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**Aircraft accident investigation bureau AAIB**

# Final Report No. 1928 by the Aircraft Accident Investigation Bureau

concerning the accident

to the Bell 407 Helicopter, HB-ZBA

on 2 September 2004

Steinweid-Gross Band, Bisistal, municipality of Muotathal/SZ

approx. 40 km ESE of Lucerne

Bundeshaus Nord, CH-3003 Berne

## Ursachen

Der Unfall ist darauf zurückzuführen, dass das Anhängen einer Aussenlast an Hindernissen grosse Drehmoment- und Lastwechsel am Helikopter verursachte. Dies führte dazu, dass der Hauptrotor die Heckrotorwelle durchtrennte, es zu einem Kontrollverlust um die Hochachse kam, was zur anschliessenden Kollision mit dem Gelände führte.

Zum Unfall beigetragen haben:

- Auf Effizienz ausgerichtete Flugtaktik ohne genügende Sicherheitsreserve
- Fehlen einer gedanklich vorbereiteten und abrufbaren Handlungsoption

# General information on this report

This report contains conclusions by the AAIB 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/serious incident causes and circumstances is expressly no concern of the investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

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

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

Unless otherwise indicated, all times in this report are indicated in Swiss local time (LT), corresponding at the time of the accident to Central European Summer Time (CEST). The relationship between LT, CEST and universal time coordinated (UTC) is as follows: LT = CEST = UTC + 2 h.

The masculine form is used in this report regardless of gender for reasons of data protection.

## Contents

# Final Report

| | |
|---|---|
| Owner | Dreieck Leasing AG, 5402 Baden, Switzerland |
| Keeper | Helog AG, 6403 Küssnacht am Rigi, Switzerland |
| Aircraft type | Bell Helicopter Textron, B 407 |
| Country of manufacture | Canada |
| Country of registration | Switzerland |
| Registration | HB-ZBA |
| Location | Steinweid – Gross Band, Bisistal,<br>municipality of Muotathal, canton of Schwyz, Switzerland |
| Date and time | 2 September 2004, 09:16 LT |

## General

### Brief description

Whilst engaged in logging operations for a forestry corporation in the Bisistal valley, on a Thursday morning at about 09:00 in fine weather, the pilot had already flown several round trips (turns) with tree trunks between various loading areas and the unloading area (log deck). Shortly after picking up the load for a further turn, parts of a multiple load on the longline became entangled in the branches of a tree. A few seconds later, the helicopter began to rotate around its vertical axis and, with the load still suspended, crashed on the very steep and rocky terrain below the loading area. The pilot was able to vacate the cockpit unaided. The helicopter was destroyed.

### Investigation

The notification was received at the Aircraft Accident Investigation Bureau at 09:31. The investigation was opened on the same day at 12:00 in cooperation with the Schwyz cantonal police.

The accident was caused by an external load entangling on an obstacle, causing large moment and load variations on the helicopter. As a result the main rotor damaged parts of the tailboom. A main rotor blade severed the tail rotor shaft. This led to an immediate loss of control around the vertical axis and to the subsequent collision with the terrain.

The following factors contributed to the accident:

- flight tactics focused on efficiency with insufficient safety margins
- no mentally prepared and recallable recovery option

# 1 History

## 1.1 Pre-flight history and history of the flight

### 1.1.1 Pre-flight history

In the Muotathal and Bisistal area, tree trunks with their branches removed are flown out every year to maintain the protection-forest. The cantonal forestry office requested that this insect-infested timber be flown out from the impassable steep southern slope and the Oberallmeindkorporation had commissioned the HELOG aviation company to do this on the day of the accident. The order was placed on the basis of a quotation from the company dated 23 August 2004. In the days and weeks prior to the planned logging flights, the forestry personnel had prepared and measured the trunks. Generally, the calibration is based on the required assortment of timber or the possible transport capacities.

The pilot responsible for the order was very busy in the weeks before the day of the accident, flying the aircraft involved in the accident on other transport operations. After he had had a free weekend, as usual, on Monday he flew just 5 hours in a different region and on Tuesday he flew 27 round trips in an hour at the same location, again in HB-ZBA. On the Wednesday, the day before the accident, he was in his office, because the same aircraft was in use on another mission. After some exercise and dinner, he went to bed at about 23:00.

Helicopter HB-ZBA was, as it had mostly been for the preceding days, parked directly on the ground in the vicinity of the next transport operation and it was handed over by telephone to the pilot who would be flying it next. From the pilot's log: "*Wednesday, telephone with X. X confirmed to me that the aircraft is in order and located in the Muotathal at Schlattli on the large parking area.*"

### 1.1.2 History of the flight

Chronological sequence of the day of the accident from the pilot's viewpoint; the following information is taken from several conversations:

"*05:30 Got up and had breakfast at home.*

*05:50 Journey by car direct to the helicopter in the Muotathal.*

*06:45 Daily check on the helicopter, all covers removed, visual check over the entire aircraft, oil levels on turbine, gearbox and hydraulics checked, tail rotor transmission examined for traces of oil, fuel drain carried out at all three points, windows cleaned."*

*The pilot stated further: "Pitchlink checked, end stops and blades checked visually, main rotor head checked, oil level (tail rotor gearbox) not seen, nothing greased.*

*07:15 Journey by car to Stoosbahnen valley station, as no mobile reception at the helicopter. Coffee break in restaurant.*

*Approx. 07:40 Telephone confirmation by flight assistant A that the crew is ready for work.*

*Approx. 07:50 Departure from Schlattli direction Bisisthal. Radio instruction from flight assistant A, landing near refuelling area/unloading area.*

*Mechanical inspection of the cargo hook on the chopper. Flight operations material unloaded from the chopper by the flight assistant.*

*Flight without line with flight assistant M and forest ranger H to the "top strip" with landing in a meadow (full landing, no hover).*

*Return flight to the refuelling area, securing the line and checking the remote cargo hook by flight assistant A.*

*Start with logging line (50 m) to flight assistant D, approx. 13 trips from different loading points – nests – until first refuelling stop.*

*Fuel approx. 325 lbs, filled by flight assistant A.*

*After I had cleared out the first nest with flight assistant M, he moved on with the forest ranger to the second nest. I approached the nest for about the sixth time from the south-east, so that I had the sun to the rear when bringing up the cargo hook. When the load was suspended, I turned the helicopter towards the south-east using the right pedal. M stated on the radio: "Up, triple load, one trunk broken, secured with additional choker cable."*

*Where M was hooking up, I was against the sun. It didn't bother me. When I began to pull away, I was going away from the sun. I was wearing a basketball cap and sunglasses.*

*Taking the strain of the load, approx. 1000 kg.*

*M, on the radio: "All three off the ground."*

*From "Gügeli"* – 100% torque warning tone – *until the load became entangled, the flight was horizontal.*

*As the power built up, I let the chopper turn to the right until the nose was pointing directly into the valley (south). Easing the load out through a forest aisle.*

*The beech tree was to the right of the aisle. The beech was fairly tall, so I flew to the left of it.*

*After approx. 30 m I touched a beech tree with the lowest trunk in the load. At this time, the chopper was flying forward slowly and the logging line was tensioning.*

*Even after the impact, I was still looking outside from the bubble. I could see the entire longline and the beech tree. I think the yaw axis was still the same, nose into the valley, turned slightly to the right.*

*My perception is that the collective was still "high". I think that when I perceived the impact I corrected with the cyclic in a controlled movement to the rear. I cannot in all certainty say exactly when the impact occurred. The impact was a dull thud.*

*I think that the nose was pointing slightly to the right and the cargo hook was at the right-hand end of the rail, at the stop. I also think that I heard the cargo hook hit the end of the rail. I cannot say with any certainty whether I was banking.*

*I don't think I operated the pedals at all. The pedal position was neutral while weaving out, or even on the cold pedal.*

*The position of the collective remained high up until the point where I was again over the beech tree, the load was free and I wanted to fly in the direction of the valley. At this point I lowered the collective and that was exactly when the rotation began.*

*When the rotation started, I pushed the cyclic forward to gain speed, but I realised that I had lost control with the cyclic.*

The sequence from the viewpoint of flight assistant M (hookup person):

*"... The work was going well, the loads were perfectly prepared from the weight point of view. I had to clear out several small nests. It was the third nest. From this site, up to the accident, we had already flown out individual loads on about 5 round trips.*

*Now there were 4 more trunks there. One single load and three thin, short trunks, which are carried together. I estimate 800 kg. One was partially fractured in two places. I secured the breaks with choker cable – 6 m steelcable. I hooked up the load and removed myself some 10 m to the left. "Up three, one partially fractured in two places and secured with chokers." On being lifted, the two points break completely. The lowest of these three sections was jammed slightly under the single load, which was still there. I say, "still jammed a bit". P[1] comes down a little, and this section slides out from under the single load. Now the load is free. P pulls up and everything is in the air. Once the load is at a safe distance from me, I go back a few metres to the right and check. The chopper is flying down the valley, or away from the mountain, horizontally, not descending yet and the speed is slow, about the same as when he's bringing the hook, maybe twice walking pace.*

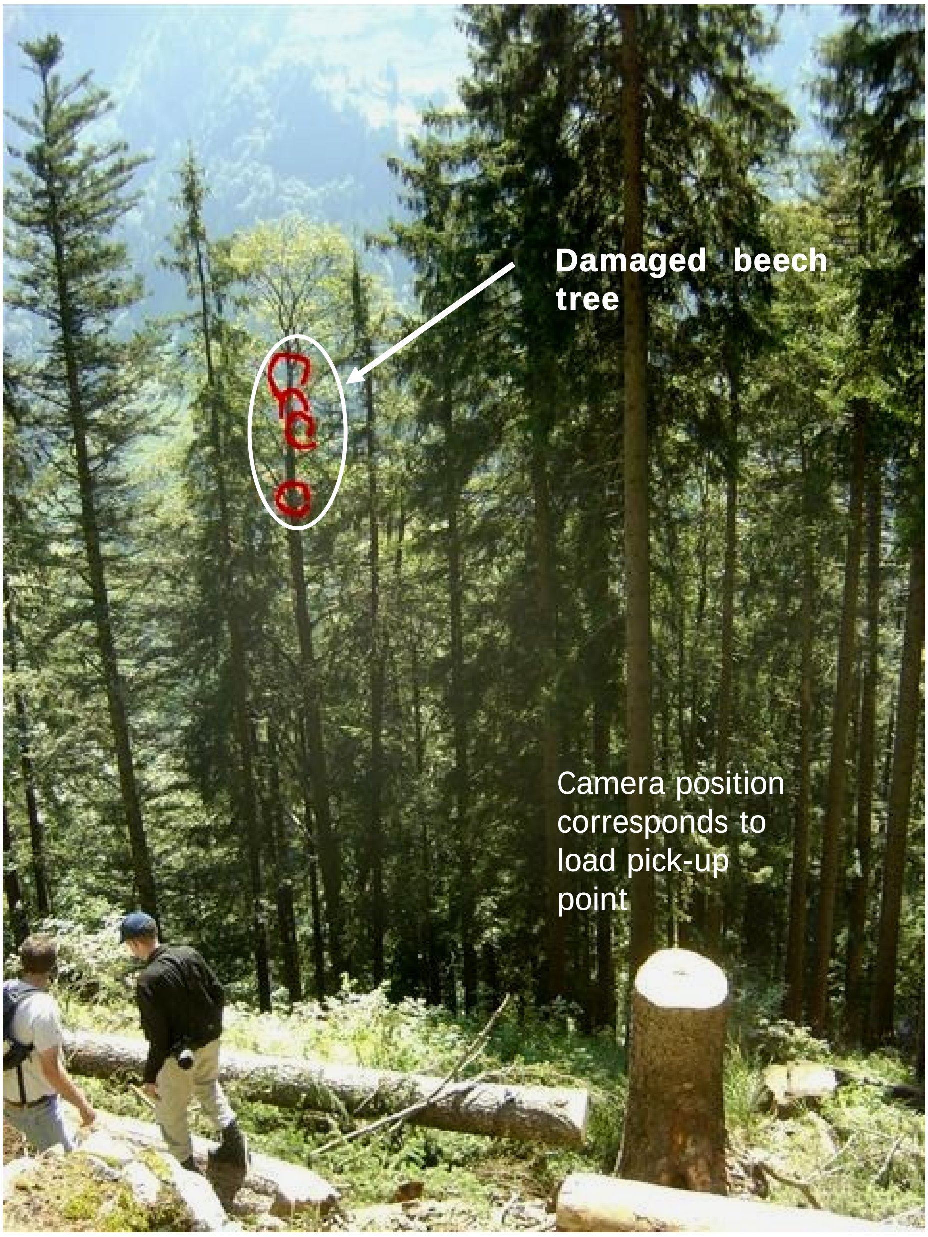
*The load becomes entangled in the beech tree about 30 m below. The forward motion of the helicopter was stopped abruptly.*

*The attitude did not change. It was an impact such as I have seen frequently. The chopper flew back maybe ten metres, nose in the direction of the valley, to untangle the load. He pulled the load straight up. Then he began to fly in the direction of the valley again. A few metres, and then there's a bang. A bit like the crack of a whip. At the same time, parts of the tail fly off. I can't exactly say where or what, but several small parts. I can't rightly say what the height of the load was at this time. At the top of the beech tree or already free. The chopper immediately began to rotate clockwise on its axis. The rotation and descent began slowly, in the direction of flight down the valley, and then got faster and faster. I saw about three revolutions and I could still hear the turbine. Then I couldn't see or hear anything any more. I estimate the time from the entanglement with the beech tree to the crack at about 10 seconds.*

*It took me a few minutes to get to the chopper – P is alive!"*

Flight assistant T observed the event from the unloading area: "*I could also see a cloud of dust from the rail rotor... Then the helicopter dropped and spun round at the same time.*"

[1] P stands for the pilot's forename.




Forest ranger K was at the “Mittlist strip”. From his position between the trees, he was not able to observe the course of events of the accident. He monitored the normal information from the flight assistant on the radio when the load was lifted and confirmed that the pilot had not said anything. He later heard: *“There was a crack. The chopper sounded different, not louder than before, just different. A few seconds passed and then I didn’t hear anything any more.”*

## 1.2 Injuries to persons

| | Crew | Passengers | Third parties |
|---|---|---|---|
| Fatally injured | --- | --- | --- |
| Seriously injured | --- | --- | --- |
| Slightly injured or uninjured | 1 | --- | |

## 1.3 Damage to the aircraft

The wreck at the site of the accident appeared as follows:


Tail section 1: Horizontal stabiliser with auxiliary vertical fins

Tail section 2: Tail rotor and vertical tail fin

Front of cabin, cockpit, airframe panelling, turbine and transmission panelling damaged; main rotor head, main rotor with various fractures and deformations, destroyed; tail destroyed with two main fractures, tail rotor shaft torn off, tail rotor blades damaged.

The longline was attached and under tension. All the chokers were still suspended from the remote cargo hook. Two trunks from the load of timber were still suspended in their chokers.

## 1.4 Damage to third parties

Slight damage to the forest floor and the forest.

## 1.5 Information on persons

### 1.5.1 Pilot

| | |
|---|---|
| Person | Swiss nationality, born 1963 |
| Licence | CPL (H) commercial pilot's licence, issued by the Federal Office for Civil Aviation on 03.05.1999 country code USA |
| | Commercial pilot's licence CPL (A) country code USA |
| Ratings | RTI VFR, NIT (A), NIT (H), MOU (H) |
| Registered aircraft classes | SEP |
| Registered aircraft types | AS 350B3, AS350 types, B206/206L/407 |
| | Hughes 300, SA315, SA332 S Puma |
| Medical fitness certificate | Class 1 |
| Last medical examination | 12 May 2004 |

#### 1.5.1.1 Flying experience

| | |
|---|---|
| Total, helicopter | 2004 hours |
| On the accident type | 640 hours |
| During the last 90 days | 136 hours total |
| | 89 hours on the accident type |
| Conversion to Bell 407 | 18 May 1999 in Switzerland |
| Last check flight on Bell 407 | 31 May 2002 in Switzerland |

On various helicopter types, the pilot had accumulated approx. 24,000 trips with external loads in approximately 1200 hours.

Approximately one third of these, some 8000 trips, were on the Bell 407.

The external load flights were all flown using the bubble window for vertical reference, the “bubble technique”.

### 1.5.2 Passengers

No passengers were on board.

## 1.6 Information on the aircraft

| | | |
|---|---|---|
| Type | Bell Helicopter Textron, B 407 | |
| Characteristics | Single-engined multi-purpose helicopter | |
| Year / serial No.: | 1998 / 53324 | |
| Turbine / serial No. | Rolls Royce Allison | |
| | 250-C47B | |
| | 650 shaft horsepower | |
| | S/N CAE-847354 | |
| Rotor | 4 main rotor blades | |
| Tail rotor | 2 tail rotor blades | |
| Equipment | Cargo hook with electronic weighing system | |
| | Modification acoustic warning signal "check instruments", installed and activated | |
| | According to work report No. 4341 Z dated 22.07.1999 bubble window part. no. 407-555-104 was installed as per STC 96-100 / SR 01076AT. | |
| Certification | Commercial VFR by day | |
| Operating hours | Flight logbook, last entry: | 2478:12 hours |
| | Engine hours instrument cockpit: | 2482:32 hours |
| Mass and centre of gravity | Before suspending the load, the mass and centre of gravity were within the permitted limits, taking account of the load according to paras. 1.16 and 1.18. | |
| Airworthiness certificate | Standard/normal | |
| Maintenance | Maintenance contract with a maintenance company based in Salzburg. This company was authorised according to JAR-145 to carry out maintenance work on Bell B407 helicopters. | |
| | Last annual check: | 14.01.04 |
| | Last 300 hour check: | 29.07.04 |
| | Last 50/100 hour check on airframe and engine was transcribed on 19.08.04. | |
| Flight time reserve | Approx. 40 minutes | |
| ELT | An ELT was fitted and was switched off by the pilot immediately after the accident. | |

### 1.6.1 Maintenance of the helicopter

Maintenance was carried out in accordance with a maintenance programme authorised by the FOCA.

The following was ascertained from an inspection of the technical documentation:

- The flight data and the maintenance records were entered in the flight logbook. However, it was noted that no technical faults of any kind were entered in this log. For example, two overtorque incidents (112.1% and 111.1%) which had occurred in the month preceding the accident were not documented in the logbook under the heading “troubles and observations”. The logbook and the technical documents reflected an incomplete picture of the condition of the helicopter.
- No “release to service” was issued on the occasion of the first overtorque inspection.
- The prescribed rechecks of the overtorque inspections were carried out after 34 and 35 flying hours respectively instead of the prescribed 25 flying hours.
- The daily checks were not regularly recorded, even though the operator provided a dedicated column in the flight logbook.
- The annual minimum service laid down by the FOCA according to TM 02.020-10 was not carried out in full according to the HIL entry of 09.04.04.
- Airworthiness certificates were double-entered in the FOCA form 52.081 in some cases. Two versions of page 3 exist, though these were not identical. AD (airworthiness directives) documentation (Fingerprints) were not archived, so airworthiness traceability was no longer possible. It could no longer be determined which parts of an airworthiness directive had been implemented. There was only one general signature for each AD. For example, it was not possible to confirm the incorporation of LTA 2002-263, ASB 407-01-48, tail boom modification.
- The 60 month inspection of the transmission and T/R gearbox were deferred several times by agreement with the manufacturer and the FOCA for a total of 10 months and had not yet been carried out.
- Helog did not employ any Bell 407 licensed mechanics.

### 1.6.2 Acoustic warning system

The helicopter had an audio “check instruments” warning signal. This audio warning system was fitted with a completion date of 22.01.99, according to a work order form. However, since approval did not yet exist, this system was deactivated on the same date.

This system was later recommissioned without approval.

## 1.7 Meteorological information

### 1.7.1 General weather situation according to MeteoSwiss

A high-pressure area centred over eastern Europe was determining the weather over Switzerland. A dry air mass resulting in fine weather lay over the north side of the Alps.

### 1.7.2 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. These interpolations were carried out by MeteoSwiss.

| | | |
|---|---|---|
| Weather/cloud | No cloud | |
| Visibility | Over 10 km | |
| Wind | Variable 1 knot, gusting to 4 knots | |
| Temperature/dewpoint | 13 °C/9 °C | |
| Atmospheric pressure | QNH LSZH 1019 hPa, QNH LSZA 1019 hPa | |
| Hazards | None detectable | |
| Position of the sun | Azimuth: 103° | Elevation: 22° |

### 1.7.3 Weather according to witness statements

Fine late summer weather with a blue sky. There was no wind.

## 1.8 Navigation aids

Not applicable.

## 1.9 Communication

When loading and unloading, the pilot was in contact with the flight assistants via channel Heli1.

## 1.10 Information on the airport

Not applicable.

## 1.11 Flight recorders

The Bell B 407 helicopter was equipped with neither a CVR – cockpit voice recorder – nor with an FDR – flight data recorder.

1.11.1 Engine parameter recorder

The engine control system was fitted with a FADEC – full authority digital engine control. On the engine side this consisted of an HMU – hydro mechanical unit – and of an ECU – electronic control unit on the airframe side.

For engine inspection purposes, the manufacturer included an IR – incident recorder – in the software of the ECU. On the basis of a detected violation of an engine limit, this function of the ECU records the key engine parameters over the 12 seconds before the event and up to 48 seconds after it. However, unlike the higher resolution of an FDR, this takes place only every 1.2 seconds.

It is not possible for the same parameter to be recorded as an exceedance until 24 seconds after an event.

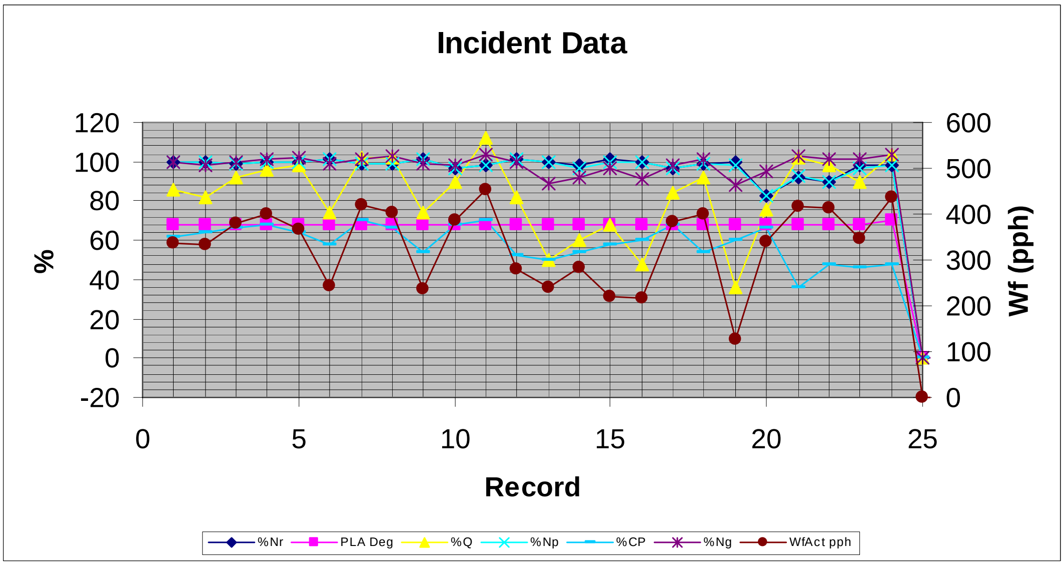
The data captured in this way can therefore only be reliably used to interpret one event for the engine and its functions. It is possible to interpret the data in a further technical aeronautical context only with the greatest caution.

The ECU had to be analysed by the manufacturer because of a connection which was damaged in the accident.

The analysis gave the following result, in summary:

*"Summary:*

*The interrogation of the Incident Recorder (IR) captured a torque exceedance. The data indicates the torque exceedance occurred between record 10 and 11 at time stamp 47:12:23.736 with a value of 110%. A rotor droop is also recorded at time stamp 47:14:34:128 with a value of 92%. There were no prior run faults recorded in the maintenance recorder."*



## 1.12 Information on the wreck, the impact and the site of the accident

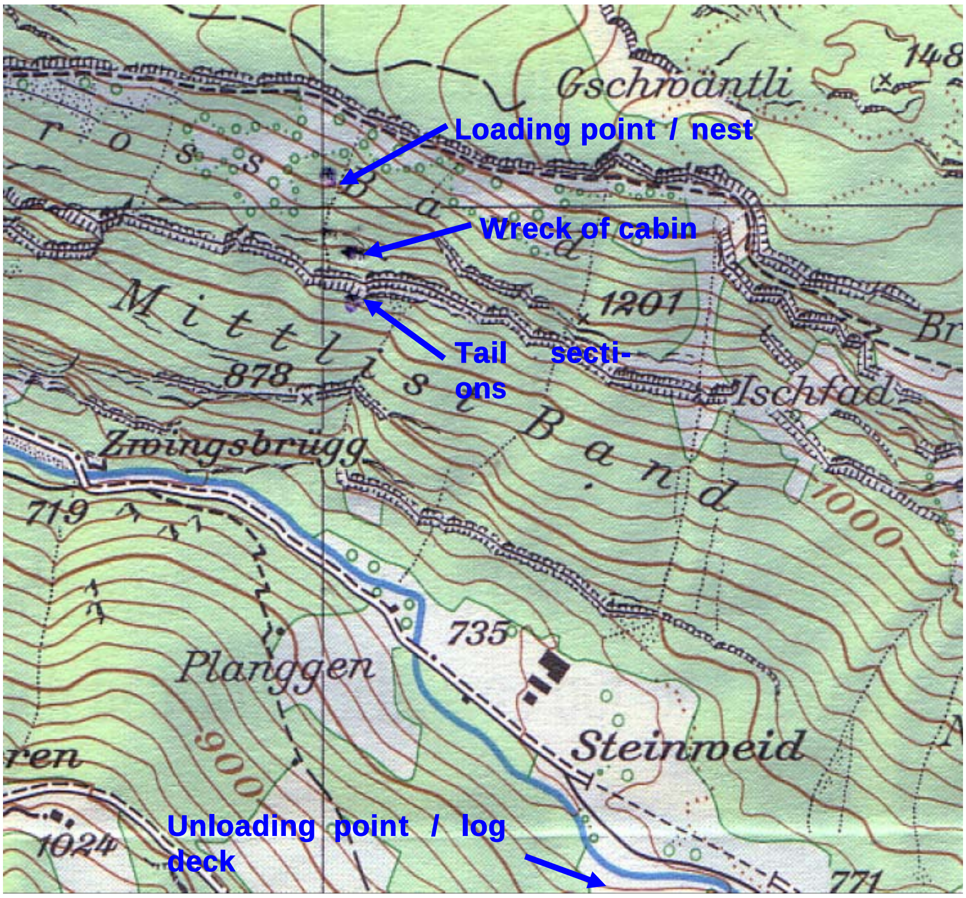
### 1.12.1 Accident site, impact

| | | | |
|---|---|---|---|
| Coordinates | Loading area: | 704.000/203.050 | Elevation: 1200 m/asl |
| | Main wreck: | 704.040/202.920 | Elevation: 1130 m/asl |
| | Tail rotor and stabilizer: | 704.040/202.890 | Elevation: 1030 m/asl |

The tree damage a few metres above the final position of the main wreckage, the alignment of the longline, which was under great tension, the anchor-like position of the trunks which were still in the choker and therefore in the remote cargo hook, the lateral position of the main wreck, the position of the tail rotor and horizontal stabilizer show that in the final phase the helicopter, rotating and under the tension of the longline, crashed into steep terrain (approx. 35°) at an angle of about 30 degrees.

The two individual larger tail sections came to rest at the foot of a vertical cliff face approximately 60 high, beginning directly below the main wreck.

The terrain was searched for parts of the wreckage in the downward direction from the loading area to the final position of the helicopter over a width of about 120 m and, in the area of the large parts of the tail, over a circumference of 150 m. The first small parts, approximately 1 $cm^2$ in size, could be found at a distance of about 100 m from the final position of the helicopter and some 60 m above it. These were located above a band of rock about 20 m high. Other small parts were in the band of rock and also underneath it. All parts were lying in the downward direction over a width of about 40 m. The small parts which were found all came from the area of the tail panels and the auxiliary vertical fins.

### 1.12.2 The wreck

#### 1.12.2.1 Initial findings after recovery

The parts of the wreckage were inspected shortly after they were recovered, primarily in the area of the tail drive system.

- The tail rotor drive was intact from the free-wheel clutch to the first break.
- At the break in the tailboom in front of the horizontal stabilisation surface, the tail rotor shaft had been violently torn out of a flange. The traces between the shaft and the flange indicate that it was not a matter of the primary cause of the tail rotor failure, as no traces of rotation could be found.
- In the central section of the tailboom, the tail rotor shaft was snapped from behind at the second segment by the main rotor. Traces of paint on all four rotor blades, the type of damage to the shaft and the panels make this clear. A piece of the tail rotor shaft about 30 cm long and parts of the panel, as well as the two top ends of the vertical fins which were also snapped off, were not found at the crash site.[2]
- At the break in the rearmost section of the tailboom, the rearmost tail rotor bearing and mount was torn out of the tailboom.
- The tail rotor was only slightly damaged and seems not to have been rotating, or no longer rotating quickly, at the time of impact.
- The tail rotor gearbox was not damaged and could be turned easily.
- All the tail rotor bearings were still operating smoothly.
- All flexible couplings were deformed to some extent but not separated.

Summary:

The tail rotor drive was separated at two points:

- by the main rotor at the second-from-last segment
- at the break of the tailboom from the fuselage during the impact.

The tail rotor drive was intact except at the above-mentioned points.

### 1.12.3 Forensic investigation

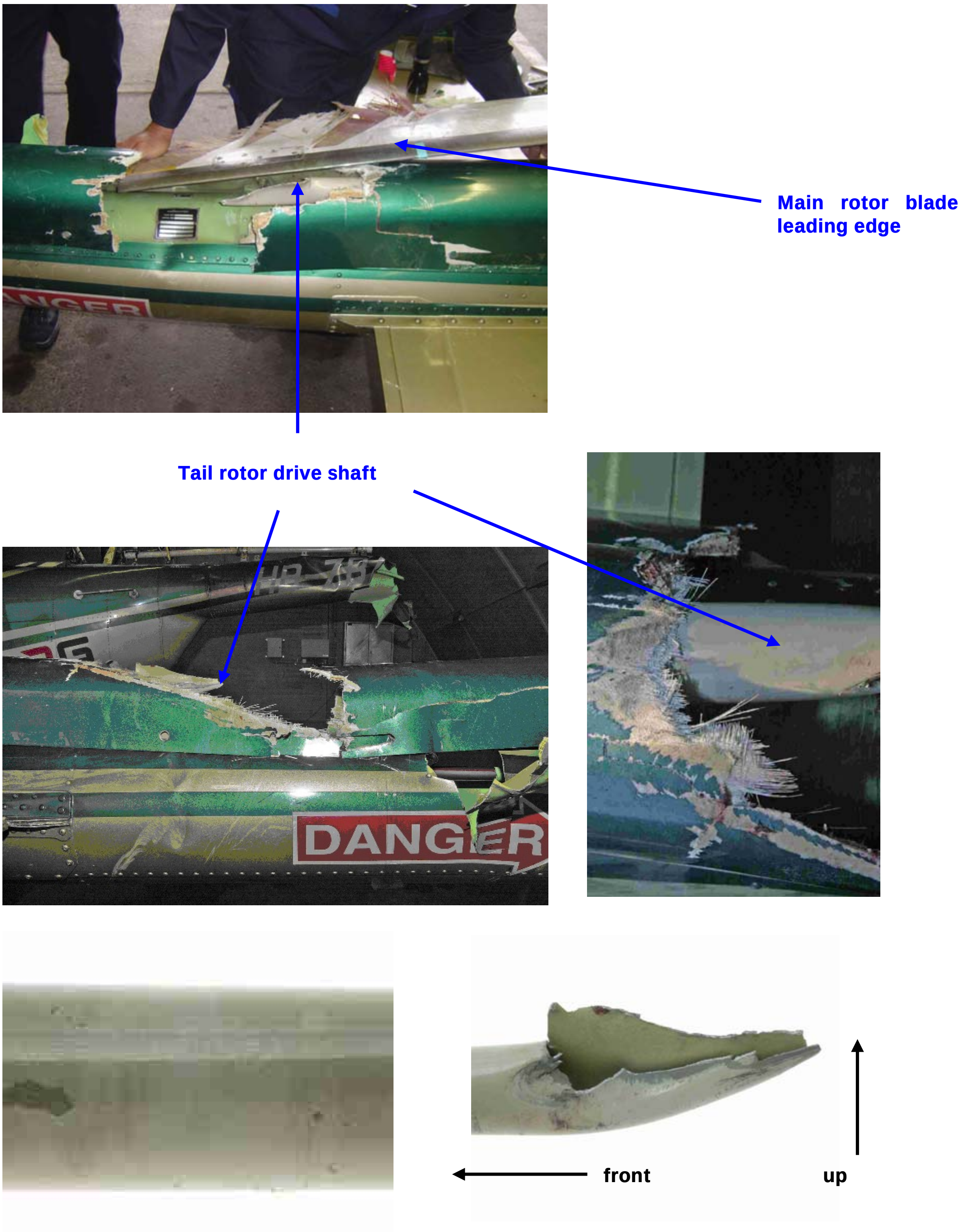
The forensic investigation concentrated on two areas:

- general forensic investigation, particularly of the tail rotor drive shaft, the tail panels and the main rotor blades
- forensic evidence of contact between the main rotor blades and the vertical stabilisation fins, the tail panels and the tail rotor drive shaft.

[2] During the search of the terrain on the following day, several small parts up to 1 $cm^2$ from the tail panel area and the vertical fins were found.

1.12.3.1 Summary of findings

Tail rotor drive shaft:




The entire area of damage, or rather the ruptured zone of the shaft, measures approximately 17 cm and starts with a dent, from which the wall of the tube is torn, on the one hand in the longitudinal direction and on the other hand along the circumference.

The damaged tube is compacted over the entire length of the defect, partly turned up and running conically to the rear. It is apparent that a substantial part of the shaft material is missing at this point.

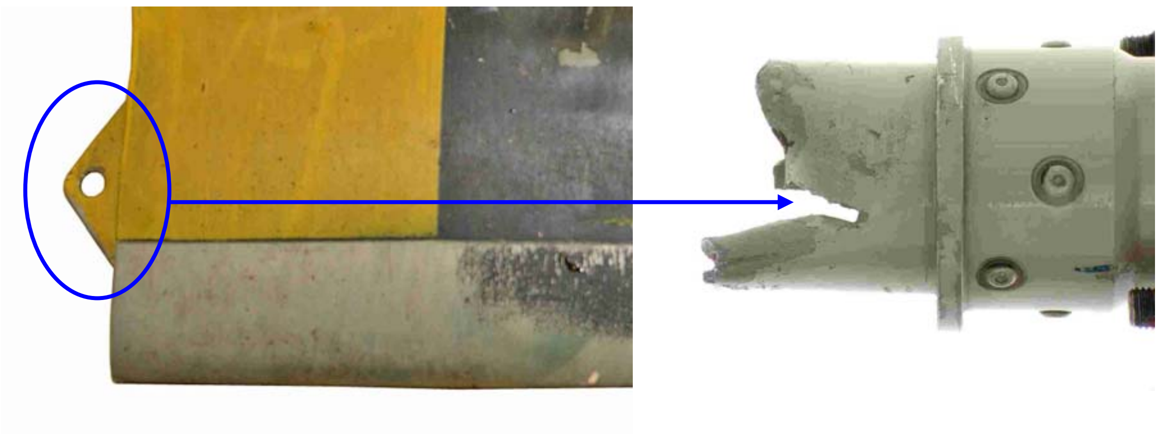
From an overall viewpoint, the end of the break in the shaft, viewed from above, is deformed in an anti-clockwise direction.

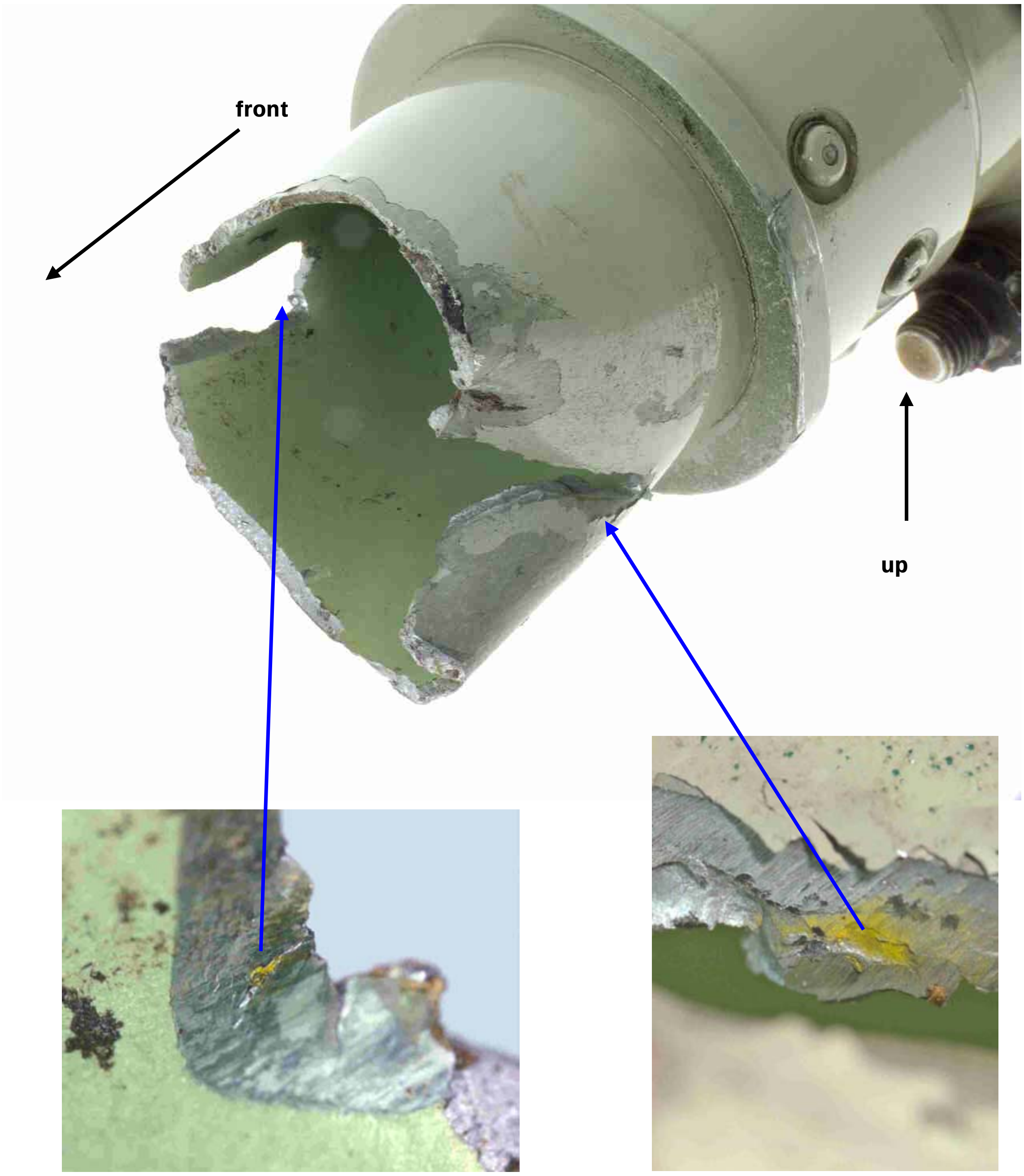
In the damage complex, black adhesions are present.

Scratches in the beige paint are present immediately in front of the damage described, on approximately three quarters of the circumference of the shaft and over a length of approximately 20 cm.

The part of the shaft protruding from the sleeve, with the break, measures max. 43 mm and, viewed from above, is deformed with the flanged flexible coupling in an anti-clockwise direction.

Although a short piece of the tail rotor drive shaft is missing between the two breaks, it must be assumed that only one main rotor blade, the "blue" one, was involved in the separation process: this statement is based on the panel which is penetrated obliquely (approximately 10° - 12°); its fracture ran to the part of the shaft on the tail rotor side, or rather to the two notches present in it. Also, the imprint of the leading edge of the main rotor on the front part of the shaft break and the traces of paint on the inside of the tail rotor drive shaft panelling which were found only on the "blue" main rotor blade. Superimposed traces which would have been made by other main rotor blades were not found on the components examined.





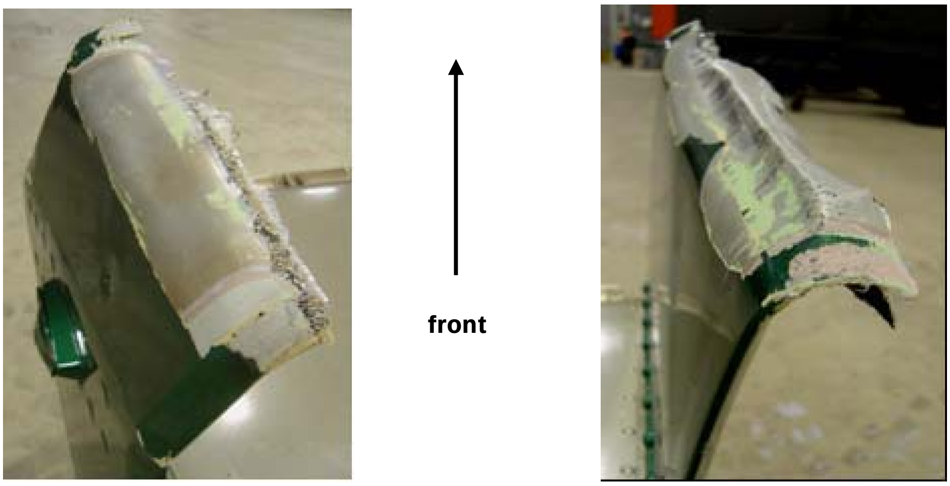

Two opposed nicks of 24 mm maximum length are present in the wall of the tube.

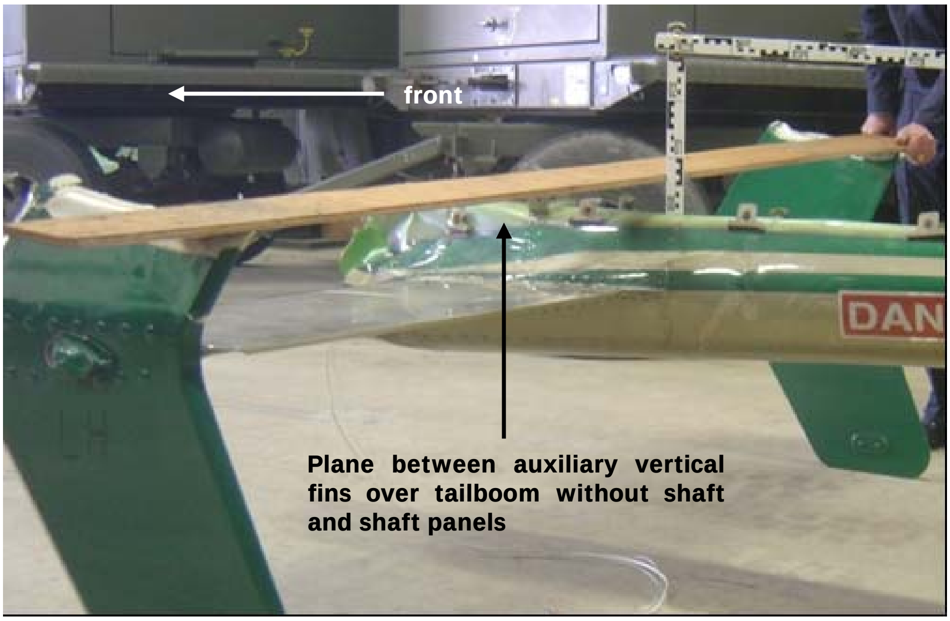
In the case of the “left” nick the force acted from the outside to the inside against the tube and vice versa in the case of the “right-hand” nick (viewing direction: cabin).

The deformations are formed accordingly. The “left” nick has sharp contours.

Traces of yellow paint could be detected in both nicks under the stereomicroscope.

Auxiliary vertical fins:




The LH vertical fin is buckled inwards slightly above the fixing points on the horizontal stabilizer.

Over the entire width of the approximately 37 cm long rupture, a sharp-edged dark impact can be seen at the beginning of the structural plate which is deformed inwards. At the front, this trace is approximately 26 cm above the top of the horizontal stabilizer and at the rear it is approximately 17 cm above it.

The part of the RH vertical fin exhibits no deformation above the horizontal stabilizer up to the point of separation, unlike the LH vertical fin.

Just below the rupture, there is a distinct dark trace of the shape of a main rotor blade leading edge over the entire width of approximately 36 cm. Above the rupture, the structural material is buckled outwards.

At the front the trace of the leading edge is approximately 27 cm above the top edge of the horizontal stabilizer and at the back it is approximately 21 cm above it.

The transection of the vertical fins took place at an angle of approximately 13°-14° (as viewed from the cabin, with reference to the top of the horizontal stabiliser) and rose slightly in the direction of rotation of the main rotor.

#### 1.12.3.2 Result

In summary, the following statement can be made:

The various traces on the panels, on both breaks in the tail rotor drive shaft and on the "blue" main rotor blade allow the conclusion that the separation was caused by an impact.

No forensic traces were found on the area concerned to indicate any other effect of force either before or afterwards.

### 1.12.4 Engine examination

*"The engine examination revealed the following:*

- *The engine N1 drive train turned freely with no binding noted.*
- *The engine N2 drive train turned freely with no binding noted.*
- *All rigid and flexible oil and fuel lines were checked and found to be intact, and all fittings were found to be at least finger tight.*
- *The HMU and CEFA were intact.*
- *The ECU (electronic control unit) J2 connector was damaged by impact forces.*
- *The engine fuel system was not compromised.*
- *Both gearbox magnetic indicating plugs were void of metallic material.*
- *The compressor intake area contained a considerable amount of impact debris. This debris was comprised of tree twigs and small branches.*
- *The left hand discharge tube sustained impact damage.*
- *The exhaust cowling sustained impact damage.*

***FINDINGS & CONCLUSIONS.***

- *No engine mechanical pre-impact anomalies were noted.*
- *A download of the ECU revealed the Incident Recorder (IR), captured a torque and NR exceedance. The engine parameters monitored indicate the engine was running in a normal condition at impact."*

## 1.13 Medical findings

There are no indications for a medical impairment of the pilot.

The pilot suffered a fractured rib, several contused wounds and contusions.

No traces of drugs, pharmaceuticals or alcohol were found.

He was able to leave hospital after one night of observation.

## 1.14 Fire

Since the aircraft came to rest on its side, the hot exhaust gases from the turbine, which was still running, ignited nearby leaves, ferns and some branches of bushes. The pilot heard the crackling of the fire and climbed out of the cabin through the RH front window.

Shortly afterwards, the pilot was able to turn off the fuel valve.

## 1.15 Survival-related aspects

The pilot described the phase of the rotating fall and the first minutes after impact in the clear, steep area of the wood:

*"...it turned me round, speeding up, from nothing, then faster and faster. I couldn't control the helicopter any more. I held on to the collective, but didn't release it. I was trying to hang on to the collective so as not to hit the ground so hard. I don't know whether I was still able to hold the collective at the end, I hadn't reduced. Cargo hooks and autorotation were not an issue for me at this point in time. It didn't occur to me, probably because of an experience from America. I tried to control the cyclic, it didn't work. I couldn't maintain attitude. I had difficulty keeping the cyclic stick in my hand. I saw that it was now coming down to earth. I came down turning. Shortly before contact with the ground, it pulled me to the right. I heard leaves rustling. Everything happened in fractions of a second.*

*The turbine was still running. Thinking of a possible fire, I had to get out, at the front via the right window. The turbine itself was not burning, only a tree trunk and grass. I switched the fuel valve to the off position, to shut down the turbine. I switched off the battery and the ELT. I looked for the mobile phone for a few minutes. I switched the battery on again, but the pilot's headset cable had been torn out. The turbine was still getting fuel. I got away from the helicopter and saw blood on me. I began to treat myself..."*

In the final phase of the rotating impact, the longline acted as an anchor and prevented a further fall over the cliff face which was about 60 m high. This was in steep terrain about 4 m away from the cabin.

The pilot was not wearing a helmet.

The Swiss Air Rescue Services (REGA) were informed at 09:19 by the Helog controllers. Shortly after the arrival of the rescue helicopter at 09:32, the pilot was rescued by winch.

The pilot was hospitalised for one night for observation in the Schwyz hospital.

## 1.16 Tests and research results

The parts of tree trunks suspended from the logging line at the time of the accident were found in the area of the main load and below the high cliff face, some of them in fragments, and identified unambiguously by the breaks in them.

Subsequent weighing of the parts of tree trunks excluding suspension gear produced an approximate weight of 1080 kg, allowing for missing splinters of timber and the large tolerance of the scales used.

Broken-off branches from the healthy beech tree which were found and which had come into contact with the cargo had a diameter of approximately 5 – 6 cm at the base of the branches.

## 1.17 Information on various organisations and their management

The Helog company had two helicopters of this type in commercial use. These were deployed as multi-purpose helicopters within their full rating range. Among other things, they were used for many different types of cargo flights.

Helicopter HB-ZBA was parked on site overnight 9 times in the 10 days before the accident. Among other things, 506 repetitive loads were accumulated during this period. The daily checks were carried out on site by the respective pilot. There was no licensed mechanic authorised to work on the Bell B 407 on the site.

After the initial findings shortly after the accident, the investigations focused on a possible technical cause. Without awaiting other investigation results, on the day after the accident the same company's second helicopter of the same type was again in use for underslung repetitive loads.

## 1.18 Additional information

### 1.18.1 Mass and centre of gravity

Basic weight 1328.4 kg/2928 lb

Pilot 85 kg/187 lb, fuel approx. 104 kg/230 lb

External load in accordance with Paragraph 1.16:

Recovered and weighed tree parts: approx. 1080 kg/2380 lb, suspension gear approx. 60 kg/132 lb

Resulting gross weight approximately 2657.4 kg/5857 lb

External load in accordance with Paragraph 1.18.4:

Last load recorded by the electronic scales: 1250 kg/2755 lb (according to pilot including the suspension gear)

Resulting gross weight approximately 2767.4 kg/6099 lb.

The centre of gravity with a suspended external load in stationary hovering flight, at approximately 127.3 inches longitudinal CG, was within the permitted limits.

### 1.18.2 Performance

The calculated maximum mass for stationary hovering flight at the loading area outside of the ground effect was approximately 2670 kg/5880 lbs.

The profile of the flight path from the loading area as far as the beech tree confirms the calculated performance.

### 1.18.3 Limitations

In the annex to the aircraft manual, the following LIMITATIONS are described concerning the CARGO HOOK:

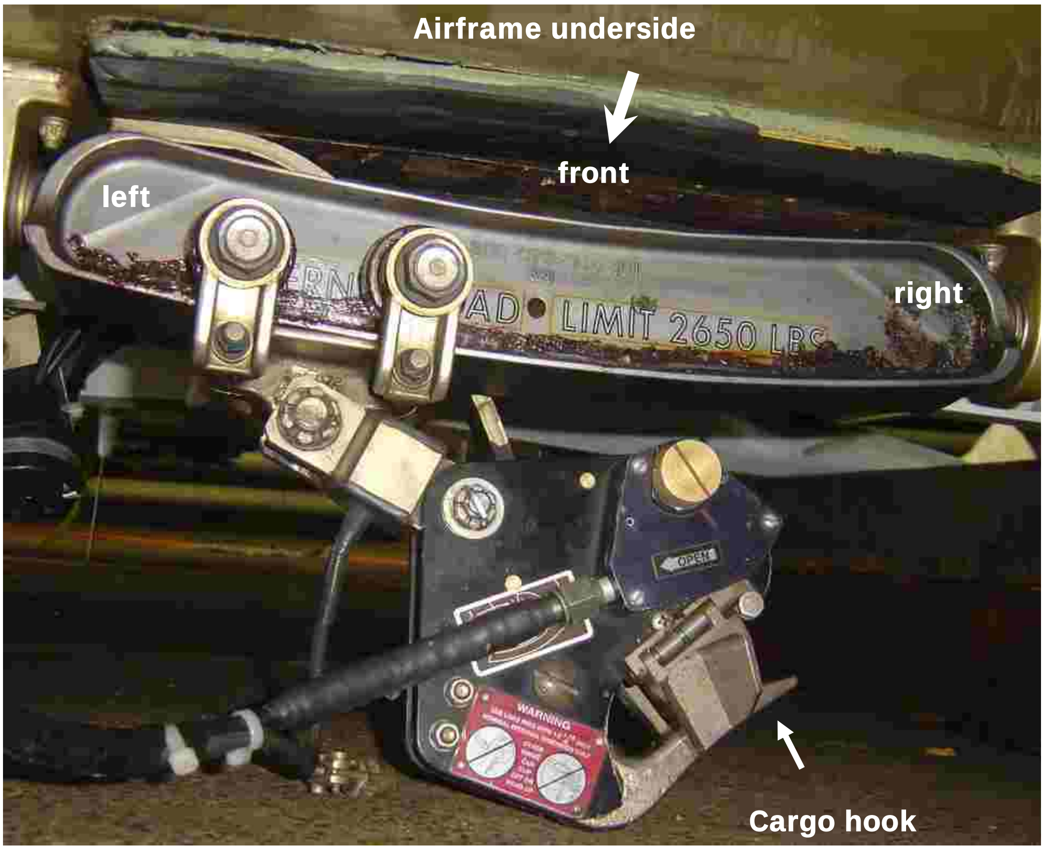
*1-6. WEIGHT AND CENTER OF GRAVITY*

*Caution*

*LOADS THAT RESULT IN GROSS WEIGHT ABOVE 5000 POUNDS (2268 KILOGRAMS) SHALL BE CARRIED ON CARGO HOOK AND SHALL BE JETISONABLE.*

*Maximum gross weight of helicopter and external load operation is 6000 pounds (2724 kilograms).*

*Maximum cargo hook load is 2650 pounds (1202 kilograms).*




1.18.4 Weighing system and analysis

The weight of the suspended load can be recorded automatically given that weight and time conditions are met, or manually shortly after “load off ground”. The pilot selects this mode on the recording device installed in the cockpit. According to the weighing record for this day, the time of the recording was selected manually, and the resulting weights were corrected in the weighing system by accelerometer. Of 33 recorded weights, only 2 were recorded automatically between the first lift and the resistance to travel which rose shortly afterwards.

The pilot stated that he “zeroed” the scales that day on the ground before take-off. He always did this for suspended load flights, so that in the evening when carrying out the analysis he had no other data on the scales. He had to re-enter the basic settings of the scales, because the backup battery no longer supplied sufficient current to store the settings. When doing so, however, he restricted himself to the essential settings only such as mode: manual, unit: kilogram and the weight detection threshold.

The manufacturer describes the first signs of failure of the lithium battery as inconsistent date and time information.

This load recorder, with unset or incorrect basic data (customer, location, pilot, aircraft, day of the month, winter time), otherwise gave a consistent picture in relation to the flights (number of flights, flying times) and the transport operations (round trip times in relation to nests, weights) on the day of the accident.

In summary, for round trip times of one and a half to two and a half minutes, 31 loads (excluding 2 local movements of a few seconds) were recorded in the following weight ranges:

| Weight range | 500-699 kg | 700-799 kg | 800-899 kg | 900-999 kg | 1000-1099 kg | 1100-1199 kg | 1200-1299 kg |
|---|---|---|---|---|---|---|---|
| Number of trips | 3 | 2 | 8 | 5 | 9 | 1 | 3 |

1.18.5 Emergency procedures according to the operating manual

1.18.5.1 Tail rotor failure

In chapter 3, the operating manual for the Bell 407 helicopter describes the emergency procedure for a tail rotor failure as follows:

*"3-5. TAIL ROTOR*

*There is no single emergency procedure for all types of antitorque malfunctions. One key to a pilot successfully handling a tail rotor emergency lies in the ability to quickly recognize the type of malfunction that has occurred.*

*3-5-A. COMPLETE LOSS OF TAIL ROTOR THRUST*

*This is a situation involving a break in drive system (e.g., severed driveshaft), wherein tail rotor stops turning and delivers no thrust.*

- *INDICATIONS*
    1. *Uncontrollable yawing to right (left side slip)*
    2. *Nose down tuckling*
    3. *Possible roll of fuselage*

*NOTE*

*Severity of initial reaction of helicopter will be affected by AIRSPEED, CG, power being used, and HD.*

- *PROCEDURE*

*3-5-A-1. HOVERING*

*Close throttle and perform a hovering autorotation landing. A slight rotation can be expected on touchdown.*

*3-5-A-2. IN-FLIGHT*

*Reduce throttle to idle, immediately enter autorotation, and maintain a minimum AIRSPEED of 55 KIAS during descent.*

*NOTE*

*When a suitable landing site is not available, vertical fin may permit controlled flight at low power levels and sufficient AIRSPEED. During final stages of approach, a mild flare should be executed, making sure all power to rotor is off. Maintain helicopter in a slight flare and smoothly use collective to execute a soft,* *slightly nose-high landing. Landing on aft portion of skids will tend to correct side drift. This technique will, in most cases, result in a run-on type landing. …"*

1.18.5.2 Cargo hook

For suspended load transport with the electric release mechanism in the remote cargo hook at the end of the longline, cockpit operation was enhanced by means of a selector switch for upper or lower release respectively. The normal procedure has already been applied several times for the cargo trips before the accident and had functioned without any problems. The emergency procedure is described as follows in the annex to the operating manual:

*Chapter 3. Emergency procedure*

*If the suspended load has to be jettisoned in an emergency, the electric release pushbutton is located at the top on the control stick. If the electric release does not operate, the mechanical release must be operated according to Basis AFM Supplement.*

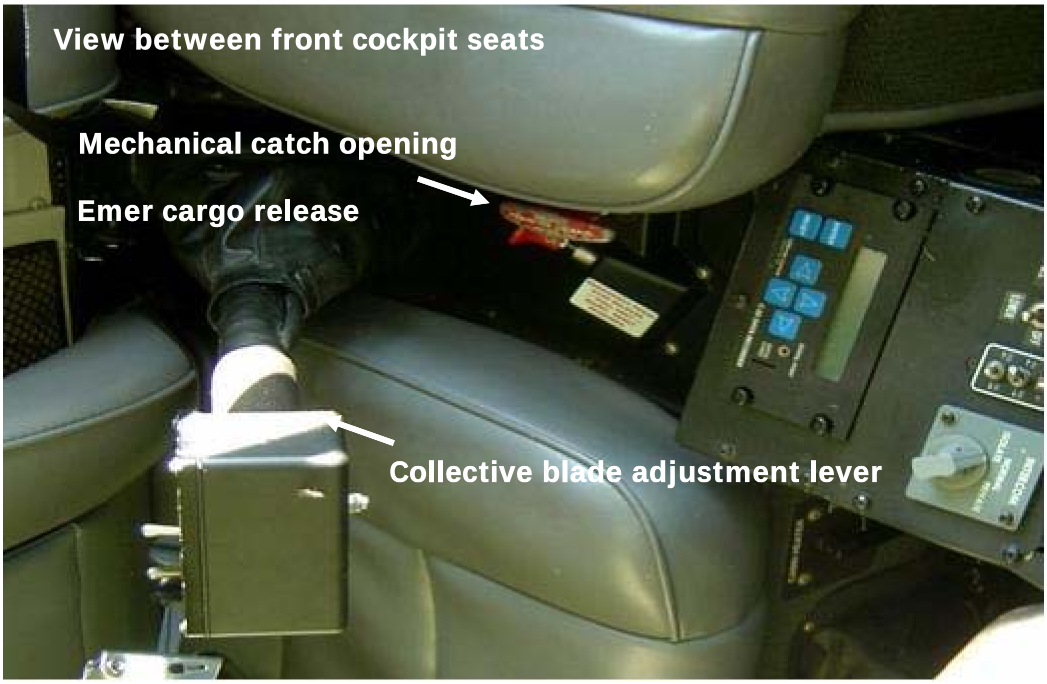
*BASIS AFM 3-13. CARGO FAILS TO RELEASE ELECTRICALLY*

*Warning*

*EMER CARGO RELEASE PULL handle will function regardless of CARGO RELEASE switch position. In event cargo hook will not release sling when cyclic CARGO RELEASE switch is pressed, proceed as follows:*

1. *Maintain tension on sling.*
2. *Pull EMER CARGO RELEASE PULL handle to release load.*

To recover the wreck, tension on the logging line first had to be released and the line had to be removed. The mechanical release operated to do this functioned perfectly.



## 1.19 Useful or effective investigation techniques

According to data received from the manufacturer of this helicopter on clearance between the main rotor and the tail, a dimensionally accurate visualisation of this clearance was produced. The two weight configurations of 4000 lbs and 6000 lbs were represented in three different combinations of the main rotor control:

1. *collective-position for steady hover*, *cyclic stick centred*
2. *collective-position for steady hover*, *cyclic stick full aft position*
3. *collective down*, *cyclic stick full aft position*

For technical reasons, the data produce minimum distances which can be attained only for a short time, given the assumed digital maximum deflections of the collective or cyclic main rotor control.

This applies only as long as the helicopter airframe is in flight, motionless and within the prescribed limits for the centre of gravity.

The clearance can be seen in Annex 1 “Blade clearance over tailboom”.

# 2 Analysis

## 2.1 Technical aspects

### 2.1.1 General

The results of the investigation of the parts of the wreckage, the various components of the aircraft controls and the engine produced no indications of any pre-existing technical faults which might have caused the accident.

### 2.1.2 Analysis of the circumstances of the main rotor impact on the tailboom

The observations of flight assistant M: "…*then there was a bang. A bit like the crack of a whip. At the same time, parts of the tail flew off. I can't say more precisely where or what, but several small parts…"* provide a clear statement about the location and point in time of damage to the tail area. This moment corresponds to the observation made by flight assistant T from the unloading point about 500 m away and some 460 m lower down: "…*There was a cloud of dust from the rail rotor… Then the helicopter dropped and spun round at the same time…*".

The description of a "*cloud of dust …at the tail rotor*", allowing for the blurring due to distance, matches the statement of the flight assistant who was very close and who speaks of "…*several small parts*". These small parts, which would have looked like a cloud of dust from a distance, were found only in an area within the steep wooded terrain. This area was located fairly precisely below the hovering position of the helicopter in the seconds during which it was attempted to disentangle the suspended load. Small parts of the tailboom panelling and above all of the auxiliary vertical fins, of different sizes, but with very many up to approximately 1 $cm^2$, with their typical honeycomb aluminium structure, were found.

The forensic investigation indicated that the main shaft to the tail rotor was severed by an impact from a main rotor blade. The helicopter, in a hovering attitude and without forward motion, had to begin to rotate clockwise as a result of the absence of torque compensation.

The change in the noise from the helicopter described by forest ranger K: "…*There was a crack. The chopper sounded different, not louder than before, just different. A few seconds passed and then I didn't hear anything any more*", can be explained by the failure of the tail rotor drive.

The pilot's statement and the analysis of the ECU confirmed that the turbine was operating normally.

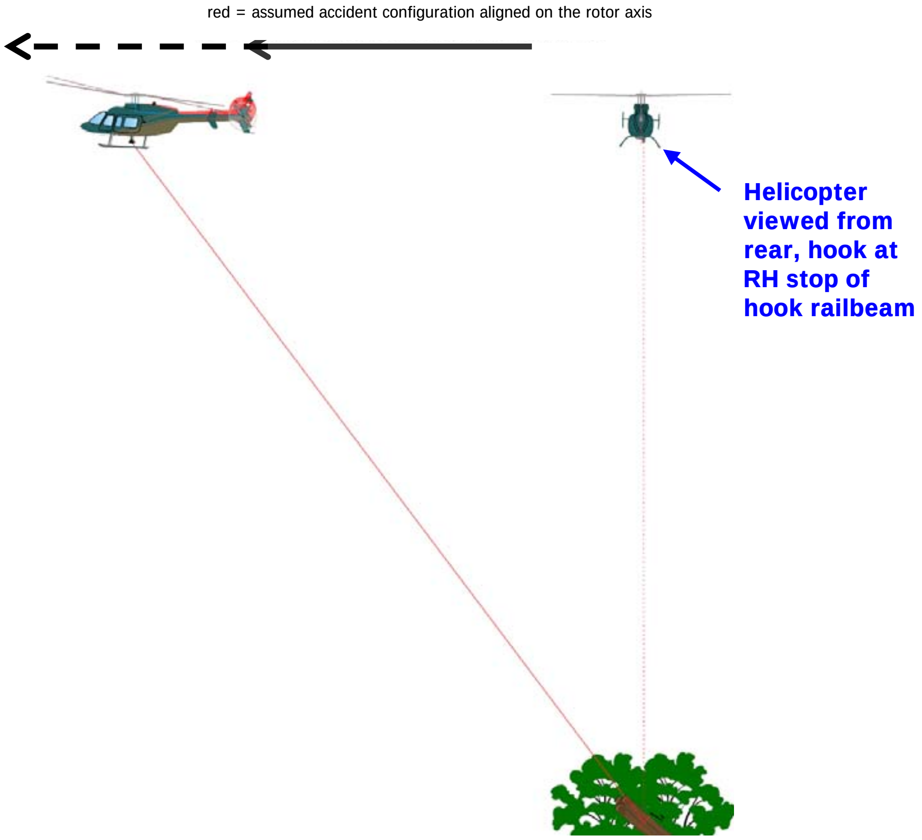
The course of events during the accident can be explained by the forensic analysis of the two main breaks in the tailboom. In particular, the traces of tearing and fracture on the tailboom panelling indicate the sequence of events. Thus the panelling, other than the damage caused by the main rotor, is torn upwards in the direction contrary to the rotation of the main rotor. The complete fracture of the tailboom can only have happened after the severing of the tail rotor drive shaft by the main rotor.

The position of the parts of the wreckage of the tailboom indicate that this fracture took place during the final phase of the rotating fall, shortly before or during the impact on the mountainside. The mass of the tail rotor section, in particular the gearbox, caused the panel structure to fracture and tear apart under the acceleration forces caused by the rotation and additionally by the tension of the suspended longline. The second fracture to the rear also exhibits similar characteristics and can have occurred only in the final phase of the crash or on impact at the position of the parts of the tailboom found below the cliff face.

The relatively undamaged reinforced steel sleeve on the leading edge of the "blue" rotor blade can be explained by the very sudden separation of the tail rotor shaft, rotating at 6317 rpm, due to the high speed of the rotor blade. At the end of the blade, the speed of the tip of the rotor blade corresponds to 231 metres per second. The angle of impact and the shape of the two points of contact produced only a very small area of contact. It was not possible to find the part of the tail rotor shaft which was ejected in the nearby terrain, despite a detailed search.

The "blade clearance over tailboom" in the annex, for two weights particularly relevant for cargo flights, indicates the small residual clearance between the main rotor plane and the area of the tailboom concerned as long as the centre of gravity is within the permissible limits.

As in the case of this underslung cargo flight under investigation, the force of an entangled longline would act through the cargo hook in the direction of flight and offset to the centre of the rotor, resulting in a nose-down pitching moment. In the absence of corrective control inputs the resulting flight path of the helicopter would be an accelerated motion towards a vertical trajectory to the ground, along an arc with the length of the long line as the radius. The magnitude of this moment dependends on the horizontal speed. The pilot reacted to this pitching moment by instinctively attempting to maintain the horizontal attitude of the helicopter by applying the necessary control inputs. Consequently the rotor disk tilted aft. In addition he manoeuvred the helicopter backwards. According to the pilot's statements, he was under the impression that he had freed the load and wanted to quickly initiate the descent. However, as the airframe movement was most likely still restricted by the load, the distance between the main rotor and the tail decreased below minimum separation.




From the ground, abrupt load changes were observed and these were clearly perceived by the pilot in the cockpit as hard shocks. The healthy and strong beech branches which were found, broken off by the suspended load, indicate instantaneous large forces as described above. In addition, when the break-away occurred, there was a brief and extreme load change with effects, among other things, on the individual rotor blades, the ends of which underwent major vertical oscillatory deflections.

Thus as regards rotor blade clearance, a number of unfavourable factors are combined:

1. The small minimum distance between the rotor blade and the tailboom during appropriate control, with the centre of gravity within the permissible limits.
2. The moment of an entangled load on the transverse axis, which acted about the suspension point of the cargo hook over a lever arm approx. 2.3 m long.
3. Impulses as a result of load changes on the helicopter result in oscillations of the ends of the rotors in the vertical direction. With regard to the longitudinal centre of gravity, a load entangled to the rear induces large pitch moments.

In Annex 2 “Sum of factors”, the resulting effect is illustrated as a red shadow.

### 2.1.3 Maintenance of the helicopter

Obviously, the helicopter was subject to very harsh operating conditions, which was particularly severe for all mechanical components. It is reasonable to place a high emphasis on the maintenance of such an aircraft. In this case, the flight and technical logbooks present an incomplete picture of the condition of the helicopter. Considering the type of operation, it must remain open whether adequate importance was placed on maintenance.

## 2.2 Human and operational aspects

### 2.2.1 General

Helicopter logging operations impose particular demands on persons and equipment. Those involved, on the ground and in the air, are particularly challenged precisely because of the special conditions of the location, such as steep, rocky terrain, overgrown loading areas with poor visibility, and the variation and position of the felled "timber" which has to be transported. The ability of the ground crew to estimate weights and positions when preparing timber is primarily of great importance for smooth, efficient operation.

The pilot: *"Until the accident, the day had been "a perfect day", the best weather, no wind, everything was optimal. Uniformly heavy loads and smooth operation. I can still remember radioing the flight assistants to ask then to compliment the forest rangers on how consistently they had prepared the timber."*

### 2.2.2 Operational latitude and limitations

Because of the many factors involved, including those mentioned above, estimating the weight of a cargo is difficult in actual operations, even if the timber is measured. With the attempt to increase productivity or "daily output" in terms of transported timber, the probability of a conflict with the limits of the transport aircraft involved also increases.

These technical limits are the absolute limit values specified in the helicopter's operating manual under Section 1, Limitations. Ultimately, these can be upheld and complied with only by the pilot.

Within these limits, the respective pilot's individual assessment of feasibility is also a factor. The operational demands of a transport operation which is primarily focused on expeditiousness and efficiency result in reduced margins for obstacle clearances. This was one of the latent hazards in the present case; another was the weights at the performance limit of the available flying profile.

Furthermore, there was an immediate hazard from the load which was secured with chokers, and which was close to spreading, thus making an entanglement with obstacles more likely.

Considering his actions after the surprising entanglement of the load, the pilot was not aware of the hazards resulting from an airframe which was limited in its free movement by a restriction on the cargo hook. There may not have been any possibility to make effective flight path corrections using control inputs, due to the involved moments and rapid force fluctuations, unless the load were immediately jettisoned.

A pilot recognising the threat of entangling a load has the following options, provided that there is sufficient margin between the load and the helicopter's maximum lifting capability, and provided that he selects a suitable forward speed: He can either correct the anticipated and temporary entanglement using normal control inputs within operating limits, or he can consciously execute the mentally prepared option to jettison the load.

2.2.3 Control using the vertical reference technique

Individual perception regarding control and coordination is worthy of consideration particularly with regarding to cargo flights using the "vertical reference" technique.

With regard to the question of whether the special attitude of the head in the "bubble window" technique may have a labyrinthine effect on control, the following statements can be made from the medical viewpoint:

- Disorientation due to erroneous information from the labyrinthine system or the organ of balance actually occurs only in the absence of visual references. Where visual references do exist, these are 90% responsible for spatial orientation.
- However, control of the helicopter may be problematic when the pilot's view is directed towards the suspended load – i.e. downwards to the rear – and when the direction of flight is forward. Converting visual perception into appropriate actions on the controls involves a substantially higher effort by the central nervous system (CNS), and this may lead to coarser control inputs.

  As in all complicated CNS control procedures, different factors play a role, e.g. training, predisposition or aptitude in respect of orientation in three-dimensional space under difficult conditions.
- This intrinsically complex process may possibly have become even more difficult as a result of the cargo becoming entangled, and may have led to large control movements.

2.2.4 Application of emergency procedures

The position of the helicopter over the steep slope at a height of at least 50 m above the wooded terrain with its nose in the direction of the open valley would have made possible the emergency procedures specified in the helicopter's operating manual:

**1. After the entanglement:**

A. Jettisoning only of the load of timber under tension, electrically on the cyclic with an instantaneous improvement in the centre of gravity.

B. Jettisoning of the entire load with suspension gear using the red "e-mer cargo release" handle. No workers were in the forest below the helicopter's hovering position. However, the handle is difficult to reach under the collective and between the seats on the cockpit floor. This is aggravated by the pilot's seating position, inclined away to the right because of the bubble window.

The pilot confirmed by his actions that the easy jettisoning of a cargo of timber of no value was not an option for him in the first moment when the load became entangled.

### 2. After commencement the first sign of rotation:

Jettisoning of the entire load as above and immediately initiating autorotation.

Statement by the pilot:

*"…I was being pushed against the bubble window, but never lost my grip on the cyclic and collective. I never thought of releasing the cargo hook. This would in any event have been possible only with great difficulty, as the position of the mechanical release on the Bell 407 is not exactly optimal."*

Then, at the instant rotation began, a reflex reaction took over. Impressive descriptions by his former flight instructor, i.e. experiences from the past were subconsciously recalled from long term memory upon the recognition of similar circumstances.

In the case of a developed and accelerating rotation, the survivability can be greatly increased by the dense forest by cushioning the impact and decelerating the rotation.

This effect, and particularly the impact angle in the already steep terrain with the anchoring effect of the entangled longline, resulted in a successful outcome to the pilots actions.

The focus should be on the crucial initial instant of the entanglement when determining the appropriate actions in case of an emergency. If the load is not jettisoned in this instant then the outcome is solely dependent on the conditions and random rather than controlled.

Procedures designed for specific emergencies only have a chance of success, even of being recalled, if they are consciously rehearsed again and again before and during flying operations and adapted to the local situation. This facilitates the decision to jettison a load or a load line, based on personally defined criteria or triggers. The occurrence of the criteria "surprise" could result in an immediate jettisoning of the load.

# 3 Conclusions

## 3.1 Findings

- The pilot was in possession of a commercial pilot's licence (category: helicopter).
- The pilot concluded conversion to the Bell 407 type on 18 May 1999.
- The last check flight on the Bell 407 type took place on 31 May 2002.
- There are no indications of the pilot having any health problems.
- The pilot was not wearing a helmet.
- The helicopter was rated for commercial transport, VFR, by day.
- The last 50/100 hour check on airframe and engine was transcribed on 19.08.2004.
- The helicopter underwent a check by the FOCA on 14.01.04.
- At the time of the accident, the helicopter had an operating time since manufacture of 2478:12 hours.
- The mass of approximately 5857 lb in accordance with Paragraph 1.18.1 and the longitudinal centre of gravity of approximately 127.3 inches were within the limits before the accident and with the cargo being carried at the time of the accident.
- For helicopter HB-ZBA a maintenance contract existed with a maintenance company based in Salzburg. The aviation company did not employ any mechanics licensed for this helicopter type.
- No technical faults were entered in the log-book.
- The last two overtorque incidents were not dealt with in accordance with the prescribed procedure.
- The pre-flight checks were not regularly confirmed in the flight logbook.
- The helicopter had an audio warning system with a "check instrument" warning signal. This was installed in Switzerland and deactivated because approval was lacking. This system was later recommissioned without approval. The pilot used the warning signal at 100% torque as an aid in his flying using the "vertical reference" technique.
- The investigation found no indication that a technical fault was present on the helicopter.
- The investigation of the engine and the analysis of the ECU produced no anomalies.
- The longline was entangled and under tension after the accident.
- The tail rotor drive was separated at two points:
  - by the main rotor at the second-from-last segment
  - at the fracture of the tailboom from the fuselage during the impact.

- The various traces on the panels, on both breaks in the tail rotor drive shaft and on the “blue” main rotor blade, allow the conclusion that the rupture was caused by an impact. No forensic traces were found on the area concerned to indicate any other forceful effect either before or afterwards.
- An ELT was installed and was switched off by the pilot.
- Up to the accident, the cargo recorder recorded 31 loads in the weight range between 500 and 1299 kg. Three loads were in the range above 1200 kg.

## 3.2 Causes

The accident was caused by an external load entangling on an obstacle, causing large moment and load variations on the helicopter. As a result the main rotor damaged parts of the tailboom. A main rotor blade severed the tail rotor shaft. This led to an immediate loss of control around the vertical axis and to the subsequent collision with the terrain.

The following factors contributed to the accident:

- flight tactics focused on efficiency with insufficient safety margins
- no mentally prepared and recallable recovery option

# 4 Safety redommendations and safety actions taken

## 4.1 Safety recommendations

### 4.1.1 Technical equipment of the helicopter for cargo flights with vertical reference

4.1.1.1 Safety deficiency

For cargo flights with mirror reference, the pilot sits upright and looking straight ahead in the cockpit. He has an indirect view on the external load and a limited field of view due to the mirror. The cockpit instrumentation is in his peripheral view. Visual warnings are perceptible and relevant parameters are quickly visible.

As compared to cargo flights with mirror reference, a bubble window or floor window permits a direct vertical view to the load and the conditions on the ground.

Helicopters which are operated using this vertical reference also for cargo flights often present certain interface issues.

Various monitoring instruments and controls are not readily visible or accessible anymore as the pilots upper body is tilted outwards to the bubble window and facing down. Therefore, the original installation as certified for normal cargo flights is not fully compatible with operations using vertical reference.

4.1.1.2 Safety recommendation No. 383

The FOCA should ensure that for helicopter cargo flights using vertical reference:

- the emergency jettison mechanism for the cargo hook is readily accessible
- the pilot is made aware when parameters vital for the operation of the helicopter become marginal

### 4.1.2 Personal equipment of the pilot for cargo flights with vertical reference

4.1.2.1 Safety deficiency

Pilots of cargo flights using vertical reference often cannot wear a helmet due to the space restraints when tilting the head outwards.

4.1.2.2 Safety recommendation No. 384

The FOCA should ensure that it is possible for the pilot of a cargo flight using vertical reference to wear a helmet, and that a helmet is utilized.

### 4.1.3 Flight data recording

4.1.3.1 Safety deficiency

Readily available flight data recording devices allow for simple access and analysis of the data for various purposes. In particular, the data can be used for the crucial quality assurance of daily operations. Flight data monitoring fosters the safety awareness of all involved.

Furthermore, cargo operation flight data facilitates administrative tasks and provides transparency to the customer.

Flight data recorders (FDR) certainly are of high importance for accident investigations. The majority of the currently operated helicopter fleet is not equipped with FDRs.

The AAIB restates the necessecity for flight data recording, with reference to the following previous safety recommendations in final reports No. 1418, 1444, 1505, 1572, 1568, 1638.

Final Report No. 1418 (HB-XPJ 1990): Recommendation No. 77: "The Federal Aircraft Accident Review Board recommends to investigate the usefulness of installing a flight data recorder on helicopters in commercial suspended load operations."

Final Report No. 1444 (HB-XUB 1989): "The Federal Aircraft Accident Review Board recommends to investigate whether it would be required: Recommendation No. 81: to mandate, as applicable to fixed wing aircraft, the installation of a flight data recorder on helicopters of that mass. Safety Recommendation No. 82: to modify the ergonomics so that instruments indicating information relating to maximum performance are visible at all times during flights using vertical reference."

Final Report No. 1505 (HB-XXD 1991): "The Federal Aircraft Accident Review Board presents the following recommendations: No. 102: A flight data recorder should be prescribed for all helicopters exceeding a mass of 6000 lbs (approx. 2.7 tons) engaged in suspended cargo operations."

Final Report No. 1572 (HB-XRZ 1993): Safety recommendation Nr. 122: "Helicopters of this weight category should be equipped with a flight data recorder, as addressed by JAR OPS Part 3."

Final Report No. 1586 (HB-XOL 1994): Safety recommendation No. 126: "The fuel flow limiting device warning should also be aural. SR No. 129: It is necessary to consider a flight data recorder for helicopters of this weight category."

Final Report No. 1638 (HB-XXF 1995): Safety recommendation No. 156: Helicopters of this mass category, in commercial operations, must be equipped with flight data recorders."

4.1.3.2 Safety recommendation No. 385

The FOCA should ensure that significant flight and performance parameters as well as suspended loads are recorded. This data should be systematically downloaded, analyzed and archived by designated personnel under the responsibility of the operator or owner.

## Annexes

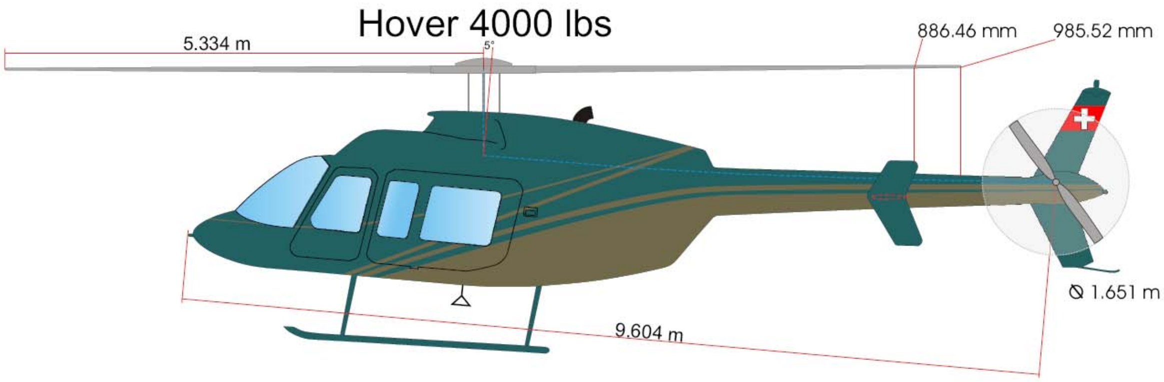
### Annex 1: “Blade clearance over tailboom”

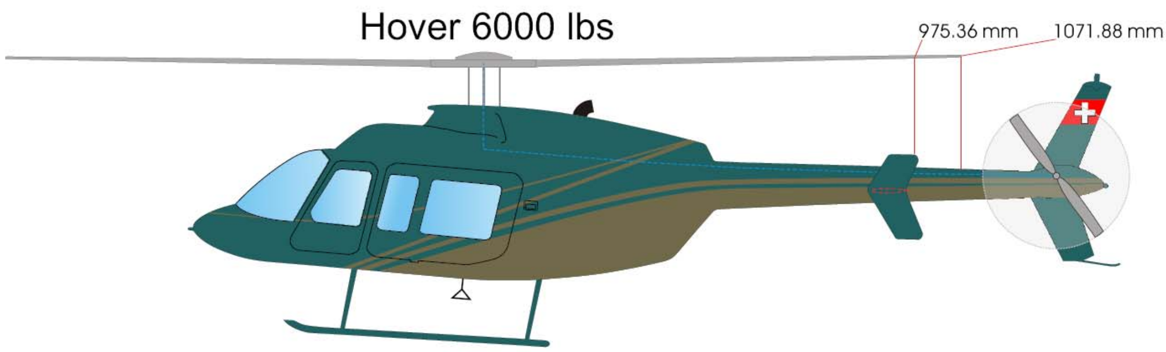
### Annex 2: “Sum of factors”

Berne, 20 December 2006 Aircraft Accident Investigation Bureau

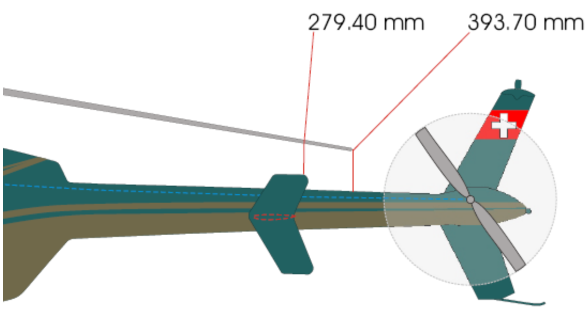
**Annex 1**

## Blade clearance over tailboom

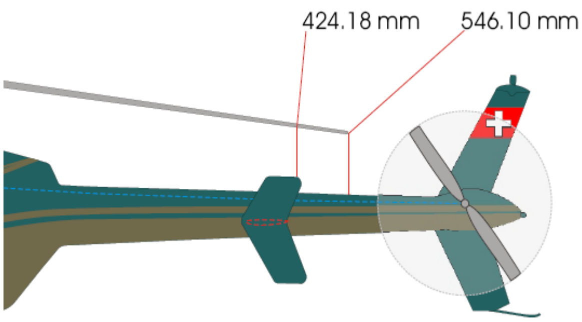


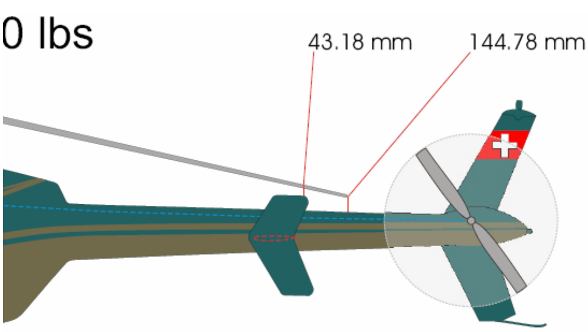

FULL CYCLIC BACK 4000LBS



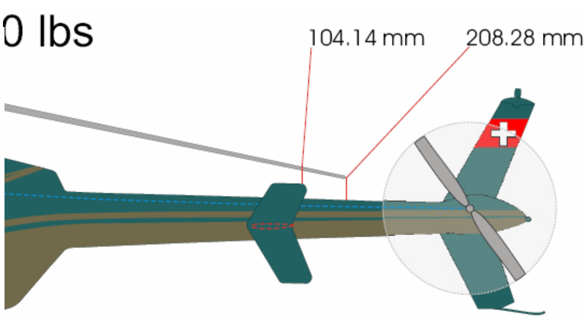

FULL CYCLIC BACK 6000LBS




CYCL BACK, COLL DOWN 4000LBS




CYCL BACK, COLL DOWN 6000LBS



**Annex 2**

## Sum of factors