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Aircraft Accident Investigation Bureau AAIB

Final Report No. 2028 by the Aircraft Accident Investigation Bureau

concerning the accident

to the aircraft Bombardier DHC-8-402, registration HB-JGA

operated by Sky Work AG under flight number SRK 172

on 22 June 2008

Bern-Belp Airport

Aéropôle 1, Route de Morens, CH-1530 Payerne

Ursachen

Der Unfall ist darauf zurückzuführen, dass das Flugzeug zuerst mit dem Heck auf der Piste aufschlug, weil die Besatzung auf eine hohe Sinkrate mit einem zu grossen Lagewinkel statt mit einer Leistungserhöhung reagierte.

Zur Entstehung des Unfalls könnte eine Ermüdung der Besatzung beigetragen haben.

General information on this report

This report contains the AAIB's conclusions on the circumstances and causes of the accident which is the subject of the investigation.

In accordance with art. 3.1 of the 9th edition of Annex 13, valid from 1 November 2001, of the Convention on International Civil Aviation of 7 December 1944 and article 24 of the Federal Air Navigation Act, 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/incident causes and circumstances is expressly no concern of the accident investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

If this report is used for purposes other than accident prevention, due consideration shall be given to this circumstance.

The definitive version of this report is the original in the German language.

All times in this report, unless otherwise indicated, follow the coordinated universal time (UTC) format. At the time of the accident, Central European Summer Time (CEST) applied as local time (LT) in Switzerland. The relation between LT, CEST and UTC is:
LT = CEST = UTC +2 h.

Contents

Final Report

Owner	BTV Leasing Schweiz AG, Haupstr. 19, 9422 Staad, Switzerland
Operator	Sky Work AG, Airport Terminal North, 3123 Belp, Switzerland
Aircraft type	DHC-8-402
Country of registration	Switzerland
Registration	HB-JGA
Location	Bern-Belp Airport
Date and time	22.06.2008, 10:43 UTC

Synopsis

On 22 June 2008 aircraft Bombardier DHC-8-402, registration HB-JGA, under flight number SRK 172, took off at 09:02 UTC from Palma de Mallorca (E) on a charter flight under instrument flight rules to Bern-Belp (CH). Five crew members and 62 passengers were on board. After an uneventful flight, at 10:32:38 UTC the crew of SRK 172 contacted the “Bern Arrival” air traffic controller (ATCO). Runway 32 was in service at Bern-Belp. The ATCO asked the crew if they wanted to make a visual approach. The crew answered in the affirmative and requested an approach on runway 14; this was granted immediately, with a reference to the tailwind to be expected.

During the aircraft’s landing flare shortly before touching down on the runway, the crew noticed an above-average rate of descent, which they wanted to correct by increasing the pitch attitude of the aircraft. Subsequently, the aircraft struck the runway aft fuselage first.

The crew and passengers were able to disembark the aircraft normally. One flight attendant and one passenger suffered minor injuries. The aircraft was considerably damaged. The airport emergency services were not mobilized.

Investigation

The accident occurred at 10:43 UTC. The Swiss Aircraft Accident Investigation Bureau (AAIB) was informed at 11:25 UTC. The investigation was opened the same day at approximately 13:00 UTC.

Causes

The accident is attributable to the fact that the aircraft touched the runway with the aft fuselage first because the crew reacted to a high sink rate by a too high pitch attitude rather than by a power increase.

Fatigue may have contributed to the development of the accident.

1 Factual information

1.1 Pre-history and history of the flight

1.1.1 General

For the following pre-history and history of the flight description, the recordings of the radio communication, conversations and sounds in the cockpit (cockpit voice recorder – CVR), the flight data (flight data recorder – FDR), radar data and the statements of the crew members were used. Throughout the flight the commander under supervision, in the left-hand seat, was pilot flying (PF) and the training captain supervising him in the right-hand seat was pilot not flying (PNF). The co-pilot, who was also still under supervision, was sitting on the jump seat and was responsible for radio communication towards the end of the flight.

The flight took place under instrument flight rules.

1.1.2 Pre-history

According to the duty regulations in the operator's operations manual OM A, the crew should have met on 22.06.2008, at the latest 60 minutes before the scheduled departure time, i.e. at 04:15 UTC, to prepare for the flight to Palma de Mallorca.

According to the commander under supervision, he arrived only 30 minutes before the scheduled departure time. He had agreed this with the training captain, in order not to drop below the minimum rest time as a result of the delayed arrival on the previous evening. He said the training captain had taken over preparation of the flight for this reason.

The SRK 171 and SRK 172 operations flight plans pre-printed by the operator bear the date 21 June 2008 and the entered departure time from Bern-Belp of 05:30 UTC, corresponds to the one as published for aircraft type Do 328, in service from 06.04.2008 to 27.04.2008. A departure time of 05:15 UTC is published for the DHC-8-402 aircraft.

The information prepared by the operator is collected in a so-called Pre-Flight Information Bulletin (PIB). The publisher of this PIB is the "Austria Aeronautical Information Service". The PIB contains the NOTAM, Aerodrome Information, En-Route FIR Information and the various weather and wind charts. The flight from Bern to Palma de Mallorca was uneventful.

1.1.3 History of the flight

On 22 June 2008 the DHC-8-402 aircraft, registration HB-JGA, took off at 09:02 UTC from Palma de Mallorca (LEPA) on a charter flight under flight number SRK 172 and callsign "Skyfox one seven two" to Bern-Belp (LSZB). Five crew members and 62 passengers were on board. After an uneventful flight, at 10:32:38 UTC the flight crew of SRK 172 contacted the "Bern Arrival" air traffic control unit on the 127.325 MHz frequency.

At 10:32:46 UTC, when the air traffic controller (ATCO) asked the crew if they were planning a visual approach, flight SRK 172 was approximately 10 NM south-south-west of Bern-Belp airport. The aircraft was at 15 200 ft PA (pressure alti-

tude), descending and at a speed of 278 KCAS[1]. At 10:32:51 UTC, the crew answered as follows: *"Er, affirmative Skyfox one seven two could we have latest wind at runway in use?"*. After a short pause, the ATCO informed them of wind from direction 310 degrees at 3 knots, maximum 6 knots.

At 10:33:15 UTC, the training captain twice said: *"over there is the runway"*. At practically the same time, the crew of SRK 172 informed the ATCO as follows: *"Ok erm, in this case erm, we would prefer runway one four and erm from this position to Muri if possible"*. The ATCO immediately gave the crew the corresponding clearance and instructed them to descend to FL 80. At this time the aircraft was about 6 NM south-south-west of the airport, at 14 300 ft PA, descending and at a speed of 280 KCAS.

At 10:33:33 UTC the ATCO gave the crew of SRK 172 the following clearance: *"Skyfox one seven two cleared for the visual approach runway one four descend initially flight level eight zero"*. This clearance was acknowledged as follows by the crew eight seconds later: *"Cleared to visual runway three two and er initial climb er descend eight zero Skyfox one seven two"*. The incorrect runway direction which the crew read back was not corrected by the ATCO.

At 10:34:20 UTC the ATCO cleared the crew to descend to 6000 ft QNH. At 10:34:33 UTC, the commander under supervision requested the approach check, which was carried out immediately by the training captain. At this time the aircraft had already flown over the extended centre line of runway 14 and was about 3 NM north-north-west of the airport (cf. Annex 1).

At 10:35:44 UTC the ATCO gave the crew of SRK 172 a further instruction: *"Skyfox one seven two make a wide approach to allow IFR departure from runway one four"*. This instruction was repeated by the ATCO 13 seconds later.

At 10:36:16 UTC, during its descent, at 8100 ft PA and a speed of 254 KCAS, the flight data recorder (FDR) recorded the autopilot being disengaged. This event was not mentioned by the crew. The warning tone of the disengaged autopilot sounded twice.

At 10:36:32 UTC the commander under supervision asked the training captain: *"do you have the runway in sight?"*. The training captain replied in the negative and at 10:36:36 UTC a discussion began about the position of the aircraft, which was at this time about 12 NM north of beacon “MURI”. At this time, the aircraft was flying at 7900 ft PA, descending and at a speed of 235 KCAS. The co-pilot on the jump seat now entered the discussion as follows: *"I think this is not correct we have to make a left turn back"*. The training captain remarked at the same time, in agreement: *“... a left turn back”*. Only three seconds later, the ATCO gave the following clearance: *"Skyfox one seven two you may turn base now"*. Then, at 10:36:53 UTC the crew requested radar vectors. The ATCO then instructed the crew to make a left turn onto heading 220 degrees. The training captain subsequently asked the commander under supervision whether he wanted to engage the autopilot again. The commander under supervision answered in the affirmative and the training captain engaged the autopilot at 10:37:16 UTC, at an altitude of 6900 ft PA, and confirmed this action verbally.

[1] KCAS: knots calibrated airspeed

At 10:38:45 UTC, on the 220° heading, the training captain reported: *"there is the high antenna right there and there is Berne right over there and there is the airport"*. At this time the aircraft was approximately 15 NM north of the aerodrome.

The crew of SRK 172 then received clearance to descend to 4000 ft QNH and at 10:39:08 UTC the ATCO asked: *"And confirm you are again ready for the visual approach runway one four?"*. The crew confirmed this five seconds later.

At 10:39:40 UTC the training captain informed the commander under supervision: *"there is the field over there"*. The commander under supervision confirmed immediately that he could also see the aerodrome. At this time the aircraft was descending, at 5800 ft QNH, with a speed of 232 KCAS. The average rate of descent was approximately 1000 ft/min (Annex 2). According to the FDR recordings, the autopilot was disengaged again at 10:39:49 UTC. The disengagement was not mentioned this time either; however, the corresponding warning tone is audible on the CVR.

At 10:40:03 UTC, the crew received the following clearance from the ATCO: *"Skyfox one seven two further descent at your discretion radar service terminated contact tower one two one decimal zero two five good by"*. According to radar recordings, aircraft HB-JGA was at this time 10 NM north-north-west of the airport.

The crew of SRK 172 acknowledged this clearance as follows: *"Ok further descent on discretion and tower one two one er seven two five good by Skyfox one seven two"*. The incorrect readback of the frequency was corrected immediately by the ATCO.

At 10:40:19 UTC, at a speed of 217 KCAS, the commander under supervision slowly brought the throttles back to the idle position. At almost the same time, a tone indicating a switched-on mobile phone sounded in the cockpit. The training captain remarked: *"I got the phone on"*.

The crew of SRK 172 subsequently reported to the "Bern Tower" ATCO and received the following clearance from him at 10:40:39 UTC: *"Skyfox one seven two Bern Tower hello tail wind three one zero degrees five knots maximum eight knots runway one four cleared to land"*. This clearance was confirmed by the crew as follows: *"Runway one four cleared to land wind is checked Skyfox one seven two"*.

From 10:40:40 UTC the rate of descent was increased to just under 2000 ft/min on average (Annex 2). At a speed of 198 KCAS, at an altitude of 4592 ft QNH, the commander under supervision requested at 10:40:47 UTC: *"Flaps five"*. Four seconds later, the commander under supervision ordered: "*speed checked, gear down*". At this time the aircraft was on an intercept heading of 165°, approximately 6 NM north-west of the threshold of runway 14. At 10:41:05 UTC, at an altitude of 4088 ft PA and at a speed of 188 KCAS, the aircraft turned onto the runway centre line.

At 10:41:18 UTC the commander under supervision ordered: *"Flaps ten"*. The training captain selected the corresponding flap position and shortly afterwards, at a speed of 171 KCAS, offered: *"I can give you flaps fifteen"*. Loud radio communication intermittently drowned out the conversations in the cockpit. At 10:41:33 UTC the 15° flap position was selected. The rate of descent was then reduced to just under 1000 ft/min.

At 10:41:42 UTC, at a radio height (RH) of 1450 ft and at a speed of 158 KCAS, the commander under supervision ordered the flaps to be extended to the 35° position and at virtually the same time he requested: *"final check"*.

The 35° flap position was selected without delay and then the landing checklist was performed by the training captain.

At 10:41:58 UTC, at a radio height of 1144 ft and at a speed of 126 KCAS, the commander under supervision again pushed the throttles slightly forward. Five seconds later, the training captain commented: *"again this time one one eight, no more, no more than like about plus five knots because you got a little bit of a tailwind, not much"*.

At 10:42:10 UTC the acoustic altitude advisory from the radio altimeter sounded: *"one thousand"*. At this time the aircraft was in landing configuration on the extended centre line of runway 14 and was flying at a speed of 122 KCAS.

To that phase of flight the commander under supervision later stated (translated from German): "At the beginning of the final approach, I have asked Mr. [name of the training captain] to help me during the approach, to give me instructions, to talk me down, because I knew that I did not have much experience at that time. Mentally, I handed over the aircraft to him. I relied on his advices. During the approach this has gone well: he gave me instructions. (...) I have decidedly entrusted to him all the responsibility for the approach and landing and asked him explicitly for help."

The aircraft was flying approximately on a 4° glide path, corresponding to the precision approach path indicator (PAPI). At 10:42:14 UTC the training captain made the following remark: *"so one one eight so you know like one twenty three its good like where you got it nice and stabilized looks good - slightly high"*. At this time the aircraft was slightly above the 4° glide path and the throttles were slightly forward. About 20 seconds later he mentioned: *"power where you got it is good right now, you maintain fairly good plus five on the speed, that's good ..."*. At 10:42:48 UTC, on an radio height of 416 ft, he made the following comment: *"don't work too much on the power, speed is good right where you got it, looks good ..."* and shortly afterwards, on a radio height of 311 ft: *"and now start easing the power back a little bit, gradually working it back, start working the power back a little bit ..."*.

The throttle position remained virtually unchanged between 750 ft RH and 150 ft RH. Subsequently the throttles were taken back imperceptibly. Starting from 50 ft, an almost continuous power reduction took place. The difference between the calibrated airspeed (CAS) and the groundspeed remained relatively constant (Annex 4).

According to their statement immediately after the flight, shortly before reaching a radio height of 50 ft the crew noticed an increased rate of descent and the training captain expressed with emphasis: *"nose up! nose up! nose up! ... much faster than that ..."*. According to the FDR, the rate of descent of just under 1000 ft/min was maintained until a height of just under 30 ft RH (Annex 5). Starting from approximately 50 ft RH, the pitch was changed from 0.7° attitude nose down (AND) to 8.17° attitude nose up (ANU) within 3 seconds.

According to the training captain's statement, he had helped in this phase pulling lightly on the control column in order to reduce the sink rate. Subsequently and shortly before ground contact he used both hands at the controls in an attempt to hinder a too strong pull by the commander under supervision. According to the training captain's statement the latter pulled the control column further back in spite of this pressure.

The commander under supervision stated after the accident that the training captain had pulled the control column back at the very end. The Copilot on the jump seat mentioned to have observed that the training captain pulled back the controls with both hands during landing.

On contact with the runway, the recordings indicate a maximum pitch attitude of 8.17° ANU and a vertical acceleration of 2.58 g.

The engine data recordings do not indicate any irregularities. At a height of 90 ft RH engine control changes from propeller constant speed range to Beta range as per design.

The aft fuselage struck the runway at 10:43:09 UTC. Half a second later the main gear made contact with the runway and three seconds later the nosewheel touched down. The following warning illuminated in the cockpit: "TOUCHED RUNWAY".

The aircraft's hard touchdown was not noticed by air traffic control and the aircraft received a standard taxi clearance to the assigned stand.

The passengers were able to disembark the aircraft normally after the two engines had been shut down at the stand. One flight attendant and one passenger suffered minor injuries. The aircraft was considerably damaged. The airport emergency services were not mobilized.

1.2 Injuries to persons

Injuries	Crew	Passengers	Total number of occupants	Others
Fatal	0	0	0	0
Serious	0	0	0	0
Minor	1	1	2	0
None	4	61	65	Not applicable
Total	5	62	67	0

1.3 Damage to aircraft

The aft lower fuselage of the aircraft was considerably damaged. As a result, all structural parts as well as the skin panels had to be replaced between fuselage stations FS X683.450 and FS X819.102 and between stringers #30 left and #30 right.

1.4 Other damage

Scrape marks from the lower fuselage contact were clearly visible on the runway. They were located about one metre left of the centre line and extended over a length of approximately eight metres. Small metal parts from the aircraft fuselage which had been torn off had embedded themselves in the surface of the runway.

1.5 Personnel information

1.5.1 Training captain

Person	English citizen, born 1956
Licence	Air Transport Pilot Licence (ATPL (A)), issued by the Canadian Transport Ministry on 08.04.2008, valid till 30.09.2008.
	Special Flight Permit for the DHC-8-402 aircraft, registration HB-JGA, issued by the Federal Office of Civil Aviation (FOCA) on 22.05.2008, valid till 05.07.2008.
Ratings	*Language proficiency- English*
	All single pilot non-high performance, single land multi-engine land aeroplanes
	DH8
	Currency provisions

Instrument flying ratings	*Group 1 instrument rating to 2010/05/01*
Last proficiency check	01.05.2008
Medical fitness certificate	Class 1 Restrictions: glasses must be available Commencement of validity: 27.03.2008 End of validity: 30.09.2008
Last medical examination	27.03.2008
Commencement of pilot training	1975

According to information from "Transport Canada", a pilot can, in agreement with Canadian regulation (CAR) 245.21, act as a training captain under the following conditions:

"7) A person who conducts flight training toward the issuance of an aircraft type rating shall:

(a) in the case of training for a holder of an aeroplane pilot permit or pilot licence: (amended 2006/12/14; previous version)

(i) be the holder of a Commercial Pilot Licence - Aeroplane or an Airline Transport Pilot Licence - Aeroplane; and (amended 2005/12/01; previous version)

(ii) have experience of not less than 50 hours flight time on the class of aeroplane used for the training, of which not less than 10 hours must be on the aeroplane type; (...)"

The Swiss Federal Office of Civil Aviation FOCA, based on attachment 3 to the joint aviation requirements flight crew licensing (JAR-FCL) 1.015 – "Validation of pilot licences of non-JAA States for specific tasks", granted a "special flight permit" as a "temporary validation" of the Canadian license.

1.5.1.1 Flying experience

Total	6564.7 hours [2]
On the accident type	310.5 hours
During the last 90 days	75.0 hours
Of which on the accident type	55.0 hours
As instructor on aircraft	3550.0 hours
As instructor on the accident type	125.5 hours
During the last 90 days	30.6 hours

According to the training captain's statement he had, as employee of Flight Safety International (FSI), instructed approximately 10 000 hours on Dash 8 Flight Simulators.

1.5.1.2 Crew duty times

Start of duty on 21.06.2008	15:15 UTC
End of duty on 21.06.2008	21:25 UTC

[2] The entries in the pilot's American logbook are given in decimal hours.

Flight duty time on 21.06.2008	6:10 hours
Start of duty on 22.06.2008	04:15 UTC
Rest time	6:50 hours
Flight duty time at the time of the accident	5:13 hours

The published arrival time of the flight on the evening of 21.06.08 is 19:35 UTC.

The crew duty times take into account 60 minutes for preflight duty and 30 minutes for postflight duty, as defined in the operator's OM A.

According to information in the pilot's log book of the commander under supervision, the training captain had made the last two flights on 21.06.08 with him.

The aircraft manufacturer states that according to a contract between them and the operator, regarding rest time, the regulations by the Canadian Authorities were applicable for the training captain, if they were more stringent than the Swiss rules.

In the present case the Canadian regulations stipulate that a crew member, between two missions, must have a minimum rest time of 8 hours. Transfer times from the airport to the rest facility and back must be added to those 8 hours.

Both, the above rest time as well as the minimum rest time of 8 hours, as specified in the operator's OM A, was not complied with on the night of 21.06.08 to 22.06.08.

1.5.2 Commander under supervision

Person	Austrian citizen, born 1961
Licence	Air transport pilot licence aeroplane (ATPL(A)) according to joint aviation requirements (JAR), first issued by Austro Control GmbH, Vienna, on 16.08.2006, valid till 23.04.2013
Ratings	Type rating DHC8 as pilot in command, valid till 14.03.2009 Type rating DO328-100 as pilot in command, valid till 15.01.2009 Class rating for single engine piston – SEP, valid till 16.08.2008 Class rating for touring motor glider – TMG), valid till 16.08.2008 Radiotelephony ratings: English / German
Instrument flying ratings	Instrument flight aircraft IR DHC8 Category I instrument approaches, valid till 14.03.2009 DO328 Category II instrument approaches, valid till 15.01.2009
Type Rating Course DHC-8 Q400	14.03.08

Medical fitness certificate	Class 1 Restrictions: VNL (must wear optimally correcting spectacles and carry similar spare spectacles) Commencement of validity: 05.11.2007 End of validity: 05.11.2008
Last medical examination	05.11.2007
Commencement of pilot training	1987 in the USA

1.5.2.1 Flying experience

Total	3744:02 hours
As commander	531:37 hours
During the last 90 days	60:36 hours
Of which on the accident type	60:36 hours
Total landings on the accident type	30

1.5.2.2 Type rating course

The commander under supervision had completed transition to the DHC-8 Q400 aircraft type with the Flight Safety International company in Toronto, Canada. He was awarded certification of successful transition dated 14.03.08. At this time, the commander under supervision had completed 20.30 hours on the simulator as PF (pilot flying) and 19.30 hours as PNF (pilot not flying).

For the first five out of a total of nine exercises, the corresponding qualification sheets indicated that more attention was required regarding speed monitoring and power setting on approach.

The qualification sheets during route familiarisation certify good to very good performance for the commander under supervision. On 20.06.2008, during a flight from Bern-Belp to Olbia and back, the commander under supervision was attested by the operator as being “ready for line check”.

1.5.2.3 Crew duty times

Start of duty on 21.06.2008, after a break of 11 days	09:05 UTC
End of duty on 21.06.2008	21:25 UTC
Flight duty time on 21.06.2008	12:20 hours
Start of duty on 22.06.2008	04:15 UTC
Rest time	6:50 hours
Flight duty time at the time of the accident	5:13 hours

The published arrival time of the flight on the evening of 21.06.08 is 19:35 UTC.

The crew duty times take into account 60 minutes for preflight duty and 30 minutes for postflight duty, as defined in the operator's OM A.

The minimum rest time of 8 hours, as specified in the operator's OM A, was not complied with on the night of 21.06.08 to 22.06.08.

According to the statement by the commander under supervision, the training captain and he himself were aware that given normal planning the rest time would be too short. For this reason they agreed to count a postflight duty time of 15 minutes on 21.06.2008 and a preflight duty time of 30 minutes on 22.06.2008 for the commander under supervision. Even under these conditions, which increased the minimum rest time for the commander under supervision by 45 minutes, the prescribed limit of 8 felt short.

The actual times were taken from the pilot's log book of the commander under supervision. Completion of the pilot's log book does not fully meet the standards of JAR OPS. For example, the number of landings and the corresponding total times for different types of flying are lacking. Likewise, the flights of 20 June 2008 are not entered in the pilot's log book.

1.5.3 Copilot under supervision

Person	Austrian citizen, born 1980
Licence	Commercial pilot's licence aeroplane, (CPL(A)), according to joint aviation requirements (JAR), first issued by Austro Control GmbH, Vienna, on 27.06.2006, valid till 22.04.2013 Radiotelephony ratings: English / German
Ratings	Type rating DHC8 as co-pilot, valid till 01.03.2009 Class rating for single engine piston – SEP, valid till 27.06.2008 Class rating for multiple engine piston – MEP, valid until 15.09.2008 Class rating for touring motor glider – TMG, valid till 27.06.2008
Instrument flying ratings	Instrument flight aircraft IR DHC8 Category I instrument approaches as copi, valid till 01.03.2009 SEP Category I instrument approaches, valid till 27.06.2008 MEP Category I instrument approaches, valid till 15.09.2008
Type Rating Course DHC-8 Q400	01.03.08
Medical fitness certificate	Class 1 & 2 Restrictions: VDL (shall wear corrective lenses) Commencement of validity: 18.06.2008 End of validity Class 1: 20.06.2009 End of validity Class 2: 20.06.2013

Last medical examination	18.06.2008
Commencement of pilot training	2004

1.5.3.1 Flying experience

Total	277:50 hours
During the last 90 days	63:53 hours
Of which on the accident type	63:53 hours
Total landings on the accident type	36

1.5.3.2 Type rating course

The co-pilot had completed transition to the DHC-8 Q400 aircraft type with the Flight Safety International company in Farnborough, UK. He was awarded certification of successful transition dated 01.03.08. At this time, the co-pilot had completed 18 hours each on the simulator as PF (pilot flying) and as PNF (pilot not flying).

For the eight exercises completed, the corresponding qualification sheets indicated good to very good performance throughout.

1.5.3.3 Crew duty times

Start of duty on 21.06.2008, after a break of 6 days	04:05 UTC
End of duty on 21.06.2008	10:38 UTC
Flight duty time on 21.06.2008	6:33 hours
Start of duty on 22.06.2008	04:15 UTC
Rest time	15:37 hours
Flight duty time at the time of the accident	5:13 hours

The crew duty times take into account 60 minutes for preflight duty and 30 minutes for postflight duty, as defined in the operator's OM A.

1.6 Aircraft information

1.6.1 General

Registration	HB-JGA
Aircraft type	DHC-8-402
Characteristics	Twin-engine transport aircraft with turboprop engines
Manufacturer	Bombardier Inc. Canada
Year of construction	2008
Serial number	4198
Category	Large Aircraft, Standard, Transport
Owner	BTV Leasing Schweiz AG, 9422 Staad, Switzerland

Operator	Sky Work AG, Airport Terminal North, 3123 Belp, Switzerland
Engine	2 Pratt & Whitney Canada PW150A engines
Propeller	R408/6-123F/17 (Dowty Propellers Gloucester, GB)
Operating hours, airframe	Total since manufacture: 279:24 hours
Number of airframe cycles	Total since manufacture: 203 cycles
Max. permitted take-off mass	28 998 kg
Max. permitted landing mass	28 009 kg
Mass and centre of gravity	The mass of the aircraft at the time of the accident was approximately 27 000 kg. The mass and centre of gravity were within the permitted limits according to the aircraft flight manual (AFM).
Maintenance	The last inspection took place on 21.06.2008 at 275:56 operating hours and 201 cycles.
Registration certificate	Issued by the FOCA on 04.04.2008 / No. 1, valid till removal from the aircraft register.
Airworthiness certificate	Issued by the FOCA on 15.04.2008, valid till revoked.
Certification	Within 30 W to 60 E and 0 N to 80 N VFR day and night IFR Category I + II B-RNAV (RNP 5) P-RNAV LVTO RVR 150 m

1.7 Meteorological information

1.7.1 General

The information in chapter 1.7.2 to 1.7.5 was provided by MeteoSwiss.

1.7.2 General meteorological situation

An area of high-pressure centred over Hungary determined the weather in the Alpine area. Dry air was flowing towards Switzerland from the south-west.

1.7.3 Weather at the time and location of the accident

On the basis of the listed information, it is possible to conclude that the weather conditions at the time and location of the accident were as follows:

Cloud	*1/8 at 8000 ft AMSL*
Weather	*--*
Visibility	*About 30 km*
Wind	*West-north-west wind at 6 kt*
Temp./Dewpt.	*28 °C / 15 °C*
Atmospheric pressure	*QNH LSZB 1020 hPa, LSZH 1019 hPa, LSZA 1021 hPa*
Position of the sun	*Azimuth 154°, elevation 65°*
Hazards	*None detectable*

1.7.4 Airport weather reports

In the period from 09:20 UTC up to the time immediately after the accident, the following METAR airport weather reports applied:

LSZB 220920Z VAR03KT CAVOK 27/15 Q1020 NOSIG
LSZB 220950Z 32006KT 270V010 CAVOK 27/15 Q1020 NOSIG
LSZB 221020Z 32005KT 280V010 9999 FEW055 28/14 Q1020 NOSIG
LSZB 221050Z 30005KT 260V010 9999 FEW065 28/15 Q1020 NOSIG

1.7.5 Forecasts

At the time of the accident, the following terminal aerodrome forecast (TAF) applied for Bern-Belp airport:

LSZB 220900Z 221019 VRB03KT CAVOK BECMG 1012 FEW050 TEMPO 1015 30005KT PROB30 TEMPO 1619 5000 TSRA BKN040CB=

In clear text, this means: on 22.06.08, the following weather conditions were forecast between 10:00 UTC and 19:00 UTC:

Wind	Variable at 3 kt
Meteorological visibility	At least 10 km
Cloud	No cloud below 15 000 ft AAL
Changes	1-2/8 cloud at 5 000 ft AAL to be expected between 10:00 UTC and 12:00 UTC.
	Wind from 300° at 5 kt to be expected occasionally between 10:00 UTC and 15:00 UTC. It is expected that the total time of this change will be less than one and a half hours.
	Between 16:00 UTC and 19:00 UTC, with 30% probability, occasionally a visibility of 5000 m, thunder showers and 5-7/8 cumulonimbus clouds at 4000 ft AAL to be expected. It is expected that the total time of this change will be less than one and a half hours.

1.7.6 Bern-Belp airport ATIS reports

Before and during the time of the accident, ATIS reports were being transmitted. Skyguide was no longer able to provide these reports. However, Skyguide communicated that according to their logbook runway 32 was in use from 09:20 to 19:11 UTC.

1.8 Aids to navigation

For approaches on runway 14/32 at Bern-Belp airport, the three NDBs (non directional beacons) BERN (BER), MURI (MUR) and SCHÜPBERG (SHU) are available; these are in operation 24 hours a day.

Runway 14 is equipped with ILS/DME equipment. The instrument landing system is classified as Category I, since it has an approach angle of 4°, among other things.

At the time of the accident, the following restrictions, among others, were published for Bern-Belp airport:

(B0327/08):
from 04.04.08 00:00 UTC to 24.09.08 23:59 UTC
RWY 14 ILS LOCALIZER TST 110.1 MHZ ON TEST, DO NOT USE

(B0441/08):
from 07.05.08 00:00 UTC to 24.09.08 23:59 UTC
RWY 14 ILS GP IBE 334.400 MHZ ON TEST, DO NOT USE

1.9 Communications

Radiocommunication between the crew and the air traffic controllers involved took place mostly normally and without substantial difficulties up to the time of the accident.

1.10 Aerodrome information

1.10.1 General

Bern-Belp airport is located 9 km south-east of the Swiss federal capital, Bern. The airport reference point (ARP) has coordinates N 46 54 44 / E 007 29 57.

The reference elevation of the airport is 1673 ft AMSL and the calculated reference temperature was 23.5 °C.

The dimensions of the Bern-Belp airport runways are as follows:

Runway	Dimensions	Elevation of runway thresholds
14/32	1730 x 30 m	1668/1675 ft AMSL
14R/32L (Grass runway)	650 x 30 m	

Runway 14 has a displaced threshold and the available landing distance is 1530 meters.

1.10.2 Runway equipment

Bern-Belp airport has a concrete runway (14/32) and to the south-west of this a parallel grass runway (14R/32L).

Runway 14 is equipped for precision approaches with a Category I instrument landing system (ILS) with a distance measuring equipment (DME). In addition, a PAPI (precision approach path indicator) with a glide path angle of 4.0°, corresponding to the ILS glide path angle, is installed. Non precision approaches can be made with the aid of NDB (non directional beacons).

On runway 32, only non precision approaches, termed circling approaches, can be made. In addition, a PAPI with a glide path angle of 3.4° is installed.

1.10.3 Rescue and fire-fighting services

Bern-Belp airport is equipped with Category 5 fire-fighting resources for scheduled traffic and Category 4 for other traffic. A higher category for commercial traffic is possible on request within 3 hours of the scheduled arrival/departure time.

1.11 Flight recorders

1.11.1 Flight data recorder

Type	Solid state memory flight data recorder - SSFDR
Manufacturer	Honeywell
Year of manufacture	2002
Serial number	09779
Part number	980-4700-027
Recording medium	Solid state memory
Duration of recording	50 hours

The recordings were complete and could be analysed.

1.11.2 Cockpit voice recorder

Type	CVR 120
Manufacturer	Honeywell
Serial number	09952
Part number	980-6022-011
Recording medium	Solid state memory
Duration of recording	2 hours

Since after the accident, contrary to the instructions of the Swiss AAIB, the cockpit voice recorder circuit breaker was not pulled, only the last 12 minutes of the flight were recorded, despite the two-hour recording time.

1.12 Wreckage and impact information

The aft fuselage of the aircraft made contact with runway 14 approximately 60 m after the displaced runway threshold. The subsequent landing took place normally and the aircraft taxied to the assigned stand.

On the runway, about 8 m to the south of the number 14 painted on the runway and about 1.5 m to the left of the centre line, there were pronounced skid and scratch marks. Small aluminium parts of the aircraft's skin panels had caught in the grooves of the runway.

1.13 Medical and pathological information

There are no indications of any of the pilots suffering health problems during the flight involved in the accident.

The flight attendant in the front section of the cabin suffered slight shock. Due to this she was only able to resume work after a few days.

One passenger and the flight attendant in the aft section of the cabin suffered minor injuries during the impact. Medical care was not organized right after the accident. Transportation of the injured flight attendant was organized by herself and by workmates. The injured passenger consulted a doctor by her own and reported her injuries only a few months after the accident.

1.14 Fire

Fire did not break out.

1.15 Survival aspects

There was no immediate life-threatening endangerment to the crew and passengers, as the airframe remained intact.

1.16 Tests and research

Not applicable.

1.17 Organisational and management information

1.17.1 Information about the airline operator

1.17.1.1 General

The operator Sky Work Airlines AG was founded in 2004 as a subsidiary of Sky Work AG. Sky Work AG is certificated by the Federal Office of Civil Aviation under Air Operator Certificate (AOC) number 1039, issued on 10.11.05 and is authorised for commercial air transport. At the time of the accident, the operator was operating two aircraft, a Dornier 328 and the DHC-8-402 involved in the accident.

1.17.1.2 Crew duty times

The corresponding crew duty times are defined in chapter 7.1 of the airline's Operations Manual A (OM A). Chapter 7.1.5, "Reporting Regulations", states the following, among other things:

The check in time and place depends on the type of operation and/or duty assignment. Recommended check in time for at least one flight crewmember is

90 minutes prior to estimated time of departure (ETD), as company policy determines that, whenever possible, the pre-flight preparations be completed 60 minutes before ETD, providing total flight duty period limitations are not exceeded. In any case it shall never be less than 60 minutes prior to expected off block time.

Moreover, chapter 7.1.5.1 "Check In", states:

Check in time represents the official beginning of a flight duty period. All crewmembers must report to the designated place (meeting point) at the agreed check-in time.

With regard to post flight duty, chapter 7.1.5.3 "Check Out", states:

The flight duty period ends, when a crewmember receives the release from the Commander / office and all post flight duties / job assignments are completed. Minimum check out time is 30 minutes after block on.

If, with regard to check in and check out, one takes into account the times specified as minimum times, there results a pre-flight duty of 60 minutes and a post-flight duty of 30 minutes.

With regard to rest time, chapter 7.1.2.8 "Rest Time Requirements" of the OM A states that for a crew duty time of up to 12 hours, a minimum rest time of 8 hours must be complied with. This rest time was not complied with neither by the commander in training nor the training captain on the night of 21.06.08 to 22.06.08.

1.17.1.3 Directives relating to appointments as pilot under supervision

In the accident under investigation, both pilots, the commander under supervision in the left-hand seat and the copilot on the jump seat, had achieved the type rating for the DHC-8-402 but had not yet completed the phase as pilot under supervision. This is why a training captain from the aircraft manufacturer was sitting in the right-hand seat. In this context, chapter 5.2.4 "Pilot under Supervision" of the OM A states, among other things:

The minimum sectors to be flown under supervision for Commanders and Co-pilots is as follows:

- *20 sectors including the line check for commanders and co-pilots converting to a new aeroplane type*

These conditions were fulfilled when the commander under supervision was qualified as “ready for line check” by the operator.

1.17.1.4 Procedures regarding use of the autopilot

The operator’s Operations Manual B (OM B) states the following, among other things, concerning the use of the autopilot, in chapter 2.1.12 "Auto Flight Control System (AFCS)", under 2.1.12.2 "Autopilot":

*When the PF engages calls PNF **"ENGAGE AP"** and then the PNF will announce **"AP ENGAGED"**.*

*Before the PF disengages the autopilot (AP) he or she will announce: **"AP DISENGAGED"** to make the PNF aware of the situation and presses the AP DIS BUTTON on the Control Wheel two times, once to disengage the AP, and the second time to reset the warning system for AP and YD (Yaw Damper).*

In the accident under investigation, the procedure was complied with when the autopilot was engaged. Disengagement of the autopilot at 10:36:16 UTC and at 10:39:49 UTC was not mentioned by the crew.

1.17.1.5 Procedure concerning stabilised approaches

The operator's Operations Manual A (OM A) states the following in chapter 8.4 "All Weather Operations", among other things, under 8.4.3.8 "Stabilisation on Approach":

Approaches must be fully stabilized at the final speed and in the final landing configuration when leaving 1,000 feet AAL (Above Aerodrome Level). All pre-landing checks should be completed, excepting only late phase items such as landing lights or windscreen wipers. This is in order that the final stages of the approach can be adequately monitored.

The Operations Manual B (OM B) states the following in chapter 2.2.6 "AP-PROACH – LANDING Preparation and Briefing", among other things, under item 2.2.6.1 "Decelerated Approach and Final Stabilisation":

Approach configuration and the landing configuration may be planned to be the same. Therefore, VREF and VAPP will be the same speed and the approach and landing speeds will be based on a single reference speed i.e. VREF. If winds are gusting over 10 knots, a gust factor (GF) of half the maximum gust value is added to the VREF. Normal approach speed is 170 KIAS to approximately 5 NM from the airport, followed by a gradual reduction in airspeed and change in configuration to be stabilized and configured for landing at VREF not later than 500 ft AGL. If a Flap 35° landing is planned the approach will be flown at Flap 15° and Flap 35° is selected when the landing is assured. Under these circumstances the minimum speed on approach will be referenced to the Flap 15° VREF until flap 35° is selected.

1.17.1.6 Procedure concerning landing technique

The operator's Operations Manual B (OM B) states the following concerning landing techniques, among other things, in chapter 2.2.10 NORMAL LANDING:

2.2.10.0 General

A stable approach with small corrections regarding control inputs and power is the basis of a good landing. A normal landing is performed as follows:

- *Condition levers to MAX/1020.*
- *Check FLAP indication #2 MFD.*
- *Land into wind, maintaining VREF until immediately prior to flare.*

The landing performance given, assumes that the appropriate VREF is achieved by 50 ft AGL. It is good practice to aim a 5° nose up pitch for the flare, which should be observed by both pilots. To assist the flare manoeuvre of PF, 50/20 callouts are done by PNF or synthetic voice.

2.2.10.1 Flare

- *Commence flare to achieve zero vertical velocity immediately prior to ground contact.*
- *DO NOT exceed 6° nose up during landing flare to avoid the fuselage contacting the run-way.*

- *To decrease the landing descent rate, when the landing descent rate is higher than desired, power will be required in the landing flare through to touchdown.*
- *To decrease the landing descent rate at airport altitudes greater than 5000 ft., power may be required in the landing flare to decrease the landing descent rate. It may be necessary to maintain power in the landing flare through to touchdown.*

2.2.10.2 Touchdown

- *DO NOT exceed 6° nose up during landing flare to avoid the fuselage contacting the runway.*
- *Power levers to FLIGHT IDLE prior to touch down then to DISC after touch down.*
- *Check PROPELLER GROUND RANGE advisory lights illuminate*
- *Check ROLL OUTB and ROLL INBD SPOILER advisory lights on at mainwheel contact.*
- *Nosewheel should be promptly brought into contact with the ground after mainwheel contact.*
- *Apply anti-skid brakes.*

1.17.2 Information about the aircraft manufacturer

1.17.2.1 General

The aircraft manufacturer de Havilland Aircraft Company was founded in 1928 in Toronto. In the seventies the manufacturer began developing a twin engine turboprop regional aircraft with 30 to 40 seats and with the designation Havilland Canada DHC-8, also known as Dash 8. The maiden flight took place in 1983.

In the following years, from this aircraft an aircraft family was developed, of which the newest version is the DHC-8 Q400 with up to 78 seats.

In the year 1992 de Havilland Canada was taken over by Bombardier Inc. based in Montreal who was founded in 1942. The company is one of the world's largest manufacturers of business-jets, regional transport aircraft and rail vehicles.

The DHC-8 Q400 made its first flight in January 1998 and the first delivery took place in summer 1999. The DHC-8 Q400 is the latest version of the DHC-8 line and is equipped with modern avionics.

Up to April 2008, Bombardier had delivered two hundred DHC-8 Q400 aircraft. From 2009, the DHC-8 Q400 is to be delivered as a "NextGen" variant.

1.17.2.2 Limitations

In the manufacturer's AFM (airplane flight manual), among other things, the following limitations are published for the extension of the landing gear and flaps, under chapter 2.4.1 AIRSPEED LIMITATIONS:

		KNOTS IAS
2. Flap Extended Speed (V_{FE})	*Flap 5°*	*200*
	Flap 10°	*181*
	Flap 15°	*172*
	Flap 35°	*158*

4. Landing Gear Operating Speed (V_{LO}) 200
The maximum speed at which it is safe to extend or retract the Landing gear

1.17.2.3 Airplane flight manual

The manufacturer's airplane flight manual (AFM) states, among other things, the following regarding landing in Section 4, under 4.4.1 NORMAL LANDING:

1. FLAPS lever 10°, 15° or 35°. Check FLAP indication on #2 MFD

2. Airspeed – V_{REF} flap 10°, flap 15° or flap 35°

NOTE

... the appropriate VREF is achieved by 50 ft AGL

3. Condition levers – MAX/1020

4. POWER levers to FLIGHT IDLE prior to touchdown then to DISC after touchdown. Check PROPELLER GROUND RANGE advisory lights illuminate

NOTE

1. To decrease the landing descent rate, when the landing descent rate is higher than desired, power will be required in the landing flare through touchdown

2. To decrease the landing descent rate at airport altitudes greater than 5,000 ft, it may be necessary to maintain power in the landing flare through to touchdown

CAUTION

Pitch attitudes greater than 6° in the landing flare may cause the fuselage to contact the runway.

5. ROLL OUTB and ROLL INBD SPOILER advisory lights – Check illuminated at mainwheel contact.

NOTE

The nosewheel should be promptly brought into contact with the ground following mainwheel contact.

6. *Anti-skid brakes – As required*

1.17.2.4 Aircraft operations manual

The manufacturer's aircraft operations manual (AOM) DASH 8-Q400, which the manufacturer produces tailored to the operator's requirements, states in chapter 2 NORMAL PROCEDURES the following, among other things, under 2.7 NORMAL LANDING:

2.7.1 General

A stable approach with small corrections regarding control inputs and power is the basis of a good landing. A normal landing is performed as follows:

- *Check FLAP indication on #2 MFD*
- *Land into wind, maintaining V_{REF} until immediately prior to flare*

NOTE: *The landing performance given in chapter 4.4 assumes that the appropriate V_{REF} is achieved by 50 ft AGL.*

- *Condition levers MAX/1020*
- *Commence flare to achieve zero vertical velocity immediately prior ground contact.*

- *DO NOT exceed 6° nose up during landing flare to avoid the fuselage contacting the runway.*
- *Power levers to FLIGHT IDLE prior to touch down then to DISC after touch down.*
- *Check PROPELLER GROUND RANGE advisory lights illuminate.*
- *Check ROLL OUTBD and ROLLINBD SPOILER advisory lights on at mainwheel contact.*
- *The nosewheel should be promptly brought into contact with the ground following mainwheel contact.*
- *Apply anti-skid brakes as required.*

NOTE: *At airport altitudes greater than 5000 ft, power may be required in the landing flare to decrease the landing descent rate.*

1.17.2.5 Pitch Awareness Training

In 2002, the aircraft manufacturer produced a CD entitled: "Dash 8 Q400 Pitch Awareness". This CD was presented to the various operators on the occasion of the FOSC#3 (Flight Operations Steering Committee) meeting, which took place from 3 to 5 December 2002. Since that time, this CD has been available and is handed out to operators either during the bi-annual FOSC meetings or on visits to the operators by the manufacturer's contact pilot.

According to the aircraft manufacturer's statement, "Flight Safety International" is in possession of the "Dash 8 Q400 Pitch Awareness" CD and crews would be instructed that they would have to become acquainted with it in the computer-based trainer (CBT). This statement contradicts the information provided by both pilots from the airline operator. These stated that the CD was not an integral part of the training. The co-pilot stated that he was confronted with the CD only after the accident. In particular, he remarked that he was not instructed in the simulator concerning corrective procedures at high rates of descent during landing. The commander under supervision was aware of the CD. According to his statement, he had discovered it by chance during training, on a computer-based trainer. He also stressed that his flying instructor had informed him that during landing a pitch attitude greater than 5° had to be called out verbally by the PNF.

On this "Dash 8 Q400 Pitch Awareness" CD, among other things, key statements are made which are also supported by corresponding images and/or video animations:

- *With the longer length of the aircraft comes a requirement that the flight crew must be aware of the pitch attitude during the landing flare and touchdown.*
- *The theoretical contact angle on a firm landing is approximately 7.5 degrees. … Therefore the potential for aft fuselage contact is reduced to 7 degrees pitch. The importance of not exceeding the AFM limit of 6 degrees in the landing flare is evident.*
- *If a higher descent rate develops during landing, the temptation to control this descent rate by pitching up must be avoided.*
- *Careful application of power is the required technique of controlling the descent rate in the flare through touchdown.*
- *A slight increase in power will increase airflow over the wing and produce additional lift, even if forward velocity does not change very much. This alone can significantly reduce the rate of descent.*

- *The increase in power may be needed to be maintained through the landing manoeuvre until touchdown.*

The SOP recommended by Bombardier Aerospace [section 1.17.2.3] *calls for extra vigilance of the pitch angle below 100 ft during flare and landing and use of power to control rate of descent.*

1.17.3 Flight Safety International

1.17.3.1 General

The company Flight Safety International (FSI) is an enterprise that on various places offers type rating courses. To provide training documents they basically use manufacturer data.

1.17.3.2 Training manual

The FSI training manual, which is used for initial and recurrent training, states the following in section 5, page 5-25 under STANDARD OPERATING PROCEDURE, FLIGHT CREW OPERATING MANUAL (REV. 4.0 FOR TRAINING PURPOSES ONLY):

AIRPLANE PITCH AWARENESS

Pitch Callout Procedure During landing Flare and Landing

Below 100 ft AGL, the PNF is to state the pitch attitude anytime the pitch is greater than or equal to 5 degrees.

Table 13 Pitch Callout procedure

PF	***PNF***
If pitch is between 5 or 6 degrees nose up	
	"<aircraft pitch> DEGREES"
"<aircraft pitch> DEGREES"	
If pitch is above 6 degrees nose up	
	"<aircraft pitch> DEGREES"
"CORRECTING"	

NOTE

To decrease the landing descent rate and not exceed a pitch attitude of 6 degrees, at anytime the landing descent rate is higher than desired, power will be required in the landing flare through touchdown.

According to the aircraft manufacturer, every operator which has trained its pilots with “Flight Safety International” is in possession of an FSI manual. This FSI manual is used in initial and recurrent training.

After the accident both pilots stated that during training with Flight Safety International they had been trained in accordance with the procedures contained in the operator’s OM B. Both pilots confirmed that they had been made emphatically aware that a maximum pitch attitude of 6° should not be exceeded during landing.

1.18 Additional information

1.18.1 Further aft fuselage contact accidents of this aircraft type

According to the aircraft manufacturer's statement, a further seven cases are known in which the aft fuselage of a DHC-8-400 aircraft had made contact with the runway. A corresponding response letter from the aircraft manufacturer states, among other things:

These typically occur during landing as a result of inappropriate power and attitude management in the flare. A synopsis of each of these occurrences is provided below:

Aircraft S/N 4018, May 2000

"Aircraft 4018 was performing a flap 15 degree, visual approach for landing in gusty wind conditions. The aircraft touched down heavily in a nose-high attitude and contacted the runway with its lower aft fuselage. This resulted in structural damage ... The Flight Data Recorder showed a nose-up pitch attitude of 8.3° at touchdown ... The investigation concluded that the nose-high attitude and inappropriate power management in the flare, led to a high sink rate, which resulted in the aft fuselage contacting the surface of the runway. ..."

Aircraft S/N 4022, October 2000

"Aircraft 4022 was performing a flap 35 degree landing in visual conditions. The aircraft's aft fuselage contacted the runway during landing. ... this investigation, which also determined that inappropriate power and attitude management in the flare were causal to the event."

Aircraft S/N 4003, April 2005

"The aircraft was performing a landing in visual meteorological conditions. The aft fuselage contacted the runway during the landing resulting in minor damage to the aircraft."

Aircraft S/N 4093, October 2005

"Aircraft was performing a normal landing ... Immediately after touchdown the flight crew reported illumination of the touch runway light. The AAIB investigation revealed that only the frangible disk and the tail scrape fairing were damaged ... The aircraft was not structurally damaged."

Aircraft S/N 4129, August 2006

"...During the landing, the aft fuselage contacted the runway ... Attitude and power management in the flare have been found causal to this event."

Aircraft S/N 4089, May 2008

"The aircraft landed and the flight crew reported illumination of the "touch runway" light. The aircraft descent rate was arrested using pitch attitude rather than increasing engine power, which resulted in aft fuselage, runway contact."

Aircraft S/N 4168, June 2008

"Aircraft 4168 was landing in windy conditions at ... and the aft fuselage contacted the runway surface. Preliminary data indicates the aircraft touched down with a high rate of descent in a nose high attitude."

1.18.2 Measures taken after these accidents

After the two accidents in year 2000, the Canadian Authority (Transport Canada) upon request from the Danish AAIB (Aircraft Accident Investigation Bureau) and the TSB of Canada (Transportation Safety Board) required a change of the manufacturer's AFM concerning the landing technique.

Based on this, the aircraft manufacturer published, dated 8 June 2001, the following NOTE in the AFM in *section* 4, unter 4.4.1 *NORMAL LANDING* :

To decrease the landing descent rate, when the landing descent rate is higher than desired, power will be required in the landing flare through touchdown.

1.19 Useful or effective investigation techniques

Not applicable.

2 Analysis

2.1 Technical aspects

There are no indications of any pre-existing technical defects which may have caused or contributed to the accident.

2.2 Human and operational aspects

2.2.1 Aircraft manufacturer

2.2.1.1 Procedures

The aircraft manufacturer's AFM (airplane flight manual), section 4, under 4.4.1 NORMAL LANDING, describes in detail how approach and landing should be carried out. The following is mentioned under point 4, in NOTE 1:

1. *To decrease the landing descent rate, when the landing descent rate is higher than desired, power will be required in the landing flare through touchdown.*

The AOM (aircraft operation manual), under 2.7 NORMAL LANDING, likewise describes the procedure for approach and landing, but the above-mentioned comment about reducing an excessively high rate of descent during the flare by increasing power, is absent.

Both manuals emphasize the important point that the pitch attitude during the landing flare must not exceed the value of 6° nose up. Mention is also made of the fact that in the case of aerodromes at an altitude of more than 5000 ft it may be necessary not to bring power fully back to idle until after the landing.

The relationship between a high descent rate, critical pitch attitude and power setting is explicitly mentioned in the FSI (Flight Safety International) manual, which includes the following as a NOTE:

To decrease the landing descent rate and not exceed a pitch attitude of 6 degrees, at anytime the landing descent rate is higher than desired, power will be required in the landing flare through touchdown.

Just how important this relationship is becomes evident from the fact that as early as 2002 the manufacturer issued a CD entitled "Dash 8 Q400 Pitch Awareness", in order to prevent aft fuselage contact on landing. This programme also makes reference to the following, among other things:

- *If a higher descent rate develops during landing, the temptation to control this descent rate by pitching up must be avoided.*
- *Careful application of power is the required technique of controlling the descent rate in the flare through touchdown.*

The SOP (standard operating procedure), as described in the FSI manual in section 5, page 5-25, is not published in this form either in the aircraft manufacturer's AFM or AOM. Publication of this SOP in one of these two manuals would have met the requirement for an identical publication in the operator's manuals.

The two pilots stated that during transition they had worked according to the procedures in the operator's OM B. This procedure is not unusual.

In summary it can not be excluded that tiredness of the crew had contributed to the accident.

2.2.2 The airline operator

2.2.2.1 Crew planning

Crew duty times are clearly defined in the airline's Operations Manual A (OM A). The commander under supervision and the training captain had already made the evening flight together on the day before the accident. Taking into account a preflight duty time of 60 minutes and a postflight duty time of 30 minutes, a rest time of 6:50 hours is obtained for the night of 21 to 22 June. Thus the minimum rest time of 8 hours was not attained.

According to the statement by the commander under supervision, the training captain and he himself were aware that given normal planning the rest time would be too short. The agreement between the two – to count a postflight duty time of only 15 minutes on the previous evening and a preflight duty time of only 30 minutes on the day of the accident for the commander under supervision – contravened on the one hand the operator's duty regulations and on the other hand could not prevent a foreshortening of rest time for both pilots.

If the published arrival and departure times of the flights on 21 and 22.06.08 are used as a basis, there results a rest time of 8:10 hours. In this context, a period of 60 minutes is calculated for preflight duty; this is considered to be an absolute minimum according to the information in the OM A. It is recommended that at least one crew member comes on duty 90 minutes before the scheduled departure time.

It has to be mentioned further that the training captain should have to be planned according to the Canadian flight duty regulations, which compared to the Swiss regulations, were more stringent. These regulations would have required a rest time at the rest facility of 8 hours.

In view of the above factors, the crew planning for both pilots by the operator must be described as inappropriate.

In the same context, the question arises how appropriate it was to deploy the commander under supervision on 21.06.08 after a break of 11 days in such a way that even in purely planning terms a rest time of 8:10 hours followed a crew duty time of 11 hours, this taking into account a preflight duty time of 60 minutes.

2.2.2.2 Flight planning documentation

The documents supplied to the crew were very extensive and had permitted comprehensive planning of the flight. The date and departure time pre-printed on the flight plan for the flight from Bern-Belp to Palma de Mallorca do not match the data for the flight on 22.06.08. This circumstance was of no significance in relation to the accident.

2.2.2.3 Procedures

The procedures in the OM A and OM B published by the operator and relevant to the flight involved in the accident fully comply with the manufacturer's instructions as contained in the corresponding AFM and AOM. The procedures in the OM B are in some cases more detailed and are arranged more clearly for the benefit of crews. They may be deemed appropriate, with the exception of one point.

The „pitch call out procedure during landing flare and landing", as published in the FSI manual (cf. chapter 1.17.2.3), was not found in this manner in the OM B

of Sky Work AG. Particularly, the respective call outs were missing at the time of the accident. With this, the pilots who were working according to the OM B of the air transport company were not used to warn of high pitch attitudes during landing by respective call outs when acting as PNF.

Mentioning the pitch attitude by the PNF, with the corresponding reaction from the PF, is useful and increases the crew's awareness of pitch during flare. In addition, the NOTE appended to the SOP draws attention to the relationship between a high descent rate, a critical pitch attitude and the power setting.

After the accident the air transport company have completed and revised the respective chapter in their OM B (cf. chapter 4.2.1).

2.2.3 Crew cooperation

2.2.3.1 General

The cooperation in a multi crew requires that the tasks of the individual crew members are defined and coordinated. Closely linked with that is the awareness of what the individual crew member has to contribute to the team's performance and what it can expect as support from the other crew members.

Based on experience of numerous accidents in which insufficient coordination between individual crew members was a causal factor, a training tool for crews, called "crew resource management" (CRM), was developed in the early eighties of the last century and subsequently was implemented as part of training and further training of airline pilots. Crew resource management shall sharpen the awareness that beside technical knowledge on board of an aircraft human relations are a decisive factor for safe conduction of flight.

In the actual case the training captain delegated by the aircraft manufacturer was entrusted with the task to supervise and coach an already trained commander during line flights. The contribution of the training captain was primarily to familiarise the commander under supervision with the characteristics of the DHC-8-402 aircraft.

The commander under supervision had obtained the type rating not long before but was not yet experienced on the type. During the first phase of building up experience a training captain who had the necessary experience on the type was designated for that reason.

In this composition of a crew the differential in hierarchy is rather low because two qualified commanders are working together. In this specific constellation the CRM is therefore of expressly importance.

2.2.3.2 Commander under supervision in cooperation with the training captain

According to the statement of the commander under supervision, during the approach briefing he had envisaged landing on runway 32. This corresponded to the operator's standard procedure, which envisages using the runway in use as transmitted in the Automatic Terminal Information Service (ATIS). He justified the subsequent decision for an approach on runway 14, with a corresponding re-briefing, on the basis that visibility was good, the tailwind did not exceed the maximum permitted limit and time could be saved by adopting an approach to runway 14. In this context, the high rate of descent resulting from the 4° glide path angle and the tailwind on approach was not discussed.

The FDR recordings show that the autopilot was disengaged for the first time at 10:36:16 UTC. On the basis of the training captain's question to the commander under supervision, just one minute later, as to whether he wished to engage the autopilot again, it can be assumed that the commander under supervision had deliberately disengaged the autopilot. It must be noted that in so doing the crew were not complying with the operator's procedure, which in such a case requires the PF to inform the PNF of his action before disengaging the autopilot, by means of the call out: *"AP DISENGAGED*". The same was true when the autopilot was disengaged at 10:39:49 UTC.

The CVR recordings show that the crew, just before receiving the clearance for the base turn at 10:36:48 UTC, discussed the position of the aircraft, because they obviously were not clear about this. The resulting request for radar vectors was the logical consequence. In the case of a clearance for a visual approach, however, the crew should know anytime where they are geographically situated in relation to the aerodrome. It cannot be excluded that this phase of the flight was responsible for a degree of stress in the cockpit.

Shortly before the crew received a further clearance to descend at 10:38:28 UTC, the throttles were pushed forward a little. The throttles remained in this position when the descent was initiated. This resulted in the speed increasing continuously from 200 knots and only when it reached 230 knots, the throttles were pulled back (Annex 2). This coordination between power and pitch attitude was not optimal. It meant that subsequent speed reduction was made more difficult. In addition, there was the fact that the aircraft was above the nominal glide path for the approach on runway 14 and therefore the rate of descent had to be further increased. As a result, aerodynamic resistances such as landing flaps and landing gear had to be extended at the respective maximum permitted speeds. This inevitably led to a heavier workload and to a certain pressure in the cockpit. It can not be excluded that this pressure had an effect on the subsequent progress of the flight.

The training captain's comment at 10:41:29 UTC: *"I can give you flaps fifteen"*, indicated in any event that he felt it appropriate to reduce speed even further. The fact that the training captain's mobile telephone rang just beforehand was hardly a calming influence in this situation. It must be stated that the mobile telephone should have been switched off before take-off anyway.

The FDR recordings show that the aircraft was stabilised at 1000 ft above ground in terms of aircraft configuration, speed and glide path, as required by the procedures in the OM A and OM B (chapter 1.17.1.5).

It is remarkable that the commander under supervision stated after the accident, among others, the following (translated from German): "At the beginning of the final approach, I have asked Mr. [name of the training captain] to help me during the approach, to give me instructions, to talk me down, because I knew that I did not have much experience at that time." The CVR recordings prove that such a request was not expressed at the beginning of the final approach. However, based on the many comments and advices made by the training captain during the approach, it can be assumed that the respective request by the commander under supervision was expressed some time earlier.

Furthermore, the commander under supervision described his attitude regarding controlling the aircraft as follows (translated from German): "Mentally, I handed over the aircraft to him [to the training captain]. (...)." Such an attitude of a qualified commander, who only was under supervision regarding aircraft specific

aspects, can not be understood. Much more one would expect that at a time where the air transport company declared the commander under supervision as "ready for line check", the latter would be familiar with controlling the aircraft, control it himself and ask for help in exceptional situations only.

The approach from 1000 ft above ground until shortly before landing was stabilised on the nominal glide path. The comments and instructions by the training captain during the approach were given calmly, advisedly and were appropriate to the situation. The nominal 4° glide path angle and to a minimal extent the prevailing tailwind explain the descent rate of just under 1000 ft/min during the final approach. It is remarkable that this rate of descent and its consequences on the flare was never mentioned by the training captain throughout the final approach. The relatively high rate of descent, given the circumstances, should have made the crew aware that during flare of the aircraft, the following points, emphasized in the Pitch Awareness Programme, among others, were of eminent importance:

- *If a higher descent rate develops during landing, the temptation to control this descent rate by pitching up must be avoided.*
- *Careful application of power is the required technique of controlling the descent rate in the flare through touchdown.*

A corresponding point is also to be found in the OM B under 2.2.10.1 "Flare", which states, among other things:

- *To decrease the landing descent rate, when the landing descent rate is higher than desired, power will be required in the landing flare through to touchdown.*

From the FDR recording it is apparent (Annex 4 and 5) that at 50 ft the nose of the aircraft was raised slightly in order to reduce the rate of descent. In relation to the sink rate, the flare occurred relatively late, at a radio height of just under 30 ft. At this point the throttles were slowly but constantly brought back to the idle position.

The training captain's order given immediately before touchdown in an ever more rapid sequence: *"nose up! nose up! nose up! ... much faster than that ..."* resulted in one or both pilots pulling the stick until a maximum pitch attitude of 8.17° ANU was reached. Such a reaction is in contradiction to the manufacturer's instructions mentioned above. It can not be understood why a training captain who is familiar with the aircraft type reacts on such a situation with the order: *"nose up! nose up! nose up! ... much faster than that ..."*. A slight push on the throttles would have been sufficient to break the rate of descent and to make a successful landing.

Based on his experience and the knowledge of the landing characteristic of the DHC-8-402 aircraft one would have expected that the training captain, in the course of the final approach, would address again a possibly necessary power correction. Thereby, the readiness to act would have been increased, which is particularly important during a time critical phase such as the landing. The last option that remained to the training captain was, to do the power correction himself. It is hard to understand that regarding the necessary power correction, the training captain did not take any influence.

The statements given by the three crew members after the accident, which of the two pilots finally pulled decisively on the stick do not match. Based on the available data this contradiction can not be cleared up since the FDR does not record the forces applied on the individual sticks.

The recording of the groundspeed and calibrated airspeed (CAS) show that throughout the approach there was a more or less constant tailwind prevailing (Annex 4). This tailwind increased slightly during the final approach. A significant wind shear, which might have affected the landing sequence, can therefore be excluded.

2.2.3.3 Copilot under supervision

Basically, the DHC-8-402 aircraft is designed for a two man cockpit crew. The respective procedures provide that one pilot controls the aircraft while the other pilot assists, which includes the radio communication. In the actual case the copilot under supervision on the jump seat was responsible for radio communication towards the end of the flight. This resulted in a complication of familiar procedures and workflow by including an additional person. However, there is no evidence that this rather unusual work distribution had influenced the circumstances of the accident.

3 Conclusions

3.1 Findings

3.1.1 Technical aspects

- The aircraft was licensed for VFR and IFR transport.
- The airworthiness certificate was issued by the FOCA on 15.04.2008.
- The mass and centre of gravity of the aircraft were within the permitted limits according to the AFM at the time of the accident.
- The investigation showed no indications of any pre-existing technical defects which might have caused or influenced the accident.
- The last inspection took place on 21.06.2008 at 275:56 hours of operation and 201 cycles.

3.1.2 Crew

- The pilots were in possession of the necessary licences for the flight.
- There are no indications of the pilots suffering any health problems during the flight involved in the accident.
- The minimum rest time in the night before the accident was not complied with by the commander under supervision and the training captain.
- The commander under supervision concluded his transition to the DHC-8 Q400 aircraft on 14.03.08.
- The co-pilot flying on the jump seat concluded his transition to the DHC-8 Q400 aircraft on 01.03.08.
- The crew decided to make a visual approach on runway 14.
- The procedures laid down in the operator's instructions were not implemented consistently by the crew.
- According to a statement of the commander under supervision he had asked the training captain for help, among others, as follows (translated from German): "(...) to help me during the approach, to give me instructions, to talk me down, because I knew that I did not have much experience at that time."
- About his attitude during the approach the commander under supervision mentioned for the minutes, among others, the following (translated from German): "Mentally, I handed over the aircraft to him [to the training captain]. I relied on his advices. (...) I have decidedly entrusted to him all the responsibility for the approach and landing and asked him explicitly for help."
- The training captain's comments regarding speed and glide path during the final approach until shortly before landing were appropriate to the situation.
- The relatively high rate of descent on final approach and the consequences on the flare was not a subject of discussion by the crew.
- The training captain did not correct the situation in time.

3.1.3 History of the flight

- Aircraft HB-JGA took off on 22 June 2008 at 09:02 UTC under flight number SRK 172 on a charter flight from Palma de Mallorca to Bern.
- After an uneventful flight, at 10:32:38 UTC the crew of SRK 172 contacted the "Bern Arrival" air traffic controller (ATCO).
- Runway 32 was in use at the airport Bern-Belp.
- The ATCO's question as to whether the crew were planning a visual approach was answered in the affirmative.
- The crew then requested a visual approach on runway 14.
- At 10:33:33 UTC the crew received clearance with an altitude restriction for a visual approach on runway 14.
- The crew acknowledged this clearance stating a visual approach on runway 32; this was not corrected by the ATCO.
- In order not to impede take-off traffic on runway 14, the ATCO requested flight SRK 172 to make a wide approach. This instruction had to be repeated.
- At 10:40:03 UTC the crew of SRK 172 received clearance for a visual approach on runway 14 and was simultaneously requested to make contact with "Bern Tower".
- Among other things, the "Bern Tower" ATCO cleared the crew of SRK 172 to land as follows: *"... tail wind three one zero degrees five knots maximum eight knots runway one four cleared to land"*.
- During the approach on runway 14, the aircraft got slightly above the nominal 4° glide path; this was corrected by the pilot flying.
- During the aircraft's landing flare shortly before touching down on the runway, the crew noticed that the sink rate would not decrease as expected. They wanted to correct this by pitching up the aircraft.
- As a result the aircraft struck the runway lower aft fuselage first.
- During the landing roll, the "TOUCHED RUNWAY" warning illuminated in the cockpit.
- The aircraft was able to exit the runway normally and taxi to the assigned stand.
- The passengers were able to vacate the aircraft normally.
- One passenger and one flight attendant suffered minor injuries.
- The airport emergency services were not mobilized.
- Transportation of the injured flight attendant was organized by herself and by workmates.
- The injured passenger consulted a doctor by her own.
- The aft fuselage of the aircraft was considerably damaged.

3.1.4 General conditions

- The operator's procedures in the OM A and OM B corresponded to those of the aircraft manufacturer in the AFM and AOM.
- The SOP with a note, published in the FSI manual, was published neither in the manufacturer's AFM or AOM nor in the operator's OM A or OM B.
- According to the FDR recordings a moderate tailwind component was prevailing with an increasing tendency towards touchdown. Significant windshears can be excluded.

3.2 Causes

The accident is attributable to the fact that the aircraft touched the runway with the aft fuselage first because the crew reacted to a high sink rate by a too high pitch attitude rather than by a power increase.

Fatigue may have contributed to the development of the accident.

4 Safety recommendations and measures taken since the accident

4.1 Safety recommendations

None.

4.2 Measures taken since the accident

4.2.1 By the operator

On 16.07.08, the "Flight Operation" department informed all Q400 cockpit crews in a so called Notice to Staff (NTS), among other things, as follows:

Due to some incidents which were recorded in the latest time on our Aircraft model and which unluckily happened also with our aircraft, we have to assure the awareness of pitch attitude during Take Off and especially during landing and flare to touchdown.

Action:

1.) Additional normal procedure drill will being added pitch awareness during very final approach from immediately according the attachment to this NTS

2.) Additionally this procedure will be added in the OM B chapter 2 with the next Revision.

3.) *Computer based Pitch Awareness Refresher has to be performed by every Skywork DH8-Q400 Flight Crew before next intended Flight / Simulator. The program is installed in the crew briefing Room and the attendance list which is posted in the FO Office, has to be signed after performing the refresher.*

The chapter 2 in the OM B mentioned in this NTS had been revised as follows (cf. section 1.17.1.6):

2.2.10.0 General

To reduce the possibility of an inadvertent high pitch attitude pilots are urged to have pitch attitude and power setting in their scan pattern, especially during short final and approaching threshold just before landing.

A continued stabilized Approach with minimum Speed VREF (minus 0 – plus 5 KIAS) or target Speed as calculated (VREF plus max 20) down to touchdown will give the adequate Power and Pitch configuration.(depending on Flap Setting normally: 2-4 °steady pitch and Power 12-15% TRQ). Power Off Landing must be avoided, due to very high induced sink rate at this stage.

SOP & Callouts during short final

	PF	***PNF***
If Pitch Attitude 5°		*Calls* ***PITCH 5°***
	Calls ***FIVE DEGREE***	
	Adjusts to avoid further pitch rise. *Usually add power and reducing descent rate*	
If Pitch rising through 5°		*Calls* ***PITCH 6°***
	Calls ***CORRECTING***	
	OR *If the Approach is getting destabilized and descent rate cannot be easily reduced to normal value – conduct GO AROUND*	

Comment by the Swiss AAIB:

The airline operator's information after the accident, particularly the "SOP and callouts during short final" was published quickly and is based on the information in the FSI manual. However, it must be stated that the following NOTE, which is contained in the FSI manual, is absent:

To decrease the landing descent rate and not exceed a pitch attitude of 6 degrees, at anytime the landing descent rate is higher than desired, power will be required in the landing flare through touchdown.

4.2.2 By the aircraft manufacturer

In a so called Flight Operation Service Letter (DH8-400-SL-00-020), dated 11 November 2008 the manufacturer informed all DASH 8-Q400 operators, among other things, about the following:

PURPOSE:

This Flight Operation Service Letter (FOSL) is issued to remind Flight Operations of the importance of pitch attitude awareness for the Q400 during the landing flare and touchdown phase of flight.

DISCUSSION:

During the operational history of the Q400 there have been several runway/fuselage strikes resulting in structural damage that varies from minor to significant. The out of service repair time can take a few days to as much as two month.

A combination of disciplined procedures and technique, and ensuring that the aircraft is always operated in accordance with the Aircraft Flight Manual will eliminate the possibility of a tail strike.

OPERATOR ACTION:

Operators should provide initial and annual recurrent pitch awareness training for flight crews.

Company Standard Operating Procedures should include Pitch Callouts during the landing flare and touchdown phase of flight. Bombardier recommends:

Pilot not Flying (PNF)	*Pilot Flying (PF)*
5 degrees	*Check*
6 degrees	*Correcting*

Descent rate control, below 200 feet agl., must be through Power lever management rather than adjusting pitch.

A Q400 Pitch Awareness training CD is available to assist in training flight crews on the importance of attitude awareness during the landing flare and touchdown phases of flight.

Furthermore, the aircraft manufacturer offered all operators of this aircraft type a free copy of the "Dash 8 Q400 Pitch Awareness" CD.

Payerne, 3 November 2009 Aircraft Accident Investigation Bureau

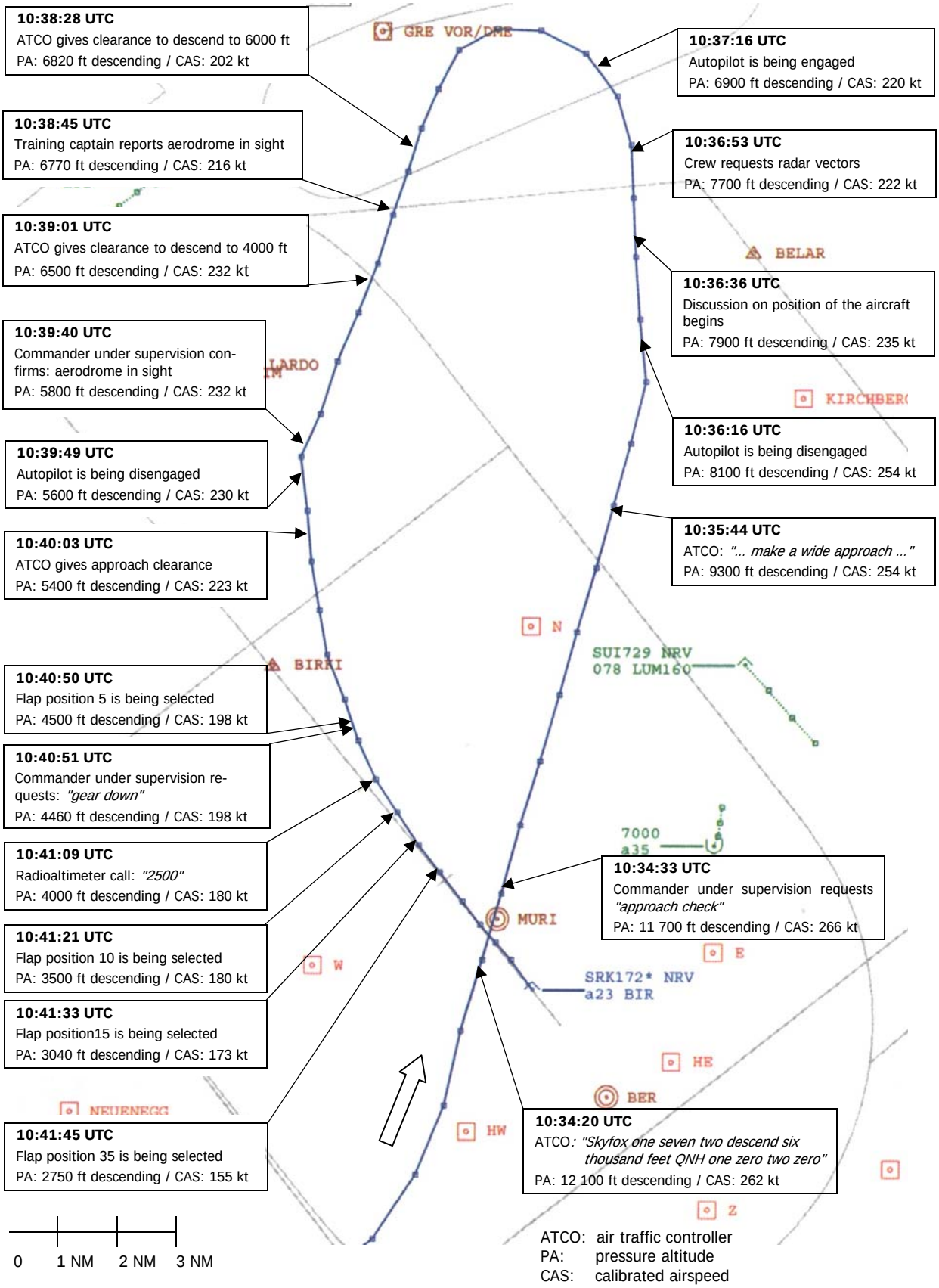
This report contains the AAIB's conclusions on the circumstances and causes of the accident which is the subject of the investigation.

In accordance with art. 3.1 of the 9th edition of Annex 13, valid from 1 November 2001, of the Convention on International Civil Aviation of 7 December 1944 and article 24 of the Federal Air Navigation Act, 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/incident causes and circumstances is expressly no concern of the accident investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

If this report is used for purposes other than accident prevention, due consideration shall be given to this circumstance.

Annexes

Annex 1: Flight path (radar plot) SRK 172, HB-JGA



10:38:28 UTC
ATCO gives clearance to descend to 6000 ft
PA: 6820 ft descending / CAS: 202 kt

10:38:45 UTC
Training captain reports aerodrome in sight
PA: 6770 ft descending / CAS: 216 kt

10:39:01 UTC
ATCO gives clearance to descend to 4000 ft
PA: 6500 ft descending / CAS: 232 kt

10:39:40 UTC
Commander under supervision confirms: aerodrome in sight
PA: 5800 ft descending / CAS: 232 kt

10:39:49 UTC
Autopilot is being disengaged
PA: 5600 ft descending / CAS: 230 kt

10:40:03 UTC
ATCO gives approach clearance
PA: 5400 ft descending / CAS: 223 kt

10:40:50 UTC
Flap position 5 is being selected
PA: 4500 ft descending / CAS: 198 kt

10:40:51 UTC
Commander under supervision requests: *"gear down"*
PA: 4460 ft descending / CAS: 198 kt

10:41:09 UTC
Radioaltimeter call: *"2500"*
PA: 4000 ft descending / CAS: 180 kt

10:41:21 UTC
Flap position 10 is being selected
PA: 3500 ft descending / CAS: 180 kt

10:41:33 UTC
Flap position15 is being selected
PA: 3040 ft descending / CAS: 173 kt

10:41:45 UTC
Flap position 35 is being selected
PA: 2750 ft descending / CAS: 155 kt

10:37:16 UTC
Autopilot is being engaged
PA: 6900 ft descending / CAS: 220 kt

10:36:53 UTC
Crew requests radar vectors
PA: 7700 ft descending / CAS: 222 kt

10:36:36 UTC
Discussion on position of the aircraft begins
PA: 7900 ft descending / CAS: 235 kt

10:36:16 UTC
Autopilot is being disengaged
PA: 8100 ft descending / CAS: 254 kt

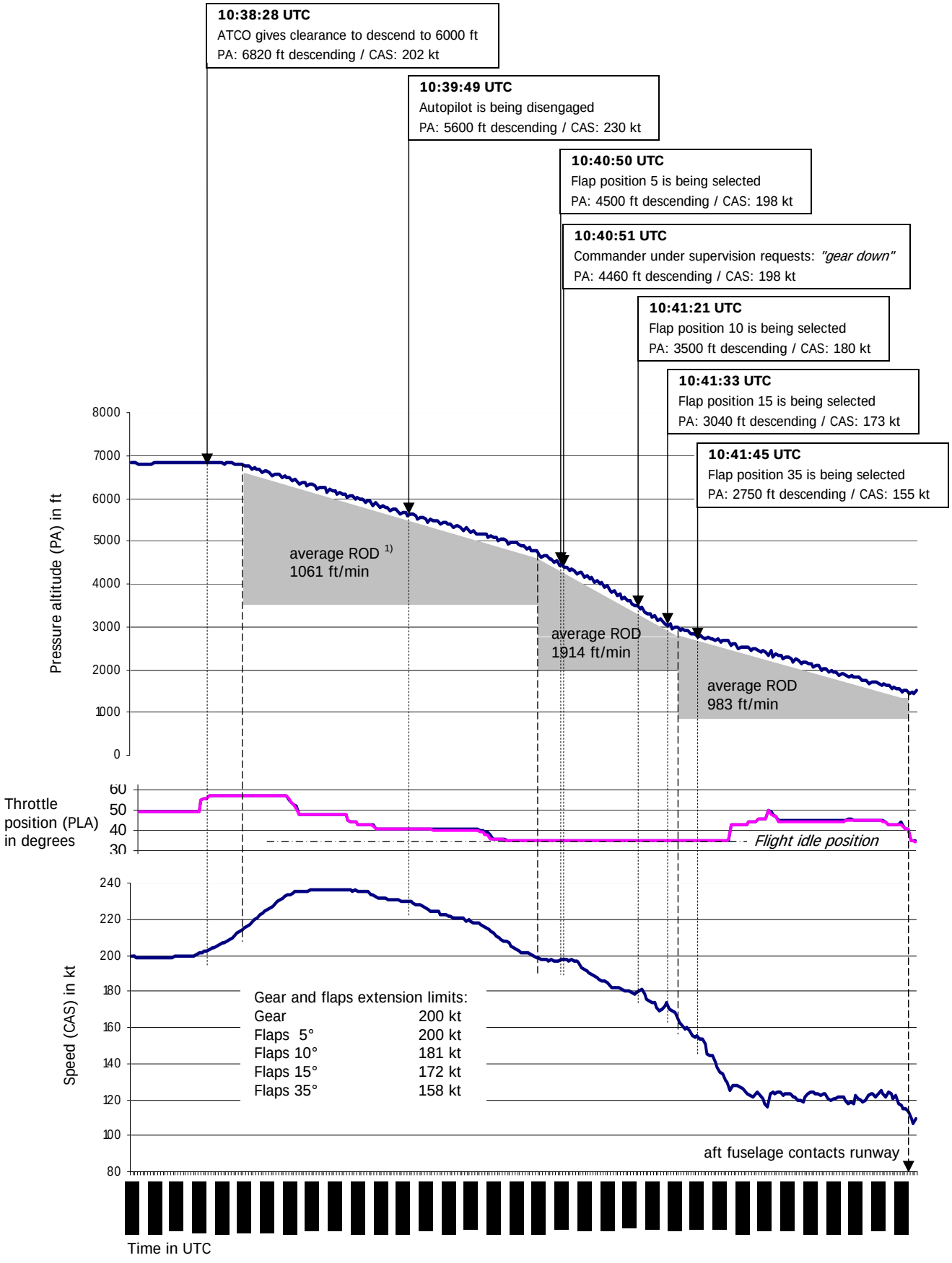
10:35:44 UTC
ATCO: *"... make a wide approach ..."*
PA: 9300 ft descending / CAS: 254 kt

10:34:33 UTC
Commander under supervision requests *"approach check"*
PA: 11 700 ft descending / CAS: 266 kt

10:34:20 UTC
ATCO: *"Skyfox one seven two descend six thousand feet QNH one zero two zero"*
PA: 12 100 ft descending / CAS: 262 kt

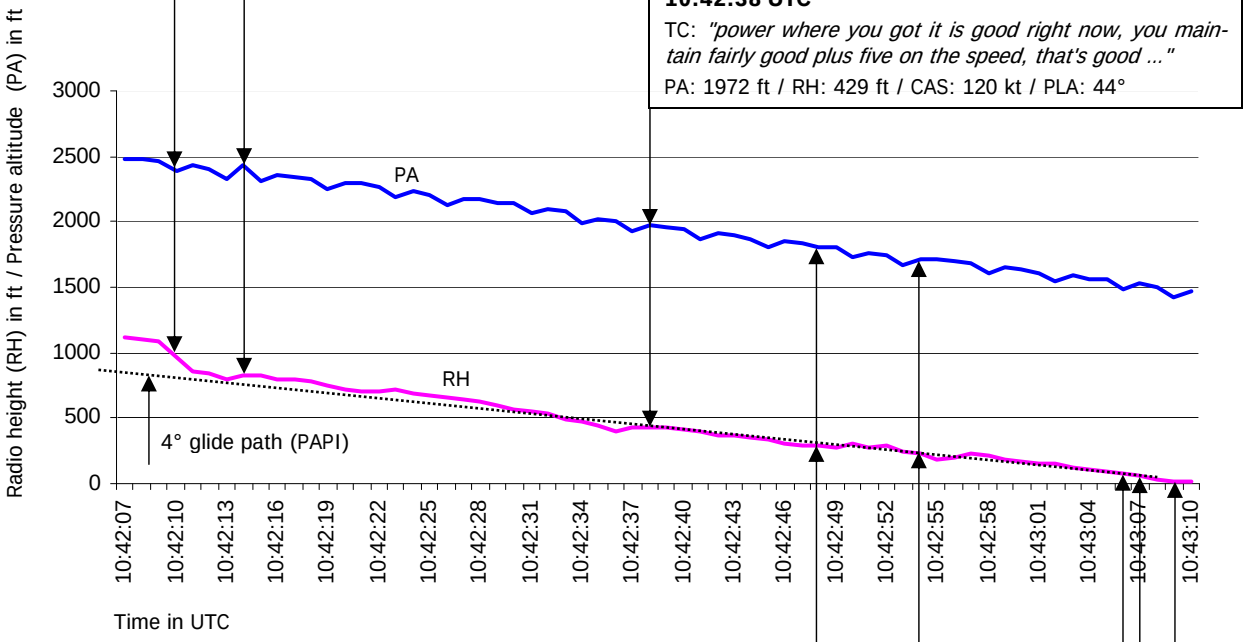
ATCO: air traffic controller
PA: pressure altitude
CAS: calibrated airspeed

Annex 2: Rate of descent and speed on the flight path



1) average ROD: average rate of descent in ft per minute

Annex 3: Flight progress from 1000 ft radio height



10:42:10 UTC
Automatically generated call *"one thousand"* (1000 ft radio height) sounds
PA: 2394 ft / RH: 958 ft / CAS: 122 KT / PLA: 46°

10:42:14 UTC
TC: *"so one one eight so you know like one twenty three is good like where you got it, nice and stabilized looks good, slightly high"*
PA: 2428 ft / RH: 831 ft / CAS: 123 kt / PLA: 49°

10:42:38 UTC
TC: *"power where you got it is good right now, you maintain fairly good plus five on the speed, that's good …"*
PA: 1972 ft / RH: 429 ft / CAS: 120 kt / PLA: 44°

10:42:48 UTC
TC: *"don't work too much on the power, speed is good right where you got it, looks good …"*
PA: 1810 ft / RH: 287 ft / CAS: 122 kt / PLA: 45°

10:42:54 UTC
TC: *"and now start easing the power back a little bit, gradually working it back, start working the power back a little bit …"*
PA: 1714 ft / RH: 231 ft / CAS: 124 kt / PLA: 45°

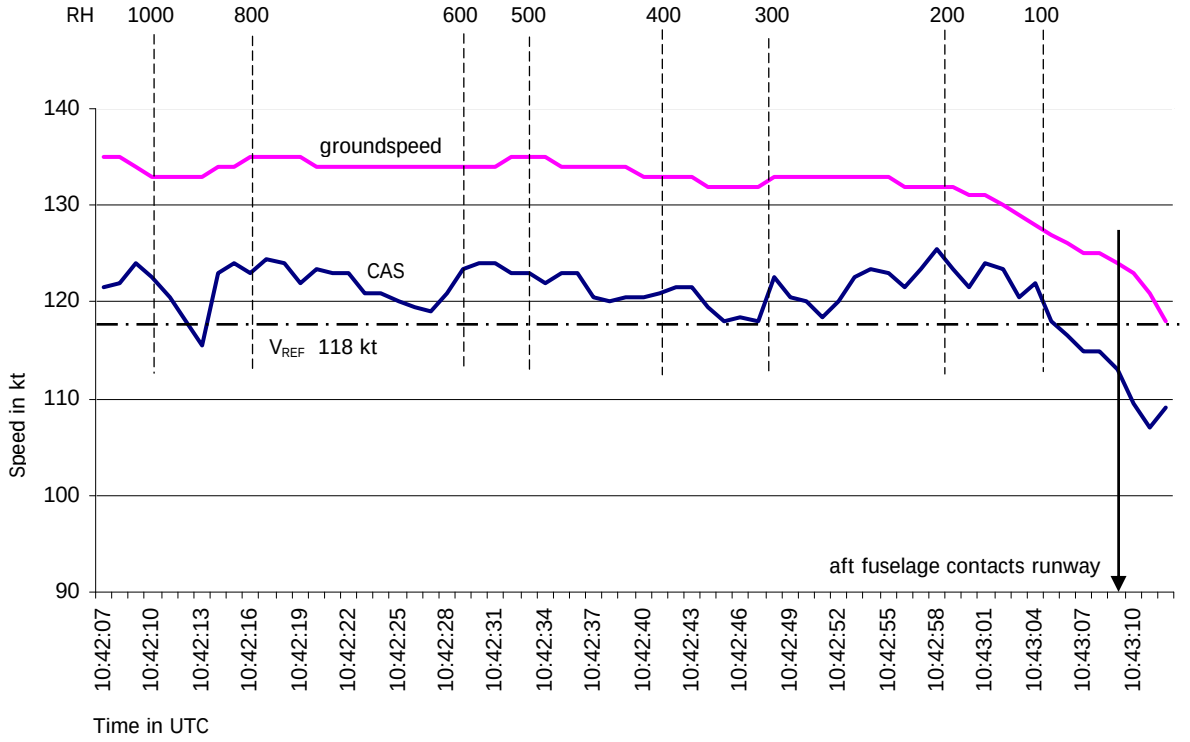
10:43:06 UTC
TC: *"nose up, nose up, nose up ….much faster than that …"*
PA: 1486 ft / RH: 72 ft / CAS: 116 kt / PLA: 44°

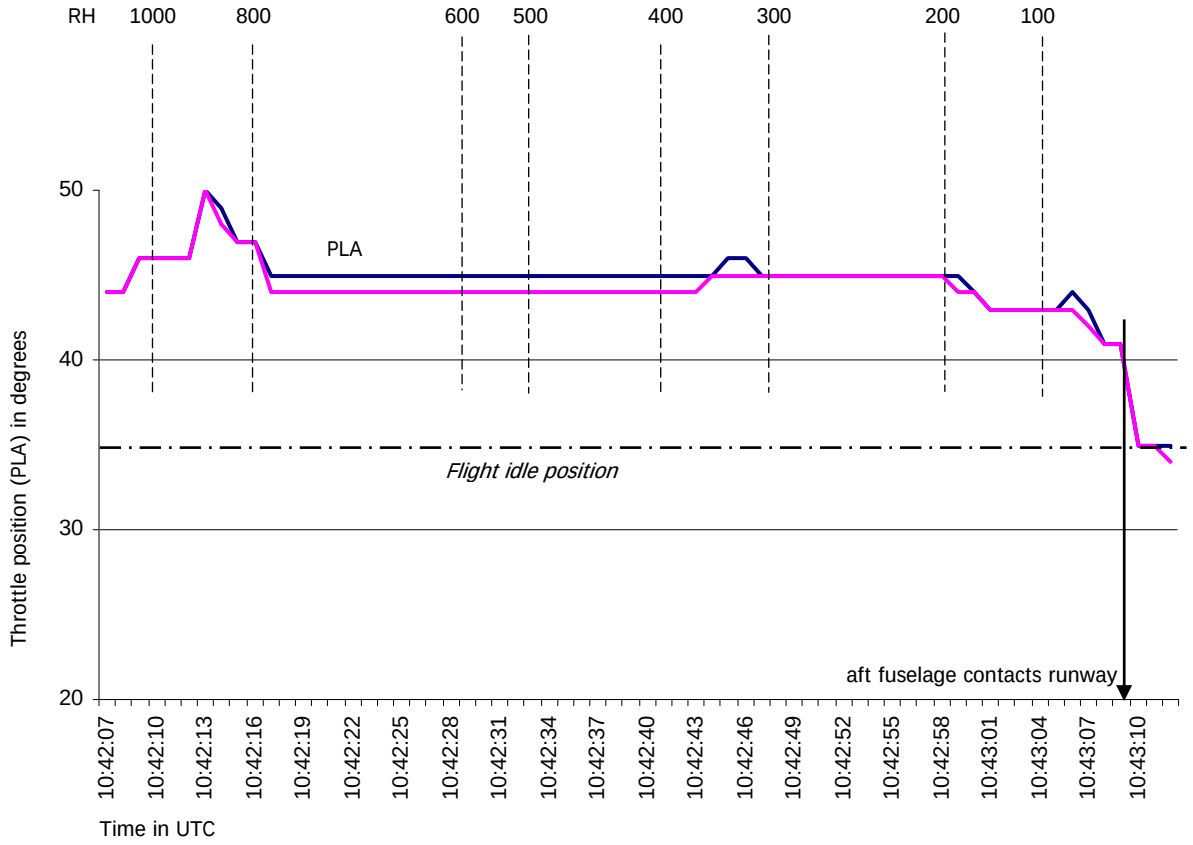
10:43:07 UTC
Radio call out: *"fifty –forty-thirty"* begins
PA: 1526 ft / RH: 54 ft / CAS: 115 kt / PLA: 43°

10:43:09 UTC
Radio call out *"twenty"* sounds and immediately afterwards the lower fuselage can be heard striking the ground

TC: *training captain*
PA: *pressure altitude*
RH: *radio height*
CAS: *calibrated airspeed*
PLA: *power lever angle*
PAPI: *precision approach path indicator*

Annex 4: Progression of various parameters from 1000 ft radio height





Annex 5: Progression of various parameters from 150 ft radio height