Federal Safety Investigation Authority

Final Report

Accident with aircraft Bombardier DHC-8-402,

on 04 April 2019, at ca. 08:56 UTC on Innsbruck Airport (LOWI),

A-6020, Innsbruck, Tyrol

Ref.: 2021-0.432.817

Vienna, 2021

Content

Preamble

The safety investigation took place in accordance with Regulation (EU) No. 996/2010 and Accident Investigation Act, BGBI. [Federal Law Gazette] I No. 123/2005 as amended.

The sole purpose of the safety investigation is prevention of future accidents or incidents, without apportioning blame or liability.

Unless stated otherwise, the safety recommendations are directed at bodies in a position to implement these recommendations in the form of suitable actions. Decisions to implement these safety recommendations will be at the discretion of such bodies.

The content of the draft final report is subject to restrictions in order to ensure the anonymity of all natural or legal persons involved in the accident or possibly serious incident.

All times given in this report are in 24 hour format and refer to UTC (local time = UTC + 2 hours).

This is a courtesy translation of the draft final report on the safety investigation. As accurate as the translation may be, the original text in German is the work of reference.

Note

The extent of the safety investigation and the procedure to be followed will be determined by the SIA, taking into account the lessons it expects to draw from the investigation for the improvement of aviation safety. Regulation (EU) No. 996/2010 Art. 5.

The determination of causes does not imply the assignment of fault or administrative, civil or criminal liability. Regulation (EU) No. 996/2010 Art. 2.

Notes on persons in photographs:

The photographs of objects and locations included in this report may show persons that may be uninvolved or involved with investigations into the accident or with recovery and possibly anonymized. The colours of clothing worn by these persons (e.g. luminous reflective vests) were digitally retouched as needed (e.g. greyed) since colours may distract from the purpose of the illustrations.

Introduction

Aircraft operator:	Austrian airline
Operating mode:	Scheduled flight under instrument flight rules (IFR)
Aircraft manufacturer:	Bombardier Inc.
Type designation:	DHC-8-402
Aircraft type:	Powered aircraft
Nationality:	Austria

Accident site:	Innsbruck Airport (LOWI), runway 08
Coordinates (WGS84):	47° 15' 37" N, 011° 20' 38" E
Altitude above sea level:	581 m / 1907 ft
Date and time:	04 April 2019 at ca. 08:56 UTC (10:56 local time)

On 04 April 2019, an accident occurred at Innsbruck Airport (LOWI) involving a Bombardier DHC-8 powered aircraft. The domestic flight was carried out on schedule from Vienna Airport (LOWW) to Innsbruck Airport (LOWI). In the course of the landing at Innsbruck, the aircraft experienced an excessive pitch angle. As a result, the tail of the aircraft grazed the runway (tail strike), resulting in damage to the tail.

The civil aviation department of the Austrian Federal Safety Investigation Authority (SUB) was informed of the occurrence on 04 April 2019 at ca. 11:20 by the aircraft operator. A safety investigation was opened pursuant to Article 5 (1) of Regulation (EU) No. 996/2010.

In accordance with Article 9 (2) of Regulation (EU) No. 996/2010, the following involved states were informed about the accident:

State of design, state of manufacturer:	Canada
Crew member nationality:	Germany

1 Factual information

1.1 Events and history of the flight

The history of the flight and the course of the accident were reconstructed as follows, based on statements and reports from the crew and the air traffic control services, the flight data recordings and the inquiries by the Austrian Federal Safety Investigation Authority:

The flight from Vienna Airport (LOWW) to Innsbruck Airport (LOWI) was scheduled for 04 April 2019. The first officer (F/O) was assigned to take off, conduct the flight and land.

The F/O was picked up at 03:15 in Innsbruck (LOWI) and flew to Vienna (LOWW) the flight directly preceding the accident flight. That flight was conducted by the same captain, whereas the F/O was pilot monitoring. The check-in time was used by the F/O to prepare for the flight. Thereby, it was found that there were already mild foehn conditions in Innsbruck. The departure procedure chosen for this flight was already a special procedure for foehn conditions (foehn departure) along the northern range ("Nordkette", alpine formation). The rest of the flight took place without any particular events. In Vienna, the crew changed the aircraft as planned. During the flight preparations in Vienna for the upcoming (accident) flight, according to the crew's statements, clear foehn conditions were already foreseeable, but wind shears were not forecast, which is why the decision was made that the F/O should carry out the upcoming flight. For this purpose, the F/O stored the respective waypoints for the visual approach part of the foehn approach procedure in the FMS, so that this activity would not have to be carried out during the flight. The further events took place as follows:

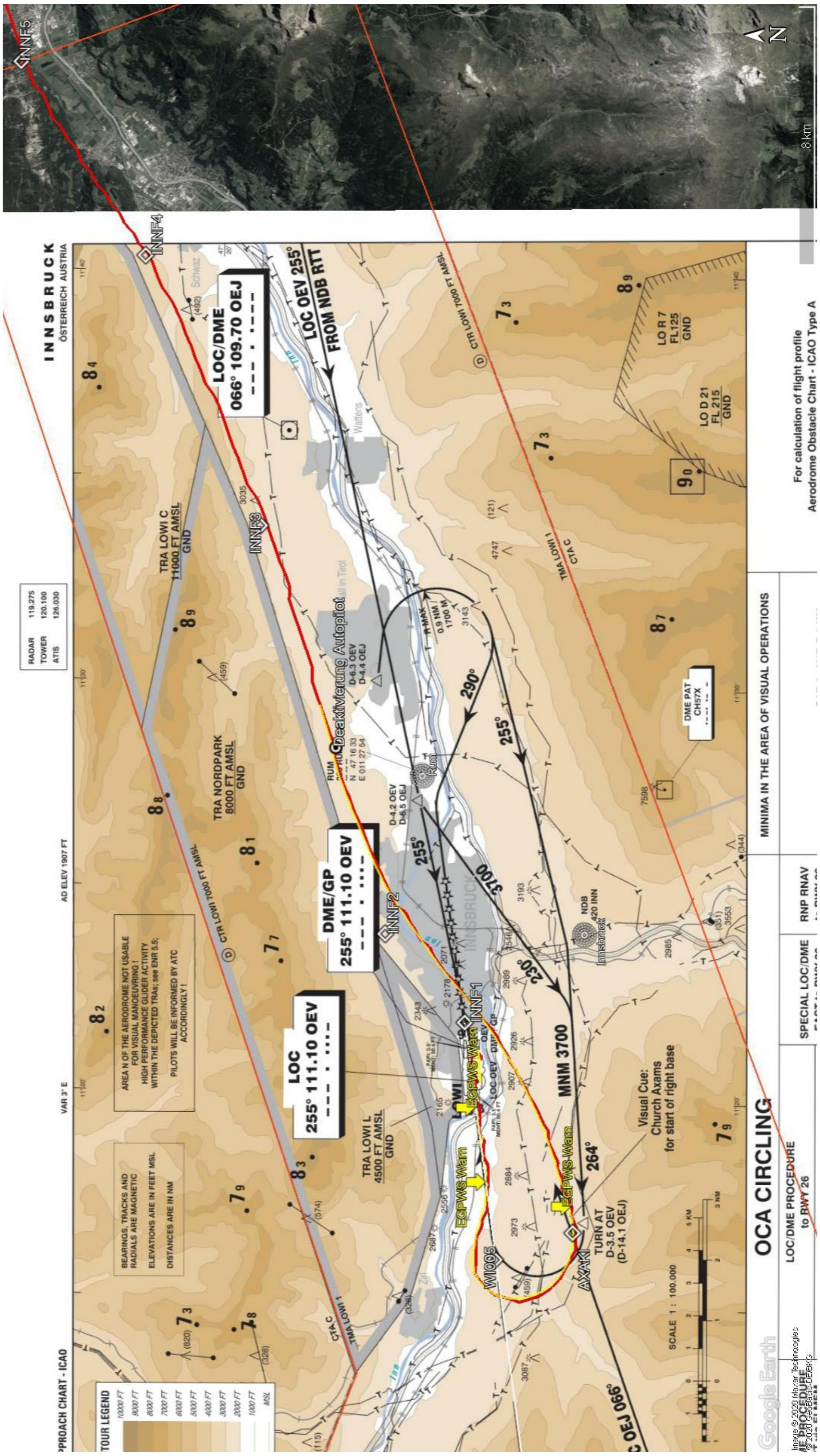
08:03	Departure from Vienna Airport (LOWW).
08:17	Reaching of cruising altitude of around 20,000 ft (FL200) near mountain Ötscher. Before initiating the descent, the captain checked the ATIS information. Based on that information, the further distribution of roles was discussed and it was decided that the F/O should continue to be the pilot flying.
08:32	Initiation of descent at the height of the Tennen mountain range ("Tennengebirge"). Radio contact established with LOWI APP.

08:41	Brief weather information from LOWI APP to the flight crew and clearance for the visual foehn arrival procedure.
08:36	Reaching of an altitude of ca. 16,000 ft (FL160) about 10 km north of Saalfelden. Level off and maintain level height.
08:41:20	Initiation of further descent.
08:45	Leaving of the radio frequency of LOWI APP and establishing contact with LOWI TWR. Aircraft crew receives the wind information "090 deg 22 kt".
08:46:21	Flyover of waypoint INNF5 and entry to Innsbruck Airport control zone (CTR LOWI).
08:47:30	Flyover of waypoint INNF4.
08:48:59	Flyover of waypoint INNF3 at an altitude of approximately 9,000 ft.
08:50:07	Deactivation of autopilot due to turbulence.
08:50:25	Flight crew receives landing clearance and wind information “020 deg 11 kt” with the addition “Kematen 070 deg 17, gusting 32, expect wind checks on final”.
08:50:48	Landing gear extended.
08:51:19	Flaps extended to 15°.
08:51:53	Flypast waypoint INNF1, crosstrack distance approx. 400 m. It was planned to deliberately lengthen the downwind leg and marginally also the base leg (up to approximately village Oberperfuss) in order to reduce altitude and avoid the risk of receiving terrain warnings.
08:53:23	Recording of an "EGPWS Alert/Warning" signal for five seconds.
08:53:25	Initiation of right turn for the final approach. Flyover of the waypoint AXAKI (church in village Axams) at about 4,700 ft barometric altitude.
08:54:11	Overshooting of the runway centre line. This was expected by the crew, due to the wind conditions and the flaps position.
08:55:01	Reaching the runway centre line at approx. 700 ft AGL (approx. 3,150 ft barometric altitude) and 1.5 nm (approx. 2.8 km) from the runway threshold. The average rate of descent in the last 30 seconds up to this point was around 1100[(1)] ft/min. Seconds later, the rate of descent increased for a few seconds to approx. 1800 ft/min, which triggered the following "EGPWS" warning.
08:55:07	Recording of an "EGPWS Alert/Warning" signal for two seconds. During the alert, the F/O had already corrected the rate of descent so that at 08:55:11 the rate of descent was back to 300 ft/min.

[1] All climb / descent rates are calculated from *Altitude Baro L*, *Altitude Baro R* and *Radio Altitude* data (see also Annex 6.1)

08:55:30	While the aircraft was flying over the Inn river, and the nine seconds before, a brief increases in lift occurred. As a result of that, among other factors, the rate of descent fluctuated between 500 and 1000 ft/min in the last 15 seconds before landing.
08:55:42	Recording of an "EGPWS Alert/Warning" signal for one second.
08:55:44	At this point the speed (IAS) was about 141 kt, the rate of descent was about 700 ft/min and the altitude was about 30 ft AGL. The pitch angle was about 1.4°, the torque was 5.5% (L) and 6% (R), respectively. The final target speed calculated by the crew for the approach was 134 kt (see section 1.6.5). The F/O retrospectively estimated the airspeed during the entire approach at an average of around 140 kt to 150 kt at times. During the next two seconds, the aircraft quickly lost altitude and speed. The F/O noticed that the aircraft was "pushed down". The rate of descent was according to the F/O approximately 500-700 ft/min. He increased the power, but at this point the aircraft was already touching down on the runway.
08:55:47.125	First touchdown of the main landing gear. At this point, the speed was about 123 kt. The F/O pulled up the nose of the aircraft, because of which the pitch angle of the aircraft rose to 7.65° when touching down. The rate of descent decreased to approximately 200-500 ft/min by the time of touchdown. The maximum vertical acceleration (along the yaw axis) when touching down was 2.1 g. The engine torque values at the time of contact were 11% (L) and 14.5% (R), respectively.
08:55:47.500	Recording of "Touched Runway" signal together with "Master Caution". Neither the cockpit crew nor the cabin crew (according to the cockpit crew's statement) immediately perceived the tail touching the runway.
08:55:49.125	Second and final touchdown of the main landing gear.
08:55:50.625	Touchdown of the nose landing gear.
08:56	Inquiry from LOWI TWR as to whether support is required ("any assistance?"). The flight crew negated. The taxiing to the parking position and the disembarking of the passengers proceeded normally and without further incident.

Figure 1: Visual Approach LOWI 08



Source: Google Earth, ACG, SUB, operator

The day before the accident flight, the F/O was already flying a scheduled flight from Vienna to Innsbruck, the landing time was 12:25. The approach and landing were also carried out by the F/O using the same approach procedure (visual foehn arrival on runway 08) under similar weather conditions. The captain was off-duty on the two days before the accident flight.

Figure 1 shows the approach of the aircraft on runway 08 at Innsbruck Airport. The position data of the flight data recorder (FDR) is shown in red, the radar data from Austro Control is yellow. The control zone at Innsbruck Airport (CTR LOWI) is shown in orange. The approach procedure "Föhn Approach along Nordkette" leads along the northern range (“Nordkette”) via points INNF5, INNF4, INNF3, INNF2, INNF1, AXAKI, WI005 to runway threshold 08 and is defined as shown in section 1.10.2.

1.1.1 Flight preparation

The necessary flight preparation was carried out in accordance with Regulation (EU) No. 923/2012 Annex SERA.2010/b as amended. A corresponding operational flight plan consisting of flight route and fuel planning, technical aircraft log and weather information as well as a load sheet was made available to the Austrian Federal Safety Investigation Authority.

1.2 Injuries to persons

Table 1: Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Serious	0	0	0
None	2 cockpit + 2 cabin	74	–

1.3 Damage to aircraft

The aircraft suffered damage to the outer fairings and panels, an antenna, and to the stringers and frames on the tail. The damage was limited to part of the aircraft tail and had no further effects on the structural integrity of the aircraft or on its systems.

1.4 Other damage

There was no further damage.

1.5 Personnel information

1.5.1 Pilot Flying (F/O)

Age:	26 years
Type of civil aviation license:	MPL(A)
For aircraft category:	Fixed-wing powered airplane
Model/type ratings:	DHC8 (COP, IR)
Validity:	Valid on the day of the accident
Checks:	
Medical check:	Medical Class 1/2/LAPL issued on 17 August 2018, valid on the day of the accident
Total flight experience (including accident flight):	ca. 1,146 hours
of which in the last 90 days:	ca. 116 hours
of which in the last 30 days:	ca. 43 hours
of which in the last 24 hours:	ca. 1 hours
Last 3 landings at LOWI:	4, 3 and 1 day (s) ago

The specified flying hours were carried out exclusively on the accident type (except for any other occasional flights, e.g. in the course of training).

1.5.2 Pilot Monitoring (Captain)

Age:	62 years
Type of civil aviation license:	ATPL(A)
For aircraft category:	Fixed-wing powered airplane
Model/type ratings:	DHC8
Validity:	Valid on the day of the accident

Checks:

Medical check:	Medical Class 1/2/LAPL issued on 02 April 2019, valid on the day of the accident
Total flight experience since 26 March 1997	
(including accident flight):	ca. 13,162 hours
of which in the last 90 days:	ca. 139 hours
of which in the last 30 days:	ca. 55 hours
of which in the last 24 hours:	0 hours
Last 3 landings at LOWI:	9, 3 and 3 day (s) ago

The flying hours were carried out exclusively on the accident type (except for any other occasional flights, e.g. in the course of training). The flight hours recorded for the assisting pilot go back to March 1997. However, he started work in 1992, so he actually has a greater total flight experience than given above (according to the captain, about 17,500 hours).

1.6 Aircraft information

The Bombardier DHC-8 is a cantilever high-wing aircraft. The DHC-8-402 version of the aircraft has up to 80 seats in accordance with its TCDS, and two propeller turboshaft engines, each with 3781 kW of maximum continuous shaft horsepower (SHP).

Aircraft type:	Powered aircraft
Manufacturer:	Bombardier Inc.
Type designation:	DHC-8-402
Year of manufacture:	2010
Aircraft operator and owner:	Austrian airline
Total flying hours:	ca. 17,192 hours and 47 minutes

Total cycles (take-off – landing):	ca. 19,703
Max. take-off mass (MTOM):	28,998 kg (63,930 lb)

Engines

Type:	Two propeller turboshaft engines
Manufacturer:	Pratt and Whitney Canada
Manufacturer designation:	PW150A
Propeller	Two Dowty Aerospace Propellers, Model R408/6-123-F/17

1.6.1 Aircraft documents

Certificate of registration:	Issued on 01 April 2015 by ACG, valid on the day of the accident
Certificate of airworthiness:	Issued on 15 July 2010 by ACG, valid on the day of the accident
Airworthiness review cert. (ARC):	issued on 13 June 2018, valid on the day of the accident
Noise certificate:	Issued on 15 July 2010 by ACG, valid on the day of the accident
Insurance:	insured from 15 November 2018 to 15 November 2019, valid on the day of the accident
Radio station authorisation:	Issued on 12 March 2015 by the telecommunications office for Vienna, Lower Austria and Burgenland, valid on the day of the accident

1.6.2 Certification

The initial type certification was issued on 28 September 1984 by Transport Canada Civil Aviation (TCCA) for the version DHC-8-101 with TCDS A-142. The initial certification for the versions DHC-8-301 was issued on 14 February 1989, DHC-8-201 on 24 August 1995 and DHC-8-400 on 30 July 1999.

The type certification for the Europe region (JAA) was first issued on 27 January 1988 with TCDS EASA.IM.A.191 for version DHC-8-102 by the Austrian civil aviation authority ACG. Further European type certificates were issued for DHC-8-301 on 23 February 1995, for DHC-8-201 on 17 February 1998 and for DHC-8-402 on 01 December 1999. JAR Part 25 served as the certification basis.

The fuselage length was elongated several times in the course of the certification of the different versions, so that the versions DHC-8-1XX and DHC-8-2XX have a length of 22.25 m (73 ft), version DHC-8-3XX has a length of 25.68 m (84 ft 3 in) and version DHC-8-4XX has a length of 32.8 m (107 ft 9 in) (Figure 4). The length of the fuselage in conjunction with the height of the landing gear of the respective aircraft version results in different maximum possible pitch angles at which the tail will get in contact with the ground (section 1.6.7).

1.6.3 Maintenance and airworthiness

The last annual airworthiness review certificate (ARC) was issued on 13 June 2018 with airframe total flight hours of 15,539 hours and 59 minutes.

1.6.4 Aircraft loading and centre of gravity

A calculation of mass and centre of gravity was carried out by the operator (load sheet) and checked by the pilot; the values were within the permissible range during the entire flight. The corresponding data are shown in Table 2 and Table 3. The MAC limit of 17.3 – 36 applies to the maximum take-off mass (MTOM) of 28,998 kg and was taken from the aircraft flight manual (AFM).

Table 2: Aircraft masses

	Mass	Limit / Maximum
Zero fuel weight (ZFW)	25,061 kg *55,250 lb*	
Take-off fuel (TOF)	3,230 kg *7,121 lb*	
Take-off weight (TOW)	28,291 kg *62,371 lb*	28,998 kg *63,930 lb*
Trip fuel (TIF)	952 kg *2,099 lb*	
Landing weight (LAW)	27,339 kg *60,272 lb*	28,009 kg *61,749 lb*

Source: Operator, TCDS

Table 3: Aircraft centre of gravity (CG)

	Centre of gravity [% MAC]	MAC limits	Loaded Index (LI)	Limit LI FWD	Limit LI AFT
TOW (take-off)	25.9	17.3 – 36	58.97 *(LITOW)*	15.74	105.52
LAW (landing)	25.7		58.97 *(LOLAW)*	15.66	106.30

Source: Operator, AFM

1.6.5 Approach speed

The approach speed V_A (corresponds to V_{REF}) is 124 kt for a landing weight of 27,216 kg (closest to the actual landing weight), according to the table in OM-B. With a flap position of 15° and the anti-ice system deactivated, a surcharge (V_{REF} increment) of 10 kt must be added. This results in a final target speed for the approach of 134 kt (124 kt + 10 kt).

1.6.6 Operator's criteria for stabilized approach

The operating manual OM-A describes the general criteria for a stabilized approach:

Figure 2: OM-A, Stabilized Approach

8.4.5.15 Stabilization on Final Approach

Stabilization during approach shall be achieved not later than 1.000 ft above threshold elevation.

The PM shall closely monitor the flight's progress and point out, in due time,

- Conditions that might lead to an unstabilized approach;
- Deviations from stabilized approach tolerances.

Whenever the approach becomes unstabilized, a go-around shall be performed.

An approach is considered stabilized if, from a height of 1.000ft above threshold elevation until touchdown, the aircraft is

- Tracking on the approach path and profile;
  (Precision approach: half scale deflection or less, radio tracking within +/- 5° of nominal track, RNP approach within approach tolerance);

with the required

- Configuration
  - Landing Gear down,
  - Final Landing Flaps set,
  - Speedbrakes according OM-B;
- Attitude;
- Rate of Descent;
- Approach Speed according OM-B;
- Corresponding Thrust/Power;
- Trim.

Note: An approach in gusty conditions may be continued where airspeed and descent rate fluctuations exceed the stabilized approach criteria if the excursions are brief in duration and in the judgment of the Flight Crew, it is safe to continue.

Source: Operator

Figure 3: OM-A, Stabilized Approach - Exceptions

Exceptions

- A later stabilization in speed is only acceptable if higher approach speeds are required by ATC procedures. Stabilization in speed shall, however, be achieved not later than 500 ft above threshold elevation;
- A runway alignment lower than 1.000 ft, but not lower than 500ft, is only authorized,
  - If required by a specific approach procedure according approach chart;
  - For visual approaches along prescribed flight tracks;
  - Swing-over approaches;
  - Training patterns according OM-B.
- Circling Approaches shall be flown according OM-B. Runway alignment, final flaps setting and stabilization in approach speed may be delayed acc. SOP, however shall be achieved not later than 500 ft above aerodrome elevation.

Source: Operator

The operating manual OM-B defines the criteria for a stabilized approach for the specific Dash 8 aircraft as follows:

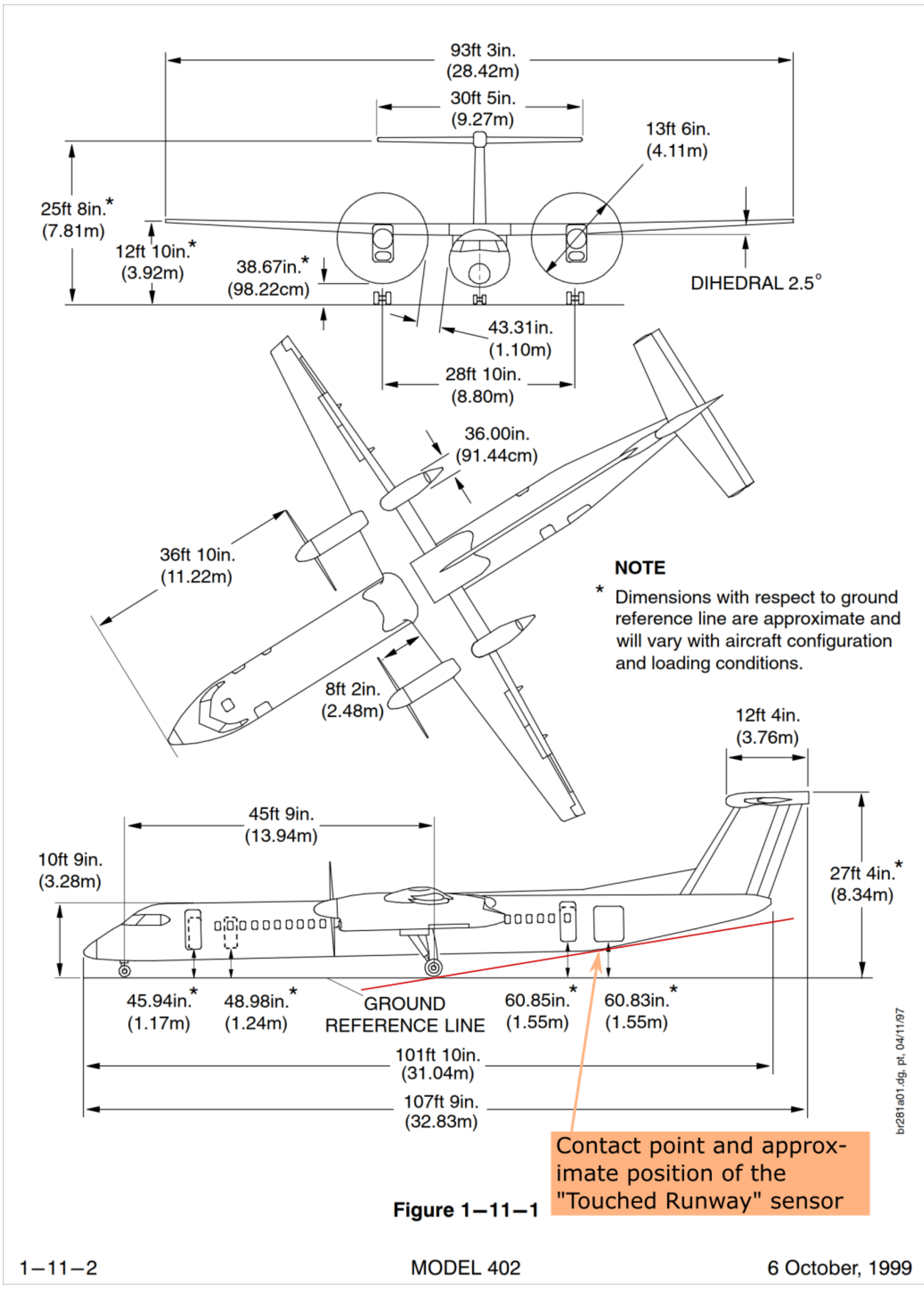
- The speed (IAS) may deviate by a maximum of ±5 kt from the final target speed at a height of 1000 ft ARTE. Under certain circumstances (e.g. special approach procedures) this altitude can be reduced to 500 ft ARTE.
- Power settings of less than 8% torque should be avoided.
- The aircraft must be laterally and vertically stable, i.e. it must be on the specified flight path with the prescribed rate of descent. In the case of a visual approach, this means that the approach slope must be chosen in a way at 1000 ft ARTE at the latest in order so that no EGPWS warnings are triggered. The approach slope is usually displayed visually (e.g. using PAPI) or electronically. Laterally, the aircraft must be aligned with the runway centre line at 1000 ft ARTE. For special approach procedures, this limit can be reduced to 500 ft ARTE.

1.6.7 Tail contact with runway

The flight manual (AFM) PSM 1-84-1A provided by the operator (last amendment on 09 January 2019, at the time of the accident) specifies a maximum pitch of +6° for the landing.

According to the final report HCL 25/00 of the Danish Aircraft Accident Investigation Board on an accident on 27 May 2000 (or HCL 62/00, accident of 22 October 2000), according to the aircraft manufacturer, with full compression of the suspension struts of the landing gear, a pitch angle of +7.6° is needed on touchdown in order for a type DHC-8-400 to have contact between the tail and the runway. The manufacturer considered the difference between the 6° from the AFM and the 7.6° as a safety factor.

Figure 4: Dimensions DHC-8-402 incl. contact point with runway



Source: AFM de Havilland Inc., SUB

1.7 Meteorological information

Innsbruck Airport (LOWI) is known for wind shears or downdraughts, often occurring when approaching Runway 08 above or near the Inn river. Foehn conditions are also frequent (specifically "Alpenföhn"). If the wind is coming from the south, as it was pursuant to the weather situation at the time of the accident, it is a southern foehn ("Südföhn"). A foehn is a warm, strong, mostly dry wind. Usually, the southern foehn is also associated with a rise in temperature north of the Alpine ridge and correspondingly lower humidity and better visibility, since air humidity is withdrawn on the windward side by cloud formation and precipitation. Since the wind blows from south to north over the Alpine ridge when the southern foehn is blowing, gusty winds can occur along the southern ridge ("Südkamm") in the Inn Valley, which is why approaches to Innsbruck are usually carried out along the northern ridge ("Nordkamm") to increase passenger comfort.

1.7.1 METAR, TAF and weather charts

Table 4: Weather observation Innsbruck Airport (METAR LOWI)

METAR LOWI
LOWI 040650Z 04018KT 020V090 9999 FEW050 SCT080 14/01 Q0993 WS ALL RWY NOSIG
LOWI 040720Z 07015KT 030V120 9999 FEW060 SCT080 15/01 Q0993 **WS ALL RWY** NOSIG
LOWI 040750Z 08012G23KT 340V140 9999 FEW060 SCT080 15/02 Q0994 NOSIG
LOWI 040820Z **08013G24KT 040V130** 9999 FEW060 SCT080 16/02 Q0993 NOSIG
LOWI 040850Z 06013KT 010V130 9999 FEW060 SCT080 16/02 Q0993 NOSIG
LOWI 040920Z **04014G24KT 360V070** 9999 FEW060 SCT080 16/02 Q0993 NOSIG
LOWI 040950Z VRB09G29KT 9999 FEW060 SCT150 17/02 Q0994 NOSIG
LOWI 041020Z VRB09G27KT 9999 FEW060 SCT150 17/02 Q0994 NOSIG
LOWI 041050Z 06014G24KT 360V110 9999 FEW060 SCT150 17/03 Q0993 **WS ALL RWY** NOSIG

According to the data from Table 4, there was a wind of approx. 13 kt from east to north-east at Innsbruck Airport at the time of the accident (the weather observation from 08:50 is closest to the time of the accident, in bold). Wind variability was noted from roughly north to south-east. The visibility was above 10 km. There was low cloud cover (FEW) at approximately 6,000 ft (1,829 m) and moderate cloud cover (SCT) at approximately 8,000 ft (2,438 m) above the airport level.

The weather observation before the accident (08:20) and after the accident (09:20) also indicated gusts of up to 24 kt. Warnings about wind shear on or near the runways were issued before the accident at 07:20, and after the accident at 10:50, but not between those times.

Table 5: Weather observation comparison Munich (EDDM), Innsbruck (LOWI), Bolzano (LIPB)

METAR EDDM, LOWI, LIPB
EDDM 040850Z 09009KT 050V120 CAVOK 10/03 Q0994 NOSIG=
LOWI 040850Z 06013KT 010V130 9999 FEW060 SCT080 16/02 Q0993 NOSIG
LIPB 040850Z VRB02KT 7000 RA FEW010 SCT025 BKN040 10/09 Q1000=

By comparing the weather observation, especially between Bolzano and Innsbruck, the characteristics of southern foehn conditions can be seen: Air pressure difference from 1000 to 993 hPa, temperature/dew point of 10°C/9°C (dew point spread: 1°C) to 16°C/2°C (dew point spread: 14°C) and significantly better cloud conditions and visibility in Innsbruck. The southern foehn conditions are also evident in the QNH / foehn chart in Figure 5.

Table 6: Weather forecast Innsbruck Airport (TAF LOWI)

TAF LOWI
TAF LOWI 040515Z 0406/0506 09012G25KT 9999 FEW060 SCT080 BKN120 TX16/0412Z TN02/0506Z TEMPO 0406/0410 12015G35KT TEMPO 0410/0418 12020G40KT BECMG 0416/0418 27012KT -RA SCT020 BKN040 TEMPO 0418/0422 29015G25KT SHRA BECMG 0422/0424 08005KT -RASN TEMPO 0500/0504 08008KT 3000 RASN SCT008 BKN012=
TAF AMD LOWI 040602Z 0406/0506 09012G25KT 9999 FEW060 SCT080 BKN120 TX16/0412Z TN02/0506Z TEMPO 0406/0418 12020G40KT

TAF LOWI
PROB40 TEMPO 0406/0409 03015G30KT BECMG 0416/0418 27012KT -RA SCT020 BKN040 TEMPO 0418/0422 29015G25KT SHRA BECMG 0422/0424 08005KT -RASN TEMPO 0500/0504 08008KT 3000 RASN SCT008 BKN012=
TAF AMD LOWI 040931Z 0409/0506 06012G25KT 9999 FEW060 SCT080 BKN120 TX16/0412Z TN02/0506Z TEMPO 0409/0418 12020G35KT BECMG 0416/0418 27012KT -RA SCT020 BKN040 TEMPO 0418/0422 29015G25KT SHRA BECMG 0422/0424 08005KT -RASN TEMPO 0500/0504 08008KT 3000 RASN SCT008 BKN012=

Table 7: Warnings for Innsbruck Airport (WARNINGS AD)

Aerodrome Warnings and Windshear Warnings
WOOS54 LOWI 040900 LOWI AD WRNG 3 VALID 041000/041600 SFC WIND SE 20KT MAX 35 FCST NC =
WOOS44 LOWI 040519 LOWI WS WRNG 1 040519 VALID 040520/040700 MOD WS ON FNA FCST=
WOOS44 LOWI 041057 LOWI WS WRNG 3 041057 VALID 041100/041200 MOD WS ON FNA ALL RWY FCST=

At 10:57 (after the time of the accident), a warning was issued for the airport, according to which moderate wind shear should be expected on all runways between 11:00 and 12:00. In addition, at 09:00 (also after the time of the accident) a warning was issued that between 10:00 and 16:00, a wind from the south-east was to be expected with 20 kt up to a maximum of 35 kt.

Figure 5 shows the southern foehn situation forecast with a pressure difference of +9 hPa between Bolzano (LIPB) and Innsbruck (LOWW) (evaluation time 00:00, validity time 06:00). The forecast wind direction was approximately 40 kt from the south (170°).

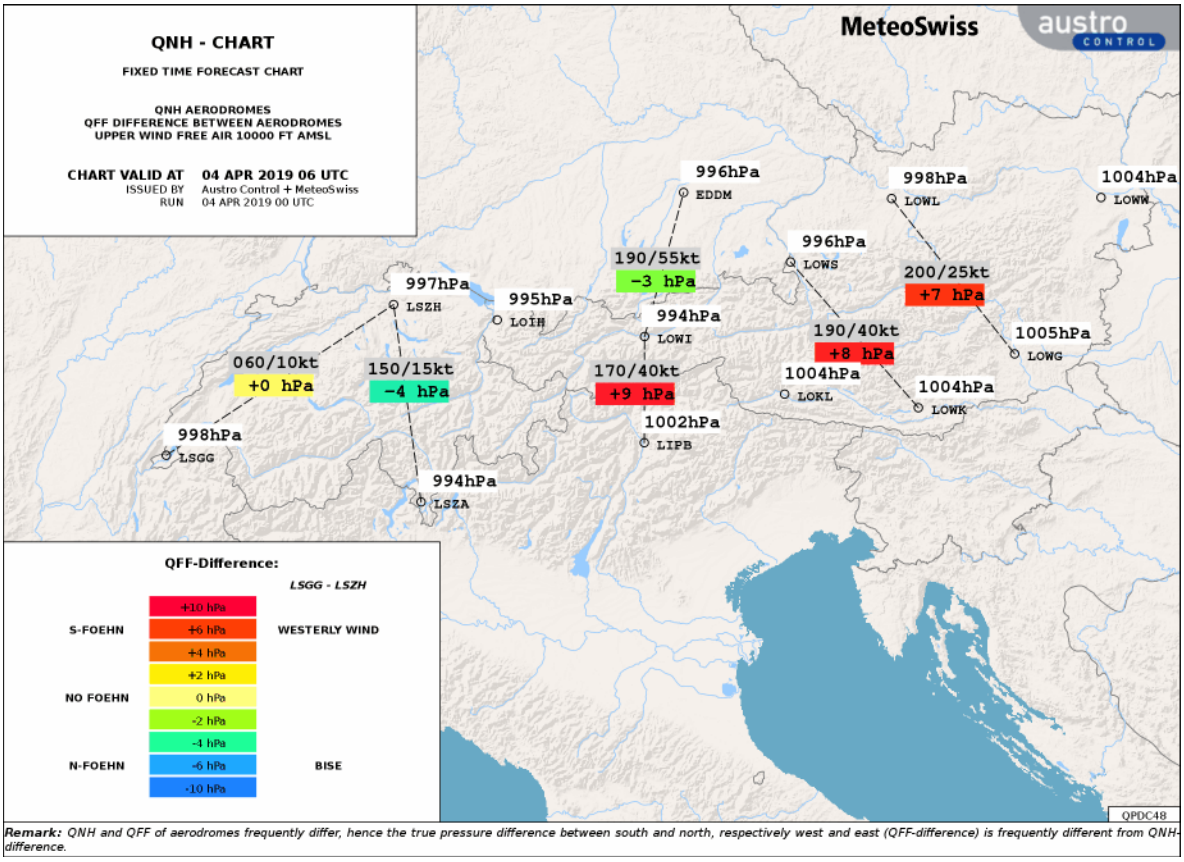
Table 8: Routine weather reports, ATIS

MET REPORT / ATIS
SXOS54 LOWI 040620 MET REPORT LOWI 040620Z WIND RWY 08 TDZ 030/22KT MAX 33 MNM 13 RWY 26 TDZ VRB BTN 010/ AND 110/13KT MAX 28 MNM 4 VIS RWY 08 TDZ 50KM RWY 26 TDZ 50KM CLD RWY 08 FEW 5000FT SCT 8000FT RWY 26 FEW 5000FT SCT 8000FT T 13 DP MS0 QNH 994HPA 2935INS QFE 927HPA QFE RWY 26 927HPA WS WRNG MOD WS ON FNA EXP **MOD / SEV** TURB ON APCH SFC / 12000FT AMSL EXP STNR NC EST WIND LOWI AREA 10000FT AMSL 180/35KT AD TREND NOSIG=
SXOS54 LOWI 040650 MET REPORT LOWI 040650Z WIND RWY 08 TDZ VRB BTN 350/ AND 080/27KT RWY 26 TDZ VRB BTN 020/ AND 090/17KT VIS RWY 08 TDZ 50KM RWY 26 TDZ 50KM CLD RWY 08 FEW 5000FT SCT 8000FT RWY 26 FEW 5000FT SCT 8000FT T 14 DP 1 QNH 993HPA 2934INS QFE 927HPA QFE RWY 26 927HPA WS WRNG MOD WS ON FNA EXP **MOD / SEV** TURB ON APCH SFC / 12000FT AMSL EXP STNR NC EST WIND LOWI AREA 10000FT AMSL 180/45KT AD TREND NOSIG=
SXOS54 LOWI 040720 MET REPORT LOWI 040720Z WIND RWY 08 TDZ 050/24KT RWY 26 TDZ VRB BTN 030/ AND 120/13KT MAX 23 MNM 6 VIS RWY 08 TDZ 50KM RWY 26 TDZ 50KM CLD RWY 08 FEW 6000FT SCT 8000FT RWY 26 FEW 6000FT SCT 8000FT T 15 DP 1 QNH 993HPA 2933INS QFE 926HPA QFE RWY 26 927HPA WS WRNG MOD WS ON FNA EXP **MOD / SEV** TURB ON APCH SFC / 12000FT AMSL EXP STNR NC EST WIND LOWI AREA 10000FT AMSL 180/45KT AD TREND NOSIG=

MET REPORT / ATIS
SXOS54 LOWI 040750 MET REPORT LOWI 040750Z WIND RWY 08 TDZ VRB BTN 020/ AND 120/17KT MAX 35 MNM 5 RWY 26 TDZ VRB BTN 340/ AND 140/15KT VIS RWY 08 TDZ 50KM RWY 26 TDZ 50KM CLD RWY 08 FEW 6000FT SCT 8000FT RWY 26 FEW 6000FT SCT 8000FT T 15 DP 2 QNH 994HPA 2935INS QFE 927HPA QFE RWY 26 927HPA **MOD** TURB ON APCH SFC / 12000FT AMSL EXP STNR NC EST WIND LOWI AREA 10000FT AMSL 180/45KT AD TREND NOSIG=
SXOS54 LOWI 040820 MET REPORT LOWI 040820Z WIND RWY 08 TDZ VRB BTN 020/ AND 090/24KT MAX 36 MNM 13 RWY 26 TDZ VRB BTN 040/ AND 130/13KT MAX 24 MNM 4 VIS RWY 08 TDZ 60KM RWY 26 TDZ 60KM CLD RWY 08 FEW 6000FT SCT 8000FT RWY 26 FEW 6000FT SCT 8000FT T 16 DP 2 QNH 993HPA 2934INS QFE 927HPA QFE RWY 26 927HPA **MOD** TURB ON APCH SFC / 12000FT AMSL EXP STNR NC EST WIND LOWI AREA 10000FT AMSL 180/40KT AD TREND NOSIG=
SXOS54 LOWI 040850 MET REPORT LOWI 040850Z WIND RWY 08 TDZ VRB BTN 360/ AND 060/16KT MAX 26 MNM 7 RWY 26 TDZ VRB BTN 010/ AND 130/15KT VIS RWY 08 TDZ 60KM RWY 26 TDZ 60KM CLD RWY 08 FEW 6000FT SCT 8000FT RWY 26 FEW 6000FT SCT 8000FT T 16 DP 2 QNH 993HPA 2934INS QFE 927HPA QFE RWY 26 927HPA MOD TURB ON APCH SFC / 12000FT AMSL EXP STNR NC EST WIND LOWI AREA 10000FT AMSL 180/40KT AD TREND NOSIG=

According to above data, from 07:50, the severity of the turbulence was downgraded from MOD/SEV (moderate to severe turbulence) to MOD and the warnings for wind shear removed (WS WRNG).

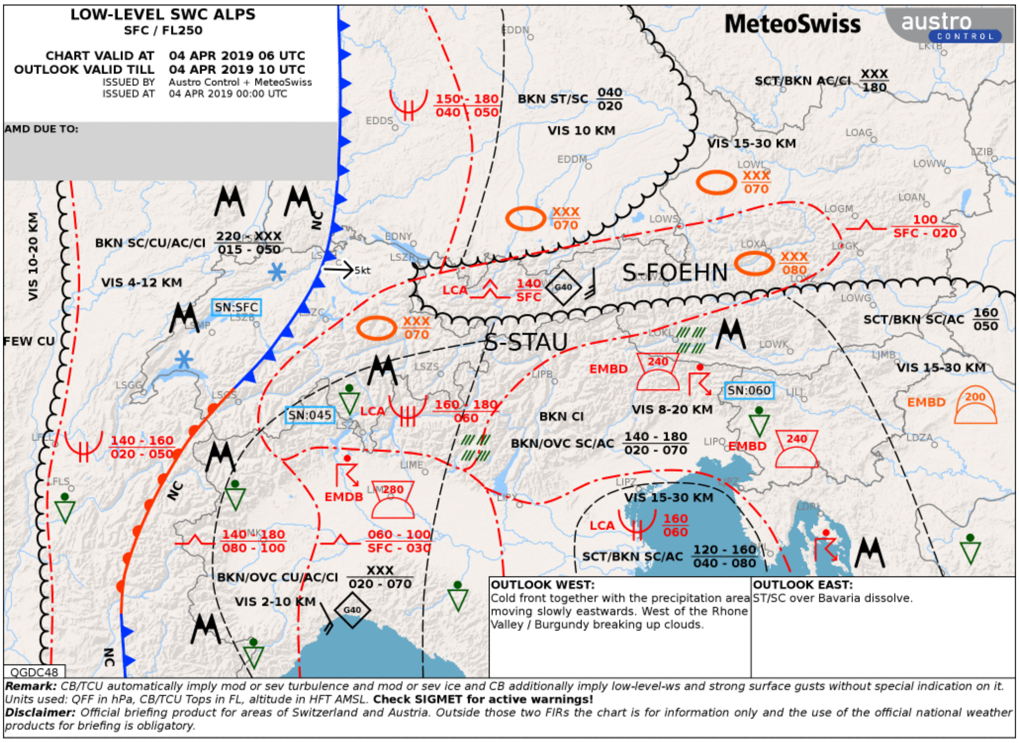
Figure 5: QNH / Foehn chart



Source: ACG

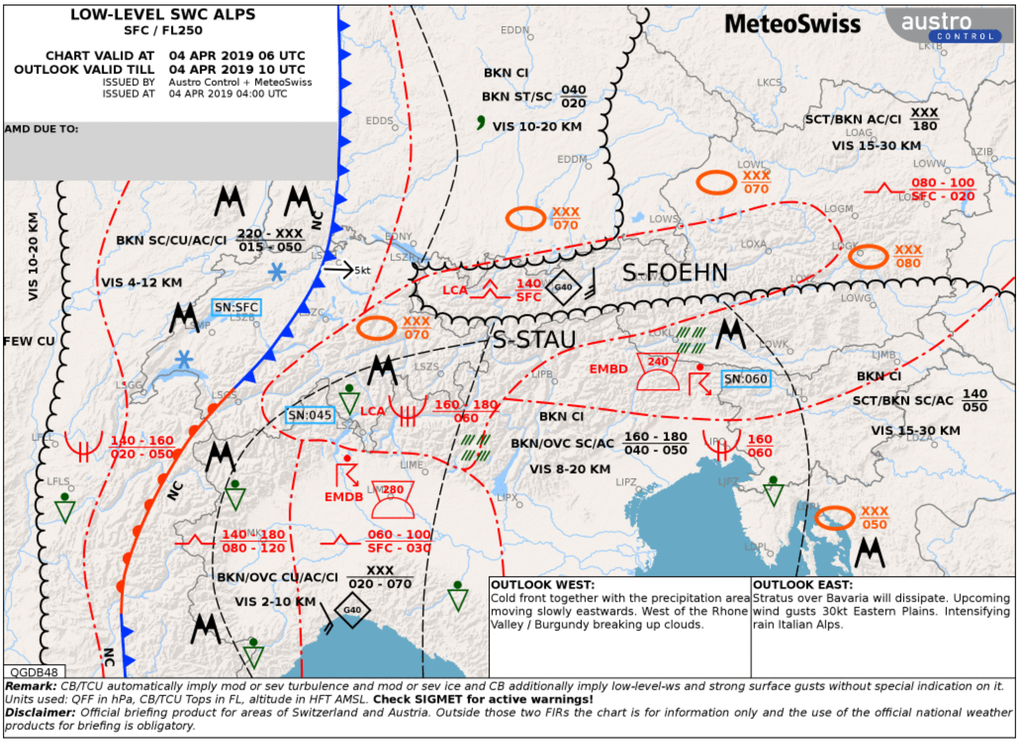
The SWC (significant weather charts) in Figure 6 and Figure 7 also show a southern accumulation ("Südstau", S-STAU) south of the Alps, in combination with a southern foehn ("Südföhn", S-FOEHN), for the period between 06:00 and 10:00. Wind of 25 kt was forecast from the south with gusts of up to 40 kt and heavy local turbulence.

Figure 6: Low-level significant weather chart Alps (SWC ALPS) from 04 April 2010, 00:00



Source: ACG

Figure 7: Low-level significant weather chart Alps (SWC ALPS) from 04 April 2010, 04:00



Source: ACG

1.7.2 Flight crew weather briefing

Before the flight, the crew carried out a weather briefing. According to the crew's statements, the foehn conditions were known. Wind shear was not forecast for the time around the landing. It was only forecast for the time before the flight.

During the flight, weather information was obtained from various telecommunications services (Table 9). The ATIS information was checked and noted by the captain around mid-flight, but the exact time is not known. The ATIS information is not transmitted via ACARS.

Table 9: Weather information during the flight (APP, TWR, ATIS)

Time	Source	Weather information
08:33	APP	Wind 25 kt from direction 030
08:45	TWR	Wind 22 kt from direction 090
08:50	TWR	Wind 11 kt from direction 020, wind at Kematen 17 kt from direction 070, gusts up to 32 kt
ca. 08:30 hours	ATIS - *(pilot's notes in **bold**)*	**INN** - Information **L** - Report Time **0820** - Runway **08** - Transition Level**?** - Wind **V020-090 / 24-36-13 (**mean gusts 24, minimum 13, maximum 36 kt**)** - Visibility **60 km** - **MOD TB ~ SFC + 12000 exp** - **FEW060 SCT080** - Temperature **16/2** - QNH **993** - **180 / 40** - **NS** (= NOSIG)

Source: ACG, operator, pilots

1.7.3 Natural light conditions

The accident occurred at approximately 08:56 UTC or 10:56 local time. At that time, natural daylight conditions prevailed.

1.8 Aids to navigation

Visual meteorological conditions (VMC) prevailed during the flight (see also section 1.7). The approach was carried out according to instrument flight rules (IFR) with the help of satellite navigation (GPS). The last part of the approach up to landing on runway 08 was carried out as visual approach.

1.9 Communications

The flight crew was in contact with Innsbruck Radar (APP – 119.275 MHz) and Innsbruck Tower (TWR – 120.100 MHz) during the approach to Innsbruck. Current information on the weather and the aerodrome was obtained from Innsbruck Information (ATIS – 126.030 MHz).

1.10 Aerodrome information

Location:	on the western outskirts of Innsbruck
ICAO / IATA identifier:	LOWI / INN
ARP (Aerodrome Reference Point):	47° 15 '37" N, 011° 20' 38" E
Aerodrome elevation above MSL:	581 m / 1907 ft

A topographical, special characteristic of Innsbruck Airport is the massive mountain ranges north and south of the airport, and as a result the slightly steeper approach angles (3.5° PAPI for runways 08 and 26 and 3.77° GP for 26 ILS), compared to many other airports (usually 3° PAPI and GP).

1.10.1 AIP foehn procedure

Figure 8 and Figure 9 depict special flight procedures in foehn conditions, as published in AIP Austria. Para. 2.9 and 3.1.2.6 state that partly severe downdraughts have to be expected during final approach over the Inn river and over the city of Innsbruck.

Figure 8: Foehn flight procedure, AIP Austria

2.9. Föhn

2.9.1. Bei Föhnlagen (Bodenwind 100° - 180°, Windgeschwindigkeit 15 - 25 KT, Böen von 30 - 50 KT) ist mit starker Turbulenz, verbunden mit horizontalen Windscherungen und starken Abwinden, in allen Flughöhen und innerhalb des gesamten Inntales zu rechnen.

2.9.2. Um längere Flüge in starker Turbulenz zu vermeiden, wird empfohlen, An- und Abflüge in großer Höhe und entlang der Nordseite des Inntales durchzuführen.

Achtung: Erhöhte Segelflugtätigkeit innerhalb des Segelfluggebietes, sowie andere Luftfahrzeuge auf Gegenkurs.

2.9.3. Bei Anflügen aus dem Osten und Süden sollte der Flughafen nicht unter 5000 FT MSL überflogen werden. Im Endanflug zur Piste 08 über dem Fluß Inn ist mit starken Abwinden zu rechnen.

2.9.4. Ein detailliertes Föhn-briefing erstellt von Experten aus Innsbruck finden Sie auf der Homepage des Flughafen Innsbruck unter dem Link:
https://www.innsbruck-airport.com/de/business-partner/piloteninformationen

2.9. Foehn

2.9.1. During FOEHN conditions (surface wind 100° - 180°, windspeed 15 - 25 KT, gusts 30 - 50 KT) expect severe turbulence associated with horizontal windshears and severe downdraughts at all altitudes.

2.9.2. In order to avoid strong turbulence it is recommended to execute approaches and departures at high altitudes along the northern part of the Inn valley.

Attention: Intensive glider activity within the glider areas as well as other aircraft in opposite direction.

2.9.3. Approaches from the east and the south should overfly the airport not below 5000 FT MSL. On final for RWY 08 severe downdraughts have to be expected over the Inn river.

2.9.4. A detailed Föhn-briefing created by experts from Innsbruck can be found on the homepage of Innsbruck Airport under the link:
https://www.innsbruck-airport.com/en/business-aviation/aviation/pilots-information

Source: ACG

Figure 9: Instrument procedures, foehn flight procedures, AIP Austria

3.1.2.6. During FOEHN conditions (surface wind 100° - 180°, average windspeed 15 - 25 KT, gusts 30 - 50 KT) with horizontal / vertical windshear and associated with possible moderate to severe turbulence and following partly severe down-draughts at various altitudes have to be expected especially over the city of Innsbruck below 5000 FT AMSL.
To minimize operation in turbulence, pilots may during an approach procedure request a visual approach to RWY 08 from a position west of the aerodrome or stop descent at 7000 FT AMSL and proceed visually to a position over or south of the aerodrome but not below 5000 FT AMSL. Thereafter continue descent and join right hand baseleg for RWY 08. A down-draught over the river Inn on final approach to RWY 08 is most likely too.

Source: ACG

1.10.2 Operator’s procedure for foehn approach along the northern range

In view of the prevailing southern foehn situation, the crew opted for the “Föhn Approach along Nordkette” (northern chain) procedure for landing at Innsbruck, which is specified by the operator as an addition to the OM-B, in accordance with the "Airport Procedures Innsbruck" bulletin for the Dash 8 type (Figure 10, see also section 1.13).

Figure 10: Approach procedure "Föhn Approach along Nordkette"

5.4.1.1 Föhn Approach along Nordkette

Procedure for INN experienced, familiar crews.

The intention of this visual approach is to fly close to the northern mountain range ("Nordkette") and stay as high as possible the avoid turbulence.

A routing along FMS waypoints …INNF5 - INNF4 - INNF3 - INNF2 - INNF1 - AXAKI* - WI005 - LOWI provide guidance to stay outside the glider areas.

Descent so to reach a position abeam Seegrube (INNF2) at 7.000ft MSL with Gear down, Flaps 15°, target speed max. V_{FE}-20 kts. Turn left to cross the Inn valley, overfly the threshold 26 and continue to join OEJ backcourse to AXAKI (village of Axams) descending to 3.700ft MSL.

Note: When AXAKI is programmed into the FMS for guidance, the overfly function (AXAKI*) must be used in this situation.

Strong turbulence may be encountered while crossing the valley until south of the field.

Passing AXAKI, complete final landing configuration and turn right onto base. Start the descent to cross the northern edge of terrain ("Mittelgebirge") at min. 3.200ft MSL due to the power lines below. Otherwise a significantly higher crossing altitude may result in a high descent rate necessary on final and should be avoided. Turn right onto final, adjust bank angle to avoid getting too far to the north. Be aware of possible downdrafts when crossing the river Inn on short final.

Source: Operator

The "Airport Procedures Innsbruck" bulletin also indicates that EGPWS warnings can easily be triggered in the Inn valley (Figure 11).

Figure 11: Note on EGPWS warnings

1.1.1 EGPWS warnings

EGPWS warnings can easily trigger during manoeuvring in the Inn valley. Even in VMC, adherence to prescribed tracks and avoidance of high descend rates is recommended to avoid warnings.

In general, whenever the "Mittelgebirge" is approached from the valley, warnings (GPWS Mode 2) are likely to occur due to the fast rising terrain, even when well clear of the terrain. Low speed and landing configuration are measures to reduce the probability of such warnings.

It is known that in a one-engine-out RWY 26 missed approach, at the top of the initial left turn, an EGPWS warning may occur as a result of the high closure rate towards the fast rising terrain of the "Mittelgebirge". Provided the actual altitude is already 3.200ft MSL or above and the aeroplane indicates a positive rate of climb the aeroplane is safe when adhering to prescribed tracks / procedures.

In case a warning occurs, make sure that during recovery required turns acc. given procedures are completed!

While established on the LOC DME EAST approach, in the area of Kellerjoch (~ D18 OEV) the radar altimeter may come alive but does not trigger any warning.

Source: Operator

1.11 Flight recorders

A flight data recorder (FDR) and a cockpit voice recorder (CVR) were prescribed and installed for the operation of the DHC-8. A quick access recorder (QAR) was also on board for maintenance tasks and for the purpose of flight parameter evaluation. The QAR provides the same parameters and data as the FDR. The CVR was read out by the operator on 11 April 2019 under the supervision of an organ of the Austrian Federal Safety Investigation Authority. CVR and QAR data were handed over to the Austrian Federal Safety Investigation Authority.

FDR/QAR

FDR/QAR data are available from the time of taxiing at Vienna Airport (07:57:53) to the time of taxiing at Innsbruck Airport after landing (08:58:28). The data were transferred to the Austrian Federal Safety Investigation Authority as raw data (i.e. without any conversions or adjustments) and evaluated by them. An excerpt of relevant parameters of the flight and the landing can be found in the appendix.

CVR

The CVR was read out by the operator and the recorder was deleted afterwards. Recordings totalling 2 hours, 5 minutes and 20 seconds were given to the Austrian Federal Safety Investigation Authority.

Radar data

The radar data available at ACG for the approach and landing were requested, made available to the Austrian Federal Safety Investigation Authority and evaluated. There is data available from 08:50:00 to 08:57:13. These data consist of time, geo-coordinates and the transponder codes S, A and C, among other data.

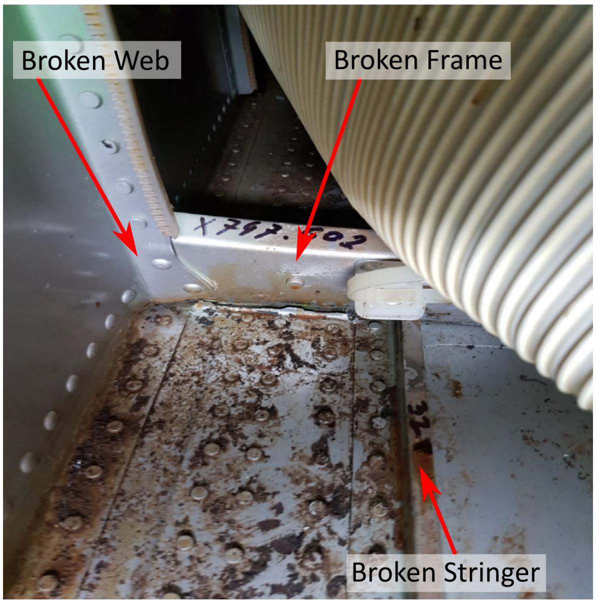
1.12 Wreckage and impact information

Damage to the aircraft was caused by abrasions and cracking of the outer skin, fairings and panels, with some rivets pulled out (Figure 12). One antenna was completely torn off. On the inside of the rear of the fuselage, stringers and frames were broken and bent, and rivets were pulled out (Figure 13 and Figure 14). The damage only affected the tail as described and had no further effects on the structural integrity of the aircraft or on its systems.

Figure 12: Damage to the tail of the aircraft

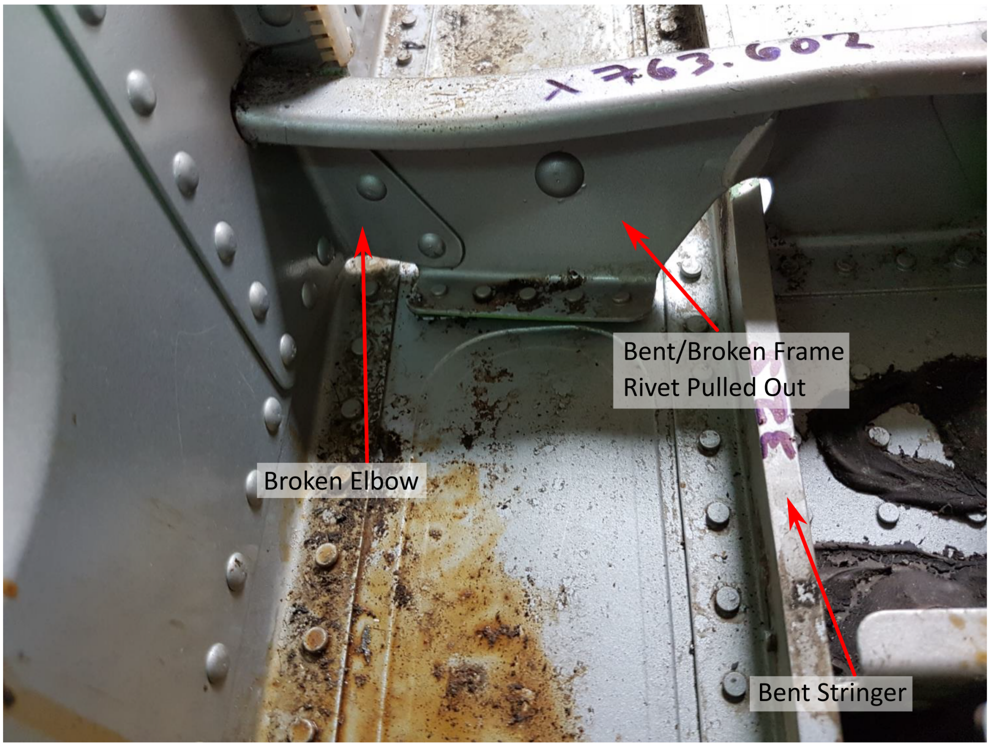
Source: Operator

Figure 13: Damage at X747.602, STR31P to 31S



Source: Operator

Figure 14: Damage at X763.602, STR31P to 31S



Source: Operator

1.13 Organisation and procedures

The operator of the aircraft issued the “Airport Procedures Innsbruck” bulletin as an addition to DASH 8 Operations Manual Part B (OM-B). That includes information on the special geographical, meteorological and operational conditions at and around Innsbruck Airport. This includes procedures for visual approaches under foehn conditions.

The charts and procedures used in Operations Manual Part C (OM-C) for Innsbruck Airport correspond to the charts and procedures published in the AIP by ACG at the time of the accident.

1.13.1 Safety Culture

As part of the safety culture, the operator runs a system for flight data monitoring (FDM), which is carried out extensively. Internal investigations are conducted when certain parameters (trigger levels) are exceeded during take-off, landing or during the flight, as well as in the event of accidents or incidents. If necessary, parameter exceedances or incidents are discussed with the respective crews on a voluntary basis in the context of a follow-up or a processing of the incident. In addition, as part of the safety promotion, selected incidents and their analyses are used to draw attention to current safety-relevant topics within the respective fleets.

1.13.2 Safety actions taken by the operator

The operator has carried out or implemented the following measures since the accident:

- Internal investigation conducted by the flight safety department in accordance with the operator's internal safety management system (SMS).
- Visualization of the FDM data as a video for training and instruction purposes.
- Creation of a flight crew briefing guide “Landetechnik Q400” (“landing techniques Q400”).
- The “Landetechnik Q400” guide is a focus point in the crew simulator training.
- FDM: A separate FDM profile has been implemented, which specifically monitors already stable approaches for subsequent possible deviations in the parameters.

2 Analysis

2.1 Meteorological analysis

At the time of the occurrence, good visibility and moderate cloud cover prevailed at Innsbruck Airport. The southern foehn situation that was just building up indicated possible wind shear and turbulence. Warnings of wind shear for the airport were only active until 07:00. Therefore, warnings were not active at the time of landing or in the hour before. In the MET REPORT, the wind shear warning was removed at 07:50. At the same time, turbulence warnings were downgraded from MOD/SEV (medium to severe) to MOD (medium). The crew was aware of the information about "moderate turbulence". After the situation had been discussed, there was no change of pilot flying. The approach was described as turbulent. Nevertheless, based on the available information the wind shear that was flown through about three seconds before landing could not be anticipated in this form. This wind shear or downdraught immediately before landing can be regarded as the cause of the accident, and as crucial to the further chain of events, including the contact of the tail of the aircraft with the runway.

2.1.1 Handling of the weather situation in Innsbruck

Due to the specific location of Innsbruck Airport, the special meteorological characteristics in Innsbruck and their handling were discussed in the course of the accident investigation with the aviation meteorological service located at Innsbruck Airport. Up to this accident, the practice in a classic foehn situation was that wind shear warnings (Bulletin, METAR, MET REPORT) were only issued until the foehn breakthrough, as long as the southerly foehn wind in the approach and aerodrome area meets the westerly wind from the Upper Inn Valley. If the south or south-east wind also prevailed in the direction of the Upper Inn Valley, the wind shear warning was omitted and only the turbulence warning for the approach remained.

Although this practice is correct from a meteorological point of view, it was possible that pilots could sometimes seem to interpret that information differently. It is conceivable and not uncommon for wind shear to be perceived as more dangerous than turbulence. One of the reasons for this is that wind shear tends to be perceived as a danger in combination with the inherent risk during take-offs and landings, whereas turbulence is usually more often connected to cruising flight. This unconscious prioritisation of wind shear to be more dangerous than turbulence, ultimately leads to the fallacy that the cancellation of a wind shear warning is considered as a relaxation of the wind situation. This also applies if the turbulence warning persists. The correct procedure of the Innsbruck aviation meteorological service could therefore possibly inadvertently convey that the situation is relaxing or less risky as soon as the foehn has established itself, since no further wind shear warning is issued. However, this is a fallacy, as approaches are by no means easier, because the foehn wind from the south or south-east in the aerodrome area is much more gusty and turbulent than the westerly wind.

Based on these considerations, the Innsbruck aviation meteorological service concluded that the wind shear warnings should be maintained even after the foehn breakthrough. This is justified, among other things, by the fact that after the foehn breakthrough there would indeed no longer be two air masses meeting at a shear plane. Even so, wind shears in the form of turbulences and rotors occur in the same way, if not more intensely.

2.2 History of flight

Visibility was good during the approach and at the time of the accident at 08:56. The crew was informed comprehensively about the weather situation both before and during the flight, and they obtained weather information themselves. A warning regarding wind shear that was issued earlier that day was no longer valid at the time of the accident. The crew had known at least since the pre-flight briefing that the approach would begin at a time close to a southern foehn situation that was currently forming.

During the pre-flight briefing, it was discussed that the experienced captain, who was familiar with such weather situations, would perform the approach and landing if the conditions deteriorated. Based on the available weather information, the flight crew did not make use of this possibility.

The flight preparation and also the in-flight weather evaluations were carried out in accordance with the applicable standards and regulations. The approach was performed by the co-pilot in accordance with the published foehn approach procedure. The criteria for a stabilized approach were briefly exceeded on the final approach, but these were recognized immediately and corrected in a targeted manner. The approach is therefore to be designated *as a stabilized approach* in accordance with OM-A 8.4.5.15.

The exceedance of the nose-up pitch limit while touching down was minimal (7.65° when touching down vs. 7.6° mechanical limit with full compression of the struts, see section 1.6.7). It is possible that the operationally necessary crown of the runway contributed to the accident.

In the very last phase of the approach, there was a sudden decrease in wind speed. The increase in engine power in response was correct, but it came too late. The decrease in wind speed did not occur until about 3 seconds before touchdown, which in itself gives the pilot very little time to react. If more power had been set, this would have further increased the nose-up pitching moment. Taking into account the reaction time of the pilot and the inertia of the aircraft, if at all, contact of the tail with the runway in the given circumstances could only have been prevented if a higher vertical acceleration (G-load) was accepted during landing.

Wind shear and turbulence are typical of foehn conditions. Fluctuations in wind speed, as in the present case, can occur not only in combination with foehn conditions but generally at any time. Whether an immediately initiated go-around manoeuvre would have prevented the tail of the aircraft from contacting the runway cannot be clearly deduced from the parameters available.

2.3 Aircraft

2.3.1 Loading and centre of gravity

Both the mass of the aircraft and the position of the centre of gravity were within the permissible range during the entire flight.

2.3.2 Maintenance

In the maintenance records that were made available, no indication was found of missing, open or unperformed maintenance or checks.

2.4 Flight crew

2.4.1 Human factors and crew resource management

The leadership behaviour of the captain, the cooperation between the two pilots, the joint decision-making before the approach and the associated communication can be described as optimal, following the evaluation of all the available documents by the Austrian Federal Safety Investigation Authority.

The captain's decision to transfer the duties of the pilot flying to the F/O was covered by the specifications in the OM-A. The OM-A grants the captain this delegation of tasks. The reason for this is the opportunity of the F/O to improve flying skills (specialist knowledge). Additionally, this policy also shows the importance and the responsibility of preparing co-pilots in everyday operation for later retraining and also for the duties of a captain in due course.

All co-pilots who do not yet have the necessary flight experience for further training to become a captain must gain this practical experience. The weather situation on the day of the accident was by no means ideal, but it was very well suited for a co-pilot in the role of pilot flying to experience a situation such as this approach at the beginning of a foehn situation.

However, the OM-A also gives the captain the opportunity to perform every flight himself as the pilot flying, and to entrust the co-pilot exclusively with the tasks of pilot monitoring. It would be sensible to point out that doing so would not be ideal with regard to an effective CRM.

2.5 Safety Actions

The operator analysed, discussed and reviewed the accident together with the two pilots. The lessons learned from the accident were channelled into flight operations in the form of bulletins, briefings, training documents, training priorities and an adapted FDM profile. From the point of view of the Austrian Federal Security Investigation Authority, these proactive actions are to be assessed as positive.

The Innsbruck aviation meteorological service has reviewed and adapted its own procedures, especially with regard to the handling and output of wind shear warnings (see section 2.1.1). The adaption is positively noted by the Austrian Federal Security Investigation Authority.

3 Conclusions

3.1 Findings

- Proper maintenance and airworthiness of the aircraft have been demonstrated.
- The aircraft was properly equipped, licensed and insured to operate flights for the transport of passengers and cargo.
- Both pilots held the permissions required to carry out the flight. Those were valid on the day of the accident.
- Both pilots had sufficient flight experience and were familiar with the special procedures at Innsbruck Airport.
- The pilots carried out a conscientious and systematic flight preparation.
- The aircraft was operated within the operational limits in terms of mass and centre of gravity at every phase of the flight.
- It can be precluded that a technical problem led to the accident.
- At the time of the accident, a southern foehn situation began to develop or was already established.
- A wind shear warning was issued up to about an hour before the accident, but was not active at the time of the accident.
- There was a gusty wind from the east. No significant changes in wind direction were observed during the final approach or landing.
- Immediately before landing, the crew was confronted with the effects of a sudden change in wind speed (low-level negative wind shear). The pilot flying then increased the engine power.
- This increase in engine power to correct the rapid decrease in speed and also the descent below the glide path corresponds to the manufacturer's recommendations. However, it came too late. Thus, the aircraft had already touched down.
- The short time of around 3 seconds between the emerging of the change in wind speed and the touchdown made it impossible to take further actions.
- The pilots’ crew resource management can be described as optimal. Decisions were made in a logical and understandable way. Alternative options for action were identified and discussed.
- The lessons learned from the accident were channelled into flight operations in the form of bulletins, briefings, training documents, training priorities and an adapted FDM profile.

- The Innsbruck aviation meteorological service has checked and adapted its own procedures, especially with regard to the handling and output of wind shear warnings.

3.2 Type of accident

Abnormal Runway Contact

3.3 Probable causes

Sudden decrease in wind speed just before touchdown (Low-level negative wind shear)

4 Safety recommendations

As measures have already been taken by both the operator and the Innsbruck aviation meteorological service, no further safety recommendations are made.

5 Consultation

Pursuant to Art. 16 (4) Regulation (EU) No. 996/2010, the Federal Safety Investigation Authority shall solicit comments from the authorities concerned, including EASA, the type certificate holder, the manufacturer and the operator concerned prior to publishing the final report.

In solociting such response, the Federal Safety Investigation Authority followed the international guidelines and recommendations regarding investigations of aviation accidents and incidents as approved under Article 37 of the Chicago Convention on International Civil Aviation.

Pursuant to section 14 para. 1 of the UUG [Accident Investigation Act] 2005 as amended, the Federal Safety Investigation Authority asked the owner of the aircraft and any survivors or victims for their written comment on the facts and conclusions pertinent to the occurrence under investigation before finalization of the report on the investigation ("Stellungnahmeverfahren").

The Federal Safety Investigation Authority received comments from the captain, the Austrian Civil Aviation Authority ("OZB"), Austro Control GmbH ("ACG"), the European Aviation Safety Agency ("EASA") and the German Federal Bureau of Aircraft Accident Investigation ("BFU").

The responses obtained were taken into consideration and incorporated in the investigation report as applicable.

List of Tables

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List of Figures, Appendices

List of Regulations

Federal Act on the Independent Safety **Investigation of Accidents and Incidents (Accident Investigation Act 2005 - UUG**), Federal Law Gazette I No. 123/2005 last amended by Federal Law Gazette I No. 143/2020.

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 and the repeal of Directive 94/56/EC.

Implementing Regulation (EU) No. 923/2012 of the Commission of 26 September 2012 laying down common air traffic rules and operating rules for air traffic control services and procedures and amending Implementing Regulation (EC) No. 1035/2011 and Regulations (EC) No. 1265/2007, (EC) No. 1794/2006, (EC) No. 730/2006, (EC) No. 1033/2006 and (EU) No. 255/2010. (**SERA**)

Implementing Regulation (EU) No. 2016/1185 of the Commission of 20 July 2016 amending Implementing Regulation (EU) No. 923/2012 with regard to updating and completing the common air traffic rules and operating rules for air traffic control services and procedures (SERA Part C) and repealing Regulation (EC) No. 730/2006.

Abbreviations

ACARS	Aircraft Communications Addressing and Reporting System
ACG	Austro Control GmbH
AD	Aerodrome (in the AIP)
AGL	Above Ground Level
AFM	Aircraft/Airplane Flight Manual
AFT	Aft (tail, back side of aircraft)
AIP	Aeronautical Information Publication
AMD	Amended
AMSL	Above Mean Sea Level
APP	Approach; Approach Control Service
ARC	Airworthiness Review Certificate
ARP	Aerodrome reference point
ARTE	Above Runway Threshold Elevation
ATIS	Automatic Terminal Information Service
ATPL(A)	Airline Transport Pilot License, Airplane
CAA	Civil Aviation Authority
COP	Co-pilot
CTR	Control zone
CVR	Cockpit Voice Recorder
EASA	European Aviation Safety Agency
EDDM	ICAO identifier of Munich airport
EGPWS	Enhanced Ground Proximity Warning System
EU	European Union
FCST	Forecast (weather-)
FDM	Flight Data Monitoring
FL	Flight Level
FMS	Flight Management System
FNA	Final approach
F/O	First Officer

FWD	Forward (side of aircraft)
GP	Glide Path (transmitter for IL)
GPS	Global Positioning System
IFR	Instrument Flight Rules
IAS	Indicated Airspeed
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
IR	Instrument Rating
LAPL	Light Aircraft Pilot License
LAW	Landing Weight
LI	Loaded Index
LIPB	ICAO identifier of Bolzano Airport
LOWI	ICAO identifier of Innsbruck Airport
LOWW	ICAO identifier of Vienna-Schwechat Airport
MAC	Mean Aerodynamic Chord
METAR	Meteorological Aerodrome Report
MOD	Moderate
MPL	Multi-Crew Pilot License
MSL	Mean Sea Level
MTOM	Maximum take-off mass
OM	Operations Manual
PAPI	Precision Approach Path Indicator
QAR	Quick Access Recorder
QNH	Atmospheric pressure at mean sea level in hPa
RWY	Runway
SERA	Standardized European Rules of the Air
SFC	Surface (ground; height reference)
SHP	Shaft horse power
SMS	Safety Management System

SUB	Sicherheitsuntersuchungsstelle des Bundes (Austrian Federal Safety Investigation Authority)
TAF	Terminal Aerodrome Forecast
TCCA	Transport Canada Civil Aviation
TCDS	Type Certificate Datasheet
TIF	Trip Fuel
TOF	Take-off fuel
TOW	Take-Off Weight
TWR	(Aerodrome Control) Tower
UTC	Coordinated Universal Time
VMC	Visual meteorological conditions
WGS84	World Geodetic System 1984
ZFW	Zero Fuel Weight (aircraft mass - DOM (dry operating mass) plus payload, therefore passengers and freight, but without fuel)

ft	Feet (1 ft = 0.3048 m) (in the AIP also: FT)
ft / min	Feet per minute (1 ft / min = 0.00508 m/s)
hPa	Hectopascal (1 hPa = 100 N / m^2)
km	Kilometres (1 km = 1000 m)
kt	Knots (1 kt = 0.514444 m / s)
kW	Kilowatts (1 kW = 1000 W = 1.35962 PS)
lb	Pound (1 lb = 0.453592 kg)
MHz	Megahertz (1 MHz = 106 Hz)
nm	Nautical mile (1 nm = 1852 m)

Abbreviations related to weather observations (METAR) and forecasts (TAF) can be found in the WMO manual “Aerodrome Reports and Forecasts”, WMO-No. 782 (https://library.wmo.int/doc_num.php?explnum_id=5981).

6 Appendices

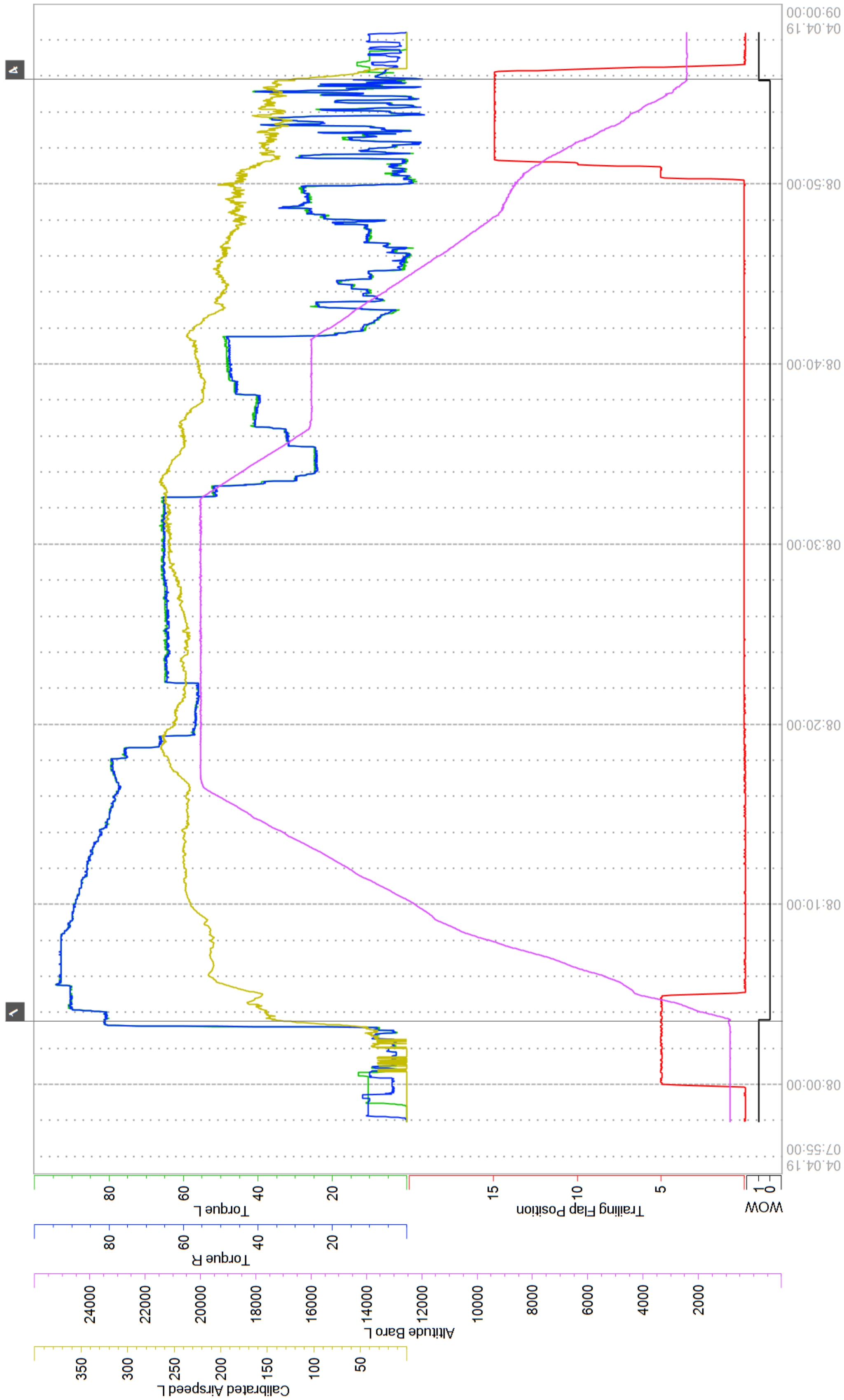
6.1 Flight Data Recorder (FDR) data

The FDR/QAR data relevant for this occurrence can be found in Figure 15 to Figure 17. At the top of the diagrams marked with [1] to [6] are:

[1] Take-off from Vienna International Airport (Schwechat)
[2] Begin of the excessive decrease in airspeed 3 seconds before landing at 08:55:44
[3] First touchdown of the main landing gear at 08:55:47
[4] Final touchdown of the main landing gear at 08:55:49
[5] EGPWS Alert / Warning at 08:55:07
[6] EGPWS Alert/Warning at 08:55:42

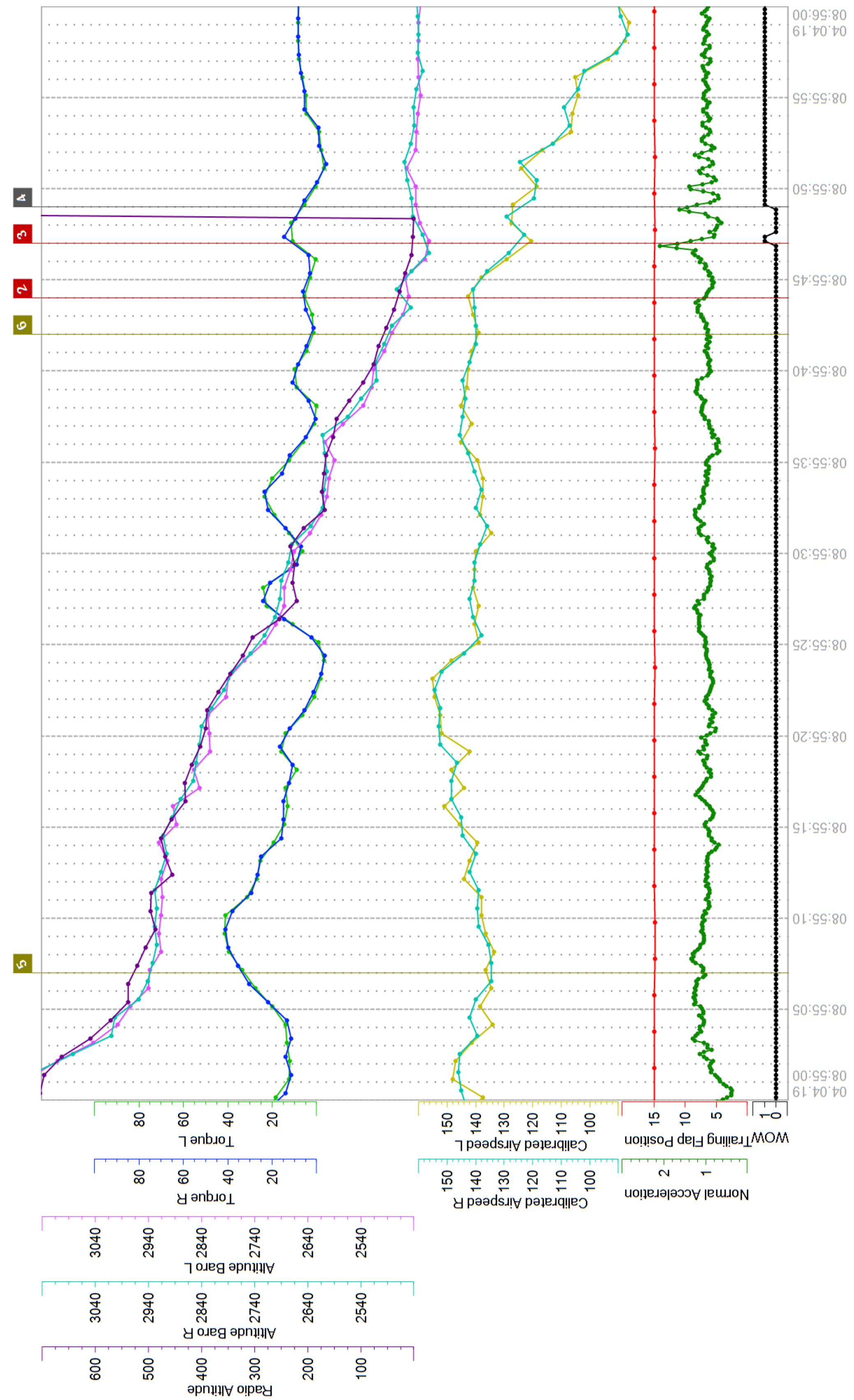
Figure 18 also shows the data of the barometric altimeter (L(eft) and R(ight)) as well as the data of the radar altimeter (Radio). Figure 19 shows the vertical rate of climb and descent calculated from this data. The rates of climb and descent were averaged for smoothing purposes over nine data points of the respective altimeter data. The data from the radar altimeter should be viewed with caution, and therefore only as an additional reference, as it is also affected by the terrain below the aircraft.

Figure 15: FDR data of the entire flight



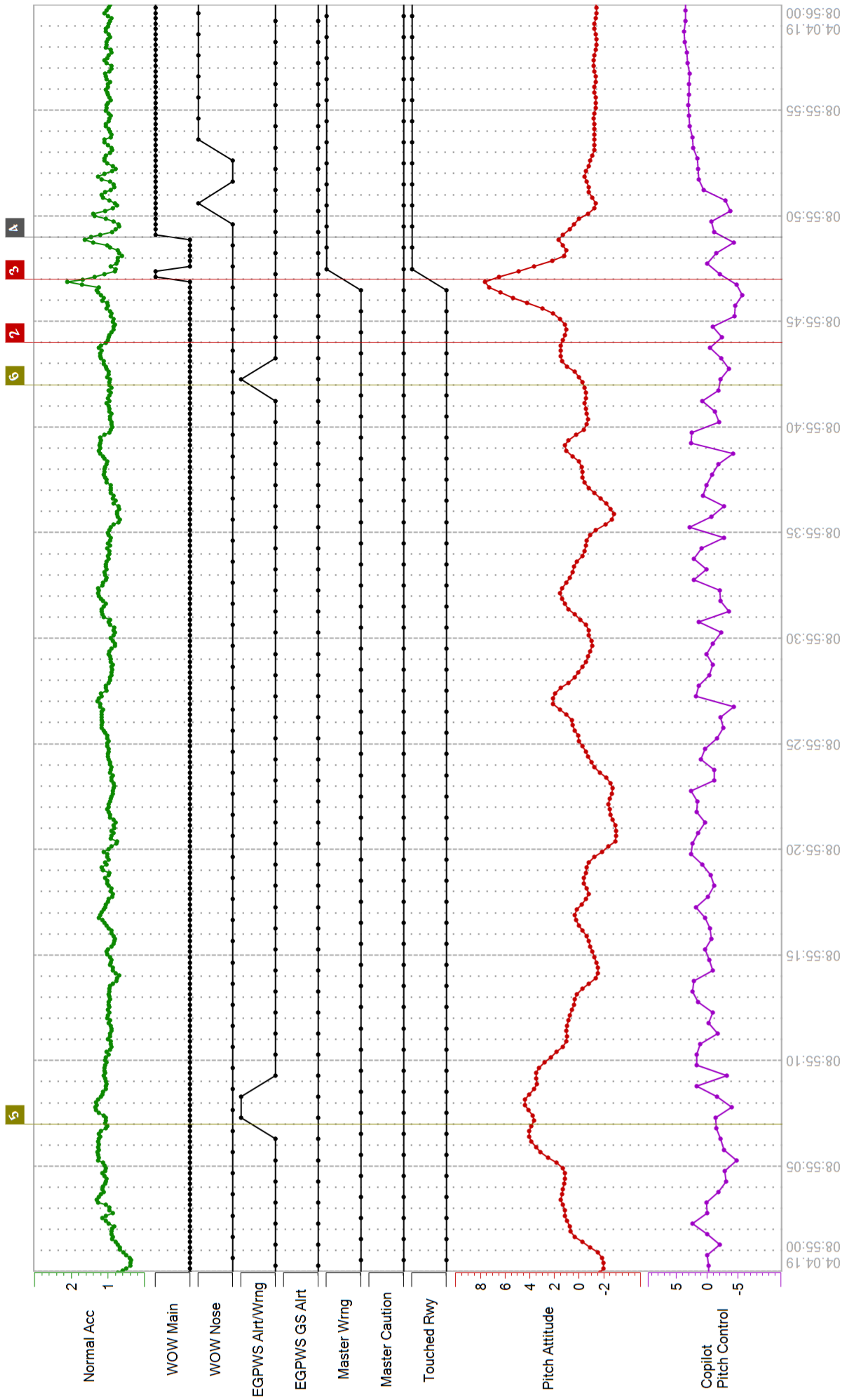
Source: SUB

Figure 16: FDR data of the landing, part 1



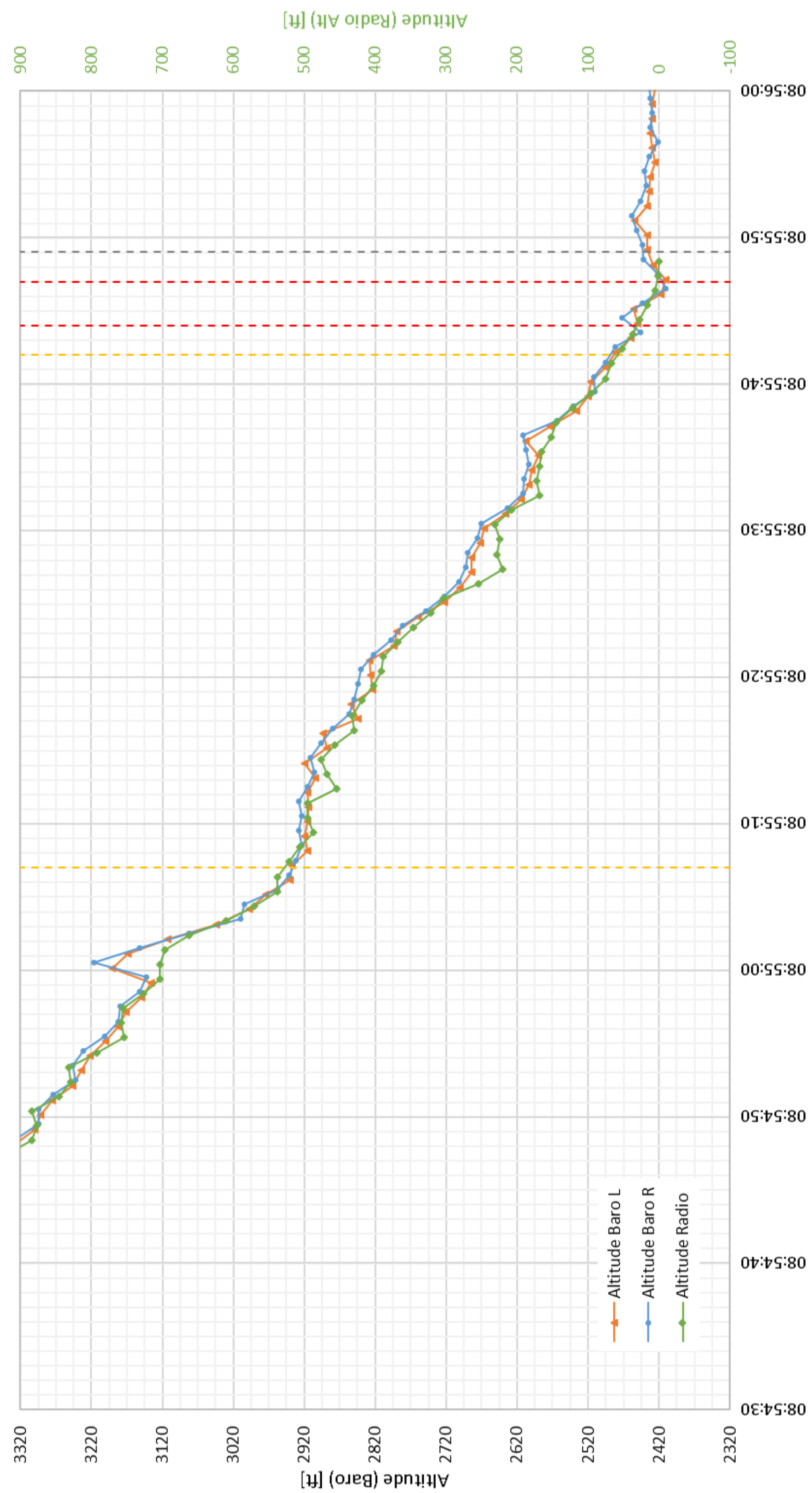
Source: SUB

Figure 17: FDR data of the landing, part 2



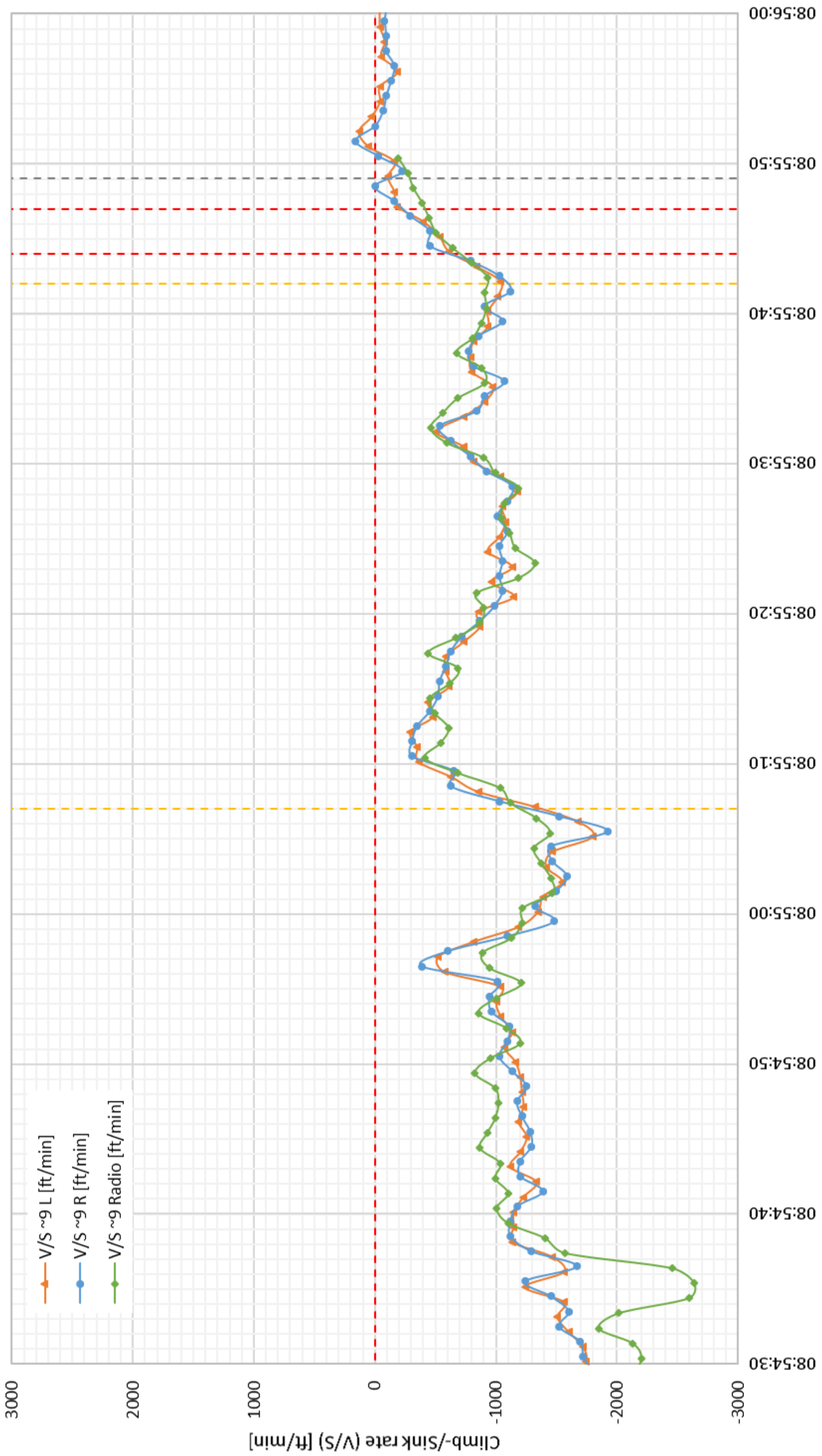
Source: SUB

Figure 18: Altitude information



Source: SUB

Figure 19: Rate of climb and descent as calculated from altimeter data



Source: SUB

Imprint

Republic of Austria
Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology
Federal Safety Investigation Authority – Civil Aviation Department
Radetzkystrasse 2, 1030 Vienna
Vienna, 2021. Version: 02 July 2021

Investigation Report

This Investigation report pursuant to Article 16 of Regulation (EU) Nr.996/2010 was approved by the Head of the Federal Safety Investigation Authority after finalisation of the consultation procedure in accordance with Article 16 of Regulation (EU) 996/2010 in conjunction with § 14 (1) UUG [*Accident Investigation Act*] 2005.

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All data protection information can be found under the following link:
www.bmk.gv.at/datenschutz

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