FINAL REPORT

Investigation of a serious incident, occurred on February 26, 2018 at Sofia Airport, Bulgaria, involving the AIRBUS 321-231 aircraft, registration marks HA-LXP, HA-LXL and HA-LXD, operated by "Wizz Air"

2022

Purpose of Report and Responsibility Level

Under Annex 13 of the Chicago Civil Aviation Convention of 07.12.1944, Regulation 996/20.10.2010 of the European Parliament and the Council on the investigation and prevention of accidents and events in Civil Aviation and Ordinance No. 13/27.01.1999 of MT (last amendment and addition - 22.01.2016), the investigation of an aviation event aims at identifying the reasons that led to the event to eliminate and exclude these in future **without identifying someone's guilt or liability**.

Contents

01. List of abbreviations

AAIU	-	Aviation Accident Investigation Unit;
ATS	-	Air Traffic Services
ALT	-	Altitude;
AMRAUD	-	Aircraft, Maritime and Railway Accident Investigation Unit Directorate
ARP	-	Aerodrome reference point;
ATC	-	Air traffic control;
ATIS	-	Automatic terminal information service;
ATPL(A)	-	Airline Transport Pilot License
BULATSA	-	Bulgarian Air Traffic Services Authority;
CAA	-	Civil Aviation Authority;
CPL(A)	-	Commercial Pilot License;
CVR	-	Cockpit Voice Recorder;
DG CAA	-	Directorate General Civil Aviation Administration;
EASA	-	European Aviation Safety Agency;
ECAM	-	Electronic Centralized Aircraft Monitor;
FDR	-	Flight Data Recorder;
FEW	-	Cloud amount - few (1-2 oktas),
FH	-	Flight Hour
ft	-	Foot;
GSE	-	Ground Support Equipment;
ICAO	-	International Civil Aviation Organization;
KT	-	Knots;
LBSF	-	Sofia Airport
MAG	-	Magnetic course
METAR	-	Aviation routine weather report
MEL	-	Minimum Equipment List
MSN	-	Manufacturer Serial Number;
MTITC	-	Ministry of transport, information technology and communications;
NOTAM	-	Notice to airmen (съобщение за екипажите);
OVC	-	Overcast;
QRH	-	Quick Reference Handbook
p.	-	page;
QNH	-	Altimeter sub-scale setting to obtain elevation when on the ground;
RWY	-	Runway;
RTO	-	Reject takeoff

PFR	-	Post Flight Report
SCT	-	Cloud amount-scattered (3-4 oktas),
SN	-	Snow;
SRIS	-	Safety Recommendations Information System;
TDZ	-	Touchdown zone;
TEMPO	-	Temporary or temporarily;
TLB	-	Technical Log Book;
TWY	-	Taxiway;
UTC	-	Universal Coordinated Time;
VC	-	Vicinity of the aerodrome;
MTOM	-	Maximum Take-Off Mass;

1. Introduction

Date and time of the aviation event: February 26, 2018, 08:24 h, 10:20 h, 13:12 LT (06:24, 08:20, 11:12 h UTC). The difference between local and universal coordinated times is +2 h. All times in the report are given in UTC.

Notified: Aircraft, Maritime and Railway Accident Investigation Unit Directorate (AMRAUD) and Directorate General "Civil Aviation Administration" (DG CAA) of the Republic of Bulgaria, the European Commission, the European Aviation Safety Agency (EASA), The International Civil Aviation Organization (ICAO), the National Bureau of Aviation Occurrences Investigation (BEA) of the Republic of France and the Transportation Safety Bureau (TSB) of the Republic Hungary.

On the grounds of the provisions of Article 9, para.1 of Ordinance No. 13, dated 27.01.1999, on Investigation of Aviation Accidents; the occurrence was classified as a serious incident by the Aircraft Accident Investigation Unit at the Aircraft, Maritime and Railway Accident Investigation Unit Directorate (AMRAIU) at the Ministry of Transport, Information Technology and Communications. The materials on the aviation occurrence have been filed in case No. 01/26.02.2018 in AAIU archives.
In accordance with the provisions of Article 5, para.1 of Regulation (EU) No. 996/2010 on the investigation and prevention of accidents and incidents in civil aviation, Article 142. Para. 2 of the Civil Aviation Act of the Republic of Bulgaria, dated 01.12.1972, and Article 10, para. 1 of Ordinance No. 13 of the Ministry of Transport, dated 27.01.1999, on the Investigation of Aviation Occurrences, by Order No. RD-08-94, dated 09.03.2018 of the Minister of MTITC, a Commission is appointed for investigation of the serious incident.

Summary:
On 25 and 26 February 2018 the entire Balkan Peninsula is under the influence of a large Mediterranean cyclone associated with prolonged snowfall at low temperatures. The weather situation has been complex, with no change in the last 20 hours. Sofia Airport operates in irregular mode, flights are running with delays due to frequent closures for snow cleaning of the runway, apron and taxiways.

After two-stage of de-icing treatment on the upper surface of the fuselage behind the cockpit, wings and tails, performed on a specially designated western place, without prior removal of accumulated snow and ice, three A321- 231 of the Hungarian low coast airline Wizz Air take their first flights of the day to various destinations at intervals of about 2 hours each. In the process of takeoff roll, when reaching 80 kts, the pilots found a difference in the airspeed readings. The crew of the first HA-LXP aircraft continued take-off and after coordination with ATC authorities, entered a holding pattern to perform the actions prescribed in QRH. After their completion and after analysis of the complex MTO conditions at Sofia Airport, the flight crew canceled the flight to Tel Aviv and diverted to Budapest, where the conditions were acceptable.
The flight crew of the second aircraft with registration marks HA-LXL decided to reject take off for safety reason, despite the low braking factor and returned to the apron of Sofia Airport. Subsequently the flight was cancelled.
The flight crew of the third aircraft with registration marks HA-LXD, similar to the first case, continued take-off after finding the differences in speed, in the process of the initial climb declared an unreliable speed indication and instead to the planned destination airport Milan (Bergamo) the flight diverted to Budapest, where it landed uneventfully.

During the post-flight inspection, all three aircraft were found ice ridges on the lower nose fuselage, which disrupted the airflow upstream to the pitot probes and led to airspeed discrepancies.

All three planes landed the night before and stayed for more than 8 hours with accumulated snow and ice in conditions of low temperature and heavy rainfall. On that day, in the same period between 00:00 h and 13 00 h, after a short intermediate stay, a total of 31 aircraft were processed using the same de-icing procedure and two A321s, seven A320s, two A319s, ten E190s, one ATR42 and six B737.
Their flight crews did not report any airspeed discrepancies or other failures. After the third consecutive event with Wizz Air's A321, the management of BULATSA declared an emergency situation and an

emergency headquarters was convened to take adequate measures. As a result, day departures are prohibited on all A321 flights. After a quick analysis by the CAA DG and the Aircraft, Maritime and Railway Accident Investigation Unit Directorate, the reasons were established and the ban was repealed.

Because of the investigation, the Commission considers that the serious incident is due to the following reason:

1. Non-compliance with the adverse weather conditions of snowfall by the ground crews performing and participating in the preparation of the aircraft for the flights related to the serious incident.
2. Admission to flight of the aircraft with the presence of ice after De-icing procedure with anti-icing fluid by the ground crew, organizing and performing the treatment.

2. Factual information

The commission received information about the realization of an aviation occurrence from the Airbus Report, written explanations from the flight crews, ground crew serving the flights, witnesses of the event and data from the BULATSA.

2.1.1. Flight number and type of flight, the last point of departure and time, planned destination Flight Number: WZZ4427.

Registration: HA-LXP
Type of flight: Commercial Air Transport - Passenger – Airline-Schedule
Last point of departure: Sofia Airport (LBSF), Bulgaria.
Take-off time: planned at 06:13 UTC
Planned destination point: Tel Aviv (Israel (LLBG)

2.1.1.1 Flight Number: WZZ4321.

Registration: HA-LXL
Type of flight: Commercial Air Transport - Passenger – Airline-Schedule
Last point of departure: Sofia Airport (LBSF), Bulgaria.
Take-off time: planned at 08:19 UTC
Planned destination point: Beauvais, France (LFOB)

2.1.1.2 Flight Number: WZZ4351.

Registration: HA-LXD
Type of flight: Commercial Air Transport - Passenger – Airline-Schedule
Last point of departure: Sofia Airport (LBSF), Bulgaria.
Take-off time: planned at 10:58 UTC;
Planned destination point: Milan Bergamo (LIME) Italy

2.1.2. Flight preparation and description of the flights

- On February 26, 2018, a Wizz Air Airbus A321-231, registration HA-LXP during flight WZZ4427 from Sofia (Bulgaria) to Tel Aviv (Israel), was climbing to FL230 when the crew reported unreliable airspeed. The flight crew decided to divert to Budapest (Hungary) where an uneventful landing.

- On February 26, 2018, a Wizz Air Airbus A321-231, registration HA-LXL, during flight WZZ4321 from Sofia (Bulgaria) to Beauvais (France), performed a rejected take-off (RTO) at 80 knots due to unreliable airspeed indications. The RTO was uneventful.

- On February 26, 2018, a Wizz Air Airbus A321-231, registration HA-LXD, during flight WZZ4351 from Sofia (Bulgaria) to Milan Bergamo (Italy), climbing out of Sofia cleared to climb to FL280 when the crew reported unreliable airspeed indications. The flight crew decided to divert to Budapest (Hungary) and landed there uneventfully.

Before the flights, the above-mentioned aircraft spend the night under continuous snowfall in negative temperatures for more than 6 hours. On the day of the event at Sofia Airport, realized until 15:00 pm, more than 30 aircrafts of different aviation operators arrive and depart without any problems, which were performed the obligatory anti-icing and anti-icing procedure before take-off.
From all departing aircraft, only those A 321 of the Hungarian airline WizzAir with registration marks HA-LXP, HA-LXL and HA-LXD received identical failures related to unreliable airspeed indications in the cockpit.
These aircraft are not able to perform their flight tasks normally and executed emergency procedures. The post-flight inspections revealed the presence of ice ridges in front of the pitot probes.

Unlike other aircraft operating normally after a short stay, the three Airbus A321 operated by aviation operator WizzAir landed at Sofia Airport the previous day and were overcooled and covered with a significant amount of snow during their long stay.

Without prior removal of the accumulated snow, the airplanes were treated approximately 30 minutes before take-off with type II fluid in the areas of the wing and tails, but not in the area of the front of the cockpit above the dynamic and static pressure sensors.

During the pre-flight preparation, the cockpit and passenger cabin were heated, as a result of which the accumulated snow over the fuselage melted and flowed down on the lower part, which in this area has a low temperature for obvious reasons and the melted slush freezes in the form of ice ridges. These ice ridges have formed on the lateral and lower surface of the aircrafts fuselage as the snow in the upper fuselage is not removed and melted and flowed after warming the aircraft cabins during standstill, taxiing or waiting for anti-icing treatment or other delay before take-off.

Detailed information for generating of ice ridges, their impact on aviation instruments and measures to prevent such ridges are given in Annex № 4 as developed and published by the aircraft manufacturer. The AIRBUS recommendations for winter operation are given in Annex № 5. The operating procedures in these extreme conditions are given in Annex № 6.

Neither the ground operator nor the operations centre of aviation operator or flight crews have requested that the accumulated snow and ice be removed from the aircrafts before the flights. As a result, all three flights were cancelled, with the first and third continuing take-off after the airspeed discrepancies found at 80-100kts. Their commanders decided that it would be safer to continue departure, because the surface friction (Poor-Medium) on the runway and they were not convinced of a safe stop within the runway. However, in the process of the initial climb, they were in a difficult situation due to unreliable speed readings, lack of visual conditions and the procedure for carrying out the activities envisaged in QRH. After about 15-20 minutes the flight crew decided to divert to Budapest (Hungary).

The crew of the second aircraft a few days before the event passed a regular training session on a flight simulator, where they repeatedly performed a rejected take-off in different conditions and poor braking action. Therefore, upon noticing the airspeed discrepancies during the takeoff run on the runway, the commander in his capacity as a pilot flying (PF) without hesitation rejected the takeoff and the aircraft returned to the parking apron at Sofia Airport without any problems.

As a result of the stress of the ATCO, which are direct witnesses of the events with the three similar aircraft of Wizz Air, the management of the BULATSA banned the operator's flights and convened a

meeting of the crisis headquarters in the presence of representatives of DG CAA and the Aircraft, Maritime and Railway Accident Investigation Unit Directorate, on which the decision was revoked..

2.1.3. Location of aviation occurrence

Location	Sofia Airport (LBSF) Bulgaria
Date and time:	26 February 2018
Lighting conditions:	Daylight;
The airport control point coordinate's	42°41'42"N 023°24'30"E.

2.2. Injuries to persons

No injuries of crews, passengers or other persons because of the occurrence.

2.3. Damage to aircraft

Fig. 1

As seen from the above photo, the flowing melted snow from the warmed shelter of the aircraft on the insufficiently heated side and bottom surface of the aircraft fuselage froze in the form of ice ridges on the lateral surface of the aircraft fuselage in front of the dynamic pressure sensors, which caused deviation in the readings between the different speedometers in the cockpit and a change in aerodynamic characteristics.

2.4. Other damages

No other damages.

2.5. Personnel information:

2.5.1. Flight crews

Standard – commander and co-pilot. The pilots of all three flight crew have valid ATPL(A) licenses. They have a different and enough experience of the type of aircraft. They don't have any interruptions in flight operations. The full information for each crew member is stored in case No 01/26.02.2018 at the archive of the Aircraft, Maritime and Railway Accident Investigation Unit Directorate.

The pilots of all three flight crew have medical certificate Class 1 without restrictions, valid as of the date of the event.

The Commission assumes that the all three flight crew have the necessary training and qualifications for his functional duties and that there is no breach of the rules on working time and pre-flight rest periods.

2.5.2. Cabin crew

Standard - 4-member cabin crew, not relevant to the event.

2.6. Aircraft Information

The three aircraft are type AIRBUS A321-231.

The maintenance is performed under a contract by GLOBAL MAINTENANCE. According to the certificates of Release to Service:

2.6.1. WZZ4427 Aircraft

Registration:	**HA-LXP**;
Manufacturer:	The Airbus SE, France;
Type of aircraft:	Airbus A321-231;
Factory serial number:	7488;
Manufactured:	March, 2017;
State of Registry:	Hungary;
Air Operator:	Wizz Air.
Engines:	Model V2533-A5;

2.6.2. WZZ4321 Aircraft

Registration:	**HA-LXL**;
Manufacturer:	The Airbus SE, France;
Type of aircraft:	Airbus A321-231;
Factory serial number:	7588;
Manufactured:	January, 2017;
State of Registry:	Hungary;
Air Operator:	Wizz Air.
Engines:	Model V2533-A5;

2.6.3. WZZ4351 Aircraft

Registration:	**HA-LXD**;
Manufacturer:	The Airbus SE, France;
Type of aircraft:	Airbus A321-231;
Factory serial number:	7032;
Manufactured:	March, 2016;
State of Registry:	Hungary;
Air Operator:	Wizz Air.
Engines:	Model V2533-A5;

2.6.4. Airworthiness Information

Design features of the A321 aircraft compared to the base A320

The A321 is short to medium range, narrow-body, commercial passenger twin engine jet aircraft. In fact, the model is an extended version of the widely known Airbus A320. The changes compared to the A320 are with increased fuselage length of 7 meters for greater capacity of the passenger seats and the area of the wings, as well as reinforcement of the landing gears. The aircraft can carry over 200 passengers in economy and 186 in two-class configuration, with a maximum flight range of 5,500 kilometres.

These design features also determine the differences in the procedures for treatment of aircraft with anti-icing fluid, illustrated below. The diagrams are published in GrHM, p.38 / 39, ISSUE REV #1.1.0 by AO WIZZAIR.REV #1.1.0 by AO WIZZAIR.

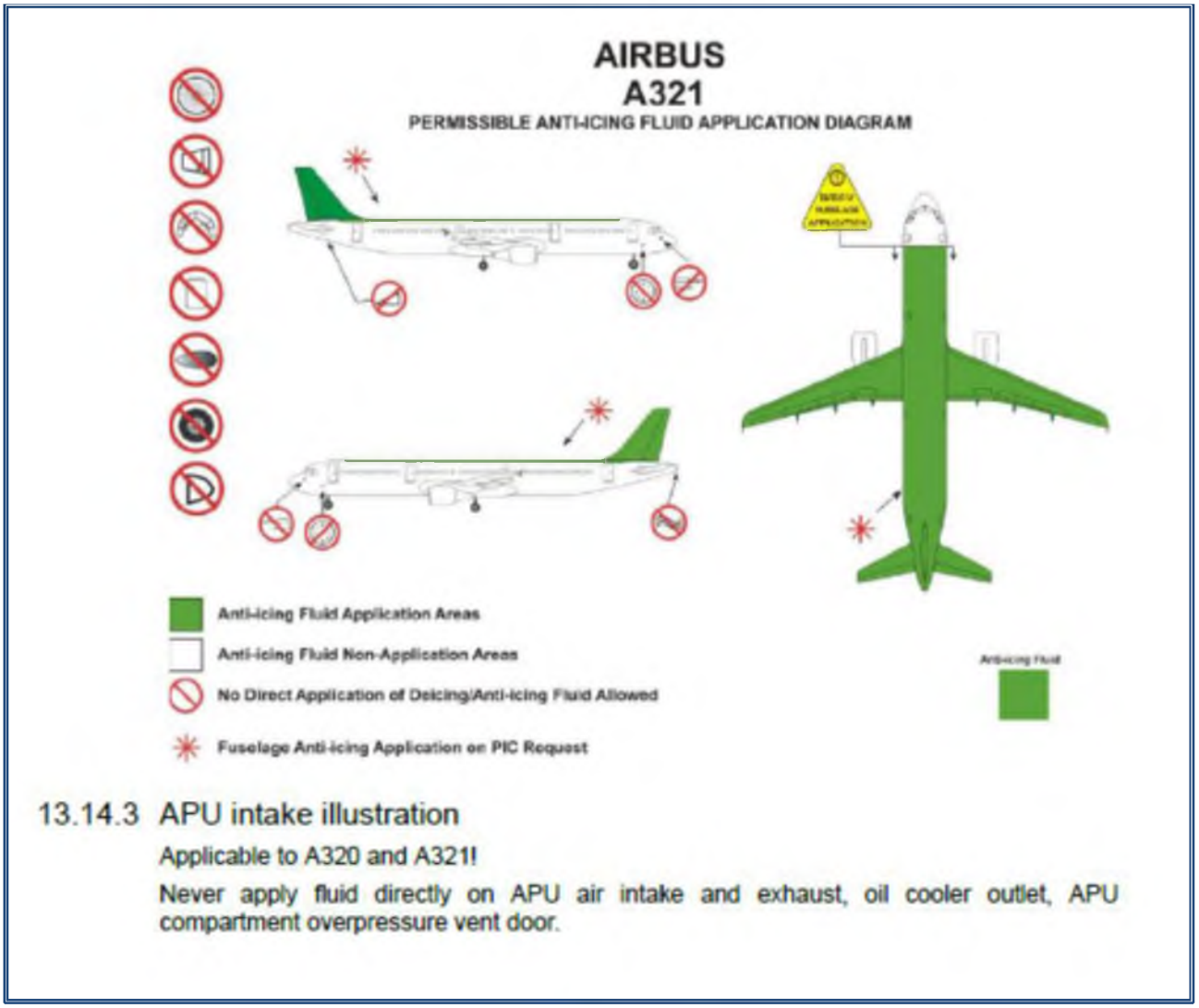


Fig.2

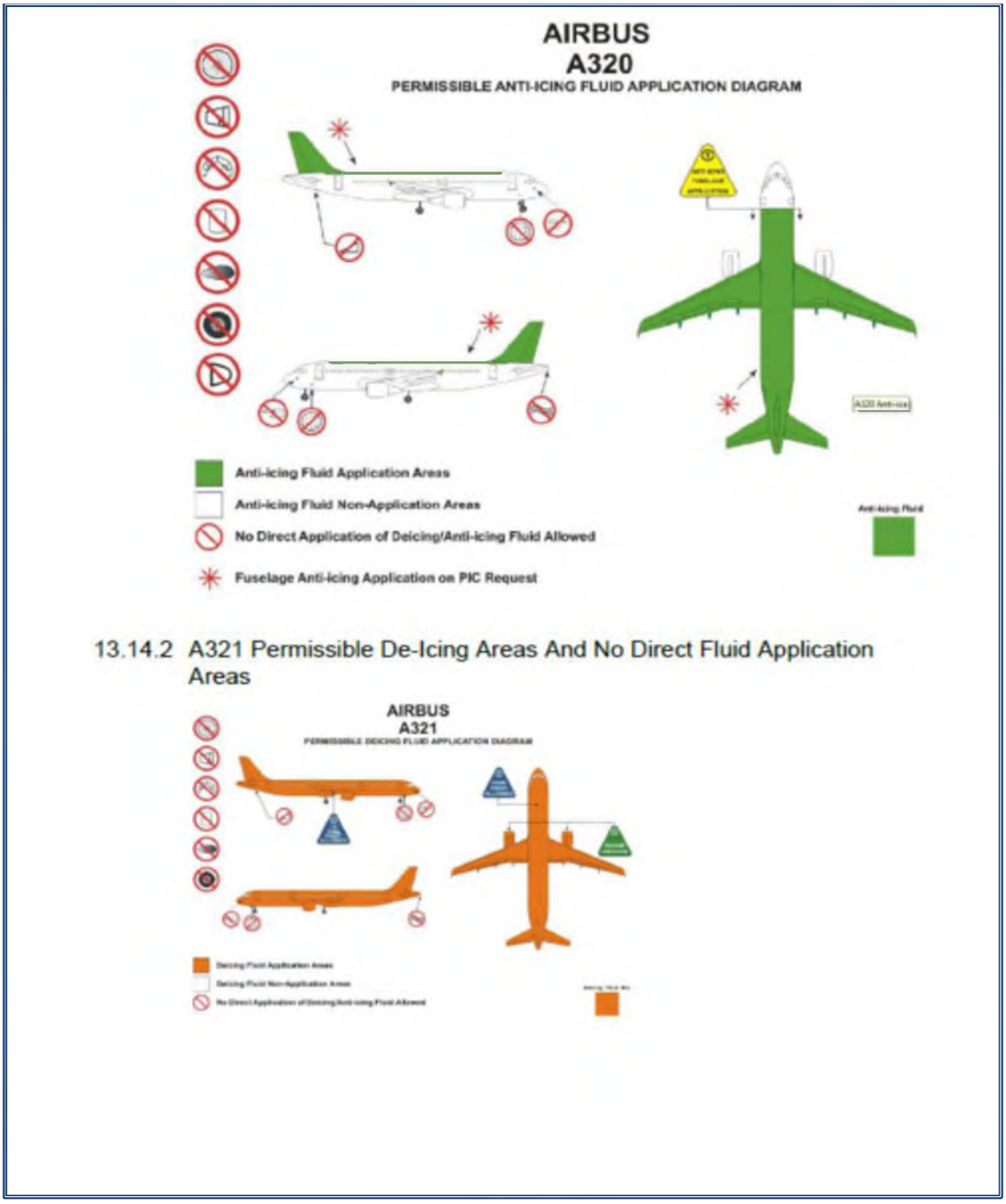


Fig.3

2.7. Meteorological information

2.7.1. Weather conditions at Sofia Airport

Period from 22:00 UTC on 25.02.2018 to 11:00 UTC on 26.02.2018

The country is under the influence of a Mediterranean cyclone in the process of occlusion and with a centre south - southwest of the country. From North East the southern part of a large anticyclone is observed transfer of cold air from the north-eastern part of Europe. This transmission enhances the observed processes. Accordingly, this leads to the formation of dense layered clouds reaching a height of about 6 km in which there are suitable conditions for icing of the aircraft, there is heavy snowfall and reduced visibility, increased wind, and its gusts on the Black Sea coast reach over 35-40 knots.

2.7.2. Aviation routine weather report METAR at Sofia Airport

LBSF 261100Z 12013KT 1900 SN FEW011 SCT020 OVC027 M07/M09 R99/4902293 TEMPO 1200 SN
LBSF 261000Z 12012KT 2500 SN FEW010 SCT027 OVC035 M09/M10 R99/4902293 TEMPO 1500 SN
LBSF 260930Z 12010KT 3500 -SN FEW010 BKN032 OVC039 M07/M09 R99/4902293 TEMPO 1500 SN
LBSF 260900Z 12010KT 2200 SN SCT009 BKN032 OVC034 M07/M09 WS ALL RWY R99/4902293 TEMPO 2000
LBSF 260800Z 05007KT 2200 SN FEW010 BKN031 OVC039 M07/M09 WS ALL RWY R99/4902293 TEMPO 1200
LBSF 260700Z 05007KT 2800 SN FEW009 SCT010 OVC030 M07/M09 WS ALL RWY R99/4902293 TEMPO 1200
LBSF 260600Z 04006KT 1800 SN FEW009 BKN015 OVC025 M08/M09 R99/4902293 TEMPO 0600 +SN

As shown above, the conditions are valid for the time from 06:00 h to 11:00 h UTC and are identical for all three flights. It is the weather condition that contributes to the escalation of incidents. Detailed information on the specific weather conditions for all three flight is given in Annex No2.

2.8. Aids to navigation

The three aircraft performed the flights with the standard navigation equipment for the aircraft type.

There are no reported technical failures of the navigation equipment of the aircraft.

The flights of the two aircraft were carried out in air space of Bulgaria, under the conditions of zonal navigation and in conformity with the Instrument Flight Rules.

There is no information about technical failures of the navigation system of the Bulgarian Air Traffic Services Authority (BULATSA), which could cause the occurrence.

All facilities included in the national net for course navigation operated normally.

In the daily briefing statement of the ACC Sofia, no technical failures were recorded, which might directly affect the operational ability at the time of the occurrence.

2.9. Communications

The three aircraft performed the flights with the standard communication equipment for the types of aircraft.

The air-ground radio communication in the FS Tower, the Approach and the aircraft serviced was carried out at the frequency of 118,100 MHz and 123.7 MHz in English.

After hearing the radio conversations at the operating frequencies of FS Tower and Approach, the Investigation Commission found that there had been no loss of radio communication and that there were no interruptions and disturbances during the radio broadcasting with not a single aircraft in the sector.

2.10. Aerodrome information

Aerodrome Location Indicator and Name – LBSF-SOFIA;
ARP coordinates and site at aerodrome - N42°41'42" E023°24'30", RWY centre;
Elevation - 1742 ft (531m);
Designations - RWY 09/27 - MAG 091°/271°;
Dimensions of RWY (m) - 3600 x 45 m;

Aircraft de-icing procedures are performed at designated places: Aircraft De-icing Pads EAST and WEST. Depending on RWY operation, only one Aircraft De-icing Pads shall be used. Aircraft de-icing

is done with engines on IDLE, in accordance with the standard operating procedures for the particular type of aircraft.

Aircraft De-icing Pads EAST is located at Twy L.

Aircraft De-icing Pads WEST is located between Twy A and Twy B.

Aircraft are taxiing and stop on their own at the designated position at the Aircraft De-icing Pads. On the left side of the lead-in line, there is a stop line, whose layout and dimensions

The communication between the cockpit and the aircraft de-icing coordinator at the Aircraft De-icing Pads is carried out on a special de-icing frequency.

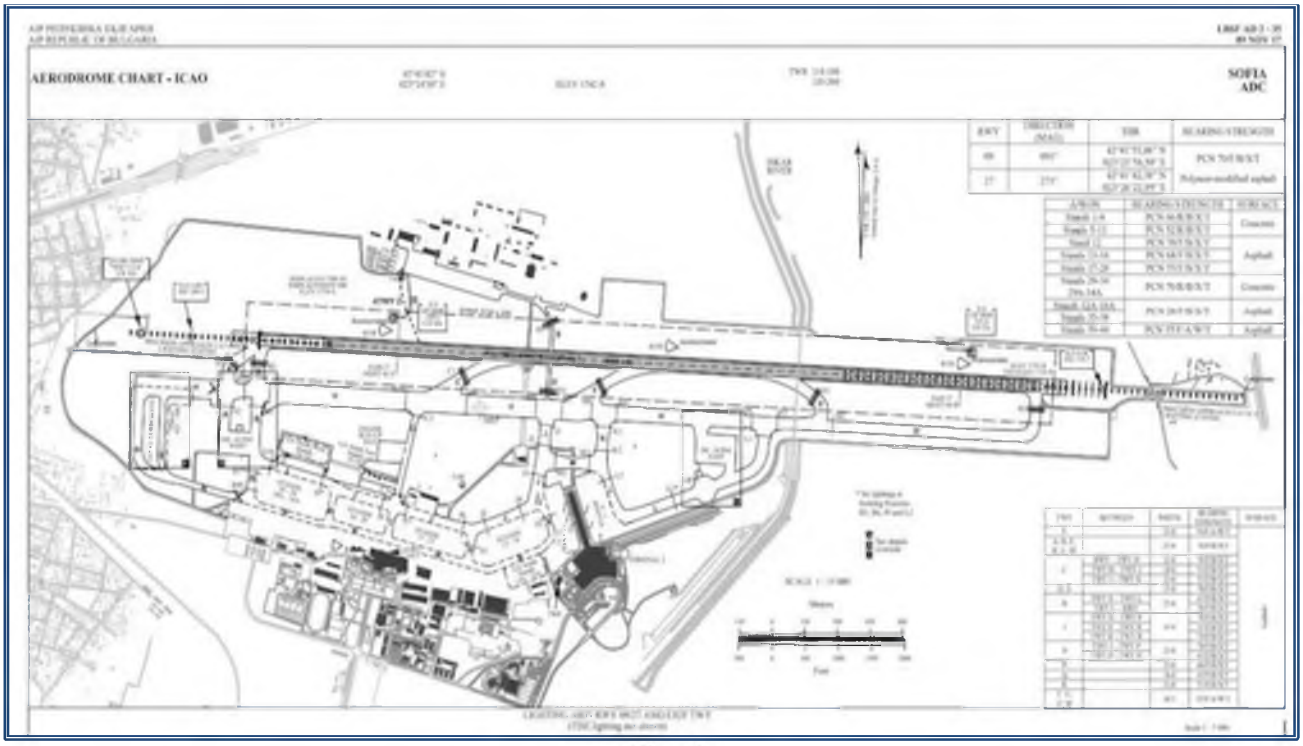


Fig. 4

2.11. Flight recorders

Data were used from the flight data recorders and post flight report of the A321-231 aircraft with registration marks HA-LXP, HA-LXL and HA-LXD, read by Airman-web, analyzed by the Commission.
The records are attached to the materials of the investigation in case № 01/26.02.2018.

Below are some of the warnings and messages that have appeared on ECAM for all three flight taken from the PFR. Brief information and excerpts from the analysis of flight recorders is given in Annex No3.

2.11.1. Flight WZZ4427/HA-LXP

Phase	Date Time	ATA	Source	Title
04-80 KTS	26 Feb 18 - 06:14	341200	EFCS 1	[ADR2]
05-LIFT OFF	26 Feb 18 - 06:14	279400	EFCS 1	[SEC2 OR BUS2 FROMADR1]
05-LIFT OFF	26 Feb 18 - 06:14	279400	EFCS 1	[SEC3 OR BUS2 FROMADR3]
				[null]
05-LIFT OFF	26 Feb 18 - 06:14	2700		[F/CTL]
05-LIFT OFF	26 Feb 18 - 06:15	2700		[F/CTL ALTN LAW]
				[null]
05-LIFT OFF	26 Feb 18 - 06:15	2200		[AUTO FLT]
05-LIFT OFF	26 Feb 18 - 06:15	2200		[AUTO FLT A/THR OFF]
05-LIFT OFF	26 Feb 18 - 06:15	2200		[AUTO FLT RUD TRV LIM SYS]
06-CRUISE	26 Feb 18 - 06:18	228300	AFS 1	[AFS:FMGC1]
06-CRUISE	26 Feb 18 - 06:18	228300	AFS 1	[AFS:FMGC2]
				[null]
06-CRUISE	26 Feb 18 - 06:15	226600	EIS 2	[FAC1(1CC1)/DMC2(1WT2)]
				[null]
05-LIFT OFF	26 Feb 18 - 06:15	3400		[NAV ADR DISAGREE]
				[null]
06-CRUISE	26 Feb 18 - 06:22	3400		[NAV ADR 1 FAULT]
06-CRUISE	26 Feb 18 - 06:23	345200	TCAS	[ATC1 (1SH1) / TCAS (1SG)]
06-CRUISE	26 Feb 18 - 06:23	3400		[NAV ATC/XPDR 1 FAULT]
06-CRUISE	26 Feb 18 - 06:23	3400		[NAV TCAS FAULT]
06-CRUISE	26 Feb 18 - 06:29	3400		[NAV ADR 1 3 FAULT]
06-CRUISE	26 Feb 18 - 06:29	3400		[NAV TCAS FAULT]
				[null]
06-CRUISE	26 Feb 18 - 06:23	341200	CFDS	[NO ADR 1 DATA (INTM)]
06-CRUISE	26 Feb 18 - 06:24	341200	CSAS FTIS	[ADIRU1(1FP1)/IGGS CTL UNIT (1YA)]
06-CRUISE	26 Feb 18 - 06:29	341200	CFDS	[NO ADR 3 DATA]
				[null]
06-CRUISE	26 Feb 18 - 06:23	2700		[SFCS]
Phase	**Date Time**	**ATA**	**Source**	**Title**
06-CRUISE	*26 Feb 18 - 06:24*	*226600*	*AFS 1*	*[AFS:FAC1(FIDS)/FMGC2]*
06-CRUISE	26 Feb 18 - 06:27	226600	AFS 1	[AFS:FAC1/P-B SW 12CC1]
06-CRUISE	26 Feb 18 - 06:27	226600	AFS 1	[AFS:FAC2/P-B SW 12CC2]
				[null]
06-CRUISE	26 Feb 18 - 06:27	2200		[AUTO FLT RUD TRIM1 FAULT]
06-CRUISE	26 Feb 18 - 06:27	2200		[AUTO FLT RUD TRIM2 FAULT]
06-CRUISE	26 Feb 18 - 06:27	2200		[AUTO FLT RUD TRV LIM SYS]
				[null]
06-CRUISE	26 Feb 18 - 07:06	3400		[NAV ADR 3 FAULT]
06-CRUISE	26 Feb 18 - 07:10	3400		[NAV ADR 3 FAULT]
				[null]
06-CRUISE	26 Feb 18 - 07:07	226600	AFS 1	[AFS:FAC1]
				[null]
06-CRUISE	26 Feb 18 - 07:07	2200		[AUTO FLT AP OFF]
				[null]
06-CRUISE	26 Feb 18 - 07:11	341200	EFCS 1	[ADR3]
				[null]
06-CRUISE	26 Feb 18 - 07:54	2700		[F/CTL DIRECT LAW]
08-TOUCH DOWN	26 Feb 18 - 07:56	2700		[F/CTL ALTN LAW]

2.11.2. FlightWZZ4321/HA-LXD

Phase	Date Time	ATA	Source	Title
02-ENG START	26 Feb 18 - 10:32	3600		[AIR ENG 1 2 BLEED FAULT]
				[null]
04-80 KTS	26 Feb 18 - 10:58	341200	EFCS 1	[ADR2]
06-CRUISE	26 Feb 18 - 11:02	341200	AFS 1	[AFS:ADIRU1/2/3 DISAGREE]
				[null]
04-80 KTS	26 Feb 18 - 10:58	2200		[AUTO FLT A/THR OFF]
05-LIFT OFF	26 Feb 18 - 10:59	2200		[AUTO FLT]
05-LIFT OFF	26 Feb 18 - 10:59	2200		[AUTO FLT RUD TRV LIM 1]
05-LIFT OFF	26 Feb 18 - 10:59	2200		[AUTO FLT RUD TRV LIM SYS]
06-CRUISE	26 Feb 18 - 11:02	2200		[AUTO FLT]
06-CRUISE	26 Feb 18 - 11:02	2200		[AUTO FLT AP OFF]
06-CRUISE	26 Feb 18 - 11:02	2200		[AUTO FLT RUD TRIM1 FAULT]
06-CRUISE	26 Feb 18 - 11:02	2200		[AUTO FLT RUD TRV LIM 1]
06-CRUISE	26 Feb 18 - 11:02	2200		[AUTO FLT RUD TRV LIM 2]
06-CRUISE	26 Feb 18 - 11:02	2200		[AUTO FLT RUD TRV LIM SYS]
				[null]
04-80 KTS	26 Feb 18 - 10:58	2700		[F/CTL]
04-80 KTS	26 Feb 18 - 10:58	2700		[F/CTL ALTN LAW]
				[null]
04-80 KTS	26 Feb 18 - 10:58	3400		[NAV ADR DISAGREE]
				[null]
05-LIFT OFF	26 Feb 18 - 10:59	226600	EIS 2	[FAC1(1CC1)/DMC2(1WT2)]
06-CRUISE	26 Feb 18 - 11:02	226600	AFS 1	[AFS:FAC1(FIDS)/FMGC2]
06-CRUISE	26 Feb 18 - 11:02	226600	AFS 1	[AFS:FAC1/P-B SW 12CC1]
06-CRUISE	26 Feb 18 - 11:02	226600	AFS 1	[AFS:FAC2/P-B SW 12CC2]
06-CRUISE	26 Feb 18 - 11:03	226600	AFS 1	[AFS:FAC2]
				[null]
05-LIFT OFF	26 Feb 18 - 10:59	279400	EFCS 1	[SEC2 OR BUS2 FROMADR1]
06-CRUISE	26 Feb 18 - 11:03	279400	EFCS 1	[SEC3 OR BUS2 FROMADR3]
Phase	Date Time	ATA	Source	Title
06-CRUISE	26 Feb 18 - 11:02	228300	AFS 1	[AFS:FMGC1]
06-CRUISE	26 Feb 18 - 11:02	228300	AFS 1	[AFS:FMGC2]
				[null]
06-CRUISE	26 Feb 18 - 11:10	2200		[AUTO FLT RUD TRIM2 FAULT]
06-CRUISE	26 Feb 18 - 11:14	2200		[AUTO FLT A/THR OFF]
06-CRUISE	26 Feb 18 - 11:14	2200		[AUTO FLT AP OFF]
06-CRUISE	26 Feb 18 - 11:14	2200		[AUTO FLT RUD TRV LIM SYS]
				[null]
06-CRUISE	26 Feb 18 - 11:16	3400		[NAV ADR 2 FAULT]
				[null]
06-CRUISE	26 Feb 18 - 11:16	341200	CFDS	[NO ADR 2 DATA]
				[null]
06-CRUISE	26 Feb 18 - 11:17	2700		[SFCS]
				[null]
06-CRUISE	26 Feb 18 - 12:45	2200		[AUTO FLT]
				[null]
06-CRUISE	26 Feb 18 - 12:54	2700		[F/CTL DIRECT LAW]
08-TOUCH DOWN	26 Feb 18 - 12:56	2700		[F/CTL ALTN LAW]

2.11.3. FlightWZZ4351/HA-LXL

Phase	Date Time	ATA	Source	Title
02-ENG START	26 Feb 18 - 07:51	3600		[AIR ENG 1 2 BLEED FAULT]
				[null]
04-80 KTS	26 Feb 18 - 08:19	341200	EFCS 1	[ADR2]
				[null]
04-80 KTS	26 Feb 18 - 08:19	2700		[F/CTL]
08-TOUCH DOWN	26 Feb 18 - 08:20	2700		[F/CTL ALTN LAW]
				[null]
08-TOUCH DOWN	26 Feb 18 - 08:20	2161		[AIR PACK 1 2 FAULT]
				[null]
04-80 KTS	26 Feb 18 - 08:20	3400		[NAV ADR DISAGREE]

2.12. Wreckage and impact information

The occurrence was not related to the aircraft destruction.

2.13. Medical and pathological information

Because of the nature of the aviation occurrence, medical and pathological research was not performed.

2.14. Fire

No fire arising.

2.15. Factors for Survival

The occurrence was not related to the need to carry out emergency - rescue actions.

2.16. Tests and research

For the safety investigation, the following activities were carried out:

- Collection, generalization and analysis of the factual information about the aviation occurrence at Sofia Airport;
- Research and analysis of the reports of the written reports, given by the flight crew, ATCO-Tower and Approach and grown crew performed the anti-icing treatment of the aircraft.
- Converses with the staff of the operational centre of the airline at Sofia airport and Budapest;
- Inspection of the aircraft with HA-LXL registration marks, which has rejected takeoff at Sofia Airport. Assessment of the status of the aircraft at the apron.
- Research and analysis of the photos of the other two aircrafts that landed in Budapest. The photos and the report of the investigation of the AO are stored in the archive of the AMRAUD;
- Operational meetings with the management of the BULATSA and representatives of DG CAA;
- Individual converses with the flight crews of the three aircraft;
- Research and analysis of the reports of the written reports, given by the flight crews;
- Analysis of the flight crew documents - validity of licenses, inspections, flight simulator training, medical certificates;
- Analysis of the flight time, engaged time and rest time of the flight crews referred to in point 2.5;
- Analysis of the anti-icing treatment program of WIZZAIR aircraft, their contract with the ground operator and the audits performed to ensure it;
- Collection and analysis of AO manuals relevant to the operation of the aircraft and its systems FCOM, AMM, MEL, QRH, TLB;
- Analysis of flight parameter records (DFDR) and post-flight record for technical failures and defects (PFR) of the on-board electronic system;
- Analysis of the operational and operational-technical documentation required and provided by the operator
- Analysis of the actions of the flight crews during the aviation occurrence

- Analysis of the meteorological information in the area of Sofia Airport and the condition of the runway during the occurrence;
- Operational and technical consultation with BEA and the aircraft manufacturer AIRBUS for similar incidents, possible causes and broadcast bulletins;
- Logical-probabilistic analysis of the possible causes for the realization of the aviation event.

2.17. Organizational and management information.

The pre-flight preparation of the aircraft of WIZZ AIR operating from and to Sofia Airport, including those with registration marks HA-LXP, HA-LXL and HA-LXD on the day of the event, is performed by the maintenance organization "Global Maintenance" Ltd. (№ BG.145.0015), according to a valid contract with WIZZ AIR.

According to a reference attached to the case, aircraft with registration marks HA-LXP, HA-LXL and HA-LXD were carried out an anti-icing treatment by Sofia Airport in accordance with a valid contract with WIZZ AIR. There is no evidence of snow removal and anti-icing protective spraying on the front of the aircraft fuselage. The terms and responsibilities of the contract between the aviation and airport operators are set out in the current Ground Handling Agreement Contract cover sheet.

2.18. Additional information

Documents issued by ICAO, EASA, Airbus and the air operator, as well as with subcontracts concluded by JSC WIZZ AIR, regulating the ground handling of aircraft, in case of removal and protection against icing.

- ICAO - The Manual of Aircraft Ground De-icing/Anti-icing Operations (Doc 9640) Second Edition 2000;

- EASA Safety Information Notice (SIN) 2008-29 Ground De-/Anti-Icing of Aeroplanes; Intake/Fan-blade Icing and effects of fluid residues on flight controls;
- EASA Safety Information Bulletin (SIB) 2010-26R1 Potential Performance Degradation of Anti-icing Fluids - Reduced Holdover Times;
- EASA Safety Information Bulletin (SIB) 2017-11 Global Aircraft De-icing Standards Starting this winter;
- EASA recommends air operators to use the latest published versions of the „Global Aircraft De-icing Standards“ as their reference material to establish their ground de-icing procedures;
- „FAA Holdover Time Guidelines“ as their reference to usable HOT tables, and to timely inform their de-icing service providers about these changes;
- EASA.2009.OP 21 Study on the regulation of ground de-icing and anti-icing services in the EASA Member States. Regulation (EU) No 965/2012, specifically point CAT.OP.MPA.250
- Regulation (EU) No 1321/2014
- ED Decision 2016/011/R
- Airbus -Getting to grips with Cold Weather Operations, 2000
- WIZZ AIR -COLD WEATHER OPERATIONS MANUAL REV 3 [10/2016], Page 5 of 152;
- AMM Selected applicability : ALL Customer : WZZ Type : A318/A319/A320/A321 Rev. Date : Feb 01, 2018 - Manual : AMM Selected applicability : ALL 12-31-00 – AIRCRAFT PROTECTION;
- Ground Handling Agreement (WIZZ AIR/ SOFIA AIRPORT)- Customer: WZZ Type: A318/A319/A320/A321 Rev. Date: Feb 01, 2018 Manual: AMM Selected applicability: ALL 12-31-12 - ICE AND SNOW REMOVAL - Type : A318/A319/A320/A321 Rev. Date: Feb 01, 2018. 12-31-12-660-008-A - Forward Fuselage Ice Accretion De-Icing.

3. Analysis

The analysis of the serious aviation accident is based on the conducted tests and research, described in item 2.16 of this report.

The Safety Investigation Commission were considered the following main hypotheses in order to identify the possible causes of the serious incident realized.

First hypothesis: Improper De-icing/Anti-icing procedures of aircraft before take-off, performed in violation of the written and agreed procedures between the aviation operator and ground handling operator.

Second hypothesis: Lack of control or incorrect control of the condition of the aircraft after the performed de-icing and anti-icing procedures.

Hypothesis Three: Errors of the flight crews related to the operation of the aircraft and the interaction, which led to a violation of the standard procedures of the aviation operator.

With regard to the first hypothesis, the Commission analyzed the regulating documents referred to in point 2.18 and contracts between aviation operator, the ground handling operator and the aerodrome operator carrying out the De-icing/Anti-icing procedures of aircraft before take-off. There were no deficiencies from the prescribed procedures. The pre-flight preparation of aircraft with registration HA-LXP, HA-LXL and HA-LXD, on the day of the event was carried out by the maintenance organization "Global Maintenance" Ltd. (No BG.145.0015), under an existing contract with AO WIZZ AIR. The work task submitted and signed for activities carried out, omissions and violations in the implementation of it have not been established.

According to a reference described in the table below, aircraft with registration marks HA-LXP, HA-LXL and HA-LXD have been carried out the De-icing procedures by the ground crew of Sofia Airport under an existing contract with AO WIZZ AIR. There is no evidence of snow removal and De-icing protective spraying on the front of the fuselage of the aircraft. The terms and responsibilities of the contract between the aviation operator and airport operators are set out in the ground handling agreement cover sheet in force at the time of the event.

Aviation operator	Type of aircraft	Flight number	Destination	Data and time of landing	Time of De-icing procedures	Total of treatment aircrafts
Wizz Air (W6)	A-320	4301	LTN	25/21:33	06:18	5
		4331	DTM	26/02:17	07:04	
	A-321	4427	TLV	25/18:49	07:45	
		4321	BVA	25/16:47	09:56	
		4351	BGY		12:40	
		4329	FRA		15:20	

Because of the fact that all three A321 aircraft, involved in the serious incident, operated by one airline operator, the focus of the investigation was mainly on the following factors:

•Why there are the failures only on an Airbus A321-type aircraft?

•Are the procedures for removing snow and ice protection of aircraft operated by AO WIZZ AIR correct?

•Is the permissible time for protection from aircraft icing observed in the interval between processing and take-off for the type of liquid used.

The accumulation of snow and the formation of ice on the surfaces of aircraft is a familiar phenomenon in operation of the Aircraft in winter conditions. The reasons for icing of aircraft surfaces and removal and protection measures are well known and repeatedly addressed and described in ICAO, EASA, Airbus documents, investigative committee reports, national Regulations and descriptions of aviation operators.

These documents address concepts of Clean Aircraft, Aircraft Protection, Anti-Icing Protection Tools, Removal and Protection Fluids on Land, Defensive Action Times, and Procedural Checks when Conducting Anti-Icing Protection of Aircraft on Land, Responsibilities, Anti-Icing Protection Methods, Personnel Training, Aircraft Management, Plan from the BULATSA in winter conditions, etc.

The aircrafts of WIZZ AIR landed the day before at Sofia Airport and during their stay were covered with a significant amount of snow, and the fuselage of the aircraft has cooled to temperatures below 0°. According to the explanations of the ground crew during the preparation, the aircraft were treated with Type II liquid in the areas of the wing and tails, but not in the area of the front part of the cabin above the receivers for dynamic and static pressure. The attached table shows the processing time, which lasted about 15 minutes and the interval until their departure.

Registration	**Time of De-icing procedures (UTC)**	**Time of takeoff run**	**Interval between de-icing procedures and takeoff (min)**	**Permissible time for protection (iaw. GOM of WIZZ AIR) Type 2-100%-(min)**
HA-LXP	05:45+15	06:07	(22 -15)=7	8
HA-LXL	07:56+15	08:19	(23 -15)=8	8
HA-LXD	10:40+15	10:58	(18 -15)=3	8

In preparation for the flight, the cockpit and passenger cabin are heated, as a result of which the snow accumulated on the aircraft of the aircraft melted and running down, which in this area has a lower temperature for obvious reasons and the melted water freeze in the form of ice ridges. Such ice ridges are often observed on the lateral and lower surface of the fuselage of aircraft when the snow in the upper part of the fuselage is not removed and melted after warming the aircraft cabins during parking on apron, taxiing or waiting for De-icing procedure or other delay before takeoff.

The GLOBAL MAINTENANCE report after the occurrence stated that "…the problem with the A320 is known and the precautions are described below in the excerpt from the WIZZ AIR WINTER OPERATIONS SAFETY PROGRAM Winter 2017/2018.

These ice ridges in front of the sensors are a common phenomenon for the aircraft type and are considered and described in the manufacturer's and operator's documents as follows in the annex.

"…

TRAINING DEPARTMENT COLD WEATHER OPERATIONS MANUAL REV 3 [10/2016] Page 119 of 152
- ICE/SNOW REMOVE FROM WINDSHIELD/UPPER COCKPIT FUSELAGE
- PROBE/WINDOW HEAT ON

- SURFACES CHECKED FREE OF FROST, ICE AND SNOW
CAUTION With ice or snow accumulated on the windshield/upper cockpit fuselage, and if the PROBE/WINDOW HEAT pb is turned on, melted snow running down from the cockpit windows could re-freeze on the fuselage area below, when the temperature is very low. This could create ice build-up on the forward fuselage that could possibly disturb the airflow around the static/pitot/angle-of-attack probes.
..."

The attached excerpts from Airbus and WIZZ AIR documents show that the procedures for protection of aircraft from ice in critical areas are provided;

(„These procedures are Airbus recommended for de-icing and anti-icing requirements. Job Set-up Information Ref 12-31-12-660-008-A). 2 Forward Fuselage Ice Accretion De-Icing Cause of Ice Ridges -Main root cause •Ice accretion at lower nose fuselage during long stay on ground in cold temperature conditions •AND lower nose fuselage not de-iced before departure Conclusion Even thin Ice Ridges should be removed from the fuselage Ice Ridges •be aware that ice ridges build-up on the lower nose fuselage •may create airflow perturbation in front of probes •may result in unreliable air data measurement from take-off and subsequent UAS situation Threat and error management in aircraft preparation •Lower nose fuselage should be free of ice & snow before take-off •In case of any doubt request de-icing.
COLD WEATHER OPERATIONS MANUAL REV 3 [10/2016] Page 17 of 152
4. Procedure Subtask 12-31-12-660-069-A A. Radom and Forward Fuselage De-icing
WIZZ AIR POLICY (OMA): RESPONSIBILITIES GROUND ENGINEER AND/OR DE-ICING/ANTI-ICING AGENT At stations where no ground engineer is available, the de-icing/anti-icing ***handling agent is responsible*** *for the correct and complete de-icing/anti-icing treatment of the aircraft.*
COMMANDER ***The Commander is responsible*** *for determining the need for de/anti icing and has final responsibility for ensuring that all critical aircraft surfaces are free of frost, ice, snow or slush prior to departure and at take-off "*

Based on the reviewed documents, the commission assumed that the manuals of the aviation operator WIZZ AIR include all current requirements from the documents of ICAO, EASA and Airbus for conducting anti-icing protection of aircraft on the ground.

De-icing procedure of aircraft with registration HA-LXP, HA-LXL and HA-LXD on the day of the occurrence was executed by the composition of Sofia Airport under an existing contract with AO WIZZ AIR. According to the terms and responsibilities of the contract, and in particular on page 6 – item 3.17.3; 3.17.7 and 3.17.8. it is recorded that the composition of Sofia Airport carries out the removal and protection of the air from ice, as well as a final inspection and informing the crew of the results.

According to EASA regulations, the implementation of icing removal and protection activities does not require the approval of a maintenance organization. However, the necessary checks to detect and, where necessary, remove de-icing fluid residues are considered maintenance. Such inspections may only be carried out by suitably authorized personnel. The basic requirements are:

(*TRAINING AND QUALIFYING OF PERSONNEL 1.1 Standards for personnel carrying out the de-icing/anti-icing procedures are explained in this chapter and policies and procedures that the ground and flight crews must learn in training are listed. 1.2 De-icing/anti-icing procedures must be carried out only by trained and qualified personnel. 1.3 Both initial and recurrent training for flight crews and ground crews are to be conducted to ensure that all such crews obtain and retain a thorough knowledge of aeroplane ground de-icing/anti-icing policies and procedures, including new procedures and lessons learned.).*

Regarding second hypothesis: Lack of control or incorrect control of the condition of the aircraft after the performed de-icing and anti-icing procedures.

All aircraft of the "family" of Airbus A320 - (A318, A319, A320 and A321) are similar in appearance, with small differences in dimensions. The procedures for anti-icing and de-icing of the different operators are similar. Quality control of the completed activity is performed in the De-icing Pads by a ground crew who reports by the radio to the flight crew about the results. In all three cases, the inspections were carried out by three different personnel who did not detect the untreated lower nose fuselage of the aircraft.

The lack of adequate training of the staff performing the work directly and of the controlling personnel's after that has significantly contributed to the poor quality and incomplete de-icing/anti-icing procedure. As a result, pilots are unprepared for the difficult situation of running take-off in bad weather and poor surface friction on RWY.

Regarding the third hypothesis - Errors of the flight crews related to the operation of the aircraft and the interaction.

The Commission did not detect the weaknesses in the actions of the flight crews, errors and deviations from the prescribed procedures. Pre-flight preparation has been thoroughly conducted, severe weather and RWY conditions have been foreseen. It is a pilots responsibility to reject or to continue take-off and the decision to ensure safety has been taken in time deficit.-Thanks to the pilot's skills, they have coped with the difficult situation and the flights have ended uneventfully.

The flight crews of the other two aircraft with registration HA-LXP and HA-LXD, were found a discrepancy between airspeed tape on PDF 1 and PDF 2 at about 80-100 kt, but surprised and the rapid acceleration and rapid reach of V1, they decided to continue take off due to braking action in Sofia. As a result, they performed a holding pattern above the airport and ran into themselves in an abnormal situation. Their tensions are also being passed on to air traffic controllers, who are waiting for developments of situation without being able to provide assistance.

In view of the above analysis, the dominant factors for the realization of the serious incident could be attributed to mainly to:

1. Non-compliance with the adverse snowy weather conditions by the ground crews, performing and participating in the preparation of the aircraft for the flights related to the serious incident.
2. Admission to flight of the aircraft with the presence of ice after De-icing procedure with anti-icing fluid by the ground crew, organizing and performing the treatment.

4. Conclusion

4.1. Findings

As result of the investigation, the Commission made the following conclusions:

1. The three Aircraft AIRBUS A321-231, have been certified, equipped and serviced in accordance with existing regulations.

2. All three airplanes have a valid certificates of airworthiness in accordance with the regulations.

3. The technical logbooks (TLBs) shall certify that the maintenance and preparation of the aircraft for the flights on that day has been carried out in accordance with existing regulations.

4. The mass and balance of the aeroplanes were within the permissible limits.

5. There is no evidence of a failure or malfunction that led to the serious incident.

6. On the day of the event, the weather conditions at Sofia Airport are typically winter with continuous snowfall and negative temperatures below -5°C.

7. The accumulated snow during the night stay of the aircrafts has not been removed.

8. No De-icing procedure has been performed on the front of the aircraft fuselage.

9. De-icing procedure was performed by an operator of Sofia Airport in the area of the wings, the fuselage behind the cockpit and the tails of the aircraft.

10. The procedures in the Airbus and WIZZAIR documents provide protection from ice and snow in the critical areas of the aircraft, but have not actually been fulfilled by the ground staff.

11. A person of the Ground Handling Operator Sofia Airport operator shall carry out a final inspection and inform the crew of the results.

12. The flight crew is not able to personally check the quality of the De-icing procedure performed.

13. The snow falling on the snow warmed in the upper fuselage of the aircraft melted, then ran down the cold of stay and under heated lateral and lower surface of the fuselage of the aircraft and frozen in form of ice ridges.

14. The formed ice ridges on the side surface of the aircraft fuselage in front of the dynamic pressure sensors is the reason for discrepancies between airspeed tape on PFD1 and PFD2.

15. The Aviation Operators WIZZ AIR and the Ground Handling Operator Sofia Airport submitted training protocols as well as audits carried out in accordance with EASA recommendations.

16. The flight crew of three aircraft, Commanders and Co-pilots, possess the required qualification and medical fitness for flights in accordance with existing regulations.

17. There are no violations of the norms for flight and working hours of the crews.

4.2. Causes

Based on the analysis performed, the Commission points out that the serious incident resulted from the following causes:

1. Non-compliance with the adverse weather conditions of snowfall by the ground crews performing and participating in the preparation of the aircraft for the flights related to the serious incident.

2. Admission to flight of the aircraft with the presence of ice after De-icing procedure with anti-icing fluid by the ground crew, organizing and performing the treatment

5. Safety Recommendations and measures taken since the serious incident

5.1 Safety recommendations

Taking into account the causes of the serious incident and the deficiencies found in the investigation, the Commission recommends that the following measures should be taken to ensure the flight safety:
BG.SIA-2018/01/01. Bulgarian DG CAA to include in the National Safety Plan as a risk factor the risk of disruption of airspeed discrepancies for A321 aircraft, as well as for all other similar aircraft types, in the presence of snow cover on the fuselage of the aircraft and requires aviation organizations associated with the operation of this type of aircraft to have developed procedures to minimize its impact.

5.2 Safety actions taken since the serious incident
5.2.1 Action taken by the ***aviation operator WIZZ AIR***
The aviation operator WIZZ AIR informed in e-mail of 26th of February 2018, that amongst others the following measures have been taken:

- The lower part of the fuselage in the cockpit zone before departure in the similar meteorological conditions will be additionally treated with a brush and hot air.
- Special attention to rivet on the clean area of Pitot probes after de-icing procedures completed.

5.2.2 Action taken by the ***airport operator SOFIA apt***
Sofia apt gave up approved De-icing/Antiicing Program for year 2017/2018. All causes, Safety Recommendations and measures taken since the serious incident will be included in seasonal theoretical preparation. There was no writing information about other taken measures up to now.
5.2.3 Action taken by the ***manufacturer AIRBUS***
Airbus has communicated towards its operators around the risk of unreliable airspeed measurements in case of ice ridges presence in front of the pitot probes, through the following different means:
- Magazine AIRBUS SAFETY FIRST (issue 26), article "Look out for Ice Ridges on the Lower Nose Fuselage" - https://safetyfirst.airbus.com/look-out-for-ice-ridges-on-the-lower-nose-fuselage/
- Specific presentation on the Ice Ridges "A320 event in adverse weather conditions" at the Airbus 24th Flight Safety Conference (2018)
- AIRBUS WIN (Worldwide Instructor News), video "*What about the Exterior Walkaround?*" https://www.airbuswin.com/wp-content/uploads/2020/09/external-walkaround-en.mp4

The following are Annexes 1, 2, 3, 4, 5, and 6, which are an integral part of the report.

The Investigation Commission reminds all organizations, to which flight safety recommendations are sent that, on the grounds of Article 18 of Regulation (EU) 996/2010 on Investigation and Prevention of Accidents and Incidents in Civil Aviation and Article 19, paragraph 7 of Ordinance No. 13 on the Investigation of Aviation Accidents are obliged to notify the Air, Maritime and Railway Accidents Investigation National Board in writing of the action taken on the recommendations made.

AIR, MARITIME AND RAILWAY ACCIDENTS INVESTIGATION NATIONAL BOARD

COMMISSION ON INVESTIGATION OF THE SERIOUS INCIDENT

Sofia **31.01.2022**

ANNEX 1
PILOT REPORTS (PIREP)

PIREP - FLIGHT W6-4427/HA-LXP

SR-201802-429 Unreliable speed indication - Diverted to BUD 26/02/2018 10:32 UTC HA-LXP, A321

Flight # 4327 (SOF-TLV)

It was a long que for de-icing. We had a delay of 25min for de-icing. Than we were cleared to start-up and taxied to the de-icing area west, with follow me car due to the adverse weather conditions. Tower told us to hold on the taxiway due to the snow removal vehicles. Than we continued to the de-icing area and tower advised us to expect a delay due to snow removal of 20min. We decided to shut down the engines due to fuel saving reasons. Started de-icing. When de-icing in 2steps, 50/50 full aircraft, 100 wings and tail was finished. We started the engines again and taxied behind Lufthansa to hp 09. 10min after we could line up were cleared for takeoff.

During the takeoff roll capt pf/fo pm, at approx. 100 kts we found a discrepancy between airspeed tape on PDF 1 and 2. Decision to continue due to braking action in Sofia. During lift off we experienced unreliable speed. Capt applied memory items toga 15 and at thrust reduction climb 10. Continued climb 10.000ft and later 12.000ft due to msa. Started with paper checklist and cleaned up the aircraft. Crew found unreliable speed on pfd1 and isis. Pfd 2 was reliable. Crew switched controls, switched bird on and started ecam and paper checklist. Options were considered regarding lw/fuel/wx. Initially decision was taken to go to lybe. Dodar was applied, nits briefing was performed, company was notified and pax were informed. During descent when workload was decreased we decided to put adr 1 back on trying to recover and adr 3 as well. During this process we realized that adr 1 became reliable and isis not. Than we tried to re-engage the automation and a/trust was recovered. FD's and AP failed. Finally we continued toflied with adr 1 and 2 on, a/trust on, bird on, AP off, manually flight. During this time the distress call was pan pan. After review the situation we decided to proceed to Budapest due to ops reasons and because we recovered adr1. We continued climb to FL 280 due to RVSM restrictions. Approach was done 31R in direct law after gear was down. At 800ft capt took control to continue with stabilization criteria. Aircraft landed uneventful at Budapest and stopped on the RWY for assessment and standard were made to cabin. We continued to stand where we parked. During the flight we never declared an emergency, because it was a pan pan. Also the ATC was informed about this.

PIREP - FLIGHT W6-0401 / HA-LXL

SR-201802-434 Rejected take-off (110 kt) due to unreliable speed after de-icing in snowy weather 26/02/2018 8:28 UTC HA-LXL, A321

Flight # 4321 (SOF-BVA)

Our flight was delayed for 2h and 30min due to heavy snow and low temperature -7C at SOF (number 9 for de-icing). After two steps of de-icing we received take off clearance for RW09. I was LH seated PF.

At 100kt I did not receive a call from PM, so I did a call 100kt and PM respond me that his speed is 80kt I checked quickly his PFD and find out that the speed trend fluctuate up and downaround 80kt. My call was UNRELIABLE SPEED and STOP (at around 100-110kt), followed by rejected take off procedure as per company SOP (Attention crew at station and cancel alert).

Later on we have an ECAM. OCC and MCC was informed as soon as we stop on stand. The flight was cancelled. Additionally I send a pilot report about a small speed discrepancy of aircraft, departed from SOF airport.

PIREP - FLIGHT W6-1208 / HA-LXD

SR-201802-443 Unreliable speed indication - diverted to BUD

26/02/2018 11:05 UTC HA-LXD, A321

Flight # 4351 (SOF-BGY)

After take-off unreliable speed was observed. QRH procedure was applied. Flight was levelled at FL180 for troubleshooting. ADR2 was detected faulty and switched off. The flight continued according to flight plan and was climbing as cleared to FL240. We decided to stop climb at FL200 and held position to divert back to SOF. We were holding for about 20 minutes waiting for snow removal at SOF. After snow removal the reported braking action was MEDIUM- POOR.

Decision was made to divert to BUD due to the weather and runway condition.

ANNEX 2
WEATHER INFORMATION

METAR DATA

LBSF 261100Z 12013KT 1900 SN FEW011 SCT020 OVC027 M07/M09 Q1006 R99/490293 TEMPO 1200 SN BKN010= LBSF 261000Z 12012KT 2500 SN FEW010 SCT027 OVC035 M09/M10 Q1007 R99/490293 TEMPO 1500 SN BKN010= LBSF 260930Z 12010KT 3500 -SN FEW010 BKN032 OVC039 M07/M09 Q1007 R99/490293 TEMPO 1500 SN BKN010=

LBSF 260900Z 12010KT 3200 -SN FEW009 OVC034 M07/M09 Q1008 WS ALL RWY R99/490293 TEMPO 2000 SN BKN010= LBSF 260830Z 07007KT 2200 SN SCT009 OVC034 M07/M08 Q1008 WS ALL RWY R99/490293 TEMPO 1200 SN BKN008=

LBSF 260800Z 05007KT 2200 SN FEW010 BKN031 OVC039 M07/M09 Q1008 WS ALL RWY R09/490293 TEMPO 1200 SN BKN008= LBSF 260730Z 05007KT 2400 SN SCT010 OVC035 M07/M10 Q1008 WS ALL RWY R99/490093 TEMPO 1200 SN BKN008=

LBSF 260700Z 05007KT 2800 SN FEW009 SCT024 OVC030 M07/M09 Q1009 WS ALL RWY R99/490093 TEMPO 1200 SN BKN005= LBSF 260630Z 04007KT 2000 SN FEW007 SCT009 OVC027 M07/M09 Q1009 WS ALL RWY R09/490093 TEMPO 1200 SN BKN005= LBSF 260600Z 04006KT 1800 SN FEW009 BKN015 OVC025 M08/M09 Q1009 R09/490292 TEMPO 0600 +SN BKN003=

METAR DATA ANALYSIS LINKED TO FLIGHT W6-4427

LBSF 260600Z 04006KT 1800 SN FEW009 BKN015 OVC025 M08/M09 Q1009 R09/490292 TEMPO 0600 +SN BKN003=

Analysis:

The last available METAR published at 06h00 UTC, ~10min before the take-off of flight W6- 4427 (06h14 UTC), provides the following main information:

-Wind direction North-North-East 40°, wind speed 6kt
-Visibility 1800m
-Moderate snow
-Few clouds at 900 feet
-broken clouds at 1500ft
-overcast at 2500ft
-Temperature -8°C, Dew point -9°C
-Relative humidity 92%
-QNH 1009 hPa.
-Runway 09 dry snow, 51-100 % of runway covered, deposit depth 2 mm, poor/medium braking action.

METAR DATA ANALYSIS LINKED TO FLIGHT W6-0401

LBSF 260730Z 05007KT 2400 SN SCT010 OVC035 M07/M10 Q1008 WS ALL RWY R09/490093 TEMPO 1200 SN BKN008=

Analysis:

The last available METAR published at 07h30h UTC, ~10min before the rejected take-off of flight W6-0401 (07h41 UTC), provides the following main information:

-Wind direction North-East 50°, wind speed 7kt
-Visibility 2400m, Moderate Snow
-Scattered clouds at 1000 feet, overcast at 3500 feet
-Temperature -7°C, Dew point -10°C
-Relative humidity 79%
-QNH 1008 hPa.

-Wind shear
-Runway 09: dry snow, 51-100 % of runway covered, depth <1 mm, medium braking action

METARS DATA ANALYSIS LINKED TO FLIGHT W6-1208

LBSF 261100Z 12013KT 1900 SN FEW011 SCT020 OVC027 M07/M09 Q1006 R09/490293 TEMPO 1200 SN BKN010=

Analysis:
The last available METAR published at 11h00 UTC, corresponding to the take-off time of flight W6-1208 (10h59 UTC), provides the following main information:
-Wind direction East-South-East 120°, wind speed 13kt
-Visibility above 1900m
-Moderate Snow
-Few clouds at 1100 feet
-Scattered clouds with its base at 2000 feet
-sky overcast at 2700 feet
-Temperature is -7°C with a dew point at -9°C
-Relative humidity 86%
-QNH 1006 hPa.
-Runway 09: dry snow, 51-100 % of runway covered, deposit depth 2 mm, medium braking action

These weather conditions were present from 06:00 h to 11:00 h UTC, and therefore applicable to the all 3 flights.

ANNEX 3

FLIGHT DATA READOUT AND ANALYSIS

The following analyses are based on the data extracted from the DAR he 3 following events are analysed separately, however a common synthesis is provided in the end of annex.

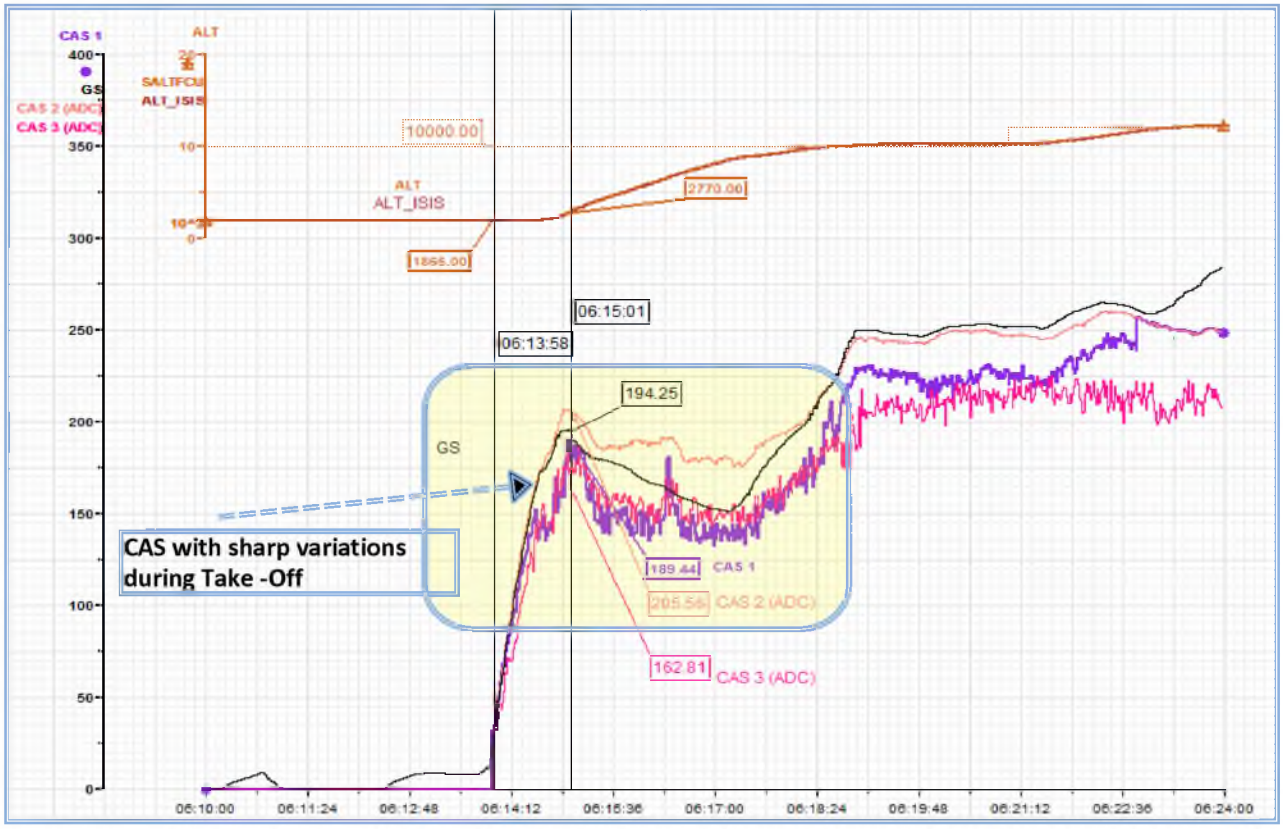
FLIGHT W6-4427

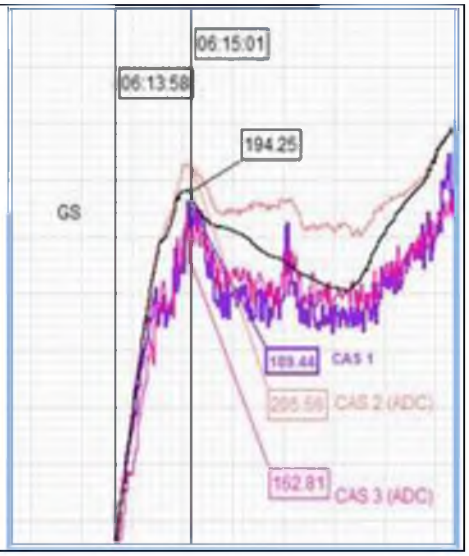
MSN 7578, a Wizz Air Airbus A321, registration HA-LXP performing flight W6-4427 from Sofia (Bulgaria) to Tel Aviv (Israel), experienced an unreliable airspeed with reversion to alternate law.
The crew decided to divert to Budapest (Hungary) for an uneventful landing on runway 31R about 105 minutes after departure from Sofia.

Take-Off phase, AFS and normal law loss

Initial conditions at 06:14 UTC:

- A/C was in CONF 2
- A/C was aligned on RWY 09 (HDG = 090°)
- TLs were set to MCT notch (Flex Take-Off)
- Both FDs engaged in SRS/RWY mode
- A/THR armed in THRUST mode
- GS and CAS started to increase
- SAT was recorded at -8.3°C



At 06:14:35 UTC, A/C took-off with GS=170kt - CAS1 reached 136kt, CAS2 was 171kt and CAS3 was 146kt - The three CAS were varying with sharp variations In the PFR at 06:14 UTC, the following failure messages were recorded: - "ADR2" [source EFCS] meaning that both ELAC or SEC (EFCS) incriminate ADR2 - "SEC2 OR BUS2 FROM ADR1" meaning that EFCS (SEC2) has detected a difference between ADR 1&2 - "SEC3 OR BUS2 FROM ADR3" meaning that EFCS (SEC3) has detected a difference between ADR 2&3	

Analysis:

Most probably, the ADR2 was rejected by EFCS during the take-off roll due to CAS2 discrepancy with the 2 other CAS.

At 06:14:44 UTC, At 06:14:44 UTC, A/C was crossing 183ft RA, at GS=179kt,
- TLs were set to TOGA notch,
- Pitch was +15

Analysis:

After the lift off, pilots have maintained the Pitch angle to +15° in TOGA notch before reaching the Thrust Reduction Altitude. This is consistent with the Pitch & Thrust Memory Items from the Unreliable Airspeed Indication procedure (see the Figure below).
The AP was OFF, the ATHR and FDs were kept engaged.

UNRELIABLE SPEED INDICATION

- **If the safe conduct of the flight is impacted:**

AP	OFF
A/THR	OFF
FD	OFF
PITCH/THRUST:	
Below THRUST RED ALT	15° / TOGA
Above THRUST RED ALT and Below FL 100	10° / CLB
Above THRUST RED ALT and Above FL 100	5° / CLB
FLAPS (if CONF 0(1)(2)(3))	MAINTAIN CURRENT CONF
FLAPS (if CONF FULL)	SELECT CONF 3 AND MAINTAIN
SPEEDBRAKES	CHECK RETRACTED
L/G	UP

When at, or above MSA or Circuit Altitude: Level off for troubleshooting.

Unreliable Airspeed Indication procedure (QRH)

At 06:15:00 UTC, A/C was crossing 850ft RA
- A/C was manually handled
- TLs were set to MCT notch,
- CAS1=189kt, CAS2=205kt and CAS3=162kt.

Sharp variations are observed on the three CAS.
- FD1 and FD2 disengaged
- ATHR disengaged
- FAC1F and FAC2F Boolean were recorded at 1

At 06:15 UTC, in the PFR, the following ECAM alerts and failure messages were recorded:
- **AUTO FLT A/THR OFF**
- **AUTO FLT RUD TRV LIM SYS**
- **F/CTL ALTN LAW**
- **NAV ADR DISAGREE**
- FAC(1CC1)/DMC2(1WT2) [source EIS2]

Zoom from figure 6

Analysis:
Then, during lift off, the CAS discrepancy has increased with a difference of more than 40kt between CAS1 and CAS3 (considering ADR2 already rejected).
In accordance with the different ECAM and maintenance messages mentioned above, at this time it most likely leads to the rejection of at least another ADRs by the AFS (FAC) and EFCS with the following impacts:
- AP, FD and ATHR functions were lost.
- The rudder travel limiter function and the characteristic speeds were lost.
- Flight control reverted to ALTERNATE LAW

ADR rejections are latched in the EFCS. Therefore, normal law was not recovered up to the end of the flight.

FLIGHT DATA ANALYSIS OF FLIGHT W6-0401

The 26th February 2018, a Wizz Air Airbus A321, MSN 7488, registration HA-LXL performing flight W6-0401 from Sofia (Bulgaria) to Beauvais (France), was accelerating for take-off on Sofia's runway 09 when the crew rejected take-off at 80 knots reporting unreliable airspeed indications. The RTO was uneventful.

Rejected Take-Off

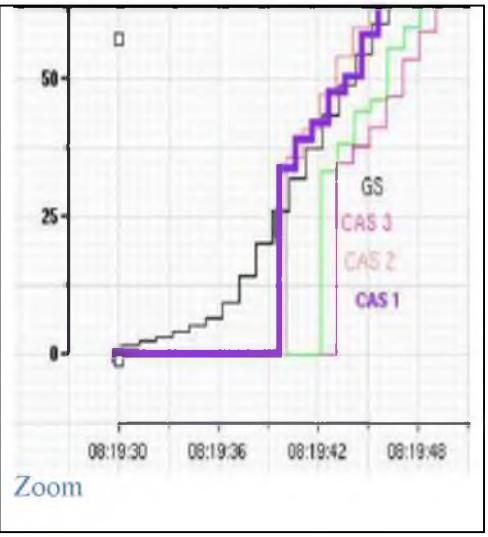
Initial conditions at 08:19:38 UTC:
- - A/C was aligned on RWY 09
- - A/C was in CONF 2
- - BRKMAX recorded at 1
- - Thrust Levers were pushed to TOGA notch
- - Both FDs engaged in SRS/RWY mode
- - A/THR was engaged and armed in THRUST mode
- - GS started to increase ;
- - CAS1 and CAS2 became valid at 08:19:39 UTC
- - CAS3 became valid at 08:19:43 UTC
- - SAT was recorded at -7°C

Plotted data / Speed and Altitude data

At 08:19:43 UTC, when CAS3 became valid:

1

- GS=43kt, CAS2 = 54kt and CAS1 =47kt.



Analysis:

During take-off roll, CAS1 and CAS2 became valid first (i.e. increased above 30kt) then the CAS3 became valid 4s later meaning that CAS3 was not consistent with CAS1 and CAS2.

When CAS3 reached 30 kt, the following airspeed discrepancies were recorded:

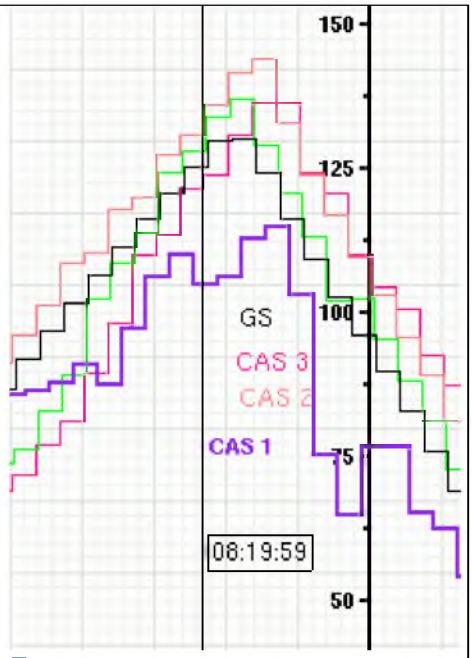
- up to 20kt between CAS3 and CAS2
- more than 10kt between CAS1 and CAS3
- more than 10kt between CAS1 and CAS2

At 08:19:59 UTC, A/C reached GS=125kt:

2

- CAS1=104kt,
- CAS2=130kt
- CAS3=121kt.

In this time, the PFR recorded the following failure message:
- 08:19 UTC : 'ADR2 [source EFCS]'
- - 08:20 UTC : **NAV ADR DISAGREE AND F/CTL ALTN LAW alerts**

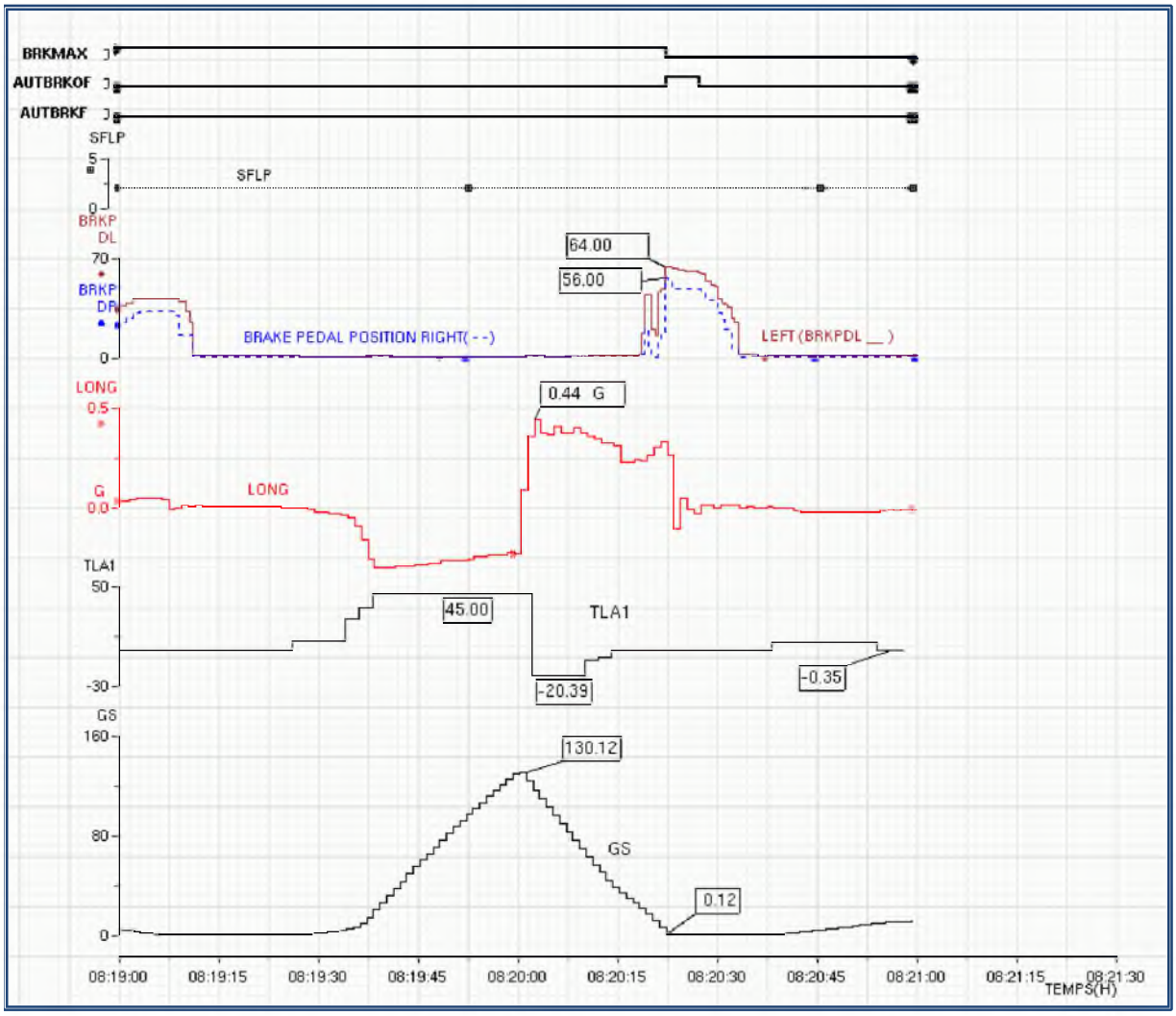


Zoom

Analysis:
The message on ECAM and maintenance messages, the message NAV ADR DISAGREE was triggered most probably because ADR2 was already rejected by ELAC and whether another discrepancy was detected between the 2 remaining ADRs. As a result of at least two ADR rejected by EFCS, Flight control reverted to ALTERNATE LAW.

At 08:20:02 UTC:
- Thrust Levers were set to MAX REVERSE notch
- - Ground speed was recorded at 130 kt
- - Ground spoiler deployed accordingly
- - BRKMAX and BRKMAX2 recorded at 1
- - Longitudinal Acceleration recorded at 0.44G

At 08:20:10 UTC:
- - Thrust Levers were set to IDLE notch.
- - Ground speed was recorded at 69kt,
- At 08:20:22 UTC,
- - BRKMAX recorded from 1 to 0
- - Brake Pedal Position left = 64 degA
- - Brake Pedal Position left = 55 degA
- - AUTBRKOF recorded at 1 during 5 seconds
- - A/C stopped (GS=0kt).



Rejected Take-Off

Analysis:

Following the Thrust Levers set to MAX REVERSE, the A/C started to decrease with the Autobrake function at the maximum (BRKMAX=1).

The autobrake was disconnected by pedal application when both brake pedals were manually deflected (Brake Pedal Positions left and right recorded above 40degA)

The take-off was rejected and the aircraft slowed uneventfully from 130kt until final stop in around 20 seconds.

FLIGHT DATA ANALYSIS OF FLIGHT W6-1208

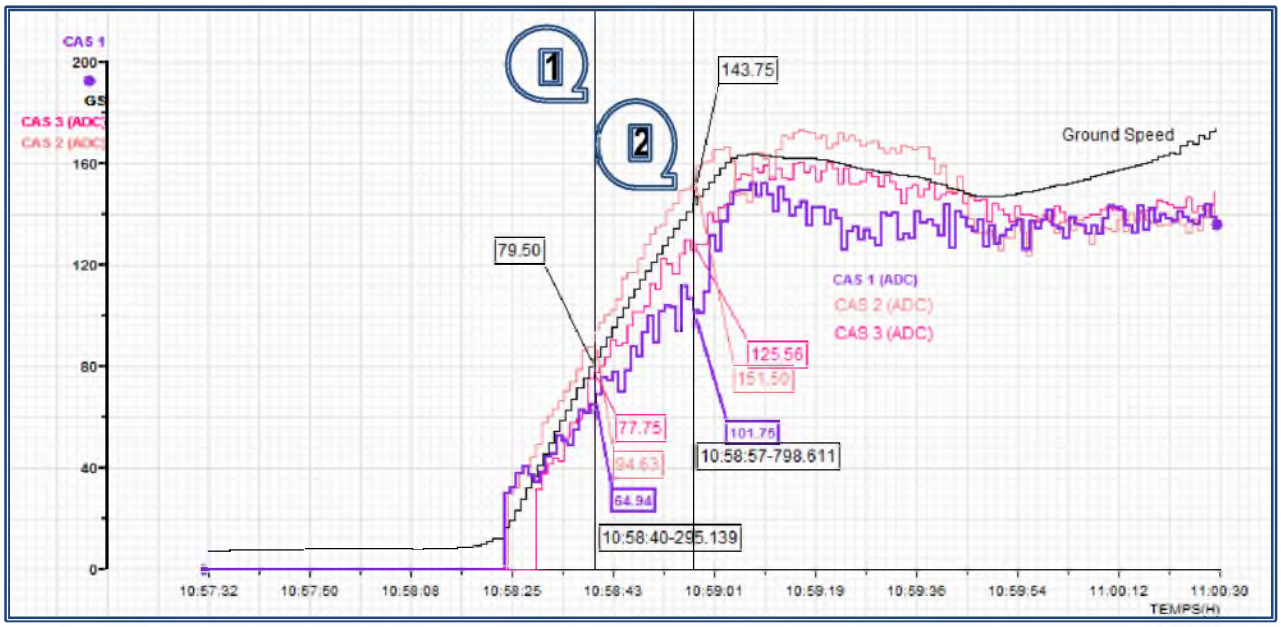
The 26th February 2018, a Wizz Air Airbus A321, MSN 7032, registration HA-LXD performing flight W6-1208 from Sofia (Bulgaria) to Milan Bergamo (Italy) was climbing out of Sofia cleared to climb to FL280 when the crew reported unreliable airspeed indications.

The crew decided to divert to Budapest (Hungary), and landed uneventfully.

Take-Off phase, loss of AFS and normal law

Initial conditions at 10:58:27 UTC:

- A/C was aligned on RWY 09 in CONF 2
- TLs were pushed to TOGA notch
- Both FDs engaged in SRS/RWY mode
- A/THR engaged and armed in THRUST mode
- GS and CAS started to increase
- SAT was recorded at -7.5°C



Plotted data / Take-Off

At 10:58:40 UTC:

1

- A/C reached GS=79kt
- - CAS1 =65kt, CAS2= 95kt, and CAS3 = 78kt.

10:58:50 UTC:

Flight controls reverted to alternate law.

At 10:58:58 UTC:

2

- A/C reached GS=144kt;
- CAS1=106kt, CAS2=151kt and CAS3=125kt;
- All three recorded CAS present sharp variations;
- ATHR disengaged
- - FD1 and FD2 still engaged in SRS/RWY mode

At 10:59:03 UTC, the A/C lifted off

At 10:59:20 UTC:

- CAS1=142kt, CAS2=169kt and CAS3=152 kt
- FAC1F and FAC2F Booleans were recorded at 1
- FD1 and FD2 disengaged

Analysis:

During take-off roll and initial climb, discrepancies up to 45 kt were recorded between CAS1 and CAS2 and up to 25 kt were recorded between CAS1 and CAS3.
All three CAS were presenting sharp variations.
In the PFR, the following ECAM alerts and failure messages were recorded in this time window:
- 10:58 UTC: ADR2 [source EFCS1]
- 10:58 UTC: NAV ADR DISAGREE
- 10:58 UTC: AUTO FLT A/THR OFF
- 10:58 UTC : F/CTL ALTN LAW
- 10:59 UTC : SEC2 OR BUS2 FROM ADR1 [source EFCS1]
- 10:59 UTC : FAC1(1CC1)/DMC2(1WT2) [source EIS2]
- 10:59 UTC: AUTO FLT RUD TRV LIM 1
- 10:59 UTC: AUTO FLT RUD TRV LIM SYS

At this time at least two ADR sources were rejected by AFS (FAC1, then FAC2) and EFCS. As a result:
- A/THR function was lost and FDs lost twenty seconds later
- RTL and characteristic speeds were lost by FAC1 then FAC2

Flight controls reverted to ALTERNATE LAW.
As ADR rejections are latched in the EFCS, Normal law was not recovered up to the end of the flight.

At 11:02:05 UTC:

CAS1= 135kt, CAS2= 167kt и CAS3= 156kt.

FLIGHT DATA ANALYSIS SYNTHESIS

The flight data analysis from the 3 flights presented in the previous paragraphs indicates the following common points between the 3 events:

- The 3 aircraft were departing from the same airport, Sofia in Bulgaria

- It was the first of the day for each aircraft, after a night stop

- Weather conditions were similar:

  - cold and humid conditions
  - temperatures from -7°deg to -10°C, close to the dew point
  - moderate snow

- These 3 flights were affected by unreliable airspeed indications (sharp variations of the 3 recorded CAS)

- These airspeed discrepancies were detected as expected by the AFS and the EFCS and resulted in:

  - Loss of AP, FD and ATHR
  - Loss of characteristic speeds
  - Loss of RTL function

Loss of NORMAL LOW and reversion to ALTERNATE LAW until the end of flight (except for the RTO)

ANNEX 4

ICE RIDGES

On ground, in cold weather conditions, water could freeze on the fuselage, generating ice accretion ("ice ridges") on the lower part.

Several causes can lead to such ice ridges being present on the aircraft, even after de-icing:

- Lower (nose) fuselage not properly de-iced before departure
- After de-icing / anti-icing operation, snow melts on the heated windshield and runs down from windshield onto the nose fuselage, creating ice accretion (re-freezing)

Examples of Ice ridges

Even thin ice ridges on the lower nose fuselage may disrupt the airflow upstream to the pitot probes. AoA measurement can also be impacted by this phenomenon.
Such discrepancies can disappear in flight or remain until A/C landing.

Airspeed discrepancies will be detected by the AFS and EFCS, potentially resulting in the following degradations if 2 or 3 probes are affected:

- Loss of AP, FD and ATHR
- Loss of characteristic speeds
- Loss of RTL function
- Loss of normal law and reversion to alternate law until the end of flight.

Ice build-up in front of air data probes can lead to erroneous air data measurement.

These 3 events are consistent with the ice ridges scenario as:

- Weather conditions were favourable to ice accretion
- Unreliable airspeeds were recorded, starting during the take-off roll.
- EFCS and AFS impacts were as described above.

ANNEX 5

RECOMMENDATIONS

In ground icing conditions, Airbus recommends to:

- Closely inspect nose fuselage in search of any trace of ice ridges.
- Perform de-icing procedure to remove any ice build-up trace, even thin it is, not only on windshield and probes surroundings but on the entire nose fuselage paying specific attention to lower nose fuselage.
- In case of any doubt request additional de-icing

Zoom on Ice accretion on lower fuselage

ANNEX 6

OPERATIONAL CONSIDERATIONS

This section contains the relevant FCOM procedure and FCTM extract related to prevention of such events. They are provided by Airbus in the Operational Documentation available on Airbus-World and valid at the date of this Analysis report publication.

FCOM - ADVERSE WEATHER

PRO-NOR-SUP-ADVWXR Adverse Weather "Cold Weather"

GROUND OPERATIONS IN COLD WEATHER CONDITIONS

Ident.: PRO-NOR-SUP-ADVWXR-B-00020700.0001001 / 19 APR 18 - IN CREATION
Criteria: (SA)

EXTERIOR WALKAROUND

SURFACES ..... CHECK FREE OF FROST, ICE AND SNOW

L2 Check critical surfaces: leading edges, upper wing surfaces, vertical and horizontal stabilizers, all control surfaces, slats and flaps.

Note: *Thin hoarfrost is acceptable on the upper surface of the fuselage. Refer to LIM-ICE_RAIN Definition of Thin Hoarfrost*

On the underside of the wing tank areas, a maximum layer of 3 mm (0.125 in) of frost is acceptable.

L1 LANDING GEAR..... CHECK FREE OF FROST, ICE AND SNOW

L2 Check gear assemblies, lever locks, tires and doors

L1 ENGINES..... CHECK FREE OF FROST, ICE AND SNOW

L2 Check inlets, inlet lips, fans, spinners, fan exhaust ducts, reversers assemblies.

L1 ENGINE FANS..... CHECK FREE ROTATION

L2 Check that engine fans are not stuck and can rotate freely.

L1 DRAINS, BLEEDS, PROBES..... CHECK FREE OF FROST, ICE AND SNOW

L2 Probes: pitot tubes, static ports, TAT sensors and AOA sensors.

L1 FUEL TANK VENTS..... CHECK FREE OF FROST, ICE AND SNOW

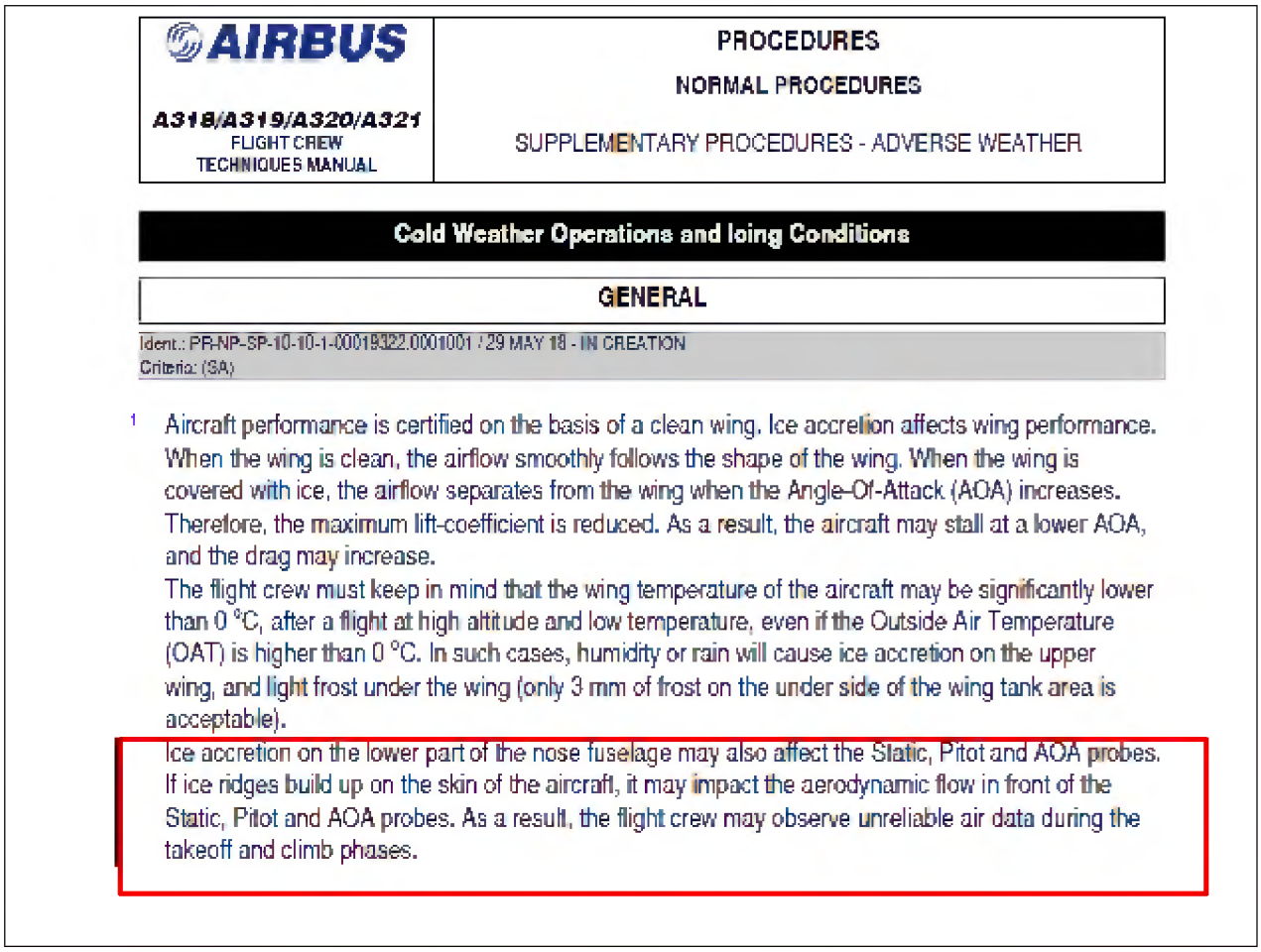
RADOME CHECK FREE OF FROST, ICE AND SNOW

Lower part of the NOSE FUSELAGE..... CHECK FREE OF FROST, ICE AND SNOW

WATER SUPPLIES..... CHECK NOT FROZEN AND REFILLED

L2 Commercial water supplies should have been previously emptied prior to aircraft cold soak.

FCTM - ADVERSE WHEATER



AIRBUS

A318/A319/A320/A321
FLIGHT CREW
TECHNIQUES MANUAL

PROCEDURES

NORMAL PROCEDURES

SUPPLEMENTARY PROCEDURES - ADVERSE WEATHER

Cold Weather Operations and Icing Conditions

GENERAL

Ident.: PR-NP-SP-10-10-1-00019322.0001001 / 29 MAY 18 - IN CREATION
Criteria: (SA)

1 Aircraft performance is certified on the basis of a clean wing. Ice accretion affects wing performance. When the wing is clean, the airflow smoothly follows the shape of the wing. When the wing is covered with ice, the airflow separates from the wing when the Angle-Of-Attack (AOA) increases. Therefore, the maximum lift-coefficient is reduced. As a result, the aircraft may stall at a lower AOA, and the drag may increase.
The flight crew must keep in mind that the wing temperature of the aircraft may be significantly lower than 0 °C, after a flight at high altitude and low temperature, even if the Outside Air Temperature (OAT) is higher than 0 °C. In such cases, humidity or rain will cause ice accretion on the upper wing, and light frost under the wing (only 3 mm of frost on the under side of the wing tank area is acceptable).
Ice accretion on the lower part of the nose fuselage may also affect the Static, Pitot and AOA probes. If ice ridges build up on the skin of the aircraft, it may impact the aerodynamic flow in front of the Static, Pitot and AOA probes. As a result, the flight crew may observe unreliable air data during the takeoff and climb phases.

ADDITIONAL REFERENCES

There is additional *Airbus Documentation*, available on *AirbusWorld*, and valid at the date of this report publication:

- Getting to Grips with Cold weather operations.

- Airline Operations Policy Manual (AOPM) Chapter 8.2.4 – De-icing and anti-icing on the ground.
- "ICEMAN" LM Handbook.
- 24th Flight Safety Conference presentation "A320 event in adverse weather conditions"
- Airbus Safety first issue #26 article "Look out for Ice Ridges on the Lower Nose Fuselage"

Airbus has developed and Airbus WIN (Worldwide Instructor News) video "What about the ExteriorWalkaround?" which covers the verification of ice ridges presence during the walkaround.

https://www.airbus-win.com/wpcontent/uploads/2020/09/external-walkaround-en.mp4