#### FINAL REPORT of AIR ACCIDENT

Type of occurrence

Type of aircraft

Registration

Owner

Operator

Place of Occurrence

Date and Time

accident

airplane, Challenger CL-604 (CL-600-2B16)

D-ARWE (Federal Republic of Germany)

Falcon 007 S.A.R.L., France

JetConnection Businessflight AG Airline, Federal Republic of Germany

Almaty Airport, Republic of Kazakhstan

25 December 2007, 21 h 02 min UTC

(26 December 2007, 03 h 02 min local time), night

In accordance with ICAO standards and recommended practices, it is not the purpose of this report to apportion blame or liability.

The sole objective of the investigation and the Final Report is the prevention of accidents. Criminal aspects of the accident are tackled within the framework of a separate criminal case.

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#### Abbreviations

AEA	_	Association of European Airlines
AFM	_	Airplane Flight Manual (approved by the Aviation Authorities of Canada for the CL-604 Aircraft)
ATC	-	Air Traffic Control
ATIS	_	Airdrome Terminal Information Service
ATPL	-	Airline Transport Pilot License
BFU	_	Bundesstelle für Flugunfalluntersuchung (German Federal Bureau of Aircraft Accident Investigation)
	_	
CVR	_	Cockpit Voice Recorder
DWD	-	Deutschen Wetterdienstes (German Meteorological Service)
FDR	-	Flight Data Recorder
FFS	-	Full Flight Simulator
IAC	-	Interstate Aviation Committee
ILS	-	Instrument Landing System
ITT	_	Inter Turbine Temperature
JAR	_	Joint Aviation Requirements
JAR-FCL	_	JAR Flight Control License
LBA	_	Luftfahrt-Bundesamt (German Civil Aviation Authority)
OAT	_	Outside Air Temperature
OM	—	Operating Manual (developed by the Bombardier Company, Canada for the CL-604 Aircraft)
PIC	_	Pilot-in-Command
QFE	-	Atmospheric Pressure at Aerodrome Elevation, altimeter pressure setting
QNH	4	Atmospheric Pressure at Nautical Height, altimeter pressure setting
RVR	-	Runway Visual Range
RWY		Runway
SPS	_	Stall Protection System
TC-1	_	type of aviation fuel
TCCA	_	Transport Canada, Directorate of Civil Aviation
TSB	_	Transportation Safety Board (Canada)
UTC	_	Coordinated Universal Time
WAI	_	Wing Anti-Ice

#### Synopsis

26.12.2007 at 03 h 02 min local time (25.12.2007 at 21 h 02 min UTC) a CL-604 aircraft (registered D-ARWE) owned by Falcon 007 S.A.R.L. (France) and operated by JetConnection Businessflight AG (Germany) crashed at Almaty International Airport.

During the takeoff after the aircraft lifted off it developed an intensive right bank accompanied by loss of height. As the bank was developing the right wing touched the runway edge and then turning right the aircraft impacted the airfield. Moving further the aircraft collided with the reinforced airdrome fence, was destroyed and partially burnt in the ground fire.

On board the aircraft there were three crew members and one passenger. As a result of the accident one crew member died. Other persons on board have sustained serious injuries.

The accident investigation was conducted by a team appointed by the Order of the Chairman of Civil Aviation Committee, Ministry of Transport and Communications of the Republic of Kazakhstan № 278 of 26.12.2007 and Order of the Chairman of the Interstate Committee № 33/419-P of 27.12.2007.

The investigation was participated by experts of the German Federal Bureau of Aircraft Accident Investigation (BFU), the Transportation Safety Board of Canada (TSB), the Bombardier Company (Canada) and the JetConnection Businessflight AG (Germany), the Ministry of Home Affairs of the Republic of Kazakhstan, and Almaty International Airport.

The notifications about the accident were sent in due manner to the IAC, TSB and BFU.

The preliminary judicial investigation was conducted by the department of the South-East Transport Prosecutor's Office of Almaty.

Start of investigation:	December	26,	2007
End of investigation:	June	06,	2011

#### **1. Factual Information**

#### 1.1. History of Flight

On December 25, 2007 a crew of JetConnection Businessflight AG airline including the PIC, the co-pilot and a flight attendant was conducting a charter flight LCX 826 routed Hannover (Germany), Astana (Republic of Kazakhstan) – Macao (China) on a CL-604 aircraft (registration D-ARWE). Apart from the crew there was one passenger on board.

At 12:10 (hereinafter UTC time is used) on December 25, 2007 the crew took off at Hannover Airport. During the flight the crew was informed that there was no fuel available for refueling the aircraft at Astana Airport. Due to this the crew decided to change the flight route and refuel the aircraft at Almaty International Airport (Republic of Kazakhstan). The flight from Hannover to Almaty in accordance with the PIC explanations was normal. No faults in the operation of the aircraft systems or equipment were detected. At 18:46 the crew landed at Almaty Airport. The ground handling service at Almaty Airport was provided by Bercut Air Services KZ based at the airport.

The departure from Almaty to Macao according to the schedule was planned for 20:50 on December 25, 2007. The ground handling and servicing was provided by Bercut Air Services KZ Company. In accordance with the work order the Almaty ground services conducted refueling and anti-icing. The Pre-Flight Check was conducted by the PIC. He also monitored the refueling and stabilizer and wing anti-icing. According to the PIC interrogation there were no faults detected in the operation of aircraft systems and equipment.

8460 liters (6827 kg) of TC-1 condition fuel was refueled. According to the estimations, total fuel on board was 7605 kg. The refueled fuel was distributed in the fuel tanks in accordance with the AFM of the CL-604 aircraft. In accordance with the estimations the aircraft weight was 20659 kg, CG 33,1%, which was within the CL-604 AFM limitations.

During the pre-flight preparation for the flight to Macao the crew of the CL-604 D-ARWE did not receive the meteorological consultation or documentation at the Almaty Meteorological Center. According to BFU information the crew of the JCX 826 flight had received the integrated meteorological consultation for the flight to Macao before the takeoff from Hannover. In Almaty PIC has received updated data through the Internet from the website of the German Meteorological Service (DWD) and also from the PPS provider of the JetConnection Businessflight AG (Billund, Denmark).

According to the ATC tape recorder data containing the communication of the CL-604 D-ARWE crew with the ATC offices of Almaty airport, at 20:17:55 the crew informed the Ground Control that they were ready to start up and taxi right after the completion of the antiicing procedure. At 20:18:24 the Ground Control instructed the crew: "JCX 826, expect start up in 5 minutes." At 20:20:48 in reply to the Controller's request if they were ready for start-up the crew reported: "We are expecting anti-icing which is about to start now". While waiting for the anti-icing the crew received the ATC clearance for departure.

In accordance with the DE-ICING\ANTI-ICING REQUEST from the 25.12.2007, signed by the PIC and the Bercut Air Servises KZ manager the processing with using Type 1 and Type 2 fluids was conducted in two steps. On the first stage Type 1 de-icing fluid (Killfrost DF Plus) was applied to remove the icing with the estimated fluid to water ratio of 70/30%. According to the enquiry of the de-icing operator the temperature of the Type 1 fluid in the tank of the *SIMON GLOBAL 2110* machine used for the fluid application was about + 80° C, and at the outlet of the sprayer it was not less than +60° C.

*Note:* The check of the SIMON GLOBAL 2110 machine conducted by the investigation team after the accident revealed that the temperature of the Type 1 fluid at the outlet of the sprayer is +66° C, which complies with the CL-604 OM (Part 1, page 06-12-17).

On the second stage of the anti-icing procedure the Type 2 anti-icing fluid was used (Killfrost ABC 2000) with the estimated fluid to water ratio of 100/0%.

*Note:* In the fluid Type 1 and Type 2 delivery receipt No.4002014 by mistake was shown unreal concentration 70/00 for the Type 2 fluid instead of its real concentration 100/00.

The OM of the CL-604 does not suggest preliminary heating and heating monitoring of Type 2 fluid. According to the record in the aircraft fuelling receipt the amount of the applied Type 2 fluid was 250 liters. According to the requirements of Annex A, page XXI of the AEA, Training Recommendation and background Information for de-icing/anti-icing of aircraft on the ground, Edition 2, September 2005 the recommended anti-icing fluid minimum for the wing and stabilizer of a CL-604 type aircraft was 100 liters. Thus enough Type 2 fluid was applied for the anti-icing of CL-604 D-ARWE.

The inspection of the fluid samples used for the de-icing/anti-icing of the CL-604 D-ARWE aircraft conducted at Almaty airport laboratory revealed that the Type 1 fluid had an actual fluid to water ratio of 67/33% while the Type 2 fluid 99/1%. Provided the OAT at Almaty airport at the time of the fluid application was minus 13° C, the mentioned ratios were within the requirements of the CL-604 OM (Part 1, Section VI, Cold Weather Operations).

The actual weather at Almaty airport according to the request of the Approach Control for 20:49 was as follows: surface wind 360° 2 m/sec, RVR 2900 m, light snow, mist, clouds

8 oktas, nimbostratus, fractonimbus, cloudbase 150 m, QFE 718 mm mercury, OAT minus 12,9° C, dewpoint minus 13,7°, moisture content 93%, QFE 718 mm mercury.

In accordance with the de-icing/anti-icing operator the de-/anti-icing procedure was conducted in compliance with the CL-604 OM recommendations in the following order: stabilizer, left wing, right wing. Every surface was applied first with Type 1 and then Type 2 fluid. The time between the completion of the Type 1 application and the beginning of the Type 2 application in accordance with the operator's explanations did not exceed 1.5-2 minutes which is suggested in Section VI of the CL0604 OM. According to the estimations conducted by the investigation team the application of the Type 2 fluid was started at 20:37.

*Note:* In accordance with the CL-604 OM (Part 1, page 06-12-13), the holdover time of the Type 2 fluid with the fluid to water ration of 100/0 in the OAT range of -3...-20° C, with precipitation in the form of snow and snow grain is 15...30 minutes.

According to the information recorded by the FDR, during the de-/anti-icing the aircraft flaps were retracted while the stabilizer deflection was minus 4,7°.

By 20:43 the de-/anti-icing procedure was completed. On leaving the aircraft the PIC made a visual and tactile (by touching the wing surface) inspection of the anti-icing quality, admitted that it was satisfactory by signing in the de-/anti-icing receipt. After that the PIC returned to the aircraft and the crew began the engine start-up.

In accordance with the FDR information, by 20:46 the crew had started up first the right engine and then the left engine. The N2 of the right and left engine in the idle mode was 61,5 % and 62,0 % respectively. In 10 seconds after the left engine start-up the Cowl Anti-Ice was engaged.

In accordance with the CVR information, a check at a stage After Engine Start was performed by the flight crew in a volume which stipulated by the JetConnection Businessflight AG "ABBRIVATED CHECKLIST". However a comparison of this checklist with the CL-604 D-ARWE AFM checklist (Chapter 4 "Normal Procedures" Section "Consolidated Checklists" Item L "After Engine Start Check") shows the absences of WAI and CAI systems checks.

*Note:* For a number of other preflight preparation stages the JetConnection Businessflight AG "ABBRIVATED CHECKLIST" also doesn't cover all procedures stipulated by the CL-604 AFM.

At 20:47:42 the crew reported the Ground Control that they were ready for taxiing. At 20:48:25 the Ground Control cleared the crew for the holding point following the leader van. Within 20:51:17 – 20:51:45, the crew checked the rudder, the ailerons and elevators and

extended the flaps to the takeoff position (Flaps 20). The stabilizer position  $(-4,7^{\circ})$  did not change. At 20:51:55 the crew was instructed by the Ground Control to expect further instructions at the holding point and contact the Tower Control.

At 20:52:17 after contacting the Tower Control the crew was instructed to wait on the holding point as there was an MD-83 aircraft making Flight UKM 109 on final at a distance of 14 km.

At 20:57:15, after the MD-83 landed the Tower Control cleared the CL-604 D-ARWE to line up at RWY 05 and at 21:01:30 they were cleared for takeoff.

During the takeoff an increasing right bank started developing. As the aircraft was banking to the right it touched the right runway edge with its right wing tip. Then the aircraft, leaning on the right wing, moved to the graded airfield to the right of the runway and hit its surface with the right main landing gear and nose landing gear. During the further movement the aircraft hit the reinforced fence of the airdrome and shifting on the ground 190 m beyond the airdrome finally stopped. At the final stage of movement a fire occurred which was extinguished by the airport fire brigades.

The actual weather at Almaty airport checked after the accident alert at 21:04 was as follows: wind 350° 4 m/sec, visibility 1200 m (RVR 2500 m), snow, mist, clouds 8 oktas, nimbostratus, fractonimbus, cloudbase 120 m, OAT minus 14° C, dewpoint minus 15° C, moisture content 92%, pressure 718 mm mercury. Runway 05 condition – dry snow up to 10 mm, friction factor 0.32.

The accident occurred on December 25, 2007 at 21:02 UTC (26.12.2007 at 03:02 local time).

Injuries	Crew	Passengers	Others
Fatal	1	-	-
Serious	2	1	-
Minor/None	_/_	_/_	-/-

#### 1.2. Injuries to Persons

#### **1.3.** Damage to Aircraft

As a result of the accident the aircraft was totally destroyed and significantly burnt in the ground fire.

#### 1.4. Other Damage

As a result of the accident a part of the reinforced fence encircling the airdrome was destroyed.

#### 1.5. Personnel Information

### 1.5.1. Flight Crew

PIC	male
Citizenship	Germany
Year of birth	1955
Pilot's license	№ 3311008158 ATPL, issued by the German
	Civil Aviation Authority (LBA) in accordance
	with JAR-FCL on 24.05.1994, valid until
	26.11.2008. According to the JetConnection
	Businessflight AG Operation Manual (OM-A) the
	pilot-in-command has been certified as
	supervision captain and line check captain.
Education	N/A
Weather minimum	Authorized for CAT-1 JAR OPS (60x550x200)
Total flying experience	7200 hours
Experience on CL-604	1258 hours
Experience on CL-604 as a PIC	1258 hours
Flight time on the day of the accident	6 h 36 min
Checkrides	25.07.2007, on-the-job
Simulator Training	14.03.2007, CL-204 FFS
Accidents and incidents in the past	No data
Total working time on the day of the	9 h 52 min
accident	

Co-pilot	male
Citizenship	Germany
Year of birth	1965
Pilot's license	№ 3341010870, issued by the German Civil Aviation Authority (LBA) in accordance with
	JAR-FCL on 20.09.2007, valid until 16.07.2009
Education	No data
Total flying experience	2650 h

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Experience on CL-604	60 h
Experience on Learjet 35/55	1950 h
Flight time on the day of the accident	6 h 36 min
Checkrides	No data
Simulator training	29.08.2007, CL-604 FFS
Accidents and incidents in the past	No data
Total working time on the day of the	9 h 52 min
accident	

The level of the PIC's professional training complied with the character of the flight task.

In accordance with the data obtained from the BFU the co-pilot was undergoing commissioning to fly in the right-hand pilot seat of the CL-604. The completion of the commissioning was not confirmed by any inspection. According to the BFU information the supervision of the Co-pilot was performed by the PIC who has been qualified as supervision captain and line check captain (in accordance with OM-A).

#### 1.5.2. Cabin Crew

Flight Attendant	female
Citizenship	Turkey
Year of birth	1976

## 1.6. Aircraft Information

Aircraft Type	Challenger CL - 604 (CL-600-2B16)
Registration	D-ARWE
Manufacturer, date of manufacture, MSN	«Bombardier Inc. Canadair Group»,
	April 2000, 5454
State of Registration	Germany
Owner	Falcon 007 S.A.R.L. (France)
Operator	«JetConnection Businessflight AG» Airline
Time in Service	7882 h, 4556 landings
Number of overhauls	None
Service life:	Service life estimation not provided. Service on
	condition.

№ L/33358, issued on 03.09.2007 by the Federal
Civil Aviation Administration of Germany
№ 33358, issued on 27.09.2007 by the Federal
Civil Aviation Administration of Germany

The last base maintenance (100-hour check) was performed on 21.12.2007 by the personnel of Lufthansa Bombardier Aviation Services after the service time of 7876 h. The last line maintenance (Pre-Flight Check) was made by the PIC on 25.12.2007 at Almaty airport.

The aircraft maintenance was provided in compliance with the maintenance program of the JetConnection Businessflight AG Airline.

#### **1.7.** Meteorological Information

The accident occurred at night time.

On 25.12.2007 the south-eastern regions of Kazakhstan was influenced by the frontal part of a spreading anticyclone centered at Aktyubinsk. The anticyclone was shifting eastwards at a speed of 50 km/h and was intensified. At 21:00 UTC a high pressure center was formed over Lake Balkhash. The weather at Almaty airport was affected by two arctic fronts spreading parallel from near Ust-Kamenogorsk along the mountains of the south-eastern Kazakhstan further to the west.

The actual weather at Almaty airdrome according to the request made by the Approach Control for 20:49 was as follows: surface wind 360° 2 m/sec, RVR 2900 m, light snow, mist, clouds 8 oktas, nimbostratus, fractonimbus, cloudbase 150 m, QFE 718 mm mercury, OAT minus 12,9° C, dewpoint minus 13,7°, moisture content 93%, atmospheric pressure 718 mm mercury (957 hPa).

ATIS Information: «Almaty Information «Bravo» at 20.35.

Expect «ILS» approach; RW 05; covered with dry snow 10 mm breaking action «medium»; transition level 2100ms; apron and TWs are slippery taxi with caution; birds strike hazard in vicinity of airfield; TW 3 out of operation; wind 350/2 m. per second; visibility 2300 ms; light snow, mist «overcast» 145; t – 13; dew point – 14; QNH 1037; QFE 957 hpks; moderate turbulence from 4000 ms to 6000 ms; no sig. Acknowledge information «Bravo», QFE and current altitude on transition level».

The test check of the weather parameters made upon the accident alarm at 21:04 UTC showed the following actual weather: wind 350° 4 m/sec, visibility 1200 m (RVR 2500 m), snow, mist, clouds 8 oktas, nimbostratus, fractonimbus, cloudbase 120 m, OAT minus 14° C, dewpoint minus 15° C, moisture content 92%, QFE 718 mm mercury (957 hPa). Runway 05 condition – dry snow up to 10 mm, braking action 0.32.

Before departure the crew of Flight JCX 826 (Almaty-Macao) did not obtain meteorological consultation at Almaty weather station nor did they receive any meteorological documentation. According to BFU information before the takeoff from Hannover the crew of the JCX 826 flight had received the integrated meteorological consultation for the whole flight rout to Macao. In Almaty PIC has received updated data through the Internet from the website of the German Meteorological Service (DWD) and also from the PPS provider of the JetConnection Businessflight AG (Billund, Denmark).

#### **1.8.** Aids to Navigation

The aids to navigation did not impact the accident.

#### **1.9.** Communications

The communications aids did not contribute to the accident.

#### 1.10. Airdrome Information

The Almaty airdrome (mountainous) is located at the north-eastern outskirts of Almaty City. The airdrome is Class A. It has a Certificate of Airdrome Registration № 02-CP issued by the Civil Aviation Board of the Ministry of Transport and Communications of the Republic of Kazakhstan on 29.10.2003, and Certificate of Airworthiness APД № 000070-05, issued by the Civil Aviation Board of the Ministry of Transport and Communications of the Republic of Kazakhstan on 30.06.2005 and valid till 30.04.2008.

The airdrome has only one runway with fibercrete covering reinforced with asphaltic concrete, 4398 m long and 45 m wide, with reinforced edges of 7.5 m on each side. The covering is 68-74 cm thick. There is no graveled runway.

The runway has the following magnetic landing courses and relative threshold numbers: 052° M (RWY-05), 232° (RWY-23). RWY 23 provides ICAO Cat II landing (30x350), while RWY 05 is suitable for ICAO Cat I landing (60x1000).

The airdrome airstrip is extended perpendicular to the runway centerline 150 m to the north-west and 120 m to the south east. Part of the airstrip on both sides of the runway centerline is graded for 80 m both sides. It is extended beyond the runway edges for courses 052° M and 232° M for 150 m.

The airdrome altitude is 681,13 m. The airdrome reference fix is  $N43^{\circ}21'07''42$ , E077°02′25″84. Magnetic declination is +4°10′.

The airdrome is suitable for the operation of An-124, B747-400, IL-96, IL-86, IL-62 (index 6), Tu-154 (index 5) and aircraft of other types and indices.

At the time of the accident involving CL-604 D-ARWE the runway condition was as follows: RWY-05 dry snow up to 10 mm, braking action 0.32.

#### 1.11. Flight Recorders

The aircraft was equipped with two on-board recorders the S800-2000-00 FDR and the S100-0080-01 CVR. The containers of both recorders were deformed and bore traces of high temperature impact. The connectors were burnt.

After the casings of the memory modules were disassembled it was revealed that the memory units were in satisfactory condition.

The S800-2000-00 FDR readout was performed with the help of the ROSE readout software. The S100-0080-01 CVR readout was made with the help of the MODEL A860 TEST PANEL unit and the AUDIO MONITORING ADAPTER AMA/1. The data analysis revealed that the flight recorders recorded information on the accident flight within their technical capabilities. The records were used to establish the causes of and contributing factors to the accident.

#### 1.12. Wreckage Information

The accident site is located to the right (takeoff direction 52° M) of the runway, adjacent to its right edge. The first touch was made by the right wing tip on the line of the runway edge lights (southern) 1640 m from the threshold.

The fragments of the aircraft structure were located right of the runway, partially within the graded reinforced fence encircling the airdrome territory from the south-east.

The wreckage plot on the graded airfield had a spread approximately equal to the wingspan and is located along the arch drawn on the ground by the right wing. Judging by the tracks on the ground, at a distance of 108 m from the site of first touch the aircraft impacted the ground with the right landing gear. It was followed with the nose landing gear impacting the ground and its destruction. At a distance of 135 m from the site of first impact a trace of the lower fuselage begins. The mentioned wreckage strip contains fragments of the right wind tip, both nose wheels, fragments of the upper skin panel of the right wing, fragments of antenna and the radome.

Moving further, at about 245 m from the site of first impact, the aircraft hit the reinforced airdrome fence. This resulted in the separation of the main landing gear struts and further destruction of the lower fuselage.

The movement of the aircraft after its collision with the airdrome fence was accompanied with separating equipment units, assemblies and appliances in the forward lower fuselage. Shifting beyond the airdrome fence for about 190 m the aircraft turned left 120° and stopped.

The turn was probably abrupt enough to destroy the fuselage into three large fragments – cockpit, middle and tail part of the fuselage, forming by the time they finally stopped a compact group of wreckage (Figure 1). Further, probably due to the emerged ground fire the aircraft was significantly burnt.

#### 1.13. Medical and Pathological Information

As a result of the accident the co-pilot died; other persons on board received serious injuries.

In accordance with the medical coronary autopsy report, the cause of death of the co-pilot was blunt force trauma. The forensic chemical expertise of the co-pilot's inner organ tissues (stomach, liver and kidneys) revealed traces of ethanol. No narcotic substances were detected. The forensic chemical examination of the co-pilot's blood revealed no presence of ethanol or narcotics.

According to the medical conclusion, the persons on board who survived sustained the following injuries:

- PIC – closed craniocerebral injury, closed fracture of the right shin, second and third degree face burn;

- flight attendant – closed craniocerebral injury, lacerated right ankle joint wound;

- passenger – closed craniocerebral injury, separation of the right auricle, chest contusion, numerous face abrasions.

The medical examination of the PIC and the flight attendant no traces of alcohol were detected.

#### 1.14. Survival Aspects

From the interrogation of the surviving persons on board, at the time of the accident the flight crew members were in the cockpit on their working stations and fastened with the seatbelts, the passenger was in the cabin. However from the CVR transcripts may be concluded that the passenger was sitting on the cockpit jumpseat and that his jumpseat shoulder harness had been fastened. It may be assumed that the flight attendant was sitting in the cabin on the passenger seat and her belt was also fastened.

The injuries sustained by the surviving persons resulted from their impact on the cockpit and cabin equipment and structures due to the aircraft ground impacts.

#### 1.15. Search and Rescue Information

On 26.12.2007 at 03:03 local time the observant at the rescue tower noticed a flash of light that accompanied the crash of the CL-604 D-ARWE aircraft to the south of the runway

beyond the airdrome and declare alert for the search and rescue team. In compliance with the Horn-2 accident notification system the Alert was declared for the search and rescue team of the Almaty airport. Six fire trucks and an emergency reanimation car with the airport medical staff and equipment set off to the accident site.

At 03:05 the C-04 fire brigade arrived at the break in the airdrome fence. As they found the burning aircraft behind the fence they went to the aircraft on foot to render assistance to the passengers and crew and evacuate them. The fire staff and the arriving airdrome security personnel found the two surviving crew members (PIC and flight attendant) and passenger near the burning aircraft. At 03:11 the airport medical personnel arrived at the accident site to render first aid to the injured persons. Later, the co-pilot's body was found 30 m away from the aircraft. Further, the injured persons and the dead were taken to Almaty hospitals by the city ambulance cars.

By 03:25 other fire brigades arrived at the accident site using a pass road and started extinguishing the fire. At 03:47 the fire was extinguished. At 03:55 the airport security service provided cordon and security of the accident site.

#### 1.16. Tests and Research

The Air accident scientific and Technical Support Commission of the Interstate Aviation Committee conducted special research involving the readout and processing of the CVR and FRD data and their analysis. The conducted research made it possible to analyze the aircraft dynamics at takeoff, build the aircraft trajectory from the site of the first impact until the stop and assess the crew actions.

Upon request from the investigation team, the Bombardier Company conducted the following: simulation of the CL-604 D-ARWE takeoff at Almaty airport on December 25, 2007; simulation of the anti-icing system operation; assessment of the Wing Anti-Ice during the takeoff in STANDBY mode.

The BFU (Germany) made clarification of the CL-604 D-ARWE crew communications during the pre-flight preparation at Almaty airport as they were conducted in German.

## 1.16.1. Mathematical Simulation of the CL-604 D-ARWE takeoff at Almaty Airport

The simulation of the CL-604 D-ARWE takeoff at Almaty airport on 25.12.2007 was made with the use of a mathematic model based on Matrix X including the aircraft aerodynamic model (six degrees of freedom) and a model of the aircraft control system, equipment and engines.

The simulation was conducted from the moment when the engines were switched from idle at the line-up to a higher operating mode for the takeoff roll. The initial conditions and aircraft configuration were taken from the FDR data. The position of the throttles was determined on the basis of the N2 values from the FDR. Further aircraft movement was calculated considering the control column deflections recorded by the FDR.

In the course of the modeling the Deltas for the lift and side force coefficients, as well as the pitch, roll and yaw moment coefficients which had to be introduced in the model to match the calculated vertical and lateral acceleration, pitch and roll angles and course with their actual values recorded by the FDR.

The simulation revealed that the need to introduce a negative correction to the simulated delta lift coefficient appears about 2 seconds after the nose wheel rotation. In the course of further takeoff the absolute delta lift coefficient was growing and by the time the right bank was 63° it reached minus 0, 225.

The need to introduce correction to the delta roll moment coefficient also appears after the rotation. Further it was about 0,05 (right bank) despite the fact that all that time the ailerons were deflected to create left bank.

**Conclusion:** shortly after the aircraft liftoff the lift significantly decreased as compared with its simulation value. The loss of lift was asymmetric and was accompanied with a significant right roll moment not compensated by the full left aileron deflection. This is a typical case of right wing stall.

## 1.16.2. Natural Experiment to Check the Possibility of Wing Anti-Ice of the CL-604 D-ARWE Switching to STANDBY before Takeoff at Almaty Airport

The visual examination of the CL-604 D-ARWE cockpit after the accident revealed that the WAI switch was in the STBY position (standby mode). The possibility of the WAI switch being in that position during the takeoff was estimated in an experimental way. The experiment was conducted at a CRJ200 AC7002 aircraft whose engines and WAI performance are similar to those of the CL-604 aircraft. Due to this similarity the observations made during the experiments at the CRJ200 could just as well apply to the CL-604.

It is known that if the WAI is operating in the STANDBY mode the leading edge bleed valve is either fully open (ON) or fully closed (OFF) depending on the leading edge temperature gauge indications. The duration of the ON-OFF cycle depends on the outside conditions. Theoretically, the ON-OFF cycles should affect the inter turbine temperature (ITT) which is synchronized with the engagement of air bleed to the WAI.

The conducted experiment revealed that the air bleed from the engine to various aircraft systems affects the ITT in the following way:

- when the Cowl Anti-Ice is engaged, the ITT increases by about 25° C;

- when both CAI and WAI are engaged the ITT increases by about 50° C;

- when the WAI is engaged in its STANDBY mode the ITT changes in a cyclic way affected by the cyclic air bleed. The ITT gradually increases when the air is bled to the WAI and then gradually decreases when the air bleed is off by about 25° C. The interval between the increases in the ITT is about 3 minutes.

According to the FDR data of the CL-604 D-ARWE, within 15 minutes before the takeoff attempt on the day of the accident the ITT remained quite stable, except when the pilot increased engine thrust during the taxiing (Figure 2).

**Conclusion:** the changes in the ITT of the CL-604 D-ARWE before takeoff (no repeating modulations) exclude the possibility of the WAI being in the STANDBY mode at that stage.

## 1.16.3. Simulation of the CL-604 D-ARWE WAI Operation during Takeoff at Almaty Airport

The assessment of the WAI operation at Almaty airport was conducted with use of the mathematical thermodynamic model of the GE CF34-3B engine that has similar characteristics to the CF34-3B engines mounted on the CL-604 aircraft. The simulation was conducted for conditions equal to the CL-604 D-ARWE takeoff conditions and provided the air bleed to the anti-ice systems was zero. The results of the simulation were compared to the CL-604 D-ARWE FDR data on the two previous flights. In one of those flights the WAI was certainly off. The ITT were compared.

The simulation revealed that during the CL-604 D-ARWE accident takeoff at Almaty airport there was no air bleed to the WAI, i.e. the WAI was disengaged.

*Note:* The WING AN

The WING ANTI-ICE switch has three position:

- *1. «OFF» the WAI is disengaged.*
- 2. «NORM» the WAI NORMAL mode is engaged keeping the leading edge temperature at 88° C.
- *3. «STBY» the WAI STANDBY mode is engaged during which the leading edge temperature changes in a cyclic way within 49...82° C.*

According to the FDR of the CL-604 D-ARWE, after the engine start-up on 25.12.2007 at Almaty airport the ITT gradually increased by about 25° C. Considering the data obtained in the course of the CRJ200 AC7002 experiment (see Section 1.16.2.), it can be concluded that the abovementioned ITT change indicated the engagement of the Cowl Anti-Ice. This suggestion

complies with the CL-604 AFM recommendations to engage the Cowl Anti-Ice and Wing Anti-Ice after the engine start-up if necessary.

**Conclusion:** during the CL-604 D-ARWE takeoff at Almaty airport on 25.12.2007 the WAI was disengaged (the WING ANTI-ICE switch was OFF), the CAI was most probably ON (the COWL ANTI-ICE (L и R) lights were ON).

## 1.16.4. Clarification of the CL-604 D-ARWE Crew Communications when Preparing for Takeoff at Almaty Airport

The BFU (Germany) made clarification of the CL-604 D-ARWE crew communications during the pre-flight preparation at Almaty airport concerning the content of communications conducted in German. The major problems were connected with the understanding of the meaning of several phrases pronounced by the crew in the time period from 20:57:35 to 20:57:44 UTC. At that period the co-pilot's (FO) request: «So, dann kommt die Line-up Check List... machst Du?» was replied by the PIC (Cpt) with: «Ja, das mach mal schnell. Ich äh geb dir die Wing anti-ice dann nachher im climb out ja?». Which was followed by the FO reply: «Mh».

It was obvious that the mentioned phrases concerned the usage of the WAI at takeoff. However, the special manner of the sentence construction and their probable conventional character typical of crew communications made it necessary to obtain additional clarifications from the PIC.

According to the information provided by the BFU the PIC commented the phrases above in the following way: The phrase pronounced by the co-pilot at 20:57:35 «So, dann kommt die Line-up Check List ... machst Du?» meant "So now the Line-up Check List... will you do it?". By this the co-pilot suggested that the PIC do the Takeoff-Checklist calling it Line-up Check List. The PIC's reply: «Ja, das mach mal schnell. Ich äh geb dir die Wing anti-ice dann nachher im climb out ja?» meant "Yes, make it quickly... I... er... will give you Wing Anti-Ice later in climb out, right?" This phrase is to be understood as the PIC's suggestion to engage the Wing Anti-Ice during the climb after the takeoff. The "Mh" interjection pronounced by the co-pilot at 20:57:44 meant "Ok" and indicated the co-pilot's agreement to the PIC's suggestion concerning the Wing Anti-Ice engagement after the takeoff.

The PIC explained his decision not to engage the Wing Anti-Ice before the takeoff in the following way. According to his estimations, as the aircraft was standing at Almaty airport and taxiing to the line-up position there was no threat of icing. Besides, the PIC supposed that the Type 2 anti-icing fluid applied to the aircraft must have provided additional anti-icing protection for about 30 minutes. Therefore the PIC decided to use the engine thrust wholly for the takeoff roll and engage the Wing Anti-Ice right after the takeoff.

#### 1.17. Organizational and Management Information

The JetConnection Businessflight AG Airline has an Air Operator Certificate № D-094 AOC issued by the Civil Aviation Authority of Germany (Luftfahrt - Bundesamt LBA) on September 20, 2007 and valid till September 30, 2009. The airline provides commercial air transportation in compliance with JAR OPS Deutsch and German Federal aviation Rules.

#### 1.18. Additional Information

#### 1.18.1. Previous cases

Within the operation of CL-600-2B19 and CL-600-2B16 type aircraft several accidents occurred with similar circumstances:

- January 4, 2002, Birmingham Airport (Great Britain), accident involving a CL-600-2B16 aircraft registered N90AG;

- November 21, 2004, Baotou airport (China), accident involving a CL-600-2B19 aircraft, registered B-3072;

- November 28, 2004, Montrose Airport (Colorado, USA), accident involving a CL-600-2B16 aircraft, registered N873G;

- February 13, 2007, Vnukovo Airport (Russia) accident involving a CL-600-2B19 aircraft, registered N168CK.

In all the abovementioned cases it was determined that right after the liftoff the aircraft entered stall with intensive uncommanded roll and further crash. The stall occurred before the firing of the relative stall protection system warning with significant loss in lift performance and at angles of attack significantly lower than stall angle of attack of a type aircraft with a clear (non-contaminated) wing estimated by test flights. The weather conditions in all cases were determined as those described in the Cold Weather Operations. All the investigations revealed that the contamination of the wing leading edge (with snow, frost, etc.) was one of the main factors contributing to the accident.

Note:

- 1. On February 14, 2008, while the accident in question was still under investigation, another accident involving a CL-600-2B19 aircraft, registered EW-101PJ at Zvartnots Airport (Erevan, Republic of Armenia) due to a similar cause.
- 2. The same causes led to a number of serious incidents at takeoff. The last one occurred on January 31, 2008 in Norway involving a CL-600-2B19 aircraft, registered OY-RJC.

## 1.18.2. Operational Peculiarities of CL-600-2B19 and CL-600-2B16 Aircraft

In the course of the accident investigation the Canadian representatives provided materials on the structural and operational peculiarities of these aircraft types. Special attention was drawn to cold weather operations of the aircraft with supercritical wing profile without slats. This information was copied on CD's and sent to the Contracting States to the Agreement on Civil Aviation and Use of Airspace to be studied with the flight and maintenance personnel operating CRJ-100 type aircraft.

Additionally, from 09.12.2008 to 19.12.2008 representatives of the Bombardier Company held cluster meetings (in Koln, Innsbruck, Moscow, Almaty and London) concerning this issue with representatives of airlines operating CRJ-100 type aircraft.

#### **1.18.3.** Airworthiness Directives

As precautionary measures to improve flight safety during cold weather operations on March 7, 2008 the Ministry of Transport, Canada issued two Airworthiness Directives  $\mathbb{N}$  CF-2008-15 and  $\mathbb{N}$  CF-2008-16, that introduces additional limitations to the crew actions when preparing to take off in cold weather conditions. Thus, if the anti-icing fluid had not been applied it is mandatory to engage the WAI at the final stage of taxiing when the OAT is +5° C or below. It was also mandated to perform a tactile (touch) check of the wing surface in all cases when the OAT is +5° C or below. Upon the request of IAC Aviation Register, there was introduced another limitation for aircraft operated under IAC Type Certificate mandating to apply the anti-icing fluid when the OAT is +5° C or below and to use the Wing Anti-Ice when taking off in such conditions in accordance with the manufacturer's recommendations.

On 20 August 2008 TCCA issued two newly updated revision of the abovementioned Directives (AD CF-2008-15R1 and AD CF-2008-16R1). These Directives mandate the amendment of the AFM Limitations section that requires specific pilot training with regard to enhanced takeoff procedures and winter operations.

# **1.18.4.** Factors Affecting the Critical Angle of Attack Value for Challenger and CRJ Aircraft

A systematization of the available experimental data and special estimations concerning the influence of the ground effect, the contamination of the wing surface and rate of rotation during takeoff on the stall angle of attack for the aircraft of the mentioned types conducted by the Bombardier Company revealed the following:

- the ground effect by the time of the liftoff leads to a decrease of the critical angle of attack by  $2...4^{\circ}$ ;

- contamination of the leading edge surface and its roughness caused by a thick layer of frost or rough ice leads to a decrease in the wing critical angle of attack by  $5...7^{\circ}$ ;

- high rate of rotation at takeoff intensifies the effect of the two abovementioned factors as the actual angles of attack are increasing in the ground effect.

Thus, the actual wing stall angle of attack when taking off with a contaminated wing can be  $7...11^{\circ}$  lower than the estimated critical value.

#### 1.19. New Investigation Techniques

No new techniques were used.

INTERSTATE AVIATION COMMITTEE

#### 2. Analysis<sup>1</sup>

The clearance to line up was obtained by the crew at 20:57:15. They were instructed to wait for further instructions at the line-up position as the runway was occupied by the landing MD-83 aircraft conducting Flight UKM 109.

The analysis of the cockpit communications between the crew members revealed that at the line-up position when going through the Takeoff Checklist the crew decided to engage the Wing Anti-Ice after the takeoff.

In the CL-604 Aircraft AFM (Chapter 2 Limitations, Section Operating Limitations, Item 3 Operation in Icing Conditions, Sub-item B (1) Wing Anti-Ice System. Ground Operations) are indicated the conditions under which the wing anti-ice (WAI) system must be on for takeoff. These conditions are following:

- The wing anti-ice system must be on for takeoff when the OAT is 5°C (41°F) or below and visible moisture in any form is present (such as fog with visibility of one mile or less, rain, snow, sleet and ice crystals).
- The wing anti-ice system must also be on for takeoff when the OAT is 5°C (41°F) or below and the runway is contaminated with surface snow, slush or standing water.

Here is also indicated that by the abovementioned conditions when Type II, III or IV antiicing fluids have been applied, the WAI system must only be selected on just prior to thrust increase for takeoff.

Considering the actual weather and the RWY conditions at the takeoff (see Section 1.7 of present Report) one can establish a fact that a decision to perform takeoff with the WAI off was made by the flight crew contrary to the CL-604 AFM recommendations.

The PIC commented to the BFU that according to his estimations there was no threat of icing at takeoff. Besides, the PIC supposed that the applied Type 2 anti-icing fluid must have provided additional anti-icing protection for about 30 minutes. Therefore the PIC decided to use the maximum engine thrust for the takeoff run and engage the Wing Anti-Ice right after the takeoff.

CVR record analysis showed that the updated ATIS-B information which was broadcasted at 129,9 MHz since 20 h 36 min UTC on the 26<sup>th</sup> of December, 2007, was missed by the flight crew before takeoff. The above mentioned broadcast specifically pointed (see Section 1.7 of present Report) that the RWY was covered with dry snow 10 mm; there were atmospheric precipitates such as light snow.

<sup>&</sup>lt;sup>1</sup> The analysis of events before the crew was cleared to line up is given in Section 1.1.

As follows from the PIC's explanations and the CVR record, at line-up position the PIC conducted the duties distribution for the takeoff, in accordance to which the co-pilot was to be the pilot-flying.

At 21:01:30 the crew obtained clearance for departure from the Tower and started following it. By that time about 25 minutes had passed since the start of the Type 2 anti-icing fluid application.

This period of time was needed for the PIC to inspect the anti-icing treatment quality, to start engines, to taxi to holding point and lineup, to conduct inspection checks at each stage, as well as to hold (due to traffic management by tower) while the arriving aircraft performs a landing and vacates the RWY.

Before the takeoff upon the co-pilot's request the PIC set the engines to higher thrust for takeoff. According to the FDR (Figure 2), the N1 was about 85,6 % and N2 was about 89,1 %.

In accordance with the estimations of the Bombardier Company the N1 set by the PIC was 1,4 % lower than recommended by the CL-604 AFM for the changed flight conditions. The lack of engine takeoff thrust was about 4,2 %.

At 21:01:57 the crew started the takeoff run. In the course of the run within 21:01:57 to 21:02:15 the elevator was deflected to minus 2°, which corresponds to the control column position close to neutral (Figure 3). The rudder position at the same time was changing within  $0...-5,7^{\circ}$  (right pedal forward) (Figure 4). Such rudder actions were probably connected with the presence of left crosswind component.

According to the PIC's callout: "V1, rotation", the rotation was initiated at 21:02:15 at an indicated speed of 144 knots. It should be noted that provided the takeoff weight was 20659 kg, the CG was 33,1 % and the takeoff reference speeds had the following values:  $V_1 = 136$  knots,  $V_r = 137$  knots,  $V_2 = 145$  knots.

From that time the co-pilot started pulling the control column and in 1.5 seconds the elevator was deflected at  $-6.7^{\circ}$ , and the fuselage angle of attack reached  $4.3^{\circ}$ .

The rotation started at 21:02:17 at a speed of 150 knots. Further the co-pilot pushed the control column and by 21:02:17,5 the elevator reached -2,2°, i.e. close to its position during the takeoff run. It could be assumed that by pushing the control column the pilot was trying to decrease the intensity of the increasing pitch angle. According to the CL-604 OM (Part 1, Chapter 6 "Supplementary Procedures", Section "Cold weather Operations", Para 8.E.) it is not recommended to exceed the rate of rotation (pitch rate) more than 3 degrees per second. The crew must be ready for higher than usual increase of initial climb speed.

*Note:* Here the Section "Cold weather Operations" of the CL-604 OM is mentioned because there is a reference to this document in the CL-604 AFM.

It should be noted that Chapter 4, Part 1 of the CL-604 OM describing Normal Procedures at takeoff does not contain this caution. Upon the request of the investigation team the Manufacturer explained that there are no objective data (flight tests, wind tunnel tests) to confirm this recommendation. The recommendation is based more on the experience of this aircraft's type operations. The investigation team analyzed the changes of the flight parameters recorded both in a number of accident or incident takeoffs and in eventless takeoffs. The analysis revealed that if the clear wing concept is maintained even double exceedence of the recommended rate of rotation (3 degrees per second) does not lead to loss of wing lift performance. On the other hand the analysis of the accident and incident data assumes that contamination of the wing leading edge leads to significant loss of longitudinal stability which, provided the elevator efficiency does not change, leads to a significant increase in the actual pitch rate. Performing rotation with the usual deflection of the control column the pilot does not expect and therefore cannot counteract the unusually high pitch rate which in its turn makes it difficult for the air flow to restructure on the wing and can lead to early stall. Thus, this issue requires additional research while the recommendation is to be reconsidered.

According to the estimations the pitch rate during the takeoff run of the CL-604 D-ARWE within 21:02:16,5... 21:02:17,5 peaked at 5,8 degrees/second, which is twice as high as the maximum limit. The analysis of the FDR data for the previous flights revealed that in almost all flights the pitch rate exceeded the established limitations (Figure 5). Most probably this was caused by the fact that the crew could not monitor this parameter with use of flight instruments. Therefore, when assessing pitch rate the crew has to rely on their personal sensations.

By 21:02:18,2 the fuselage angle of attack was 10° and 11,2° while the right bank reached 4°. From that moment on, right bank was developing abruptly reaching 28,4° in one second. Judging by the FDR record the pilot tried to counteract the right bank by deflecting the control wheel to full left stop and advancing the left pedal. It should be noted that the left yaw control pedal was only advanced for 30% and provided the rudder deflection of only 7,5°, i.e. the pilot did not completely use the opportunity to counteract the bank by the rudder deflection. Besides the crew did not take measures to increase the engine thrust as recommended by the CL-604 OM (Part 1, Chapter 6 "Supplementary Procedures", Section "Cold weather Operations", p. 06-12-29) for the emerging situation.

Note: According to the PIC's explanations, which has been received in presence of the Consul General of the Federal Republic of Germany in the Republic of Kazakhstan and of the interpreter of Consulate, when the aircraft lifted off he leant to reach for the checklist and was distracted from the flight monitoring.

# *After the PIC lifted his head he saw that the aircraft was in severe right bank and the co-pilot was trying to level the aircraft*<sup>2</sup>.

The actions taken by the co-pilot did not prevent the developing emergency situation. At 21:02:20 the right bank reached  $50,5^{\circ}$  with the fuselage angle of attack being  $10,5^{\circ}$ .

The right bank was developing and by 21:02:21,2 reached 64,2°. At that time the aircraft right wing tip touched the ground near the right edge of RWY 05 (course 52°M). The aircraft collided with the ground at a speed of 159 knots, course 73,7° M, pitch angle 7,6°. Right after that, probably to avoid further collision the co-pilot abruptly shifted the elevator to -13°. However, a second later judging by the interruption of signals on all FDR channels the aircraft crashed on the airfield surface. Further moving the aircraft crashed into a reinforced airdrome fence. Then, gradually destroyed the aircraft shifted about 190 m beyond the fence, stopped and caught fire. Two crew members (PIC and flight attendant) and the passenger left the aircraft through the breaks in the fuselage. Near the aircraft they were met by the airdrome security staff and fire brigade arriving to the burning aircraft and led to the airport medical staff. Later, about 30 m from the burning aircraft the body of the co-pilot was found as he was probably thrown away from the cockpit as it was destroyed.

All the surviving persons, after they were rendered first aid, were taken to the reanimation department of Almaty city hospital  $N_{2}$  4. On 28.12.2007 they were sent by the General Consulate of the Federation Republic of Germany in the Republic of Kazakhstan to Germany on a sanitary aircraft.

The forensic chemical expertise of the co-pilot's inner organ tissues (stomach, liver and kidneys) revealed traces of ethanol. No narcotic substances were detected. The forensic chemical examination of the co-pilot's blood revealed no trace of ethanol or narcotics.

To determine the origin of ethanol presence in the co-pilot's inner organ tissues and estimate how that had affected his performance during takeoff based on available data does not seem possible.

In the course of the examination of the aircraft condition, analysis of the FDR and CVR data and the wreckage plot the investigation team considered all possible causes of the uncommanded right bank development. The investigation revealed that the uncommanded right bank after the liftoff was not connected with the aircraft technical condition or its engine and systems operation.

<sup>&</sup>lt;sup>2</sup>According to the PIC statement there was a translation problem during the interview. According to his allegation he was always aware of the situation during takeoff and was not distracted by anything.

The analysis of the flight recorder information after the liftoff revealed that the uncommanded right bank started developing at angles of attack lower than the firing angles for the stall Protection System Warning and before the Stall Warbler Tone.

The mathematical simulation of the accident conducted by the Bombardier Company revealed that shortly after the liftoff there was a significant loss of lift as compared to lift value extracted by simulation. The lift loss was accompanied with a significant rolling moment and developing right bank despite the full left aileron deflection. It was concluded that the simulated process was a typical case of right wing stall.

It is known that a number of Bombardier aircraft types including the CL-604 have supercritical wing profile and no slats. At low flight speeds, as the angle of attack is increased to the critical value, the appearing stall on the wing of such profile can almost immediately spread over its upper surface. The cautioning shaking accompanying stall at normal profile wings is absent in this case. This airflow separation character leads to a sudden lift loss and abrupt unexpected stall.

The efficiency of wings with supercritical profile is reached in case of the estimated air flow which is completely realized only provided the wing is clear. The wing contamination with the deposits of ice, frost, snow, etc. leads to the distortion of the airflow especially if the angle of attack increases followed by abrupt airflow separation. Usually the separation is asymmetric which leads to intensive bank.

As was mentioned in Section 1.18.1 of this report, within the operation of the CL-600-2B19 and CL-600-2B16 type aircraft there were a number of accidents with similar circumstances. In all the mentioned case it was revealed that right after the liftoff the aircraft entered a stall with intensive uncommanded banking and further crash. The stall occurred before the relative SPS warning was fired with significant lift loss and at angles of attack significantly lower than the stall angles of attack for the clear-wing (non-contaminated) aircraft obtained from the test flights. The weather conditions in all the cases could be determined as cold weather. All the completed investigations revealed that contamination of the wing leading edge (with frost, snow, etc.) was one of the main factors contributing to the accident.

It can be seen that the aircraft dynamics in the investigated case is typical for stall at takeoff with contaminated wing. The analysis of the weather conditions at the period of the aircraft departure and the crew actions during the pre-flight preparation reveals that there were actual conditions for the wing contamination.

Thus the test check of the weather parameters taken at Almaty airdrome after the accident alert at 21:04 UTC registered mist and precipitation in the form of snow. The runway was covered with snow up to 10 mm thick. The OAT at that time was minus 14° C, dewpoint minus

 $15^{\circ}$  C, moisture content 92 %. Besides the crew did not engage the Wing Anti-Ice before setting the engines to takeoff mode which is mandated by the CL-604 AFM (Limitations) if the OAT is  $+5^{\circ}$  C or below and in sight of visual moisture in any form<sup>3</sup>.

The presence of contamination is indicated by the aircraft stall after the liftoff with fuselage angles of attack being  $10...10,5^{\circ}$ , whereas the critical angle of attack for the clear wing aircraft, according to the data of the Bombardier Company, is about  $17^{\circ}$ .

Most probably, the wing contamination occurred as a result of precipitation in the form of snow sticking to its surface covered with Type 2 anti-icing fluid during the taxiing and at the holding point and line-up position which took altogether about 27 minutes. During the takeoff run the contamination could have continued with pieces of snow raised into the air as the aircraft was moving along the snow-covered runway.

The use of Wing Anti-Ice at takeoff would have provided heating and discharge of the snow stuck to the wing leading edge whose clear surface is critical for the continuous airflow on the supercritical profile wings.

The visual examination of the CL-604 D-ARWE cockpit after the accident revealed that the WING ANTI-ICE switch was on STBY (standby mode). It should be noted that the WAI standby mode is used by the crew only if the NORMAL WAI mode fails.

The examination conducted by the Bombardier Company revealed that at takeoff the WING ANTI-ICE switch was OFF (see Section 1.16.3). The switch was probably shifted to STBY as a result of the aircraft destruction as it was colliding with the ground obstacles.

<sup>&</sup>lt;sup>3</sup> According to the PIC he did not observe moisture in any form before takeoff.

#### 3. Conclusion

The accident involving a CL-604 aircraft registered D-ARWE was caused by the asymmetric lift loss at takeoff which led to aircraft stall right after the liftoff, collision with the ground and obstacles, aircraft destruction and ground fire.

The lift loss was most probably caused by the contamination of the wing leading edge with precipitation in the form of snow after the anti-icing which occurred as the crew did not engage the Wing Anti-Ice before the takeoff which is a mandatory requirement of the CL-604 AFM in the actual weather conditions (moderate snow, OAT minus 14° C, moisture content 92 %, dewpoint minus 15° C, dry snow on the runway, 10 mm thick).

Significant violation of the CL-604 AFM/OM limitations concerning the rate of rotation (pitch rate) when taking off with contaminated wing provided it was impossible to monitor this parameter instrumentally could have contributed to the situation.

The inefficiency of the availably stall protection system at takeoff due to the hypersensitive wing as to contamination of its leading edge cannot completely guarantee prevention of similar accidents in the future.

#### 4. Safety Recommendations

- 4.1. Airlines which have the CL-604 type aircraft in operation consider the practicability of:
  - arranging of debriefings to study the causes and contributing factors to the CL-604
    D-ARWE accident;
  - arranging of training for the flight crews operating this aircraft type when preparing for the cold weather period operations concerning the aircraft aerodynamics highlighting the possibility of stall in case of contaminated wing with deposits of ice, snow, frost etc. as well as the de-icing/anti-icing rules and use of Wing Anti-Ice system;
  - recommend captains operating CL-604 type aircraft, in case the co-pilot has low (less than 200 hours) experience on this aircraft type conduct takeoffs and landings by themselves in case of contamination, precipitation, low braking action, and excessive crosswind component.
- 4.2. The Bombardier Company, consider the practicability of working out more efficient recommendations for pilots to avoid stalling at takeoff due to wing contamination.
- 4.3. JetConnection Businessflight AG Airline, review the content of the Airline ABBRIVATED CHECKLIST in order to avoid the omissions of stipulated by the CL-604 AFM checklist items.

## Appendix

















Figure 5. Changes in the elevator position and pitch angle of the CL-604 D-ARWE aircraft at liftoff