Transporta nelaimes gadījumu un incidentu izmeklēšanas birojs

Transport Accident and Incident Investigation Bureau of the Republic of Latvia

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FINAL REPORT No 4-02/1-23(1-24)

on the serious incident to the aircraft Airbus A220-300 (CS300) registered YL-AAP operated by airBaltic runway excursion at the Riga International Airport (RIX), on March 8, 2023

The Aircraft Accident and Incident Investigation Bureau of the Republic of Latvia is a governmental, independent of all aviation authorities and, in general, of any other party or entity the interests or missions of which could conflict with the task entrusted to the safety investigation authority or influence its objectivity, organization established by law to investigate and determine the cause or probable cause of accidents and serious incidents that occurred in the civil aviation, as well if necessary for enhancing flight safety incidents. The sole objective of the safety investigation in accordance with Annex 13 to the Convention on International Civil Aviation, the Regulation (EU) No 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in Civil Aviation as well as Cabinet Regulation No 423 of May 31, 2011 “Procedures of Civil Aviation Accident and Incident investigation” is the prevention of future accidents and incidents. The Report shall contain, where appropriate, safety recommendations. Safety investigation is separate from any judicial or administrative proceedings and Investigation Report is not deal with purpose to apportion blame or liability but only for purpose of the safety enhancement. The Report shall protect the anonymity of any individual involved in the accident or serious incident.

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ABBREVIATIONS

ATM	Air Traffic Management
AC	Aircraft
ATPL	Air Transport Pilot's License
ANSP	Air Navigation Service Provider
CVR	Cockpit Voice Recorder
DME	Distance Measuring Equipment
FDR	Flight Data Recorder
METAR	Meteorological Aerodrome Report
CAMET	General Aviation Meteorological forecast
TAF	Terminal Area Forecast
OFC	Operational Flight Check
QNH	Altimeter setting to obtain aerodrome elevation when on the ground
NOTAM	Notice to Airmen
TO/GA	Take-Off/Go-Around thrust
UTC	Coordinated Universal Time
PIC	Pilot-in-Command
FO	First Officer
PM	Pilot Monitoring (First Officer)
PF	Pilot Flying (PIC)
ATC	Air Traffic Controller
ATIS	Automatic Terminal Information Service
ASDA	Accelerate Stop Distance Available
IFR	Instrument Flight Rules
TORA	Take-off Run Available
TODA	Take-off Distance available
LDA	Landing Distance Available
RWY	Runway
THR	Threshold
ILS	Instrument Landing System
RWYCC	Runway Condition Code
RCR	Runway Condition Report
SNOWTAM	Snow Notam
OM	Aircraft Operation Manual
TLA	Thrust Lever Angle
AGL	Above Ground Level
RFFS	The Rescue and Fire Fighting Services of the Riga airport
TWY	Taxiway
APP	The approach controller
A-SMGCS	Advanced Surface Movement, Guidance and Control Systems
TWR	Tower
TR	Thrust reversers
FMS	Flight Management System (an aircraft operations computer)
QRH	Quick Reference Handbook
MFS	Multi-Function Spoiler

Investigation No 4-02/1-23	**Aircraft Registration:** YL-AAP
Aircraft: Airbus A220-300 (Bombardier/BD-500-1A11(CS300))	**Type of flight:** Scheduled (BT 694), IFR
Engines: Pratt & Whitney PW1521G-3	**Flight:** BT1-4HE
Crew: 6	**Passengers:** 89
Place: Riga, Latvia	**Date and Time:** 2023.03.08/21.18 UTC

All times in this report are UTC. Local time UTC + 2 hours.

Synopsis

Unless stated otherwise the time in this Report is UTC

The aircraft involved in the serious incident on March 8, 2023 was operating a scheduled flight from the Paris, Charles de Gaulle International airport (**LFPG**), to the Riga International airport (**EVRA**); the aircraft call sign was BT1-4HE. This was the second flight on that day for the flight crew.

At **21:18** p.m., the flight BTI-4HE of the AirBaltic airline aircraft suffered a runway excursion after landing on the RWY18 in the Riga International airport (RIX). During the landing ground roll and after reducing of airspeed the aircraft deviated to the right of the runway centerline and started skidding. The aircraft came to a complete stop with the nose landing gear wheels approximately 11m from the runway paved surface (see Figure 1 and 2) and 1560m from the THR18 (Threshold of the RWY). Both MGL (Main Landing Gear) remained on runway paved surface. The passengers and the crew of the aircraft were disembarked safely.

Figure 1: The aircraft at the serious incident site

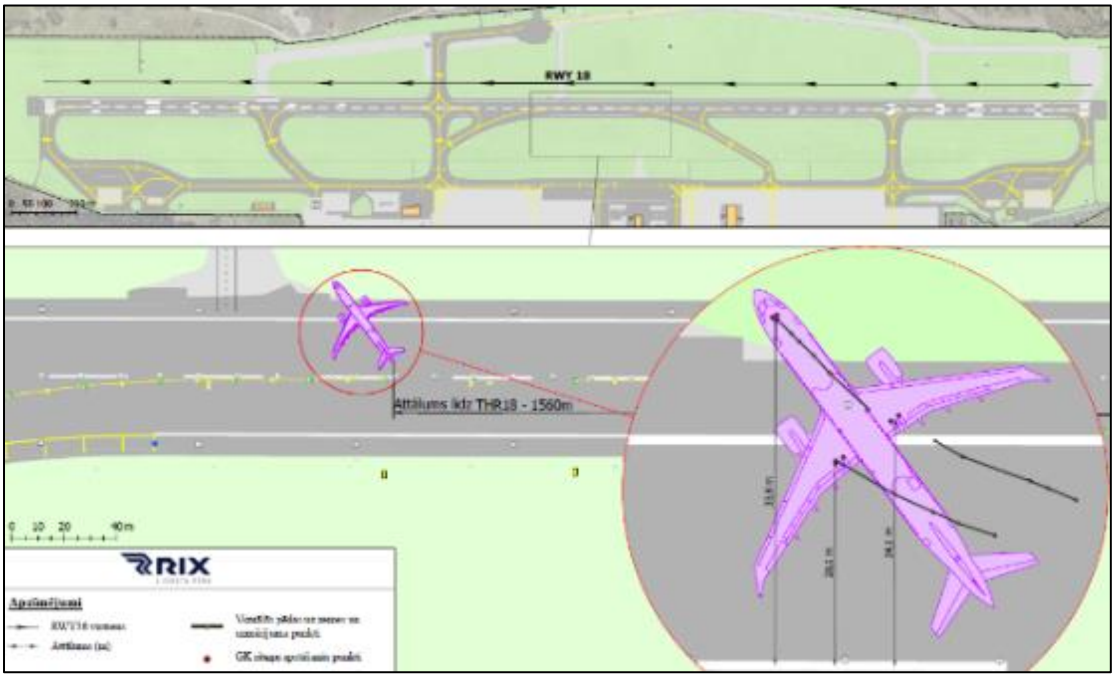


Figure 2: Location of the aircraft after the occurrence (source: RIX scheme on 08.03.2023)

Notification

The RIX OVC notified the Transport Accident and Incident Investigation Bureau of the Republic of Latvia (TAIIB) about the occurrence on March 8, 2023 at 23:24 local time.

Immediately after the occurrence the following organizations have been notified by the TAIIB according to Annex 13 and Regulation (EU) No 996/2010:
- the International Civil Aviation Organisation (ICAO);
- the European Aviation Safety Agency (EASA);
- the European Commission (EC);
- the Investigation Authority of Canada (TSB);
- the Investigation Authority of USA (NTSB);
- the Latvian CAA.

Investigation

The TAIIB of Latvia as the State of Occurrence, the State of Registry and the State of Operator instituted an investigation into the circumstances of the occurrence according to Annex 13, Section 5.1 and started to conduct the investigation with the Canadian TSB as an accredited representative, as well as with Airbus as a technical advisor.

Under the provisions of Annex 13 to the Convention on International Civil Aviation (Chicago 1944) and the Regulation (EU) No 996/2010 the TAIIB initiated a data collection from the institutions involved in this serious incident: aircraft operator, Riga International airport (RIX), ANS provider etc.

Investigation materials:

- Reports from the airport and the air traffic control (ATC);
- Flight crew licences and Medical Certificates;
- Flight crew interviews;
- Flight Safety Report of the airBaltic;
- Riga Airport Investigation Report, video recordings and scheme of the occurrence;
- GAMET and ATIS data;
- METAR and TAF to the Riga Airport;
- FDR and CVR data;
- Advanced Surface Movement Guidance and Control System (A-SMGCS) records;
- Technical documentation and manuals for the A220 aircraft;
- Comments and clarifications from Airbus;
- Riga Tower and Ground radiotelephony transcripts;
- Aircraft Certificate of Registration;
- Aircraft Certificate of Airworthiness.

1. FACTUAL INFORMATION

1.1 History of the Flight

On March 8, 2023 the scheduled flight BT-694 from the Paris, Charles de Gaulle International airport (CDG), to the Riga International airport (RIX) was performed by the airBaltic airlines aircraft A220-300 (BD500 1A11), national registration number YL-AAP.
The aviation serious incident took place during the second flight of the day. There were two pilots (PIC and FO) and the third pilot on the jump seat in a function of an observer in the aircraft cockpit; the flight leg Captain (PIC) was a Pilot Flying. The cabin crew consisted of the standard three cabin crew members per 89 passengers on board.

During the approach to the RWY18 (landing course 185.16º) the aircraft crew received RIX ATIS weather conditions (see Figure 3). The flight BTI-4HE was cleared ILS approach RWY18 at **21.04.04** by APP ATC (on a frequency of 129.925 MHz). The pilot did not report any deviation in ILS operation.

Message: UMN=8919700
Created 2023-03-08/21:07:59

ATV0766 082107
GG EVRRYMYA
082107 EVRRYMYT
ATIS/DATIS INFORMATION
EVRA ARRDEP ATIS INFO ${TRIGGER} A. 2107 Z. EXP ILS APCH.
RWY 18.
RWY COND REP NR 0274 AT 03081923.
*RWY COND **CODE 3, 3, 3**.*
*FIRST PART 100 PERCENT **5 MM DRY SN**.*
*SECOND PART 100 PERCENT **5 MM DRY SN**.*
*THIRD PART 100 PERCENT **5 MM DRY SN**.*
DRIFTING SN. ALL TWYS POOR. ALL APNS POOR.
*TRL 70. WIND **240 DEG, 8 KT GUSTING TO 19 KT**, VRB BTN 200 AND 290 DEG. VIS. TDZ 2600 M. WX MOD SHSN. CLD SCT 700 FT, BKN CB 900 FT, OVC 1400 FT. T MS 2. DP MS 3. QNH 0989.*
END OF INFO A

Figure 3: RIGA-ATIS

After receiving of the RIX ATIS weather conditions, the flight crew selected the runway and inserted the appropriate parameters:

- the latest weather information,
- corresponding runway status code,
- landing flap position,
- and automatic braking level.

During the calculation the module calculated the operating landing distance (OLD) (see Figure 4).

The aircraft landing performance was calculated:

• Aircraft weight: 50400kg
• Flap 2/4 configuration
• Vappr: Vref + 5kt = 135kt
• Autobrake Medium was selected
• The final approach was stabilized

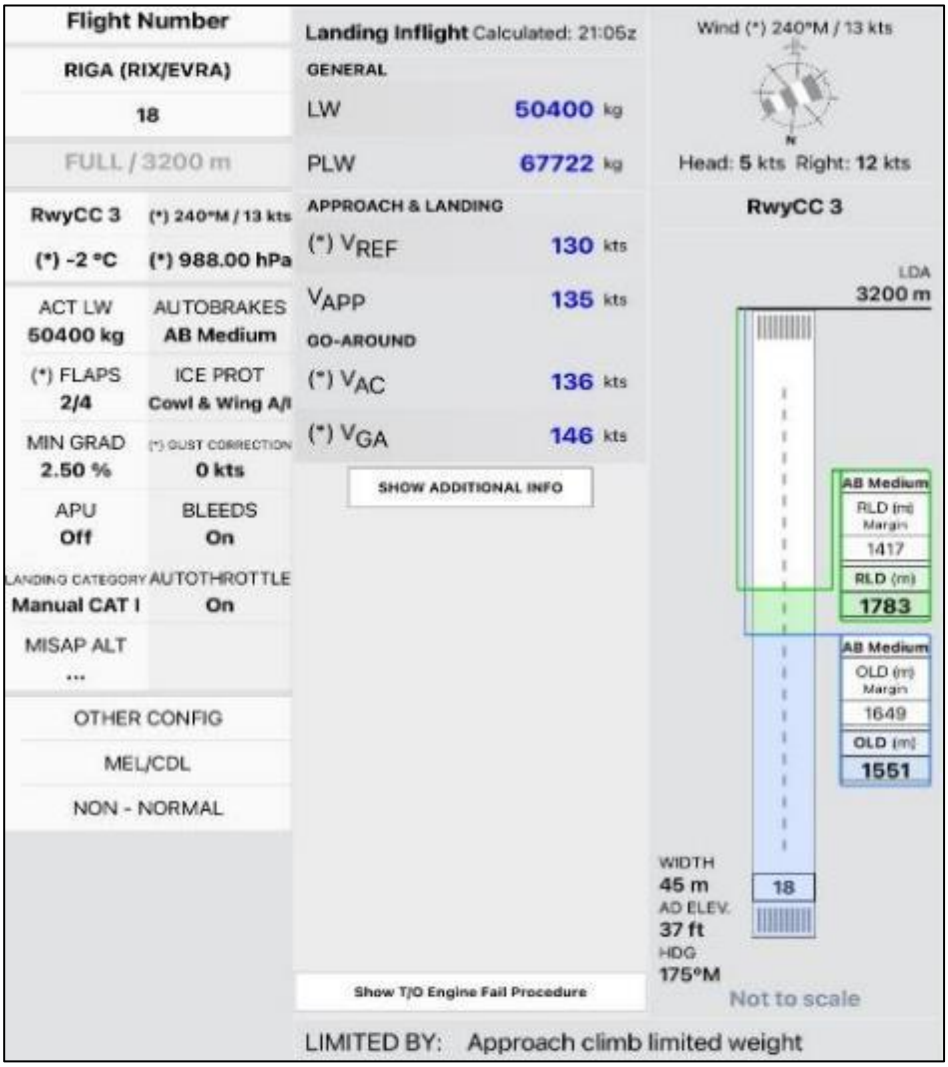


Figure 4: Landing performance

At **21.15.05**, TOWER ATC issued the landing clearance and the up-to-date meteorological information to the flight BTI-4HE: "*Wind 250 degrees 12 kts, RWY18 cleared to land*".

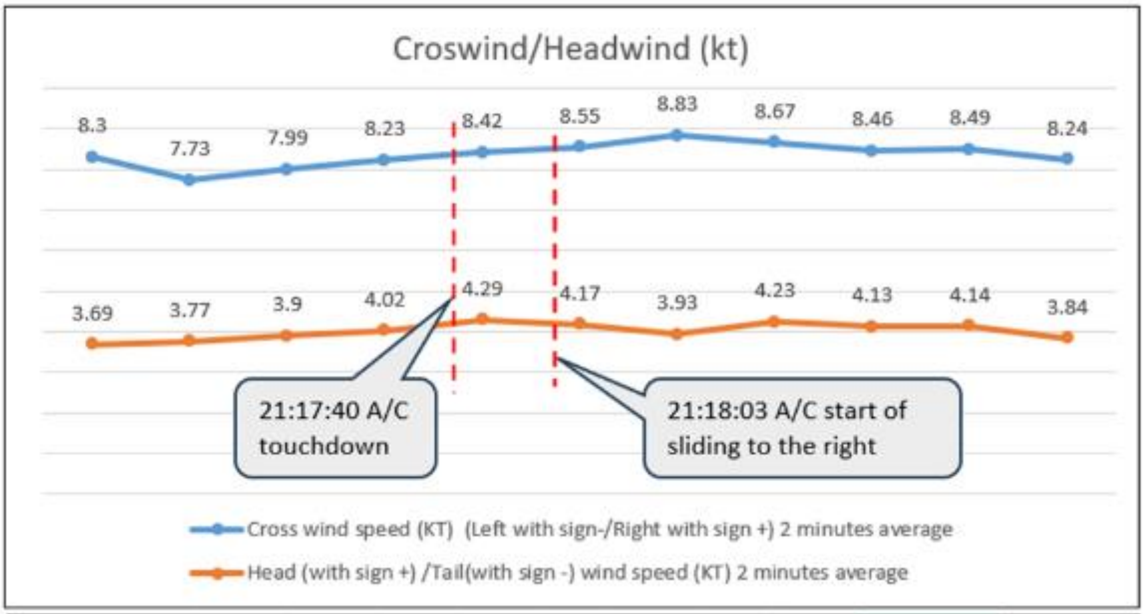
At **21.16.18**, TOWER ATC issued the landing clearance and the up-to-date meteorological information to the next approaching flight – BTI-62D: *"Baltic 62 Delta" good evening, Tower continue approach runway18, wind check 250 degrees 10 knots gusts 21 knots"*.

At **21.17.37**, the aircraft flight BTI-4HE made a touchdown on the right main landing gear (MLG) and the ground spoilers started to deploy (ground speed **124** kts), the autobrake was in MEDIUM mode.

At **21.17.39**, the contact of the left MLG wheels with the runway was detected.

At **21.17.40**, the thrust levers were set to IDLE, the nose landing gear was recorded compressed after wheels' touching of the runway (ground speed **121** kts). The brake clamping force on the MLG wheels increased to an average of 400 lbs and continued to increase gradually to 1200 lbs within 8 seconds (until **21.17.48**), after that the brake pressure began to decrease. The rudder pedals were used as required to capture and to maintain the runway centreline.

According to the meteorological wind measurements provided by ATC, the crosswind speed was about 8.3 kts, the headwind speed was about 4.2 kts, and the average gust speed was 20.99 kts when the aircraft made touchdown (see Figure 5).



History file	Wind speed (KT) 2 minute average min	Wind speed (KT) 2 minute average	Wind speed (KT) 2 minute average max	Wind direction 2 minute average min	Wind direction 2 minute average	Wind direction 2 minute average max	Gust speed (KT)	Gust direction (degrees)	Cross wind speed (KT) (Left with sign- /Right with sign +) 2 minutes average	Head (with sign +) /Tail(with sign -) wind speed (KT) 2 minutes average
08.03.2023 21:17:00	5.44	8.6	12.83	215	239	273	20.99	244	7.73	3.77
08.03.2023 21:17:15	5.44	8.89	16.52	215	239	273	20.99	244	7.99	3.9
08.03.2023 21:17:30	5.44	9.16	16.52	215	239	273	20.99	244	8.23	4.02
08.03.2023 21:17:45	5.44	9.45	16.52	215	238	259	20.99	244	8.42	4.29
08.03.2023 21:18:00	5.44	9.51	16.52	215	239	259	20.99	244	8.55	4.17
08.03.2023 21:18:15	5.44	9.66	16.52	215	241	260	20.99	244	8.83	3.93
08.03.2023 21:18:30	5.44	9.65	16.52	215	239	260	20.99	244	8.67	4.23
08.03.2023 21:18:45	4.28	9.41	16.52	215	239	260	20.99	244	8.46	4.13

Figure 5: Meteorological information updated every 15 seconds with wind options measurements provided by ATC for landing at RIX

At **21.17.43**, after the activating of the aircraft's thrust reversers the ground speed decreased to **110** kts.

At **21.17.53**, the right MLG wheels were skidding the aircraft started to yaw left (Yaw rate was approximately – 1.9 deg./sec) with the ground speed **63** kts; the aircraft pilot reduced its right rudder pedal input to correct the yaw (see Figure 6).

Figure 6: Computer simulated scheme of the aircraft deflection after landing on the RWY18

At **21.17.54**, the aircraft turned close to the RWY centerline, the ground speed was **57** kts.

At **21.17.59**, the aircraft started to yaw right due to the MLG wheels skidding. The yaw rate was approximately +**2** deg./sec (ground speed **44** kts). The pilot of the aircraft compensated gradually the movement of the aircraft to the right with the left rudder pedal until the moment (at **21.18.05**) when the brakes were applied manually.

From **21.17.53** to **21.18.02**, according to the FDR data, an active operation of the anti-skid protection and auto-braking systems was observed.

At **21.18.02**, the aircraft wheels rotation speed dropped to less than **10** kts, the wheels were completely blocked and the aircraft began to drift constantly towards the right side of the runway (Heading True **194.8** degrees, ground speed **34** kts).

At **21.18.04**, to prevent the aircraft from the drifting downwind, the pilot of the aircraft applied the throttles above IDLE, the right thrust lever increased up to +**7.12** degrees (ground speed **28** kts).

At **21.18.05**, the aircraft pilot pressed the brakes more than 20%, the autobrake mode was deactivated by the pedal command as per the BCS (Brake Control System) logic, the main wheels were unlocked, and the wheels rotation speed reached the ground speed of the aircraft ~**27** kts.

At **21.18.07**, the aircraft continued to drift to the right at about 3 deg/sec (Heading True **211** degrees), trying to prevent the runway excursion the pilot applied left and right brake pedals up to full command causing the braked wheels stop to rotate (wheels speed **0** kts, ground speed ~**23** kts), until the aircraft skidded off the runway.

At **21.18.16**, the aircraft came to a complete stop with its nose wheels off the runway, approximately 11 m from the paved runway surface, with a heading true **240.6** degrees and **1560** m from the threshold near the closed taxiway "J", located on the right side of the RWY18. Both MGL remained on runway paved surface.

At **21.18.21**, the pilot of the aircraft flight BTI-4HE reported to the TOWER ATC about the runway excursion.

At **21.18.26**, the TWR ATC instructed two aircrafts to go around from the final. The RWY was closed until 00:40 (09.03.2023).

At **21.18.39**, the GROUND ATC activated the TEAS (Tower Emergency Alerting System). There was a notification "Aircraft Accident" on the aerodrome for all emergency services.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others	Total in the aircraft
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	-
None	5	89	1	95
TOTAL	5	89	1	95

1.3 Damage to aircraft

Performing a visual inspection of the aircraft at the incident site the MLG wheels outboard tires damages were detected: skid abrasion marks were found on the MLG wheels tires (see Figure 7a and 7b).

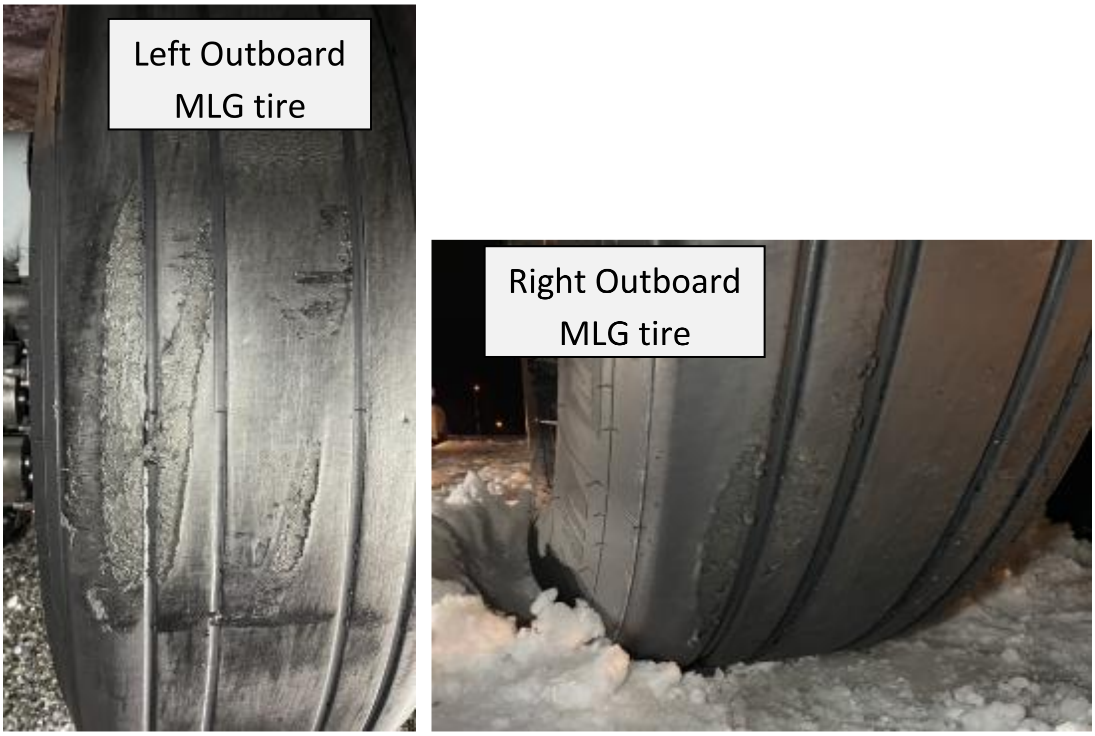


Figure 7a, 7b: The MLG tires abrasions marks

Note: The visible tires wear marks on the MLG wheels tires may be due to the wheels locking when the aircraft was on the runway, and/or sideslip moment of the aircraft when the nose landing gear left the runway surface.

No additional damage to the aircraft was determined.

1.4 Other damage

NIL

1.5 Personnel information

The flight crew was certified and qualified for the flight in accordance with existing regulations.

PIC	
Age	30
Pilot Licence	ATPL(A) No LVA.FCL.000566A; valid
Medical Certificate (Medical conclusion)	Class 1; No LVA/MED-1-A-0472; valid
Total flying hours	4650:05
Hours on type	3458:10
A/C captain hours	918:55
Last base check	25.02.2023
Rest period before duty	17:52

FO	Line Training
Age	26
Pilot Licence	CPL(A) No LVA.FCL.001500C; valid
Medical Certificate (Medical conclusion)	No LVA/MED-1-C-1432; valid
Total flying hours	874:08
Hours on type	80:51
A/C captain hours	-
Last base check	26.01.2023

PNF (Pilot Not Flying)	On jump seat
Age	44
Pilot Licence	ATPL(A) No LT.FCL.ATPL-493; valid
Medical Certificate (Medical conclusion)	Class 1; No LT-LT/MED-1-A-011209; valid
Total flying hours	10149:27
Hours on type	1582:14
A/C captain hours	918:55
Last base check	28.12.2021

The analysis of the data provided to the investigation allows to conclude, that the pilots were not fatigued at the time of the occurrence.

1.6 Aircraft information

1.6.1. General information about the aircraft

The A220 manufactured by Airbus Canada Limited Partnership, Mirabel Canada is a twin-engine turbofan transport aircraft. The aircraft has Type-Certificate No EASA.IM.A.570, Type-Certificate holder Airbus Canada Limited Partnership.

Aircraft model: A220-300
Year of manufacture: 2019
Serial number: 55051
Engines: PRATT & WHITNEY (PW1521G-3)
Registration: YL-AAP, registered in Latvia on March 29, 2019
MTOM: 67585 kg
Certificate of airworthiness: The certificate No236 was issued by Civil Aviation Agency of the Ministry of Transport Republic of Latvia on June 15, 2017.
No Limitations, it was valid.
Total Flight Hours: 8923 FH
Total Flight Cycles: 5261 FC
The weight and centre of gravity were within prescribed limits. The aircraft had sufficient fuel to proceed to the alternate airport.

1.6.2. Aircraft braking system

BD500 SERIES (PW1500G) Technical Training Manual (CMUI: CS130-21.05-06.00-121418; VERSION V6.00)

32-40 Wheels and Brakes

Antiskid Protection
Antiskid protection provides modulated brake control to prevent a deep skid at the individual brake to minimize the stopping distance. Antiskid is available for wheel speeds up to **204** kts. Wheel speeds less than **10** kts do not generate the required wheel rotation signal to provide antiskid protection.
Antiskid protection uses the wheel speed transducer signal to determine wheel speed. If one wheel speed transducer (WST) coil fails, the wheel speed signal from the other coil is used for wheel speed measurement (see Figure 8).
Locked Wheel Protection
Locked wheel protection relieves brake clamping force in order to recover from a locked wheel condition.
Locked wheel protection pairs each main wheel WST, with another inboard or outboard wheel WST. This feature enables the second paired wheel speed to be used as reference.

The EMACs provide locked wheel protection to a given wheel by controlling the brake release. The brake release occurs when the wheel speed is less than 30% of the reference wheel speed.
Locked wheel protection is inhibited when the reference wheel speed is below 30 kts. This feature avoids braking command release during turning manoeuvres on the ground. If locked wheel protection is active for more than 5 seconds, locked wheel protection is inhibited (braking allowed) for that wheel. The locked wheel protection re-engages when the reference speed is above 30 kts.

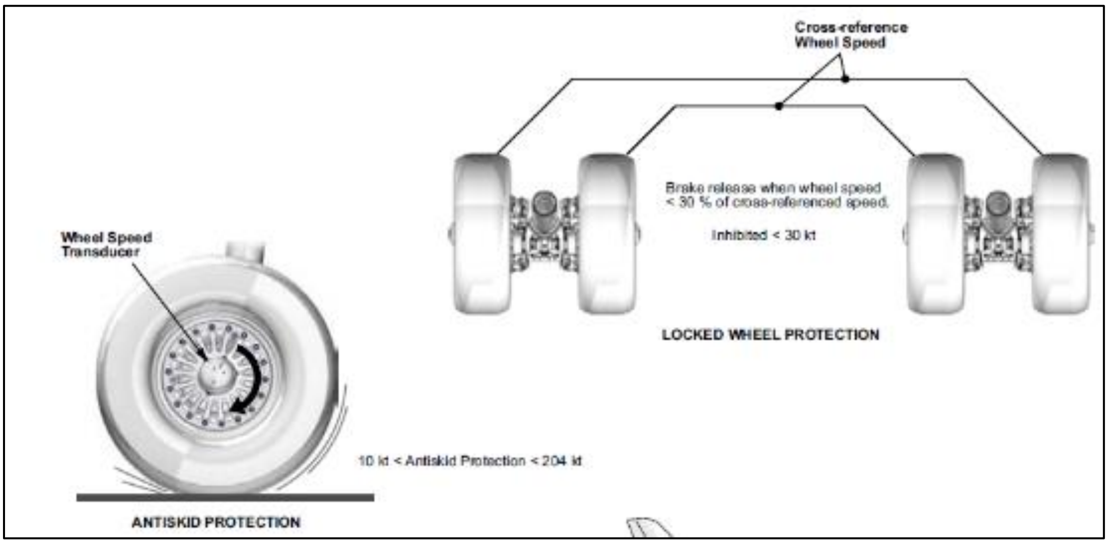


Figure 8: Braking Protection

Autobrake Mode
The autobrake mode uses the AUTOBRAKE switch position signals, and interfaces with the normal mode sections of the brake data concentrator units (BDCUs). Braking protection such as antiskid, locked wheel, and touchdown protection is active during autobraking.

In flight, the AUTOBRAKE switch solenoid must be energized to hold the switch in the desired position. The solenoid is armed by both BDCUs. The solenoid arms for the selected position, when the following conditions are true:

- Antiskid status is normal
- Autobrake switch is manually selected to LO, MED, or HI position
- Airspeed greater than 60 kts
- ALTN BRAKE Cockpit Switch is OFF (i.e. not selected)
- Weight-off-wheels

The braking level and brake applied signals are then provided to all the electric motor actuators (EMACs) by the BDCUs. Upon landing, after the MLG are detected on ground (Weight-On-Wheels or WST spin-up more than 60 kts), autobraking activates when the thrust lever angles are below **5**°.

The AUTOBRAKE deceleration levels for the LO, MED, and HI switch positions are as follows:

• LO - 6 ft/sec²
• MED - 9 ft/sec²
• HI – is maximum available (no limitation)

During landing the AUTOBRAKE selection can be changed without disarming the system. On ground, if the throttles are advanced above idle or if any brake pedal is pressed more than **20%**, the autobrake mode is disabled (see Figure 9).

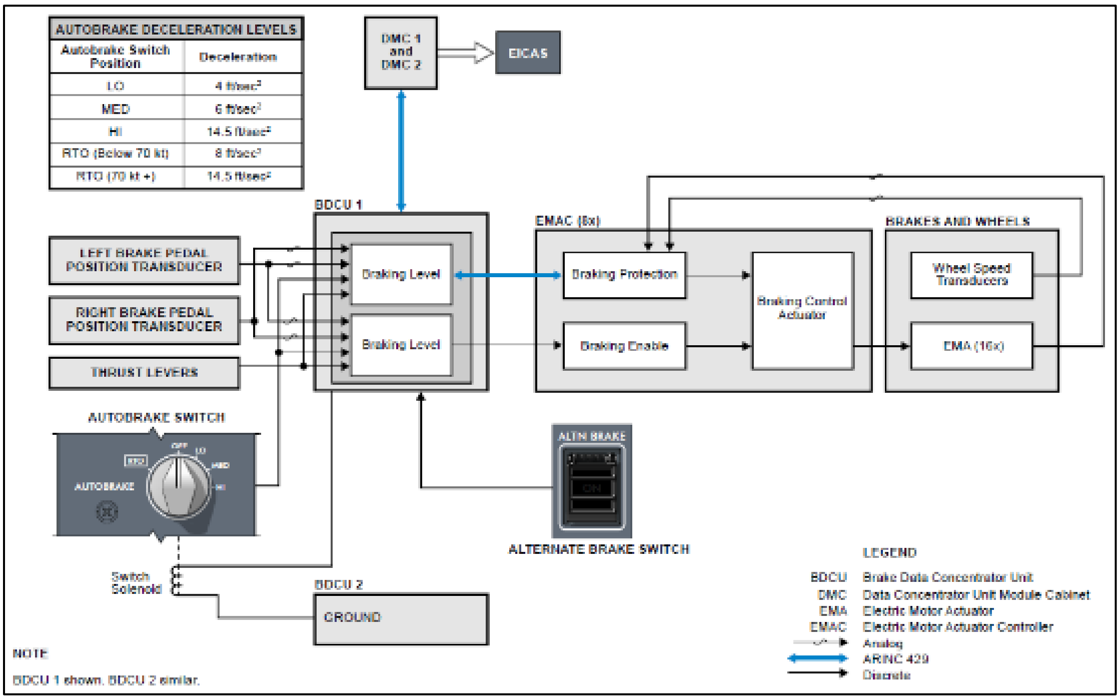


Figure 9: Autobrake Mode

Addition information to explain Figure 9:	1) LO (6 ft/sec²) 2) MED (9 ft/sec²) 3) HI (maximum available deceleration) 4) RTO (maximum available deceleration) OR if the RTO started at reference speed below 70 kts then the deceleration will be controlled to 8 ft/sec² 5) OFF

1.7 Meteorological information

1.7.1 GAMET for the Riga International airport

Message: UMN=8901123
Created 2023-03-08/13:35:11

DPA057
GG EETNEMHX EGZZWPXX EKCHYBYX EVRRITNX EYVIYMYX
081335 EVRCYMYX
FALV51 EVRA 081300
EVRR GAMET VALID 081500/082100 EVRA-
EVRR RIGA FIR BLW FL100
SECN I
SIG SFC WIND: FOR AREAS S AND W OF 1 280/32KT
SIG SFC VIS: ISOL 2000M SHSN SHSNRA
SIG CLD: ISOL CB 1200/ABV 10000FT AGL AND
LCA 800/7000FT AGL
ICE:MOD INC BLW 10000FT AMSL
TURB:MOD SFC/5000FT AMSL
SIGMET APPLICABLE: U03
SECN II
PSYS:15 L 980HPA OVER ESTONIA MOV NE 05KT NC
WIND: FOR AREAS S AND W OF 1 NIL
FOR AREAS 2, E OF 1 210/17-22KT GUSTS TO 30-32KT
FOR AREA 3 180/13-18KT LCA GUSTS TO 30KT
WIND/T:

FOR AREAS S 1	FOR AREAS 2 3
1000FT 280/40KT MS01	1000FT 240/30KT MS03
2000FT 280/40KT MS06	2000FT 240/40KT MS07
5000FT 280/40KT MS13	5000FT 260/40KT MS14
10000FT 290/40KT MS23	10000FT 260/40KT MS22

SFC VIS:7-9KM
CLD: BKN SC/AC 1500/ABV 10000FT AGL
FZLVL: SFC-500FT AMSL
MNM QNH:
15/18 982HPA FOR S, 981HPA FOR 1 2 3
18/21 985HPA FOR S, 983HPA FOR 1
982HPA FOR 2 3
SEA: T03 HGT 4.0M
OTLK:082100/082400 NOT PREPARED=

1.17.2 TAF forecast for Riga aerodrome from March 8, 2023

Message: UMN=4385531
Created 2023-03-08/20:01:21

FFF622 082001
GG EVRRITNX
082001 ESWIYMYX
FTLV31 EVRA 082000
TAF EVRA 082001Z 0821/0921 22015G26KT 4000 -SN OVC015 TEMPO
0821/0824 25018G30KT 0700 +SHSN BKN005 BKN012CB
TEMPO 0900/0909 1000 SHSN BKN009 BKN012CB BECMG
0901/0903 28007KT 9999 NSW=

1.7.3 The actual weather at the Riga International airport in METAR code form from March 8, 2023 during the period. 20:20:01 to 22:20:01 UTC

Message: UMN=4392112
Created 2023-03-08/22:20:01

FFF895 082220
GG EVRAAISM EVRRITNX
082220 EVRAYMYS
SALV31 EVRA 082220
METAR EVRA 082220Z 24008KT 210V280 9999 -SHSN SCT008
BKN021CB OVC043
M02/M03 Q0990 RESN NOSIG=

Message: UMN=4390394
Created 2023-03-08/21:50:00

FFF243 082150
GG EVRAAISM EVRRITNX
082150 EVRAYMYS
SALV31 EVRA 082150
METAR EVRA 082150Z 24010KT 210V290 5000 SHSN SCT007
BKN013CB OVC015
M02/M03 Q0990 TEMPO 3000=

Message: UMN=4389536
Created 2023-03-08/21:20:01

FFF436 082120
GG EVRAAISM EVRRITNX

082120 EVRAYMYS
SALV31 EVRA 082120
METAR EVRA 082120Z 25010G23KT 200V290 3200 SHSN SCT007 BKN009CB OVC014 M02/M03 Q0989 BECMG 6000 NSW=

Message: UMN=4387813
Created 2023-03-08/20:50:00

FFF786 082050
GG EVRAAISM EVRRITNX
082050 EVRAYMYS
SALV31 EVRA 082050
METAR EVRA 082050Z 25010KT 200V300 2500 SHSN SCT007
BKN010CB OVC014
M02/M03 Q0989 BECMG 6000 NSW=

Message: UMN=4386723
Created 2023-03-08/20:20:01

FFF786 082020
GG EVRAAISM EVRRITNX
082020 EVRAYMYS SALV31 EVRA 082020
METAR EVRA 082020Z 24013G25KT 210V290 4000 SHSN SCT007 BKN010CB OVC016 M02/M03 Q0988 BECMG 6000 NSW=

1.7.4 SNOWTAM

19:27 UTC
MGL0006 081926
GG EVRRYURI EVRRVOVA EVRRSVET EVRAYNYN EVRAYNOF
081926 EUECYIYN
SWEV0274 EVRA 03081923
(SNOWTAM 0274
EVRA 03081923 18 3/3/3 100/100/100 05/05/05 DRY SNOW/DRY SNOW/DRY SNOW

21:46 UTC
MGL0007 082145
GG EVRRYURI EVRRVOVA EVRRSVET EVRAYNYN EVRAYNOF
082145 EUECYIYN
SWEV0275 EVRA 03082141
(SNOWTAM 0275
EVRA 03082141 18 0/0/0 100/100/100 10/10/10 DRY SNOW/DRY SNOW/DRY SNOW
DRIFTING SNOW. ALL TWYS POOR. ALL APRONS POOR.)

22:51 UTC
MGL0009 082250
GG EVRRYURI EVRRVOVA EVRRSVET EVRAYNYN EVRAYNOF
082250 EUECYIYN
SWEV0276 EVRA 03082247
(SNOWTAM 0276
EVRA 03082247 18 2/2/2 50/50/50 NR/NR/NR COMPACTED
SNOW/COMPACTED SNOW/COMPACTED SNOW
ALL TWYS POOR. ALL APRONS POOR.)

1.7.5 NOTAM (after the occurrence)

MGL0008 082153
GG EVRAYNOF
082153 EUECYIYN
(A0236/23 NOTAMN
Q) EVRR/QMRLC/IV/NBO/A /000/999/5655N02358E005
A) EVRA B) 2303082153 C) 2303082350EST
E) RWY 18/36 CLSD.)

1.8 Aids to Navigation

At the time of the occurrence the Riga International Airport had the following radio navigation and landing aids for the RWY18: ILS CAT II, GP, DME and VOR. All navigation aids were functioning at time of the event without any remarks.

Type of aid, MAG VAR, Type of supported OPS (for VOR/ILS/MLS, give declination)	ID	Frequency, Channel number, Service provider	Hours of operation	Position of transmitting antenna coordinates	Elevation of DME transmitting antenna
1	2	3	4	5	6
DVOR/DME 7.0° E/ 2012	RIA	112.050 MHz CH-57Y SJSC "Latvijas gaisa satiksme"	H24	565515.1N 0235754.7E	100 FT
LOC 18 ILS CAT II	IRV	111.100 MHz	H24	565404.3N 0235803.0E	
GP 18		331.700 MHz	H24	565556.3N 0235814.3E	
DME18	IRV	CH - 48X SJSC "Latvijas gaisa satiksme"	H24	565556.3N 0235814.3E	100 FT
LOC 36 ILS CAT II	IRP	108.100 MHz	H24	565624.9N 0235826.2E	
GP 36		334.700 MHz	H24	565433.2N 0235800.6E	
DME36	IRP	CH - 18X SJSC "Latvijas gaisa satiksme"	H24	565433.2N 0235800.6E	100 FT
VOR/DME 7.0° E/2010	TUK	112.300 MHz CH-70X SJSC "Latvijas gaisa satiksme"	H24	565550.1N 0231423.9E	200 FT

Figure 10: Aeronautical Information Publication (AIP)

The ILS System was fully operational. The ATCs and technical staff did not perform any input into the system and the system did not show any failures when landing traffic was provided by ILS approach on the RWY18.

1.9 Communications

The radio communication between the crew and the Riga Tower (TWR) on frequency 118.1MHz, the Riga Approach (APP) controller on frequency 129.925MHz, the Riga Ground Controller (GMC) on frequency 118.805 MHz was recorded and made available to the TAIIB for evaluation.

1.10 Aerodrome information

The Riga International airport (EVRA) has been approved for VFR and IFR operations. The airport has one runway 18/36. The dimensions of the runway 18/36 is 3200 x 45 meters, CONC+ASPH composite construction. The runway used for landing during the occurrence was No 18 (True BRG 185.16°)

EVRA Declared Distances

RWY designator	TORA(m)	TODA(m)	ASDA(m)	LDA(m)
36/18	3200	3200	3200	3200

At **19.27**, due to increased crosswind and rapidly changing adverse weather conditions the Airport Duty Engineer (ADE) issued a SNOWTAM, downgrading the RWY18 surface condition code from “5” to “3”.

After the analysing of the A-SMGCS screen recording the investigators verified that the snow removal and chemical treatment works on the runway were carried out under the control of the ADE and using five units of snow removal vehicles:

- in the period from **21.01.14** to **21.05.47**, all surface of the RWY18/36 was swept, involving five snow cleaning vehicles with the call signs Sweeper 1, 3, 4, 8, 11 (SWP1, 3, 4, 8, 11) and vehicle Master 2 (MST2);
- in the period from **21.06.51** to **21.11.44**, all surface of the runway 36/18 was swept again (in the opposite direction of the runway), involving the same snow cleaning vehicles with the call signs SWP1, 3, 4, 8, 11. The ADE (by the vehicle MST2) was monitoring the runway surface condition 6 minutes before the occurrence while the cleaning vehicles completed a full-cycle runway sweep.

According to the information provided by the aerodrome services, at the time of the occurrence at **21.18.18** the runway surface was covered with “Dry Snow” about 5 mm thick, which corresponds to the runway condition code RWYCC “3” (see Figure 11).

Note: In accordance with the ICAO Doc 9981 Table II-2-5 (see paragraph 1.18) of the Runway Condition Assessment Matrix (RCAM), the runway surface description "Dry snow over compacted snow" also corresponds to the runway condition code "3".

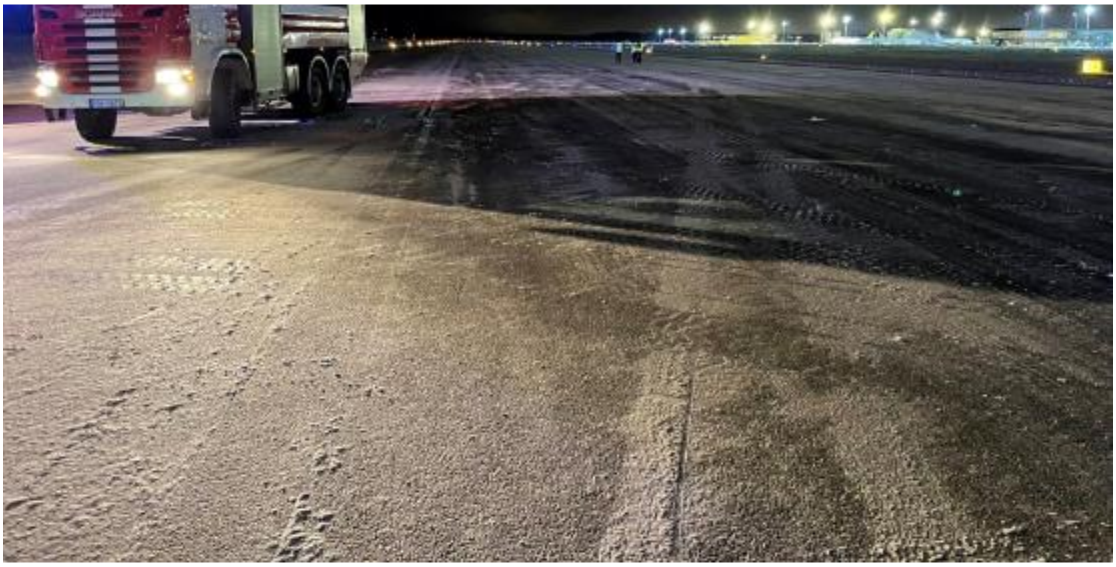


Figure 11: Visual surface condition of the RWY18 approximately an hour after the occurrence

At **21.15.05**, the TOWER ATC issued the landing clearance and up-to date meteorological information for the flight BTI-4HE:

- the latest wind check was 250 degrees, 12 kts,
- RWCC 3/3/3; percentage 100/100/100; dry snow/dry snow/dry snow; 5mm/5mm/5mm.

The FDR data indicates slippery sections of the RWY18, that proves the operation of the aircraft's anti-skid protection starting 13 seconds after the aircraft touchdown on the runway. Although, approximately 4 minutes before the occurrence another airBaltic flight BTI49E landed at **21.13.35** and the pilot of the aircraft did not inform the TWR ATC of any abnormal braking actions on the RWY18.

An hour before the serious incident, due to the gusting crosswind two airBaltic flights landed at the Riga International Airport only on their second approach (see Figure 12).

Incidents during the operation of the Riga International Airport on March 8, 2023, recorded by the TWR ATC

08.03 11:00 LOT 7LK during taxi made a turn on T instead of U;
08.03 13:06 DLH 890 during taxi made turn un U1 instead of U;
08.03 14:23 BTI-34P (BCS3) missed app. RW18 due to gusting winds. At 4:39 landed;
08.03 15:49 LOT 7RM (E190) go around due to WS. At 16:03 landed RWY18;
08.03 20:07 BTI-2PG (BCS3) go around due to wind gusts. At 20:33 landed;
08.03 20:41 BTI-6C4 (BCS3) go around due to crosswind component. At 20:58 landed;
08.03 21:18 **BTI-4HE** (BCS3) skidded off the RWY. TEAS A/C accident announced.
09.03 A/C accident cancelled at 00:29.
09.03 RWY18/36 was closed till 00:40.

Figure 12: TWR ATC information

At **21:32**, 14 minutes after the serious incident with the aircraft flight BTI-4HE, the ADE completed the Winter Runway Condition Report (RCR) form and issued a SNOWTAM at **21:41** indicating that the runway condition was “18 0/0/0 100/100/100 10/10/10 DRY SNOW/DRY SNOW/DRY SNOW DRIFTING SNOW”.
After checking the runway and taxiways at **22.51**, the ADE issued a new SNOWTAM after preparation of the RCR with the runway surface condition at least “18 2/2/2 50/50/50 NR/NR/NR COMPACTED SNOW/COMPACTED SNOW/COMPACTED SNOW”.

TAIIB comment: According to existing investigative information the RCR reports were compiled incorrectly by the ADE with the purpose of closing the runway. It is possible that the ADE of the Riga International airport did not have a full understanding of the runway closure procedures as he entered a runway surface condition code "0" to close the runway. But at 22.51, 1,5 hours after the occurrence, the ADE issued a new assessment with the runway surface condition code "2", despite that the RWY18 had not been cleaned for the last 1.5 hours.

According to the information from the Riga International airport Aerodrome Management and Safety Department investigation and data the ADE was successfully and timely trained according to the training programs “Airfield clearance from snow and ice PD 0600 P” and “Runway surface condition assessment PD 0617P” before the occurrence.

1.11 Flight recorders

1.11.1 Cockpit Voice Recorder (CVR)

Recordings from the aircraft's CVR (Honeywell SSCVR) were downloaded and the CVR data were of good quality and used in the investigation. The CVR contained recordings of 5 hours 46 minutes.

1.11.2 Flight Data Recorder (FDR)

Aircraft FDR records (Honeywell SSFDR) were downloaded and presented as 2D graphs for further investigation and analysis of FDR data.

1.12 Wreckage and impact information

At the incident site the aircraft's tire sliding track was visible for a length of 97.2 m, in the direction to the right from the runway centerline, until the aircraft left the paved surface of the runway and stopped (see Figure 13a and 13b).

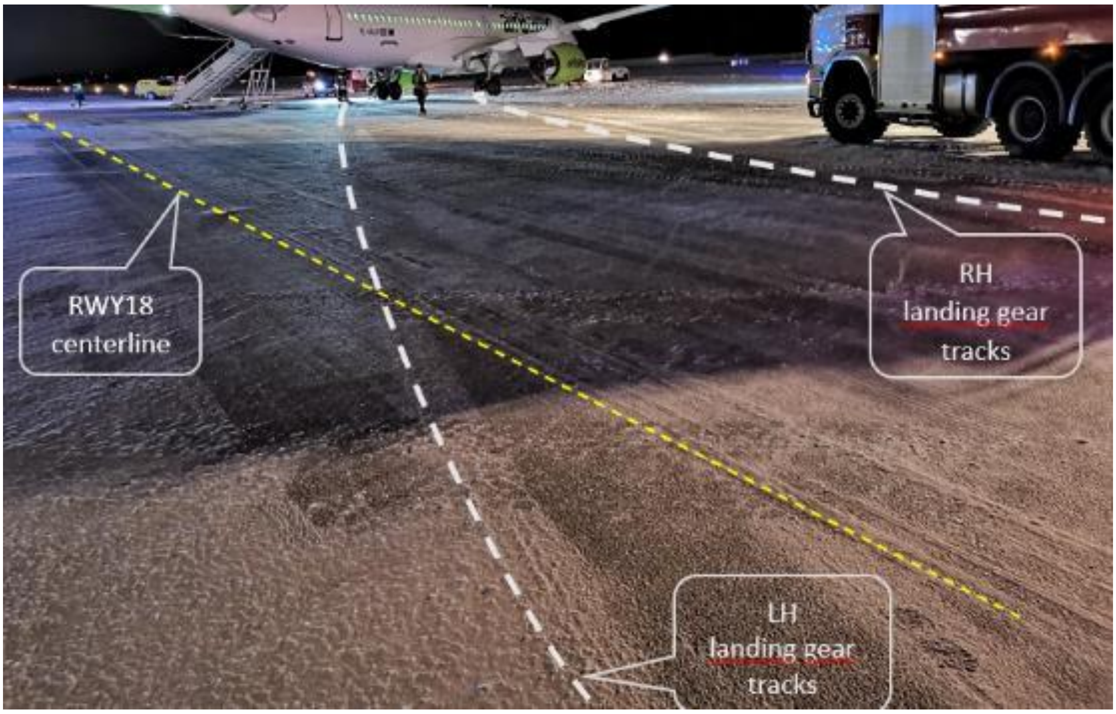


Figure 13a: Visible tracks of the aircraft tires on the runway

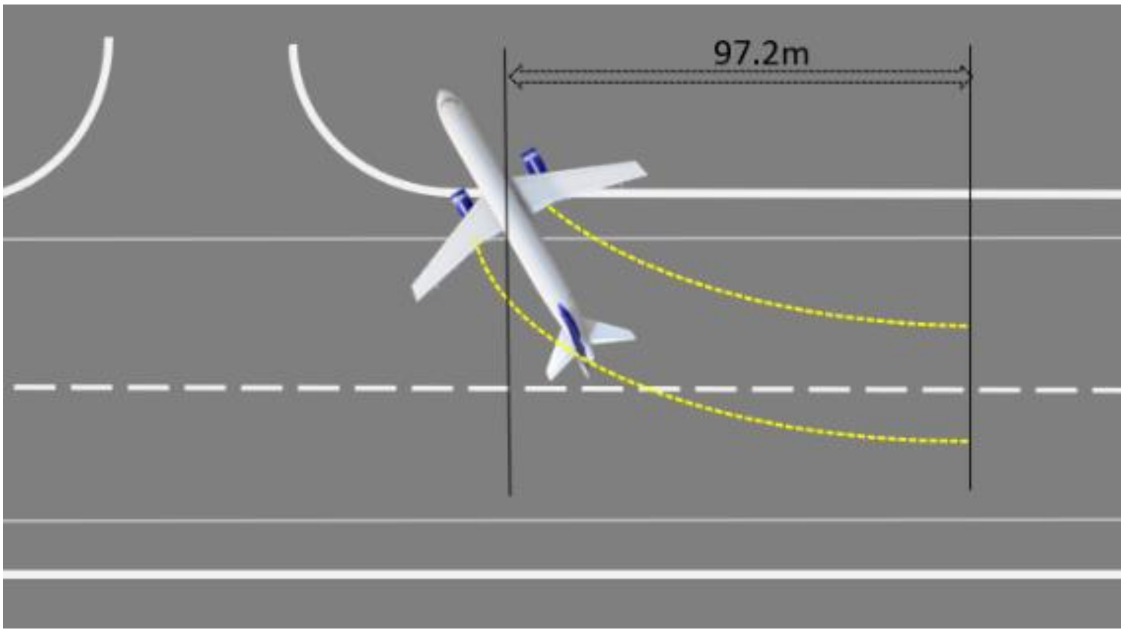


Figure 13b: Scheme of the aircraft runway sliding distance

1.13 Medical and pathological information

The State police attended the flight crew in the hospital, where blood samples were taken from the Pilot, the First Officer and the Pilot Not Flying to reveal any presence of narcotics or medicines. No such substances were found in the screening.

1.14 Fire

There was no fire before or after the occurrence.

1.15 Survival aspects

NIL

1.16 Tests and research

NIL

1.17 Organizational and management information

1.17.1 The airBaltic Operations Manual Part B A220 ("OM-B A220")

1.6 WEATHER LIMITATIONS

1.6.1 Wind Limitations

Maximum Wind Components CAT II and CAT III, and Autoland Operations (AFM Supplement 8):

Maximum Wind Components	APPR 2	LAND 2	
	Autopilot coupled	Weather: CAT II or III	Weather: CAT I or better
Headwind	25 kts	25 kts	29 kts
Crosswind	15 kts	15 kts	24 kts
Tailwind	10 kts	10 kts	10 kts

2 NORMAL PROCEDURES

2.2.11.3 Landing Execution

F. Reverse Thrust

Reverse thrust significantly reduces the aircraft stopping distance when used in conjunction with braking, especially on slippery surfaces.

2.2.11.5 Crew Coordination

Phase	PF	PM
Touchdown	Lower the nose gear and select Thrust Levers to REV or a higher reverse setting, if required. Maintain runway direction. If required apply brakes.	Monitor engine indications and call abnormal thrust reversers deployment (none, single or failed): *NO REVERSE*
Landing Roll	Maintain directional control. Monitor the deceleration with autobrake performance or apply manual braking as required. Maintain reverse thrust as required.	
Below 80 KTS	Start to reduce reverse thrust. Override autobrakes and call: **AUTOBRAKE OFF** Decelerate to a safe taxi speed and stow reversers.	

2.5.2 Contaminated Runway Operation

2.5.2.1 Introduction

F. Landing

Recommendation:

- Use autobrake, if available. If not, apply brakes normally with steadily increasing pressure to allow the anti-skid system to modulate brake pressures to achieve maximum braking.

• Use maximum reverse thrust as soon as possible after touchdown. Thrust reversers are most effective at high speed.

• Expect skidding and hydroplaning to occur, and be prepared to make the necessary corrections.

• If a loss of directional control occurs, reduce reverse thrust to idle reverse and if necessary, return the engines to forward idle thrust to return to the centerline. Regain the centerline with the rudder and/or differential braking.

Wind Limitations in accordance with Operator's OM Part B

Tailwind Conditions:
The maximum tailwind component approved for landing is **10 kts.**
Crosswind Conditions (Landing):
The maximum crosswind component approved for landing is **29 kts**.

Runway CC	Equivalent Pilot Reported Braking Action / FC	Maximum Crosswind Component
4	Good to Medium / 0.39 – 0.36	27 kts
3	Medium / 0.35 – 0.30	20 kts
2	Medium to Poor / 0.29 – 0.25	10 kts
1	Poor / ≤ 0.25	10 kts
0	NIL	NIL

1.17.2 The assessment of the runway condition is regulated by the ICAO Doc 9981

The declared runway condition code is "3" and the braking action on the runway "Medium" at the time of the occurrence according to the assessment of the runway condition based on the RCAM matrix.

Runway surface condition with code "3" according to the RCAM matrix of ICAO Doc 9981 is as follows:

Aeroplane deceleration or directional control observation

Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced.

- **Runway surface description**

- WET ("slippery wet" runway)
- DRY SNOW or WET SNOW (any depth) ON TOP OF COMPACTED SNOW
- ***More than 3 mm depth:***

- DRY SNOW
- WET SNOW
- ***Higher than −15ºC outside air temperature*:**
- COMPACTED SNOW

1.18 Additional information

1.18.1 Flight Operations Transmission (FOT) A220-FOT-00-00-001

To: All BD-500-1A10/BD-500-1A11 (A220-100/300) Operators

Subject: ATA 00-00 - Contaminated Runway Guidance

FOT Number: A220-FOT-00-00-001

Original Date: 03 February, 2023

FOT Category: Operational Recommendation

NOTICE: This FOT provides recommendations on flight operations issues/information. It is left to each Operator's discretion whether to distribute this FOT, or to distribute the information contained in this FOT, to all their applicable flight operations organizations for information or application of the recommendation.

Article 3. OPERATIONAL RECOMMENDATION

Autobrake Selection

Autobrake LO or MED is recommended. Selection of HI is not recommended since the target deceleration may not be achieved due to the reduced braking action.

Thrust Reversers

Use of MAX REV is recommended. As the Autobrake targets for an overall deceleration of the aircraft, to achieve highest deceleration capability on a contaminated runway, it is recommended to maintain Max reverse and let the auto cutback reduce the thrust to REV Idle (could be limited by forward visibility or reduction of directional stability). The deceleration provided by the thrust reversers will reduce the need for wheel braking, hence maintaining a good deceleration rate even if braking action is poor.

Directional Control

When required, differential braking must be applied by completely releasing the pedal on the side that is opposite to the expected direction of the turn. This is because, on a slippery runway, the same braking effect may be produced by a full or half-deflection of the pedal.

Landing on a contaminated runway in crosswind requires careful consideration. In such a case, directional control problems are caused by two different factors:

If the aircraft touches down with some crab and the reverse thrust is selected, the side force component of reverse adds to the crosswind component and causes the aircraft to drift to the downwind side of the runway.
• As the braking efficiency increases, the cornering force of the main wheel's decreases. This adds to any problems there may be with directional control.

If there is a problem with directional control:
• The Autobrakes should be released by pressing the brake pedal momentarily, to increase the cornering force.
• Reverse thrust should be set to REV idle, in order to reduce the reverse thrust side-force component.
• The pilot should return to the runway centerline, using pedal and or differential braking as required.

1.18.2 Flight Operations Transmission A220-FOT-32-40-002

To: All BD-500-1A10/BD-500-1A11 (A220-100/300) Operators
Subject: Degraded Anti-Skid Performance when Landing on a Contaminated RWY
FOT Number: A220-FOT-32-40-002 Rev-
Revision Date: 12 September, 2023
Applicable Aircraft: This FOT is applicable to all A220 aircraft

Subsequently following the RIXs accident, the Airbus issued a new on September 12, 2023, where the Airbus issued a specific recommendation for the flight crews, that they should apply the following guidelines when operating on a contaminated runway RWYCC 3 and below.

- Select the widest runway with minimal crosswind at the destination
- Select AUTOBRAKE LO
- Use MAXIMUM REVERSE when the main landing gear touches down and let the auto cutback reduce the thrust to REVERSE IDLE, even on a long runway in order to minimize the anti-skid activity.

In the case of one (or both) thrust reverser(s) inoperative and the destination runway with reported
RWYCC 2 or below:

- Consider landing on a runway where the reported condition is RWYCC 3 or above
- If the operations require landing on a runway with RWYCC 2 or below, select the widest runway with minimal crosswind and best runway condition.
  Note: The flight crew should be aware of the possible degradation of the runway condition between the report and the landing.

1.18.3 Operations Engineering Bulletin (OEB) 003.01

To: A220-100/300

Subject: Landing on Contaminated Runway (RWYCC 2 or below)

Number: 003.01

Original Date: 12 September, 2023

Reason for Issue:
This OEB is issued to provide operational recommendations for landing on contaminated runways with reported RWYCC 2 or below, with one (or both) thrust reversers inoperative.
Procedure:
In the case of one (or both) thrust reverser(s) inoperative and the destination runway with reported RWYCC 2 or below:
- Consider landing on a runway where the reported condition is RWYCC 3 or above;
- If the operations require landing on a runway with RWYCC 2 or below, select the widest runway with minimal crosswind and best runway condition.

Note: On September 12, 2023, the aircraft manufacturer, in the **OEB 003.01**, formulated the possible root cause and operational consequences of the occurrence at the Riga International Airport.

Root Cause*: When landing on a contaminated runway, the anti-skid performance may be degraded and may induce a locked wheel condition.*

Operational Consequences*: The locked wheel conditions may be asymmetric or symmetric between both tires on one main gear and/or between both main gears. This may result in a degraded braking performance and directional control issues: The aircraft may deviate laterally, when operating on contaminated surfaces, particularly with a crosswind. The tires may also be found damaged post flight or during the external walkaround.*

1.19 Useful or effective investigation techniques

NIL

2. ANALYSIS

2.1 General

The flight crew was properly certificated and qualified in accordance with existing regulations and company requirements. The flight crew fatigue was likely not a factor in this occurrence. The aircraft was properly certificated, equipped and maintained in accordance with existing regulations. No evidence indicated of any structural, engine, or system failures before the serious incident.

2.2 Weather information at the time of the occurrence and actual runway conditions

The crew did not report any flight abnormal situation during the approach to the RIX airport. The flight BT1-4HE was informed about the wind change at distance of about 2 nm final from the RWY18. According to the ATIS EVRA message at **21.07** the runway surface was covered with dry snow about 5 mm, the wind speed was 8 kts with wind gusts **19** kts and the wind direction 240º.
But at **21.10**, according to the constant wind measurements provided by ATC services for the RIX landing the wind gust speed increased to 20.99 kts, and at **21.16.13** the ATC informed the next flight BTI-62D: "*wind check 250 degrees 10 kts gusts **21** kts*". The gust speed was close to the maximum recommended crosswind of **20** kts according to the runway condition assessment matrix (RCAM) code "3" in Table II-2-5 of ICAO Doc 9981.
Despite the increased gusts of wind and the actual runway surface condition with the code "3" 4 minutes before the flight BT1-4HE another airBaltic flight BTI-49E performed an uneventful landing on the RWY18 and the aircraft crew did not provide information about the slippery surface condition on any runway sections.

At **21.17.40**, the aircraft A220, call sign BT1-4HE, performed landing on the RWY18 (Landing course ~185º). The flight crew calculated the landing characteristics according to the received weather information. The flight crew did not indicate that any limits were exceeded. The estimated required landing distance (RLD) for the aircraft landing was ranged from 1551 m to 1783 m. After landing the aircraft rolled only 1560 m to a complete stop.
An hour after the occurrence, during the inspection of the incident site and assessing the surface condition of the runway and carrying out the necessary measurements the TAIIB investigators together with the responsible representatives of the airport established visually that the surface of the runway was not covered with ice and assessed the slipperiness of the runway surface by shoe scraping (ICAO Circular 355); in some places the RWY18 was covered with dry drifting snow. Consistent with a SNOWTAM issued by the ADE at 22.51, the RWYCC was declared the code "2" for the runway covered with compacted snow; but according to the runway condition assessment matrix (RCAM) the surface description "compacted snow" corresponds to the RWY surface

condition with the code "3" (Table II-2-5 of ICAO Doc 9981).

```
MGL0009 082250
GG EVRRYURI EVRRVOVA EVRRSVET EVRAYNYN EVRAYNOF
082250 EUECYIY SWEV0276 EVRA 03082247
(SNOWTAM 0276 EVRA 03082247 18 2/2/2 50/50/50 NR/NR/NR COMPACTED SNOW/COMPACTED SNOW/COMPACTED SNOW ALL TWYS POOR. ALL APRONS POOR.)
```

According to the Section 1.12 of the TAIIB investigation report, snow tracks of the main landing gear tires found on the runway surface 97.2 meters long from the runway centerline, could have been caused by sliding of the blocked wheels of the main landing gear (see Figure 14).

Figure 14: The aircraft MLG tires sliding traces

Possibly the main landing gear wheels were completely blocked after the pilot had rapidly pressed the brakes of the aircraft, subsequently the aircraft began to slide uncontrollably to the right from the RWY centerline.

Note: *On 11 December, 2023 the aircraft manufacturer Airbus, as a part of an investigation of previous incidents with the A220 aircraft, reproduced a computer simulation of the actual runway conditions based on the FDR data. The incident's data of the speed reducing were compared graphically with a performance model of the aircraft. The resulting computer data showed that the runway condition was consistent with the RWYCC "3" at the beginning of the roll-out. However, the incident deceleration reduced between RWYCC 1 and RWYCC 2 values below 70kts ground speed. Significant wheel skidding was experienced (more on the left side than on the right side) until wheel lock at 35kts. Therefore, the RWYCC 3 deceleration could not be maintained below70kts.*

From **21.17.53** to **21.18.02**, according to FDR data the active operation of the anti-skid and auto-braking systems was observed. The active operation of the anti-skid protection and the further wheels locking at the time of the serious incident could happen possibly because there was so much water from the melted snow and runway de-icing fluids that it could freeze and form invisible ice ("black ice") at an air temperature of -1^0 C and a surface temperature of -3.6^0 C degrees. An hour after the serious incident when TAIIB investigators arrived to the incident site, the RWY18 surface condition could have changed under the influence of meteorological conditions at an air temperature of 0^0 C and a surface temperature of -4.9^0 C, so it is likely that icing was not detected by the investigators during the inspection of the RWY18 surface.

During the investigation it was established that it remains a partial possibility that the runway surface condition code did not correspond to the code "3" in the anti-skid protection area, and thus, after considering all weather conditions it can be assumed that one of the contributing factors of the serious incident was the possible icing of some runway sections (middle part) on the braking actions of the aircraft in autobraking mode, although RWY was assessed according to ICAO Doc 9981 Runway Condition Assessment Matrix (RCAM).

2.3 Flight crew actions during landing conditions

Before the landing of the flight BT1-4HE at the Riga International airport the flight crew received information about wind gusts of 19 kts and the RWYCC "3. The crew checked the fuel on board, because of which it was determined that there was enough fuel for a comfortable landing without rushing to complete a safety landing or to divert to an alternate airport.

Immediately before landing, the flight crew did not receive updated information about increased wind gusts, so the landing parameters were calculated considering the current ATIS-RIGA weather information and the information from ATC about wind change at distance of about 2 nm final from RWY18. The received weather information was within the capabilities of the aircraft (headwind and crosswind components), so the flight crew took a decision to land at the Riga International airport. During the landing approach the flight crew reported of a severe turbulence, but all flight crew actions and weather conditions were within the parameters for a safe landing of the aircraft.

2.3.1 Crew statements

According to the testimony of the aircraft pilot (PF), the landing was carried out exactly along the centerline of the runway, immediately after landing he felt the anti-skid protection working and there was no traction with the surface of the runway, after the aircraft speed decreased, the aircraft began to veer to the right and the pilot felt that he had lost control of the aircraft landing ground roll. According to the co-pilot (PM), the aircraft began to slide and the anti-skid protection was activated at a speed around 60 kts, after that the aircraft started to deviate to the right. The third pilot (PNF) on the jump seat in a function of an observer also confirmed that the aircraft was moving to the right at 50-60 kts and that the PF was trying to correct it.

2.3.2 The FDR data of the anti-skid protection operation

The anti-skid protection activation and aircraft wheels skidding intervals during the landing ground roll are supported by FDR data displayed graphically (see Figure 15).

The FDR data displayed graphically reveal that:

- the active operation phase of the anti-skid protection ranges from 11 sec to 23 sec after the aircraft touchdown and at a ground speed of about 60 kts;
- the skidding of the main landing gears wheels is from 14 sec to 23 sec after the aircraft touchdown, until the MLG wheels lock at 23 sec at a ground speed of about 30 kts.

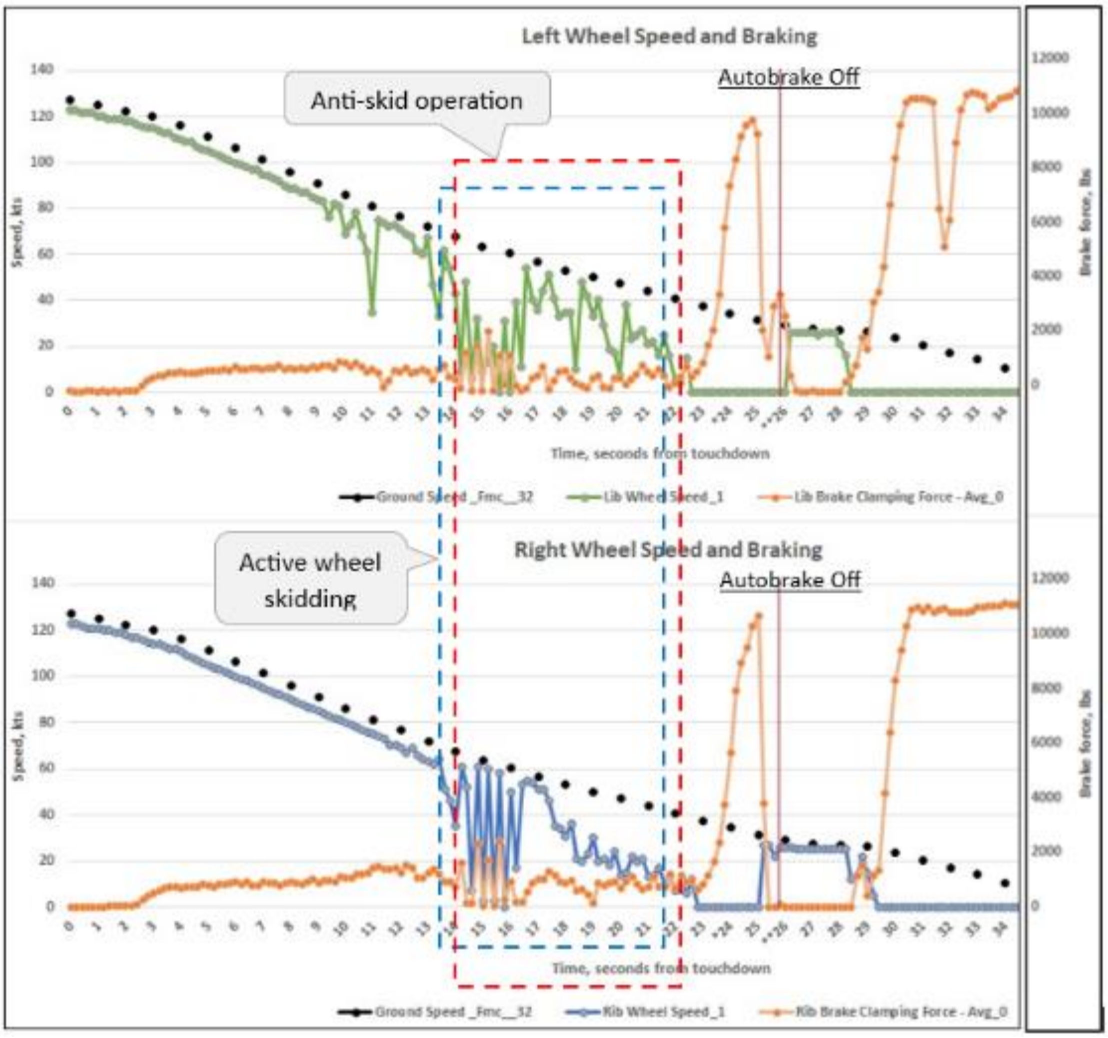


Figure 15: Areas of the aircraft wheels skidding and anti-skid protection operation according to the FDR data

Thus, it can be assumed that after the active operation of the anti-skid protection due to wheels skidding, the decreased wheels rotation speed could be a cause of the divergence of the wheel speed vs aircraft speed and early inhibition of the locked wheel protection and anti-skid function, and the subsequent MLG non-symmetrical wheels blocking, was probably a contributing factor for the pilot loss of control of the aircraft landing ground roll and the aircraft began to veer uncontrollably to the right.

2.3.3 Airbus A220-300 landing procedures on a contaminated runway

According to the **Flight Crew Operating Manual** (FCOM) for Airbus A220-300 (BD500−3AB48−32600−02 (300) Issue 015B, Sep 22/2020 Section "Operation on contaminated runways" Article C "Landing", the following actions of a pilot are provided: "*If a loss of directional control occurs, it may be necessary to move the thrust levers out of reverse thrust and go to forward idle thrust to recover the centerline*"

According to the FLIGHT OPERATIONS TRANSMISSION (FOT) **Operational Recommendation** No A220-FOT-00-00-001 for A220-100/300 Operators on 03 February, 2023 Article "Directional Control" the following actions of a pilot are provided: "*If there is a problem with directional control: The pilot should return to the runway centerline, using pedal and or differential braking as required*".

The analysis of the recommendations and procedures for the Airbus A220-300 aircraft for landing on a contaminated runway indicates that the procedures for operators of this type of aircraft (until March 8, 2023) did not contain information about possible aircraft wheels blocking after the anti-skid function deactivation during the landing ground roll and about further consequences for the aircraft's controllability.

2.4 The Airbus A220 Brake Control System (BCS) operation during landing ground roll

During the 23 seconds of the aircraft landing ground roll to approximately half up the RWY18 the A220 aircraft remained close to the centerline of the runway until the anti-skid protection turned off and the aircraft began to deviate to the right from the runway centerline. According to the FDR data and the displayed aircraft heading change plot the aircraft deviation from centerline at a ground speed of about 60 kts was also minimal, approximately $+1.5^0$ from the RWY18 true direction (see Figure 16).

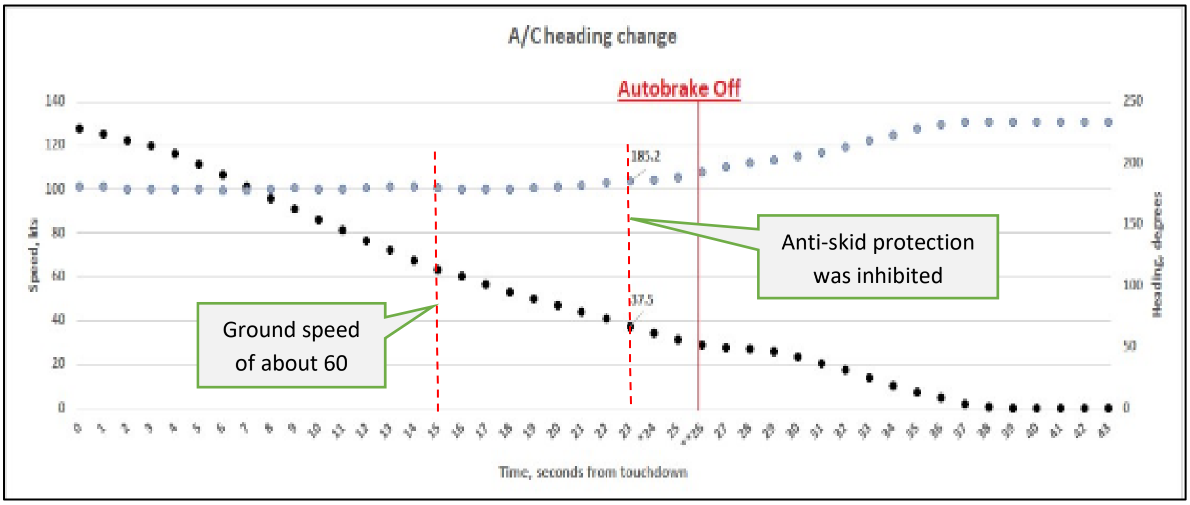


Figure 16: The aircraft heading change

At **21.18.02**, due to the skidding of the aircraft wheels the wheels rotation speed dropped to less than **10** kts, therefore, the wheel rotation signal, necessary for the operation of the anti-skid system, disappeared. It is possible that the wheels blocking and the crosswind were the primary reasons for the gradual deviation of the aircraft to the right.

Note: *Wheel speed information is directly controlled by the EMCU (Electric Motor Control Unit) and exchanged between EMCUs via CAN (Controller Air Network) communication. The BDCUs (Brake Data Concentrator Units) is receiving and providing the wheel speeds information to the other aircraft system via ARINC429 communication. The BDCU is providing to each EMCU the brake application signals.*

As the wheels rotation signals from wheel speed transducers (WST) reduced below 10 kts, the anti-skid protection was de-activated and therefore the aircraft's automatic braking system activated full braking force (increased to ~10400lbs), the wheels blocked completely, and the aircraft began to drift towards the right side of the runway at a ground speed **34** kts (see Figure 17).

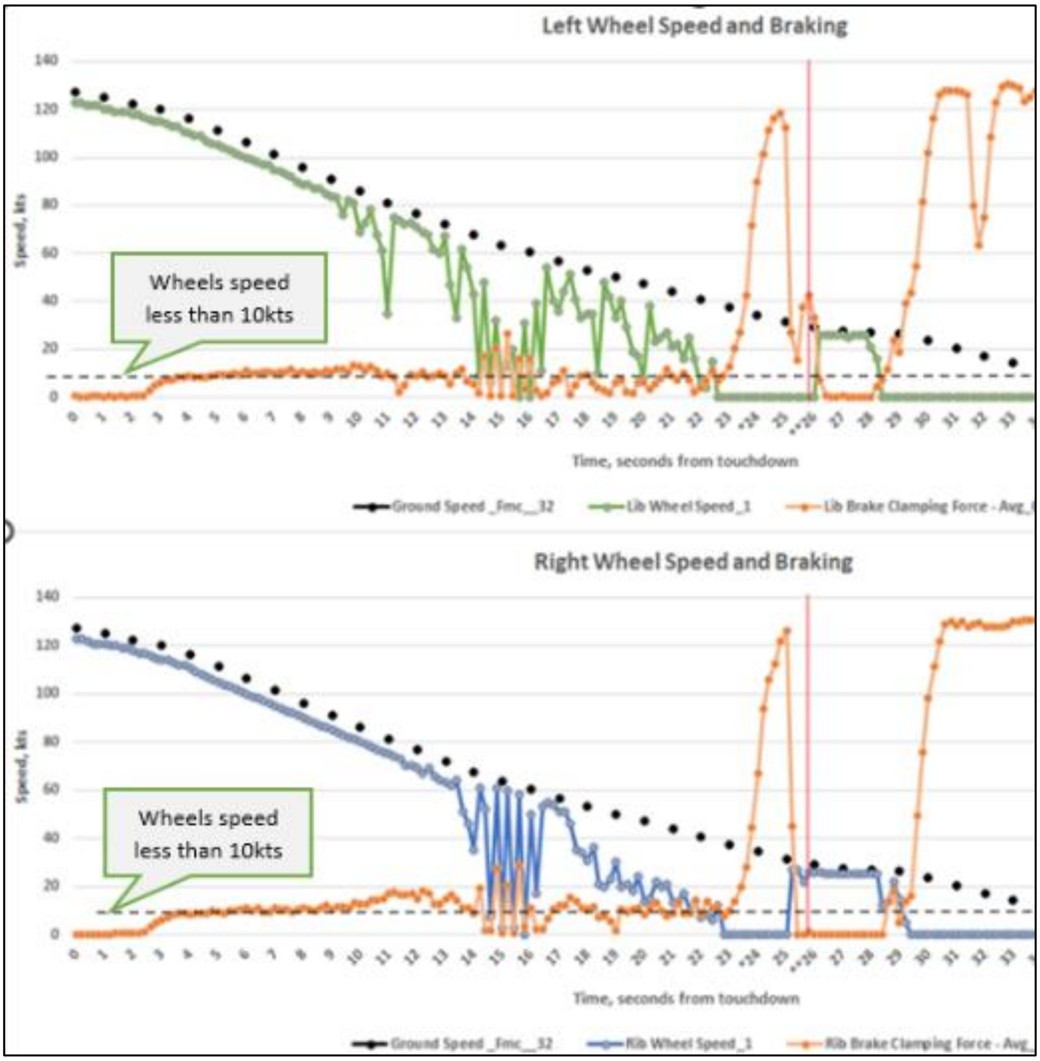


Figure 17: Display of the decrease in the wheels speed rotation of the aircraft

Note: In the automatic braking mode, the software sets a level of brake clamping force to achieve a target deceleration associated to the mode selection on the Autobrake switch panel. The aircraft's automatic braking system performs its main function of stopping of the aircraft until the automatic braking system is deactivated by one of the three methods:

1. the AUTOBRAKE switch is selected to OFF,
2. manual braking is applied (greater than 20%). (*In case of autobrake disconnection through the brake pedals, if the pilot then fully releases the brake pedals, the commanded brake force will drop to 0 and the wheels will unlock and spin-up again towards the aircraft ground speed*),
3. the thrust levers are advanced above idle.

At **21.18.03**, the aircraft pilot pressed the brakes more than 20% trying to maintain the aircraft direction, the autobraking mode was turned off, the MLG wheels were unlocked, and the wheel rotation speed reached the ground speed of the aircraft ~**27** kts.

Under the influence of the right crosswind the aircraft continued to drift to the right at a speed of about +3 deg/sec, so at **21.18.07**, the pilot of the aircraft, probably trying to prevent the plane from drifting off the runway, applied full braking and the wheels locked again (wheel rotation speed **0** kts). However, the ground speed of the drifting aircraft was ~**25** kts and the aircraft slid uncontrollable to the right by inertia for more than 20 degrees, followed by the nose gear leaving the runway surface and coming to a complete stop. The deviation of the aircraft from the runway centerline was ~55 degrees (Heading True 240.6 degrees).

The analysis of the FDR data and the aircraft flight crew actions during the aircraft landing ground roll allows to conclude that the incorrect operation of the aircraft autobrake system when the aircraft was landing on a contaminated runway surface led to the wheels blocking due to the anti-skid protection deactivation. The anti-skid protection deactivation was most likely caused by the difference in wheels speed rotation and the ground speed of the aircraft due to low friction between the runway surface and tire, what probably was the main cause for the pilot's inability to maintain the directional control of the aircraft.

3. CONCLUSIONS

During the process of the investigation the following conclusions were made and these are not to be read as apportioning blame or liability to any specific organization or individual.

3.1 Findings

- The aircraft had a valid airworthiness certificate;
- The mass and centre of gravity was within the limitations;
- The aircraft was properly certificated, equipped and maintained;
- No evidence indicated any preimpact structural, engine or system failures;
- The flight crew was properly certificated and qualified;
- The flight crew fatigue was likely not a factor in this serious incident;
- The flight crew prepared for the approach and set the aircraft landing performance in accordance with the Operation Manual;
- There were no abnormalities reported by the crew during the flight;
- The ATC information on the weather conditions and wind changes was provided at distance of about 2 nm final from the RWY18;
- It is possible that at the time of the occurrence the certain sections of the RWY18 surface were slippery, causing the aircraft's wheels to skid;
- The difference of the friction ground coefficient in some runway areas was possible due to the different condition of the runway surface;

- The anti-skid protection response data let assume that the actual surface condition in the second part of the RWY18 was different from the reported in the Runway Condition Report (RCR);
- According to the previous recommendations of the aircraft manufacturer, the pilot of the aircraft could possibly use the manual braking if there was problem with the directional control of the aircraft;
- The actual weather conditions were within the capabilities of the aircraft, and the maximum values of headwind and crosswind components at the time of the occurrence were not exceeded;
- The condition of the runway surface was assessed by an appropriately trained employee (Aerodrome Duty Engineer);
- During assessment of the runway condition the ADE possibly did not consider the condition of all parts of the runway in the rapidly changing weather conditions;
- The cleaning of the RWY18 before the occurrence was carried out twice and was organized in accordance with the Riga Airport Operating Instructions - LV 1119I;
- The pilot was not able to maintain the directional control of the aircraft probably due to the poor performance of the anti-skid system during the landing ground roll on the contaminate runway surface;
- Before the runway excursion at the Riga Airport the designer and manufacturer of the Airbus A220-300 aircraft had suspicions that anti-skid performance issues were present, which resulted in the issuance of the first FOT A220-FOT-00-00-001 (Rev NC) in February 2023. In addition, there were on-going investigations regarding prior incidents at the time of the Riga serious incident.

3.2 Causes

3.2.1 Primary cause

The runway excursion of the aircraft during landing.

3.2.2 Contributing causes

- Landing on the contaminated runway surface under increasing wind gusts;
- Rapidly changes of the runway surface condition due to the meteorology;
- Uncontrolled sliding of the aircraft on the runway surface;
- Inaccuracy of assessment of the airport runway condition;
- Delay in the apply of the manual braking by the pilot.

3.2.3 Proximate cause

The deficiencies in the operation of the aircraft brake control system.

4. SAFETY RECOMMENDATIONS

4.1 In connection with the identified deficiencies in the maintenance, operation, assessment of the runway surface condition and reporting at the airport, the Transport Accidents and Incident Investigation Bureau is addressing the following safety recommendations to the Riga International airport operator:

Recommendation LV2024001

Review the training program provided to the responsible employees for the runway surface assessment with a special emphasis and attention placed on the RWY assessment in rapidly changing weather conditions and emergency situations.

Recommendation LV2024002

Consider a possibility to use an additional method (e.g. mechanical equipment, runway surface measurement sensors etc.) during the runway surface condition assessment to avoid a human error when assessing the runway condition, especially in adverse weather conditions.

4.2 In connection with the identified deficiencies in the brake control system of the Airbus A220-300 aircraft associated with wheels blocking during the landing ground roll on a contaminated runway and in order to eliminate the preconditions for incidents and to improve the safe use of this type of aircraft in the future, the Transport Accidents and Incident Investigation Bureau is addressing the following safety recommendation to the Airbus Canada Limited Partnership company as the manufacturer of the aircraft type:

Recommendation LV2024003

Find a solution and take measures in addition to the mitigation actions already taken, as well as finalise the development of the Brake Control System (BCS) enhancement to improve the performance of the anti-skid function on contaminated runway in order to avoid disabling of the anti-skid protection, what is necessary to provide a modulated brake control and to prevent the unrecovered deep skidding of the aircraft on a contaminated surface.

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