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Swiss Accident Investigation Board SAIB

Aviation Division

Final Report No. 2122 by the Swiss Accident Investigation Board SAIB

concerning the accident involving the Agusta A109K2 helicopter, registration HB-XWJ

on 23 June 2008

Helicopter landing pad on the roof of Samedan Hospital/GR

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Ursache

Der Unfall ist auf eine Bodenresonanz bei der Landung des Helikopters auf der Heliplattform eines Helikopterlandeplatzes zurückzuführen, weil deren Konstruktion nicht fachgerecht ausgelegt worden war.

Der mangelhafte technische Zustand des Autopilot-Systems könnte zum Unfall beigetragen haben.

General information on this report

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

In accordance with Art 3.1 of the 10th edition, applicable from 18th November 2010, of Annex 13 to the Convention on International Civil Aviation of 7 December 1944 and Article 24 of the Federal Air Navigation Act, the sole purpose of the investigation of an aircraft accident or serious incident is to prevent accidents or serious incidents. The legal assessment of accident/incident causes and circumstances is expressly no concern of the accident investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

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

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

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

Contents

Final Report

Synopsis

Owner	Schweiz. 7Luft-Ambulanz AG, Postfach 1414, 8058 Zurich Airport, Switzerland
Operator	Schweiz. Luft-Ambulanz AG, Postfach 1414, 8058 Zurich Airport, Switzerland
Aircraft type	Agusta A109K2 helicopter
Country of registration	Switzerland
Registration	HB-XWJ
Location	Helicopter landing pad on the roof of Samedan Hospital, municipality of Samedan/GR
Date and time	23 June 2008, approx. 20:00

Investigation

The accident occurred on 23 June 2008 at approximately 20:00. The notification was received at 20:15. The investigation was opened on the same day by the Aircraft Accident Investigation Bureau (AAIB) in cooperation with the Grisons cantonal police.

Summary

At 19:58 on 23 June 2008, the pilot took off in the Agusta A109K2 helicopter registration HB-XWJ from Samedan airport in the direction of the helicopter landing site at Samedan Hospital.He was accompanied by two other crew members, a paramedic and an emergency doctor. The pilot approached the landing site at an approach angle of 4 to 5°, continuously reduced speed and then initiated the landing at approximately 20:00.

On touchdown, the pilot perceived slight ground resonance. According to his statements, he chose to lower the collective lever fully, firmly but not abruptly. Immediately thereafter the resonant motion began to increase and became more pronounced. With difficulty, the pilot was able to grab and pull back the two power levers, which are located in the centre of the cockpit ceiling above the pilot, in order to shut down the engines.

After exiting, the pilot and the other two crew members observed major damage to the helicopter and damage to the helipad of the helicopter landing site. A shattered rotor blade and severely damaged landing gear were evident. The helicopter was located at the outer edge of the helipad of the helicopter landing site and the tail extended approximately 1 m beyond the facade of the building. The gratings of the helipad in the landing zone had been partially detached from their fixings and had shifted.

The pilot and passengers were unharmed.

Cause

The accident is attributable to ground resonance during the landing on the helipad of a helicopter landing site, because its structure had been incorrectly designed.

The defective technical condition of the autopilot system may have contributed to the accident.

Safety recommendations

Within the framework of the investigation, one safety recommendation was made.

In accordance with Annex 13 of the ICAO, all safety recommendations listed in this report are addressed to the supervisory authority of the competent State, which must decide on the extent to which these recommendations are to be implemented. However, every agency, undertaking and individual is invited to attempt to improve aviation safety in the sense of the issued safety recommendations.

In the Ordinance on the Investigation of Air Accidents and Serious Incidents, Swiss legislation provides for the following regulation:

"Art. 32 Safety recommendations

[1] DETEC shall address implementation assignments or recommendations to FOCA, based on the safety recommendations in the reports from SAIB or on the foreign reports.

[2] FOCA shall inform DETEC regularly about the implementation of the assignments or recommendations.

[3] DETEC shall inform the SAIB at least twice a year about the progress made by FOCA with implementation."

1 Factual information

1.1 History of the flight

1.1.1 General

For the following description of the flight preparations and history of the flight, the recordings of a data recorder (health and usage monitoring system – HUMS) installed on the aircraft and the information from an eyewitness, the pilot and two other crew members of the operator were used.

It was a commercial flight taking place under visual flight rules.

1.1.2 Flight preparations

On 23 June 2008, the Engadine operational base of Schweiz. Luft-Ambulanz AG (Rega) was instructed to fly a patient from Samedan Hospital in the Upper Engadine to Chur. The timing of the patient pick-up had been agreed between the Rega operations centre and the hospital for approximately 20:00.

At the time, pleasant and warm summer weather with good visibility prevailed in the Upper Engadine. There was a constant wind of 10 to 15 kt from the south-south-west (a "Maloja" wind).

Since 2001, helicopter landings for medical transports to and from the Upper Engadine Samedan Hospital had been conducted on a helipad at the helicopter landing area, the dimensions of which were 9 x 9 m. The helipad was on the roof of the eight-story hospital. To the north-west of the helicopter landing platform, a windsock had been erected on the roof of the elevator machine tower.

1.1.3 History of the flight

At 19:58 the pilot took off in the helicopter from Samedan aerodrome in the direction of the helipad at Samedan Hospital. He was accompanied by two other crew members, a paramedic and a doctor. After passing the control tower he initiated a left turn, followed runway 03 and after approximately 1.5 km turned towards the north-east, to reach the Samedan Hospital helicopter landing site in a wide left turn from the north. The pilot approached the landing site at an approach angle of 4 to 5°, continuously reduced speed and then initiated the landing at approximately 20:00.

The pilot carried out the landing on the helicopter platform with the assistance of the stabilisation system (automatic flight control system – AFCS).

The wheel brakes had already been locked before take-off. According to the pilot's statements, the helicopter first made contact with the helipad with the left main landing gear and almost simultaneously with the right main landing gear. He then lowered the nose gear onto the helicopter platform. At that moment he perceived slight ground resonance. According to his statements, he decided to fully lower the collective lever, firmly but not abruptly, in order to reduce rotor blade lift.

Immediately afterwards, the resonant motion amplified and continued to increase. The motion occurred simultaneously around the vertical axis (yaw) and the longitudinal axis (roll). With difficulty, the pilot was able to grab and pull back the two power levers, which are located in the centre of the cockpit ceiling above the pilot, in order to shut down the engines. Then he grabbed the collective again. Throughout the entire phase after the touchdown, he was holding the cyclic (joystick) with his right hand.

The doctor sitting in the back seat, who had an experience of at least 100 operations on the A109K2 helicopter, described the accident phase as follows:

"(...) *I felt the two wheels of the main landing gear touch down one after the other. This is what I considered to be normal. Normally it is then quiet and the engine is shut off. In this case, however, unusual noise and an unusual motion began shortly after initial touchdown of the wheels. The noise was very loud and with a continuous frequency. It grew increasingly loud and the helicopter began to sway about its longitudinal axis. I saw the two crew members* [pilot and paramedic, note added] *swaying sideways. Then the helicopter practically began to bounce up and down (dance). After some time, the pilot was able slowly to raise his arms and shut down the engines."*

In addition, the doctor made the following statements concerning the landing phase and her perceptions following touchdown:

"(...) *In my opinion it first touched down on the left and then on the right. The sound of the initial contact was louder than normal but I didn't perceive the contact with the platform to be at all unusual or hard. The noise was brief, or rather dull (a boom). Only then did the vibration and noise begin, as described above. Once the engine had been switched off, we exited immediately. At this point the rotor was motionless. In my opinion, the rotor stopped turning more quickly than normal."*

The statements of the paramedic are consistent with those of the doctor.

After exiting, the pilot and the other two crew members observed major damage to the helicopter and damage to the helipad of the helicopter landing site. A shattered rotor blade and badly damaged landing gear were evident. The two main landing gears were collapsed. The helicopter was at the outer edge of the helipad and the tail extended approximately 1 m beyond the facade of the building. The gratings of the helipad had been partially detached from their fixation and had shifted.

Figure 1: The damaged helicopter extends beyond the helipad and the facade of the building.

An eyewitness (a helicopter mechanic) observed the approach and the subsequent landing from in front of his house at a distance of approximately 150 m. He watched as the pilot decelerated the helicopter normally before landing and touched down gently, vertically on the platform, first with the main landing gear and then with the nose gear. When all three wheels had made contact with the ground, he observed how the helicopter began to oscillate very rapidly and laterally. The lateral oscillation was very pronounced and intensified until the main landing gear collapsed. At this point the eyewitness heard the pilot shut off both engines simultaneously and there was a loud bang. He also observed a dark object propelled towards him at high speed. He heard a hissing sound as the object flew by. This object was a drag damper from the helicopter involved in the accident. The drag damper was found on the day of the accident in the attic of his house.

The Grisons cantonal police and the fire brigade arrived at the scene of the accident at approximately 20:20.

1.1.4 Accident location

Accident location	Helicopter landing site on the roof of Samedan Hospital , municipality of Samedan/GR, 5 km north-east of St. Moritz
Date and time	23 June 2008 at 20:00
Lighting conditions	Daylight, good visibility
Coordinates	787 131 / 157 231 (Swiss grid 1903)
	N 46° 32’ 23’’ 73/ E 009° 52’ 24’’ 66 (WGS 84)
Elevation	1708 m AMSL
	5604 ft AMSL
Final position of the wreckage	Helicopter landing site on the roof of Samedan Hospital
Map of Switzerland	Sheet no. 1257, St. Moritz, scale 1:25,000

1.2 Injuries to persons

1.2.1 Occupants

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

1.2.2 Nationality of the occupants of the aircraft

The crew consisted of two Swiss citizens and one German citizen.

1.3 Damage to aircraft

The helicopter was severely damaged.

1.4 Other damage

There was major damage to the building caused by kerosene leakage and the damaged gratings. The roof of a building approximately 150 m away was also damaged.

1.5 Personnel information

1.5.1 Pilot

Person	Swiss citizen, born 1966
Licence	Commercial pilot helicopter licence CPL (H) ICAO, initially issued by the Federal Office of Civil Aviation (FOCA) on 25 June 1990, replaced on 10 March 2007 by the CPL(H) JAR. Commercial pilot airplane licence – CPL(A) ICAO, initially issued by the FOCA on 16 April 1991.
Ratings (H)	A109 valid till 30 October 2008 and valid ratings on AS332/EC225MP, AS332/EC225 AS350, Bell206, Bell407, SA316/319/315, SA318/SE313 Flying instructor rating (FI/H), valid till 22 April 2011. Language Proficiency Level 4 in English and German, valid till 5 December 2010. Night flying NIT (H)
Medical fitness certificate	First class, no restrictions, valid from 16 January 2008 till 16 February 2009.
Last aeromedical examination	16 January 2008

1.5.1.1 Helicopter flying experience

Total	7499 hours
On the accident type	1172 hours
During the last 90 days	66 hours
Of which on the accident type	12 hours
Total no. of landings	42 730
Of which on the accident type	9326

1.5.1.2 Crew duty times

Flight duty times in the 48 hours before the accident	No flight duty on 21 and 22 June 2008
Flight duty time at the time of the accident on 23 June 2008	Stand-by from 08:00 to 18:30, on-call from 18:30

1.5.2 Paramedic

Swiss citizen, born 1955, no pilot's licences.

1.5.3 Doctor

German citizen, born 1965, no pilot's licences.

1.6 Aircraft information

1.6.1 General information

Registration	HB-XWJ
Aircraft type	Agusta A109K2 helicopter
Characteristics	Twin-engine general purpose helicopter with fixed-wheel landing gear
Manufacturer	Agusta S.p.A Samarate, Cascina Costa (VA), Italy
Year of manufacture	1994
Serial number	10010
Owner	Schweiz. Luft-Ambulanz AG, Postfach 1414, 8058 Zurich Airport, Switzerland
Operator	Schweiz. Luft-Ambulanz AG, Postfach 1414, 8058 Zurich Airport, Switzerland
Engine	Manufacturer: Turboméca, 64511 Bordes, France
	Type: Arriel 1K1
	Power: At ISA sea level
	One engine inoperative (OEI) 2.5 min. 575 kW / 771 shp
	All engines operative (AEO) take-off 550 kW / 738 shp
Main rotor/tail rotor	Main rotor with 4 blades, rotating counter-clockwise. Tail rotor with 2 blades

Landing gear	Wheels, nose-wheel configuration, non-retractable, with protection from sinking in. Hydraulic wheel brake.	
Equipment	Hydromechanical flight control system. Digital autopilot Sextant AFCS 95, rescue winch, GPS, health and usage monitoring system (HUMS), moving terrain display system, Floice collision warning system.	
Operating hours, airframe	Total time since new:	3212:48 hours
	Since last 300-hour inspection:	204:48 hours
	Since last 100-hour inspection:	94:51 hours
Operating hours, engine 1 (left) No. 16033	Total time since new:	3212:48 hours
	Since last installation:	204:48 hours
	Since last service:	204:48 hours
	Since last periodic check:	94:51 hours
	Total cycles:	15 376
Operating hours, engine 2 (right) No. 16011	Total time since new:	3578:48 hours
	Since last installation:	204:48 hours
	Since last service:	204:48 hours
	Since last periodic check:	94:51 hours
	Total cycles:	17 104
Number of landings	23 284	
Maximum take-off mass (MTOM)	2850 kg	
Mass and centre of gravity	On take-off the helicopter's mass was 2758 kg; at the time of the accident the mass was approximately 2748 kg. The centre of gravity was at an arm of 3388 mm. Permissible range at this weight 3320 – 3460 mm. Both the mass and centre of gravity were within the permitted limits according to the rotorcraft flight manual (RFM).	
Technical limitations	None; in particular no limitations for landing on the Samedan Hospital helipad are apparent from the documentation.	
Permitted fuel grade	Jet A1 kerosene	
Fuel	Tank contents were approximately 290 kg	
Certificate of Registration	Issued by the FOCA on 17 April 2007 / no. 2, valid till deletion from the aircraft register.	

Certificate of Airworthiness	Issued by the FOCA on 17 April 2007, valid till revoked.
Airworthiness Review Certificate	Date of issue: 7 February 2008 Date of expiry of validity: 27 February 2009.
Operation approval	Commercial
Types of operation	VFR by day VFR by night (restricted according to FOM) Helicopter departures in ground fog and high fog

1.6.2 Maintenance

Maintenance was carried out by the maintenance service of Swiss Air Ambulance Ltd (Schweiz. Luft-Ambulanz AG or Rega).

The last scheduled maintenance tasks on both the airframe and engine were 100-hour inspections. These were carried out on 28 April 2008 at 3117:57 hours (due at 3100 hours with a tolerance of +/- 10 hours). Exceeding the tolerated number of flying hours by 7:57 hours had been approved internally on 25 February 2008.

According to the Aircraft and Engine Maintenance programmes (AMP) for the Agusta A109K2, the tolerance for the 100-hour inspection is +/- 10 hours. In the maintenance organization exposition (MOE), an extension of this interval by +10 hours to +20 hours is declared to be an exception. The person authorized to grant an extension of 10 to 20 hours was the continuing airworthiness manager (CAM).

On inspection of the technical documentation for helicopter HB-XWJ, it was found that Rega had increased the tolerance of the inspection interval for the two 100-hour inspections due on HB-XWJ in 2008 to +20 hours.

1.6.3 Certification Basis of the A109K2 helicopter

The Agusta type A109K2 was certified in the normal category for helicopters by the American national aviation authority (Federal Aviation Administration – FAA) in accordance with Federal Aviation Regulations (FAR) Part 27 on 15 January 1993.

All Agusta A109K2 helicopters were delivered by the manufacturer without an autopilot system. The development of the AFDS 95-1 was undertaken by the Sextant company. FAA certification resulted in the issue of Supplemental Type Certificate (STC) SR09075RC on 16 October 1996:

"Description of type design change:

Installation of Sextant AFDS 95 autopilot system for IFR operations in accordance with Rega Master Drawing List TP876/1996, Revision B, dated March 26, 1996, or later FAA approved revision."

Subsequent modifications to the installation were required because Rega waived the IFR operation capability. On 16 January 1998 the FOCA approved the "Appendix Rega VFR installation Sextant AFDS 95-1 System".

Installation of the equipment was carried out at Rega .

1.6.4 FAR Part 27.241 Ground resonance

The FAR Part 27 design requirements related to ground resonance state:

"The rotorcraft may have no dangerous tendency to oscillate on the ground with the rotor turning."

1.6.5 Autopilot system

1.6.5.1 Description

"The helicopter was equipped with a digital, simplex four axes Automatic Flight Director System (SEXTANT AFDS 95-1) installed by Rega.

The SEXTANT AFDS 95-1 is a modular system and mainly consists of:

- *An Automatic Flight Control System (AFCS)*
- *A Coupled Flight Director System (CFD)*

AFCS and CFD sub-systems may work independently (decoupled) or may be connected together (coupled). When the two sub-systems are coupled, the system allows the automatic piloting of the helicopter on the four axes. When they are decoupled, the AFCS is able to ensure the automatic control of the roll, pitch and yaw axes, while the CFD sub-system operating alone allows the flight in manual piloting by using displayed information on the ADI horizon.

Control actuation is done by electromechanical series and trims actuators for each of the pitch, roll and yaw axis while the collective uses only one trim motor. The system interfaces with the primary ADI's (stand-by horizon is backup) and with the EHSI. The system also integrates elements of the avionics.

The AFCS basic system provides stability augmentation (SAS) for the pitch, roll and yaw axis plus Attitude hold. Heading hold is active up to 40 kt and sideslip control is active above 40 kt. Heading hold is also active during CLB mode operation and during the lower portion of APP mode (below 200 ft AGL). Additional functions include automatic trim for the cyclic and yaw axis, fly-through control, force trim release system and basic system functional surveillances.

The AFCS is also provided with a monitor safety function (AFSC MTR) for the pitch axis. Additionally there is an AFCS and CFD automatic preflight test required."

1.6.5.2 System safety analysis of the autopilot system

The manufacturer's document "Rega A109K2 Helicopter, Automatic Flight Director System – AFDS 95-1, Safety analysis for IFR certification" states the following:

"Serial actuator oscillations:

The serial actuator oscillation may mainly occur in the following case:

- *Loss of the serial actuator feedback 1 signal.*

In this case of failure, the helicopter evolution is less significant than the one due to a hardover.

The loss of the feedback1 information induces only the loss of the serial actuator control loopback. Consequently, the heading hold and the stabilization are done with a serial actuator which oscillates quickly between its stops.

The failure is classified as Minor."

1.6.5.3 Results of the flight tests

As part of the type certification process for the A109K2, the manufacturer carried out flight test which assessed the behaviour of the helicopter with respect to ground resonance. The results were recorded in a comprehensive flight test report. The tests were carried out on the first A109K2 (S/N 10001) in 1991, with no built-in autopilot.

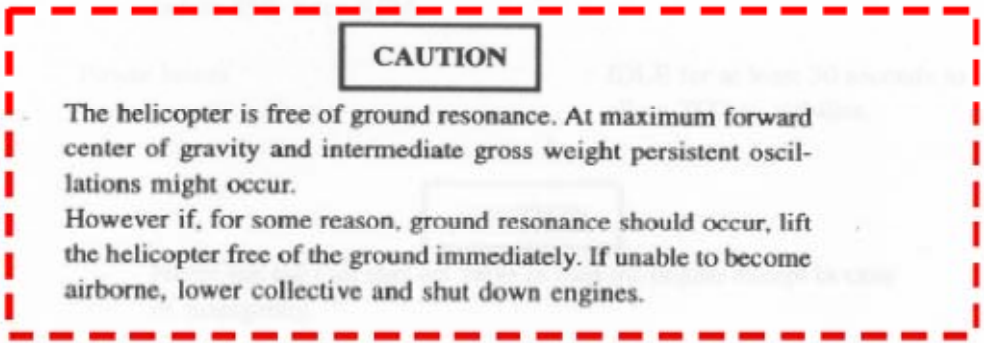
In summary, the following was established (German text is a translation from the English):

"The helicopter is free of ground resonance. At maximum forward centre of gravity and a mass of 2720 kg, persistent oscillations may occur. However if, for some reason, ground resonance should occur, lift the helicopter free of the ground immediately. If unable to become airborne, lower collective and shut down engines."

The manufacturer of the helicopter provided the following statement after the accident:

"The helicopter A109K2 is certified for no sensitivity to the ground resonance (rule FAR 27.241) through experimental test.

According to the above the A109K2 RFM furthermore reports the following "CAUTION":



CAUTION

The helicopter is free of ground resonance. At maximum forward center of gravity and intermediate gross weight persistent oscillations might occur.
However if, for some reason, ground resonance should occur, lift the helicopter free of the ground immediately. If unable to become airborne, lower collective and shut down engines.

No accidents due to ground resonance phenomena are recorded on A109K2 fleet in service and during the helicopter development phase."

This "*CAUTION"* note had been included in the RFM since 1994.

1.6.6 General remarks on resonance in the helicopter system

Instability respectively resonance can occur on ground or in the air on all rotor systems with softly dampened lead/lag rotor blade attachments as a result of coupling with the airframe dynamics.

The centre of mass of a rotating rotor may be shifted away from the axis of rotation due to blade movement. As a result of this displacement of the centre of mass from the axis of rotation of the rotor, unbalanced forces are generated which are transmitted via the rotor's articulated joints to the airframe of the helicopter and cause it to oscillate.

In flight, i.e. without ground contact, the resulting resonance has no further effects, apart from the normal movements and vibrations of the helicopter. On the ground, however, the oscillations of the airframe are transferred to the landing gear. The landing gear must absorb and dissipate these forces. The construction of the landing gear, consisting of shock absorbers, struts and wheels, causes resilience and damping. If a regressive oscillation frequency coincides with a natural frequency of the airframe, this can lead to unstable rotor blade/airframe oscil-

lations. At certain frequencies or rotor speeds, the amplitude of the helicopter's oscillation may increase. As the amplitude increases, the energy of the oscillations may become excessive, leading to the disintegration of the helicopter.

The aeromechanical stability of the helicopter system depends crucially on the drag damping of the rotor blades, the airframe and the landing gear and on the characteristics of the landing site.

Preventing ground resonance is therefore an important task of certain airframe components. To reduce the displacement of the centre of mass, on the one hand the flapping and lead-lagging motion of the rotor blades is damped and limited. On the other hand, the design of the gas-liquid shock absorbers of the landing gear is set to a specific difference between compression and rebound, i.e., for example, fast compression and a slower rebound, so that they absorb the oscillation energy. This reduces the likelihood of ground resonance.

1.6.7 Manufacturer's information on the natural frequencies of the A109K2 helicopter

With regard to the natural frequencies of the A109K2 helicopter, the manufacturer provided the following explanations:

"For what concerns the dynamics of the helicopter on the ground, the most relevant natural frequencies of the system are those related to the models of the entire helicopter resting on the ground on its landing gear. In this respect, the helicopter fuselage can be considered as a rigid body mass, because its first elastic modes, having a higher frequency, tend to be decoupled.

Considering therefore the aircraft on the ground as a rigid body with elastic restraints (represented by the dynamic characteristics of the landing gear) to the ground, it will have six degrees of freedom and six natural frequencies, corresponding to the various modes of the aircraft (fore/aft. lateral, vertical pitch. roll and yaw). The main rotor is normally considered as a concentrated mass for the evaluation of the airframe frequencies.

For the A109K2 helicopter, the lowest frequency modes are the lateral and longitudinal ones. The natural frequency of these modes is typically in the range from 1-2 Hz to 2-2.5 Hz depending on the aircraft weight. The longitudinal mode is also affected by the parking brake effect: releasing the brake reduces the natural frequency (neglecting friction effects into the wheel/axle system the limit tends to zero frequency). The yaw and vertical modes have higher frequency, in the range from 3-3.5 to 4-5.5 Hz, but these modes play a small effect into the ground resonance phenomenon since they involve small displacements of the rotor hub center into the rotor disk plane. The next modes are the pitch and roll mode which have higher frequency, in the range from 5-6 Hz to 6.5-8 Hz depending on aircraft weight and also on pitch and roll mass moments of inertia."

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 sections 1.7.6 to 1.7.7 was provided by eyewitness reports.

1.7.2 General situation

"The distribution of pressure over central Europe is currently flat; to the north of Switzerland there is an air mass boundary. With westerly to south-westerly winds at altitude, very warm air, but with unstable stratification, continues to flow in Switzerland. The chance of showers or thunderstorms therefore remains high."

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.

Cloud	*2/8 at around 13,000 ft AMSL*
Visibility	*Around 30 km*
Wind	*South-south-west wind at approximately 10 kt, gusting to 18 kt*
Temperature/dewpoint	*18 °C / 08 °C*
Atmospheric pressure:	*QNH LSZH 1017 hPa, LSZA 1017 hPa*
Position of the sun:	*Azimuth 293°, elevation 11°*
Hazards:	*Weak local turbulence not excluded*

1.7.4 Weather in Samedan according to the 18:00 UTC Synop report

Elevation	*1708 m AMSL (5603 ft AMSL)*
Wind (kt)	*210/10*
Cloud	*2/8 8000 ft AGL (13,603 ft AMSL)*
Visibility	*30 km*
Temperature/dewpoint	*18 °C / 08 °C*

1.7.5 Aviation weather advisory

The following AIRMET was active at the time of the accident:

LSA AIRMET 1 VALID 231630/231930 LSZH-

LSAS Switzerland FIR/UIR ISOL TS OBS E PART OF ALPS MOV E WKN=

The decoded AIRMET is as follows:

LSA AIRMET 1, valid on the 23rd of the month from 16:30 till 19:30 UTC. Switzerland Flight Information Region and Upper Information Region: Isolated thunderstorms observed and forecase in the eastern parts of the Alps, moving eastwards and weakening."

No SIGMET was issued on the day of the accident.

1.7.6 Wind information according to eyewitness reports

Uninvolved informant:

"The windsock (hospital roof) was extended between 45 and 90 degrees. The wind was coming from the direction of Celerina. As far as I could judge the wind was laminar."

Pilot:

"There was a wind more or less from the SW (a "Maloja" wind), which was blowing at between 10 and 15 knots. This is rather strong for the time of day."

1.7.7 Information on meteorological conditions at the accident site

With the aid of photos taken shortly after the accident it was possible to confirm the windsock position cited by the eyewitnesses – between 45° and extended – from a south- to south-westerly wind direction, and the meteorological information provided by MeteoSwiss.

1.8 Aids to navigation

No navigation aids were available for the landing on the Samedan Hospital helicopter platform.

1.9 Communication

Not applicable.

1.10 Information on the helipad on the roof of Samedan Hospital

1.10.1 General

In 2007, the following types and quantities of helicopter landing sites were available in Switzerland for transport to and from hospitals:

Platform on roof	34
On roof without platform	29
On the ground, at ground-floor level	103
Total	166

1.10.2 Number of landings by A109K2 at Samedan Hospital

Year	Jan. – Apr.	May – Oct.	Nov. – Dec.
2003	111	117	27
2004	92	95	23
2005	101	109	21
2006	120	112	28
2007	114	132	32
2008*)	103	19	-

*) In 2008, the period from 1 January to 20 July was taken into account.

1.10.3 Helicopter landing site on the roof of Samedan Hospital

Appendix 1 shows a view of the helicopter landing site at Samedan Hospital.

1.10.3.1 General description

The helipad of the helicopter landing site on the roof of Samedan Hospital consists essentially of a frame, the cross beams mounted to the frame and the gratings placed on them. All the components are made of galvanised steel. The steel beams are bolted together. The gratings are secured to the cross beams with clips to prevent lifting.

1.10.3.2 Design

The design of the helipad of the helicopter landing site was drawn up by an architectural firm on the basis of the existing helipad at a Zurich hospital. The Samedan helipad was put into operation in 2001.

1.10.3.3 Principles of design and calculation

The helicopter platform was designed for helicopters with a maximum permitted mass of 4.5 t, assuming that the helipad is subject to three identical point loads of 1.5 t and that the distance between two load points is approximately 2 metres. According to the information from the engineering organisation which was responsible, the calculation was performed in accordance with the SIA Standards no. 160, "Effects on load-bearing structures" and no. 161 "Steel structures"; a

load factor of 1.75 was taken into account. The elastic deformations of the structure were examined.

Dynamic stresses were not taken into consideration in the calculations.

1.10.3.4 Maintenance

Instructions concerning regular inspections and maintenance on the helipad did not exist. The managers of Samedan Hospital's technical department mentioned when asked that they had found that over time some of the clips which secured the gratings to the cross beams had become loose. As a result, the clamping screws had to be re-tightened.

1.10.3.5 Approvals

According to information provided by the FOCA, at the time of the accident such landing sites at hospitals were considered to be remote landing sites for emergency flights. They could be built and used without approval from the Federal Office.

According to Article 56 of the Ordinance on Aviation Infrastructure, however, the FOCA can issue guidelines for the design and operation of such landing sites. Such guidelines were first published in 1987. However, they now no longer correspond to the state of the art and the current nature of operations.

In JAR-OPS 3, specifications are now available for Helicopter Emergency Medical Services which describe the design of landing sites from an operational viewpoint and which complement the structural specifications of ICAO Annex 14.

Therefore, the FOCA has withdrawn the guidelines dating from 1987.

Internationally, with regard to the design, dimensioning, manufacture and operation of helicopter landing sites, the two publications of the ICAO Annex 14 Volume II and the Heliport Manual are the standard.

1.10.3.6 Substantiation of structural strength in accordance with ICAO

According to the Heliport Manual, helicopter landing sites are divided into categories:

Category 1 landing sites are approved for helicopters with a maximum take-off mass (MTOM) of up to 2.3 tonnes and category 2 landing sites for helicopters with an MTOM up to 5 t.

Static strength analyses of the landing site are required for the landing site. In the case of vertical loads, the calculation forces – which result from the MTOM –must be multiplied by load factors for a normal landing impact, extreme landing impacts (emergency impact) and vibration. The analysis must include the weight of the landing site itself and a payload defined per square metre. In addition to the analysis of the vertical loads, an analysis of lateral loads must also be performed. Lateral forces are effective in cases of oscillations of the helicopter and in wind.

Load factors must be applied in the analysis of the lateral loads.

All analyses must be correlated with the breaking strength of the material.

Deformation studies and vibration analyses (modal analysis) are not required.

The helipad of the helicopter landing site at Samedan Hospital did not meet the requirements of the strength analyses.

1.11 Flight recorders

1.11.1 Flight data recorder

Type	Health and Usage Monitoring Systems (HUMS)
Manufacturer	BF Goodrich Aerospace USA
Year of manufacture	1997
Part and Serial number	PN 30142-0201 / SN 0008
Parameters	A total of 41 different parameters, including: airspeed, main rotor speed, main gearbox torque, engine parameters, outside temperature OAT, squat switch
Recording medium	Flashcard solid state memory
Duration of recording	approx. 5 hours

1.11.1.1 Condition

It was possible to analyse the recorded parameters.

1.11.1.2 Results of the analysis

All the parameters recorded during the landing up to the point when the engines were shut down indicated that at the time of the accident the engine, gearbox and main rotor systems were functioning normally.

1.11.2 Cockpit voice recorder

No devices for recording communication between the crew members were installed; nor were any devices prescribed.

1.11.3 Other recorders

The collision warning system with acoustic voice output – Floice – and the Moving Terrain system provided no data which could be used to determine the cause of the accident.

1.12 Wreckage and impact information

1.12.1 Site of the accident

Accident location	Helicopter landing site on the roof of Samedan Hospital, municipality of Samedan/GR
Elevation	1730 m AMSL
	5675 ft AMSL
Final position	787 150 / 157 225
	Latitude: N 46° 32’ 24”
	Longitude: E 009° 52’ 43”
Map of Switzerland	Sheet no. 1257, St. Moritz, scale 1:25,000

1.12.2 Wreckage information

Figure 2: Final position of the severely damaged helicopter on the helicopter platform

1.12.2.1 Findings on the helicopter at the site of the accident

The severely damaged helicopter was located at the outer edge of the helipad.

The tail extended approximately 1 m beyond the facade of the building. During an initial investigation, the following damage was observed:

- One rotor blade was destroyed.
- The red drag damper was missing.
- The two main landing gear were collapsed. The structure of the nosewheel landing gear was severly damaged.

- The skin of the rear section of the fuselage exhibited major deformation approximately 1 metre aft of the main landing gear.
- The upper part of the fin was severly damaged.

The missing drag damper was found on the day of the accident approximately 150 m from the site of the accident, in the attic of a house. The piston rod of the damper was missing and could not be found despite an intensive search.

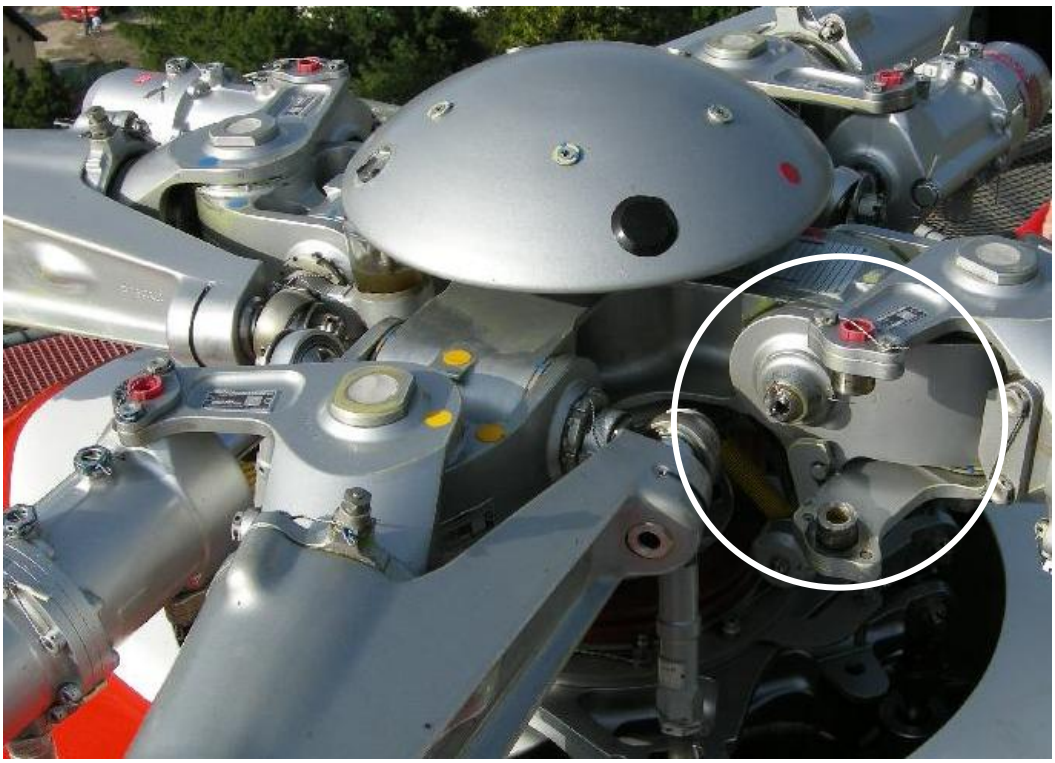


Figure 3: “Red” drag damper missing, fracture area on the rotor head

The following individual findings were made on the wreckage:

The park and emergency brake handle was pulled (wheels braked). The nose wheel lock handle was in the ON position (nosewheel centred).

The engine power control levers Power Lever 1 and 2 were in the Off position.

The lever for the rotor brake was in the "up" position (released).

1.12.2.2 Findings on the autopilot in installed condition

The autopilot was tested after the accident, in accordance with the system manufacturer's test instructions. Essentially, all the tested functions met the requirements. The representative of the maintenance organisation reported as follows concerning the test item "AFCS – pre-flight no. 1 –– functional test”:

> *"After the pre-flight test no. 1 has finished, the yaw linear actuator begins with a marginal fast oscillation. The oscillation of the yaw linear actuator stops the oscillation when the autopilot is switched to OFF (AFCS OFF -> AP control unit).*
>
> *Such actuator became replaced with regular maintenance.”*

The serial actuators were removed and examined on the manufacturer’s premises. See section 1.16.2.9.

1.12.2.3 Findings on the landing gear

The landing gear was examined and the following values were measured:

	P/N	S/N	Prescribed pressure	Actual pressure
Main landing gear shock strut LH	109-0502-86-103	MN 138	70.0 psi	68.5 psi
Main landing gear shock strut RH	109-0502-86-104	MN 141	70.0 psi	68.0 psi
Nose landing gear shock strut	109-0501-28-107	MN 320	100.0 psi	90.0 psi
Wheel LH	109-0502-07-3		6.0 bar	4.95 bar
Wheel RH	109-0502-07-3		6.0 bar	4.80 bar
Nose wheel	109-0502-07-3		6.0 bar	5.35 bar

With regard to the wheels, according to the maintenance manual (MM), the loss within 24 hours must be less than 5% or 0.3 bar.

The measurements were taken with the landing gear not under load.

1.12.2.4 Findings on the helipad of the helicopter landing site after salvage

The visual inspection after the accident found damage to the helipad as listed below:

- On individual gratings, grating bars with local plastic deformation.
- Looseness and bending of clips that were used to secure the gratings against lifting.
- Gratings which were displaced laterally on the supporting structure.
- Edge retaining profiles which had been torn out at the welding points by the lateral displacement of the gratings.
- Local plastic deformation of cross beams.

Figure 4: Displaced grating

Figure 5: Torn out retaining clip and damage to grating

1.13 Medical and pathological information

There is no indication of the crew suffering any health problems which might have been a factor in the accident.

1.14 Fire

Fire did not break out.

1.15 Survival aspects

1.15.1 General

The crew wore helmets.

The accident was survivable. The helicopter was equipped with three crashworthy seats. The three crew members were wearing safety belts and were able to exit the helicopter normally after the accident.

1.15.2 Emergency transmitter

The helicopter was equipped with an emergency transmitter (emergency location beacon aircraft – ELBA). The device was installed and ready for operation.

No signals were transmitted.

1.15.3 Rescue and fire-fighting services

Samedan fire brigade's operations control centre was alerted immediately after the accident via the 118 emergency call centre because of the kerosene leaking onto the hospital roof.

The fire brigade dispatched seven fire-fighters who, on their arrival at 20:20, immediately began to collect the spilled kerosene together with members of the technical department of Samedan Hospital.

Based on an assessment of the situation, the fire brigade officer in charge decided not to request any additional support or resources from the Samedan aerodrome fire brigade.

1.16 Tests and research

1.16.1 General

The damage to the rotor, the four drag dampers, the rotor head, the airframe and the fuselage structure was consequential damage due to increasing helicopter vibration.

The main areas of focus of the technical investigations are listed below.

1.16.2 Technical investigations

To determine the cause of the accident, the following technical investigations were carried out, among others:

- X-ray examination of the four drag dampers.
- Examination of the four drag dampers.
- Examination of the hydraulic oil of the four drag dampers.
- Forensic investigations in the rotor area.
- Material examination of the four flat hinge pins of the rotor head.
- Examination of the fracture surface of the flat hinge pin of the torn-off "Red" drag damper.
- Examination of the three other flat hinge pins.
- X-ray examinations of the three autopilot actuators.
- Examination of the three autopilot actuators on the manufacturer's premises.

1.16.2.1 X-ray examination of the four drag dampers

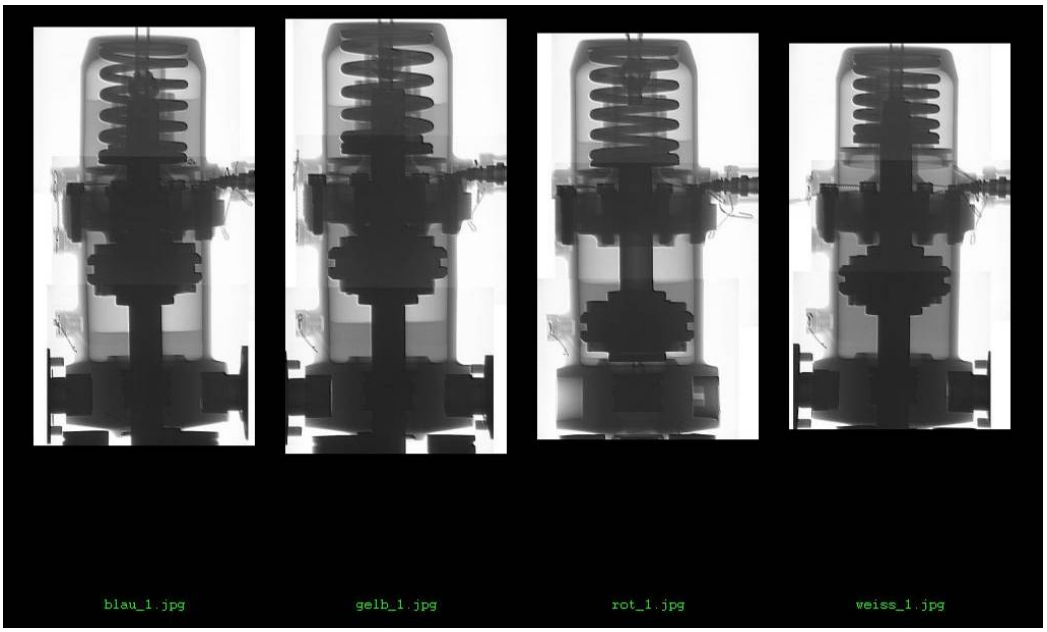


Figure 6: X-ray images, shock absorbers: Blue – Yellow – Red – White

The x-ray examination of the four drag dampers showed that the piston rod mounting nut was missing on each of the three shock absorbers – “Red”, “Yellow” and “Blue”. The absorber springs were accordingly expanded.

1.16.2.2 Investigations of the four shock absorbers

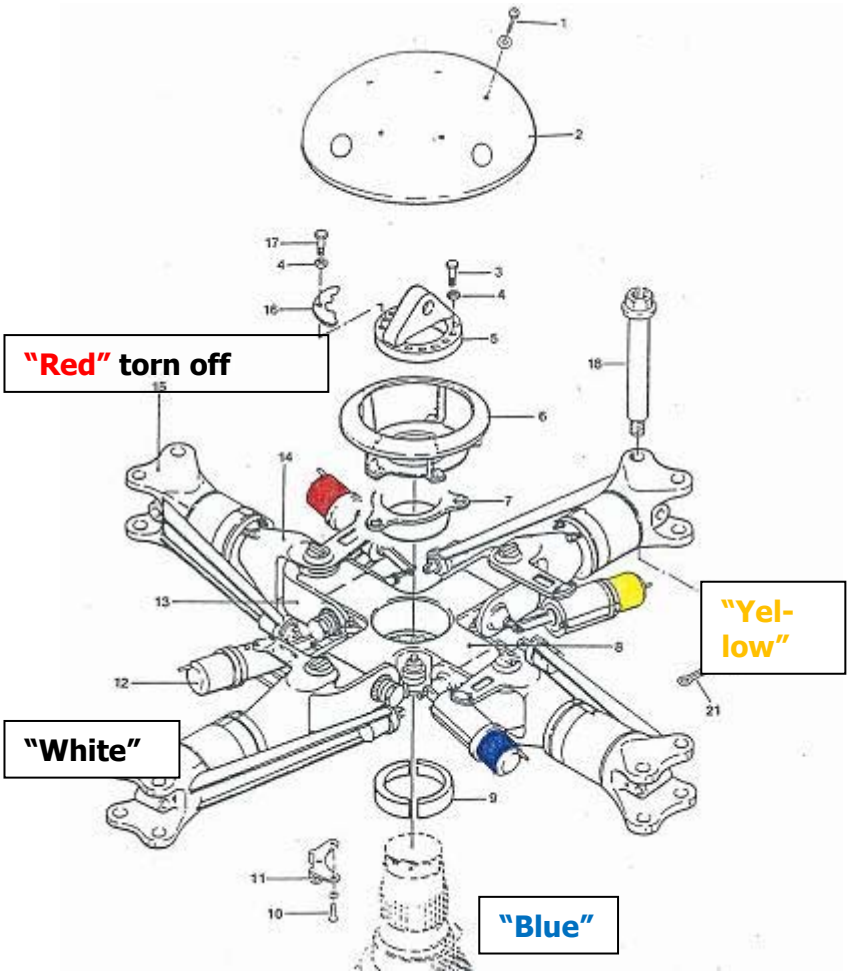


Figure 7: Exploded view of the rotor head with the four drag dampers

The condition and test results for the four drag dampers were as follows:

Shock absorber P/N 2-3584	Notable features Visible damage	Test results after fitting a replacement piston rod
Red S/N 2945	Shock absorber torn off, piston rod missing. Thread of the piston rod mounting nut stripped, nut found loose in housing.	The missing piston rod was replaced to check the functions. Function OK
Yellow S/N 2415	Thread of piston rod mounting nut stripped, nut found loose in housing.	Function OK
Blue S/N 1441	Thread of piston rod mounting nut stripped, nut found loose in housing.	Function OK
White S/N 1964	No visible damage; this drag damper is the fourth damper from the red in the direction of rotation.	Function OK

In summary it can be stated that the tearing off of the piston rod mounting nut is the result of excessive force from the rotor blades. There are no indications for a possible malfunction of the drag dampers.

1.16.2.3 Examination of the drag damper hydraulic oil samples

1.16.2.3.1 Chemical-physical investigations of the four oil samples

On disassembly of the four drag dampers, the hydraulic oil contained in the devices was recovered. Three of the four oil samples exhibited noticeable colour differences from the original colour of the prescribed hydraulic oil. The oil samples were analysed in the laboratory to determine the cause of this discoloration.

Comparisons with several fresh oils showed that the oil in the four samples corresponded to the Aeroshell Fluid 41 (MIL-H-5606) oil prescribed for the drag dampers. It is highly probable that no mixing with other oils used in the A109K2 helicopter took place.

The oil samples that were recovered from the drag dampers after the accident and examined exhibited some notable differences compared to the fresh oil:

Oil sample from shock absorber:	red	yellow	blue	white
Oil colour magenta or purple, corresponding to original colour		X		
Oil colour red (with brown streak)	X		X	
Oil colour light brown				X
High silicon content		X	X	
Low phosphorus content	X			

According to the laboratory report of the chemical and physical analysis, the above-mentioned differences in colour, silicon and phosphorus content did not affect the performance of the helicopter's four drag dampers.

1.16.2.3.2 Oil level check and oil change as part of maintenance work

On 26 September 2007 a damper service according to MM 12-20-23 was performed on three of the four drag dampers during a 3000-hour inspection of helicopter HB-XWJ. The drag dampers were bled, flushed with fresh oil and filled to the prescribed level. A new "white" shock absorber was installed during the 3000-hour inspection. After this, the helicopter flew for approximately 200 hours up to the accident, without any further work on the oil system of the four drag dampers being performed.

1.16.2.4 Forensic investigations in the rotor area

The forensic investigations showed that

- the deformations of the metal leading edge with subsequent destruction of the rotor blade were the result of a collision of the rotor blade with the torn-off drag damper (Red);
- the damage to the tail boom was caused by parts of the rotor blade which were flung away;
- no material foreign to the helicopter was found in the rotor area.

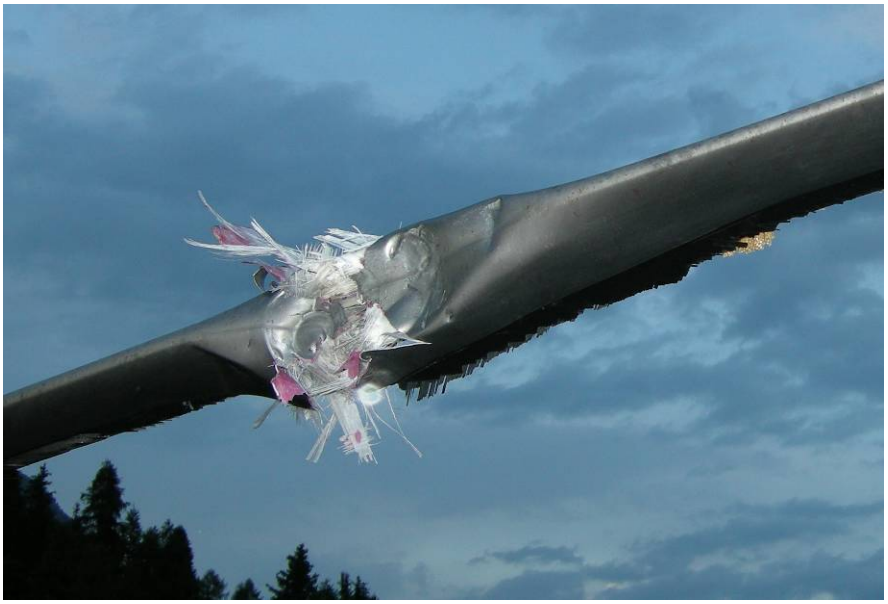


Figure 8: Deformations of the metal leading edge of the destroyed rotor blade

1.16.2.5 Material examination of the four flat hinge pins of the rotor head

All four pins met the manufacturer's specification for composition and tensile strength.

1.16.2.6 Examination of the fracture surface of the flat hinge pin

From the examination of the fracture surface it is apparent that the fracture was caused by an instantaneous overload in shear. A fracture due to material fatigue can be excluded.

1.16.2.7 Examination of the other three flat hinge pins

All three pins exhibited plastic deformation. The pin of the "white" shock drag damper was found cracked in the critical area.

The two pins of the "blue" and "yellow" shock absorbers exhibited plastic deformation but were not cracked in the critical area.

The bending deformation was most pronounced on the "white" pin and least pronounced on the "yellow" pin.

Based on the observed damage, fatigue on all three pins can be excluded.

1.16.2.8 X-ray examinations of the three autopilot linear actuators

The potentiometers p1/p2 of the three linear autopilot actuators

- Roll actuator, Part Number L24AAM1, Serial Number 5633

- Pitch actuator, Part Number L24AAM1, Serial Number 5631
- Yaw actuator, Part Number L24ACM2, Serial Number 5626

were subjected to an X-ray examination. It was found that all the wiper contacts were present and were of a geometrically correct shape. The four contacts of the potentiometer on the roll actuator, however, were mounted "mirrored" on the resistive element compared to the other two potentiometers.

1.16.2.9 Examination of the three autopilot actuators on the manufacturer's premises

The following three serial actuators were examined on the manufacturer's premises:

- Serial Actuator P/N L24AAM1 S/N 5631 (pitch axis)

- Serial Actuator P/N L24AAM1 S/N 5633 (roll axis)

- Serial Actuator P/N L24ACM2 S/N 5626 (yaw axis)

Reminder of actuators activities history:

	L24AAM1 5631	L24AAM1 5633	L24ACM2 5626	Installed
Built in	30/12/1996	30/12/1996	30/12/1996	
Retrofitted in Amdt A	04:04 hours	04:04 hours	04:04 hours	HB-XWP
Repair activities	07/12/2006	07/12/2006	07/12/2006	HB-XWP

Summary of the results of the investigation:

"P/N L24AAM1 S/N 5631 (Pitch axis):

Low mechanical play observed (into tolerance).

We have observed, an actuator speed in a lower limit (34.96mm/s instead of 35mm/s minimum).

P/N L24AAM1 S/N 5633 (Roll axis):

Low mechanical play observed (into tolerance).

We have observed, a non-linearity potentiometer response on center position (loss of electrical continuity).

P/N L24ACM2 S/N 5626 (Yaw axis):

Low mechanical play observed (into tolerance).

(…)

4. NOTE

(…)

We have observed on these three actuators, at the rod end level, mechanical play on spherical bearing, qualitative measurement.

FAA certification or Rega or Suisse FOCA never requested landing test on building roof heliport or on surfaces other than concrete surface.

Pitch axis is permanently monitored (compare of artificial horizon position and pitch actuator feedback position) -> FAA mandatory. This is not the case for Roll and Yaw axis."

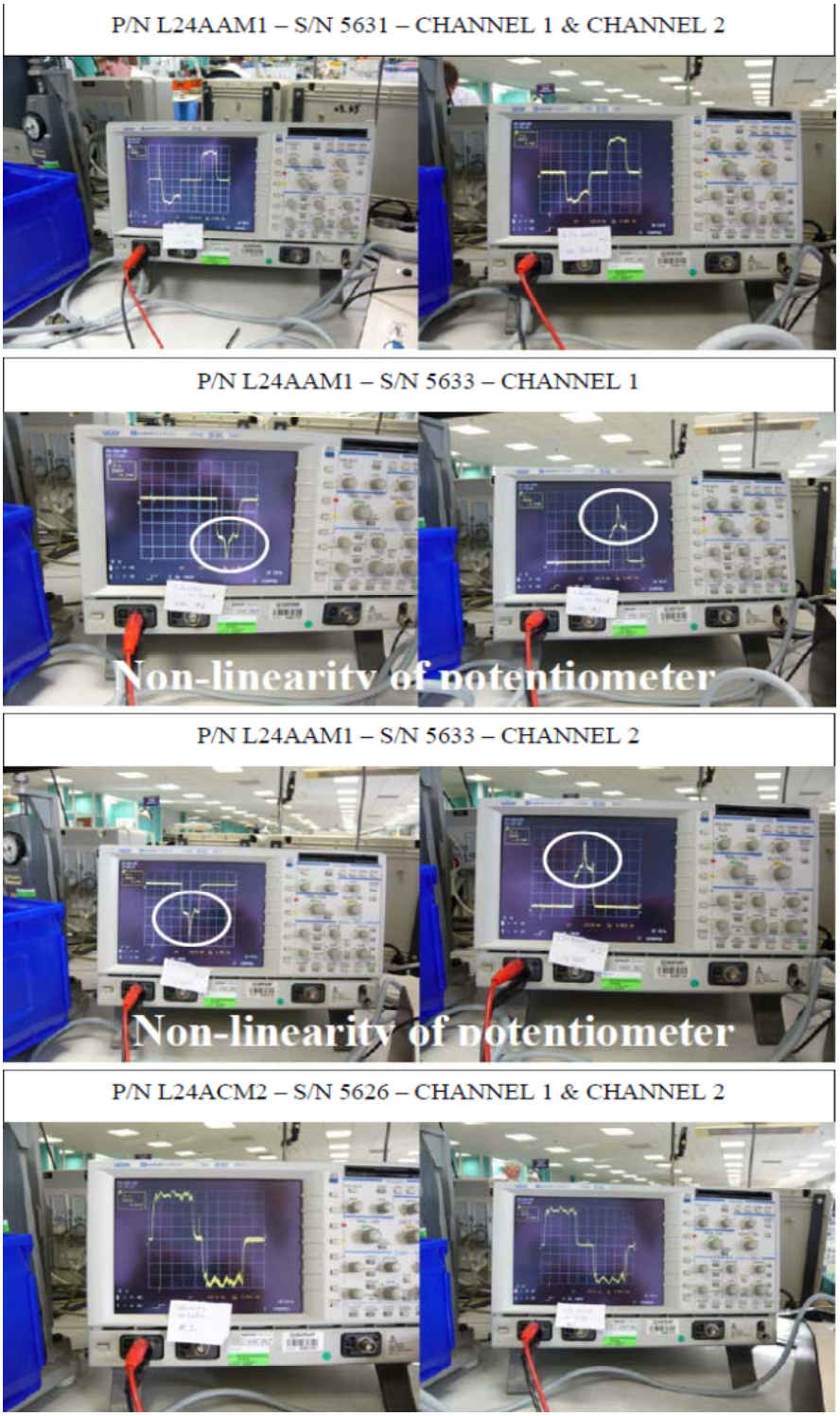


Figure 9: Potentiometer examination of the three serial actuators. The defect in the two potentiometers (channels 1 + 2) in serial actuator P/N L24AAM1-S/N5633 is detectable from the spiked trace (white circles).

In summary, the manufacturer of the system answered the investigator's questions as follows:

"(…)

To provide impact of "non-linearity potentiometer response" (shortcircuit/open circuit/…) on AFDS95-1 system.

(…) Type of defect observed, on roll actuator, during serial actuators investigation, held in France at the beginning of 2009, called "non-linearity" is linked to normal wear (contact defect).

Auto-Pilot system impact:

On two tracks, depending of track wear level and of its active loop, actuator motion oscillation can appear.

At the maximum, and regarding total loss of feedback signal, actuator can move between its stops. But, it isn't our observation case.

Actuator Position Display (APD) is always the image of serial actuators movement.

What is the coverage of the pre-flight test regarding wrong feedback position of actuator (like a short circuit / open circuit / non-linear signal)?

Description of Pre-Flight Tests (PFT):

Test 0 ==> Checks the AP controller annunciators.

(…)

Test 1 ==> Checks the serial actuators motions and recentering.

(…)

Test 2 ==> Checks the pitch monitor, the cooling fan, associated annunciators.

(…)

Pre-Flight Tests conclusions:

Both tracks of each actuators, steering and recentering loops, are tested.

PFT are performed to guarantee good functioning of steering and recentering loop and pitch monitor.

Slight defect, like potentiometer track wear, can't be clearly identified through PFT."

1.16.3 Maintenance of the autopilot actuators

The maintenance of the autopilot yaw actuator P/N L24ACM2 and of the pitch/roll actuator P/N L24AAM1 is performed on-condition. The time-between-overhaul is 10 000 hours. The average total operating time of the actuators at the time of the accident was approximately 2000 hours.

Removals due to failures since modification 2001-2002:

Total replacements L24ACM2 (yaw) 10 devices

Total replacements L24AAM1 (pitch) 16 devices

Total replacements L24AAM1 (roll) 6 devices

Of the total of 32 replaced devices, 31 were sent to the manufacturer for repair. A fault was condirmed on 19 units; of these, defective potentiometers were found to be the cause of the defect (actuator oscillation) in 14 devices.

1.16.4 Examination of the helipad of the helicopter landing site at Samedan Hospital

1.16.4.1 Investigation of oscillation behaviour

As described in section 1.6.6, the rotating rotor of the helicopter generates unbalanced forces. When the helicopter lands, these unbalanced forces are transferred via the structure of the helicopter to the ground – in this case to the helipad. These unbalanced forces can cause landing platforms which are capable of

oscillation to oscillate. Oscillation of a helipad becomes critical if the natural frequency of the platform coincides with the excitation frequency emanating from the helicopter. This is known as a resonant state.

As part of the investigation, the natural frequencies and the resulting oscillation modes of the Samedan helipad were calculated. The calculations were made for different landing positions of the helicopter on the platform. Depending on the landing position on the platform, the calculated natural frequencies of the helipad were between 4.45 and 11.7 Hertz.

General considerations indicate that the excitation frequencies of the helicopter are between 1 and 8 Hertz.

This means that the helicopter may resonate with the platform when landing.

1.16.4.2 Examination of structural strength according to ICAO standards

The examination of structural strength according to ICAO standards produced inadequate safety factors for all load cases. In particular, the safety deficit with regard to lateral forces is considerable for the Samedan Hospital helipad.

Lateral loads result from the horizontal forces which are transferred from the skids or landing gear of the helicopter to the helipad.

Since the gratings which were laid on the platform were secured only by clips to the supporting structure to prevent lifting, these could slip on the substructure in the event of lateral loads.

According to the ICAO standards, the attachment of each grating must be designed so that it can withstand a load which is composed of 50% of the weight of the helicopter and a maximum wind load. In this way the load is safely transferred to the substructure. This requirement was not met by the type of grating assembly on the Samedan helipad.

The helipad of the Samedan Hospital helicopter landing site did not meet the strength requirements of the ICAO standards

1.16.4.3 Comparative tests

As described in section 1.16.4.1, the helipad of the Samedan Hospital helicopter landing site was investigated for oscillation behaviour.

According to ICAO design standards, such substantiation need not be provided, as high safety factors must be applied in the design of the static structural strength.

For comparison, the AAIB calculated the oscillation characteristics of two helicopter platforms abroad which are designed according to the ICAO standards. The calculations produced significantly lower natural frequencies than for the helipad in Samedan.

1.17 Organisational and management information

1.17.1 Operator

The Rega Air Rescue organisation was founded in 1952. Rega has an operating license to carry passengers and cargo by helicopter. Rega's headquarters are in Zurich-Kloten. The maintenance organisation is also located in Zurich-Kloten and performs base and line maintenance of its aircraft. This was approved by an EASA Approval Certificate.

Rega operates 10 operational bases for helicopters. These bases are responsible for the daily maintenance of their helicopters.

1.18 Additional information

1.18.1 Incident on 8 October 2009

After the accident, repairs to the roof of Samedan Hospital and helipad were carried out. The re-commissioning of the helipad by Rega took place on 14 August 2008. Subsequently, a total of 278 helicopter landings were carried out by Rega until 8 October 2009.

On 8 October 2009, the pilot of HB-XWJ involved in the accident landed with an identical type on the repaired helipad at Samedan Hospital. During the start-up of the first engine he perceived pronounced vibration.

The pilot described the incident as follows:

"After starting the first engine, on acceleration of the main rotor massive high-frequency vibration occurred, so I had to drop back again. A second attempt produced the same result. Only after about a minute's wait was I able to accelerate as usual. AP was not switched on at this time, as per the checklist.

Although this was a different constellation, the vibration immediately reminded me of my accident in June 2008. Interestingly, I felt the wind was almost identical (relatively strong and constant from the SW)."

According to MeteoSwiss, at the time of the event there was a prevalent wind of approximately 15 kt from the south-west.

After the incident of 8 October 2009, the helipad at Samedan Hospital was re-examined. It was noted that since the re-commissioning on 14 August 2008, the following defects had arisen:

- 9 loose fixings
- 11 gratings with slight play
- 6 gratings with play

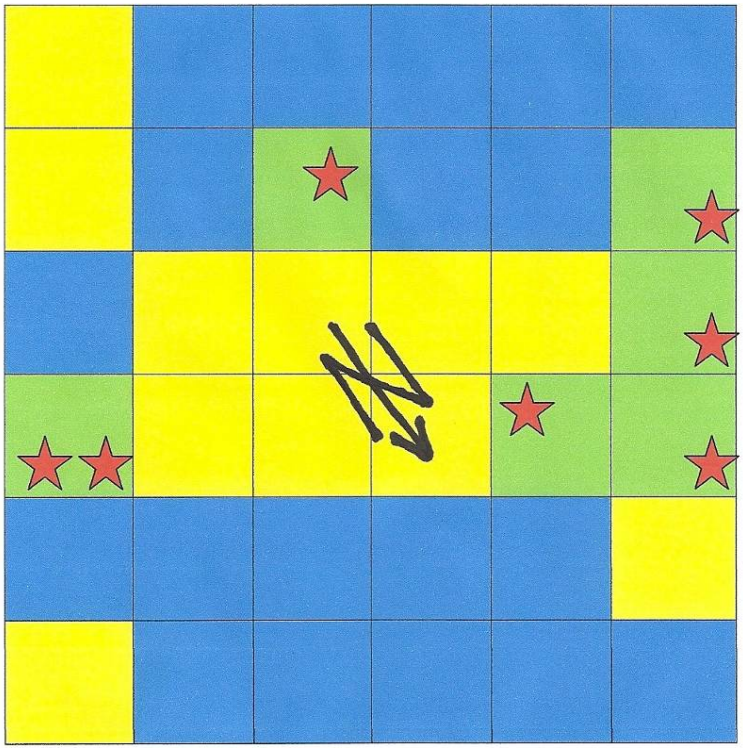


Figure 10: Samedan helipad, condition of the 36 gratings (G) after the incident on 8 October 2009

Grating OK Grating with slight play Grating with play

Loose fixings

Because of the incident, the Samedan Hospital helicopter platform was barred for further operation and underwent an overhaul. The re-commissioning took place on 24 November 2009.

1.18.2 Information provided to Rega pilots concerning operation of the autopilot

1.18.2.1 Rega Technical Note of 11 January 2002

On the basis of the increasing number of defects identified regarding the autopilot's linear actuators, all pilots registered in the FOM were alerted to a problem when switching the autopilot on or off without hydraulic pressure.

1.18.2.2 Rega Operational Instruction of 20 August 2003

Initial experience with the autopilot identified a few minor problems which may cause adverse reactions in "higher mode" or on the ground in "SAS mode".

According to operational instruction (OI) no. 2-99 the following instructions were issued for the pilots:

1. *If the helicopter starts to oscillate laterally on the ground after the AFCS is switched on (SAS mode), the A/P must be switched off using quick disconnect.*
2. *If the helicopter is being flown in "higher mode", only combinations with all 4 axes may be flown, as otherwise the A/P lacks information on values which must be complied with. This leads to illogical responses from the helicopter.*

1.18.3 Administrative procedure in neighbouring countries for the licensing of helicopter landing sites on hospitals

1.18.3.1 France

Since 2010, the French competent authority (*Direction générale de l'Aviation civile* – DGAC) has been checking helicopter landing pads on hospitals using a checklist which corresponds to ICAO Annex 14 Vol. II.

In case of structural discrepancies, a deadline is set for them to be remedied.

1.18.3.2 Germany

According to information from the Federal Ministry of Transport, landing sites for helicopters with more than 100 aircraft movements per year are treated as helicopter aerodromes with a corresponding operating licence. This includes helicopter landing sites on hospitals.

Licensing is essentially based on ICAO Annex 14 Vol. II.

1.19 Useful or effective investigation techniques

No new methods applied.

2 Analysis

2.1 Technical aspects

2.1.1 Helipad of the helicopter platform

The investigation of the helipad of the helicopter landing site at Samedan Hospital shows that structures which do not meet the requirements of ICAO Annex 14 Vol. II and the Heliport Manual are unsuitable for safe operation.

Helicopter landing sites which are designed and constructed in accordance with ICAO standards exhibit no critical behaviour in terms of resonance.

The failure of a helipad on a hospital roof could lead to a catastrophe.

2.1.2 Autopilot

The examination found that the serial actuator P/N L24AAM1 S/N 5633 was defective.

The position signals which are provided to the autopilot are sensed by linear potentiometers. The resolution of these signals is low. The linear potentiometers are subject to mechanical wear. When potentiometers are worn (on the examined potentiometers the wear was predominantly in the neutral area) then the position signal is not clearly defined. Such ambiguity of the sensed signal was found on potentiometers. Any ambiguity of the sensed signal leads to undesirable and uncontrolled effects on the autopilot, which may lead to critical oscillation of the helicopter (see also p.34 *Auto-Pilot system impact:*). Ambiguity of the sensed signal is also possible if there is play in the mechanical transmission elements. The investigations revealed that there was no play in these elements. It is noteworthy that the defect in the serial actuator P/N L24AAM1 S/N 5633 was not detected by the system test. This possibly resulted in oscillations of this serial actuator.

2.2 Operational aspects

2.2.1 Aborted landing

The helicopter manufacturer notes in the RFM that persistent oscillation may occur on the helicopter when the centre of gravity is at the maximum forward postion and when the mass is 2720 kg. In the present case, the centre of gravity was more or less precisely in the middle range and the mass was 2748 kg. With regard to the position of the centre of gravity, the condition which may have caused persistent oscillation was not present on the accident flight.

It is worth noting the prescribed reaction of the pilot if persistent oscillation occurs:

- The helicopter should, if possible, be lifted off the ground immediately.
- If it is impossible to take off, the collective must be lowered and the engines shut down.

The pilot could not determine what kind of damage had already occurred when the increasing vibrations appeared. Consequently the question whether a take-off would have been possible cannot be answered.

2.3 Summary

The investigation found that persistent oscillation could occur on the helicopter involved in the accident, as is probably the case with all types of helicopters. A helicopter has many rotating parts which may be sources of oscillation for various reasons.

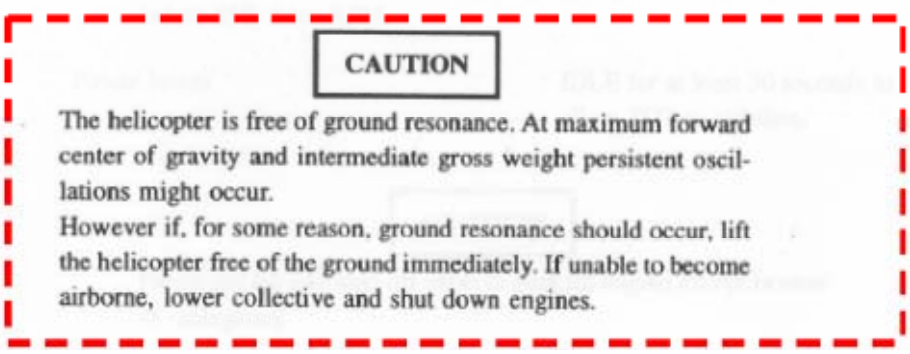
The helipad of a helicopter landing site, especially on a hospital roof, which is suitable for the safe landing of all helicopter types of a defined weight class must not have any critical reaction to any vibration emanating from the helicopter. This is ensured if a helicopter platform is designed in accordance with ICAO standards.

3 Conclusions

3.1 Findings

3.1.1 Technical aspects

- The helicopter was licensed for VFR operations.
- The last 100-hour inspection was carried out at 3117:57 operating hours.
- The investigation found that the roll serial actuator was defective. In the centre position the potentiometer exhibited a loss of electrical continuity, i.e. an interruption.
- At the time of the accident, both the mass and centre of gravity of the helicopter were within the permitted limits according to the RFM.
- At the time of the accident, the mass was approximately 2748 kg.
- At the time of the accident, the centre of gravity was at 3388 mm.
- The permitted range of the centre of gravity position is between 3320 and 3460 mm.
- The manufacturer of the helicopter provides the following caution regarding ground resonance in the RFM:



CAUTION

The helicopter is free of ground resonance. At maximum forward center of gravity and intermediate gross weight persistent oscillations might occur.
However if, for some reason, ground resonance should occur, lift the helicopter free of the ground immediately. If unable to become airborne, lower collective and shut down engines.

- The pilot could not determine what kind of damage had already occurred when the increasing vibrations appeared. Consequently the question whether a take-off would have been possible cannot be answered.
- In its operational instruction of 20 August 2003, Rega notes that lateral oscillation may occur on the ground after switching on the AFCS (SAS mode).
- The helicopter was equipped with an emergency transmitter (emergency location beacon aircraft – ELBA). The device was installed and operational. No signals were transmitted.

3.1.2 Crew

- The pilot held the necessary licences for the flight.
- There are no indications of the pilot suffering health problems during the accident flight.

3.1.3 History of the flight

- The pilot carried out the landing on the helipad with the aid of the Sextant AFDS 95-1 Automatic Flight Director System.
- The wheel brakes were locked on landing.
- An eyewitness observed that the helicopter began to oscillate laterally after touchdown and began to shake rapidly.
- When the ground resonance occurred, the pilot fully lowered the collective stick.

3.1.4 General conditions

- For the FOCA, landing sites at/on hospitals were considered to be remote landing sites for emergency flights at the time of the accident.
- It was possible to build and use the landing sites at hospitals without the approval of the FOCA.
- According to information from engineering organisation which was responsible, the helipad of the helicopter landing site at Samedan Hospital was designed for loads of 3x1500 kg. This corresponds to a helicopter weight class of 4500 kg.
- Helicopter HB-XWJ was certified for a maximum take-off mass of 2850 kg.
- The helipad of the helicopter landing site at Samedan Hospital did not meet the specifications of ICAO Annex 14 Vol. II or the Heliport Manual.
- The possible dynamic loads were not taken into consideration when the helipad of the helicopter landing site at Samedan Hospital was designed.
- The excitation frequency generated by the Agusta 109K2 helicopter is between 1 and 8 Hz.
- Depending on the landing position on the platform, the calculated natural frequency of the helipad of the helicopter landing sige at Samedan Hospital is between 4.45 and 11.7 Hertz.
- The platform starts to resonate when the excitation frequency and the natural frequency of the platform coincide.
- On 8 October 2009, another incident occurred on the same platform, when ground resonance occurred. The damage to the platform was comparable with that of the accident.
- The weather was not a factor in the accident.

3.2 Cause

The helicopter accident is attributable to ground resonance during the landing on the helipad of a helicopter landing site, because its structure had been incorrectly designed.

The defective technical condition of the autopilot system may have contributed to the accident.

4 Safety recommendations and measures taken since the accident

In accordance with Annex 13 of the ICAO, all safety recommendations listed in this report are addressed to the supervisory authority of the competent State, which must decide on the extent to which these recommendations are to be implemented. However, every agency, organisation and individual is invited to attempt to improve aviation safety in the sense of the issued safety recommendations.

In the Ordinance on the Investigation of Air Accidents and Serious Incidents, Swiss legislation provides for the following regulation:

"Art. 32 Safety recommendations

[1] DETEC shall address implementation assignments or recommendations to FOCA, based on the safety recommendations in the reports from SAIB or on the foreign reports.

[2] FOCA shall inform DETEC regularly about the implementation of the assignments or recommendations.

[3] DETEC shall inform the SAIB at least twice a year about the progress made by FOCA with implementation."

4.1 Safety recommendations

4.1.1 Safety deficit

At 19:58 on 23 June 2008, the pilot, accompanied by two other crew members, a paramedic and an emergency doctor, took off from Samedan airport in the Agusta A109K2 helicopter, registration HB-XWJ, in the direction of the helicopter landing site at Samedan Hospital. He initiated the landing at approximately 20:00.

On touchdown, the pilot perceived a "slight ground resonance". The pilot moved the collective lever fully down. Immediately thereafter "the resonant motion began to increase" and became more pronounced. The pilot pulled back both power levers and shut down the engines.

After the crew exited, major damage to the helicopter as well as damage to the helipad of the landing site was found. One rotor blade was destroyed and the landing gear was severely damaged. The helicopter was on the outer edge of the helipad of the helicopter landing site and extended approximately 1 m beyond the facade of the building. The gratings of the helicopter platform in the landing zone had been partially detached from their fixings and had shifted.

On 8 October 2009, another incident involving ground resonance occurred on the same platform. The damage to the platform was comparable with that of the accident.

The investigation of the structural strength of the helipad of the helicopter landing site at Samedan Hospital showed that it did not meet the ICAO standards.

For the FOCA, landing sites at hospitals were considered to be remote landing sites for emergency flights at the time of the accident. It was possible to build and operate landing sites at hospitals without an approval of the FOCA.

The failure of a helipad on a hospital roof could lead to a catastrophe.

In France, since 2010, the French competent authority (*Direction générale de l'Aviation civile – DGAC*) has been checking helicopter landing sites on hospitals using a checklist which corresponds to ICAO Annex 14 Vol. II. In case of structural discrepancies, a deadline is set for them to be remedied.

In Germany, helicopter landing sites with more than 100 aircraft movements per year are treated as helicopter aerodromes, with a corresponding operating licence. This includes helicopter landing pads on hospitals. Licensing is essentially based on ICAO Annex 14 Vol. II.

278 landings were made on the Samedan Hospital helicopter landing site in 2007.

In 2007 there were 166 helicopter landing sites at hospitals in Switzerland, 34 of which were helipads on roofs and 29 were on roofs without helipads.

4.1.2 Safety recommendation no. 440

The Federal Office of Civil Aviation (FOCA) should ensure that the helicopter landing sites at and on hospitals in Switzerland comply with the standards according to ICAO Annex 14 Volume II and the Heliport Manual, primarily in regards to the structural design and with a risk based approach.

Payerne, 2 November 2011 Swiss Accident Investigation Board

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

Berne, 26.01.2012

Annexes

Annex 1: Helicopter landing site on the roof of Samedan Hospital