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Aircraft Accident Investigation Bureau AAIB

Final Report No. 1965 by the Aircraft Accident Investigation Bureau

concerning the accident

to the Bell 206B Jet Ranger III helicopter, HB-XQO

on 26 March 2005

Sustenlimi, Steingletscher, municipality of Gadmen/BE

approx. 45 km south-east of Lucerne

Bundeshaus Nord, CH-3003 Berne

Ursache

Der Unfall ist darauf zurückzuführen, dass der Helikopter bei diffusen Sichtverhältnissen mit hoher Geschwindigkeit mit dem schneebedeckten Gletscher kollidierte.

Folgende Umstände haben dabei eine Rolle gespielt:

- nicht erkannte Gefahren von wechselhaften Wind- und Sichtbedingungen in Bezug auf die Kontrollcharakteristik des Helikopters
- falsch beurteilte notwendige Leistungsverhältnisse

General information on this report

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

In accordance with Annex 13 of the Convention on International Civil Aviation of 7 December 1944 and article 24 of the Federal Air Navigation Law, the sole purpose of the investigation of an aircraft accident or serious incident is to prevent future accidents or serious incidents. The legal assessment of accident/incident causes and circumstances is expressly no concern of the accident investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

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

The German version of this report corresponds to the original and is authoritative.

All times in this report unless otherwise indicated, are indicated in the standard time applicable to the area of Switzerland (local time – LT), corresponding at the time of the accident to Central European Time (CET). The relationship between LT, CET and coordinated universal time (UTC) is: LT = CET = UTC + 1 h.

For reasons of protection of privacy, the masculine form is used in this report for all natural persons, regardless of their gender.

Contents

Final Report

Owner	Heli Partner AG, 8370 Sirnach, Switzerland
Operator	Heli Partner AG, 8370 Sirnach, Switzerland
Aircraft type	Helicopter Bell 206B Jet Ranger III
State of registration	Switzerland
Registration	HB-XQO
Location	West of Sustenlimi, 3086 m AMSL, Steingletscher, municipality of Gadmen/BE Coordinates 676 004 / 171 350 Geographical latitude: N 46° 41' 21" Geographical longitude: E 008° 25' 56''
Date and time	26 March 2005, 09:01

Summary

Synopsis

On the occasion of a commercial passenger transport of three ski tourists from Nessental 940 m AMSL in the municipality of Gadmen to the mountain landing site near Sustenlimi on the Steingletscher glacier, the helicopter collided with the terrain on the glacier plateau to the east, below the Gwächtenhorn. The pilot and the three passengers were fatally injured in this accident. Most of the debris was scattered over approximately 150 m along a ridge of snow, extending as far as the adjacent crevasses.

Investigation

The accident took place on Easter Saturday, 26 March 2005, at 09:01 in the morning. At 09:43 the REGA informed the stand-by emergency service of the Aircraft Accident Investigation Bureau (AAIB). After consultation with the AAIB, the bodies of those involved in the accident were recovered, because of the worsening weather conditions, by REGA and SAC rescue teams from 11:35 and flown to Meiringen hospital. The investigation was opened on site at 13:00 by the AAIB in cooperation with the Berne cantonal police. After an initial inspection of the accident site shortly after 14:00 and questioning at the Tierberglihütte, the inspection of the wreckage had to be aborted because of fog and snow. On Easter Sunday morning, 27 March 2005, the wreckage investigation continued and the helicopter's onboard documents were secured. In view of the weather, which was again worsening due to snowfalls, recovery of the wreck had to be deferred until Tuesday 28 March 2005.

The accident is attributable to the fact that the helicopter collided at high speed with the snow-covered terrain in diffuse visibility.

The following circumstances were factors:

- unrecognized hazards of variable wind and visibility conditions, with regard to the helicopter's control characteristics
- incorrectly evaluated performance requirement conditions

1 Factual information

1.1 History of the flight

1.1.1 General

The following information is based on the statements of the flight assistants, the mountain guide, day skiers or relatives of the victims.

1.1.2 Pre-flight history

In the spring of 2005, the pilot organised a heli-skiing day for interested friends and colleagues in the Sustenlimi area. In the period from January to February, he asked his acquaintances and, about two weeks before the flight, mountain guide B. was hired as a guide for the ski trips, via a mountaineering school.

On the Good Friday, the day before the accident, the helicopter was loaded onto a trailer at the base in Sitterdorf/TG for road transport to Erstfeld in the Reusstal. This arrangement was made by the managing director and chief pilot C and the sales and operations manager E of the company, both of whom were deployed the next day in the role of flight assistants for the pilot.

The weather decision was communicated to those involved at approximately 16:00.

Four of the 10 passengers scheduled for the later meeting point met at about 05:00 on the morning of the day of the accident when they arrived at the pilot’s wife’s house in eastern Switzerland and she informed them in greater detail about the day and conduct in and around the helicopter. They then made their own way to Nessental in the Gadmertal, from where the first heli-ski flights with the other passengers were to take off.

The pilot met the two flight assistants C and E at about 06:45 at the motorway rest area near Erstfeld in the Urnerland region, to determine a suitable take-off area.

The helicopter was readied at coordinates 691 871 / 188 191 in Erstfeld. The pilot himself carried out the pre-flight check. Before departure, the pilot discussed the operation with his two flight assistants C and E. This briefing included the schedule for the day, the radio channel, the locations and the equipment check.

The envisaged sequence was as follows: a transit flight to the Steingletscher landing area and dropping off the fuel cans, then an onward flight to Nessental and commencement of the passenger transport. After about three flights from Nessental onto the glacier, redeployment with flight assistant E to Steingletscher and then a further 2 to 3 flights from Steingletscher onto the glacier. Flight assistant E was responsible for boarding in Nessental and Steingletscher respectively, and flight assistant C for disembarkation at the destination point.

The pilot carried out the fuel planning; refuelling stops were scheduled only for the take-off location at Steingletscher and were to be advised by the pilot over the radio.

The equipment was checked: kerosene canisters, radios, clothing, straps for skis, ski bag, provisions and tickets.

The commercial radio on helicopter channel 2 was checked.

The pilot had also mentioned the weather. If the weather became bad, the event would be aborted immediately. Flight assistant C emphasized that no risks will be taken.

1.1.3 History of the flight

The Jet Ranger HB-XQO took off at approximately 07:45 from Erstfeld. The pilot and the two flight assistants C and E were on board. In addition to the material for the flights, 10 canisters of reserve fuel were also loaded: seven 20 litre canisters and three 30 litre canisters of kerosene. On departure, the helicopter's fuel tank contained 58 USG of kerosene. There was not much talking during the flight. A brief reiteration of the tasks to be performed at the first landing site was carried out. Apart from a few clouds, which, however, did not particularly affect the flight, the weather was not problematic. The aircraft was functioning perfectly. Flight assistant E thought: *"(...) with everything together, we were a bit heavy, but it wasn't a problem (...)"*.

The first landing took place at the mountain landing site, Steingletscher 675 420 / 176 025, on the Sustenpass road, which was still covered in snow and the 10 fuel cans and a drinks cool box were deposited. The next landing took place a few minutes later at the Nessental meeting point, at coordinates 666 150 / 174 800.

At this location, 10 passengers and the mountain guide were waiting, ready for the flight. They had met at 07:30. The mountain guide had used the time before the helicopter arrived to discuss once more with his guests the most important rules of conduct in and around the helicopter.

The helicopter arrived at approximately 08:00. The engine was not shut down; the pilot waited in the helicopter for the readiness report from flight assistant E. Loading of the aircraft for the first flight was started immediately. The sequence of passengers was not determined. However, it had been agreed that the heaviest people would not be transported first. The skis were packed in ski bags. Straps were used to secure the two bags to the left and right flight step, the upper frame of the helicopter's landing gear.

The first round trip began at approximately 08:10. The pilot, flight assistant C, the mountain guide and one guest were on board.

The mountain guide narrated: *"Overall, I felt the flight was normal. Only the duration of the flight seemed to me to be longer than I was used to. (...) I had the impression that the helicopter was at the limit of its performance. (...) We had been en route for about 15 minutes. We had a moderate headwind from the southerly direction (...) from Nessental via Taleggligrat, up to Tierberglihütte, direction of Sustenlimi. Precisely speaking, we intended to land to the east, below the Gwächtenhorn, at an elevation of about 3200* m AMSL*. In view of the poor visibility conditions, however, we had to turn away and flew in a loop, first in a northerly direction, and we then turned towards Sustenlimi, which we approached from the NW."*

Statement by flight assistant C: *"The pilot spoke with the mountain guide about the landing site. They jointly decided on this landing site. At the highest landing site there were patches of cloud. So it was impossible to fly to this site."*

The mountain guide stated: *"We wanted to fly to the higher site 3225, originally. As we flew up, because of the cloud at the site we decided on a landing on a direct approach near the Sustenlimi. The flag near the Tierberglihütte was flapping,* *indicating a wind from the south. I was sitting in the rear of the helicopter on the left. Regarding control by the pilot, nothing unusual struck me; I had the feeling that he was sure of himself. I didn't sense any abnormal vibration or suchlike. For example, when we crossed the Taleggligrat, the aircraft shook a little, but I considered that to be normal."*

The approach to the lower landing site near the Sustenlimi took place in a straight south-easterly direction without prior reconnaissance. Flight assistant C, the chief pilot with a rating for mountain landings and the managing director of the company, who was sitting in the front of the helicopter on the right on the first rotation, made the following statement regarding the performance characteristics on landing: *"The landing site was approached directly. The conditions were good. (...) We still had reserves. He landed with about 88 - 90%. (...) In the final phase, I opened the doors to assist the pilot with accurate height information. This was because of the hazy conditions.*

The mountain guide stated: *"We had a moderate wind when we got out".*

The pilot then flew back to Nessental on his own. There a further three passengers embarked for the trip to Sustenlimi, where the mountain guide was waiting with flight assistant C and one guest.

The mountain guide narrated:

"We waited there for about 20 minutes. (...) I heard the pilot report over the radio to flight assistant C, informing him that he would be with us in approximately 1-2 minutes. I then heard the sound of the rotors approaching from the Steingletscher. I still thought the helicopter would appear at any moment, but I couldn't see it anywhere. The pilot then radioed the flight assistant again, who was with us, enquiring about visibility. The flight assistant replied that visibility was not so good at the moment. From the noise of the helicopter I then got the impression that it was no longer approaching but presumably turning away. Shortly afterwards, the rotor noise broke off abruptly and I heard a kind of bang. (...) We had heard normal engine noise until there was a sudden dull, loud thud. (...) I was immediately aware that something must have happened. I then went up to the flight assistant, who was some distance away from us, to direct the helicopter, if necessary. (...) He then tried to call the helicopter several times, but got no reply."

On the same day, another heli-ski group was being conveyed in an AS 350 B3 helicopter to the upper landing site at the Eisenstange Pt 3225 m. The locations of the various persons providing information are shown in the general map (Annex 1).

The following statements were made by persons in this group.

Mountain guide below Pt c:

"I heard the Bell206 (the helicopter in the accident) and the (...) helicopter (B3) approaching from the direction of the Sustlihütte. The Bell206 then flew towards Sustenlimi, and the (...) helicopter (B3) to (HL). Above the step in the terrain, to the south-east of me, the bell disappeared from view. Strands of cloud again pushed in from the south over the Limi. A dull thud caused me to look up again, and I saw (...) a black fragment, from the origin of the bang, fly into the crevice below. I instructed my guests to leave for the ascending track for the Sustenhorn in direction (d) and to wait. I left for (e), where a German tour group was already raising the alarm. Soon I caught sight of (f) the site of the accident. (...)"

Ski tourist 3 between points c and d:

"(...) I was busy just then (...), when I heard an irregular engine noise from the helicopter and an extremely short strange tog-tog (splintering) noise. I turned towards the noise, to the right, and saw the cabin turn onto its back. I didn't see anything of the rotor. The helicopter crashed tail first into the depths with its underside towards us. It disappeared behind a ridge of snow. In this phase, the engine noise was slightly higher and a grinding noise was audible. After it had disappeared, I heard a slight dull thud and after that, absolute silence. About three minutes later, there was a smell of exhaust fumes and oil."

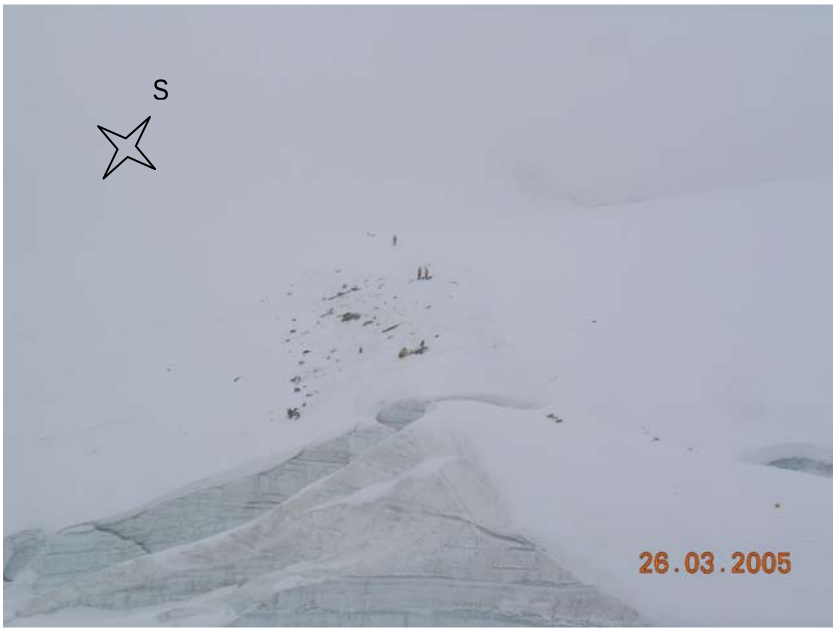
Ski tourist 1 between points c and d:

"(...) I saw a helicopter fly in a circle, I thought like our helicopter before it landed, and then concentrated on the boarding again. Then I heard a double bang and a noise like a rock fall or an avalanche. When I looked in that direction, I saw the helicopter falling headlong for about 2 seconds. The impact and the impact site were behind a hill and I never saw it."

Ski tourist 2 between points c and d:

"(...) It was striking that we had always heard a regular engine noise without rattling since we left the helipad. For about 4-5 minutes after we got out of the helicopter and made ready for departure."

Debris field from a distance of 800 m, 10:17 on the day of the accident



Debris field 3 hours after the accident, direction of view SSE

The helicopter collided with the terrain. All the occupants died immediately. The aircraft was destroyed.

1.2 Injuries to persons

Injuries	Crew	Passengers	Total number of occupants	Third parties
Fatal	1	3	4	---
Serious	---	---	---	---
Minor	---	---	---	---
None	---	---	---	---
Total	1	3	4	---

1.3 Damage to aircraft

The helicopter was destroyed.

1.4 Other damage

There was no other damage.

1.5 Personnel information

1.5.1 Pilot

Person	Swiss citizen, born 1962
Licence	Commercial pilot's licence, issued by the FOCA on 13.02.1995 21 PPL (H), issued on 13.10.1992, expiry date 26.10.2006 23 CPL (H), issued on 13.02.1995, expiry date 26.04.2005
Ratings	International radiotelephony for flights under visual and instrument flight rules RTI (VFR/IFR) MOU (rating for mountain landings)
Rated helicopter classes/types	AL III, B206/206L, EC 120B, R22
Last proficiency check	on 16.08.2004 cargo flight training ECS 1 completed
Medical certificate	Class 1, without restrictions
Last medical examination	19.10.2004
Commencement of pilot training	06.04.1992

1.5.1.1 Flying experience

Total	933:00 hours
on the accident type	786:00 hours
during the last 90 days	10:43 hours
of which on the accident type	10:43 hours
during the last 24 h	0:00 hours
of which on the accident type	0:00 hours

In September 1992, the pilot had passed a 27-minute practical private pilot's examination on the Robinson R22 helicopter after a total of 50 hours.

Conversion to the Bell 206 Jet Ranger then took place. The training for mountain landings was commenced at the same time, with a total of 51 hours, on 18 January 1993.

The pilot completed the conversion to the B206 on 2 March 1993, with approximately 66 hours in total, with an examination.

The total flying time for mountain landing training was 20 hours and was acquired on 32 different landing areas in 6 different regions.

On completion of mountain landing training on 3 August of the same year, 1993, the pilot had accumulated 94 hours.

156 landings were carried out on Switzerland's official mountain landing sites. Of these landings, 10 took place on the Sustenlimi.

On 6 February 1995,with a total flying time of 170 hours, the pilot passed the commercial helicopter examination in a 30-minute flight with the same expert as for the private pilot's examination.

Of a total of 3851 landings, 664 took place above 1100 m AMSL and were therefore nominally mountain landings. After the mountain training in summer 1993, the pilot had made only a few landings in high mountains.

According to his flying records, he had made a few landings in the Jet Ranger in April 1996 and in the Alouette III in August 2002 and March 2003 on the Sustenlimi mountain landing site. Flights to other higher mountain landing sites generally took place at the landing areas at the Hotel Steingletscher 1865 m AMSL, the Crap Sogn Gion 2230 m AMSL and the Hüfifirn 2945 m AMSL. In the logbook, some landings on the Jungfraujoch 3460 m AMSL and the pre-glacier were noted.

In the first half of 2004, he had completed cargo flight training, Stage ECS 1, on the Jet Ranger.

His experience was based primarily on the many tours often arranged by himself, in the Mittelland and the pre-Alps, and a few taxi flights.

The pilot was considered to be conscientious, precise, dependable and friendly. His flights were accurately documented. Flight reports and invoices since his helicopter training were filed in good order.

The pilot held the additional position of technical manager of the Heli Partner AG company.

1.5.2 Passengers

Person	Swiss citizen, born 1965
Person	Swiss citizen, born 1964
Person	Swiss citizen, born 1986

1.6 Aircraft information

Registration	HB-XQO
Aircraft type	Helicopter Bell 206B Jet Ranger III
Features	Five-seater single-engined turbine helicopter
Manufacturer	Bell Helicopter Textron Canada
Year of manufacture	1986
Serial number	S/N 3934
Owner	Heli Partner AG, 8370 Sirnach, Switzerland
Operator	Heli Partner AG, 8370 Sirnach, Switzerland
Engine	Rolls Royce, ALLISON CAE 250-C20J S/N 27031
Rotor system	Two-blade main rotor / two-blade tail rotor
Equipment	High skids, particle separator, snow deflectors, engine anti-ice, bleed air heater and defog
Operating hours, airframe	3441.5 hours

Operating hours, engine	3441.5 hours
Max. permitted take-off mass	3200 lb
Mass and centre of gravity	The helicopter's mass at the time of the accident was 2908 lbs – 2942 lbs. The centre of gravity was within the permitted limits.
Maintenance	The last 300-hour inspection was carried out on 09.06.2004 at 3242 hours. The last 100-hour inspection was carried out on 17.09.2004 at 3342 hours.
Fuel grade	JET A1 kerosene
Fuel remaining	35 USG – 40 USG on board; this corresponds to a flying time of approximately 1.5 hours.
Registration certificate	Issued by the FOCA on 01.09.2003
Airworthiness certificate	Issued by the FOCA on 22.05.1998, valid until revoked
Certification	VFR day commercial VFR night

1.6.1 Further information on engine maintenance

- The engine was fitted new into the helicopter airframe SN 3934 on 12 February 1986. From the logbook, it is apparent that after an engine removal on 2 September 1996, this engine was refitted in the same airframe on 17 September 1996 with total operating hours of 1713.15 hours.
- No anomalies were listed in the engine logbook at the time of the last 100-hour and 300-hour checks.
- The last documented engine maintenance took place on 27 February 2005. According to a logbook entry, both halves of the compressor housing were replaced at that time, the N1 and N2 rigging was checked and a heavy maintenance inspection (HMI) was carried out on the turbine.

1.6.2 Performance

The helicopter's mass at the time of the accident was 2908 lbs – 2942 lbs.

The following configuration as found was relevant to the performance calculation for the helicopter:

Allison 250-C20J, snow deflector/snow baffles, particle separator, engine anti ice (off), bleed air heater + defog (off), high skids

Definition of terms:

PA – *pressure altitude*

OAT – *outside air temperature*

HOGE – *hover out of ground effect*

HIGE – *hover in ground effect*

The calculation of the theoretical maximum possible flight mass of the helicopter produced the following results for the above configuration, according to the manufacturer's computer model:

PA 10190 ft, OAT – 6 °C:	HOGE 2851 lb	HIGE 4 ft	3261 lb*
PA 10660 ft, OAT – 7 °C:	HOGE 2810 lb	HIGE 4 ft	3214 lb*

* maximum take-off mass 3200 lb is limiting

These values take into account the pressure and temperature at the time of the accident, but represent conditions for calm wind conditions or for wind directions outside the critical range for this helicopter, shaded AREA B according to the flight manual (rotorcraft flight manual – RFM).

For conditions with wind, white AREA A according to the RFM (demonstrated controllability in sideward and rearward relative wind conditions up to 17 kts), the following theoretical maximum possible flight masses were calculated:

PA 10190 ft, OAT – 6 °C:	HOGE 2724 lb	HIGE 4 ft	3087 lb
PA 10660 ft, OAT – 7 °C:	HOGE 2685 lb	HIGE 4 ft	3042 lb

The accident took place in an altitude band between:

Map elevation Sustenlimi	3086 m AMSL, 10124 ft AMSL
Map elevation, accident site	3086 m AMSL, 10124 ft AMSL
Map elevation, upper landing site	3225 m AMSL, 10581 ft AMSL

The configuration basis used for the above calculation is described in the flight manual in the section entitled Flight Manual Supplement FMS – 10. The use of the relevant tables is explained in an example which is relevant to the present case:

"DETERMINATION OF PERFORMANCE VARIATION FOR DEFLECTOR KIT WITH PARTICLE SEPARATOR:

EXAMPLE (A): not applicable

EXAMPLE (B): When power condition curve is to the left of the altitude/temperature intersection, hover gross weight is 120lb less and rate of climb is 170 ft/min less than that shown for the particle separator only configuration. Refer to Particle Separator Engine Air Induction System (...) Performance Data for Power Check, Rate of Climb and Hover Capability charts.

POWER CHECK PROCEDURE

(...) With Deflector kit installed, reduce resulting Power Check torque by 3% to determine minimum torque available at a hover."

1.7 Meteorological information

1.7.1 General

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

The information in section 1.7.6 is based on eyewitness observations.

1.7.2 Aviation weather forecast for Saturday 26 March 2005

The aviation weather forecast for Switzerland for Saturday 26 March 2005, valid from 06:00 to 12 UTC, issued by MeteoSwiss:

General situation:

A trough of low pressure is approaching the Alpine area from the Atlantic. In the course of the day, an associated disturbance will reach Switzerland, bringing with it south-westerly high-altitude winds and more humid air masses.

Cloud, visibility and weather

North side of the Alps, Valais and all of Grisons:

Broken 5-7/8 base 7000-9000 ft AMSL, below this few 3-5/8 5000-7000 ft AMSL. Between these, also phases with little cloud, especially in the north-east. Initially areas of haze, especially in the central and eastern Mittelland. In western and north-western Switzerland especially, an increase in cloud and a lowering of the cloud base in the course of the morning. Isolated rain showers not excluded. Visibility 6 - 8 km, in the haze or rain 2 - 5 km.

South side of the Alps:

Initially, some haze. Otherwise, increasing clouds to 6-8/8 base 5000 - 7000 ft AMSL, in the mountains initially a higher cloud base. In the course of the morning, widespread rain setting in. Also a lower cloud base. Visibility 6-8 km, in central and southern Ticino initially 3-6 km, also reduced visibility in precipitation.

Wind and temperature, north side of the Alps (extract)*:*

Altitude	*Degr./kt*	*Temp*
Ground	*VRB/03*	
05000 ft	*210/015*	*PS05*
10000 ft	*210/020*	*MS05*
18000 ft	*240/018*	*MS22*
7600 ft	*Zero degree isotherm*	

Hazards:

- *locally reduced visibility in the Mittelland due to haze*
- *Alpine passes from the south increasingly in clouds*
- *on the south side of the Alps, some reduced visibility in rain showers*
- *on the north side of the Alps, especially in NW Switzerland, isolated rain showers in the morning not excluded*

Weather development until midnight:

In the north, continuing increase in cloud and gradually more widespread rain setting in. In the south, more precipitation.

GAFOR Switzerland VALID 06 - 12 UTC (extract)*:*

Route 53: X M X - Route Gemmipass (reference altitude 8200 ft AMSL)

Route 61: X M X - Route Grimselpass (reference altitude 7200 ft AMSL)

Route 72: X X X - Route Gotthardpass (reference altitude 7200 ft AMSL)

Route 83: X X X - Route Lukmanierpass (reference altitude 6500 ft AMSL)

1.7.3 Weather at the time and location of the accident

The following information on the weather at the time and location of the accident is based on a spatial and chronological interpolation of the observations of different weather stations.

Weather/cloud	*5-7/8 in several strata, main cloud ceiling approx. 8000 ft AMSL*
Visibility	*below main cloud ceiling 10-15 km,* *hazy visibility conditions possible*
Wind	*South-easterly wind at 10 kts, gusting to 20 kts*
Temperature/dewpoint	*-6 °C / -6 °C*
Atmospheric pressure	*QNH Zurich LSZH 1010 hPa* *QNH Lugano LSZA 1013 hPa*
Hazards	*Alpine crossings in cloud*

1.7.4 Astronomical information

Position of the sun	Azimuth: 103°	Elevation: 15°
Lighting	daylight	

1.7.5 Measured values of the automatic station network (ANETZ) and the complementary network (ENET)

Station	**Altitude (m AMSL)**	**07:40**	**07:40**	**08:40**	**08:40**	**09:40**	**09:40**
		TT	TdTd	TT	TdTd	TT	TdTd
Jungfraujoch	3580	-8,7	-9,2	-8,0	-8,4	-7,4	-8,4
Gornergrat	3130	-5,4	-9,0	-4,8	-6,4	-5,1	-6,6
Titlis	3040	-5,5	-8,2	-5,1	-8,1	-5,0	-6,4
Gütsch ob Andermatt	2287	-0,7	-1,6	-0,7	-1,8	0,1	-2,3
Grimsel Hospiz	1980	2,6	-1,2	2,7	-1,3	3,9	-1,3

1.7.6 Wind measurements

Station	**08:00 UTC**	**Alt. (m AMSL)**	**Direction**	**Speed**	**Peaks**
				kt	kt
Jungfraujoch		3580	141°	14	19
Titlis		3040	191°	10	20
Gütsch ob Andermatt		2287	170°	10	16
Grimsel Hospiz		1980	133°	13	16

1.7.7 Weather according to persons on the spot

At the time of the accident, a group of four ski tourists was approximately 200 - 300 m to the north of and below the site of the accident at the intersection of the normal ascent track and the 3000 m contour line. They described the weather conditions at the time of the accident from their viewpoint as follows:

- heavy cloud with individual swathes of fog and cloud
- at the time of the accident Rot Stock Pt 3183 and the accident site visible

- extensive band of fog and cloud to the south of Sustenlimi visible
- wind at their location moderate, plumes of snow could be seen on visible ridges, presumably gusty
- constantly changing, but always poor, hazy visibility conditions; these can be clearly seen on photos (see Annex 2, Weather Photos).

Flight assistant C: "*I was sitting in the front of the helicopter on the left. There were wisps of fog, but the situation was changing constantly. I was observing the opposite slope when we were at the landing site. The situation there was changing constantly. I saw (...) the crest (to the south near the landing site). We had both opposite slopes on the Sustenlimihorn and Gwächtenhorn in sight. However, visibility had changed. When the helicopter had flown off again, I could no longer see the rocks. While we waited at the disembarkation point near the Sustenlimi, we had little wind."*

The mountain guide on the Sustenlimi: *"When the pilot reported for the first time and informed the flight assistant that he would be there in 1-2 minutes, the weather and visibility were still very good. But this then changed very swiftly. Clouds gathered from the south, the rising air condensed and there was a kind of fog formation with very hazy light conditions. It was hard to make out the contours of the terrain. There was a moderate wind from the south. The temperature was about -5 to -10 degrees."*

The pilot for the local mountain helicopter company was working with an AS350 B3 Ecureuil helicopter: *"When I was travelling by car on Saturday morning from Interlaken towards Meiringen, it was immediately clear to me that we had a 'Föhn' wind situation that day. At the Meiringen aerodrome, I observed that the cloud base was very low in the Trift region. I was unable to assess the weather situation in the Susten region accurately because of the mountains. After arriving at the (...) base, I made a telephone call to the Tierberglihütte for safety's sake. The warden, however, assured me that the landing area on the Limi was not in fog. Nor was the wind too strong, in her opinion. (...) From the south, the Föhn wind had thrown up a wall of cloud. (...) I also knew from experience that the references on the glacier in this region are very poor. At this time the cloud base was just a little higher than the landing area* (note by the investigator: at the highest point near the iron bar).

(...) I approached the landing area from the north at a relatively low speed from below (good references due to the rocks). The references at the landing area were not very good. I had to set the aircraft down on the plateau without hovering too long. At this time (approximately 08:49), the wind was right on the nose of the helicopter, estimated at approximately 20-30 km/h laminar.

After loading up, I then took off again with three guests and a mountain guide in the direction of Gadmen (approximately 08:55). *Abeam the Tierberglihütte, we then caught up with the Jet Ranger. I again tried to make contact with the pilot, this time also without success. We then flew for a short time fairly close behind the helicopter. In view of the weather and the references, I then decided to fly a circuit and approach the landing area again from the north* (approximately 09:00). *During the approach, I was unable for a short time to see the landing area and the skiers who had been set down. The swathes of fog formed very quickly, but they cleared again very quickly. Since I had very good references at* *all times due to the rocks, the situation did not concern me. Also, downward visibility was no problem at any time.*

I was also able to offload the second group of skiers without any problems. I selected the return flight precisely as for the first round trip. We subsequently refuelled again in the Rossendale and then took off with two guests and the flight assistant in the direction of Gadmen. Shortly after take-off, the mountain guide from the second group reported on the radio. Apparently the weather at the landing area had considerably worsened in the meantime. The mountain guide had visibility in the direction of the Tierberglihütte only for short periods. We then tried once more to approach the landing area. Then, because of the poor references, I decided to abort the flight and land at the Steingletscher mountain landing area.

On the flight to the Steingletscher we were called by Raga 8 on the mountain frequency. Until then we had been unaware of the crash."

The REGA 8 pilot:

"We took off at about 09:10 from Erstfeld in the direction of the Sustenlimi. Locally we had good visibility and broken (moderate) cloud at approximately 2800 m AMSL. Our flight path took us via Arnisee-Rot Bergli (SE Schafschijen) – Sustenpass – Steingletscher. The weather was calm and unproblematic throughout the outward flight (no turbulence). Abeam the Sustenpass we saw the B3 helicopter flying down the valley from the glacier. We established contact on 130.35 MHz and the R-channel. From near the Sustenspitz we saw the site of the accident, but noted that the local weather was worse than on the entire flight. When we were about opposite the Sustenhorn, the accident site disappeared for the first time in a band of fog. We approached coordinates 676 300 / 172 200 (reference large glacier crevasses) and were still able dimly to make out people on the glacier and the bare area of the glacier below the accident site. We flew one or two circuits below the accident site and were able to establish contact with a mountain guide on the E-channel who was on site and reported to us that all four people involved in the accident were dead. On this news, we decided to fly to the Tierberglihütte and wait for better weather. Apart from very hazy light on the glacier, we also noticed a strong and turbulent SSW wind. It is perhaps also worth noting that the clouds were not only being blown across from the SSW but momentarily, in the lee of the Sustenlimi, clouds were condensing on the spot. The base of the banks of fog were never lower than approximately 3000 m AMSL. Landing at the Tierberglihütte at approximately 09:25. At 10:10, the accident site cleared significantly and we took off. (...) During the approach, there was very strong turbulence with sudden tailwind components (eddies). Because of the diffuse light, it was not possible either to seek out the ground effect with the helicopter early on the approach and we were glad to have a mountain guide on the spot as a ground reference. We did not remain on site with the helicopter because of the very unstable weather situation. Fog was again forming at the site of the accident. (...)"

The mountain guide with the other heli-ski group in the area: *"Shortly before 09:00, we landed with the helicopter* (AS350 B3) *at the Gwächtenhorn (HL) landing site. Due to the changing visibility conditions we had to make a second landing approach. I noticed light gusts of wind as we got out and unloaded the skis. As soon as the helicopter had left, visibility deteriorated considerably. The tracks from the previous day could still be made out with difficulty as far as* *point (a). Visibility improved again as we entered the crevasse zone (b). The location and ascending trail onto the Sustenhorn were recognisable again. At point (c) I had good light again and we were able to travel fairly long distances, so I was probably 50 m in front until I gathered the group together again near a small crevasse. (...) Wisps of cloud again pushed in from the south over the Limi. (...) It was a 'Föhn' wind situation. The Föhn wall cloud began to fall over the Sustenlimi. Visibility conditions changed in a short time. (...)"*

Guest 1 in this group: *"On 26.03.05, at about 08:40, we flew in the red (...) helicopter to the landing area at 3225 m. It was cloudy, but the visibility was ok. There was little wind on take-off; it was at least 20 m/sec on landing (72 km/hr). As a parachutist (licence number (...)) I am very familiar with and well aware of the jump limit (10 m/sec.). On the ridge where we landed, the wind was at least twice as strong. After a few metres in the wind shadow of the ridge, the wind dropped markedly to approximately 20-30 km/hr. For the first few minutes we were travelling into a wall of fog with visibility at approximately 15-20 m. When we came out of the fog, I had clear view as far as the Rot Stock, Sustenhorn and the Tierberglihütte. (...)"*

Guest 2: *"(...) There was a fairly strong gusty wind, so we did not stay longer at the landing site than we had to. With my parachuting experience, I estimated that the strength of the wind at the helicopter landing site was at least twice that at which I would make a jump. Converted, that would be about 20-22 m/s."*

1.8 Aids to navigation

In the cockpit, the pilot had a digital map display unit (moving terrain system) available. The system is used to receive GPS – global positioning system – data and to display the flying position on a map. These data are based on satellite communication and are received via a 12-channel receiver on a separate antenna. The area of use, resolution, etc. can be specified using a database.

On the basis of the moving terrain system which was found, but which was damaged, an attempt was made to obtain further information on the helicopter's flight path shortly before the accident.

Flight parameters such as the date, time, track and GPS altitude were recorded on the hard disk at 10-second intervals and were saved in a logfile until the next start-up.

However, because of the badly damaged hard disk, it was not possible to recover the GPS flight log, even by a specialist company commissioned to recover the data.

1.9 Communications

The Jet Ranger HB-XQO was equipped for common listening and selective transmission on aviation radio (VHF) and the helicopter working channels (FM).

Flight assistant C, who was equipped with the flight assistant's helmet-integrated professional radio, said that the pilot reported on the first flight to the Sustenlimi during his approach, on the 130.35 MHz mountain frequency.

The flight assistant of the second helicopter (B3) in the area tried unsuccessfully to make contact with the pilot of the Jet Ranger using the helicopter working channel. During the telephone readiness message to his pilot he was able to inform the latter about the second helicopter in the same area.

At approximately 08:45, the pilot of the second helicopter (B3) in the area was en route to landing area Pt 3225 with five passengers on board: *"I tried again to contact the Jet Ranger pilot on Heli1 and the mountain channel 130.350 MHz. But the pilot never responded on these two channels. Then, at the altitude of Gadmen, we crossed without any conflict.*

The Jet Ranger pilot was in contact with his flight assistants on the helicopter working channel Heli2.

1.10 Aerodrome information

Not applicable.

1.11 Flight recorders

The helicopter was not equipped with a flight data or voice recorder. These were not prescribed.

1.12 Information on the wreckage, the impact and the site of the accident

1.12.1 Wreckage

A detailed investigation of all the debris which was found was carried out. For this purpose, all the debris was laid out in its normal position in a hangar (see Annex 4 Debris).

All the damage found, such as fractures, cracks, buckling, paint marks, scratches and contact marks gave the same picture. On the basis of specific characteristics such the direction of fracture or buckling, location of the damage or reciprocal traces on individual parts of the wreckage it was possible to build up a plausible dynamic picture of the destruction from the initial impact.

The damage indicates high initial deceleration forces. The braking must have resulted in a rotation about the transverse axis and a roll-over.

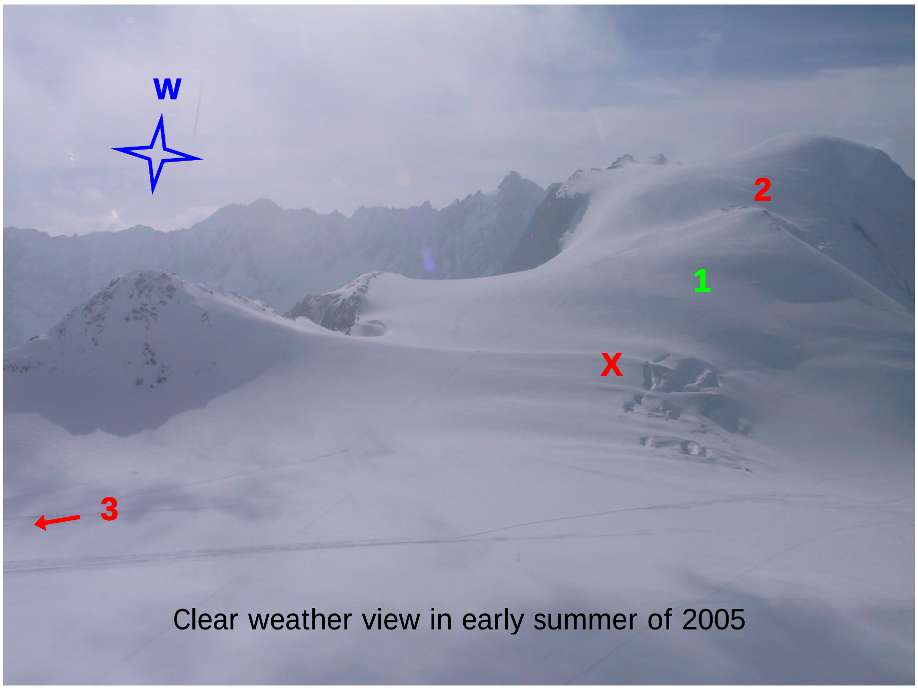
In view of the extensive destruction of the helicopter it cannot be excluded that the main rotor made contact with the tailboom shortly before the impact in the snow.

No pre-existing damage to the helicopter which might have contributed to the accident was found.

1.12.2 Site of the accident

Accident location	Sustenlimi, Steingletscher, municipality of Gadmen/BE
Swiss coordinates	676 004 / 171 350
Geographical latitude	N 46° 41’ 21”
Geographical longitude	E 008° 25’ 56”
Elevation	3086 m AMSL
	10,124 ft AMSL

National map of Switzerland	Sheet No. 1211, Meiental, scale 1:25,000 (see Annex 1)



Clear weather view in early summer of 2005

The site of the accident was located approximately 450 m east of the official "Sustenlimi 675575/171425, 3170 m AMSL" mountain landing area. The debris was approximately 650 m east of the planned original landing site (2) at point 3225. In relation to the first landing area approached (3) at the Sustenlimi Pt 3089 intersection, where the first three passengers had disembarked, the site of the accident (X) was about 750 m to the west (see Annex 1 Overview map).

The debris field lay on the open, snow-covered glacier which rises gently towards the west, along an indistinct, broad ridge of snow. This ridge begins below Pt 3183 on the southern crest of rock adjacent to the glacier and runs in a direction of approx. 330°, gently descending towards the end, into the transverse crevasses below the plateau of the glacier. The ridge is topographically recognisable on the national map.

From the first detectable point of impact of the helicopter onto the snow-covered glacier terrain, falling off to the right or the east at 15°-25° in the direction of flight, the debris was scattered in a conical pattern in the NNW direction. Individual parts, such as the fuel tank or the rear section of the turbine, were found in the large transverse crevasses visible in the photo (see Annex 3, Accident site).

Various loose documents were found on the Steingletscher to the south of the Tierberglihütte at an elevation of approximately 2800 m AMSL.

On 12 August 2005, some 5 months after the accident, the approx. 3.5 m section of the “white” main rotor blade, which had been missing, was found very close to the initial traces of the impact. It must have penetrated deep into the snow during the accident. Various other small parts, including a central section of the “red” main rotor blade, were revealed as the snow melted.

On 15 September 2005, some 6 months after the accident, the "hot section" of the engine, the turbine and the combustion section were found on the snow-free glacier about 150 m from the point of impact, in a crevasse.

1.12.3 Engine

The engine parts were examined in two phases. In the first phase, at the time of the detailed inspection of the wreckage, it was possible to examine only the compressor and accessory gearbox section which had so far been found. In the second phase, the entire engine including the turbine and combustion section was examined.

1.12.3.1 Engine examination

Extract from the findings of the first phase:

- *"The engine and engine deck were separated from the fuselage in the course of the accident sequence. The engine mounting legs remained securely fastened to the mounting pads on the accessory gearbox. The lower legs separated from the fuselage. The flanges at the base of the mounting legs exhibited distortion where they attached to the fuselage. The engine deck exhibited heavy damage and distortion.*
- *The engine to transmission drive shaft pulled out of the forward coupling attaching the drive shaft to the main transmission. The cover of the isolation mount beneath the forward coupling exhibited significant lateral scoring in a plane consistent with the tabs on the aft circumference of the forward coupling. The scoring was estimated at nearly one–eighth of an inch deep. (...)*
- *Nearly all of the air, oil, and fuel lines that remained attached to the recovered components of the engine exhibited some degree of damage in the form of crimping, crushing, bending, or fracture.*
- *There was no evidence of damage found on the struts of the compressor front support or in the first stage of the compressor to suggest the ingestion of foreign objects. There was light scoring in the blade path of the first stage of the compressor rotor in an arc of approximately 30 degrees, corresponding to between the 2 and 3 o'clock positions (viewed from the rear). (...)*
- *The compressor rotor turned smoothly with little resistance. (...)*
- *The bleed valve was found open. The valve moved freely when actuated by hand. (...)*
- *(...) both accessory gearbox magnetic chip detectors were "clean" (...)*
- *The aft end of the spur adapter gear shaft and the inner diameter of the aft end of the pinion gear exhibited scarring. (...)*
- *The five exhaust collector support mounts used to secure the turbine assembly to the accessory gearbox exhibited varying degrees of damage. Two of the mounting bolt recesses exhibited lateral fractures of the case material surrounding the bolt holes, exposing the inner threads. Two of the attaching bolts still had nuts on them and remained in the gearbox. Both exhibited bends estimated at approximately 20 degrees. The final mounting*

bolt was pulled out of the case hole stripping the threads that held it in place. (...)

- *The AAIB reported finding fuel in the lines and components throughout the engine. (...)*
- *There were no irregularities noted in a cursory review of the engine log-books. (...)"*

After approximately 6 months in the snow, the missing part of the turbine was found in a crevasse in the glacier at the site of the accident.

Extract from the findings of the second phase:

- *(...) the compressor rotor turned freely when actuated by hand.*
- *There was no evidence of foreign object ingestion noted in compressor air inlet. With the upper compressor case half removed, there was no damage noted to the blades of the compressor rotor, the stator vanes or thermoplastic liner of the removed case half. (…)*
- *The third stage turbine wheel blade path in the inlet side of the fourth stage turbine nozzle exhibited heavy scoring in a pattern consistent with the features of the knife edges of the third stage turbine wheel shroud in an arc estimated at approximately 180 degrees, from the 6:00 position, through 9:00, to approximately 12:00. There was heavy scarring to the outboard leading edges of the vanes on the inlet side of the fourth stage nozzle in an arc of approximately 105 degrees, from 3:00 to 6:30. The heaviest damage to the vane leading edges extends inward from their outboard most portions as much as one-quarter inch. The stationary labyrinth seal at the center of the fourth stage nozzle exhibited heavy scoring in a pattern consistent with the features of the rotating labyrinth seal adjacent to the curvic coupling on the outlet side of the third stage turbine wheel. The scoring of the stationary labyrinth seal is most prominent in an arc estimated at approximately 210 degrees, from 6:00, through 12:00, to approximately 1:00. The blades of the rotating labyrinth seal on the third stage turbine wheel exhibited evidence of rub around their circumference.*
- *The fourth stage turbine wheel blade path in the outlet side of the fourth stage turbine nozzle exhibited heavy scoring in a pattern consistent with the features of the outboard most portion of the fourth stage turbine wheel shroud in an arc estimated at approximately 180 degrees, from the 7:00 position, through 9:00, to approximately 1:00. There was evidence of rub at the periphery of the fourth stage turbine wheel on the forward portions of the shroud around its entire circumference. The most outboard portions of the leading edges of most of the blades exhibited notches of up to one-eighth of an inch where they join the wheel shroud.*
- *There was no damage noted to the thermocouples or wiring of the temperature measuring harness installed in the power turbine support."*

(see Annex 5 Engine investigation)

1.12.3.2 Summary

Despite damage as a result of impact forces and the effects of prolonged exposure to the elements, there was no evidence revealed in the course of a detailed *disassembly inspection of the engine to suggest this accident was as a result of a malfunction or failure of the engine.*

Heavy scoring in the turbine wheel blade paths and evidence of rub between the static and dynamic components within the turbine assembly support the conclusion the engine was running at the time it was subjected to high impact forces.

The extent of damage to the airframe and the distribution of components within the debris field establish the greatest forces acting on the airframe during the accident sequence were in the longitudinal axis and suggest the aircraft was in powered flight.

1.12.4 Investigation of the cockpit instruments

Various flight and engine indicators were forensically examined:

- airspeed indicator:
  pointer at 0 position, no pointer traces on the figure dial
- vertical speed indicator:
  indicator at 2000ft down position, no pointer traces on figure dial
- attitude gyro:
  pointer trace of the bank indicator on the bank marking scale in the area of approximately 23° to 24° right bank
- gas producer RPM indicator:
  "large pointer" at 42% rpm, no pointer traces on the figure dial
- torque indicator:
  indicator at 3% position, no pointer traces on figure dial
- engine oil indicator:
  "oil pressure" pointer seized between 10 and 11 psi, no pointer traces present, "oil temperature" pointer at 0 position, no pointer traces present
- TOT (turbine temperature) indicator:
  indicator at 125° position, trace of tip of pointer on figure dial between approximately 100 °C and 210 °C
- combined power turbine and rotor RPM indicator:
  As a result of the deformation of the instrument, the figure dial was pressed against the front glass and the pointers were clamped between them; the pointers were pressed together and fixed in their reciprocal position, pointer trace on the figure dial of the turbine speed, the pointer (T) for the turbine speed indicated a value of 33% rpm and the pointer (R) for the rotor speed indicated a value between 36% and 37% rpm.
- Caution light panel:

  The corresponding report states:

  ENG OUT:

  Based on the witness marks and the analysis findings, both filament lamps of the "ENG OUT" warning light were illuminated at the time of the accident, respectively at the time of an impact force against the lamps (for example when the helicopter impacted against the terrain or glacier).

However, it is indeterminate which impact caused the deformation. It can not be excluded that the initial contact with the terrain or glacier occurred with the lamps not illuminated (no detectable witness marks were left if the filament did not fracture at this initial contact).

Rotor low RPM:

On one hand we conclude, based on the witness marks and the analysis findings, that the filament of one of the “rotor low RPM” warning light was not under power at the time of one of the impacts against the lamp and therefore cold fractured into several pieces during the accident.

This strongly supports the scenario that the initial impact with the terrain or glacier occurred with the warning light not illuminated.

On the other hand, it can be stated that the other lamp of the “rotor low RPM” warning light was illuminated at the time of the accident, respectively at the time of an impact against the lamp (for example when the helicopter impacted against the terrain or the glacier).

However, the precise impact cannot be determined. It cannot be excluded that the initial impact with the terrain or glacier occurred with the lamps not illuminated (if the filament did not fracture at this contact no detectable witness marks were left).

1.13 Medical and pathological information

The legal examination of the four occupants involved in the accident took place on the day of the accident. The result of this examination determined multiple injuries (cranial trauma, injuries to ribcage, pelvis and extremities) with internal bleeding as the cause of death.

A post-mortem examination was carried out on the pilot on 28 March 2005.

The forensic examination carried out on the pilot specified as cause of death tearing of the aorta in the heart, which occurred as a result of the violent acceleration trauma. Death occurred immediately.

No indications of pre-existing illnesses relevant to the accident were found. Likewise, the toxicological investigations (alcohol, medication and drugs) were negative. Hypoglaecemia was also excluded.

1.14 Fire

There was no fire.

1.15 Survival aspects

1.15.1 General

The pilot and the passenger in the front seats were restrained by lap and shoulder belts. The passengers in the rear seats had fastened the lap belts. None of the occupants was wearing a helmet; all of them were equipped with headsets.

The injury to the pilot due to the enormous deceleration could not have been prevented if he had been wearing a helmet.

The force of the impact had torn some belts; some were torn from the attachment points. The entire structure of the cabin and hence the envelope of the occupants was torn apart as a result of the dynamics. The occupants were thrown about without protection along with the parts of the helicopter.

The injuries caused by the violent impact were not survivable.

1.15.2 Emergency transmitter

The helicopter was equipped with an emergency transmitter (emergency location beacon aircraft – ELBA). The device was installed horizontally on the ceiling of the luggage area. It was found at the site of the accident, still attached to the section of the ceiling which had been torn off. The device was activated but could not radiate a detectable emergency signal because of the torn-off antenna.

1.16 Tests and research

Not applicable.

1.17 Organizational and management information

The Heli Partner AG company did not have any permanent employees. About 10 pilots and several flight assistants were employed on a temporary basis. A Jet Ranger, HB-XQO, was owned by the company. In addition, it was the co-operator of two Robinson R44 helicopters. On the Jet Ranger, a total of 264 hours were flown in 2004. In 2005, the figure was 33 hours up to the date of the accident.

1.18 Additional information

1.18.1 Performance table in the helicopter

The Heli Partner AG laminated performance table for HB-XQO found at the site of the accident and, according to the chief pilot's statement, belonging to the aircraft still showed faint handwritten information about the date of the day of the accident and that day's 0° isotherm of 7600 ft. This table, marked *"Angaben ohne Gewähr"* ("no responsibility is taken for the correctness of this information"), had listed the following key values in the corresponding altitude range:

PA 10,000 ft – 5 °C: ISA critical wind 1240 kg, ISA non-critical wind 1330 kg

PA 11,000 ft – 7 °C: ISA critical wind 1210 kg, ISA non-critical wind 1320 kg

The configuration of the helicopter that the resulting values were based on was not listed in the table.

The values corresponded to the information for the "particle separator only" configuration from section FMS-12 of the flight manual.

1.18.2 Performance

The company's chief pilot and the flight assistant C who was involved stated the following regarding the first landing on the Sustenlimi: *"The landing site was approached directly. The conditions were good. (...) We still had reserves. He landed with about 88-90%. (...) After the decision point, a go-around with a climb would have been possible. I can't say whether this 12% power would have* *sufficed. (...) In the final phase, I opened the doors to assist the pilot with accurate height information. This was because of the hazy conditions.*

The helicopter manufacturer calculated the theoretical performance parameters for the corresponding conditions:

"A computer engine performance program was used to determine the max torque and TOT values for a spec 250-C20J engine at the given conditions. At 100% Nr, the TOT would reach its limit at 810 °C and torque would be 92.7%. For a spec engine the pilot should have been able to pull at least this much power without Nr and Np droop. Our predictive tools cannot tell (...) exactly what the torque and TOT would be when droop would occur since this would be above the operational TOT limit of 810 °C. The engine does not have a torque limiter, but a maximum fuel flow rate is set at the fuel control of 235 lb/hr. The (...) condition would result in a fuel flow of approximately 195 lb/hr."

1.18.3 Investigation of engine performance

The POWER CHECK last carried out on 17 September 2004 by the maintenance company indicated, at a pressure altitude of 4500 ft, an external temperature of 11 °C and with a displayed 100% torque the following result: POWER CHECK ACCEPTABLE, 91%.

1.18.4 Use of the performance table according to the rotorcraft flight manual – RFM

Extract from the general conditions to be applied in the use of the flight manual performance tables:

BHT-206B3-FM-1

OPERATION IN ALLOWABLE RELATIVE WIND

Satisfactory stability and control has been demonstrated in relative winds of 20MPH (17kts) sideward and rearward at all loading conditions within Area A or Hover Ceiling Charts.

IGE AND OGE HOVER CEILING CHARTS

Note

The Hover Ceiling charts presented in this manual reflect performance with the 65 inch diameter tail rotor (P/N 206-016-201) installed. (...)

The Hover Ceiling in Ground Effect charts (figure 4-3) and Hover Ceiling Out of Ground Effect charts (figure 4-4) present hover performance (allowable gross weight) for conditions of pressure altitude and OAT. The charts are divided into two areas.

***AREA A** (White area) as shown on the hover ceiling charts presents hover performance for which controllability has been demonstrated in sideward and rearward relative wind conditions up to 20 MPH (17 knots).*

CAUTION

ENGINE TOT WILL RISE NOTICEABLY WHEN HOVERING DOWNWIND. AVOID HOVERING DOWNWIND WHEN OPERATING NEAR TOT LIMITS.

***AREA B** (shaded area) as shown on Hover Ceiling charts presents hover performance that can be realized in CALM WINDS or winds outside the CRITICAL RELATIVE AZIMUTH AREA in figure 4-5.*

1.18.5 Characteristics of the Jet Ranger helicopter

The Jet Ranger helicopter type imposes special demands in terms of performance and general control characteristics at the tail and main rotor. At low speeds below 30 kts, the possibility of a loss of control about the vertical axis is a concern, especially in the event of variable wind conditions. The manufacturer has mentioned four particular characteristics of this helicopter in the flight manual and additional “information letters”. At low speeds and certain wind strengths and wind azimuths in relation to the longitudinal axis of the helicopter, these may lead to an “unanticipated right yaw”. Unanticipated right yaw or loss of tail rotor effectiveness (LTE) means the occurrence of a sudden and uncommanded right rotation about the vertical axis, which results in a loss of control if not corrected immediately.

1. weathercock stability, wind azimuth 120 - 240 degrees

The weathercock effect of the fuselage and tailfin of the helicopter accelerates the helicopter’s rotation about the vertical axis.

2. tail rotor vortex ring state, wind azimuth 210 - 330 degrees

Short-lived vortex ring states of the tail rotor blades cause an irregular tail rotor thrust and hence undesirable perturbation about the vertical axis.

3. main rotor disc vortex, wind azimuth 285 - 315 degrees

The tail rotor blades are affected by the disc vortex of the main rotor. Their angle of attack is changed. The helicopter exhibits a tendency for sudden and uncommanded right rotation about the vertical axis.

4. loss of translational lift, all wind azimuths

The loss of main rotor translational lift results in a greater power requirement and hence additional torque. If this loss of lift occurs in conjunction with a right rotation of the main axis, this rotation is further accelerated. In the event of operation at the performance limit, the additional power requirement may lead to a drop in rotor speed.

Extract from the manufacturer’s "operations safety notice (OSN) 206-83-10":

“(...) operators should:

When manoeuvring between hover and 30 MPH:

- *Be aware that a tail wind will reduce relative wind speed if a down wind translation occurs. If loss of translational lift occurs it can result in a high power demand and an additional anti-torque requirement.*
- *Be alert during hover (especially OGE) and high power demand situations such as low speed downwind turns.*
- *Be alert during hover in winds of about 8-12 knots (especially OGE) since there are no strong indications to the pilot, to the possibility of a reduction of translational lift. This reduction results in an unexpected high power demand and increased anti-torque requirements.*
- *Be aware that if a considerable amount of left pedal is being maintained, that a sufficient amount of left pedal may not be available to counteract an unanticipated right yaw.*
- *Be alert to changing aircraft flight and wind conditions such as experienced when flying along ridge lines and around buildings.*

Observe the relative wind conditions set out in the attached chart

If a sudden unanticipated right yaw occurs the recommended recovery technique is: 1. apply full left pedal 2. apply forward cyclic, and recover 3. if altitude permits, reduce power."

1.18.6 Extract from the flight operation manual – FOM – of the Heli Partner AG company

FOM Version 30.09.2003

"5.14 Mass and centre of gravity

5.14.1 General

Mass and centre of gravity are critical factors and are important for flight safety. The maximum load and the centre of gravity are based on the following principles:

- *hover with load according to performance OGE*
- *temperature*
- *wind and operating altitude*

For helicopters, the mass and centre of gravity configurations for take-off and landing must be checked using tables.

5.14.2 Standard mass

The following standard masses are assumed for passengers

Pax seats	*1-5 PAX*			*6-9 PAX*		
	Man	*Woman*	*Child*	*Man*	*Woman*	*Child*
	98 kg	*80 kg*	*35 kg*	*90 kg*	*72 kg*	*35 kg*
Crew incl. crewbags	*85 kg*			*85 kg*		

The above values, however, should be revised upwards if this appears necessary in the judgement of the PIC. The actual weights may also be taken into consideration.

1.18.7 Take-off mass on take-off from Erstfeld

The take-off mass of approximately 3350 lb on the first take-off from Erstfeld was approximately 150 lb above the maximum permitted mass.

The following information was considered:

58 USG fuel tank content

Pilot 105 kg including equipment according to investigation, 2 flight assistants with 85 kg standard mass including equipment according to 5.14.2

Seven 20l and three 30l filled fuel canisters

Full beverage and food cooler with approximately 15kg

Additional equipment such as radios, helmets, strapping gear etc. is not yet included.

1.18.8 Examination of disagreeing observations

The observations concerning the accident by two witnesses standing close to each other which did not match the observations from other sources were checked in the described terrain. The observation that the helicopter had hit the ridge of rock and scraped the rocky terrain could not be confirmed after extensive forensic examination of both the extended rocky area and the relevant items of debris.

1.19 Useful or effective investigation techniques

Not applicable.

2 Analysis

2.1 Technical aspects

The findings of the detailed engine investigation are confirmed by the statements of different witnesses at various locations in the area of the accident who have clearly heard turbine engine noises until the impact noise.

Statement from the engine investigation report:

"Heavy scoring in the turbine wheel blade paths and evidence of rub between the static and dynamic components within the turbine assembly support the conclusion the engine was running at the time it was subjected to high impact forces."

The rub/scratch marks or scoring found in the turbine indicate that the turbine still must have been developing power at the first impact. These witness marks are consistent with the large force during the impact which resulted in a rollover and a large debris field.

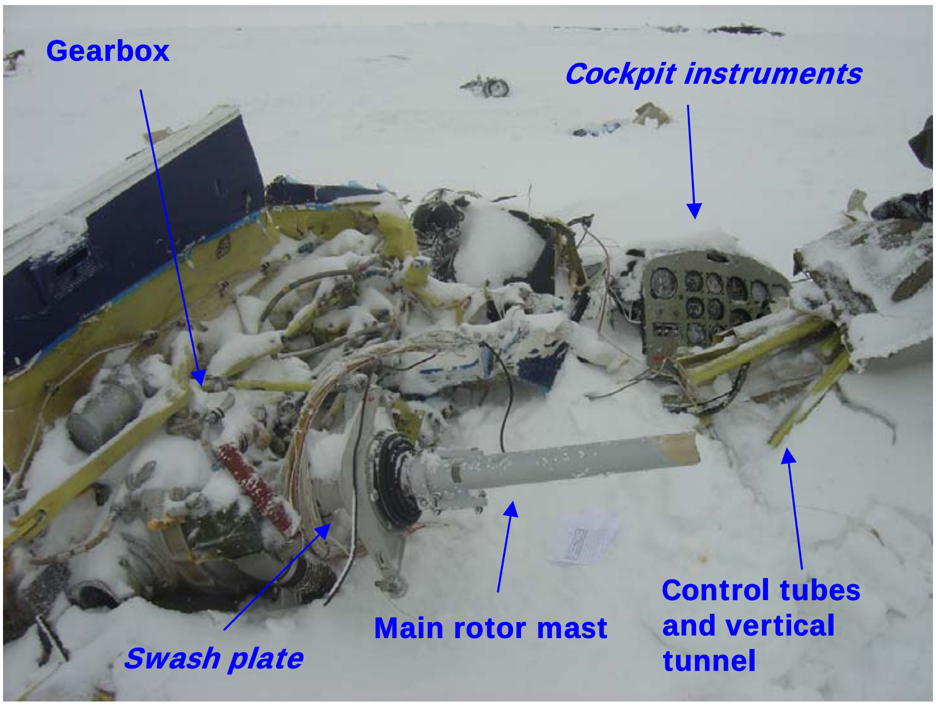
The investigation results of the cockpit instruments and warning lights indicate a possible engine failure at the time of impact with the hard snow ridge.

The cockpit instruments were found at some distance from the initial impact, together with some other solid and heavy components such as the gearbox and several control rods. It must be assumed that the needles were blocked in the position as found only after the initial impact, by a heavy collision with other solid wreckage parts.

Statement from the forensic investigation:

"The needles of the combined rotor RPM and turbine speed indicator could move to the observed low values during the time between the initial contact with the terrain or glacier and the impact which caused the observed witness marks."

The ascertained activation of the ENG OUT warning light can be explained by the chronological disintegration sequence of the helicopter.



Analysis of the traces at the accident site and on the debris:

All the debris was found in the same conical area north-west of the traces of initial impact.

It was possible to locate traces of the initial impact of the landing gear skids on the snow ridge, despite the snowfall after the accident, because of the local packing of the snow. These traces agree with the conical distribution of the debris, the traces found on the engine, the traces on the attitude indicator and certain damage to the wreck. They indicate a NNW orientation of the helicopter on impact, with a slight right bank.

The distribution of the debris which was found allows a conclusion to be drawn about the direction of movement of the helicopter.

The distance to the first point of impact of some heavy parts of the wreck such as the tank, the hot section of the turbine, gearbox, etc. indicate high kinetic energy on impact. The aircraft's speed must have been fairly high shortly before impact.

The distance and position of the occupants' bodies in relation to the point of impact and the general final direction of movement of the helicopter match the above conclusions. In addition, this is evidence of the rotation of the cabin about the transverse axis after the impact. The passengers in the rear were thrown significantly further on their side over the pilot and the front-seat passengers.

The rollover indicates a nose down attitude of the helicopter shortly before or at the time of impact. The damage to the front of the cabin in the area of the pitot tube and the battery compartment, damage and deformations to the tailboom, the matching damage to the leading edge of the vertical fin and a pushed-in trailing edge of the right horizontal stabiliser due to the accelerated mass of the tail rotor gearbox, the nature of various fractures, such as the torn-off attachment of the turbine to the compressor and gearbox indicate the position of the helicopter at the time of the initial impact.

The position of the parts of the main rotor blades as found, on the one hand cutting deep into the hard snow ridge and close to the initial impact traces and on the other hand at a great distance to the left of the axis of the debris field with the sheared-off rotor mast confirms the nose down attitude, the direction of movement and the forces involved.

The position of the debris, in particular the dynamic components of the helicopter, confirm the integrity of the aircraft up to the time of impact.

The position where the lightweight documents from the helicopter were found shortly after the accident, in the lee of the crest of the Sustenlimi, confirmed the prevailing wind and prevailing wind direction at the site of the accident.

2.2 Meteorological aspects

2.2.1 Forecasts

The aviation weather forecast for Switzerland, valid from 06:00 to 12:00 UTC, mentions that south-westerly high-altitude winds were bringing more humid air masses towards Switzerland. For the north side of the Alps, Valais and all of the Grisons, 5-7/8 coverage, base 7000-9000 ft AMSL and 3-5/8 base 5000-7000 ft AMSL, was forecast. For the south side of the Alps, increasing cloud coverage, base 5000-7000 ft AMSL was forecast. In the course of the morning, widespread rain was expected.

In the GAFOR for Switzerland, for the period from 06:00 to 08 UTC, the weather category "closed" is forecast for all Alpine routes in the vicinity of the accident site (Gemmi, Grimsel, Gotthard, Lukmanier).

According to these forecasts, a helicopter operation at an altitude of approximately 10,000 ft AMSL in the Steingletscher region would have been very difficult and would have had to be assessed according to the local conditions.

2.2.2 Observed weather conditions in Switzerland

At 06:00 UTC the northern slopes of the Alps were very cloudy, with the main base in Meiringen at 18,000 ft AMSL and in Altdorf at 16,500 ft AMSL. In Disentis it was overcast, base 8000 ft AMSL. Ulrichen in the upper Valais reported 8/8, base 8500 ft AMSL.

Piotta reported 8/8 cloud, base 4500 ft AMSL.

The main Alpine ridge was therefore already in clouds at 06:00 UTC. In the area in which the accident occurred, somewhat to the north of this line, there were still some clear areas.

At 09:00 UTC in Piotta, light precipitation was reported, and in Locarno moderate, continuous precipitation.

The high-resolution NOAA satellite image for 10:56 UTC shows solid cloud coverage which extends from Ticino over the Alpine ridge as far as the Engelberg area.

Annex 7 shows the corresponding radar composite and NOAA satellite image.

2.2.3 Weather conditions in the area of the accident

In the humid air masses flowing from the south-west, the condensation level on the southern slopes of the Alps was at an altitude of less than 5000 ft AMSL. The air masses flowing north across the Alps were therefore saturated.

To the north of the main Alpine ridge, as the air flowed over the various mountain ridges, gaps in the cloud were able to form on the lee side in the descending air. On the Steingletscher also, which was on the leeside in terms of the wind direction, eddies formed, causing localised up- and downdrafts. Given an average wind speed of about 10 kts, with gusts up to 20 kts, these caused cloud and visibility conditions to change rapidly.

The REGA 8 pilot gave the following account: *It is perhaps also worth noting that the cloud was being blown over us not only from the SSW but momentarily, in the lee of the Sustenlimi, clouds were condensing on the spot. The base of the banks of fog were never lower than approximately 3000 m AMSL. (...) During the approach, there was very strong turbulence with sudden tailwind components."*

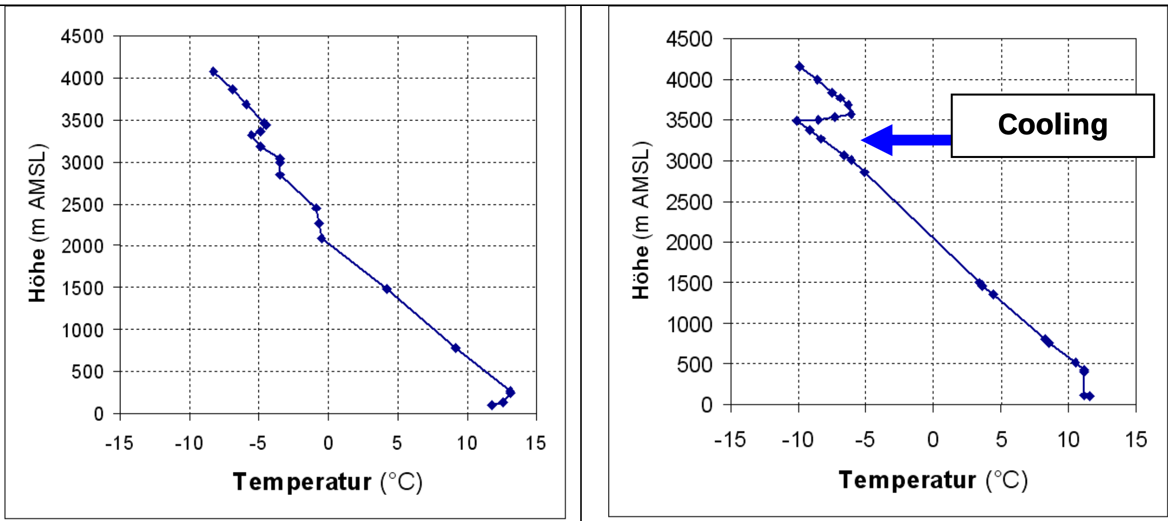
This combination of variable wind and visibility might be explained in terms of the movement and layering of the air masses at the time:

Humid air was pushing in from the south through the gap in the terrain of the Sustenlimi. At this time there was a pronounced inversion layer at approximately 3500 m AMSL. The air was being accelerated between the topography, the Hinter

Tierberg ridge, over the Gwächtenhorn, Rot Stock and as far as the Sustenhorn and this inversion layer.

The wind field and the temperature layering induced a rotor-type backflow of the air over the glacier. Consequently, the air condensed. From 3000 m AMSL, strands of fog and cloud were repeatedly forming in the area of the crest. At some distance from the ridge, however, the air was only able to flow down the valley because of the inversion, causing the clouds to dissipate.

The accentuation of the inversion between 00:00 and 06:00 is clearly indicated by the measured values from the Milan-Linate radio probe. Above 3500 m AMSL the temperature remained virtually constant. Just below this altitude, the temperature fell by about 5 degrees.



Milan Linate, 26 MAR 2005 / 00 UTC	Milan Linate, 26 MAR 2005 / 06:00 UTC

Altitude (m AMSL) / Temperature (°C)

Fig. 1: Milan-Linate (LIML) radio probe. Ascension on 26.03.2005 at 00:00 and 06:00 UTC.

Annex 6 shows the pressure conditions at 09:00 UTC and the surface pressure chart at 12:00 UTC.

2.3 Human and operational aspects

2.3.1 Organisation

For the Heli Partner AG company, a heli-ski day of this type was not an everyday event. Operation on the glaciers of the high mountains was not routine for the temporary flight assistants or the pilot. The chief pilot had described the pilot involved in the accident as his most experienced pilot.

The pilot had not made flights of this type very often. He had acquired his mountain flying experience mainly from his mountain flying training in 1993 and the few heli-ski or mountain flights he had usually organised himself.

Nor was he a regular mountaineer with the corresponding high-mountain experience in terms of wind, visibility and weather.

The heli-ski day had to be postponed once because of unfavourable weather conditions. In the invitation, a possible deferred date, 26 March 2005, the day of the accident, was scheduled in addition to the scheduled date of 5 March 2005. With regard to the necessary coordination with the participants from different regions and the rather uncommon deployment of the helicopter, the organisation of the day required considerable effort on the part of the pilot.

2.3.2 Preparation

The pilot had made intensive preparations for this heli-ski day. This is evidenced by various statements and documents relating to its organisation. He was described as very reliable and conscientious. The documents found relating to a detailed calculation of time and fuel confirm this picture. The equipment check before the flight revealed the meticulous planning for the day.

The updated handwritten entries in the helicopter's performance calculation table which was retrieved reveal that the pilot mentally dealt with the performance issue.

The statements concerning the briefing on the morning of the accident show that the general weather conditions were known. The pilot discussed the possibly of aborting the flight due to the weather. The chief pilot, in his role of flight assistant, said that as always no risks would be taken.

2.3.3 Crew's situational awareness

The chief pilot, who was serving as flight assistant on this day, was interrogated after the accident. When asked about his opinion as to what caused the accident he responded: *"I have already mentioned that I don't understand it. We have a "zero risk" philosophy. I mentioned during the briefing that we have no problem to cancel the tour in case of bad weather. I considered ... to be one of my most reliable pilots. I cannot explain it to myself.*"

The chief pilot's statement in section 1.18.3 to the effect that the first landing had taken place with approximately 88-90% and a reserve for a go-around of approximately 12% must be interpreted as referring to the torque indicator. However, the manufacturer's calculation shows that under the prevailing conditions and at a rotor speed of 100%, the TOT – turbine outlet temperature – at 810 °C represented the engine limit and that the corresponding resulting torque is 92.7%. This indicates, with reference to the indicated torque, that the helicopter was already being operated very close to its performance limit during the first landing.

It must remain open whether the pilot realised when making this landing that his helicopter was operating without reserves at the absolute performance limit for calm wind conditions.

Given an estimated mass of 2908 – 2941 lbs at the time of the accident, the helicopter was outside the theoretical maximum mass for a landing outside of the ground effect.

The following references serve to illustrate the performance conditions:

1. For a given power, the difference between HIGE and HOGE is approximately 300 lb aircraft mass.
2. For a given mass, approximately 10% more torque is required for HOGE than for HIGE.

2.3.4 Current condition and its risks

The conditions on 26 March did not correspond to the theoretically possible and optimal case. Thus, as for any flying operation, various risks had to be recognized and assessed on this day.

The general weather situation means that winds from a southerly direction were to be expected. The wind had conservatively to be assumed as of moderate strength. With a southerly wind, naturally turbulent air had to be expected because of the nature and topographical layout of the crest on the Sustenlimi adjacent to the glacier plateau. Depending on the direction and strength of the general wind, local winds would be highly variable, from momentarily weak to strong and gusty, and, depending on the actual height in relation to the breaking edge, particularly turbulent and from different directions. Thus a few metres above the Sustenlimi it might be temporarily calm, or there may have been a weak wind, because of the lee situation. A few metres higher or to the side, the situation could be quite different. Thus the normal upper landing area, somewhat exposed in this wind situation, was subject to strong winds from the south at times.

In connection with the density altitude which is relevant to performance, the above latent danger could be transformed into an acute and above all no longer controllable hazard.

2.3.4.1 Performance calculation and wind

The pilot calculated using “area b” of the performance table (see chap. 1.18.1), which gives the higher altitude, otherwise the planned sequence for the day would not have been possible because of a reduced transport capacity.

However, this area of the table absolutely demanded calm wind conditions – or laminar winds from an azimuth which was not critical for the helicopter. The possible and very probable wind conditions were not estimated accordingly. This hazard was obviously not recognised.

In addition, the pilot had not taken into account in his performance calculation the snow baffles which he had mounted himself according to the chief pilot’s statement. The ancillary table available in the helicopter also did not include this configuration. Another latent risk from the performance calculation, which was not very clear, regarding the configuration of the helicopter, becomes evident here.

2.3.4.2 Performance requirements and visual references

Calculation of the theoretically available power with the actual data for the day of the accident showed that a landing on the upper and lower area would have been possible only with a HIGE calculation. Initially only the upper area was envisaged. However, because of its topographical conditions, this required a HOGE calculation. The lower area, near the Sustenlimi, which was approached as an alternative because of the clouds at the usual heli-ski landing area, did in fact meet the “ground effect” criteria of HIGE in terms of topography and surface area. However, since on this day hazy light conditions were to be expected on the glacier and did in fact occur, this area too would have required (not only theoretically) a HOGE calculation because of the lack of references.

Thus an acute danger arose from the latent hazard of possible diffuse light conditions and a lack of references due to reduced sunlight on the snow and glacier terrain.

2.3.4.3 Characteristics of the helicopter

In hazy visibility conditions and with poor ground references or none at all, the initiation of a turn by the helicopter about its vertical axis in particular is hardly perceptible to the pilot. Consequently, the timely and decisive pedal input which is indispensable to control the helicopter about its vertical axis given the characteristics of the helicopter described in 1.18.5 in variable wind is therefore virtually impossible.

The highly variable wind, together with the hazy visibility conditions resulted in a major risk of loss of control over the helicopter.

2.3.4.4 Space for manoeuvring

In order to be able to achieve a flight path which is at least horizontal, at the performance limit a helicopter requires a velocity above transition speed. This requires a correspondingly large available flying area and appropriate visibility, particularly if there is a tailwind. The terrain, rising to the east and west, together with hazy, variable cloud bases and the rising mist on the southern crest resulted in a rapidly shrinking space for manoeuvring. Another frequent phenomenon under such conditions is the formation of fog at the helicopter's own rotor blade due to condensation of very humid air. If, as a result of this effect, fog forms unexpectedly right behind the helicopter, an attempt to exit in the opposite direction is suddenly blocked by fog patches in the already very restricted space.

2.3.4.5 Height estimation and power

A 180 degree turn, even if it was initially successful, and the attempt to escape with height and direction references in relation to the grey glacier crevasses at the lower end of the snow ridge may have led to the collision with the terrain because of the low altitude in relation to the ridge, which could not be estimated. The available power did not permit a horizontal escape in the tailwind.

2.4 Summary

2.4.1 General

The partially differing perceptions of the various witnesses in the area around the accident site have to be interpreted, for various reasons. Not only normal differences in perception and personal aspects, but also factors such as the topographical position and the associated parameters such as visibility, light, orientation to the horizon and background in the variably foggy location, exposure in locally differing wind conditions and the associated changes in the way sound carried, etc., may result in varying perceptions.

2.4.2 Operational aspects

It is ascertained that the helicopter, with its particular control characteristics, was operated (see Section 1.6.2):

- in varying wind and diffuse visibility conditions
- in topographically challenging terrain
- at the slow flight performance limits
- beyond the performance limits of landing outside of ground effect

No tolerance for error was therefore available in this phase above the Sustenlimi glacier. Any error or misestimation with regard to the flight path, operation of the controls, flight attitude or wind and visibility conditions could result immediately in irreversible consequences and inevitably in an uncontrolled situation with an uncertain outcome.

The observations of individuals in the area of the accident indicate likely difficulties by the pilot in controlling the helicopter shortly before the impact. It must remain open whether the impact on the snow-covered glacier in diffuse visibility took place in the recovery phase after a loss of control or after a late attempt to turn back. The pilot could not determine the altitude above the snow ridge due to the lack of visual references.

2.4.3 Human aspects

The ability to make judgements and the way in which decisions were made by the persons based on the situation were highly significant.

The following reasons could be probable why the pilot could not, as envisaged, make a timely decision to abort the flight in the worsening weather conditions:

- the excessive demands of the unexpected conditions and the mental resources they absorbed
- the lack of specific criteria for aborting the flight
- a self-imposed pressure to succeed in carrying out the operation which had already begun, because of the extensive preparations which it had required

3 Conclusions

3.1 Findings

3.1.1 Technical aspects

- The helicopter was licensed for VFR transport.
- The investigation revealed no indications of any pre-existing technical faults which might have influenced the accident.
- The last 100-hour inspection was carried out at 3342 hours.
- The last inspection by the FOCA took place on 19.11.2002.
- Fuel on board was approximately 35 – 40 USG, corresponding to a flight reserve of approximately 1.5 hours.
- Based on the evidence found, it can be concluded that the engine was providing power on impact.
- The damage indicates high initial deceleration forces. The deceleration resulted in a roll-over of the helicopter.

3.1.2 Crew

- The pilot possessed the necessary licences for the flight.
- There are no indications of the pilot suffering any health problems during the accident flight.
- The accident was not survivable.

3.1.3 Meteorological conditions

- At the time of the accident, there was a south-easterly wind at 10 kts gusting to 20 kts at the location of the accident.
- The wind conditions in terms of direction and strength were highly variable because of the topographical conditions.
- Variable wind and fog conditions caused highly variable and diffuse visibility conditions over the snow-covered area.

3.1.4 History

- The take-off mass of approximately 3350 lb on the first take-off from Erstfeld was approximately 150 lb above the maximum permitted mass.
- The following configuration as found was relevant to the performance calculation for the helicopter: Allison 250-C20J, snow deflector/snow baffles, particle separator, engine anti ice (off), bleed air heater + defog (off), high skids.
- The recovered table used for the performance calculation did not correspond to the helicopter's configuration at the time of the accident.

- The calculation of the theoretical maximum possible flight mass of the helicopter under the conditions prevailing at the time of the accident, in calm conditions, produced the following results, according to the manufacturer's computer model:

PA 10190 ft, OAT – 6°C:	HOGE 2851 lb	HIGE 4 ft	3261 lb
PA 10660 ft, OAT – 7°C:	HOGE 2810 lb	HIGE 4 ft	3214 lb

  For conditions with wind, *white AREA A* according to the RFM (*demonstrated controllability in sideward and rearward relative wind conditions up to 17 kts*), the following theoretical maximum possible flight masses were calculated:

PA 10190 ft, OAT – 6°C:	HOGE 2724 lb	HIGE 4 ft	3087 lb
PA 10660 ft, OAT – 7°C:	HOGE 2685 lb	HIGE 4 ft	3042 lb

- Given an estimated mass of 2908 to 2941 lbs at the time of the accident, the helicopter was outside the theoretical maximum mass for a landing outside of the ground effect.
- The centre of gravity was within the permitted limits.

3.1.5 General conditions

- The company's chief pilot, in his role as a flight assistant at the selected landing area, was approximately 1 km from the site of the accident.
- He was in communication with the pilot via aircraft radio.
- Several passenger transport flights were planned.
- A briefing took place between the flight assistants and the pilot on the morning before the operation.

3.2 Cause

The accident is attributable to the fact that the helicopter collided at high speed with the snow-covered terrain in diffuse visibility.

The following circumstances were factors:

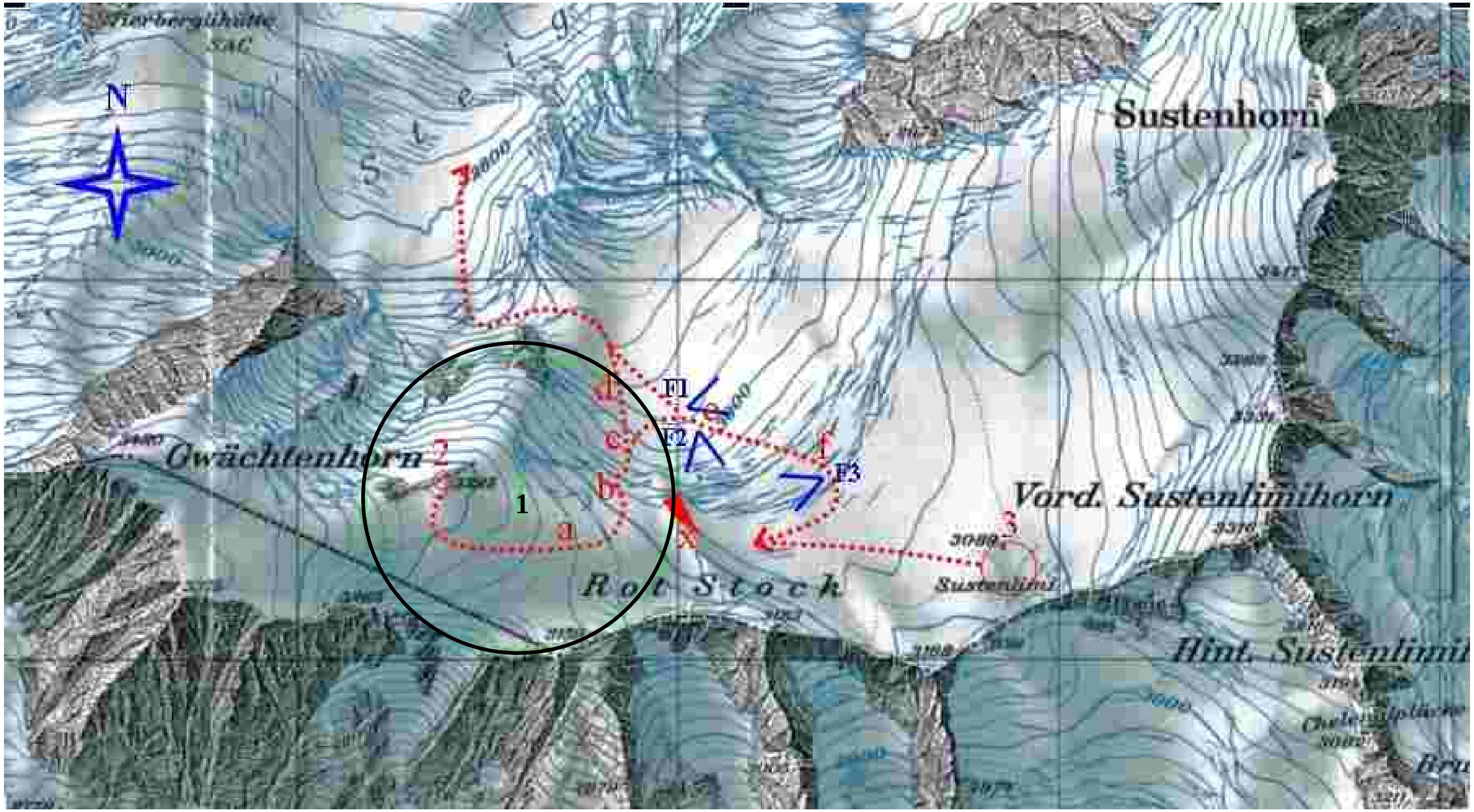
- unrecognized hazards of variable wind and visibility conditions, with regard to the helicopter's control characteristics
- incorrectly evaluated performance requirements

Berne, 19 September 2007 Aircraft Accident Investigation Bureau

Annexes

Annex 1

Overview map Sustenlimi 1:25 000



1	green	official coordinates “*Gebirgslandeplatz Sustenlimi*” with 400 m circle (permitted landing zone)
2	red	“upper” landing area close to the iron pole 3225 m/M
3	red	first selected landing area XQO at the crossing of “*Sustenlimi*” 3089 m/M
x	red	accident site, wreckage parts
a, b, c, d	red	positions of members of the B3-group during the work
F1 – F3	blue	direction of sight of the pictures taken by the ski- tour group of four during their climb

Annex 2

Photos taken by the ski-tour group of four

26.03.05 at 08:50

11 minutes before the accident

direction of sight F1

26.03.05 at 08:52

9 minutes before the accident

direction of sight F2

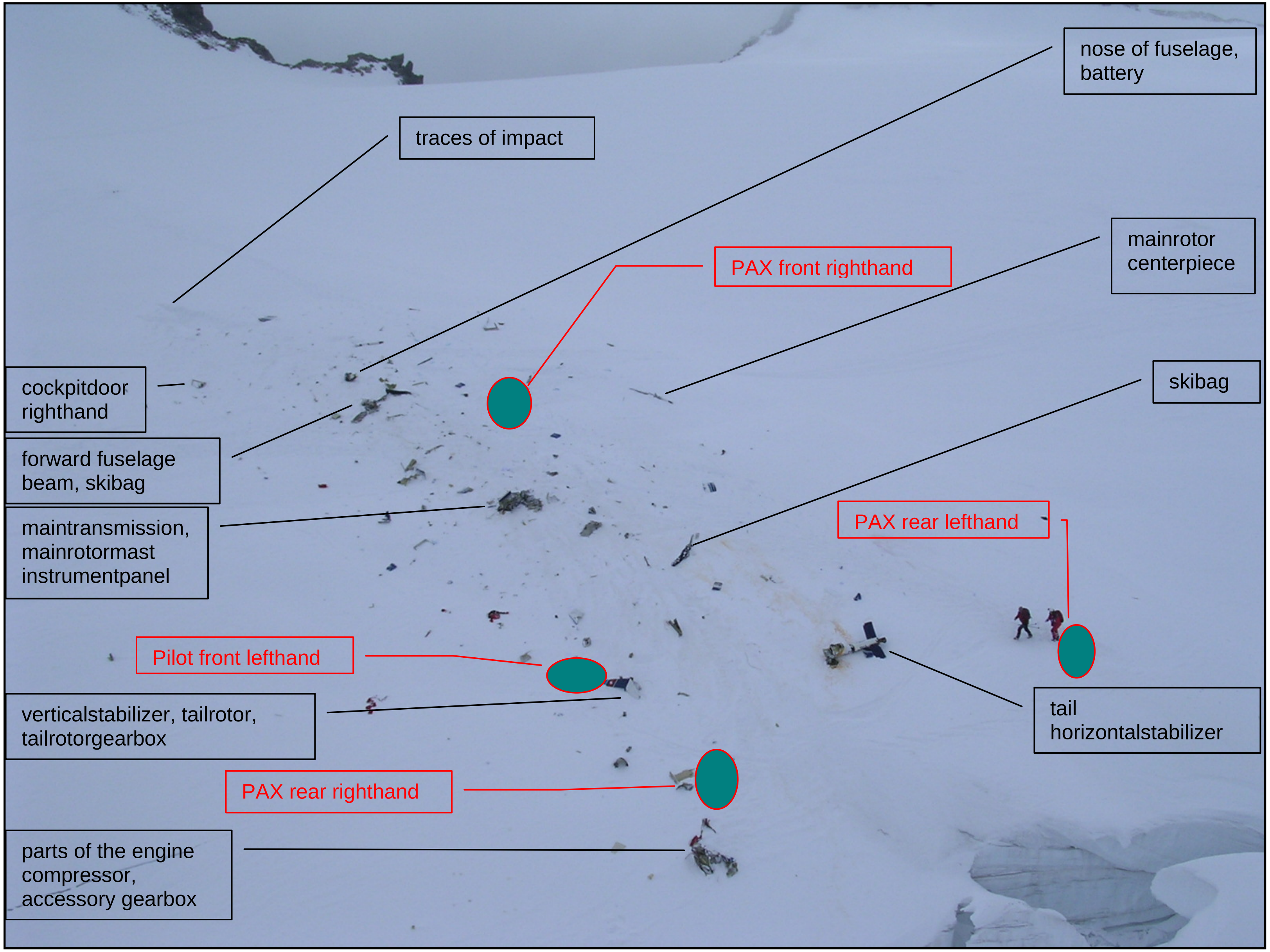
contrast and sharpness have been increased to show the dynamics of the clouds

26.03.06 at 09:09

8 minutes after the accident

direction of sight F3

Annex 3


nose of fuselage, battery
traces of impact
PAX front righthand
mainrotor centerpiece
skibag
cockpitdoor righthand
forward fuselage beam, skibag
maintransmission, mainrotormast instrumentpanel
PAX rear lefthand
Pilot front lefthand
verticalstabilizer, tailrotor, tailrotorgearbox
tail horizontalstabilizer
PAX rear righthand
parts of the engine compressor, accessory gearbox

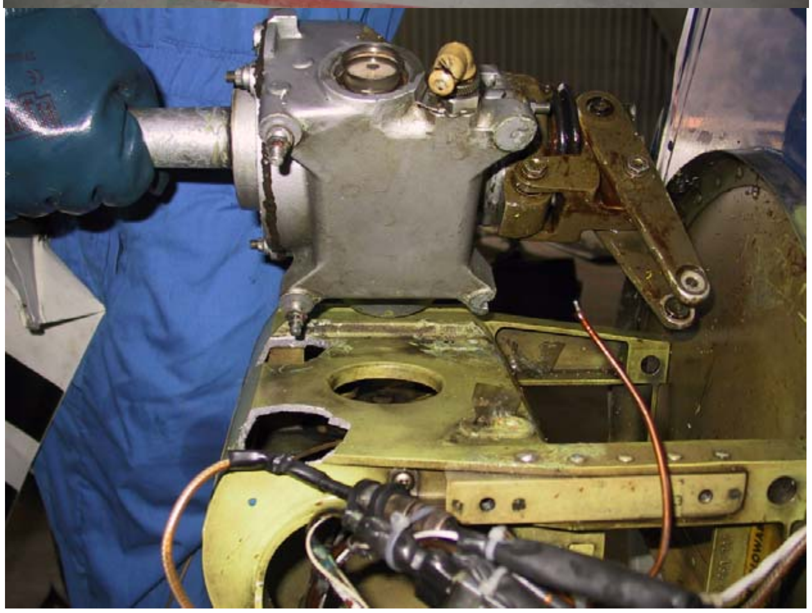
Annex 4

picture 1

layout of wreckage parts as per their position

picture 2

layout of tail with tailrotor, vertical fin and horizontal stabilizer



picture 3

torn off tailrotor-gearbox

Annex 5

scratch- and scoring marks on turbine stator

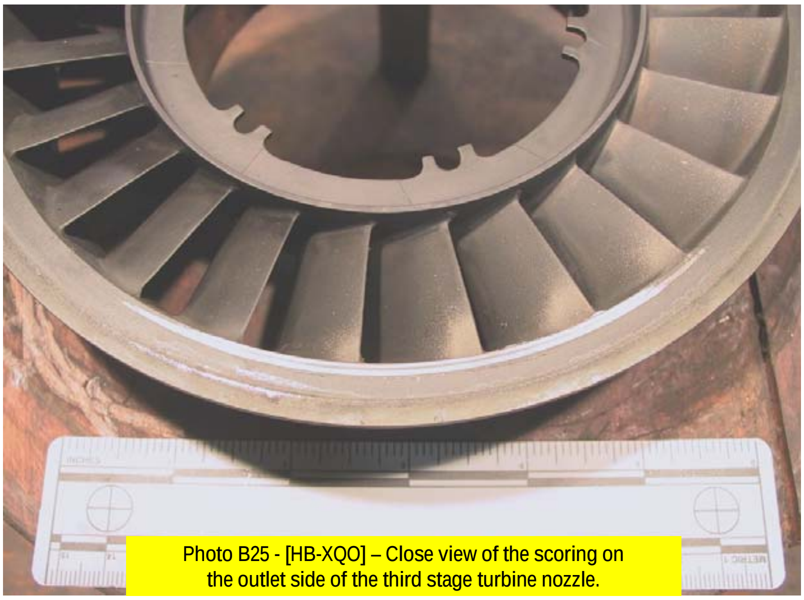


Photo B25 - [HB-XQO] – Close view of the scoring on the outlet side of the third stage turbine nozzle.

photo B25

third stage outlet side

Photo B31 - [HB-XQO] – Close view of heavy scoring in 3rd stage turbine wheel blade track and labyrinth seal surface at the hub on the inlet side of the fourth stage turbine nozzle.

photo B31

fourth stage inlet side

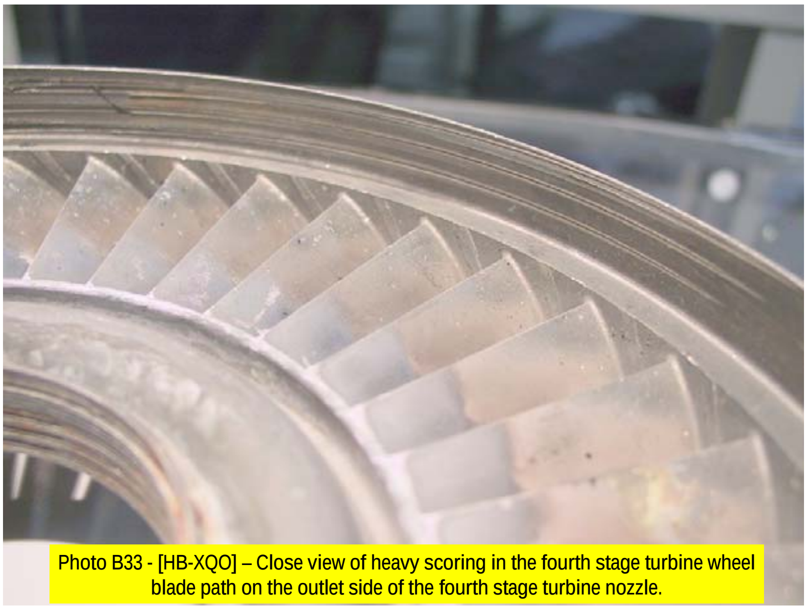
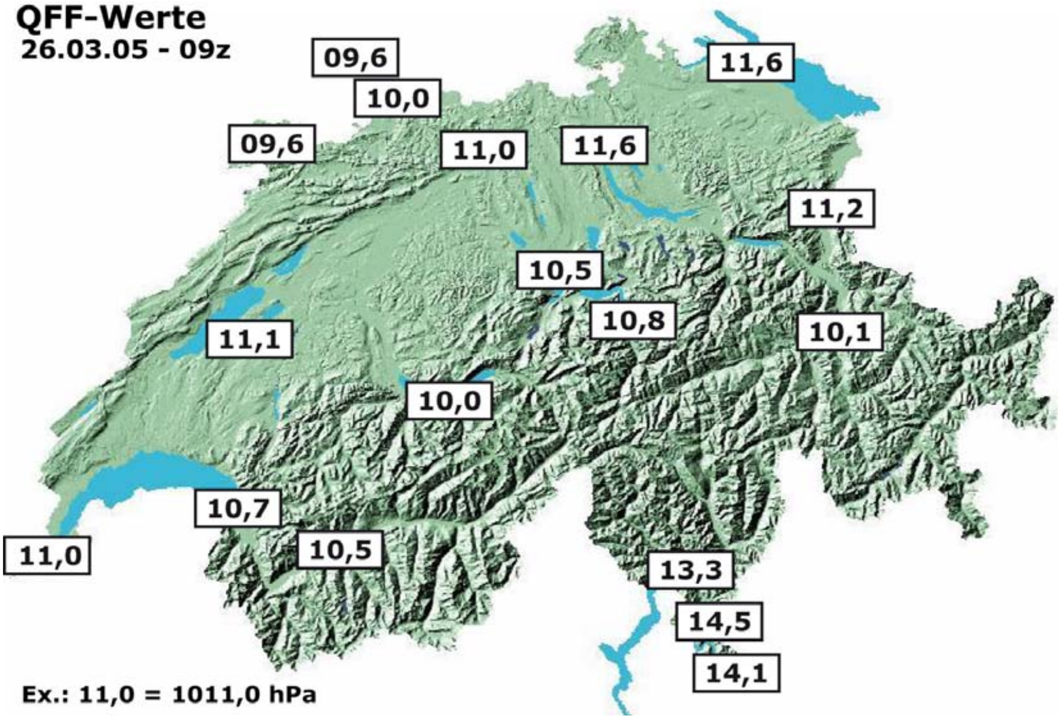


Photo B33 - [HB-XQO] – Close view of heavy scoring in the fourth stage turbine wheel blade path on the outlet side of the fourth stage turbine nozzle.

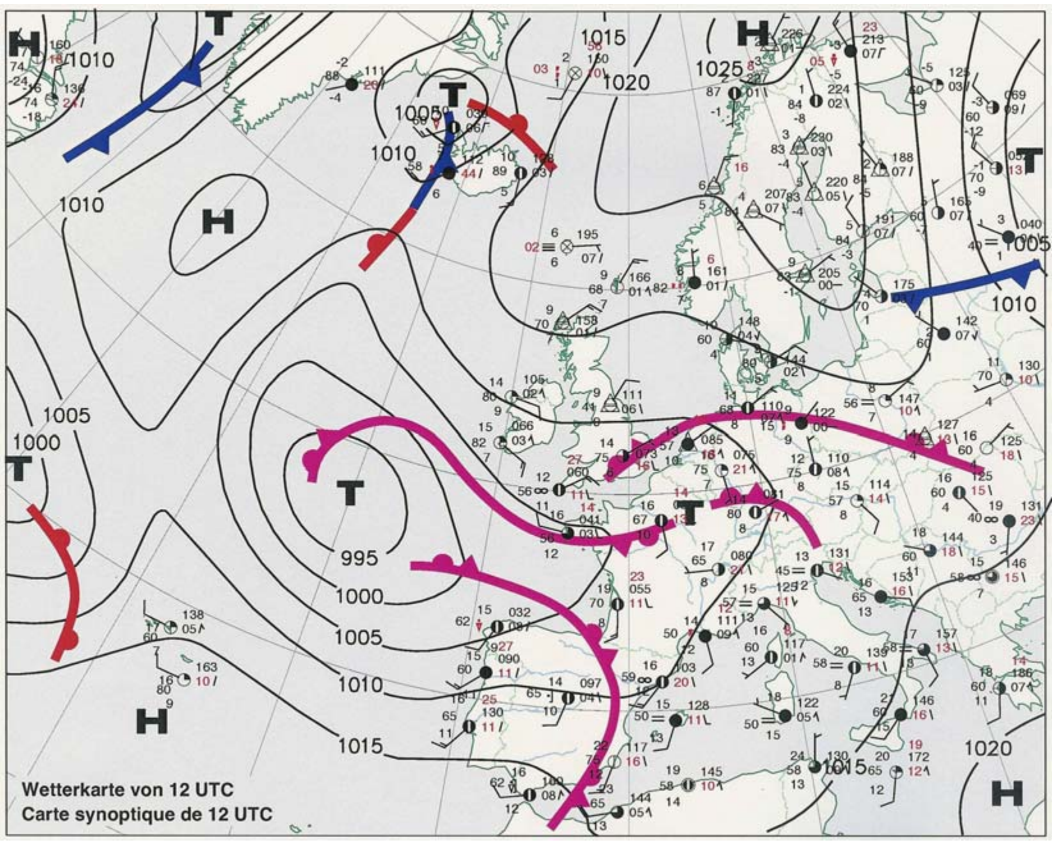
photo B33

fourth stage outlet side

Annex 6

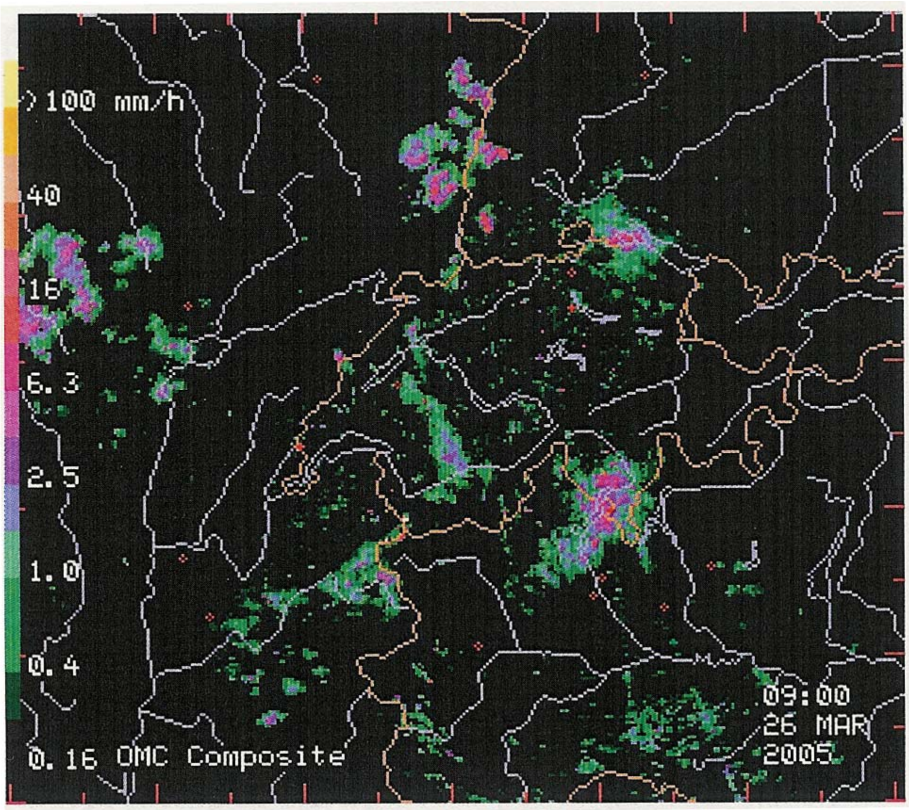


Pressure pattern on 26 March 2005 at 0900 UTC

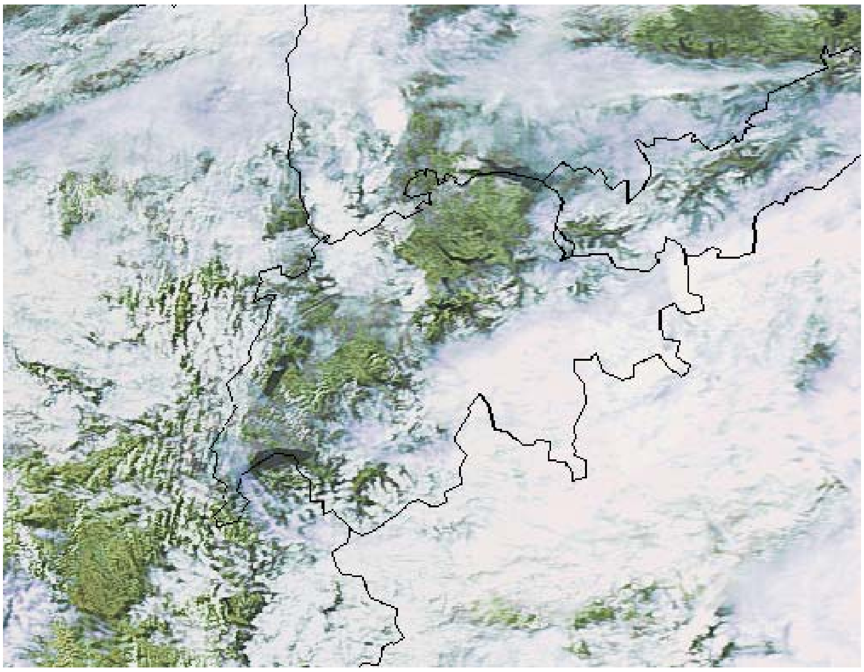


Surface chart of 26 March 2005, 12 UTC

Annex 7



Radarcomposite picture from MeteoSwiss, 26 March 2005, 0900 UTC



VIS-picture of Satellite NOAA 17, 26 March 2005, 1056 UTC