 M02/M03 Q1030 TEMPO 1000 SN SCT010 991///95=
LBWN	2007-12-16 18:00	2007-12-16 18:00	SA CCA	METAR LBWN 161800Z 35003MPS 310V030 1900 SN FEW011 BKN022 OVC030 M02/M03 Q1030 TEMPO 1000 SN SCT010 88690293=
LBWN	2007-12-16 18:30	2007-12-16 18:30	SA	METAR LBWN 161830Z 36004MPS 340V050 2200 SN BKN018 OVC030 M02/M03 Q1030 TEMPO 1000 SN SCT010 99690293=
LBWN	2007-12-16 19:00	2007-12-16 19:00	SA	METAR LBWN 161900Z 28003MPS 250V350 2200 SN FEW013 BKN020 OVC030 M02/M02 Q1030 TEMPO 1000 SN SCT010 99690293=
LBWN	2007-12-16 19:30	2007-12-16 19:30	SA	METAR LBWN 161930Z 26003MPS 220V330 1700 SN FEW012 BKN018 OVC030 M02/M02 Q1031 NOSIG 99690293=
LBWN	2007-12-16 19:33	2007-12-16 19:33	SP	SFECI LBWN 161933Z 27003MPS 240V320 1200 R09/P1500D R27/P1500D SN FEW012 BKN018 OVC030 M02/M02 Q1031 TEMPO 0800 SN SCT007 99690293=
LBWN	2007-12-16 20:00	2007-12-16 20:00	SA	METAR LBWN 162000Z 26003MPS 2100 SN FEW011 BKN020 OVC030 M02/M03 Q1031 TEMPO 0800 SN SCT005 99690293=
LBWN	2007-12-16 20:30	2007-12-16 20:30	SA	METAR LBWN 162030Z 28003MPS 2800 -SN FEW011 SCT022 OVC040 M02/M02 Q1031 TEMPO 1200 SN 99690293=

The weather information, communicated by the dispatcher at operational center of air operator was taken from www.wxsupport.com, which is official site for meteorological information.

1.8. Aids to navigation

According to Para 2.19 - Radionavigation and Landing Means of Section AD2 for Varna Airport (LBWN) of Republic of Bulgaria AIP, Varna Airport disposes with ILS (for RWY09, used for landing at the moment of aviation occurrence), first category, VOR/DME with identification letters WRN and NDB with identification letters DWN. All radio navigational means have been operational as to the moment of aviation occurrence.

The glide path of ILS 09 is formed in a way to lead the aircraft after the threshold of RWY09.

As to the moment of aviation occurrence the navigation means at the airport and on the aircraft have been operational.

1.9. Communications

The following communication means have been active and are related with the serious incident realized:

- Aircraft VHF radio, working on the respective frequencies of Varna Airport ATC;
- Approach Working Station at working frequency 121 MHz;
- Tower Working Station at working frequency 119.5 MHz;
- Ground Control at working frequency 121.825 MHz;
- Telephone line (Hotline) between Approach and Tower working stations.

The commission has established that the communication means have been operational and working normally as to the moment of serious incident.

The records of these conversations have been heard and analyzed by the commission and enclosed to the materials of the deed.

1.10. Airport

The aviation occurrence occurred during landing on RWY90 at Varna Airport. The chart of Varna Airport is shown in Enclosure 2.

RWY09 is with coordinates of the threshold 43°13'59" N and 027°48'35" E, located at 8 km to the west from the City of Varna and the elevation of runway threshold is 62 m. The airport is with 24-hours working regime.

The physical characteristics of RWY09: 2500m length and 45m width with distinctive widening at the eastern end at the side of A taxiway, which is deviating at 75° from the landing course.

According to Para 2.13, Declared distances in Section AD2 of Varna Airport (LBWN) of Republic Bulgaria AIP, landing distance available, take-off distance available and accelerated stop distance available (LDA, TODA, ASDA) in the both headings of the runway are 2500m. In landing course 90° there are several distinctive natural obstacles, without light marking and the highest to them is at 378m of elevation and coordinates 43°16'40,27"N and 027°40' 02,26" E. The distance from the obstacle to the runway threshold is 13,5 km. During the instrument landing approach (conducted by the crew during the aviation occurrence realized), the location of obstacles has not influenced the flight safety along the glide path.

The size of clearway (CWY) for runway 09 is 160m long and 120m width. The size of obstacle free zone (OFZ) for runway 09 is 190m and 150m respectively.

According to Para 2.6 Rescue and fire fighting services of Section AD2 for Varna Airport (LBWN) in Republic of Bulgaria's AIP, Varna Airport is Category 7 of rescue support. The airport possesses abilities for removal of accident suffered aircraft from the working area of the airport. The plan for removal of aircraft which has lost its ability to move under own thrust, is outside the RWY or TWY and the main landing gear struts are sank, is given on page 4.13-5 of Varna Airport AMOM.

According to Para 2.7 Use the airport during the seasons - cleaning of Section AD2 for Varna Airport (LBWN) of Republic of Bulgaria AIP, the equipment used for snow clean up, consist of:

- three brush-cleaning machines (according AMOM, Part 7.1, the airport possesses 2 Schmidt brush-cleaning machines on the base of Mercedes Unimog U1500 cross-country vehicle). The brush-cleaning machines are equipped with a fan at the rear side of the vehicle with variable tilt and it permit to blow the snow to the left- or right side depending on the direction of cleaning;

- two graders;
- three heat blowing machines;
- carbamide-dispersing machine.

The announced priority for cleaning in Para.2.7 of Section AD2 for Varna Airport (LBWN) is as follows:

1. RWY
2. TWRs A & E.
3. Apron.
4. TWRs B, C, D.

During the period from 19:00 till 20:59 on 16.12.2007, under weather conditions, discussed in Para1.7 of this report, for runway cleaning only two brush-cleaning machines Schmidt have been used.

The breaking coefficient measuring is conducted by SKH skiddometer, which, according the explanations of the officials, hasn't been operational since 14.12.2007 and

because of this the method regulated in Enclosure 11 of Regulation No 14 of the Minister of Transport on airdromes and airdrome support for breaking coefficient measuring has been applied. According to this method the breaking effect broadcasted should be determined on the base of measured breaking distance of a vehicle with specific speed (40 km/h) and according to a table the breaking coefficient should be related to the respective assessment of breaking effectiveness.

According to SNOWTAM 0037 from 17:30 UTC (19:30 local time) on 16.12.2007 the breaking coefficient determined according the above mentioned method is „medium (3)” for the three thirds of the RWY, and it has been mentioned that it has been determined by a car, the condition for RWY09 has been determined as slush (indicated by number 6) for the three thirds of RWY09. In the form of SNOWTAM 0037 it is visible, that the breaking coefficient has been broadcasted as „medium/good (4)”, but later it has been corrected to „medium (3)”.

The broadcasted message METAR from 19:00 UTC (21:00 local time, 2 minutes before the landing) shows presence of slush on the RWY 2mm tick, confirmed as actual condition of RWY09 by the aircraft crew, photo materials available and witnesses explanations.

1.11 Flight data recorders

FDR Plessey 650-1-14040-112 type, serial number 001 has been installed on the aircraft. Hemus Air Airline has submitted documentation for reading of the record, containing:

A. „Algorithms for the conversion of recorded ARINC 573 Digital Counts to Engineering Units #HSY/S/460-31/EL.6747, issued on 09.07.1990; and

B. „Flight Data Recording System Description and Algorithms for the Conversion of Recorded Digital Counts to Engineering Units (MOD NOs 01172 A to L, 30041 J & K)” #ADE-ETS-R-460-310289, issued in September 1991.

The record is according ARINC 573-7 standard.

Nowhere, except in the referenced above documents, other dates have been written, which is a reason for the investigation commission to established, that the record format and sensor calibrations have not updated since September 1991 till the present time. At the same time the AO, operating the aircraft, hasn't submitted own actual documentation for reading and analysis of FDR data.

After reading and analysis of the data it has been established by AAIU that the record quality is poor and loss of information is present. According the registered in the record counter, from counter reading FC1=2 till FC2= 829, there should be present in the record

$(FC2-FC1) \cdot 4 = 3308 \text{ s}$,

but in the record are registered total 2693 s. The loss of information is

$(3308-2693) \cdot 100 / 3308 = 18,5\%$.

The usable part of the record is 81,5%.

The poor quality of the record might be result of worn-out or stretched tape or abnormal work of mechanical part or tape drive of FDR.

The following malfunctions have been established in analogue parameter registration:

- flap position (Channel 19rh) is registered with fluctuations from 0° to 7° at 0° flap position;

- right-hand aileron position (Channel 31rh) is registered incorrectly;

- angle of attack (Channel 3rt) is registered with fluctuations from 14,5° to 16,5°;

- the pressure of green and yellow hydraulic systems of left and right wheel brakes (channels 2ds и 42ds) are incorrectly registered;

Acceptable quality of registration of the following parameter it was established:

- normal, longitudinal and transverse accelerations;

- left and right-hand elevator position and pitch trimtab positions;
- heading from heading system, bank and pitch from gyro vertical;
- indicated airspeed;
- left-hand aileron and left- and right-hand spoiler-aileron positions;
- rudder position;
- N1 engine speed for No 1, 2, 3 and 4 engines;
- barometric altitude for high and low level;
- radio height;
- full ambient air temperature;
- deviation from LOC и G/S;
- frame counter is registered correctly in setting out the starting words of subframes in following order: 0E24, 01DA, 0E25, 01DB.

All analogue channels need to be updated by calibration and test records during the checks.

It was established that the following discrete parameters have been registered correctly:

- spoilers for lift reducing, driven by green and yellow hydraulic systems;
- low pressure of green and yellow hydraulic systems;
- deviation from LOC и G/S;
- low oil pressure of No 1,2,3 & 4 engines;
- landing gear extended and locked and landing gear retracted and locked;
- radio transmission (word 14, bit 1).

Remaining discrete parameters, listed in document ADE-ETS-R-460-310289/page 21, as well these from discrete words 17ds, 25ds, 41ds and 51ds, which have not been mentioned as reliable registered here, are both not correctly registered, or for which there are not sufficient reasons to be considered as absolutely trustworthy for the reading and analysis made and because of which their presence and reliability should be confirmed by inspections and test records during the base maintenance.

Information about the names of channels, their numeration and the record format are taken from document ADE-ETS-R-460-310289/page 20-21.

CVR Fairchild type Model A100 serial number 57789 is installed on the aircraft.

It has been established from the record hearing that its duration is of 34 minutes. The CVR hasn't been switch off immediately after going of the aircraft to the ground and because of this the record contain conversations, made on ground after the occurrence and they are not related with it, but the records during the occurrence itself and the conversation before it, when the aircraft has been in-flight, have been deleted.

No remarks on technical condition of CVR.

Flight Data Recorder data has shown that at the 13-th kilometer the aircraft has stabilized on approach and till RA224 ft there are not any deviations from indicated airspeed, heading, glide path and landing configuration. At this altitude the engine regime has been increased and from N1 = 61% regime, they have been moved to N1 = 72% regime, which has leaded to increasing of indicated airspeed from 127 kt to 133 kt. Varna-Tower cleared landing and gave wind variable from 260 to 270 ° and speed of 3 m/s. The aircraft ground speed at that moment was e 139 kt with the tail component.

At RA 87 ft an increasing of pitch is visible and a flare has been started with smooth decreasing of engines regime.

The aircraft touched down 840 m after the threshold of RWY 09 at a speed of 112 kt and engines regime N1 = 43 % .

The nose wheel hasn't leveled immediately after touch down of the main landing gear in order to activate the spoilers the to increase the braking abilities of the aircraft. The nose wheel is 6 s after main landing gear touch down - at 1230 m after the RWY09 threshold. From this

point the remaining distance to the end of the runway is 1270 m. The active braking of the aircraft started at that moment.

Detailed reference from the flight parameter recorder is given in Enclosure No 3 of this report.

1.12 Wreckage and impact information

The aircraft left TWY A from the right-hand side at a speed of 52 kt , went to ground and sank at 85 m to the north of RWY 27 threshold. There were no destructions on aircraft and airdrome facilities in the area of aircraft exit from TWY A.

A sketch of aircraft movement along the RWY and TWY A is shown in Enclosure No 2.

1.13 Medical and pathological information

N/A

1.14 Fire

No fire appeared.

1.15 Survival aspects

The aviation occurrence has not lead to any consequences for the passengers, crew and aircraft and use of both aircraft and airdrome emergency equipment.

At the same time the commission established that the first signal to airdrome fire fighting service for sending a fire engine to the place of aircraft exit from TWY has been registered at 21:06 (four minutes after the aviation occurrence realization) and as to that moment the type of emergency hasn't been declared. . According the ATC technology in this case declaration of general emergency is obligatory, but because of the fact that the occurrence hasn't lead to any consequences for the passengers, crew and aircraft such emergency hasn't been declared and Local Emergency Alert might be declared. The latter has been declared at 21:19 by the Airdrome Center manager for Varna ATC, 17 min after occurrence realization.

An attempt for towing the aircraft from the place of sinking by tow bar and ropes was made, but it failed. The air operator doesn't possess such equipment at Varna Airport and they have been brought from Bourgas. An attempt was made to move the aircraft from the ground under own thrust by a person not authorized for such operation and in violation of aircraft movement when outside the RWY or TWY and the main struts are sank, given on page 4.13-5 of Varna Airport AMOM.

1.16 Tests and research

For the purposes of the technical investigation the following was accomplished:

- Investigation on the place of serious incident, aircraft traces on the runway aside of TWY A;
- Inspection of aircraft;
- Check of anti-skid system, braking system, air brake and aircraft spoilers functionality;
- Hearing and analysis of the records of conversations between the crew and respective work stations at Varna ATC;
- Hearing and analysis of radio exchange between the Coordination Center of Varna Airport and respective work stations at Varna ATC;

- Download, decoding and analysis of the records from FDR of LZ-HBE aircraft;
 - Examination of the records in the aircraft operational documentation;
 - Examination of documents on crew training;
 - Examination of the content and nature of the preliminary and pre-flight preparation of the crew;
 - Examination of the operational documentation of the Air Operator;
 - Analysis of actual weather situation influence on the aviation occurrence realization;
 - Practical examination for measuring of braking coefficient, conducted at Sofia Airport;
 - Examination of effectiveness of cleaning by brush cleaning machines during intensive snowfall conditions;
 - Logical and probabilistic analyses of the possible causes for the aviation occurrence.
- The materials and results of the tests and researches are enclosed to the deed.

2. Analysis

After investigation of the factual information on aviation occurrence, the commission considered the following basic hypothesis related with the possibility for realization of the serious incident investigated:

1. First hypothesis – The occurrence is related with a failure of aircraft systems, ensuring timely braking of the aircraft at landing.
2. Second hypothesis - Weather conditions and development of weather process influenced the required length of RWY for aircraft landing.
3. Third hypothesis - Deterioration of aircraft characteristics because of deterioration of RWY condition and related with this reduction of aircraft braking effectiveness.
4. Fourth hypothesis - Introduced errors in piloting procedures by the aircraft crew.
5. Fifth hypothesis - Complex influence of factors with dominating influence on the aircraft braking distance required (reflected in second, third and fourth hypotheses).

On first hypothesis – failure or abnormal operation of aircraft systems, ensuring timely braking of the aircraft at landing.

Timely braking of the aircraft during the landing run might be influenced by abnormal operation or malfunction of:

- aircraft braking system;
- aircraft anti-skid system;
- airbrake system;
- lift spoilers system;

The braking ability of the aircraft is influenced also by the tyre tread condition.

As it has been shown in Para1.6.1 Airworthiness Information, as to the moment of the flight on route Sofia - Varna the aircraft has been airworthy, which means that it has been line and base maintained in accordance with the approved by CAA Maintenance Program of Hemus Air for BAe 146-200/300 aircraft and all discrepancies with technical requirements have been eliminated. During the line maintenance preceded the flight Transit Check and the preflight inspection conducted by the crew, registered in technical logbook No 0014988, no defects have been revealed, no remarks have been made by the crew for the previous flight. This gives the reason to consider that as to the moment of the conducting of the flight the above mentioned systems have operated normally. The crew hasn't registered in the technical log book any remarks, related with the operation of these systems. During the interview after occurrence with the crew members no ascertaining related with abnormal operation of systems mentioned above have been established. After extraction of the aircraft from the ground normal operation of the braking system was established and the following system functional tests were conducted by request of the commission: Anti-skid system; Airbrake system; Lift spoilers system and Brake

fan system. The tests performed have shown normal operation of systems mentioned and they are reflected in Technical Deed, enclosed to the materials of investigation.

The normal operation of air brake system and lift spoilers is confirmed by FDR record, where there engagement has been fixed.

On photos shown on Fig. 8, fig. 9 and fig. 10, Enclosure 1, is visible that the tire protection condition is good and it couldn't influence adversely the braking action.

Having in view the above described data, the commission rejects the hypothesis, that the serious incident is related with failure or abnormal work of aircraft systems, ensuring timely braking of the aircraft at landing.

On second hypothesis - weather conditions and development of weather process influenced the landing parameters of the aircraft.

The meteorological information given in item 1.7 of this report describe the weather conditions and phenomena during the period from taking-off from Sofia Airport to end of aircraft landing at Varna Airport.

Operational meteorological support of the flight has been conducted by Meteorological Service at Sofia Airport and Varna Airport, which have performed regular and special observations and broadcast regular and special information and produce and broadcast airdrome prognoses. The prognosis for landing has been included also in regular weather information as a TREND – TEMPO prognosis.

1. Information about weather conditions, received by the crew during the pre-flight preparation.

During the pre-flight preparation the crew received from Operational Center of the Air Operator at 16:00 UTC from on duty dispatcher METAR information about the weather at Varna Airport and Bourgas Airport. The METAR information for Varna Airport at 16:00UTC (18:00 local time) is: wind from 350⁰/4 m/s, visibility 5000 m, light sleet, cloud base 540 m and braking effect "good" (5), without significant changes for the next two hours (NOSIG). Two prognoses have been enclosed to the METAR information - 12-hour and 24-hour, in which improvement of visibility is predicted, light snowfall and stopping of the snowfall up to CAVOK.

According to the schedule flight FB977 should take-off at 19:30 local time from Sofia Airport, but because of delay of the aircraft from the previous flight the take-off has performed at 20:27 h with delay of 57 minutes. During this period of time the aircraft commander has asked and received weather information by phone from the Operational Center of the airline. The crew hasn't visited Airdrome Meteorological Service (AMS) at Sofia Airport and hasn't asked a consultation with on-duty meteorologist, there is no signature at AMS register. The aircraft commander hasn't received a SNOWTAM.

During the period from 15:30 UTC till 19:30UTC (17:30...21:30 local time) AMS at Varna Airport has broadcasted ten METAR messages, four SPECI messages and one SNOWTAM message, which permit to assess and analyze the development of the weather processes for the period till aircraft landing. These data are shown in table 1:

Table 1

Message	Hour, UTC	Wind, m/s	Visibility, m	Weather phenomena	Cloud base, m	T, °C/ T op, °C	Note	Braking effect
METAR	15:00	350/4	>10000	light sleet	540	-01/-03	NOSIG	5
METAR	15:30	340/4	8000	light sleet	540	-01/-03	NOGIG	5
SPECI	15:53	350/4	5000	light	540	-01/-03	NOGIG	5

				sleet				
METAR	16:00	350/4	5000	light sleet	540	-01/-03	NOGIG	5
METAR	16:30	330/3	5000	light sleet	600	-01/-03	NOGIG	5
SPECI	16:50	330/3	1500	sleet	540	-01/-03	TEMPO 3000	5
METAR	17:00	340/3	1000	sleet	420	-01/-03	TEMPO 3000	5
SPECI	17:18	340/3	3500	light sleet	540	-02/-02	NOSIG	5
METAR	17:30	320/3	5000	light snowfall	540	-02/-02	NOSIG	5
METAR	18:00	350/3	1900	snowfall	330	-02/-03	TEMPO 1000	3
METAR	18:30	360/4	2200	snowfall	340	-02/-03	TEMPO Snowfall	3
METAR	19:00	280/3	2200	snowfall	390	-02/-02	TEMPO 1000 Snowfall	3
METAR	19:30	260/3	1700	snowfall	360	-02/-02	NOSIG	3
SPECI	19:33	270/3	1200	snowfall	360	-02/-02	TEMPO 800 Snowfall	3

On 16.12.2007 at 17:42:38 UTC a SNOWTAM has been broadcasted: for RWY09 100% of the runway has been covered by sleet, braking effect "medium" (3).

The analysis of the information broadcasted has shown that during the period from 14:00UTC (16:00 local time) till the aircraft landing at 19:02UTC (21:02 local time) weather phenomena and processes have been present at Varna Airport area, which later and as a result have influenced the RWY condition and the decision for aircraft landing clearance.

At 15:53 UTC a process of worsening of weather conditions started at Varna Airport area with wind of 4...5 m/s from west-north with visibility of 5000 m at 14:30 UTC started light sleet, which has intensified at 16:50 UTC and at that the visibility has lessened to 1000m, which is an evidence for fall intensity - at the boundary between the moderate and heavy. This fall lasted about 1 h, and the air temperature/dew point have dropped down to -02/-02. The temperature on the RWY surface from 0°C has dropped to -0,1°C.

At 17:30UTC (19:30 local time) the sleet fall has eased and the fall changed to light snowfall.

The sleet fall and its deposit on the RWY has been with duration of 3 hours (from 14:30UTC till 17:30UTC), and braking effect of 5 has been broadcasted.

At 17:30 UTC the fall changed to snowfall, light at the beginning, but from 18:00 UTC till aircraft landing at 19:02UTC – moderate to heavy fall. As a result of this the visibility also decreased - down to 2200...1700 m. The wind has oriented from west - up to 3 m/s. The temperature and dew point is -0.2/-0.2 respectively, and the RWY surface temperature is 0°C. At these conditions the snow started to thaw, forming sleet covering. This has been confirmed by SNOWTAM broadcasted at 17:30 UTC – sleet, braking effect 3.

In the message from 18:00 UTC the following data have been broadcasted - sleet, all RWY covered by 2 mm layer of sleet, braking effect medium (3).

After the facts and circumstances analyses, the commission concluded that AMS has carried out its obligations for broadcasting of regular and special weather information and prognoses (TAF, METAR, SPECI, SNOWTAM) according the Regulation No 3 of MT about

the meteorological servicing of civil aeronautics of 03.01.2006, reflecting the factual weather data, but to considerable degree formally, and there isn't the tendency for in-deep analysis of the developing weather process. The commission concluded that there have been present conditions for initiation of icing on RWY surface and creation of precondition for retention of the fresh snow - a complicated weather situation, which should be analyzed in-depth by the weather specialist and drawing airport services' attention to specify the means and method of RWY cleaning and the preciseness in determination of braking coefficient and braking effect.

3. Third hypothesis - Deterioration of aircraft characteristics because of deterioration of RWY condition and related with this reduction of aircraft braking effectiveness.

The aircraft slowdown might be determined as force, which depends in general by the following form:

$$F_{cn} = \mu_{BC} \cdot (W - L) + X + P_{peg}, \text{ where}$$

μ_{BC} - aircraft braking coefficient;

W – aircraft weight during the landing run along the RWY;

L – lift created by aircraft wing;

X – aircraft aerodynamic drag;

P_{peg} - reversed thrust force.

BAe 146 aircraft have no engine thrust reversing devices and the slowdown of this type of aircraft is made by:

- air brake, increasing the aerodynamic drag of the aircraft at the first stage of landing and slowdown;
- spoilers, which function is to reduce the lift and to increase the aerodynamic drag, increasing the braking force in such a way;
- braking system, equipped with Anti-Skid device.

From the above mentioned results that the slowdown process of BAe 146 aircraft is in direct relation of:

- functioning of air brake and spoilers;
- functioning of the brake system and anti-skid system;
- friction coefficient on RWY.

The effectiveness of aircraft air brake and spoilers is considerable in the first phase of landing run, because it depends mainly by the aircraft speed. The commission has conducted air brake, spoilers, brake system and anti-skid system functionality check and hasn't established any deviations from the technical specifications. The correct functioning of these systems was confirmed by the data of FDR. In view with the above stated the commission has considered the hypothesis for reduced braking effectiveness, led to the impossibility to stop the aircraft on the RWY and its rolling-off to the ground.

The braking effectiveness is directly related with the contact surfaces (tires and RWY) and the friction between them, expressed by the value of braking coefficient of the aircraft ($\mu_{aircraft}$). The commission has inspected the aircraft tires and no deviation from technical specifications has been established. This fact, as well the dynamic changes of weather conditions during the aircraft flight, approach and landing gave the reason for the commission to make in-deep analysis of the conditions of the second contact surface - the RWY surface and its influence on the process of aircraft slowdown.

During the analysis of RWY condition the commission reviewed and considered the following circumstances:

- progressively deteriorating weather conditions in Varna Airport area during the crew pre-flight preparation till the aircraft landing at Varna Airport;
- effectiveness of snow clearance at Varna Airport;

- accuracy in runway friction coefficient measuring by the respective services at Varna Airport.

1. The character of alteration of weather conditions is discussed in-depth in Para1.7 of this report.

2. Snow clearance effectiveness of the runway at Varna Airport depends on the following factors:

- cooperation between the AMS at Varna Airport and Coordination Office the the airport;

- presence of the necessary snow-removal equipment and personnel trained for its operation;

- usage of snow-removal equipment, adequate for the actual weather conditions and their changes expected;

According the Winter Conditions Support Plan of Varna Airport in Varna Airport Management and Operation Manual, page 4.6 – 27 the head of the Meteorological Support Service at Varna Airport should alarm the on duty official, when the weather prognosis requires snow cleaning operations and icing prevention. The commission established lack of good cooperation between the Coordination Center and Airport ATC having in mind dynamic changing situation. On duty meteorologist hasn't drawn attention of Coordination Center for the possibility of runway icing according the requirements of Article 19, Para. 5 of Regulation No 3 of MT of 03.01.2006 on meteorological support in civil aeronautics and Enclosure 11 of Regulation No 14 of MTC of 2000 on airdromes and airdrome support.

The present and published in Republic of Bulgaria AIP, the snow handling equipment at Varna Airport and priority for cleaning are discussed in detail in Para1.10 of this report.

According the explanations of the officials, engaged in snow cleaning process from the RWY during the period from 18:30 to 20:59 has been conducted by two Schmidt brush-cleaning machines on the base of Mercedes Unimog cross-country vehicle, equipped with brushes with working width of 4.50m and fans at the rear of the vehicle for blowing of snow in direction selected.

This type of machines are designed for processing of dry non-compacted snow. Information for presence of dry snow has broadcasted by weather office, although the on duty dispatcher at the RWY informed about thawing snow and sleet on RWY surface. Coordination Center at Varna Airport has changed the type of this covering what is clear from the conversation between the coordination and head of the shift at Flight Operations of ATC, enclosed to the materials of the deed.

The effectiveness of brush cleaning machines is lower for sleet and in this case the cleaning is still possible, but at lower speed, multiple passes with the brush and blowing by the fan. Actually the brush is not effective on iced surface and might additionally aggravate the surface condition because of smoothing by wire sheaves and cooling by the fan.

According the explanations of the officials from Coordination Center at Varna Airport, the snow removal has been conducted by two brush cleaning machines only in conditions of sleet fall initially (which might be removed from the RWY surface using brushes and fan), which changed to snowfall with increasing intensity, and sleet has formed on the RWY, the presence has been reflected in SNOWTAM 0037. The above reviewed weather conditions and created by them possibility for icing of RWY surface additionally have worsen the effectiveness of brush cleaning machines.

No carbamide dispersion have been undertaken, according the requirements of Part 4 of Airdrome Operational Procedures and Safety Ensuring Measures Description", in the part of Icing Prevention and Surface Icing Removal (page 4.6-24) of Varna Airport AMOM.

The increased time for cleaning of RWY at the whole width (having in mind the presence of sleet on the three thirds of the RWY), the moderate by intensity snowfall and the

usage of only two snow cleaning machines have led to accumulation of snow on already cleaned parts of the runway. The presence of 2 mm cover is reflected in the last METAR, valid at the moment of landing.

3. The friction coefficient measuring depends on the equipment used and its accuracy in view of weather conditions.

According to the explanations of the officials from Coordination Center, the used at airport skiddometer wasn't operable since 14.12.2007. It required as to the moment of aviation occurrence the friction coefficient to be determined by computation on the base of approved in Regulation 14 method. This method consist in measuring by a tape-measure of braking distance of a vehicle from 40 km/h up to full stop and computation according the formula $S=V^2/2\mu g$, where S – braking distance, g – terrestrial gravity, V – speed, μ – friction coefficient of RWY. The computed by this way friction coefficient should be related to the qualitative characteristics „good”, „medium/good”, „medium”, etc. and it is broadcasted to aircraft crew. The commission has established that the braking distance of the vehicle has been measured by the official person by steps but not by a tape-measure, which assumes a danger for significant inaccuracy in measuring.

During the snow clearance the effectiveness of slowdown on the RWY has been determined according the cited above method. From the radio conversation between the Tower ATC and on duty dispatcher managing the snow clearance of the RWY the commission established some hesitation of the latter regarding the RWY surface condition and braking effectiveness on RWY. From the telephone conversations between the Coordination Center of Varna Airport and head of shift at Airport Center of Varna ATC the commission has established that the Coordination Center has changed the type of broadcasted cover in SNOWTAM 0037 from „sleet” to „dry snow”, and the braking effectiveness has been determined as „3” (medium), and at the same time on duty flight dispatcher has shown in a conversation with Air Traffic Controller - Tower that there is thawing snow on the runway. The last circumstance forced the head of shift at ATC Operational Center to call the Coordination Center of Varna Airport and to ask additional specification of the information, which is to be broadcasted in ATIS for the aircraft crew. During this conversation it has been established that in ATIS, till the aircraft landing, an information about dry snow presence and braking effect „3” should be broadcasted.

At 20:49 on duty air dispatcher managing the snow clearance told Air Traffic Controller - Tower that the braking effect should be „3”, because the snowfall continued and at 20:52 he changed the cover by "dry snow".

The determination of the braking effectiveness during the period between 20:00-20:59 according the above given methodic contains considerable risk of introduced error in determination of total brake effectiveness (broadcasted later also to the aircraft) on the RWY because of:

- type of vehicle used for braking distance measurement;
- actual condition of RWY cover;
- fall intensity;
- vehicle tire condition (grapple and pressure);
- state of vehicle braking system;
- accuracy of braking distance measuring by the respective device (tape-measure);
- vehicle position regarding the column of snow-handling machines;

On the base of radio conversations between ATC- Tower and on duty air dispatcher in charge for RWY snow cleaning the commission has established that his position in the column has changed between the first and second cleaning vehicle or after the second one, what means that the braking effectiveness has determined on cleared part of the runway. In

this way the increasing snowfall intensity hasn't taken into consideration and also the fact of fast snow accumulation on the cleared RWY, which should worsen the braking action.

According an investigation of Aircraft Investigation Board of Norway (AIBN), presented by Inspector Knut Lande under the title Winter operations and friction measurement at the annual conference of international organization of air accident investigation in 2007 in Singapore, at the moment there is no authentic correlative correspondence between the friction coefficient on RWY and aircraft braking coefficient. It is especially valid in cases of flooded runway and sleet, and the case with sleet is especially dangerous and poor braking effectiveness should be broadcasted in this case. The reason for incorrect determination of the friction coefficient is in the contact surface between the wheel of the skiddometer (in case of determination of friction coefficient by skiddometer) and RWY surface. The probability for error is bigger when over the sleet another kind of cover is accumulated (snow for example). In this case, because of smaller mass of the vehicle and smaller contact with the lower layer the error in determination of friction coefficient would be bigger, because the vehicle contacts with the upper layer, while for the aircraft because of its greater mass the braking effect might be much different, the friction might be lower and the slowdown effectiveness respectively.

„Sleet and wet snow frequently give as a result braking coefficient for the aircraft from 0,05 (or friction coefficient ,2 „Poor”), and dry snow gives braking coefficient for the aircraft 0,10 (or friction coefficient 0,3 „Medium”).”

Facts and circumstances during investigation of this hypothesis gave the ground for the commission to state, that the condition of RWY09 at Varna Airport, under the described weather condition has contributed for deterioration of braking characteristics of the aircraft and for realization of the serious incident.

On the fourth hypothesis- Introduced errors in piloting procedures by the aircraft crew.

On 16.12.2007 the crew conducted Flight FB977 on route Sofia - Varna - Bourgas, scheduled for take-off from Sofia Airport at 19:30 local time.

The crew conducted pre-flight preparation in the appointed for this purpose room by AO and on the ground of received weather information took decision for execution of the flight.

From the inquiry regarding the content of the bulletin on actual weather and prognosis the commission has established that the weather permitted the execution of flight, but no in-depth analysis has been made , and no consultation has been made with the on duty meteorologist at Sofia Airport. Regardless of broadcasted „NOSIG” (without changes in next two hours, what hasn't confirmed), the presence of reduced horizontal and vertical visibility, sleet, temporarily reducing the visibility to 4 km, north wind 4...5 m/s and broadcasted braking effect should concentrate attention of the crew and to make more detailed analysis of expected approach.

After the aircraft handling the crew received the aircraft and waited the passenger embarkation..

The commission hasn't find out any confirmed information for the period of waiting to prove crew interest regarding the development of meteorological processes in Varna. No confirmed data also that the on duty dispatcher has followed the development of meteorological situation and to warn the crew about possible changes. There were no warnings from AMS at Sofia Airport and ATC- Tower in accordance with the requirements of Article 130, Para. 2 of Regulation No 3 of MT on meteorological support in civil aeronautics of 03.01.2006.

During the period from receiving of the bulletin till the aircraft landing Varna Airport has broadcasted also METAR, SPECI and SNOWTAM, according Para1.7 of this report.

At 20:27 the aircraft took-off from Sofia Airport and flew directly to Varna.

Till the beginning of descent the flight passed normally at FL230.

From flight information media the commission has established the the crew has written down correctly the broadcasted ATIS information and has familiarized with airdrome conditions at the moment of landing. The commission has no data from flight information media when and whether a briefing has been conducted and exactly when the checklist has been read before descending.

Analysis of the flight information media has shown that there is a delay of the beginning of descent, which has lead to descent with maximum indicated air speed and air brake extended.

At the 13-th kilometer the aircraft is stabilized on approach path and till RA224 ft there are not any deviations from the required indicated airspeed, heading, glide path and landing configuration, after that at the same altitude **RA 224 ft the engine speed has been increased** and from N1 = 61% the engines go to N1 = 72%, at that the indicated airspeed has increased from 127 kt to 133 kt. Varna-Tower cleared landing and gave wind variable from 260 to 270° /3 m/s. The aircraft ground speed at that moment is (with the tail component) 139 kt.

At 19:01:17 at altitude RA 87 ft an increasing of pitch is visible and a flare has been started with smooth decreasing of engines regime.

At an altitude of RA 36 ft, the aircraft is with a speed of 132 kt, engine speed N1 = 64%. After 23 seconds, at 19:01:44 the aircraft touched down at 840 m after the threshold of RWY 09 with a speed of 112 kt and engine speed N1 = 43 % .

The nose wheel hasn't leveled immediately after touch down of the main landing gear in order to activate the spoilers the to increase the braking abilities of the aircraft. The touch of the nose gear is 6 s after main landing gear touch - at 1230 meters after the RWY09 threshold. From this point the distance to the end of the runway is 1270 meters. The active braking of the aircraft started at that moment.

The crew didn't give any explanations to the questions regarding the introduced deviations in piloting procedures:

1. What is the reason at altitude of RA 224 ft to increase the engine speed and going out of normal speed of approach, led to entrance in RWY with higher than required speed, when from the 13-th kilometer till this moment there are no deviations of all approach parameters according SOP for type of aircraft?

2. What is the reason to keep the nose wheel up for 6 seconds?

As a result of information from flight data recorders and analysis of the aviation occurrence the commission has made the following conclusions regarding crew actions:

1. The crew hasn't made in-depth assessment of weather situation development at Varna Airport and has assumed deviation from normal approach parameters from altitude RA 224 ft till aircraft touch down.

2. The crew increased unjustified the engine speed, respectively the approach speed, without taking into account the tail wind at the moment of landing.

3. The crew delayed 6 seconds to touch the nose landing gear and lose the ability to use the braking effect of spoilers, which are most effective in the first third of the landing run and to reduce the landing distance down to 1270m, which proved to be insufficient to stop in the boundaries of RWY for the present weather conditions and RWY surface condition.

5. On the fifth hypothesis - Complex influence of factors with dominating influence on the aircraft braking distance required (reflected in second, third and fourth hypotheses).

On the base of data for factual weather situation as to the moment of aviation occurrence realization, given in Para 1.7, the commission has established, that the weather situation has contributed considerably for deterioration of aircraft slowdown characteristics mainly by the change of the kind of fall and its intensity and temperature. These meteorological factors have influenced negatively the RWY surface condition, reduction of friction coefficient, deterioration of braking effectiveness and increasing of the aircraft landing distance required.

The commission has established that in view of weather conditions at Varna Airport at the moment of aviation occurrence realization, the measures undertaken by the respective

official persons at Varna Airport have been ineffective. The friction coefficient measuring was incorrect and the braking effectiveness was determined incorrectly, as well the kind of covering on the RWY surface, no useful for the case chemicals (carbamide) were used.

The data from Flight Data Recorder has shown that the crew has touched down the main landing gears at 840m from the threshold of the RWY09 and the nose landing gear at 1230 m from the threshold, and at that the slowdown distance available to the end of RWY09 is 1270m, what is insufficient in view of runway condition to stop the aircraft in the runway boundaries.

In view of above-stated, the commission accepted this hypothesis for aviation occurrence realization as the most probable.

3. Conclusions

On the ground of the above mentioned facts and circumstances and the research and analysis the commission has determined as the most probable following:

Main cause for realization of the aviation occurrence

Ineffective meteorological and airdrome support at Varna Airport and deviation in piloting procedures, made by the crew and led to impossibility to reduce the aircraft speed to the required for taxi after aircraft landing run.

Immediate cause

Higher speed than allowable for the specific conditions and skidding of the aircraft on the RWY surface.

Contributing Factors:

The commission considers that for the serious incident realization the following accompanying causes have also contributed:

1. Lack of effective cooperation between the AMS and Coordination Center at Varna Airport, whereat the on duty meteorologist hasn't drawn the attention of the Coordination Center to the probability for icing of RWY and by this he hasn't fulfilled his obligations, ensuing from Article 19, Para. 5 of Regulation No 3 of MT on meteorological support in civil aeronautics of 03.01.2006 and Enclosure 11 of Regulation No 14 of MTC on airdromes and airdrome support of year 2000.

2. Ineffective snow cleaning and anti-icing measures on RWY09 at Varna Airport.

3. Incorrect determination of friction coefficient and incorrect determination of braking effectiveness.

4. Unjustified change of broadcasted kind of runway covering by Coordination Center at Varna Airport and incorrectly broadcasted ATIS information before aircraft landing at Varna.

5. Insufficient in volume meteorological information, given to the aircraft crew before taking-off from Sofia Airport and lack of consultation with on duty meteorologist at Sofia Airport regarding the actual weather conditions and development of weather process at Varna Airport.

6. Insufficient experience of the crew for landing at existing weather conditions at Varna Airport.

4. Violations and irregularities established

Regarding the AO:

1. In the Maintenance Program on page INT - 6 the first column about the engines of operated aircraft is designated as "serial number", but the type of engines is written in it. No serial numbers are given in the table.

2. Para1.8.1. Reporting of defects, page 1-25 of Exposition of Organization of the Control of Continuous Airworthiness, does not include the requirements of Directive 2003/42

of EC, reflected in Article 22 of Regulation No13 of 27.01.1999 about air accident investigation, issued by the Minister of Transport.

3. In Para 4.1.1.1. Assessment of an Inspector of Airworthiness Inspection, page 4-2 of Exposition of Organization of the Control of Continuous Airworthiness, in the requirement about the education is written "air navigation degree" instead of higher education in the field of aeronautics, which follows from M.A.707(a) of Part-M of Directive No 2042/2003/EC.

4. In the LOADSHEET for the flight FB0977/16 Sofia - Varna the maximum take-off mass of the aircraft is given as 43091 kg, but in the reference of Engineering Department of Organization of the Control of Continuous Airworthiness the aircraft maximum take-off mass is shown as 41750 kg. In Operators Manual Part B of Hemus Air AO for BAe 146 this mass is given as 92,999.81 lb. In the Noiseworthiness Certificate No 2084 of the aircraft, issued by CAA on 17.05.2007, the maximum take-off mass is 43090 kg.

5. In the LOADSHEET of the aircraft for the flight FB0977/16 Sofia - Varna the maximum take-off mass of the aircraft at landing is given as 37648 kg. In Operators Manual Part B of Hemus Air AO for BAe 146 this mass is given as 36740 kg. In the Noiseworthiness Certificate No 2084 of the aircraft, issued by CAA on 17.05.2007, the maximum landing mass is take-off mass is 37650 kg.

6. Lack of actual calibration of FDR, installed on BAe 146-300 aircraft, reg. LZ-HBE.

7. Malfunctions in registration of the following analogue parameters of aircraft FDR:

- flap position (Channel 19rh) is registered with fluctuations from 0° to 7° at 0° flap position;

-right-hand aileron position (Channel 31rh) is registered incorrectly;

- angle of attack (Channel 3rt) is registered with fluctuations from 14,5° to 16,5°;

- the pressure of green and yellow hydraulic systems of left and right wheel brakes (channels 2ds и 42ds) are incorrectly registered;

Regarding the Varna Airport:

8. Defective skiddometer SKH.

9. The attempt made to move the aircraft from the ground under own thrust by a person not authorized for such operation from Varna Airport personnel and in violation of aircraft movement when outside the RWY or TWY and the main struts are sank, given on page 4.13-5 of Varna Airport AMOM.

10. On page 5.2-14 of Varna Airport AMOM under the definition of "investigation" is written, that the investigation at Fraport Twin Star Airport Management Ltd is regarding of "...serious incidents and almost avoided accidents", what is in contradiction with Art. 142, Para. (2) of Civil Aviation Act and Article 2, Para. 1 of Regulation No 13 of MT of 27.01.1999 on the air accidents investigation.

11. There is no journal at Varna Airport for registration of the results of inspections of the airdrome and assessment of its readiness for flights according the requirements of Enclosure No № 3 to Article 14, Para. 3 of Regulation No 14 of year 2000 of MTC on airdromes and airdrome support.

Regarding Operational Center at Varna ATC:

12. Late declaration of emergency situation Local Emergency Readiness (17 minutes after the aviation occurrence realization) and late warning of fire fighting service.

Regarding CAA:

13. In Regulation No 14 of MTC from year 2000 on airdromes and airdrome support the device for measuring of friction coefficient is written as a speedometer, but not a skiddometer.

5. Safety recommendations

On the place of serious incident as a preliminary measure for safety by advice of the investigation commission an extraordinary inspection has been conducted after intensive loading of the nose landing gear in accordance with AMM of BAe 146 aircraft. The execution of this measure has been certified by Release to Operation Certificate No 0010722/ 17.12.2007 of Hemus Air AMO.

During the investigation the commission has determined the following immediate safety measures by letters No 10-01-179/ 20.12.2007 and No10-01-4/ 10.01.2008:

1. Varna Airport should bring into operational condition its devices for measuring of braking effect on the RWY in 5 working days and to report about this to AAIU and CAA.

2. Airports: Sofia, Plovdiv, Bourgas and Gorna Oryakhovitsa to check the operability of the devices for measuring of braking effect and in case of malfunctions to clear a fault in 5 working days and report in written to AAIU and CAA for their normal functioning.

3. Airports: Sofia, Plovdiv, Bourgas and Gorna Oryakhovitsa should ensure monthly control on calibration and operability of the devices for measuring of braking effect with recording of the results of the control check in the journal of Coordination Center.

4. The chief pilots of air operators should conduct flight-method lesson with flight personnel regarding:

- Standard Operating Procedures (SOPs) and flight performance of the aircraft at landing in conditions of snowfall reduced values of braking coefficient, taking into account the deterioration of these characteristics at absence or failure of engine reversal system.

- emergency procedure for crew coordination at passenger evacuation.

AAIU and CAA should be notified in written about these lessons.

5. The Managing Director of AO should ensure extra medical examination of the crew after participation in serious incident according the normative requirements.

6. The Managing Director of AO should appoint a commission for examination to check the level of knowledge of FOM, SOP and aircraft operation by the aircraft commander and co-pilot.

7. The Managing Director of AO should prescribe the aircraft commander and co-pilot to conduct three training circling flights, training en-route flight and flight check en-route for admission to operation activities after a serious incident.

8. The Managing Director of AO should order:

- till accumulation of 1000 flying hours the commander to fly with a co-pilot with no less than 500 flying hours;

- till accumulation of 1000 flying hours the commander to fly with a co-pilot with no less than 500 flying hours;

On the ground of analysis performed and ascertainments the commission recommended also the following safety measures:

9. AO to conduct the necessary actions for preparation of own actual documentation for reading and analysis of FDR data of this type of aircraft.

Time: 3 months after the date of handing over of this report.
Person responsible: Executive Director of AO.

10. AO to conduct laboratory check and repair of FDR Plessey 650-1-14040-112 serial number 001 in order to certify and extend its operability in the equipment complex of the aircraft.

Time: 30 days from the date of handing over of this report.
Person responsible: Executive Director of AO.

11. AO to undertake actions for correction of defaults shown in item 1, 2, 3, 4 and 5 of Para4 of this report.

Time: 30 days from the date of handing over of this report.
Person responsible: Executive Director of AO.

12. Chief pilots of air operators to familiarize flight personnel with this report paying attention to operation of respective aircraft of AO in winter conditions, at snowbound runways with deposits of sleet or water and to send written confirmation to CAA and AAIU for execution of this measure.

Time: 20 days from the date of this report.
Person responsible: Chief Director of CAA.

13. All AO to create organization for control and reporting of pre-flight preparation of aircraft crews.

Time: 20 days from the date of this report.
Person responsible: Chief Director of CAA.

14. Varna Airport to undertake measures for elimination of faults shown in item 8, 10 & 11 of Para.4 of this report.

Time: 30 days from the date of handing over of this report.
Person responsible: Executive Director of Varna Airport.

15. Air Navigation Meteorological Servicing Directory of ATC State Enterprise to ensure adequate procedure for observation of requirements of Article 19, Para. 5 of Regulation No № 3 of MT of 03.01.2006 and Enclosure No 11 to Regulation No 14/2000 of MTC on airdromes and airdrome support.

Time: 30 days from the date of handing over of this report.
Person responsible: General Director of ATC State Enterprise

The Commission reminds about the obligation of all organizations to which safety measures are sent, that on the ground of Article 19, Para. 7 of Regulation No 13 of MT on air accident investigation of 27.01.1999 are obliged to inform in written AAIU and CAA regarding the status and terms of implementation of flight safety measures.