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Swiss Accident Investigation Board SAIB

Aviation Division

Final Report No. 2225 by the Swiss Accident Investigation Board SAIB

concerning the accident involving the Agusta-Bell 206B helicopter, registration HB-XPQ

on 24 May 2012

Eggschwand, municipality of Reichenbach/BE

42 km south-south-east of Bern-Belp Airport

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Ursachen

Der Unfall ist darauf zurückzuführen, dass der Helikopter mit dem Tragseil einer im Luftfahrthindernisregister verzeichneten, aber nicht markierten Transportseilbahn kollidierte und in der Folge abstürzte.

Die folgenden Faktoren wurden als kausal ermittelt:

- Fehlende *situational awareness* der Besatzung bezüglich des Luftfahrthindernisses.
- Wahl eines Flugweges, welcher angesichts der Voraussetzungen risikobehaftet war.
- Fehlendes Kollisionswarngerät Floice.

Die folgenden Faktoren haben zum Unfall beigetragen:

- Fehlendes *briefing* vor dem Flug, was zu einer lückenhaften Flugvorbereitung führte.
- Fehlen jeglicher Markierung der Transportseilbahn.

Der folgende Faktor wurde weder als ursächlich noch als direkt beitragend, aber als risikoreich erkannt (*factor to risk*):

- Chronisch hohe Arbeitslast des Fluglehrers.

General information on this report

This report contains the Swiss Accident Investigation Board's (SAIB) conclusions on the circumstances and causes of the accident which is the subject of the investigation.

In accordance with Art 3.1 of the 10th edition, applicable from 18 November 2010, of Annex 13 to 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 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/incident 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, are stated in local time (LT). At the time of the accident, Central European Summer Time (CEST) applied as local time in Switzerland. The relation between LT, CEST and coordinated universal time (UTC) is:
LT = CET = UTC + 2 hours.

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Final Report

Aircraft type	Agusta-Bell 206B "Jet Ranger III" HB-XPQ
Operator	Heliswiss, Schweizerische Helikopter AG, 3123 Belp, Switzerland
Owner	Heliswiss, Schweizerische Helikopter AG, 3123 Belp, Switzerland

Flight instructor	Swiss citizen, born 1966
Licence	Commercial pilot licence helicopter (CPL(H)) according to Joint Aviation Requirements (JAR), first issued by the Federal Office of Civil Aviation (FOCA) on 22 February 1990
Essential ratings	Bell206, valid till 21 February 2013 Landings in mountainous area (MOU(H)) Flight instructor (helicopter) FI(H)), flight instructor (helicopter) for landings in mountainous area (FI(H) MOU), both valid till 4 June 2014
Medical fitness certificate	Class 1, restrictions: VDL (shall wear corrective lenses), issued on 21 February 2012, valid till 21 February 2013

Flying hours	**total**	approx. 8943 hours	**during the last 90 days**	approx. 162 hours
	on the type involved in the accident	approx. 4253 hours	**during the last 90 days**	approx. 86 hours
	as flight instructor	approx. 7047 hours	**during the last 90 days**	approx. 134 hours
	on the type involved in the accident	unknown	**during the last 90 days**	approx. 83 hours

Female pilot	Swiss citizen, born 1959
Licence	Commercial pilot licence helicopter (CPL(H)) according to JAR, first issued by the FOCA on 27 January 2006
Essential ratings	Bell206, valid till 2 June 2013 Landings in mountainous area (MOU(H))
Medical fitness certificate	Class 1, no restrictions, issued on 21 May 2012, valid till 2 June 2013

Flying hours	**total**	approx. 598 hours	**during the last 90 days**	approx. 7:20 hours
	on the type involved in the accident	approx. 360 hours	**during the last 90 days**	approx. 6:30 hours

Male pilot	Swiss citizen, born 1966
Licence	Commercial pilot licence helicopter (CPL(H)) according to JAR, first issued by the FOCA on 30 September 1991
Essential ratings	Bell206, valid till 9 March 2013 Landings in mountainous area (MOU(H))
Medical fitness certificate	Class 1, restrictions: VDL (shall wear corrective lenses), issued on 6 February 2012, valid till 16 February 2013

Flying hours	**total**	approx. 772 hours	**during the last 90 days**	approx. 9:40 hours
	on the type involved in the accident	approx. 680 hours	**during the last 90 days**	approx. 9:40 hours

Location	Eggschwand, municipality of Reichenbach/BE		
Coordinates	625 350 / 158 775 (collision) 625 065 / 158 480 (final position)	**Altitude**	approx. 1770 m AMSL approx. 1490 m AMSL
Date and time	24 May 2012, approx. 17:40		

Type of operation	VFR training
Flight phase	Cruising
Type of accident	Collision with wire cable

Injuries to persons

Injuries	Crew	Passengers	Total number of occupants	Others
Fatal	3	0	3	0
Serious	0	0	0	0
Minor	0	0	0	0
None	0	0	0	Not applicable
Total	3	0	3	0

Damage to aircraft	Destroyed
Other damage	Damage to forest, damage to cableway

1 Factual information

1.1 Pre-history and history of the flight

1.1.1 General

For the following description of the pre-history and history of the flight, the recordings of the radiotelephony communications, documents of the crew and the air operator, as well as statements of the persons called upon to testify for the purposes of the investigation were used.

There is no recorded data for the history of the flight. An on-board GPS device was found at the site of the accident, but could not be read due to the extensive damage. A Floice collision warning device, which records the flight path, was usually installed on board the helicopter involved in the accident, but was not available during the flight involved in the accident (cf. Section 1.14). According to information from skyguide, the helicopter was not detected by radar.

The flight was conducted according to visual flight rules (VFR). The flight was a training flight.

1.1.2 Background

The flight involved in the accident was a mountain check flight for company-internal training purposes of the air operator Heliswiss. Due to various accidents involving aircraft belonging to the air operator between 2008 and 2011, the insurance company and the Federal Office of Civil Aviation (FOCA) demanded measures to be taken. On 1 June 2011 the air operator issued internal rules including the provision that both private and freelance professional pilots who wished to conduct off-field landings, i.e. landings not at airports or heliports, would have to complete an annual company-internal check flight on which such landings were performed. The operator referred to this check flight as the "Aussenlandecheck" (off-field landing check). Pilots who wanted to conduct off-field landings on mountain landing sites also had to complete an annual mountain flight check as part of internal training. It was possible to complete the off-field landing check while on the mountain flight check.

The flight instructor involved in the accident, whose roles included Head of Training at the flight school involved, had developed a separate form to certify these check flights (cf. Annex 2). This form was largely based on the official FOCA form for certifying the test for acquiring the rating extension for landings in mountainous area. In particular, the form envisaged two landings to be performed at sites between 1100 m AMSL and 2000 m AMSL and three landings at official mountain landing sites. According to the law, in the context of training flights, landings at up to 2000 m AMSL may be performed at a site of choice (with a few restrictions), while landings at over 2000 m AMSL may only be made at official mountain landing sites. These are published in the Aeronautical Information Publication (AIP) Switzerland under VFR AGA 3-3-1 to 3-3-3.

The two pilots in the flight involved in the accident were both in possession of a commercial pilot licence with the rating extension for landings in mountainous area. Both regularly flew for the air operator on a freelance basis. They also conducted private flights.

1.1.3 Planning

For reasons which can no longer be determined, the decision was made at an unknown time prior to the flight that the two pilots would complete this mountain check flight together. This meant that one pilot initially completed the check flight with the flight instructor, while the other was on board as a passenger, in order to then switch roles approximately halfway through the flight. According to various statements by employees and pilots of the air operator, this procedure was not common, but was used occasionally. The employees and pilots of the air operator stated that there had been several occasions on which two students had trained together with a single flight instructor in this way, particularly in the context of training to acquire the rating extension for landings in mountainous area. On the one hand this has the advantage of being able to save long flights from the base to the training areas, and on the other hand, the increased weight of the helicopter leads to a more realistic training situation with regard to subsequent flights with passengers. It can also be instructive for a trainee pilot to observe the progress of the flight from the rear seat.

The joint check flight was originally scheduled for Friday 11 May 2012, but was then postponed until Friday 25 May 2012. The female pilot had time off from her full-time job every other Friday, which included 11 and 25 May 2012. For operational reasons the flight on 25 May 2012 was initially scheduled for 10:00, then for 12:00 and finally for 16:00. In an e-mail dated Tuesday 22 May 2012 the female pilot clearly expressed her displeasure to the flight instructor regarding the *"constant shifting"* of the mountain check flight. She went on to state that the mountain check flight was not something she wanted from him, but a requirement of the air operator. She closed with the words: *"I'm frustrated and annoyed."*

The instructor responded a short time later with the words: *"Me too – I'm doing everything I can to sort it out, which is pretty difficult at the moment. (...)"* Just a few minutes later there followed an e-mail to the two pilots, in which the instructor informed them that Friday would no longer be possible and offered alternative options on Wednesday 23 May 2012 between 9:00 and 12:00 or Thursday 24 May 2012 starting at 12:00. According to the statement of the operations manager, the reason for the latest postponement was a transport flight which was planned for the Friday with the flight instructor as the scheduled pilot.

Approximately a quarter of an hour later, there followed another e-mail from the instructor to the two pilots, in which the date was set for Thursday 24 May 2012 from 16:00 to 19:00. The flight instructor wrote: *"Sorry you two. I'm doing my best to resolve the situation. Hopefully this will be the last change, if it's OK with you."* This e-mail also contained the information that the check flight would start from the Bern-Belp base and be on the Bell 206 type helicopter. There was no evidence of the planned route or landing sites in either this e-mail or other documents available to the investigation.

1.1.4 Flight preparations

After arriving at the Heliswiss base on Thursday 24 May 2012, the two pilots first proceeded to the briefing room to address flight preparations. At this time the instructor was on board helicopter HB-XPQ on another mountain check flight. This flight had taken off at approximately 14:30. Following their preparations the two pilots waited for the flight instructor to return on board HB-XPQ.

The female pilot provided general flight preparations. These included the aviation weather forecast for 24 March 2012 issued at 04:30 UTC, which was printed out via the Homebriefing system at 11:26. The female pilot noted the temperature variations with increasing altitude according to the international standard atmosphere (ISA) by hand and also entered them in the relevant area of the accompanying GAMET chart, which was valid between 09:00 and 15:00 UTC. The flight preparations also contained a weight and centre of gravity calculation on the basis of 60 US gallons of fuel at take-off, and a hover out of ground effect (HOGE) power calculation which took into account the above-mentioned temperature variations from the ISA and provided a value of 10,000 ft pressure altitude (PA) at take-off. Finally, the preparations included the Daily Airspace Bulletin Switzerland

(DABS) and the air operator's internal flight plan. On the latter, the latest return was entered as "19:00 LT" on the "High mountains – Bernese Oberland" route. The flight preparations left behind contained no references to the specific route or the planned landing sites.

In the briefing room at the flight school was a computer on which National Maps of the 1:50,000 scale series with up-to-date air navigation obstacles were available in digital form. It was possible to print out the relevant extracts in colour directly on site. There was no evidence that extracts were printed out for the accident flight.

At approximately 16:05, HB-XPQ landed at the Bern-Belp base. The flight instructor let the engine continue to run at idle and remained in the front left pilot seat while the recently examined candidate vacated the helicopter and helped the male pilot to fuel the helicopter to 60 US gallons. In the meantime the female pilot sat in one of the rear seats. After completing refuelling the male pilot took his place in the front right pilot seat.

It was not possible to determine whether the crew took Air Navigation Obstacle Maps or electronic aids on the flight.

1.1.5 History of the flight

At 16:16:10 the pilot contacted Bern-Belp Airport aerodrome control and reported that he was ready to depart in the direction of Thun via reporting point HOTEL. The air traffic controller immediately issued clearance to take-off, but instructed the crew to hold short of the runway axis; the pilot acknowledged this. Approximately 30 seconds later the air traffic controller issued the crew clearance to cross the runway axis and depart via the reporting point HOTEL as planned.

At 16:20:42 the pilot signed off from the air traffic controller in the Gerzensee area.

At some point between 16:00 and 17:00 an Alpine herdsman on the "Aabeberg" alp (cf. Annex 1), which is located at 1912 m AMSL on the southern ridge of the "Spiggegrund" valley, observed a red and white helicopter. The helicopter flew from the "Ärmighore" peak in the direction of the "Uf der Schöni" alp (1994 m AMSL), which was south-east of where the herdsman was standing. Above the "Spiggegrund", the helicopter turned and began a first approach in the area of "Uf der Schöni". The helicopter did not touch down completely; instead it flew off again and made another approach on the same site. The helicopter did not touch down completely on the second approach either, something which the herdsman had often observed. Then the helicopter flew towards the "Blüemlisalp" massif, which meant a roughly southerly course, and disappeared from the view of the herdsman.

Approximately 20 to 30 minutes later, the herdsman again saw an approaching helicopter. He was sure that it was the same helicopter which he had previously observed. The helicopter approached from the "Blüemlisalp" and then once again flew via the "Ärmighore" towards the "Spiggegrund" in order to re-approach the "Uf der Schöni" alp. The two approaches were carried out in the same way and on the same site as before, i.e. the aircraft did not touch down completely in either case.

These two sequences of landing approaches in the area around the "Uf der Schöni" were also observed by a second person who was in the area of the "Steinenberg" alp at approximately 1470 m AMSL (cf. Annex 1). The eyewitness could not remember the exact times, but believed no more than approximately 30 minutes had elapsed between the two sequences. By chance this eyewitness observed the helicopter's final approach using binoculars. He was able to identify the helicopter as a red and white Heliswiss Jet Ranger. The witness stated that it was common for landings to be conducted in the area of the "Uf der Schöni" alp.

After the final approach the herdsman on the "Aabeberg" observed the helicopter taking off in a south-westerly direction (cf. Annex 1). The herdsman suspected that the helicopter would then fly off again, but it suddenly turned right and began to descend. The helicopter descended past the herdsman, so that he was able to look down upon it, and then descended into the "Spiggegrund" valley, where he lost sight of it. However, he was able to hear the sound of HB-XPQ and assumed that the helicopter was circling in the valley basin. Suddenly the herdsman heard an unusual, muffled sound and looked towards the other side of the "Spiggegrund" valley. He could see the helicopter above the "Eggmatti", at the mouth of the valley of the "Eggbach" creek. The herdsman saw the rotating main rotor from above. The nose of the helicopter was pointing steeply downward. The helicopter made a left turn and then disappeared from the herdsman's field of view in a steep descent. A few seconds later he heard a bang. As the herdsman could not see the area of impact, he walked a short distance from his hut and then saw a fire in the forest.

Another herdsman, who was working at his hut, the "Alti Weid", in the "Spiggegrund" valley basin at 1291 m AMSL (cf. Annex 1), saw the helicopter fly from the "Golderehore" peak in the direction of his hut and then onwards towards the "Unders Marggofel" area. The helicopter flew along the southern side of the valley into the valley. Trees behind the hut meant that the herdsman then lost sight of the helicopter, but he heard it continue. Approximately one to three minutes later, the helicopter reappeared and flew from the "Unders Marggofel" area towards the "Eggmatti". The helicopter flew slowly and at a relatively low altitude. In the area between the "Eggschwand" and the "Eggmatti" the herdsman again lost sight of the helicopter as it entered the "Eggbach" valley (cf. Annex 1 and Fig. 1). During a field reconstruction of the flight path, the eyewitness was certain that the helicopter had flown under the cable with which it subsequently collided when entering the "Eggbach" valley. He was able to hear the helicopter despite the sound of the stream. Approximately three minutes later the helicopter reappeared out of the "Eggbach" valley. The herdsman noticed a pronounced lateral movement (side slip) and that the helicopter was flying faster than when it had entered the valley. The helicopter was also *"rocking"* , which the herdsman initially interpreted as a flying exercise. He could not see any damage to the helicopter. The nose of the helicopter then dropped by approximately 30° and the helicopter fell to the left in a sharp spiral of approximately 90°. East of the "Eggbach" creek, the helicopter crashed onto a rocky knoll below the "Eggschwand" with a muffled bang. Immediately afterwards the herdsman saw a large fireball.

The helicopter was destroyed by the impact and burnt out. All three crew members were fatally injured.

The support cable for the goods cable car between the "Eggmatti" and the "Eggburgli" (cf. Annex 1 and Fig. 1) was found severed after the accident.

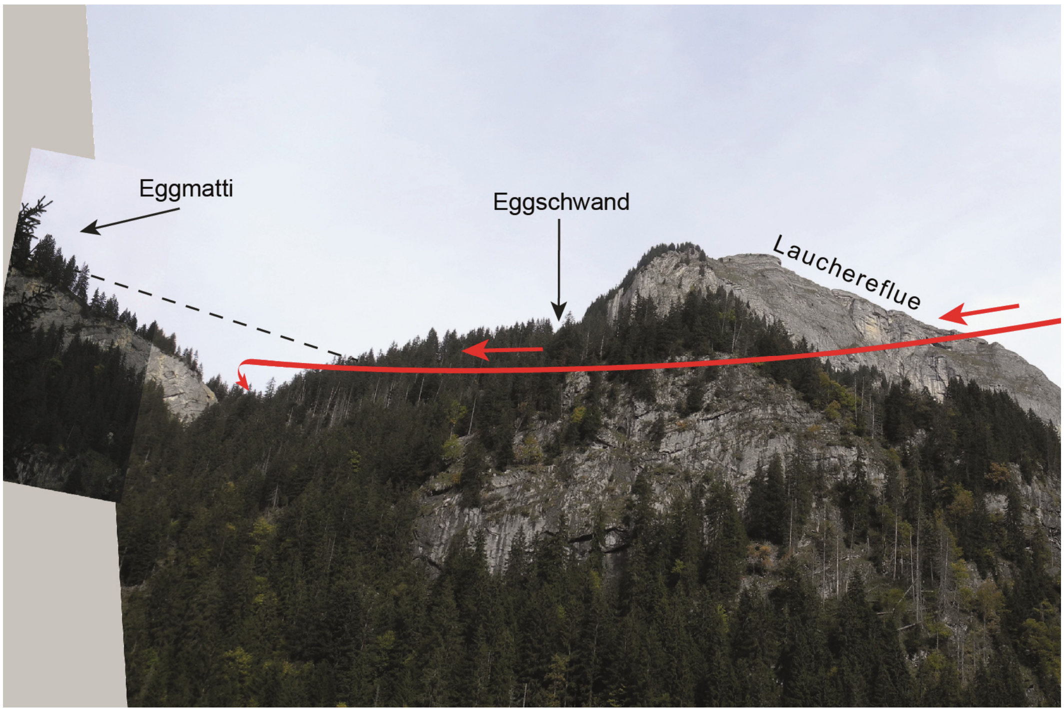


Figure 1: Flight path when entering the "Eggbach" valley according to a flight path reconstruction created with the assistance of the herdsman from his position at the "Alti Weid" (red arrow). The new cable for the goods cable car between the "Eggmatti" and the "Eggburgli" (cf. Annex 1) has been traced with black dashed lines.

1.2 Wreckage and impact information

1.2.1 Site of the accident

The final position of the wreckage was on the northern side of the Spiggegrund approximately 20 m east of the "Eggbach" creek on a rocky knoll below the "Eggschwand" (cf. Annex 1 and Fig. 2). The terrain in this area is steep, forested and almost inaccessible. There was insufficient network coverage for mobile telephony over the entire area around the site of the accident.

Figure 2: Final position of the wreckage on a rocky knoll east of the "Eggbach" creek.

1.2.2 Impact

The helicopter impacted on a rocky knoll (cf. Fig. 2).

Several trees in the area of the accident site showed signs of mechanical damage. Several trees had been severed.

1.2.3 Wreckage

The main wreckage was confined to a small area. The helicopter was almost completely destroyed by the impact and subsequent fire. The turbine, remnants of the main gearbox and the rotor mast were found at the centre of the main wreckage.

The severed tail, the rear part of the landing gear and a door were found slightly below the main wreckage and were not, or only partially, affected by the fire.

The main rotor head, which was connected to parts of the two main rotor blades, was found approximately 20 m below the main wreckage. The main rotor mast had been severed. Several large and small pieces of the main rotor blades were found both near the main wreckage and some distance away from it. The main rotor blades indicated clear traces of impact with a wire cable.

The position of the bodies at the accident scene suggests it is very likely that at the time of the accident the flight instructor was in the front-left pilot seat, the female pilot was in the front-right pilot seat and the male pilot was in one of the rear seats.

1.3 Fire

The impact caused an explosive crash fire which consequently spread to the surrounding forest. The fire was extinguished after the arrival of the first emergency services with the help of a fire helicopter.

1.4 Survival aspects

1.4.1 General

The force of the impact meant that the accident was impossible to survive.

1.4.2 Search and rescue

The helicopter was equipped with a type Kannad 406 AF emergency transmitter (emergency location beacon aircraft – ELBA). The device was installed, but was destroyed by the impact and fire. No signals were received from the ELBA.

The herdsman who had observed the impact on the floor of the "Spiggegrund” valley near the "Alti Weid" drove his car down the valley in order to get to an area with sufficient network coverage. He notified the police using his mobile phone at 17:46.

The first emergency services arrived at the site of the accident approximately 40 minutes later.

1.5 Meteorological information

1.5.1 General meteorological situation

Switzerland was on the edge of a pronounced Scandinavian high pressure area in a prominent north-easterly air stream (Bise), which was active to a high altitude.

1.5.2 Weather at the time and location of the accident

The weather was dry with dispersed cumulus clouds. A cirrus cover, generated by cumulonimbus clouds over the Vesoul area (France) and the Jura mountains, was floating in from the north.

No meteorological data is available for the area around the site of the accident. It is therefore only possible to estimate the wind conditions on the basis of model data and more distant measuring points.

The axis of the Kiental runs from north-west to south-east, at right angles to the Bise wind, which flows in from the north-east and which affects a large area. The wind in the "Spiggegrund” valley is likely to have been light. According to model data, at 2000 m AMSL, north-easterly winds of 15 to 20 kt could be expected along the Saxetental-Renggli-Latrejegrat axis. Due to the pronounced surface features of the topography, local wind speeds are likely to be lower than those indicated by the model.

It is likely that there was a light, occasionally moderate north-easterly air flow featuring downward winds in the catchment area of the "Eggbach" creek, which lay in the lee of the "Latrejegrat" ridge.

The values measured at the Niederhorn peak (1950 m AMSL) and the Männlichen peak (2,230 m AMSL) serve as a comparison. At the time of the accident, a north-easterly wind was blowing on the Niederhorn peak with an average speed of 3 kt gusting to approximately 6 kt. On the Männlichen peak, a north-north-easterly wind at 4 kt with gusts of approximately 6 kt was measured at a temperature of 11° C and a dewpoint of 6° C.

The following data refers to an elevation of 1700 m AMSL at the mouth where the "Eggbach" valley meets the "Spiggegrund" valley.

Clouds	3/8-4/8	9,100 ft AMSL
	5/8-7/8	24,700 ft AMSL
Visibility	20 km	
Wind	040 degrees / 3 kt	
Temperature/dewpoint	14 °C / 11 °C	
Atmospheric pressure QNH	1020 hPa	
Hazards	None	

1.5.3 Astronomical information at the time and location of the accident

Position of the sun	Azimuth: 267 °	Elevation: 32 °
Lighting conditions	Daylight	

1.5.4 Weather according to eye witness reports

The herdsman who had witnessed the accident from the "Alti Weid" made the following statement regarding the weather conditions at the time:

"It was a little cloudy at the time. (...)The visibility was clear, but like I said, the sky was a little overcast and the sun was not that bright."

The person who was staying in the "Steinberg" area and had observed several landings made by the helicopter in the "Uf der Schöni" area shortly before the accident made the following statement regarding the weather conditions:

"The visibility was good at the time of observation. (...) Maybe the sun was obscured by clouds, but I can't say for sure.

1.5.5 Images from webcams in the region

Figure 3: Niesen peak, 24 May 2012, 17:45, Sector South.

Figure 4: Frutigen, 24 May 2012, 17:45, Sector North-East.

1.6 Cableway information

1.6.1 General

The cableway with which the helicopter collided stretched from the "Eggmatti" (at approximately 1666 m AMSL) to the "Eggburgli" (at approximately 2031 m AMSL) (cf. Annex 1 and Fig. 5). It was built in the 1930s and during the summer months served to supply the Alpine hut on the "Eggburgli". The cableway was intended solely for transporting goods and was equipped for this purpose with an open car, which at the time of the accident was at the valley station. The drum around which the pulling cable was wound was located at the mountain station.

Figure 5: View from the valley station along the cable towards the mountain station (left). View from the mountain station along the cable towards the valley station (right). Photos from May 2013.

1.6.2 Support and pulling cables

The support cable consisted of six compacted strands, each with seven metal wires with a natural fibre core and a diameter of 14.6 mm. Clamping plates fixed the cable to a metal structure which was embedded in the soil.

The support cable was severed during the accident and was found on the ground a considerable distance from the direct line between the valley and mountain stations towards the mouth of the "Eggbach" valley.

The point where the cable was severed was 405 m along the support cable, measured from the valley station. A technical investigation showed that it is highly likely that the point where the cable was severed corresponds to the point at which the helicopter collided with the cable (cf. Section 1.8.3).

The pulling cable was not damaged during the accident. The diameter of the pull cable was 6 mm.

1.6.3 Profile

The new support cable which was installed after the accident was measured in detail (cf. Section 1.8.7). Specifically, it was possible to obtain the profile of the cable in the context of the terrain (cf. Annex 3). The possibility of small differences in length mean that this profile may be slightly different to the profile of the cable which was installed at the time of the accident.

The profile indicates that the new cable has a maximum height above ground of approximately 90 m. This maximum height is located in the middle of the valley above the stream (approximately 1620 m AMSL) and in an area slightly uphill of it, in the direction of the "Eggburgli" (cf. Annex 3).

Measuring 405 m along the new cable from base station in this profile, it is possible to identify the approximate position of the point where the original cable was severed, which is very likely to correspond to the collision point. The position determined in this way is at approximately 1770 m AMSL and is located approximately 70 m above ground level (cf. Annex 3 and Section 1.8.7).

1.6.4 Air navigation obstacles

The cableway was registered in FOCA's air navigation obstacle register under the number 254-BE-30009 and entered on sheet number 37 of the Air Navigation Obstacle Map series . The cableway itself was unmarked.

The corresponding master sheet, which contains all the relevant data for the obstacle, was last amended on 8 July 2008. The master sheet contained information including the following:

- Publication as an air navigation obstacle: 17 October 2005
- Last approval by the FOCA: 1 July 2008
- Approved until: 31 December 2023
- Coordinates of valley station: 625 000 / 158 649
- Coordinates of mountain station: 626 037 / 159 024
- Length: 1103 m
- Maximum height above ground: 100 m
- Markings: None
- Lighting: None

According to a FOCA approval of 1 July 2008, no requirements were made of the owners of the cableway in relation to markers. According to the FOCA, no records are available regarding this decision. However, the FOCA assessment is likely to have taken into account the same aspects as the reassessment of the obstacle after the accident (cf. Section 4.2.2).

1.6.5 Guidelines for dealing with air navigation obstacles

At the time of the accident the air navigation obstacle guidelines (Luftfahrthindernis-Richtlinien – LFHR) issued by the FOCA in January 1993 were in force.

Section 3.2.2. of these guidelines states the following in relation to obstacles outside of aerodrome zones:

> *"Any obstacle which infringes the obstacle definition zone* (60 m above average ground level) *will only be approved subject to FOCA / Federal Office for Military Airfields (BAMF) requirements. The requirements depend on the following:*
>
> - *Type of obstacle*
> - *Position in the terrain*
> - *Relevance in terms of flight safety."*

Section 4.2.2. is more specific in relation to the markings: [Bold in original]

"Obstacles which infringe the obstacle definition zone (60 m above average ground level) shall usually be marked, unless:

- *they are fitted with a warning marker in accordance with 4.1*
- *they are shadowed by another, immovable obstacle or*
- *their type, shape and location mean they present no hazard to air navigation.*

Any obstacle with a maximum height of 100 m above ground level or more shall be marked unless an aeronautical study confirms it presents no hazard to air navigation.

Depending on the type of the obstacle, marking shall be in accordance with 4.2.1 a), b) or c).*"*

Section 4.2.1. c) states the following in relation to permanent cable obstacles:

"Obstacles shall be marked with the aid of red/orange polyester balls attached at minimum intervals of 40 m.

They shall be mounted either on a part (typically the critical section) or over the entire length. If the nature of the obstacle or an aeronautical study demonstrates that the obstacle presents no hazard, the marking may be reduced."

The above-mentioned Section 4.1. states the following under the title *"Simple marking"*: [Bold in original]

"Measures with simple marking are primarily intended for cable systems. They may be of the following nature:

- *Hanging a load at the place of greatest vertical distance from the ground when the system is not in operation (barrel or tree trunk in red/white/red),*

or they can be realised using simple warning markers with the following characteristics:

- ***Windsock*** in *red/orange/fluorescent (...) placed at the valley station and/or mountain station.*
- ***Cable warning*** *(...)* [pyramid with a square base measuring 100 x 100 cm] *placed at the valley station and/or mountain station.*

These markings are generally fitted for cable systems with a maximum ground clearance of between 60 and 100 m and which present a hazard to general air navigation.

These systems are not, however, considered marked systems.*"*

Finally, Section 6.1.4. makes the following general statement:

"If an aeronautical study or field inspection by the FOCA / Federal Office for Military Airfields (BAMF) demonstrates that an object presents no obstacle or hazard to air navigation due to its particular position in the terrain, the marking can be reduced or dispensed with.

(…)"

1.6.6 Visibility

As part of the reconstruction flights in May 2013 (cf. Section 1.14) the visibility of the cableway from different perspectives was also investigated.

The valley and mountain stations are practically invisible when entering the "Eggbach" valley from the "Spiggegrund" valley. The valley station is located behind trees, while the mountain station is in a gully (cf. Fig. 5 and 6).

When flying in the opposite direction, from the "Eggbach" valley towards the "Spiggegrund" valley, the valley station is visible (cf. Fig. 6). In this case too, the mountain station is also hidden in a gully.

As regards the visibility of the cable itself, it is important to note from the outset that the new cable installed after the accident is very likely to have been much more visible during the reconstruction flights than the original rusty cable, as its surface had not yet been weathered. The visibility against a bright, uniform background such as blue sky or white cloud would be relatively good. With a darker, non-uniform background such as the surrounding meadow and rocks the visibility would be very poor. Even when the position of the cable was known and the area intensely scrutinized, it was only sometimes possible to guess where the cable was, even from relatively short distance when hovering. The topography in the area around the site of the accident means that the cable is nearly always seen against a background of grass and rocks when approaching from an approximately level position.

Figure 6: View of the valley station, looking from the "Eggbach" valley towards the "Spiggegrund" valley. The "Alti Weid" on the valley floor. Photo taken on the day of the accident.

1.7 Aircraft information

1.7.1 General

The helicopter type involved in the accident was an Agusta-Bell 206B "Jet Ranger III", a five-seater multi-purpose helicopter with a maximum permitted take-off mass of 3200 lb. The engine was an Allison 250-C20B freewheeling engine with a maximum output of 420 SHP[1] (313 kW). Due to the operating limits of the main gearbox the engine output was flat-rated at 317 SHP (236 kW). The Agusta-Bell 206B type has a counter-clockwise rotating, semi-rigid main rotor system. The necessary torque compensation is provided by a conventional tail rotor.

The helicopter, which had the serial number 8606 and was registered as HB-XPQ, was constructed in 1980 and at the time of the accident indicated approximately 18,309 operating hours.

1.7.2 Fuel, mass and centre of gravity

On take-off in Bern-Belp there were approximately 60 US gallons of fuel on board. Therefore, given a consumption of approximately 25 US gallons per hour, a total flying time of approximately 2:20 hours would have been possible without taking reserves into account. The mass of the helicopter at the time of departure was approximately 2850 lb.

The accident occurred after approximately 1:23 hours flight time. At time of the accident there were therefore still approximately 25 US gallons of fuel on board. The mass of the helicopter at the time of the accident was approximately 2610 lb.

Both the mass and centre of gravity were within the permitted limits according to the aircraft flight manual (AFM) during the entire flight.

1.7.3 Last scheduled maintenance information

The last scheduled maintenance on HB-XPQ before the accident took place during the period between 27 February and 18 May 2012. The following major work was carried out on the airframe in accordance with the technical documents:

- 100-hour / 300-hour inspection and annual inspection
- 1500-hour inspection including overhaul of the main rotor mast
- 1500-hour inspection of the main gearbox
- Inspection and calibration of the fuel tank
- Airframe repainted

On the engine:

- Repairs on the turbine assembly
- Overhaul of the compressor assembly
- Inspection of the gearbox assembly
- 100-hour / 300-hour inspection

The work on the engine was carried out by a certified company in Canada and completed with an engine test.

The inspection, repair and overhaul work involved the removal of the engine and the main gearbox including the main rotor mast. The main drive shaft, which is used for transmitting torque between the turbine and the main gearbox, was also removed and inspected.

All the components were then reinstalled on the helicopter.

[1] SHP – shaft horse power – corresponding to 0.746 kW per SHP

1.7.4 Flights before the flight involved in the accident

On 18 May 2012, after the extensive work described in Section 1.7.3, HB-XPQ was subjected to technical check flights. The helicopter subsequently received a release to service (RTS) certificate.

The helicopter first flew again on 24 May 2012, the day of the accident. On this day, HB-XPQ made a total of four flights with a total effective flying time of 3:21 hours before the flight involved in the accident. Both the pilot of the first flight on this day and the pilot on the last flight before the flight involved in the accident confirmed that the helicopter had been functioning properly. No issues were noted in the helicopter's technical logbook for any of these flights.

1.8 Technical investigation information

1.8.1 General

The significant damage to the helicopter caused by the impact and subsequent fire meant only limited technical investigations were possible. The investigations included the following:

- Investigation of the wreckage with regard to the relevant components in order to determine possible technical faults which could have caused or influenced the accident.
- Forensic comparison of the wire cable in the area around the point where the cable was severed and the contact points on the helicopter.
- Investigation of the wire cable at the point where the cable was severed.

1.8.2 Investigation of the wreckage

The individual components of the helicopter were subjected to a thorough investigation. The following findings are of importance for the accident:

- The dual controls were installed.
- The throttle (twist grip) on the collective lever was found in the idle position.
- All breakages on the controls, drive components and drive systems were the result of impact forces.
- There were traces of contact with the wire cable on the leading edge as well as some of the upper and lower surfaces of both main rotor blades (cf. Fig. 7).
- The pitch links for both main rotor blades were severed. One of the two pitch links was also bent and exhibited traces of the wire cable in this area.
- No evidence of foreign materials could be found on the landing gear.
- One of the four bolts on the coupling housing between the main drive shaft and the main gearbox was missing and the nut of another bolt was loose. A segment of the housing was also missing (cf. Section 1.8.5).
- Various partially incinerated charts were found. There was no evidence for an Air Navigation Obstacle Map on board.

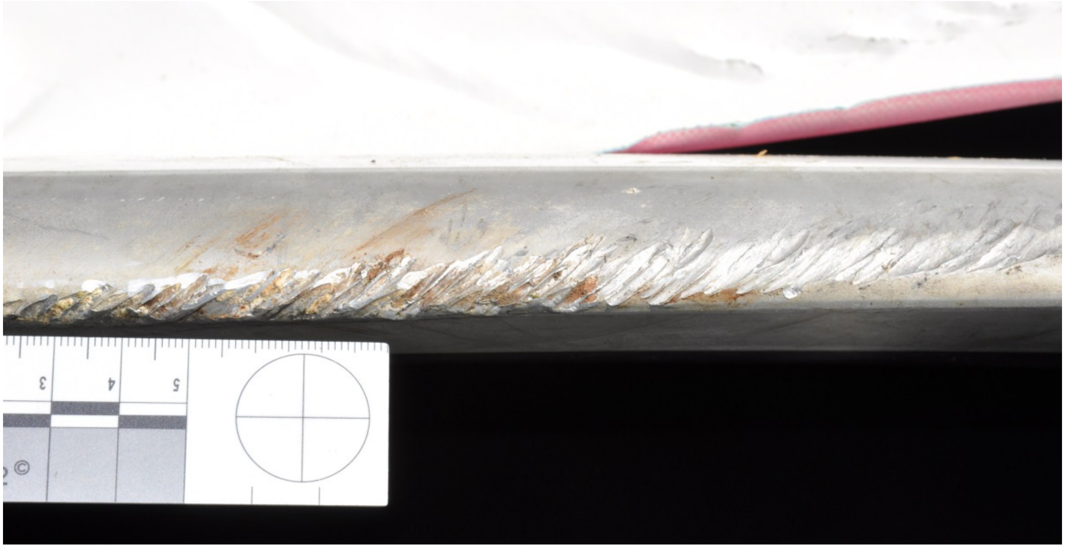


Figure 7: Traces of the wire cable on the leading edge of the main rotor blade.

1.8.3 Forensic comparison

Matching traces between the wire cable and the helicopter components are listed below:

Type of evidence (foreign material)	**Place trace found**	**Matches material from the helicopter**
Traces of abrasion	Main rotor blades	Wire cable (Size/shape/position)
Indentations	Leading edge Main rotor blade	Wire cable (Size/shape)
Metal residues (Aluminium alloy)	Wire cable	Leading edge Main rotor blade
Indentations	Pitch link	Wire cable (Size/shape)

As several traces of contact with the cable were found on both main rotor blades it can be assumed that they made contact with the cable several times.

The traces on the leading edge of the main rotor blade investigated indicate that the material (cable) shifted towards the centre of the rotor.

It was not possible to determine whether the pitch link was broken due to the contact with the cable or was a result of the ground impact.

The traces and the deformation of the wire cable in the area around the point where the cable was severed which were found mean that it is very likely that the point where the cable was severed corresponds to the point of collision with the main rotor blades of the helicopter.

1.8.4 Engine

The following findings resulted from the investigation of the engine:

- The engine gearbox housing, aggregates and fuel system were to a large extent destroyed by the high temperatures generated by the fire.

- All drive shafts were intact.
- The turbine gearbox (engine power output N2) was intact.
- Rotors and stators of the axial compressor did not show any damage other than fire-related signatures.
- Rub damage was found on the radial compressor's rotor (impeller) and on the inside of the radial compressor's shrouding.
- An indentation approximately as large as a thumb was found on the combustion chamber near the fuel nozzle.
- Rub damage was found on the 2nd and the 4th stage of the turbine.
- No foreign material or debris of such material could be found in the axial compressor, radial compressor, combustion chamber, or turbine.

1.8.5 Main drive shaft

The main drive shaft's flexible gear coupling on the main gearbox compensates for slight axial play and shaft misalignment. It was here that a tooth segment was found to be missing in the coupling housing. There was also a missing bolt and another bolt connection was loose in the area around the missing segment.

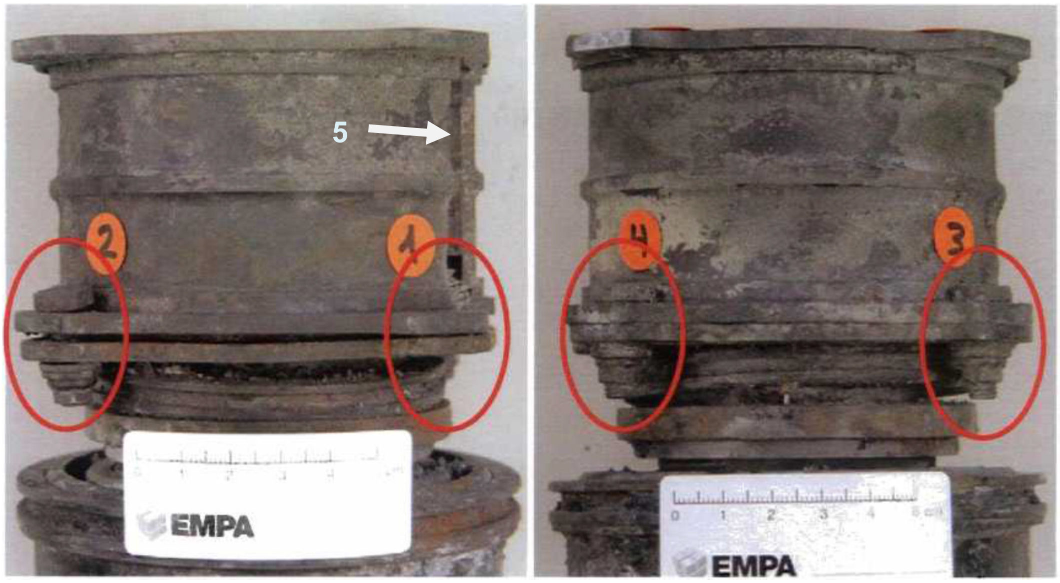


Figure 8: Missing bolt (1), loose bolt connection (2), intact bolt connections (3 & 4), missing tooth segment (5).

Detailed investigations by the Swiss Federal Laboratories for Materials Science & Technology (EMPA) provided the following indications in this regard:

- Very slight traces of abrasion were found in the borehole (1) in which the bolt was missing.
- The bolts (3 & 4) exhibited a certain degree of deformation.
- The bolt (2) was bent and when compared with the bolt connections (3 & 4) the nut was not screwed on to the bolt as tightly.
- Almost the entire length of the bolt thread (2) was deformed/damaged.
- None of the boreholes (1-4) revealed any fire residue deposits.
- The coupling housing was slightly deformed.

- The two broken edges of the missing housing segment had ingressed into the inner gear cavity and had been expanded concentrically.
- On the counterpart of the coupling housing, the gear, three teeth were partially broken.

The investigation report came to the following conclusion:

"The observations made regarding the loose screw suggest it is possible that it was not properly tightened.

(…)

It is not possible to make a reliable statement as to whether the missing screws were already missing before the impact. Circumstantial evidence, however, suggests that they were not missing.

(…)

The secondary damage means that it is no longer possible to assess the fractured surface [of the missing segment]. *It is therefore not possible to make any statement about the type of fracture*."

1.8.6 Cockpit instruments

The following two engine indicators were forensically examined:

- Gas producer RPM indicator:
  The instrument exhibited significant traces of fire and was missing its glass cover. The smaller indicator was not locked and could be turned easily. The larger pointer was locked in the zero position. It was not possible to determine any deformation or traces on the dial which could reveal the indicator position at the time of the accident.
- Power turbine and rotor RPM indicator:

  The instrument exhibited significant traces of fire and was missing its glass cover. It was still possible to move the power turbine RPM indicator (N2). The rotor rpm indicator (NR) was locked in what was formerly the green zone. There was a dark trace from the centre of the dial to approximately the "80%" mark. The length and shape of the trace matched the turbine indicator (N2) and was probably the result of the fire. However, these findings did not produce any conclusions concerning the indicator positions at the time of the accident.

1.8.7 Collision reconstruction

In order to reconstruct the collision between the helicopter and the support cable, the remaining parts of the main rotor and the support cable parts from the point where the cable was severed were assessed using optical 3D surface scanning. This light-scanning system makes it possible to create accurate high-resolution, true-colour, scale 3D surface models.

A helicopter of the same type was scanned using a laser scanner and the optical surface scanning system described above.

The path of the new support cable installed after the accident was measured by means of differential GPS and presented graphically (cf. Annex 3).

The digital 3D models created using the procedure described above were presented graphically using computer software and repositioned relative to one another. This at least provided guidelines for how the collision may have actually occurred. Specifically, it was possible to determine and visualise the probable approximate point of collision in a 3D terrain model (cf. Fig. 9).

It was also possible to compare damage and the parts which caused the damage using the same procedure.

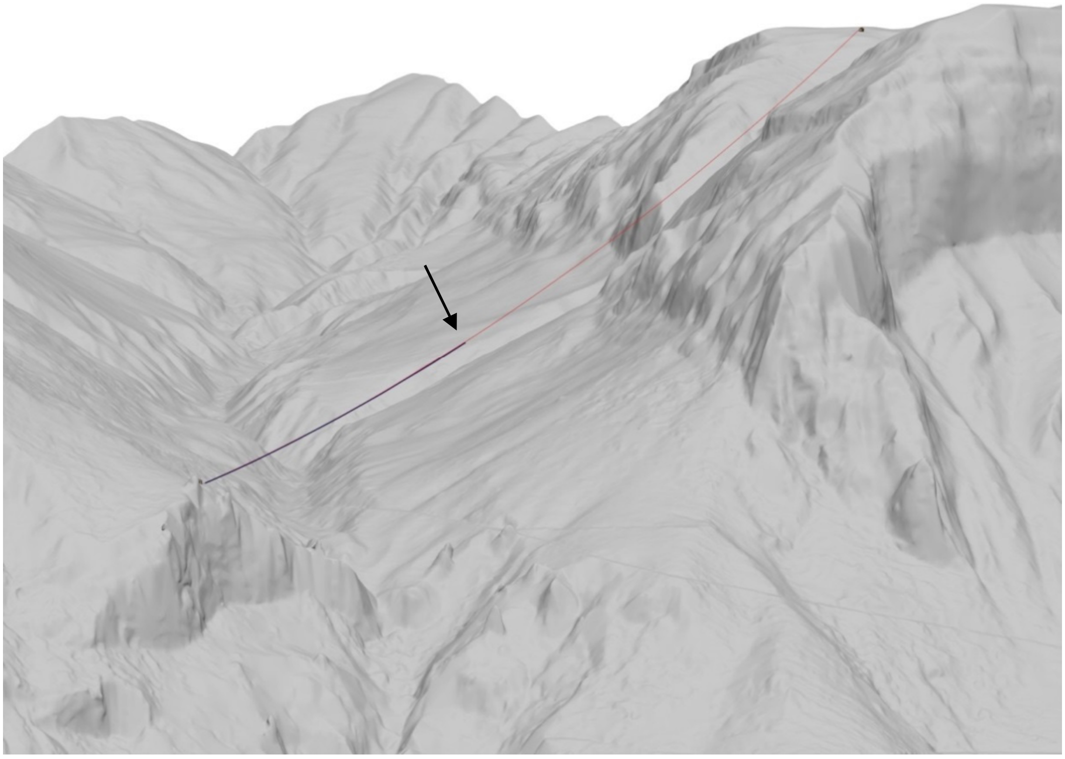


Figure 9: 3D model of the new cable installed after the accident. The first 405 m from the valley station upwards are in blue; the rest of the cable is in red. Where the two colours change (black arrow) corresponds to the approximate position the cable installed at the time of the accident was severed. The point where the cable was severed is also very likely to correspond to the collision point.

1.9 Air operator and flight school information

1.9.1 Air operator

At the time of the accident, the air operator Heliswiss operated bases in Bern-Belp, Gruyère and Gstaad (winter base only). The company offered commercial cargo and passenger flights of all kinds. It also offered chartered helicopters to private pilots and operated a flight school. Furthermore, the company was affiliated with a helicopter maintenance company.

Heliswiss was part of the Swiss Helicopter Group (SHG), an association of several independent helicopter companies throughout Switzerland.

1.9.2 Flight school

At the time of the accident, the Heliswiss flight school offered training for private and professional pilots. Furthermore, it was possible to complete mountain and night flight training as well as retraining on other helicopter types. Training for flying with an external cargo sling was also offered.

The Heliswiss flight school was part of Swiss Helicopter Training (SHT), a parent flight training organisation (FTO) with several flight schools throughout Switzerland.

1.9.3 Transferring to a new structure

There had been plans to merge the independent companies which together make up the SHG association into a joint company with a common name (Swiss Helicopter) on 1 July 2012.

Adjustments to the associated FTO, the SHT, were necessary as part of this restructuring.

At the time of the accident, the planning and preparatory work for this extensive reorganisation was in full swing.

1.10 Personnel information

1.10.1 Flight instructor

1.10.1.1 General

The flight instructor had been in possession of a Swiss professional pilot licence since 1990 and had worked, sometimes on a part-time basis, as a professional pilot since then. In 1995 he acquired flight instructor ratings and began to work as a flight instructor. In 1997 he acquired the rating extension for landing in mountainous area.

In 1999 he joined the air operator involved in the accident and the affiliated flight school as Base Manager for the Bern-Belp base and Chief Flight Instructor. In 2002 he completed his training for flying with an external cargo sling (ECS). In 2006 he assumed, in addition to his existing functions, management of the air operator.

This was followed in 2007 by ratings for flight examinations for private and professional pilots as well as examinations to acquire the mountain flight training extension and type ratings. Later in 2007, he acquired ratings to train prospective flight instructors.

1.10.1.2 Flight instructor’s tasks within the air operator

At the time of the accident, the flight instructor combined the following three functions: General Manager of the Heliswiss air operator, Base Manager of the air operator's Bern-Belp base as well as Head of Training at the affiliated flight school organisation. Furthermore, he was member of the management board of SHG. Also, the flight instructor regularly piloted cargo and other commercial flights, acted as examiner on flight examinations and check flights, and trained prospective flight instructors.

The reorganisation of the air operator planned for 1 July 2012, as well as changes to flight school organisation which were at least partially associated to the air operator reorganisation meant that the flight instructor was entrusted with additional tasks. Within this new structure, he would have assumed the functions of Base Manager of the Bern-Belp base and Head of Training and would also have become a member of the management board.

Various comments made by those interviewed during the investigation indicate that the flight instructor dealt with an enormous workload. All the pilots interviewed who had completed the flight instructor parts of their training or check flights stated that the flight instructor's method of working was competent and safe. One of the respondents explained the situation as follows:

"He left his duties on the ground and they didn't seem to bother him while he was in the air."

One of the pilots interviewed stated the following:

"[Name of instructor] *had a god-like status among the pilots who did their training with him. Quite simply, he had everything under control. It was impressive to see him perform the function of two or three roles in very different areas simultaneously at Heliswiss. His workload was definitely very high, but he never appeared to be stressed out and it seemed he had everything under control."*

One person, at the time senior manager of the Swiss Helicopter Group, made the following statement:

"[Name of instructor] *was really a brilliant personality, personable, but also an excellent professional with a very high intellectual grasp. He was unbelievably efficient with his work.* (...) *Certainly,* [name of instructor] *sometimes worked long hours, also during rather unusual times of the day; however,* [name of instructor] *was at work with much blood, sweat and tears. We often talked together. I don't think that his workload was too high.* (...) *I had the feeling that* [name of instructor] *had a good grip on himself and his life. I am convinced that* [name of instructor] *was able to mentally disconnect from work during his times off."*

Furthermore, the informant stated that he had given the advice to the flight instructor not to commence with external cargo sling (ECS) flying as this would only be an additional burden which was not really necessary. When the flight instructor started ECS flying anyway, he did not intervene.

The same person could remember that the flight instructor had once positively commented on the planned reorganisation. He had realized that after the reorganisation he would be able to focus more on the flight school.

1.10.1.3 Duty and flight duty times

A reconstruction of the duty and flight duty times of the flight instructor during the week of the accident (Monday 21 to Thursday 24 May 2012) provided the following results:

On Monday, as was typical for that day of the week, the flight instructor worked from home. In the afternoon, he acted as examiner for two proficiency checks in Balzers (total flying time 2:35 (rotor turning time - RTT), first take-off at approximately 15:45, last landing at approximately 19:05). At 22:46 the flight instructor sent a work e-mail.

On Tuesday, the flight instructor arrived at the Bern-Belp base at approximately 07:30. Several employees confirmed that the flight instructor was *"strikingly relaxed"* and that he claimed: *"I have time!"* At 09:00 a meeting took place regarding the transfer of the air operator and the affiliated flight school organisation to the new structure. In the afternoon, the flight instructor acted as examiner for a proficiency check (effective flight time 00:58, take-off approximately 14:00, landing at approximately 15:55). The instructor left the base at approximately 17:30. At 01:11 and 01:34 in the morning, the flight instructor sent two work e-mails; the second e-mail was long and concerned the transfer of the flight school organisation to the new structure.

On Wednesday, the flight instructor arrived at the Bern-Belp base at approximately 07:15. At 07:30 there was an internal meeting. The flight instructor did not have any appointments or flights the whole day. According to the statement of an employee, the instructor made a lot of time to talk with the staff and had an unusually long lunch with other employees. The flight instructor left the base at approximately 17:00; according to an electronic calendar this was for a private appointment.

On Thursday, the day of the accident, the flight instructor arrived at the base at approximately 07:00. In the morning he had to conduct cargo flights in the Thun area in a Eurocopter AS350 (take-off at approximately 09:20, landing approximately 11:00, total effective flying time 0:44). One staff member noticed that the flight instructor *"seemed to be in a good mood"*. At approximately 12:00, the flight instructor acted as examiner on a solo check for a trainee pilot of a colleague of his on a Schweizer 269C (take-off at approximately 12:35, landing approximately 13:50, total effective flying time 1:01 hours). There then followed the first mountain check flight on HB-XPQ (take-off at approximately 14:30, landing at approximately 16:05, effective flying time 1:29 hours). This was followed by the flight involved in the accident (take-off approximately 16:17). This was the last scheduled flight for the day. As the accident occurred at approximately 17:40, the flying time for the flight involved in the accident was approximately 1:23 hours. The flight instructor's total effective flying time on the day of the accident up until the accident was approximately 4:37 hours.

The flight instructor lived in the Aarau area. On duty days at the Bern-Belp base, the flight instructor typically travelled by bicycle from his house to Aarau, then by train via Bern to Belp, and then by bicycle again to the base. In the evening he repeated the trip in reverse. On an ideal day the commute was approximately 90 minutes door-to-door. Every now and then, especially when duty times went into the evening, e.g. for theory briefings, the flight instructor made use of a company car to get home and back to the base the next day.

1.10.1.4 Knowledge of the area

The location of the site of the accident in the area between the Bern-Belp base, the nearest mountain landing sites in the "Blüemlisalp" area and the long-term operations of the flight instructor from the Bern-Belp base mean it can be assumed that the flight instructor had a good knowledge of the area around the site of the accident, particularly with regard to air navigation obstacles.

In the context of the investigation all respondents who had completed the flight instructor parts of their training or check flights confirmed this assessment.

A flight instructor colleague recalled this as follows:

"I have the feeling that [name of instructor] *knew this region well. He conducted many training flights in the mountains. He probably knew about the cable* [involved in the accident]. *I was aware of it from flying over it. However, we never talked about the cable together. You only fly in that region if you have to do a cargo or training flight. Otherwise, you fly high over it."*

1.10.1.5 Previous aircraft accidents

In the course of his duties, the flight instructor had been involved in two other aviation accidents:

10 July 2003, Schweizer 269C HB-XQF (Final Report No. 1994): A trainee pilot who had successfully completed commercial pilot and mountain flight training was completing a training flight with the intention of practising landings which were more difficult and at the performance limit of the helicopter. On the third approach on an off-field landing site (1925 m AMSL) there was insufficient power for controlled hovering on the final approach. The helicopter collided with the ground and plunged down a steep slope. The trainee pilot sustained serious injuries; the instructor's injuries were minor. The helicopter was destroyed. The accident investigation report states the following cause:

"The accident is attributable to the fact that during the approach the crew lost control over the helicopter because an approach without adequate power reserves was chosen.

The following factors contributed to the accident:
non-compliance with recognised performance limits
intervention by the flying instructor which was too late"

11 November 2010, Schweizer 269C HB-XYI (Final Report No. 2178): A trainee pilot who had just completed training as a private pilot was encouraged to complete additional training in order to improve his off-field landing skills, as well as regarding the initiation and conduct of autorotations. While on such a training flight with the flight instructor, the crew ended the flight with a spontaneous 180-degree autorotation, during which it was not possible to sufficiently reduce the rate of descent during the flare before landing. The helicopter made a hard landing and was seriously damaged. The pilots were unhurt. The accident investigation report states the following cause:

"The accident is due to the fact that the helicopter collided with the terrain after an unsuccessful autorotation exercise."

1.10.2 Female pilot

The female pilot had been in possession of a private pilot licence and the type certificate for the Bell 206 since 2001, and had been in possession of a commercial pilot licence since 2006. In 2007 she acquired the extension for mountain flight training. She had flown freelance for the air operator involved in the accident since 2006. The female pilot's full-time occupation was not in aviation. In the years directly before the accident, the female pilot primarily flew the Bell 206; sometimes she conducted flights on other types using dual controls, primarily the Eurocopter AS350. It should be noted that of her 600 hours of total flying experience, more than 350 hours are recorded as having been on dual controls.

The female pilot and the flight instructor had known each other for many years and often performed training and check flights together. In particular, she had completed the majority of her mountain flight training with the flight instructor. The female pilot's last proficiency check took place with the flight instructor on a Bell 206 on 4 May 2012. Her last flight before the flight involved in the accident was on 15 May 2012.

According to the available documents, the female pilot had not completed the newly introduced company-internal mountain check flight before the flight involved in the accident.

The female pilot conducted sightseeing and taxi flights for the air operator. She also regularly flew for private purposes. In view of the range of operations it can be concluded that having flown over the area many times the female pilot certainly knew the area around the site of the accident, although she had probably only flown in the area itself on training and check flights.

During the week of the accident, the female pilot worked the following hours at her regular job: Monday and Tuesday from 07:30 until 17:00, on Wednesday from 07:30 until 15:30, and on Thursday (the day of the accident) from 07:30 until 15:00.

1.10.3 Male pilot

The male pilot had been in possession of a private pilot licence and the type certificate for the Bell 206 since 1991. A little later in 1991 he acquired a commercial pilot licence with the rating extension for landings in mountainous area. He had flown freelance for the air operator involved in the accident since 1991. The male pilot's full-time occupation was not in aviation. In the years directly before the accident, the male pilot had flown almost exclusively on the Bell 206.

The male pilot and flight instructor had known each other for many years and had often performed check flights together. The male pilot's last proficiency check took place with the flight instructor on the Bell 206 on 1 March 2012. His last flight before the flight involved in the accident was on 16 May 2012.

On 17 June 2011, the pilot completed the mountain check flight which had been newly introduced on 1 June 2011 with the flight instructor. According to the completed check form, this flight was made with helicopter HB-XPQ from the Bern-Belp base and included, in addition to landings on official mountain landing sites in the "Petersgrat" area, an approach on a landing site below 2000 m AMSL in the area around the "Suldtal", a valley parallel to the Kiental. The exact location of this landing site is unknown. According to the check form, the flight instructor's decision on an approach on this landing site was negative due to a non-fulfilled criterion (*"14 Decision (landing / go around)")* (cf. Annex 2); in the comments he added *"Cable*". In the general comments at the end of the form he added: *"Professional flying. Use and listen to your Floice!"*

The pilot conducted sightseeing, taxi and photography flights for the air operator. He also flew regularly for private purposes. In view of the range of operations it can be concluded that having flown over the area many times, the male pilot certainly knew the area around the site of the accident, although he had probably only flown in the area itself on training and check flights.

1.11 Medical and pathological information

The bodies of the three crew members were subjected to autopsy.

In the case of the flight instructor it was not possible to determine any pre-existing diseases or pathological changes which might have caused or influenced the accident.

In the case of the female pilot it was possible to determine a minor pre-existing heart defect, namely connective tissue proliferation in the cardiac muscle. This could lead to sudden cardiac arrhythmia and consequently loss of consciousness or even death. It was not possible to determine whether such a heart rhythm disorder actually occurred.

The male pilot was found to have mild to moderate calcification of the coronary arteries. The consequent narrowing of the coronary arteries could lead to a relevant circulatory disorder in the area of the cardiac muscle, which could cause loss of consciousness or even death. It was not possible to determine whether such a circulatory disturbance actually occurred.

Tests for alcohol, sleeping pills, tranquillizers and psychotropic drugs were negative for all crew members.

The severe injuries caused by the impact resulted in almost immediate death in the case of all crew members.

The results of the autopsies mean that it is very likely that the female pilot was sitting in the right pilot seat at the time of the accident.

1.12 Company-internal mountain check flight

1.12.1 Background and introduction

As already mentioned, due to various accidents involving aircraft belonging to the air operator Heliswiss between 2008 and 2011 the insurance company and the FOCA demanded measures to be taken. On 1 June 2011 the air operator issued regulations including the provision that both private and freelance professional pilots who wished to conduct off-field landings, i.e. landings not at airports or heliports, would have to complete an annual internal check flight on which such landings were performed. The operator referred to this check flight as the "off-field landing check". Pilots who wanted to conduct off-field landings on mountain landing sites also had to complete an annual mountain flight check as part of internal training. It was possible to complete the off-field landing check while on the mountain flight check.

As already mentioned, the flight instructor had developed a separate form to certify these check flights (cf. Annex 2). In an e-mail of 9 June 2011 to his flight instructor colleagues, to which the newly created form was attached, the instructor wrote:

"Please take sufficient time for check flights. Your focus should not only be on aeronautical skills but also on decision-making – this should under no circumstances be neglected."

The form was filled out during the flight and archived after the flight. This form was largely based on the official FOCA form for certifying the test for acquiring the mountain flight training extension. In particular, the form envisaged two landings to be performed at sites between 1100 m AMSL and 2000 m AMSL and three landings at official mountain landing sites. According to the law, in the context of training flights, landings at up to 2000 m AMSL may be performed at a site of choice (with a few restrictions), while landings at over 2000 m AMSL may only be made at official mountain landing sites. These are published in the AIP under VFR AGA 3-3-1 to 3-3-3.

1.12.2 Operations Manual

The flight school's Operations Manual (OM), Revision No. 6 of 1 December 2011 did not contain any information about these company-internal mountain check flights.

1.12.3 Flight programme

There was no standard programme for check flights. According to the statement of a flight instructor colleague of the flight instructor, each instructor developed a certain preference for individual landing sites during the course of his/her work. He also made the following statement:

"Usually three to five sites are approached: two below 2000 m AMSL and three above 2000 m AMSL. These sites are individually inspected with the candidate in advance. The candidate is either given the coordinates in advance or the landing sites are discussed on the day of the examination in an extended briefing. I would like to emphasise that this is the way I do it. I was never involved on such an MOU check flight with [name of instructor].*"*

From Belp, approaches are primarily made around the Blüemlisalp and Petersgrat. Furthermore, the Gurnigel/Gantrisch area, Diemtigtal and the Kiental region are interesting for approaches below 2000 m AMSL because the cable issue can be addressed in these areas. These areas are also on the route to the Blüemlisalp."

He said that he knew of two landing sites suitable for approaches in the area of the accident. One was the "Latrejefeld" (1994 m AMSL); the other was the "Glütsch" (1940 m AMSL (cf. Annex 1)). The latter had been shown to him by the flight instructor, who had e-mailed him coordinates.

1.12.4 Implementation in practice

Several pilots were interviewed at random to clarify the implementation of the company-internal mountain check flights in practice. The pilots interviewed comprised four commercial pilots who also flew freelance for the air operator, some of whom were more experienced and some of whom were less experienced than the two pilots involved in the accident in terms of total flying experience. The interview also included two private pilots who were less experienced than the two pilots involved in the accident in terms of total flight experience.

All of these pilots had completed the internal mountain check flight in the period between its launch on 1 June 2011 and the accident on 24 May 2012 with the flight instructor; one of the pilots had even completed it twice.

The interview provided the following overview in relation to planning and preparation:

- In none of the cases were the candidates notified of the landing site to be approached in advance by e-mail or telephone.
- The candidate usually met the flight instructor and discussed the landing sites to be approached approximately one hour before the flight. This always included official mountain landing sites and in most cases, also included sites below 2000 m AMSL. The candidate would then make independent pre-flight preparations and in particular study the landing sites below 2000 m AMSL to be approached on the air navigation obstacle chart, which would subsequently be used for navigation during the flight. Immediately prior to the flight, the flight instructor would refer to it and there would be a briefing on all essential points.
- There were also cases where only the approximate area and the official mountain landing sites were discussed prior to the flight, but not the landing sites below 2000 m AMSL. The flight instructor would then determine these spontaneously during the flight.

Compliance with the programme:

- The programme was sometimes flown as discussed, without spontaneous change during the flight. This was usually the case with private pilots.
- Sometimes the flight instructor would spontaneously determine additional sites below 2000 m AMSL. This was primarily in cases where no preliminary discussion of these sites had taken place. This was usually the case with commercial pilots.

Selection of landing sites below 2000 m AMSL:

- According to the candidates the flight instructor was familiar with every landing site which was actually approached.
- Most of the selected landing sites were on small knolls or ridges and were not critical with regard to air navigation obstacles.
- There were certain landing sites, typically near mountain huts, which were not uncritical in terms of air navigation obstacles and required corresponding approach tactics.
- None of the landing sites were in an area known for being "heavily affected by cables”.
- The only landing site mentioned in the immediate vicinity of the site of the accident was on the "Uf der Schöni" site (cf. Annex 1). The "Latrejefeld" and

"Glütsch" landing sites were not mentioned. No landing sites were indicated deep within the "Spiggegrund" valley or its side valleys.

Approaches on spontaneously determined landing sites:

- According to the candidates the flight instructor was familiar with every landing site.
- During reconnaissance flights, candidates sometimes had to identify or address obstacles around the landing site. In other cases the flight instructor intervened and pointed out the obstacles.
- No landing site was approached without prior discussion of air navigation obstacles around the landing site.
- One pilot reported that in certain cases landing on the specified landing site was not possible. The instructor wanted to provoke the candidate to make a corresponding decision.

Aids used:

- When landing sites had been previously discussed, they were transferred to the appropriate air navigation obstacle chart. Flight navigation was then based on this chart.
- Spontaneously selected landing sites were usually approached without consulting the air navigation obstacle chart.
- Some flights were made without any chart displaying air navigation obstacles.
- If the Floice system was installed and available for use, (cf. Section 1.13.4) it was always switched on during the flight.

Demonstrations in relation to air navigation obstacles:

- The flight instructor made no demonstrations in relation to air navigation obstacles during the check flights.
- During the training, nearly all candidates, even at the private pilot stage and especially during mountain flight training, had experienced demonstrations relating to air navigation obstacles by the flight instructor or another instructor.
- This could include searching for and identifying hazardous cables, or demonstrating the poor visibility of cables.
- The cable issue was a subject on virtually all flights. The instructor placed great emphasis on raising candidate awareness with regard to this issue.

General flight operations:

- According to the candidates, the instructor was very aware of how to challenge them according to their skills and let them approach on demanding landing sites.
- The candidates maintained that the flight instructor always had everything under control and was always particularly clear about the current position.
- Some candidates, especially the professional pilots, believed the flight instructor wanted to prepare them for situations which were unexpected, but realistic in commercial operation. They explained that although he often encouraged and provoked pilots into making decisions, the final decision always remained with him.

1.13 Aids and safety nets to protect against collisions with cables

1.13.1 Wire strike protection system

A wire strike protection system (WSPS) is a passive safety device which serves to protect against accidents caused by collisions with cables.

A WSPS consists of two blades (a lower cutter and an upper cutter), which are mounted on the canopy roof and below the airframe, and a deflecting rail, which acts as a reinforcement and a guide rail for any wire it hits (windshield deflector). This rail is mounted along the central strut of the windshield. It directs the wire into the upper or lower cutter, where it is severed (cf. Fig. 10).

However, the wire strike protection system does not offer comprehensive protection because the circumstances surrounding a collision with a wire, e.g. the attitude of the helicopter, collision angle, airspeed and the nature of the cable, play a significant role.

According to information from the WSPS manufacturer, the wire strike protection system is effective in the following situations:

- Forward speed: 24 km/h to 96 km/h
- Impact angles between flight path and wire: 60° to 90°
- Attitude of the helicopter: -5° to 5° (nose down / nose up)
- Cable span: up to 61 m
- Critical wire diameter:10 mm (1 x 7 steel strands)
- Yaw angle at impact: 30° at 24 km/h or 15° at 96 km/h

The HB-XPQ helicopter was not equipped with such a system. This was not prescribed.

Figure 10: Bell 206 with WSPS. Upper cutter (1), windshield deflector (2), lower cutter (3).

1.13.2 Air Navigation Obstacle Maps

The Federal Office of Topography in cooperation with the FOCA and the Swiss Air Force publishes the Swiss Air Navigation Obstacle Map series on a scale of 1:100,000. This includes features such as air navigation obstacles according to the FOCA database at the time of printing. The content of the charts is updated when they are reprinted (approximately every 18 months). Periodic updates are published for manual updating.

Similar representations are also available in various electronic formats.

There are no indications that the crew of HB-XPQ had appropriate charts or printouts during the flight involved in the accident.

1.13.3 Chart display device

An electronic chart display device is a GPS-based navigation system which displays the current position of the aircraft on a chart on a screen in the cockpit. The type of chart can be selected from a set of saved charts, e.g. aeronautical charts, topographical charts or aerodrome approach charts.

The system also offers the option of saving an electronic air navigation obstacle database, which can be updated periodically. The obstacles stored are then superimposed onto the selected chart. The crew can therefore access a graphical representation of the position of the aircraft relative to the recorded obstacles at any point during a flight.

This type of system was not installed on helicopter HB-XPQ. This was also not prescribed.

1.13.4 Floice

The Floice collision warning device is a further development of the Flarm and provides warnings when there is a risk of collision with either other aircraft which are also equipped with appropriate devices (Flarm or Floice), or fixed air navigation obstacles, which are stored in a data base and can be updated periodically. The device uses the position and the current velocity vector of the aircraft on which it is installed, which is determined using GPS, as well as corresponding data from other aircraft and the fixed coordinates including the elevation of obstacles in the database.

According to the pilot manual for the device, warnings of obstacles are provided as follows:

"Points of collision with obstacles are calculated using tangents to the current flight path. The reported obstacle is therefore always in the direction of current movement. Only the most hazardous current obstacle is reported.

Reports of obstacles have the following format:

<Warning tone> "Obstruction/Obstacle" <Distance>

Different warning tones are generated depending on the warning time to the calculated point of collision:

- *10 seconds or less:* *Siren tone*
- *10 to 19 seconds:* *Two beeps*
- *19 to 28 seconds:* *Beep*

The distance is reported in hectometres: "One" is equal to 100 m, "Four" signifies 400 m. (...) Distances less than 50 m are not reported. Distances are rounded (...)."

The aural warning is fed into the intercom. The warning is also displayed on the device visually via the LED.

Such a system was usually installed on helicopter HB-XPQ, but was not present on the flight involved in the accident. Its installation was not prescribed.

1.14 Floice system of the HB-XPQ helicopter

1.14.1 Background

A Floice collision warning device was usually installed on helicopter HB-XPQ. As part of the revision of the helicopter which took place shortly before the accident (cf. Section 1.7.3) the device had been removed and installed on another helicopter, whose Floice was defective. The defective device was then sent to the manufacturer for repair. After repair the device was returned to the air operator in order to be installed on HB-XPQ after the revision.

During the reinstallation and the subsequent test in the hangar the device gave the aural warning *"NO GPS"*. The relevant employee, who was not an avionics technician, thought the device was defective and therefore removed it in order to send it back to the manufacturer.

The device was therefore not available on the flight involved in the accident.

1.14.2 Function check and reconstruction flights

The removed device was secured after the accident and subjected to an initial ground-level and on-board function check. It was not possible to determine any malfunction.

According to the manufacturer, the message *"NO GPS"* is a normal status message, since the loss of the GPS position can be caused by different influences and the position can subsequently be rapidly re-acquired. This is not described in detail in the manual.

In order to check whether having the device on board the flight involved in the accident could have prevented the collision with the cable, reconstruction flights were conducted in the area of the accident in May 2013. The following findings were made:

- The Floice which was intended for HB-XPQ functioned properly during the test manoeuvres.
- The device responded sensitively to changes in the flight vector and issued warnings only when the current flight vector indicated an obstacle (or the corresponding saved coordinates and elevation) and that a collision would occur within the corresponding warning time. The warning times for the first warning during the reconstruction flight manoeuvres flown were always above an approximate minimum of 10 seconds.
- When following the probable flight path of HB-XPQ in the final phase of the flight involved in the accident (cf. Annex 1) at slightly different altitudes, flight paths and speeds, a timely warning was provided in relation to the cable involved in the accident upon both entering and leaving the "Eggbach" valley.
- It was not possible to determine an overflow of warnings when following the probable flight path of HB-XPQ in the final phase of the flight involved in the

accident. Such an overflow is in principle conceivable due to the large number of obstacles in the area of the accident.

In summary it can be stated that the device provided warnings in relation to the cable involved in the accident which were timely, reliable and sensitive to the current flight vector.

1.15 Additional information

1.15.1 Minimum flight altitudes

The Swiss ordinance on traffic rules for aircraft (Verordnung über die Verkehrsregeln für Luftfahrzeuge) stipulates a minimum elevation of 300 m above ground level for VFR flights over densely populated residential areas or major event arenas, and a minimum altitude of 150 m above ground or water level in other places.

If necessary, the minimum flight altitudes may be violated for the departure and landing needs as well as for helicopter training flights outside of densely populated residential areas.

1.15.2 Possible landing at the "Latrejefeld" site

The day after the accident a helicopter search was made in the area of the "Latrejefeld" landing site (cf. Annex 1) for any evidence of a landing made by HB-XPQ. The terrain was still partially covered in snow, so any landing which had been made in the snow would have been clearly visible. However, it was not possible to identify any traces of an actual landing.

1.15.3 Campaigns by the Federal Office of Civil Aviation

The FOCA has published various leaflets, information and posters in order to raise pilot awareness of the danger of collisions with cables.

In 1972 the leaflet "Pilots - Warning, Cable!" was published.

In October 2008, the FOCA published the document SWANS-LL-2008-002 "Beware of Cables" as part of the "Lessons Learned" from the Swiss Aviation Notification System (SWANS). Its conclusion included the following: [Bold in original]

"While the various measures have succeeded in promoting awareness of the problem, too many incidents nonetheless continue to occur. In view of this, the FOCA has decided there is further need for action, and has launched a safety awareness campaign based on a poster intended to draw the attention of the various players in the civil aviation sector to the existing risks. In this way the FOCA wants to make a significant contribution towards the reduction of the potential dangers posed by cables and wires. The message is as follows:

Minimise the risk of a collision with cables by obtaining vital information, making adequate flight preparation, keeping your eyes open and adopting appropriate flight tactics!"

This was followed by a corresponding poster campaign.

2 Analysis

2.1 Technical aspects

2.1.1 Helicopter

There are no indications of any pre-existing technical defects which might have caused or influenced the accident.

Rub damage which was found inside the compressor and on turbine wheels indicate that the engine was running at the time of impact. The indentation in the rear section of the combustion chamber can be ascribed to the impact. Thus, there is no evidence that the engine was not working properly up to the time of impact.

The somewhat prominent damage to the coupling housing of the main drive shaft is certainly consistent with the sequence of the accident. Although it is in principle possible that a bolt was forgotten or a nut was not fully tightened during the extensive revision work on the helicopter shortly before the accident, this seems unlikely considering the fact that the helicopter had been functioning properly for several hours.

The traces of the wire cable which were identified at various points over the entire length of the main rotor blades and the traces on one of the pitch links suggest that the rotor blade tips of the helicopter collided with the cable and that this then shifted towards the centre of the rotor. This resulted in deceleration and deflection of the helicopter from its flight path, as well as clockwise torque about the vertical axis. This would explain the pronounced lateral movement (side slip) of the helicopter which was observed, the *"rocking"* movements just before the crash and the flight path (cf. Annex 1). As a result of the collision, the helicopter became uncontrollable and crashed.

The position in which the throttle twist grip was found after the accident may be explained by the possibility that the crew reduced power when the helicopter experienced considerable turning moments after the collision with the cable. Another plausible explanation is that the twist grip was forced to this position during the ground impact. In contrast, due to the topography, it seems unlikely that the crew deliberately closed the throttle for training purposes before the collision with the cable.

2.1.2 Wire strike protection system

If the main rotor blades collided directly with the cable, any wire strike protection system installed would have remained ineffective.

Given the large cable diameter of 14.6 mm, the effectiveness of such a system would have been fundamentally called into question.

2.1.3 Floice

The employee entrusted with the installation of the Floice device after the revision of the helicopter conducted the function check in the hangar. This meant that the Floice could not receive signals from GPS satellites and displayed the message *"NO GPS"*. The employee was not an avionics technician and apparently unfamiliar with the expected status warnings and messages, so the message led him to believe the device to be defective and remove it from HB-XPQ.

In the context of the investigation of the present accident it was not possible to identify any malfunction of the Floice device.

Furthermore, the reconstruction flights indicated that the crew were very likely to have received a timely warning of the impending collision with the cable involved in the accident if the Floice collision warning device had been installed and used on HB-XPQ.

2.1.4 Cableway

The longitudinal profile of the cable and the topographical conditions, not taking into account the remote location, mean that the cableway must be classified as dangerous for air navigation:

- The cable spans the valley floor and in the approximate middle of the valley reaches a maximum height above ground level of approximately 90 m.
- The mountain station is located in a gully in the terrain and is practically invisible from directions at right angles to the cable.
- The valley station cannot be seen when entering the valley from the Spiggegrund, as it located behind trees.
- The cable itself is practically invisible when approaching from an approximately horizontal position.

The cableway was listed in the FOCA air navigation obstacle register, the Air Navigation Obstacle Map and the corresponding electronic databases. This was in accordance with the LFHR guidelines.

The cableway was unmarked. According to the FOCA approval of 1 July 2008, no requirements were made of the owners of the cableway in relation to markers. According to Section 4.2.2 of the LFHR, an obstacle with an indicated maximum height above ground level of 100 m or an actual height above ground level of approximately 90 m should have been fitted with a marker (this was not the case), unless in accordance with Section 4.1 of the LFHR it was shadowed by another obstacle (this was not the case) or its type, form and location meant it presented no hazard to air navigation.

The FOCA cannot substantiate how it came to this decision.

As stated above, the cable involved in the accident was a hazardous air navigation obstacle which should have been marked if the LFHR had been consistently applied.

Fitting warning markers in accordance with Section 4.1 of the LFHR would have been moderately effective, as the valley and mountain cable car stations are poorly visible. Whether the accident could have been prevented by using such a marker cannot therefore be determined.

According to the FOCA, fitting a cable with warning markers serves to improve the visibility of an obstacle which the pilot is already aware of as a result of publications. However, such markers do not help per se to effectively show the run of a cable to the pilot.

Fitting polyester balls in accordance with Section 4.2.1. c) of the LFHR certainly would have been more effective. It is therefore likely that the accident could have been prevented by using such markers.

According to the FOCA, cableways up to a maximum height above ground of 100 m are only fitted with warning markers if markers are deemed necessary. Fitting of polyester balls would require the installation of a second cable in parallel to the cableway. This measure usually is not considered appropriate.

After the accident, the FOCA reassessed the cableway (cf. Section 4.2.2). Although the points considered by the FOCA at the time tend to underline the hazard presented by this obstacle, initially, no prescription was made in relation to marking. This assessment is difficult to comprehend.

2.2 Human and operational aspects

2.2.1 Flight preparations

There are no indications that the landing sites to be approached during the check flight had been communicated to the two pilots prior to the flight. The flight instructor did not believe this was necessary.

He generally announced the landing sites to be approached in an extended briefing immediately before the flight. The fact that the refuelling of the helicopter and the change of pilots between the two mountain check flights took place with the engine running means that such a briefing could not have been possible for the accident flight. This suggests that the landing sites were determined spontaneously by the flight instructor during the flight.

The lack of a briefing made it impossible for the two pilots to adequately prepare for the flight with regard to the landing sites and in particular the specific air navigation obstacles. Though the flight preparations which the female pilot left at the base were essentially complete, the lack of information regarding the landing sites meant the flight preparations could not extend to air navigation obstacles potentially present in the vicinity of the landing site.

2.2.2 History of the flight

Based on the observations by the eyewitnesses, the timing and the findings at the site of the accident, the following general sequence of the flight seems plausible, taking into account operational aspects:

After take-off from Bern-Belp, landings were first performed below 2000 m AMSL with the male pilot at the controls. Whether other landings were made on the journey from Bern-Belp to the "Uf der Schöni" or other landing sites cannot be determined. Following the approaches in the area of the "Uf der Schöni" the crew flew to the "Blüemlisalp" area, where they conducted landings above 2000 m AMSL with the female pilot at the controls.

The change between the male pilot and the female pilot took place at one of the mountain landing sites in this area, probably shortly after 17:00. It is likely that this change took place with the engine running.

The first actions following this changeover were landings above 2000 m AMSL in the "Blüemlisalp" area with the female pilot at the controls. The crew then flew to the "Uf der Schöni" site in order to continue with landings below 2000 m AMSL.

2.2.3 Conduct of the flight

The "Uf der Schöni" alp is a well-known landing site in this area and regularly used for landings. The landing site is located on a ridge and is not critical in terms of air navigation obstacles.

There is therefore no doubt that an approach on this site could also have been conducted safely by the two pilots without extensive preparation, especially since it has been demonstrated that the instructor was familiar with the site. Given the lack of a briefing before the flight, the flight instructor's selection of this landing site was appropriate to the situation. The selection is also in line with the impressions gained after the accident when interviewing pilots who had completed this check flight with the instructor.

The deep descent to the valley floor of the "Spiggegrund" which was observed meant that the crew entered a valley in which across-the-valley cable installations were feasible. The selection of such a flight path therefore represented an increased risk. This was reinforced by the fact that the area was known to be "heavily affected by cables" (cf. Annex 1). It is likely that all three crew members were aware of this.

The selection of such a flight path is surprising and raises questions:

Approaching other familiar landing sites in this area, e.g. the "Latrejefeld" or the "Glütsch" sites would have been tactically adequate, without the necessity to descend to the valley floor, and could therefore have been carried out without the risk of collision with a cable.

Given the lack of a briefing and the flight instructor's general selection criteria for landing sites, it seems unlikely that he intended to approach a landing site deep in the "Spiggegrund" or "Eggbach" valleys as part of the check flight.

Interviews were conducted with pilots who had also participated in this sort of check flight with the flight instructor. These interviews show that during check flights, the flight instructor did not make a habit of demonstrations with regard to obstacles. Therefore, it seems to be improbable that the flight instructor, for the purpose of further training, wanted to demonstrate something towards the end of the check flight.

The deep descent into the "Spiggegrund" valley could have been performed safely, provided that the crew were at all times aware of the current position of the helicopter relative to the numerous air navigation obstacles in the area. Since the flight instructor had a profound knowledge of the area, which is likely to have included the local air navigation obstacles situation, this provision had in principle been satisfied. The two pilots' local knowledge was not comparably comprehensive. There is no evidence that the crew carried Air Navigation Obstacle Maps or electronic aids.

However, the flight path which was observed in the final stage indicates that the crew are unlikely to have been aware, upon flying into the "Eggbach" valley, of the presence of the cable which was subsequently involved in the accident. Based on the observations of the witness at the "Alti Weid" it can be concluded that HB-XPQ flew into the "Eggbach" valley very close to the cableway with which it subsequently collided. It is possible that the helicopter even flew under the cableway when entering the valley (cf. Fig. 1). A certain uncertainty with regard to the exact position of the helicopter from the perspective of eyewitnesses and the particular perspective means that it is not possible to conclusively determine whether the helicopter actually flew under the cable involved in the accident when entering the valley.

The flight instructor is very likely to have been aware of the cable. Nevertheless, he was apparently unaware of the current position of the helicopter with regard to the cableway, which meant a collision with the cable could occur. Research into accidents indicates that loss of situational awareness (often only for a short period of time) is not uncommon even among experienced professionals.

However, in descending well below the height of the ridge the crew without doubt selected a flight path which was subject to a fundamental risk of collision with a cable. However, it should be noted that the rationale for the descent cannot be determined.

2.2.4 Sun glare

Based on the observations of eyewitnesses and the course of the "Eggbach" valley, the helicopter was on a heading of approximately 220 degrees immediately before the collision with the cable (cf. Annex 1). It is therefore in principle possible that the crew were blinded by the sun, which was at that time approximately in the west.

However, clarification of the cloud situation in the area of the accident and to the west indicate that the sky was largely overcast and the sun obscured at the time of the accident. Glare therefore seems unlikely.

There was definitely no glare upon entering into the "Eggbach" valley as the sun was initially to the left of the crew and then behind them and to their left.

The cableway is barely visible even without glare. In order to safely avoid a collision with the cable it is necessary to know where the cable is. Purely visual detection is possible only by chance.

2.2.5 Medical aspects

Given the flight path which was observed in the final stages and the positioning of the flight instructor in the front-left pilot seat, it is unlikely that the pathological findings of the autopsies on the two pilots played a role in the accident.

2.2.6 General conditions

The flight instructor’s various management functions within the air operator and the affiliated flight school organisation, as well as his regular and intensive activities as a flight instructor, examiner and pilot led to a chronically high workload. This was accentuated in the period before the accident due to the planned transfer of the company to the new parent structure.

Furthermore, there was a relatively long commute, which took additional time.

The planning of the flight involved in the accident indicates how difficult it was for the instructor to meet all his commitments. The departure of the flight involved in the accident without a briefing and refuelling with the engine running illustrates the flight instructor's tight schedule.

Although it is not possible to establish any direct causal relationship to the accident and all persons interviewed believed the flight instructor's method of working to be competent and safe, from the perspective of flight safety the instructor's chronically high workload undoubtedly led to the inherent risk of long-term fatigue.

On the day of the accident, the female pilot left her regular job about one hour before the beginning of the accident flight. The documented working hours for the day of the accident as well as for the days preceding this day do not indicate that the female pilot commenced the accident flight in a fatigued state.

3 Conclusions

3.1 Findings

3.1.1 Crew

- The pilots were in possession of the necessary licences for the flight.
- It is unlikely that disease-related inflight sudden incapacitation of the pilots can explain the accident.

3.1.2 Technical aspects

- There are no indications of any pre-existing technical defects which might have caused or influenced the accident.
- The mass and centre of gravity of the helicopter were within the manufacturer's specified limits throughout the flight.
- An emergency transmitter had been installed, but was destroyed during the accident.

3.1.3 History of the flight

- The flight instructor was in the left pilot seat throughout the flight.
- The helicopter took off from the Bern-Belp base at approximately 16:17 with the male pilot at the controls.
- The helicopter was subsequently observed conducting two landing approaches in the area of the "Uf der Schöni" alp.
- The helicopter then flew towards the "Blüemlisalp" massif.
- The change between the male pilot and the female pilot took place at one of the mountain landing sites in this area, probably shortly after 17:00.
- The helicopter returned from the "Blüemlisalp" area 20 to 30 minutes after the first approach sequence in the "Uf der Schöni" area.
- Two more approaches were then conducted on the "Uf der Schöni" alp.
- The helicopter then descended into the "Spiggegrund" valley and first flew along the southern side of the valley into the valley.
- A little later, the helicopter returned to the northern side of the valley and flew into the "Eggbach" valley.
- When entering the "Eggbach" valley the helicopter flew close to the cableway with which it subsequently collided. It is possible that the helicopter even flew under the cable.
- Approximately three minutes later the helicopter reappeared out of the "Eggbach" valley.
- It was here that the helicopter collided with the support cable of the goods cable car which ran from the "Eggmatti" to the "Eggburgli".
- The cable, which had a diameter of 14.6 mm, was severed.
- As a result of the collision, the helicopter became uncontrollable and crashed.

- An impact fire developed.
- All three crew members were fatally injured.
- The helicopter was destroyed.

3.1.4 General conditions

- The flight was an company-internal mountain check flight for the air operator.
- The female pilot and male pilot were completing this check flight on a joint flight.
- There are no indications that the landing sites to be approached had been communicated to the two pilots prior to the flight.
- No briefing took place before the flight.
- After the flight instructor had returned from the previous check flight, the helicopter was refuelled with the engine running.
- A Floice collision warning device was usually on board the helicopter but was not present during the flight involved in the accident because it was considered defective and had therefore not been installed.
- The function check performed after the accident indicated that the Floice device in question was functioning.
- If a Floice collision detector had been on board and used, it is likely that it would have provided timely warning of the impending collision with the cable.
- The cableway was listed in the air navigation obstacle register with a maximum height above ground of 100 m; it was also indicated on the Air Navigation Obstacle Map.
- The maximum height above ground level of the new cable installed after the accident is approximately 90 m and is located near the middle of the valley above the stream.
- The cableway was unmarked.
- The FOCA made no requirements of the owners of the cableway in relation to markers.
- If the air navigation obstacle guidelines (LFHR) had been consistently applied the cableway would have had to be marked.
- The cableway was difficult to detect from the air.
- It is very likely that the point where the cable was severed corresponds to the point of collision between the main rotor blades of the helicopter and the cable. The point where the cable was severed was located at approximately 1770 m AMSL, approximately 70 m above ground level.
- There is no evidence that the crew carried Air Navigation Obstacle Maps or electronic aids.
- The flight instructor had a profound knowledge of the area.

- It is very likely that the flight instructor was aware of the cable involved in the accident.
- The instructor held various management positions at the air operator and the affiliated flight school organisation.
- In addition, he worked regularly and intensively as a flight instructor examiner and pilot, and was entrusted with additional tasks as part of the restructuring of the company.
- The weather conditions had no influence on the accident.

3.2 Causes

The accident is attributable to the fact that the helicopter collided with the support cable of goods cableway and subsequently crashed. The cableway was registered in the air navigation obstacle register but unmarked.

The following factors were identified as causal:

- Lack of situational awareness on the part of the crew with regard to the air navigation obstacle.
- Selection of a flight path which was subject to risk given the conditions.
- Lack of Floice collision warning device.

The following factors contributed to the accident:

- Lack of a pre-flight briefing, leading to an incomplete flight preparation.
- Lack of markers of any kind on the cableway.

The following factor was established as neither causal nor directly contributory but was recognised as a factor to risk:

- Chronically high workload of the flying instructor.

4 Safety recommendations and measures taken since the accident

According to the provisions of Annex 13 of the ICAO, all safety recommendations listed in this report are intended for the supervisory authority of the competent state, which has to decide on the extent to which these recommendations are to be implemented. Nonetheless, any agency, any establishment and any individual is invited to strive to improve aviation safety in the spirit of the safety recommendations pronounced.

Swiss legislation provides for the following regulation regarding implementation in the Ordinance on the Investigation of Aircraft Accidents and Serious Incidents:

"Art. 32 Safety recommendations

1 DETEC, on the basis of the safety recommendations in the SAIB reports and in the foreign reports, shall address implementation orders or recommendations to the FOCA.

2 The FOCA shall inform DETEC periodically about the implementation of the orders or recommendations pronounced.

3 DETEC shall inform the SAIB at least twice a year on the state of implementation by the FOCA."

4.1 Safety recommendations

None.

4.2 Measures taken since the accident

4.2.1 Air operator

After the accident the functions which the flight instructor had held were distributed among several people.

4.2.2 Federal Office of Civil Aviation

Shortly after the accident, the FOCA investigated whether the cableway should be fitted with markers after installation of the new cable. After taking into account the local conditions of the installation, the topographical situation and the longitudinal profile of the cable, the decision was made not to change the decision of 1 July 2008, according to which no marker was necessary.

With respect to the longitudinal profile of the cable and the topographical situation, the following aspects were taken into consideration for this decision, according to the FOCA:

- Maximum height above ground level in reality less than 85 m
- Height of 50 m above ground level for less than 50% of the total cable length
- Special cable geometry without intermediate mast, with upper cable section in a gully in the terrain and low height above ground level
- Mountain station far from the cable section with the maximum height above ground level, row of trees to the south of the valley station
- Valley and mountain stations easily locatable from the air, based on the publications

According to the FOCA, there was also an assessment of any possible benefits of installing cable warnings at the valley and/or mountain station in order to facilitate the recognition of the cable from the air. It was assumed that pilots would already be aware of the obstacle via a publication (air navigation obstacle chart, MovingTerrain, etc.).

In this context, the FOCA emphasised the crucial role of publications in ensuring that pilots are informed of obstacles which must be taken into consideration during the flight as early as the flight preparations stage.

The FOCA also states that the assessment of the hazard an obstacle presents to air navigation and any associated requirements imposed by the FOCA are always based on expert judgement.

In April 2013 new guidelines for air navigation obstacles entered into force.

These new guidelines do not include any significant changes from the LFHR of 1993 with respect to the marking of goods cableways outside urban areas. In particular, the guidelines stipulate that goods cableways with a maximum height above ground level in excess of 60 m must be fitted with cable markers at the valley and mountain stations and on any masts. For a maximum height above ground of 100 m, or in the case of a particular hazard, the guidelines stipulate that a separate marker cable should be fitted with orange balls.

Deviations from these safety measures are possible in special cases and will be specified by the FOCA by means of a ruling.

In August 2014, after the draft of the final report at hand had been made available to the FOCA, the FOCA once again conducted an assessment of the cableway. This time, the assessment was based on the new guidelines for air navigation obstacles of 2013. The FOCA came to the conclusion that, due to the slightly stricter wording of the new guidelines, warning markers have now to be placed at the valley and the mountain stations, respectively. However, the FOCA still has the opinion that such markers would not have prevented the accident in the present case.

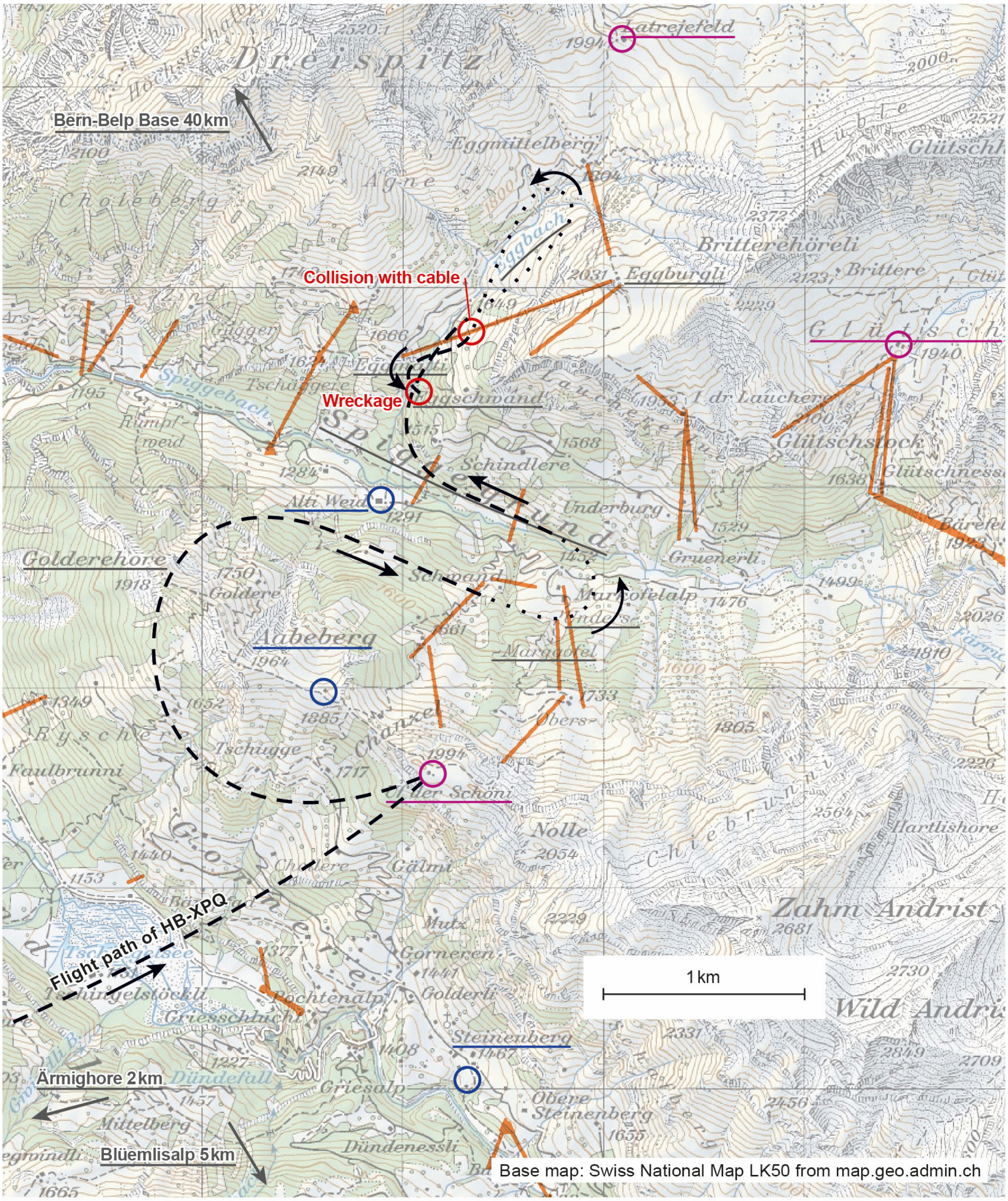
Payerne, 21 November 2014 Swiss Accident Investigation Board

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

Berne, 2 December 2014

Annexes

Annex 1: Map of the accident area



Unterstrichen	Geographic names mentioned in the report
– – – –	Flight path of HB-XPQ immediately before the accident, reconstructed according to eye-witness reports
· · · · · ·	Flight path of HB-XPQ unknown
○ (red)	Collision with cable, wreckage
○ (blue)	Eyewitnesses: herdsmen on the “Aabeberg“ alp, person at “Steinenberg“ alp, herdsman at the „Alti Weid“
○ (purple)	Landing sites: “Uf der Schöni“, “Glütsch“, “Latrejefeld“
▬ (orange)	Air navigation obstacles according to the obstacle database at the time of the accident

Annex 2: Company-internal mountain check flight form (back)

1. Flight Preparation

Documents	NO	YES
1 Pilot Certificate	☐	☐
2 Logbook	☐	☐
Checked	☐	☐

2. Meteorology

	-	+
1 Weather charts	☐	☐
2 Forcasts	☐	☐
3 Winds ant temp. up to 18'000 ft	☐	☐
4 Freezing level / altitude	☐	☐
5 Actual temperature vs. ISA	☐	☐
6 GAFOR	☐	☐
Grade (min 4 satisfactory)	☐	☐

3. Performance Calculation

Landind sites	Max. HOGE Mass	Max Fuel	-	+
Landing site 1			☐	☐
Landing site 2			☐	☐
Landing site 3			☐	☐
Landing site 4			☐	☐
Landing site 5			☐	☐
Grade (min 4 satisfactory)			☐	☐

4. Flight Information

	-	+
1 ATC Flight plan/ flight notification	☐	☐
2 Fuel calculation	☐	☐
3 100'000 Navigation charts with obstacles	☐	☐
4 AIP	☐	☐
5 NOTAM	☐	☐
6 KOSIF	☐	☐
7 Personal equipment	○	○

5. Flight Check

	Landing Sites < 2'000m				Mountain Landing Sites						
Landind Sites N°.	1 -	1 +	2 -	2 +	3 -	3 +	4 -	4 +	5 -	5 +	**Remarks:**
1 **Navigation**	○	○	○	○	○	○	○	○	○	○	
APPROACH BRIEFING											
2 Reco tactics	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
3 Wind direction and velocity	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
4 Ground obstacles	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
5 Ground illumination	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
6 Environment	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
7 OGE hover performances	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
8 Ground surface (slope, terrain structure, reference)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
9 Escape, missed approach	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
10 Downwind altitude	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
11 Flight tactics (pattern)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
12 Check for approach	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
13 Final check (vario)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
14 **Decision (landing / go around)**	○	○	○	○	○	○	○	○	○	○	
15 **Final APAC (vario)**	○	○	○	○	○	○	○	○	○	○	
16 **Touch down from hover**	○	○	○	○	○	○	○	○	○	○	
17 **Landing within 400m radius**	○	○	○	○	○	○	○	○	○	○	
18 Dep. briefing / check for dep.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
19 Take off to hover	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
20 Hover check	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
21 Standard departure	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
22 Aircraft limitations according to RFM	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
23 Flight tactics (appr. and depart.)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
24 Radio communications (position reports)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Grade (min 19 satisfactory of which 5 ○)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

6 General

	Poor	Marginal	Standard	High Standard
1 Flight tactics (inflight)	☐	☐	☐	☐
2 Airspace / collision avoidance	☐	☐	☐	☐
3 Emergencies	☐	☐	☐	☐
4 Slope Landings	○		○	
5 Smoothness of control	○		○	
6 Cockpit management	☐	☐	☐	☐
7 Regulations (transponder / cloud dist...)	☐	☐	☐	☐
8 Airspace C, D	☐	☐	☐	☐

Check Results [-] [+]

(All blocs +, All ○ Satisfactory)

Remarks:

Visa candidat:
Visum Kandidat:

Annex 3: Profile of the new cable installed after the accident