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Swiss Accident Investigation Board SAIB

Aviation Division

Interim report of the Swiss Accident Investigation Board

concerning the accident of the airplane
Bombardier DHC-8-402 registered as
9A-CQC

on 27 September 2013

on runway 14 at Zurich Airport

General information on this report

This interim report was prepared in accordance with Article 18 of the Swiss ordinance on the investigation of aircraft accidents and serious incidents (*Verordnung über die Untersuchung von Flugunfällen und schweren Vorfällen*). In accordance with Article 3.1 of the 10th edition, applicable from 18 November 2010, of Annex 13 of the Convention to International Civil Aviation of 7 December 1944 (Chicago Convention) and Article 24 of the Federal Air Navigation Act (*Bundesgesetz über die Luftfahrt*), the sole purpose of the investigation of an aircraft accident or serious incident is to prevent accidents or serious incidents. The legal assessment of accident and incident causes and circumstances is expressly no concern of the accident investigation. It is therefore not the purpose of this report to determine blame or clarify questions of liability.

If this report is used for purposes other than accident or incident prevention, this may give rise to erroneous interpretations.

All times in this report, unless otherwise indicated, are stated in Co-ordinated Universal Time (UTC). At the time of the accident, Central European Summer Time (CEST) allied as local time (LT) in Switzerland. The relation between LT, CEST and UTC is: $LT = CEST = UTC + 2$ hours.

Until synchronization of the various data recordings has been finished, published times are accurate to the minute only and may change slightly. However, any anticipated changes are within a range of seconds and do not bear any relevance concerning the sequence of events of the accident flight.

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Interim report

Summary

Aircraft

Owner Goal Verwaltungsgesellschaft mbH & C., Grünwald, Germany

Operator Croatia Airlines, Croatian air transport company Ltd, Zagreb, Croatia

Manufacturer Bombardier Aerospace Inc., Quebec, Canada

Type of aircraft DHC-8-402 (also known as Dash-8 Q400)

Country of registration Croatia

Registration 9A-CQC

Commercial flight number OU 464

ATC callsign Croatia 464

Flight rules Instrument flight rules (IFR)

Type of operation Scheduled flight

Point of departure Zagreb (LDZA), Croatia

Point of destination Zurich (LSZH), Switzerland

Location of accident Runway 14 at Zurich Airport, Switzerland

Final position of aircraft 47°28'11" N 8°33'11" E 420 m AMSL

Date and time 27 September 2013 at 18:18 UTC

Investigation

The accident occurred on Friday 27 September 2013 at 18:18 UTC. It was immediately notified to the Swiss Accident Investigation Board (SAIB) and the investigation was opened on the same day.

The SAIB reported the accident to the Canadian and Croatian authorities. Both authorities nominated an accredited representative and multiple advisors.

The final report will be issued by the Swiss Accident Investigation Board.

Synopsis

On 27 September 2013 a Bombardier DHC-8-402 airplane, registered as 9A-CQC, was operating the scheduled flight OU 464 from Zagreb (Croatia) to Zurich (Switzerland). After an uneventful flight the airplane was established on an instrument approach for runway 14. At about six nautical miles from the threshold, the flight crew selected the landing gear down; the main landing gear extended fully however the nose landing gear did not extend.

The flight crew discontinued the approach and the air traffic control offered them to join a holding pattern for troubleshooting. The extension of the nose landing gear could not be achieved, neither with reference to the non-normal/emergency checklist in the quick reference handbook (QRH) of the airplane nor with a flight operation service letter published by the aircraft manufacturer. The flight crew opted for a landing with main gear extended and nose gear up. After preparing the cabin for a planned emergency landing and informing the air traffic control a second approach was performed.

The airplane landed on runway 14 at Zurich airport at 18:18 UTC and came to a complete stop 540 meters after the forward fuselage had come into contact with the runway surface. The fire brigade was ready to intervene. There was no fire. The passengers and the crew disembarked via the forward left cabin door.

Neither the passengers nor the crew were injured. The airplane's lower forward area of the fuselage was damaged.

Cause

Due to the investigation being still underway, this interim report is limited in scope. It merely consists of a summary of the available and verified factual information and a description of the safety deficits uncovered up to this point in the investigation, as well as initial safety recommendations. More factual information, an in-depth analysis and a statement of causes will be included in the final report.

Safety recommendation

In this interim report two safety recommendations are issued.

1 Factual information

1.1 Pre-history and history of the flight

1.1.1 General

The following description of the flight history is based on statements and documents of the flight and cabin crew members, radiotelephony recordings, recordings of the cockpit voice recorder (CVR), the alert journal of the airport authority of Zurich airport, information of the fire department of Zurich airport as well as air traffic control radar data.

During the accident flight of 9A-CQC, the airplane was operated under instrument flight rules (IFR). The commander performed the duties of the pilot flying (PF), whereas the first officer performed the duties of the pilot not flying (PNF).

1.1.2 Pre-history

The crew of flight OU 464 reported for duty on 27 September 2013 at 11:40 UTC. One hour and 15 minutes were allocated for flight planning and briefing. Two flights were conducted before the flight from Zagreb (LDZA) to Zurich (LSZH). The flight crew reported that no technical problems were experienced on 9A-CQC during the two previous flights and no safety-related defects were entered on the aircraft's technical log.

1.1.3 History of the flight

On the early evening of 27 September 2013, the airplane, a Bombardier DHC-8-402 also known as Dash-8 Q400 with the registration 9A-CQC, took off from Zagreb, Croatia. There were two pilots, two flight attendants and sixty passengers on board. The flight, operated by Croatia Airlines as flight OU 464, was bound for Zurich, Switzerland. The take-off from Zagreb, climb and cruise were uneventful. During the descent toward Zurich, the ATIS information of Zurich was obtained and the weather was assessed as being not problematic for an approach to Zurich airport. Subsequently, the approach preparations were made for an instrument landing system (ILS) approach for landing on runway 14.

About 15 nautical miles (NM) northwest of the airport, the flight crew received the final heading to intercept the localizer of the ILS for runway 14. At about eight nautical miles from the threshold, the airplane was established on the ILS and the flight crew was instructed by final approach control to switch to the frequency of Zurich aerodrome control (ADC) at 17:27 UTC.

At about six nautical miles from the threshold, the first officer, following the order of the commander, lowered the landing gear lever to the DOWN position. Subsequently, the flight crew heard a loud and repetitive sound, which was described as being *"like a rubber hitting a metal"*. The flight crew was under the impression that two components were hitting each other in the nose landing gear bay. Also, one of the flight attendants heard a *"strange repetitive noise coming from the nose gear"*. The flight crew then checked the landing gear indication lights on the instrument panel. Both main landing gear indication lights were green, indicating a down and locked position. The nose landing gear indication showed a discrepancy between the landing gear control lever and the landing gear position.

At this point, the flight crew decided to discontinue the approach and informed air traffic control accordingly. Immediately, Croatia 464 was ordered by ADC to climb straight ahead to 4000 feet QNH. A holding pattern for troubleshooting was offered by ATC and accepted by the flight crew. At 17:29 UTC the flight crew was instructed to switch to the frequency of Zurich arrival. Flight OU 464 was then

cleared for further climb and to proceed to the waypoint AMIKI and enter the holding pattern.

After discontinuing the approach, the flight crew decided to and successfully retracted the landing gear. The landing gear indications were then congruent with a retracted landing gear and the unusual sound stopped.

At 17:36 UTC the cabin crew was informed about the existing problem with the nose landing gear. The flight crew then started with the application of the alternate landing gear extension checklist laid out in the quick reference handbook (QRH).

At 17:39 UTC flight OU 464 entered the holding pattern at flight level (FL) 90. Since the alternate landing gear extension procedure was not successful, the flight crew then went on with consulting the airplane manufacturer's flight operations service letter (FOSL) concerning issues with the landing gear (cf. chapter 1.6.3). Despite referring to the procedures laid out in this FOSL the problem persisted.

The flight crew finally decided to perform the landing at Zurich airport with the nose gear in the supposedly retracted position.

At 17:48 UTC the cabin crew was informed by the flight crew that a nose gear up landing was to be expected. The commander then informed the passengers about the situation. Air traffic control was informed accordingly.

The flight attendants then prepared the cabin and galley for the planned emergency landing. Some passengers were reseated, the first three passenger seat rows were emptied and able-bodied passengers were selected at appropriate seat locations in order to help with a possible evacuation. The passengers were given instructions regarding the evacuation procedures and the opening of the cabin doors.

Preparations for an emergency landing were made in the cockpit after leaving the AMIKI holding at 17:58 UTC.

After radar vectoring, flight OU 464 was established again on the ILS for runway 14 at 18:14 UTC. In the meantime measures were taken on ground for the planned emergency landing.

At 18:18 UTC, the airplane touched down on runway 14 with its main landing gear. As the airplane was decelerating, the nose was lowered and the airplane came to a complete stop 540 meters after the forward lower fuselage had come into contact with the runway surface.

The fire brigade, arriving at the airplane just seconds after the airplane had stopped, checked that there was no fire. Thereafter a controlled disembarkation was initiated through the forward left cabin door, implying that passengers had to leave their hand luggage on board the airplane.

Neither the passengers nor the crew were injured. The airplane's lower forward area of the fuselage was damaged.

1.1.4 Location and other details

Location of accident	Runway 14 at Zurich Airport, Switzerland
Final position of aircraft	47°28'11" N 8°33'11" E 420 m AMSL
Date and time	27 September 2013 at 18:18 UTC
Illumination	Night

1.2 Injuries to persons

No persons were injured in the accident.

1.3 Damage to aircraft

The airplane was damaged.

1.4 Other damage

Details will be included in the final report.

1.5 Personnel information

Details will be included in the final report.

1.6 Aircraft information

1.6.1 General

Type of aircraft	DHC-8-402 (also known as Dash-8 Q400)
Characteristics	Transport-category airplane for 78 passengers, powered by two turboprop engines, high-wing configuration, tricycle gear.
Owner	Goal Verwaltungsgesellschaft mbH & C., Grünwald, Germany
Operator	Croatia Airlines, Croatian air transport company Ltd, Zagreb, Croatia
Manufacturer	Bombardier Aerospace Inc., Quebec, Canada
Country of registration	Croatia
Registration	9A-CQC
Year of manufacture	2009
Serial number	4258

1.6.2 Landing gear

Extract from the manufacturers aircraft maintenance manual chapter 32-30-00-001:

"Normal landing gear operation is controlled by the PSEU [proximity sensor electronic unit] as a result of input signals from the landing gear selector lever. The No. 2 hydraulic system supplies the power to move the landing gear.(...) When the landing gear selector lever is moved to the DOWN position, the PSEU signals the selector valve to supply hydraulic power to the extend circuit of the landing gear hydraulic system. (...)

The alternate extension system is a self resetting, cable actuated design. The system is accessible in the flight compartment. The alternate extension system has a bypass valve and a manual handpump hydraulic system. The bypass valve isolates the landing gear hydraulics from the No.2 hydraulic system. (...)

For an alternate extension of the landing gear to occur, the NLG [nose landing gear] forward doors, the MLG [main landing gear] aft doors, and the landing gear uplocks open mechanically. The NLG free falls to the down and locked position with the help of the airflow over the fuselage. The MLGs free fall and are moved to the down and locked position by the alternate extension actuators. (...)"

1.6.3 Landing gear alternate extension

The procedure describing the extension of the landing gear by means of the alternate extension handle is laid out in the quick reference handbook (QRH) published by the manufacturer (cf. Annex 1).

In addition to that procedure the aircraft manufacturer Bombardier has published a flight operations service letter (FOSL) (DH8-400-SL-32-031A dated 21 April 2011) to remind the flight crew members of the appropriate procedures for operating the landing gear by use of the normal or alternate extension systems.

The FOSL states among others:

"(...) If the landing gear fails to extend or retract, assuming that the Normal Extension/Retraction procedures have been actioned correctly, the following list contains known conditions that have presented the Flight Crew with an abnormal landing gear configuration.: (...)"

Regarding the alternate extension the FOSL states among others:

"(...) When using the Alternate Extension procedure, Flight Crews must ensure:

- (...)
- *The main and nose landing gear release handles are pulled with sufficient force (may exceed 90 lbs) to release the doors and uplocks (pull forces in the air will likely be greater than those experienced on the ground or in a simulator). Continue pulling with whatever force is necessary to achieve release of all landing gear uplocks.*

(...)"

Furthermore a procedure is published for the condition that existed on flight OU 464:

"Nose Gear UP, Main Landing Gear Down" [bold in the FOSL] (cf. Annex 2).

1.7 Meteorological information

A shallow anticyclone ranged from Scandinavia over Central Europe to the Black Sea. A quasi-stationary air mass boundary resided over southern Germany and fed an isolated but intense thunderstorm cell in the vicinity of Constance, to the north-east of Zurich. The thunderstorm was active before and during the landing of flight OU 464 in Zurich. From Zurich airport, lightning was observed but thunders remained unheard.

At Zurich airport, there was no precipitation. The wind was blowing from various directions at a speed of one knot. The visibility was up to 14 kilometers. Neither cumulonimbus nor towering cumulus clouds were observed. There were no clouds below 8000 feet above ground level. According to the meteorological aerodrome report (METAR) of Zurich Airport at 18:20 UTC, the reported temperature was 18° C, the dew point 16° C and the QNH was 1014 hPa.

1.8 Aids to navigation

Details will be included in the final report.

1.9 Communications

Details will be included in the final report.

1.10 Aerodrome information

Zurich airport is the main international airport of Switzerland. It has a system of three runways.

1.11 Flight recorders

The airplane was equipped with a Honeywell solid state memory flight data recorder (SSFDR P/N 980-4700-027 S/N 17114) and a Honeywell solid state memory cockpit voice recorder (SSCVR P/N 980-6022-011 S/N 12564). The recordings are about to be analyzed.

1.12 Wreckage and impact information

Details will be included in the final report.

1.13 Medical and pathological information

Not applicable.

1.14 Fire

There was no fire. During the sliding of the airplane's forward lower fuselage on the runway surface, flying sparks were observed. The forward lower fuselage was cooled by the airport fire brigade.

1.15 Survival aspects

Details will be included in the final report.

1.16 Tests and research

1.16.1 Tests regarding the landing gear extension mechanism

After the damaged airplane had been recovered from the runway, the airplane's nose was jacked up. In the cockpit, an attempt was made to lower the nose landing gear by pulling the handle of the alternate release mechanism. The force applied to the release handle was gradually increased and measured by means of a force measuring device (newton meter). The nose landing gear finally extended at a pulling force of 122 lb (corresponding to 543 N) at the alternate release handle.

It was discovered that the cover plate protecting the two weight on wheel (WOW) sensors located on the front of the nose landing gear strut (subsequently referred to as *WOW cover plate*) had fractured at the lower left and right lug attachment points. The WOW cover plate had pivoted upwards around the cover's two upper mounting points (cf. Figure 1). Pictures of the nose landing gear bay taken just after the accident showed the WOW cover plate squeezed in the nose landing gear mechanism (cf. Figure 2).



Figure 1: Left side: WOW cover plate found after lowering the nose landing gear.
Right side: Normal WOW cover plate installation.



Figure 2: The nose gear WOW cover plate squeezed between the lower and the upper drag strut of the nose landing gear. The picture was taken on the accident site.

After the WOW cover plate was removed from the landing gear, the nose gear was cycled several times by means of the normal and alternate extension and retraction mechanisms without any problems. With the WOW cover plate removed, the necessary pulling force for a gear extension by means of the alternate landing gear release mechanism was measured to be 75 lb (corresponding to 334 N).

1.16.2 Analysis of the nose landing gear WOW cover plate

A metallurgical analysis is currently being conducted by the Swiss Federal Laboratories for Materials Science and Technology. An initial analysis revealed the following results for the broken-off lugs:

- *"Both fracture faces are in a very poor condition (secondary, mechanical damage). Over 90% of the fracture surface is destroyed.*
- *In the small areas where the fracture surface is still intact, a mixture of dimple fractures (due to static overload) and welding porosity was found.*
- *The analyzable areas of both fractures revealed a significant amount of freely solidified area.*
- *Freely solidified area within a weld-seam is a clear indication for welding defects such as hot-cracking and/or porosity.*
- *The area with local shear dimples is too small and isolated to draw any conclusions out of this finding at the current state of the investigation."*

A more detailed analysis of the WOW cover plate will be included in the final report.

1.17 Organizational and management information

Details will be included in the final report.

1.18 Additional information

Information from the manufacturer of the aircraft indicates that a comparable nose landing gear design is used for the entire Dash 8 fleet (DHC-8-100/200/300/400). The manufacturer of the nose landing gear stated that comparable nose landing gears in levered suspension configuration were produced for various other aircraft types.

1.19 Useful or effective investigation techniques

Details will be included in the final report.

2 Analysis

This interim report does not contain a detailed analysis. However, based on the factual information available at the present stage of the investigation, it can be concluded that the fractured and pivoted WOW cover plate of the DHC-8-402 airplane did impede the nose landing gear extension.

3 Conclusions

3.1 Findings

3.1.1 Technical aspects

- The nose gear weight on wheel (WOW) cover plate was found squeezed between the lower and the upper drag strut of the nose landing gear.
- The WOW cover plate had fractured at the lower left and right lug and had pivoted upwards.

3.1.2 History of the flight

- On final approach to runway 14 at Zurich airport (LSZH) the nose landing gear did not extend.
- The flight crew discontinued the approach and received clearance to join the AMIKI holding pattern for troubleshooting.
- The extension of the nose landing gear could not be achieved, neither with reference to the non-normal/emergency checklist in the quick reference handbook (QRH) of the airplane nor with a flight operation service letter published by the aircraft manufacturer.
- The flight crew decided to perform a landing with the main gear extended and the nose gear up.
- The passengers were informed and the cabin was prepared for a planned emergency landing.
- Air traffic control was informed accordingly and the fire brigade was prepared.
- The landing took place at 18:18 UTC and the airplane came to a complete stop 540 meters after the forward fuselage had come into contact with the runway surface.
- There was no fire and crew and passengers disembarked via the forward left cabin door.
- Neither passengers nor crew were injured.
- The airplane's lower forward area of the fuselage was damaged.

4 Safety recommendations and measures taken since the accident

4.1 Safety recommendations concerning weight on wheel cover plates

4.1.1 Safety deficit

On 27 September 2013 a Bombardier DHC-8-402 aircraft, registered as 9A-CQC, was operating the scheduled flight OU 464 from Zagreb (Croatia) to Zurich (Switzerland). After an uneventful flight the airplane was established on an instrument approach for runway 14. At about six nautical miles from the threshold, the crew selected the landing gear down; the main landing gear extended fully. However the nose landing gear did not extend.

The flight crew discontinued the approach and the air traffic control offered them to join a holding pattern for troubleshooting. The extension of the nose landing gear could not be achieved, neither with reference to the non-normal/emergency checklist in the quick reference handbook (QRH) of the airplane nor with a flight operation service letter published by the aircraft manufacturer. The flight crew opted for a landing with main gear extended and nose gear up. After preparing the cabin for a planned emergency landing and informing the air traffic control a second approach was performed.

The airplane landed on runway 14 at Zurich airport at 18:18 UTC and came to a complete stop 540 meters after the forward fuselage had come into contact with the runway surface. The airplane's lower forward area of the fuselage was damaged.

During the technical investigation of the airplane the nose gear weight on wheel (WOW) cover plate was found squeezed between the lower and the upper drag strut of the nose landing gear. The WOW cover plate had previously fractured at the lower left and right lug enabling the pivoting of the plate upwards. Normal and non-normal nose landing gear extension and retraction was restored after the fractured WOW cover plate was removed. Therefore it can be concluded that the fractured and pivoted WOW cover plate of the DHC-8-402 airplane did impede the nose landing gear extension.

As it was not possible to prove that the investigated case was an isolated event, there is a probability that nose gears of comparable design could also be affected.

4.1.2 Safety recommendation No. 476

Transport Canada and the European Aviation Safety Agency, together with the aircraft and the landing gear manufacturers, should take appropriate measures in order to facilitate early detection of damaged weight on wheel cover plates on nose landing gears in levered suspension configuration.

4.1.3 Safety recommendation No. 477

Transport Canada and the European Aviation Safety Agency, together with the aircraft and the landing gear manufacturers, should assess the risks involved with the installation of weight on wheel cover plates on nose landing gears in levered suspension configuration and take appropriate preventive measures.

4.2 Measures taken since the accident

4.2.1 Manufacturer of the aircraft

Five days after the accident, on 2 October 2013, aircraft manufacturer Bombardier sent a message (Bombardier Q400 All Operator Message No. 581) to all

Bombardier Aerospace Commercial Aircraft Q400 Operators and Bombardier Aerospace Commercial Aircraft Field Service Representatives. This message was released after consultation with the SAIB and contained the following recommendation:

"Operators are reminded that the proximity cover must be secure prior to flight. Diligence must be taken by ground crew when attaching and removing the tow bar. A tactile inspection of the nose gear WOW cover should be considered as part of the pre-flight inspection."

Payerne, 9 October 2013

Swiss Accident Investigation Board

This interim report was approved by the management of the Swiss Accident Investigation Board SAIB (Art. 3 para. 4g of the Ordinance on the Organisation of the Swiss Accident Investigation Board of 23 March 2011).

Berne, 10 October 2013

Annexes

Annex 1: Alternate landing gear extension according QRH

ALTERNATE LANDING GEAR EXTENSION or “LDG GEAR INOP” (Caution Light)

(One or more Landing Gear fail to extend)

Landing Considerations:

- Landing Gear cannot be retracted.
- Nosewheel steering will be inoperative.
- Airspeed 185 KIAS (max)
- L/G Inhibit switch Inhibit
- Landing Gear selector Down
- Landing Gear Alternate Release door Open
- Main Gear Release handle pull fully down

Note: *Gear release handle loads may exceed those experienced during practice extensions.*

- Landing Gear Alternate Extension door Open

Note: *IF LEFT and/or RIGHT green gear locked down Advisory Lights do not illuminate, insert Hydraulic Pump handle in socket and operate until LEFT and RIGHT green gear locked down Advisory Lights illuminate.*

- Nose Gear Release handle pull fully up

Note: *Gear release handle loads may exceed those experienced during practice extensions.*

Leave Landing Gear Alternate Release and Alternate Extension Doors fully open and L/G Inhibit switch at Inhibit.

- Gear–Locked–Down indicator On/check/Off
- Anti-Skid Test

After Landing:

As soon as possible after engine shutdown:

- Ground Locks install

Figure 3: Copy of the procedure published in the quick reference handbook (QRH) (PSM 1-84-1B, page 14, dated 3 May 31/11)

Annex 2: Alternate landing gear extension according FOSL

Nose Gear UP, Main Landing Gear Down:

In this situation, if after the Alternate Gear extension procedure has been completed, and it cannot be verified that the nose gear is down and locked by the normal and alternate systems, the Flight Crew must make a decision to either perform a landing with the nose gear not locked, or reset the Alternate Extension system and cycle the landing gear in an attempt to achieve all gear down and locked.

It has been demonstrated that the Dash 8 can safely land with the nose gear retracted. The geometry of the aircraft is such that the propellers will not come in contact with the runway with the main gear down and the nose gear retracted. In

addition to the direction given in the AFM in Paragraph 3.16, the following is offered for consideration:

- Reduce landing weight through fuel burn.
- Attempt to achieve an aft C of G through passenger re-seating
- Select a runway with minimal crosswind
- Land with flap 35 degrees
- Fly the appropriate Vref for the landing weight
- Touchdown offset from the runway centreline if runway equipped with a centerline lighting system
- On touchdown, hold the nose just off the runway with the elevator. Prior to losing elevator control gently lower the nose to the runway.
- Should the nose wheel not be extended or collapse, maintain directional control with rudder until no longer effective at which point asymmetric braking can be used as required
- Apply brakes or reverse thrust only after the nose-wheel is on the ground and appears to be locked. If nose gear is not extended or collapses apply brakes only.

Opting to cycle the landing gear in an effort to extend the nose gear from this abnormal situation would require a reset of Alternate Extension procedure. This may be accomplished by utilizing the following procedure:
(...)

Figure 4: Copy of the procedure published by the manufacturer in the FOSL (DH8-400-SL-32-031A dated 21 April 2011)