Statens haverikommission
Swedish Accident Investigation Board

ISSN 1400-5719

Report RL 2009:21e

Accident to helicopter SE-JGX north of Katrineholm, Södermanlands county Sweden, on 30 October 2006

Case L-28/06

Statens haverikommission
Swedish Accident Investigation Board

2009-12-17 L-28/06

The Swedish Transport Agency

SE-601 73 NORRKÖPING, Sweden

Report RL 2009:21e

The Swedish Accident Investigation Board has investigated an accident that occurred on 30 October 2006 north of Katrineholm, Södermanlands county, to a helicopter registered SE-JGX.

In accordance with section 14 of the Ordinance on the Investigation of Accidents (1990:717) the Agency herewith submits a report on the investigation.

Göran Rosvall Stefan Christensen

Report RL 2009:21e... 5

1 FACTUAL INFORMATION 7
1.1 History of flight.. 7
1.2 Injuries to persons...8
1.3 Damage to the aircraft...8
1.4 Other damage 8
1.5 Personnel information..8
1.5.1 Pilot 8
1.5.2 The pilot's duty schedule 9
1.6 The helicopter 9
1.6.1 General 9
1.6.2 Engine and power transmisssion 10
1.6.3 Governor system 11
1.6.4 Autorotation of a helicopter 11
1.6.5 Emergency checklist for SE-JGX. 13
1.6.6 Emergency checklist in the flight manual 13
1.6.7 Information part 1 concerning the risk of carburetor icing 13
1.6.8 Information part 2 concerning the risk of carburetor icing 14
1.6.9 Modification of carburetor heating 14
1.7 Meteorological information.. 14
1.8 Aids to navigation 14
1.9 Radio communications.. 14
1.10 Aerodrome information... 14
1.11 Flight recorders and voice recorders 14
1.12 Accident site... 15
1.12.1 Accident site 15
1.12.2 Aircraft wreckage 15
1.13 Medical information 17
1.13.1 General status 17
1.13.2 Regulations 18
1.14 Fire.. 18
1.15 Survival aspects 19
1.15.1 General 19
1.15.2 Actions by the rescue services 19
1.16 Tests and research 20
1.16.1 General 20
1.16.2 Power transmission 21
1.16.3 Engine 21
1.16.4 Rotors 22
1.16.5 Engine testing 22
1.16.6 Examination of the warning lamps 22
1.16.7 Carburetor icing 23
1.16.8 Bird strike 24
1.17 Organisational and management information 25
1.17.1 The business 25
1.18 Other aspects 25
1.18.1 Equal opportunities aspects 25
1.18.2 Environmental aspects 25
1.18.3 Witness statements 25
1.18.4 Radar images from the Swedish Armed Forces (FM - Försvarsmakten) 25
1.18.5 GPS 26
1.18.6 Helicopter accidents - general 28
1.18.7 Fuel on board aircraft 29

2 ANALYSIS 30
2.1 The flight...30
2.1.1 General 30
2.1.2 Conditions pertaining to the flight 30
2.1.3 The first phase of the flight 30
2.1.4 Problems 31
2.1.5 The accident 31
2.2 Technical investigations 32
2.2.1 Examination of the engine 32
2.2.2 Examination of the power transmission 33

2.2.3 .. Examination of the rotors 33
2.3 Bird strike 34
2.4 Fire on board 34
2.5 Carburetor icing 34
2.5.1 General 34
2.5.2 Conditions during the flight 35
2.6 Probable cause of disturbance 35
2.7 Medical status 35
2.7.1 Status at the time of the accident 35
2.7.2 Medical Investigations 35
2.7.3 Increased medical risks 36
2.8 The probable accident sequence 36
2.8.1 The beginning 36
2.8.2 The autorotation 36
2.8.3 Autorotation in combination with medical effects. 37
2.8.4 Summary 38

3 CONCLUSIONS 38
3.1 Findings 38
3.2 Causes of the accident 38

4 RECOMMENDATIONS 38

APPENDICES:

1. Safety Notice SN-25.
2. Safety Notice SN-31.

Report RL 2009:21e

L-28/2009
Report finalised 17 December 2009

Aircraft; registration and type	SE-JGX, Robinson R44
Class, airworthiness	Normal, valid Certificate of Airworthiness
Registered owner/Operator	Helitek Hangar i Karlskoga AB/Copterflyg AB
Time of occurrence	30 October 2006 at about 08:45 Note: All times are given in Swedish standard time (UTC + 1 hour)
Place	Bie, North Katrineholm, Södermanlands county, (posn. 59° 06.9′ N, 016° 14.2′ E, approx. 50 m above sea level)
Type of flight	Ferry flight
Weather	According to SMHI's analysis: Wind south-west 10 knots, visibility > 10 km, broken clouds 1200-300 ft in the area, temperature/dew point +5/+3°C, QNH 1011 hPa
Persons on board:	
crew members	1
Injuries to persons	Pilot killed
Damage to the aircraft	Completely destroyed
Other damage	Minor ground damage

The Swedish Accident Investigation Board (SHK) was notified on 30 October 2006 that a helicopter with registration SE-JGX had an accident early that morning north of Katrineholm in Södermanlands county.

The accident was investigated by SHK represented by Göran Rosvall, Chairperson, Stefan Christensen, Investigator in Charge, and Urban Kjellberg, Investigator Fire and Rescue.

SHK was assisted by Liselotte Yregård as medical expert and Lars-Peter Peltomaa as technical expert.

The investigation was followed by Gun Ström of the Swedish Transport Agency, Civil Aviation Department, until 1 June 2009, and thereafter Ulrika Svensson.

Summary

The pilot started took off Västerås/Johannisberg airport approx. 08:20 to conduct a ferry flight. According to the radar images that were obtained, the flight has thereafter taken place on a south-westerly course, and at altitudes varying between 240 and 270 meters (790 to 890 feet) above the ground. The last radar image was recorded shortly after 08:42 and showed that the helicopter was at 180 (590 feet) meters. The data obtained from radar has also been confirmed through the readout of the memory unit taken from the helicopter's GPS, which shows that the helicopter began a right turn toward a clearcut area during loss.

At 08:46 ARCC[1] received signals from an emergency transmitter that could be identified from a location in Södermanland. Following this signal rescue helicopter from Stockholm Arlanda airport could locate the accident site and

[1] ARCC: Aeronautical Rescue Coordination Centre

the helicopter wreckage. SE JGX had crashed in a clear-cut woodland area about 12 kilometers north of Katrineholm.

The investigation showed that the helicopter hit the ground at a steep angle. At impact the pilot was killed and the helicopter was destroyed by fire. The technical investigation could not identify any faults or failures that could have affected the course of events of the accident.

The weather conditions on the morning in question were generally good, but there was a risk of severe icing at all power outputs. The helicopter was equipped with an automatic governor system which detects the engine speed and applies the mechanical corrective movements directly to the throttle valve. If for example ice builds up in the carburetor, the governor system automatically compensates for this by modulating the throttle valve (and “turning” the pilot’s throttle control).

The pilot's medical history shows that he was treated for high blood pressure after visits to health clinics. The values obtained were not consistent with approved medical certificate. The pilot's aviation medical examinations for medical certificates indicated, however, approved blood pressure values. Civil Aviation Authority withdrew in 2006, the current physician's authorization to conduct aviation medical examinations.

SHK considers that it is likely that an engine failure - possibly caused by icing of the carburetor – was the reason for the pilot to initiate an autorotation in order to carry out an emergency landing. In the final stage of the course of events, where medical factors may have contributed, however, autorotation could not be completed subsequently the helicopter crashed in a clear-cut woodland area.

SHK has in the investigation of this accident has not found enough evidence to make a safe analysis of the events and causes of the accident.

Recommendations

None

1 FACTUAL INFORMATION

1.1 History of flight

The pilot took off from Västerås/Johannisberg airport at about 08:20 to perform a ferry flight VFR[2] to Hyltebruk, where a lifting task would be carried out. No ATC[3] flight plan had been submitted for the flight. At 08:26 the helicopter, a Robinson R44 registered SE-JGX, left Västerås control zone at Vikhus, located south-west of Västerås. No information is known about the preparations for the flight or other conditions, nor were there any witnesses to the take off or the first part of the flight.

During the flight via Vikhus the last known radio communication was made with the aircraft. No faults or abnormal conditions were reported in this communication. According to the radar images that were obtained, the flight then continued on a south-south-westerly course at altitudes varying between 240 and 270 metres (790 – 890 feet) above ground level. The last radar image was recorded just after 08:42 and showed that the helicopter was at an altitude of 180 metres (590 feet). The data obtained from the radar image was also confirmed by readouts from the memory unit that was retrieved from the helicopter GPS.

At 08:46 ARCC[4] received signals from an emergency transmitter that could be identified as being somewhere in Södermanland. Following this signal, a rescue helicopter from Stockholm Arlanda could locate the accident site and helicopter wreckage. SE-JGX had crashed at a clear-cut woodland area about 12 kilometres north of Katrineholm. Based on the position of the wreckage at the crash site it could be concluded that the helicopter had deviated from its original course and made at least one turn into the clear-cut area. The position of the wreckage facing north-west meant there had been a course deviation of about 110° from the original track. The pilot was killed in the accident and the helicopter was completely destroyed.

The accident took place at position 59° 06.9' N 016° 14.2' E.

[2] VFR: Visual Flight Rules
[3] ATC: Air Traffic Control.
[4] ARCC: Aeronautical Rescue Co-ordination Centre

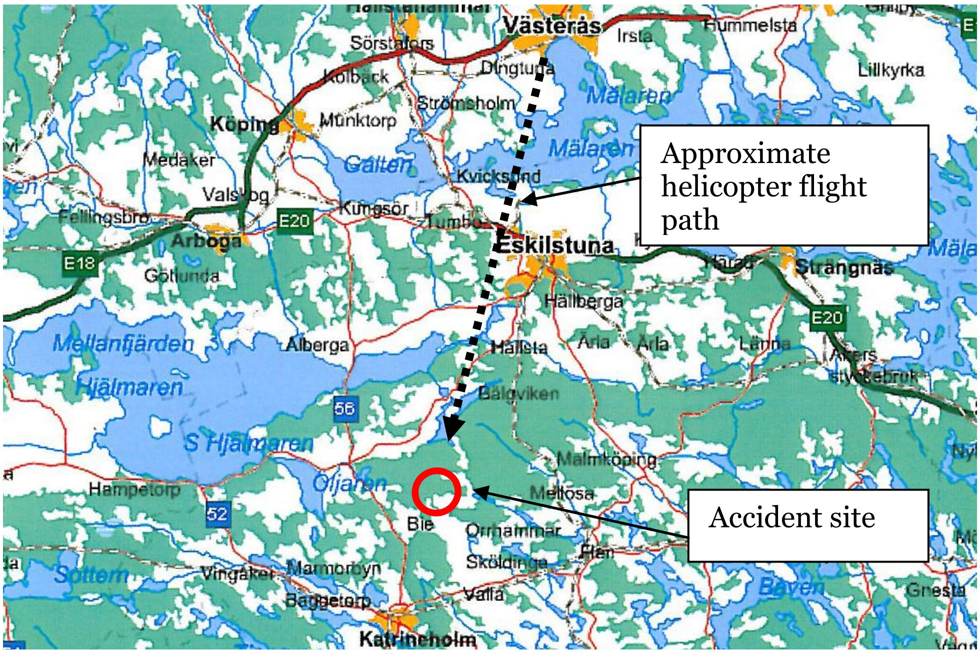

Fig.1. The flight path and the accident site.

1.2 Injuries to persons

	Crew members	Passengers	Others	Total
Fatal	1	–	–	1
Serious	–	–	–	–
Minor	–	–	–	–
None	–	–	–	–
Total	1	–	–	1

The pilot was killed in the accident. The forensic examination showed that the pilot had been subjected to extreme blunt mechanical trauma and suffered a fracture at the base of the skull, along with multiple skeletal fractures.

Several injuries to the internal organs were also present. The pilot also suffered abrasions and extensive burns, which were more severe on the left side of the body. There were no other injuries or noted effects that could not be attributed to crash injuries.

It was assessed that the cause of death had been the comprehensive injuries.

1.3 Damage to the aircraft

Completely destroyed

1.4 Other damage

Limited damage to the surrounding vegetation.

1.5 Personnel information

1.5.1 Pilot

The pilot, male, was 49 years old at the time and had a valid CPL-H Licence.

Flying hours			
Latest	24 hours	90 days	Total
All types	0.5	unknown	13,850
This type	0.5	unknown	Unknown

Type rating was completed 22 January 2004.

Latest PC (Proficiency Check) on the type was carried out on 22 June 2004, in connection with flight testing on the R 44 type. Since then additional PC's had been carried out on the following types:

- 16 August 2004 on type AS316
- 22 April 2005 on type AS350
- 2 May 2006 on type AS350

The pilot was certified to fly the type R 44 until 31 May 2007.

1.5.2 The pilot's duty schedule

Prior to the accident the pilot had been on duty for about one hour.
The previous night he had had about eight hours of sleep. The investigation has not been able to completely establish the pilot's duties in the days before the accident, but according to information received there is a strong indication it was a normal character.

1.6 The helicopter

1.6.1 General

Fig.2 The accident helicopter SE-JGX. Photo Hans-Göran Spritt

The aircraft	
Manufacturer	Robinson Helicopter Company
Type	R 44
Serial number	0113
Year of manufacture	1994

Gross mass	Max. authorised take off mass 1,089 kg, actual approx. 970 kg
Centre of mass	Within permitted limits
Total flying time	3,237.3 hours
Flying time since latest inspection	Approx. 40 hours
Fuel loaded before event	AVGAS 100LL

Engine	
Manufacture	Lycoming
Engine model	O-540-F1B5
Number of engines	1
Total flying time	1,037.3 hours
Flying time since latest inspection	40 hours

The helicopter had a valid Certificate of Airworthiness.

1.6.2 *Engine and power transmisssion*

The Robinson R 44 is a development of a smaller model of the helicopter, the R 22, and is a commonly used type for both private and lighter commercial aviation. In its normal configuration the R 44 has seating capacity for four persons. This particular helicopter was equipped for VFR flying and had no autopilot. The type is normally flown from the right front seat.

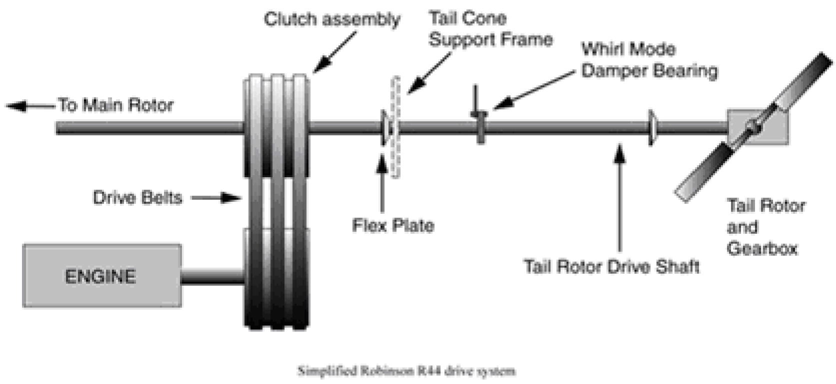

Fig. 3. Power transmission system of the R 44.

The helicopter is powered by a six-cylinder piston engine with a carburetor. The engine is of conventional type and drives the main and tail rotors. Power transmission from the engine crankshaft to the rotor gearbox is via a freewheel (clutch) that is designed in accordance with the belt drive principle with drive belts (see fig. 3). The unit has fixings for the attachment of the shafts to the main rotor and tail rotor. Power transfer to the rotors takes place through a pinion gear.

The rotor is disengaged automatically in the case of a loss of engine power (freewheel principle) but can also be disengaged manually by means of a control on the instrument panel – “clutch disengaged”. Normally, the clutch is only used during engine starting, and the rotors are engaged at a later stage via the clutch. On a helicopter the rotors are disengaged from the engine if the engine speed falls below the rotor speed.

1.6.3 Governor system

The R 44 has an automatic governor system that senses the engine speed and applies corrective mechanical movements directly to the throttle valve. By means of controlling the engine speed, the rotor speeds are also controlled. The system is regulated automatically via the helicopter collective pitch control and may also be disconnected by a switch.

The system has an electronic control unit that receives engine speed information from the right hand magneto and then provides a signal to a trim motor to increase or decrease the amount of throttle. When the trim motor is in operation it mechanically moves the throttle control, which in turn is connected to the carburetor. This means that the pilot can feel the movement of the throttle control when the trim motor (part of the governor system) is operating.

If for example ice builds up in the carburetor, the governor system automatically compensates for this by modulating the throttle valve (and “turning” the pilot’s throttle control). In the case of ice build-up in the carburetor the governor system will continue to compensate for the loss in engine speed by means of the throttle valve being fully open. On the R 44 there is a CAT – Carburetor Air Temperature - sensor, which measures the temperature in the carburetor in order to warn the pilot of impending or currently present ice build-up. This instrument has a colour scale, with a green zone indicating that there is no risk of carburetor icing. As the temperature changes the scale goes into a yellow zone to indicate that there is a risk of icing.

1.6.4 Autorotation of a helicopter

If there is a loss of engine power or misfiring of the engine in a helicopter, resulting in difficulty in maintaining rotor speed, entry into autorotation must be initiated. In such a case it could also imply that the pilot is forced to switch off the engine, if its speed cannot be controlled.

Autorotation means that the collective pitch control must be lowered into its lowest position, “flat pitch”, in which position the main rotor provides no lifting force at normal speed. The entry into autorotation also means that the nose is raised considerably while the collective is lowered rapidly. In order to prevent the rotor speed to reduce below a critical level, the entry into autorotation must take place within a few seconds after the engine has been switched off or is unable to keep the rotor at a normal speed. The transfer to autorotation means that instead of air being pushed down through the rotor disc, it comes up through the rotors disc (see Fig. 4), since the helicopter begins to descend towards the ground. This movement of air up through the rotor disc drives the rotor system at a speed that is equivalent to the normal rotor speed when flying with normal power.

During autorotation the helicopter may be manoeuvred in a normal manner, and different speeds can be selected depending on whether the longest distance or minimum sink rate are to be achieved. If the speed becomes too high during autorotation the rotor speed will reduce and the helicopter will become difficult to manoeuvre. If the speed becomes too low, the sink rate will become so high that a safe landing may not be possible.

If there is underlying terrain on which the helicopter could land, this normally allows for an altitude of 1,000 feet above ground level so that the conditions are favourable to allow entry into autorotation, turning into wind, sending an emergency message, deciding whether to attempt to restart the engine and finally deciding the touchdown spot.

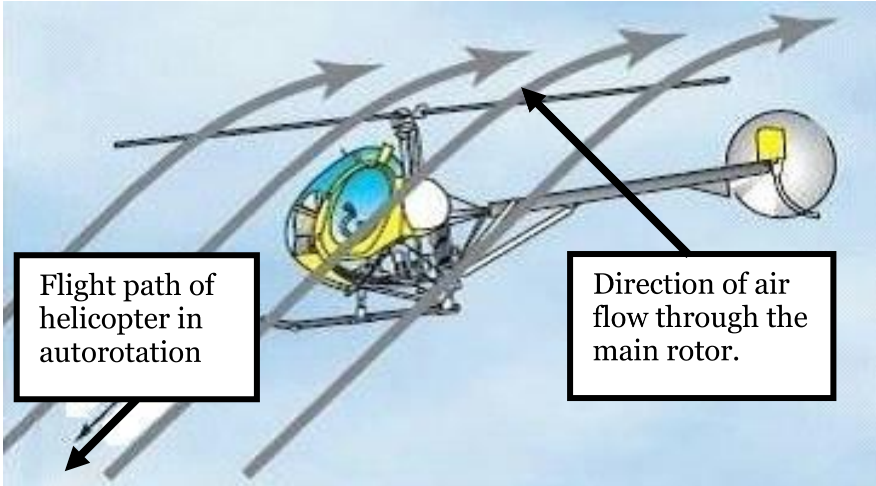

Fig.4. Autorotation

In the final phase of autorotation a flare is performed, with the nose raised which at the same time reduces forward speed and sink rate so that the subsequent touchdown can be softened, by quickly raising the collective and maintaining lifting power by using the energy stored in the rotor movement.

If the entry into autorotation does not take place within a few seconds, the rotor speed will reduce below the level where, during subsequent autorotation it cannot be made to increase, and thereby generates a high sink rate towards the ground and making the helicopter very difficult to control. In principle it can be said that the centrifugal force decreases with reduced rotor speed, meaning that the rotor blades bend upwards.

The altitude from which autorotation can be safely performed, with a successful result, is directly dependent on forward speed. If there is no forward speed, i.e. the helicopter is hovering, it can generally be said for most helicopters that the height range between 10 and about 300 feet is to be regarded as very uncertain in respect of performing a safe autorotation.

In general it can be said that the conditions for a successful autorotation depend on the pilot regularly practising this manoeuvre, selecting a flight path and altitude that offer good conditions and being on the alert for rapid entry into autorotation. Similarly, strong wind provides better conditions if a landing is attempted into it.

Autorotation also depends on other factors, such as for example the rotor mass and design, that determine the amount of rotating energy that can be stored, and other factors which generally affect performance, such as the current mass of the helicopter and the prevailing meteorological conditions.

In the case of the R 44, in similar conditions and with the same mass, the results of tests that SHK has obtained, showed that a normal autorotation in stable conditions results in an approximate sink rate of 1,450 feet per minute.

1.6.5 Emergency checklist for SE-JGX.

This particular helicopter had a permanently attached checklist on the instrument panel concerning measures to be taken in the case of:

- Power failure
- Fire in flight

The checklist for power failure (loss of engine power and/or misfiring) contained the following items:

1. Autorotation, speed 65 knots
2. Select landing spot
3. Mixture ”full rich”
4. Throttle in idle
5. Try to restart engine
6. If unable to restart or if time don’t permit
7. Shut off fuel valve
8. Land

From the list it can be seen that the first – and thereby the most important – item is to commence autorotation. The subsequent items deal with selecting a place to land and ensuring that there is a rich mixture. Then follows items concerning attempts to restart the engine.

This list is a printout of a checklist from another R 44 operated by the company and is said to be identical to that which burned up in connection with the accident.

1.6.6 Emergency checklist in the flight manual

In the FAA approved flight manual, all the procedures to be carried out in the case of a loss of engine power are collected in the section called *Emergency procedures*. These are divided into two parts for dealing with engine failure; above and below 500 feet altitude respectively. One of the differences between the checklists is that at a higher altitude the pilot could consider a restart attempt. There are no items in the approved procedures concerning checking and/or changing such control functions as mixture, carburetor heating or the magneto switches.

On examining the different documents, SHK has found that the operating company’s emergency checklist is a mixture of the items contained in various checklists, where certain items –are not described in the flight manual – have been added.

1.6.7 Information part 1 concerning the risk of carburetor icing

In 1986 the helicopter manufacturer issued *“Safety Notice SN-25”*. This Notice has the heading “CARBURETOR ICE” and contains warnings and instructions concerning operations when the conditions for carburetor icing are present. The following text introduces the Notice:

Carburetor ice can cause engine stoppage and is most likely to occur when there is high humidity or visible moisture and air temperature is below 70°F (21°C). When these conditions exist, the following precautions must be taken:

The Notice then continues with instructions concerning various phases of flight, such as take-off, cruise flight and descent. The complete Notice is contained in Appendix 1.

1.6.8 Information part 2 concerning the risk of carburetor icing

In December 1996 the manufacturer issued a further Notice concerning carburetor icing: *"Safety Notice SN-31"*. This Notice had the heading: *"GOVERNOR CAN MASK CARB ICE"* with the following text:

With throttle governor on, carb ice will not become apparent as a loss of either RPM or manifold pressure. The governor will automatically adjust throttle to maintain constant RPM which will also result in constant manifold pressure. When in doubt, apply carb heat as required to keep CAT out of yellow arc during hover, climb or cruise, and apply full carb heat when manifold pressure is below 18 inches.

The complete Notice is contained in Appendix 2.

1.6.9 Modification of carburetor heating

From and including serial number 202 onwards, the manufacturer modified the automatic control of the carburetor heating function in type R 44 helicopters. A new system – *carb heat assist* – automatically opens the hot air valve to the carburetor when the collective lever is lowered, and similarly closes the valve when the collective lever is raised. The system can be turned on and off by a switch on the lever. SE-JGX, the helicopter involved in the accident, had however an earlier serial number and was thus not equipped with this system.

1.7 Meteorological information

According to the SMHI (Swedish Meteorological and Hydrological Institute) analysis: South-west - 10 knots, visibility > 10 km, broken clouds between 1200-3000 ft. Temperature/dewpoint +5/+3°C, QNH 1011 hPa.

1.8 Aids to navigation

The helicopter carried instrumentation for VFR flight and also a permanently installed GPS as a navigation aid.

1.9 Radio communications

A VHF radio was installed, and the final communication was with Västerås control tower. The radio communications that took place were of a standard nature, and only of operational character.

1.10 Aerodrome information

Not applicable

1.11 Flight recorders and voice recorders

None. Not required.

1.12 Accident site

1.12.1 Accident site

The helicopter crashed on clear-cut ground about 6 km north-north-east of the settlement of Bie. The clear-cut area is surrounded by woods and was one of the few open areas along the route of the helicopter at that part of its flight path. The impact site was located about 50 metres into the cleared area on the probable route of the final track. The area is surrounded by relatively high masking trees. The cleared ground is uneven and rock-strewn in parts. Minor vegetation and brushwood dot the area. There was no sign of the trees having been struck in the probable descent path of the helicopter.

The accident site is rather remote and there are no buildings in the vicinity. The distance to the closest road that could carry vehicles is about 400 metres.

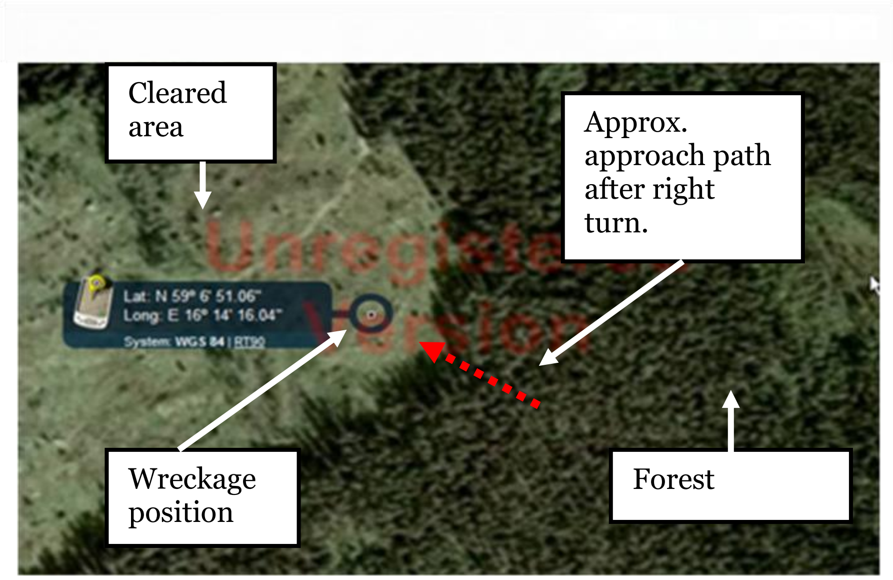

Fig. 5. The accident site.

1.12.2 Aircraft wreckage

<u>General</u>
The Accident Investigation Board made a preliminary investigation and documented the helicopter by photographing the accident site. The wreckage was found in a position that did not agree with the latest known direction of flight according to the radar images.

The position was equivalent to an approximate impact direction of 300°.

The helicopter was completely destroyed on impact and was found to be inverted at the accident site. The forward parts of the left and right landing skids ware found broken off and embedded in the ground about five metres from the wreckage at an approximate angle of 45° to the ground. The parts could be identified as pieces of the tubular construction (skids) that forms the helicopter landing gear. The rear parts of the skids were about 12 metres away from the main wreckage in the direction of impact. Other parts of the helicopter were grouped within a relatively limited area at the impact site.

Fire had obviously broken out, which meant that most of the helicopter had been destroyed. The complete cabin with its interior, engine cowling, rear fan cover and tanks had burned away. There was no trace of external influence (pieces of vegetation, remains of birds, etc.) in the wreckage or close to it.

Engine and rotors
The engine, with auxiliaries and components, showed signs of major damage. The firewall was severely deformed and the engine had suffered major fire damage. The oil sump, carburetor and one of the magnetos were all destroyed by fire. The other magneto was badly damaged by fire.

The tail section, horizontal and vertical fins with the tail rotor gearbox and blades had been torn away from the tail boom and lay about three metres away beside the wreckage. The main rotor transmission was relatively undamaged, as were also the tail boom and tail unit. Both main rotor blades were damaged.

There were clear impact marks on the ground from the blades. Before the wreckage was removed the blades were detached from the helicopter. The dismantling took place without any problem. The wreckage was then removed to a hangar for further technical examination. The engine, main rotor transmission and tail boom were detached for inspection at a workshop.

Fig.6. The helicopter wreckage.

The cabin
The entire cabin was demolished by the accident. The central parts of the helicopter were concentrated in a limited area and severely damaged by fire. No parts of the seats or other cabin fittings could be found at the accident site. Two fire-damaged jerry cans were found in the wreckage. Inside one of the cans was found part of an object that had forced its way in from one side and made a hole in the jerry can. This object was identified as probably part from one of the helicopter headsets.

Controls
Most of the instrument panel and the controls were damaged by the accident. The remains of the controls were examined as far as possible and were found to be intact. A small part of the instrument panel (see Fig. 7) had been thrown out of the wreckage and thereby avoided being burned.

Fig.7. Part of the instrument panel.

The controls and instruments that were found and were identifiable, are showed with the positions and readings they had when the wreckage was examined:

- The altimeter indicated 730 feet/1019 hPa.
- The variometer indicated 2000 feet/min (descent rate).
- The magneto selection key was broken and burnt in its "OFF" position.
- The priming pump was not in its locked position.
- The clutch switch[5] was set to "Disengage".
- The carburetor heating control was pulled out.
- The mixture control was pushed in (rich mixture).

Note The priming pump is only used when starting the engine and is not accessible during flight.

The engine and transmission unit were detached from the wreckage and sent away for examination. The warning lamps that could be retrieved were taken out and examined by SHK. See Section 1.16.

1.13 Medical information

1.13.1 General status

The pilot had undergone the prescribed medical examinations and had a valid medical certificate which did not state that he was suffering from any illness.

However examination of his medical records showed that on two visits to another clinic than that of the aviation medical examiner, between May 2005 and March 2006, the pilot had very high blood pressure (hypertension). The values that were recorded were not consistent with an approved medical certificate.

[5] Clutch: Device to disengage the rotor shaft.

In the case of the first visit treatment was prescribed, which however ceased after some months. After this the pilot, as at the time of the accident, did not take medicine nor had his blood pressure checked. In the case of the second visit – in March 2006 – his blood pressure was deemed so high that it was categorised as severe hypertension. The pilot was requested to return for further investigation and medication, but failed to visit the clinic again.

The visits to the other clinic and treatment for high blood pressure were not recorded in the medical records held by the aviation medical examiner. The blood pressure that was recorded in connection with these examinations during this period was high, however at a level consistent with the issued and approved medical certificate.

Of lesions detected at autopsy hardening of the arteries in the heart and aorta.

The forensic chemistry analysis revealed nothing that spoke to the intake of alcohol had occurred. The drug analysis demonstrated caffeine. Furthermore, it was found 1% carbon monoxide hemoglobin in blood, which is a normal value. Carbon Monoxide Hemoglobin is formed by inhalation of carbon monoxide or smoke, for example, and may then give rise to high levels in the blood.

1.13.2 *Regulations*

According to JAR-FCL, holders of medical certificates may not exercise the powers of their licenses and their associated permissions at any time they are aware of any deterioration in health status that would render them unable to safely exercise those powers. Furthermore, holders of medical certificates may not take any prescription medicine, unless they are absolutely sure that the medicine does not have a negative effect on their ability to perform their duties safely. In case of doubt, shall the Swedish Transport Agency (former), Civil Aviation Authority medicine unit or aviation medical examiner, be consulted. Holders of medical certificates shall, moreover, without undue delay, consult the Civil Aviation Authority medicine unit or an aviation medical examiner during regular use of drugs.

According to JAR-FCL shall, during introduction of drugs for hypertension, the medical certificate be suspended until it has been found that there are no significant side effects.

During the investigation it was not found that the pilot had refused to exercise his powers in accordance with his certificate, due to the hypertension problem. There is no evidence that the pilot consulted the Swedish Transport Agency, Civil Aviation Authority medicine unit or aviation medical examiner when medication for high blood pressure was introduced, or that the pilot's medical certificate was suspended in conjunction with the time of treatment.

In the autumn of 2006, the Swedish Civil Aviation Authority had withdrawn authorisation for the aviation doctor who issued the approved medical certificate due to found deficiencies in the business. This took place during the period that it was found at another healthcare facility that the pilot had excessively high blood pressure and was also being treated for this.

1.14 Fire

Most of the helicopter was destroyed by fire. The helicopter had been subjected to fire for at least 1 hour and 37 minutes, from the estimated time of the crash at 08:42 until the rescue helicopter landed at the accident site at 10:19 and extinguished the remaining fire.

1.15 Survival aspects

1.15.1 General

The appearance of the wreckage and the impact points that could be identified via the helicopter skids indicate that it was a very hard impact. Because the fire completely destroyed the cabin and its fittings it has not been possible to establish the status or possible use of the safety belts. Nor during the post mortem examination of the pilot was it possible to determine whether the belt – a lap strap and shoulder straps – were in use at the time of the accident.

Considering the design of the helicopter, with the pilot's cabin being the part that hit the ground first in this particular accident, the possibility of survival is very small in the case of a vertical or steep descent and impact. Most types of helicopters are designed in a similar way and for natural reasons do not have energy-absorbing deformation zones that could protect those on board. In the case of certain types of emergency landing – such as in a forest – it is recommended that the pilot tries to land with the nose high, which can result in that the helicopter slides backwards with the primary absorption of energy at the tail end of the helicopter, increasing the chances of survival.

In this particular accident it was found that the impact occurred in a very unfavourable manner, where the cabin was subjected to large forces at impact. The primary impact forces were immediately followed by forward directional forces from the engine and rotor. On the basis of the position and depth of impact of the skids, SHK believes that the sink rate at the instant of impact was probably relatively high. The forces that occurred at impact were therefore probably extremely high and the pilot probably died immediately in the accident.

The emergency transmitter was activated at impact and was switched off by staff from the rescue services.

1.15.2 Actions by the rescue services

From an automatic transmitter, ELT[6],that belonged to helicopter SE-JGX there was received at 08:46 an alarm via satellite (Cospas-Sarsat) to the rescue centre ARCC[7], in Gothenburg. No geographical position was given and the location was classified as unknown. The company that owned the helicopter was contacted to provide assistance and check where the helicopter was. Rescue helicopter Lifeguard 992 was given the alarm at 9:09 and took off just under 20 minutes later. Immediately after take off the rescue helicopter received the beacon signal and flew towards the indicated direction. Starting at 09:10 the ARCC received via the satellite system a number of emergency signals with the position also defined for that particular helicopter. ARCC informed the SOS centre at Eskilstuna of the current situation at 09:36.

At 10:12 the rescue helicopter reported that a totally destroyed helicopter had been localised at a clear-cut space in the forest north of Katrineholm. The ARCC sent an alarm to the SOS centre at Eskilstuna and requested that the rescue services and ambulance should be given the alarm, which in turn were

[6] ELT: Emergency Locator Transmitter

[7] ARCC: The Aeronautical Rescue Coordination Centre has the task, among others, of finding and localising missing aircraft.

called out at 10:15 and 10:16 respectively. The police were informed at the same time.

The rescue helicopter landed next to the accident site and reported at 10:19 that there was total destruction and a small fire was still burning. At the site they found the broken wreckage and a human body that among other things showed fire injuries.

The first of the two ambulances that had been called reported 36 minutes after the alarm that they had arrived on site. The rescue services reported 47 minutes after the alarm that they were also on site. In the rescue services report of their actions it was stated that they had difficulty in finding the actual accident site which was 400 m from a road that could carry vehicles. Their attendance was therefore delayed by an estimated 15 minutes and the site was only localised with assistance from the rescue helicopter that took off and showed the way.

The local district rescue services rescue leader took over from the ARCC. The site was cordoned off and secured against the fire spreading. The body that had been found beside the helicopter wreckage was taken by ambulance to the hospital in Katrineholm.

1.16 Tests and research

1.16.1 General

The helicopter wreckage was transported to an aviation workshop for a preliminary examination by a flight technician who was certified on the type. The aim was also to determine the need for detailed analyses. It was immediately obvious that the conditions for a complete investigation were limited since such a large part of the helicopter had been destroyed by the impact and the fire. For the continued investigation it was however decided to remove the engine and power transmission for separate analyses.

The remainder of the helicopter, i.e. the cabin and tail boom, were examined separately with the intention of finding any signs that there was possible fire damage before the impact. The cabin was completely burned out and the examination that could be carried out showed that the fire had begun at the time of impact.

The two jerry cans that were discovered in the wreckage were found to be upside down. Apart from fire damage the jerry cans were relatively complete.

The tail boom was found to be relatively intact after the crash. Apart from its internal components (see Section 1.16.2), the outer surface of the tail boom was also inspected for the possible presence of soot traces following for example jets of flame or similar. Any traces or signs of this would have indicated a fire in the air. The soot on the tail boom was also examined for the presence of impact fragments (earth, dirt, remains of vegetation, etc.) outside the soot.

No such traces could be found on the tail boom or other parts of the tail of the helicopter.

1.16.2 Power transmission

The main rotor gearbox was dismantled in the workshop under SHK supervision. Examination showed that the pinion wheel had moved in towards the centre of the transmission. The reason for this was that the inner bearing housing of the pinion wheel had broken at the shoulder that provided a stop for the outer bearing race.

The pinion wheel with its bearing and race were sent to SKF for analysis. There it was found that the bearing and race showed normal wear.

The broken off shoulder of the bearing housing was sent for further analysis to a laboratory in order to investigate the characteristics of the fracture surfaces. Analysis of the damaged surfaces showed no sign of fatigue, and that the damage had occurred instantaneously, i.e. at one and the same instant.

The drive line, i.e. the drive shafts with flexible plates and support bearings, was examined and found to be intact apart from damage that could be associated with the accident. The examination also included a check for free rotation of all the components involved in the drive line (drive shafts, freewheel, main rotor and tail rotor gears).

The examination resulted in the freewheel being sent for analysis to the manufacturer, Robinson Helicopter Company, USA. This part of the investigation was supervised on behalf of SHK by the American aviation authority, FAA. The examination by the manufacturer showed that the freewheel - apart from some chafing – functioned without problems.

Except for a small fragment, it was found that the drive belts from the clutch had burned away during the accident. Apart from burning damage at both ends the belts showed no sign of breaks or abnormal wear.

1.16.3 Engine

The engine was sent to an authorised workshop for examination under SHK supervision. The engine was dismantled and its parts examined to see if there was possible damage or faults that had not been caused by the accident. The extreme heat in connection with the fire meant however that certain components had melted and/or burned, which hindered the examination. It was therefore not possible to examine the magnetos and carburetor to the desired extent.

Despite the fact that the carburetor was almost completely burned away, it could be seen that the valve directing warm air to the carburetor had been in its open position and therefore agreed with the control position at the pilot’s position.

The cylinders, pistons, valve mechanism, crankshaft, piston rods, camshaft with valve pushrods and auxiliary drives were all examined. Apart from damage caused by the fire, all the components were in working condition without any signs of damage or incorrect operation.

The spark plugs were sent to a laboratory for analysis in respect of combustion products. The examination revealed however no signs of abnormality on the spark plugs in respect of fuel quality.

1.16.4 Rotors

After dismantling, the helicopter's two-blade main rotor was found to have separated into several parts. One of the blades still retained its full length, but had suffered structural damage. The blade was severely deformed and upwardly coned, i.e. showed clear signs of having been bent upwards. The other blade had broken into several pieces and showed the same signs of upward coning as the other blade. Neither of the blades showed signs of rotation damage, i.e. the damage caused when a blade strikes the ground – or an object – during the normal rotation speed for the main rotor of a helicopter.

The tail section had broken off and separated from the tail boom. The tail rotor drive shaft was flattened at about 70 cm before the rear drive flange. Both blades from the tail rotor were found and had not separated from the hub. One of the tail rotor blades was more or less undamaged, but the other showed some damage. Neither of the blades showed signs of rotation damage.

1.16.5 Engine testing

By means of practical tests SHK has examined the operation of the engine of a helicopter of the same type. During the test the engine was run with varying power outputs, with the priming pump in different positions, from closed to fully open. No serious engine disturbances were noted, only small changes in power of a marginal character.

1.16.6 Examination of the warning lamps

The warning lamps that were found in the part of the instrument panel that was found away from the wreckage were taken out and examined by SHK. The examinations were performed using a light microscope where certain results can be considered probable. It cannot however be claimed that the results were clear or definitive, since the units were subjected to forces and proximity to a long term fire.

Listed below are the lamps which could be examined. In general it can be said that there is a strong possibility that those lamps with filaments found to be intact were not lit when the accident occurred.

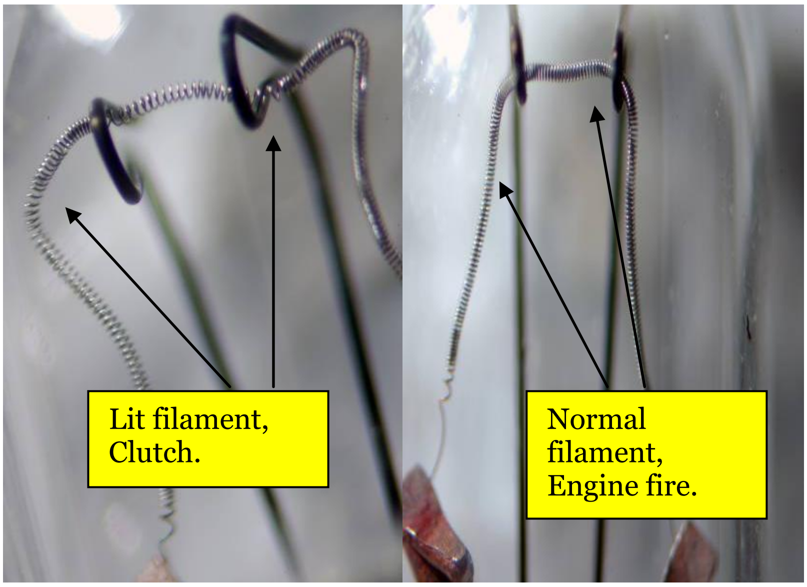

Fig.8. Examination of the warning lamps.

• Engine fire warning	Probably not lit
• Clutch (rotor freewheel)	Probably lit
• Low oil pressure warning	Probably lit
• MR temp (main rotor temperature warning)	Uncertain
• MR brake (main rotor brake)	Uncertain
• Low RPM (low speed warning)	Uncertain
• Alt (alternator warning)	Uncertain

1.16.7 Carburetor icing

Aircraft equipped with piston engines may in certain circumstances suffer from a build-up of ice in the carburetor with varying degrees of engine disturbance as a result. This phenomenon is most common at low temperatures, but can also occur at high temperatures in association with high air humidity.

When external air is drawn into the carburetor the pressure falls and so does the temperature. In certain circumstances the air humidity can then exceed 100%, whereupon water condenses. This forms ice in the carburetor and thereby reduces the flow of fuel. If the risk of ice in the carburetor is present – or if engine disturbance occurs due to this phenomenon – it can be forestalled by hot air from the engine being drawn off and fed into the carburetor.

Heating of the carburetor for a piston engine installed in a helicopter has its limits in that it cannot be made so effective that the engine power is reduced too much. The heating consists of the heated air from the exhaust pipe or its equivalent being fed to the carburetor. The heated air reduces the available engine power, as air with a lower density is entering the combustion chambers in the engine. The valve is controlled by the pilot by a control at the pilot's position. In the helicopter wreckage this control was found to be pulled out, implying that hot air was fed into the carburetor.

On an R 44 with activated governor system ice build-up is not immediately obvious, since the system automatically compensates for a reduction in speed – which is the result of icing in the carburetor – by opening the throttle towards maximum as the ice thickness increases. Unless one keeps a hand on the collective pitch control, or watches to see if the CAT does not go into the yellow zone, ice build-up can take place without being noticed by the pilot.

The diagram at Figure 9 shows the meteorological conditions for carburetor icing to build up on that particular day. The conditions at the time, with a temperature of +5°C, and a dewpoint of +3°C, show that there was a risk of severe icing at all power settings during the flight. The intensity and character of icing can vary depending on variations in the surrounding air. Small local changes in temperature and/or dewpoint can mean that the conditions for ice build-up quickly changes.

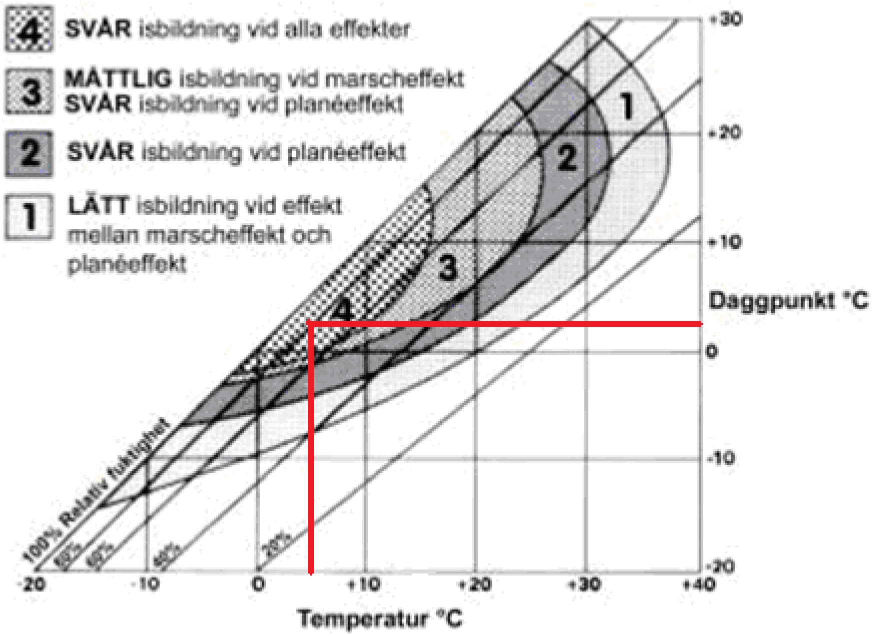

Fig. 9. Diagram showing the risk of carburetor icing. The prevailing conditions, according to the diagram, indicates that there was risk for severe icing at all power settings.

1.16.8 Bird strike

SHK has evaluated the possibilities that a bird strike could have occurred. Those bird strikes that are reported show a clear seasonal pattern, with most occurring during the spring and autumn. The autumn migration is mainly taking place in August and September, although a large number of birds also leave the country during October. Most bird strikes occur in the morning hours when there is most bird activity.

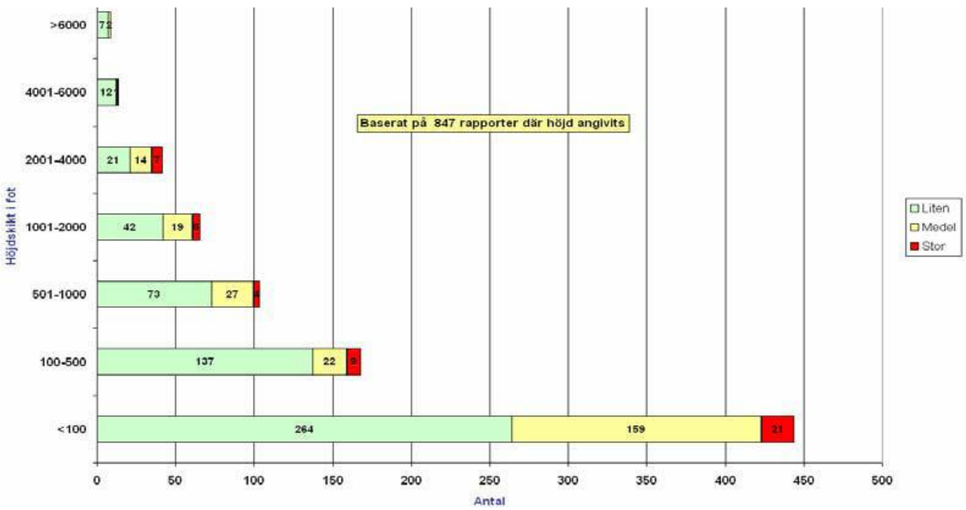

Fig.10. Bird strikes from 1998 – 2005 affecting all types of aircraft, as reported to the Swedish Civil Aviation Authority. Number of strikes per altitude band and bird size. (Graphic source: Swedish Civil Aviation Authority)

Most bird strikes take place at altitudes of below 500 feet. As a rule, most migrating birds fly at altitudes lower than 3000 feet. Birds have no special organs to be able to fly for example in clouds, they must have visual references to maintain flight and orientation. It can as a rule be said that birds fly below clouds, and preferably in daylight.

Most bird strikes of a serious character with helicopters occur when large birds strike the front windscreen or the front part of a bubble canopy. Collisions with the bird striking the main rotor are both less common – birds have a tendency to dive in the face of a collision – and also less serious, since severe rotor damage due to a bird strike is unusual.

Bird strikes on helicopters are however not to be regarded as usual occurrences. It can be read in the Swedish Civil Aviation Authority report, The Helicopter Flight Safety Project, that in a given period with 227 reported incidents of various types, only six concerned bird strikes. It can however be noted that helicopters have a higher risk factor in respect of bird strikes due to the fact that their operation takes place at altitudes where there is a greater risk of bird strikes.

1.17 Organisational and management information

1.17.1 The business

The aircraft operating company is based in Stockholm and operates commercial flights with light helicopters, with authorisation to fly helicopters as a business for profit. The pilot was contractually associated with the company through an agreement.

1.18 Other aspects

1.18.1 Equal opportunities aspects

This event has also been examined from the point of view of equal opportunities, i.e. against the background that there are circumstances to indicate that the actual event or its effects were caused by or influenced by the women and men concerned not having the same possibilities, rights or obligations in various respects. Such circumstances were however not found.

1.18.2 Environmental aspects

The accident did not have any serious consequences from the environmental viewpoint.

1.18.3 Witness statements

A person who was walking her dog in the area at the time of the accident has stated that she saw a helicopter that she thought was flying round in a circle and that after a while disappeared from her view. The witness heard the engine sound as “loud”.

1.18.4 Radar images from the Swedish Armed Forces (FM - Försvarsmakten)

According to radar images that were obtained from FM, these showed that the flight path was south-westerly at an altitude height of between 240 and 270 metres (790-890 ft). The last recorded altitude was 180 metres (590 feet).

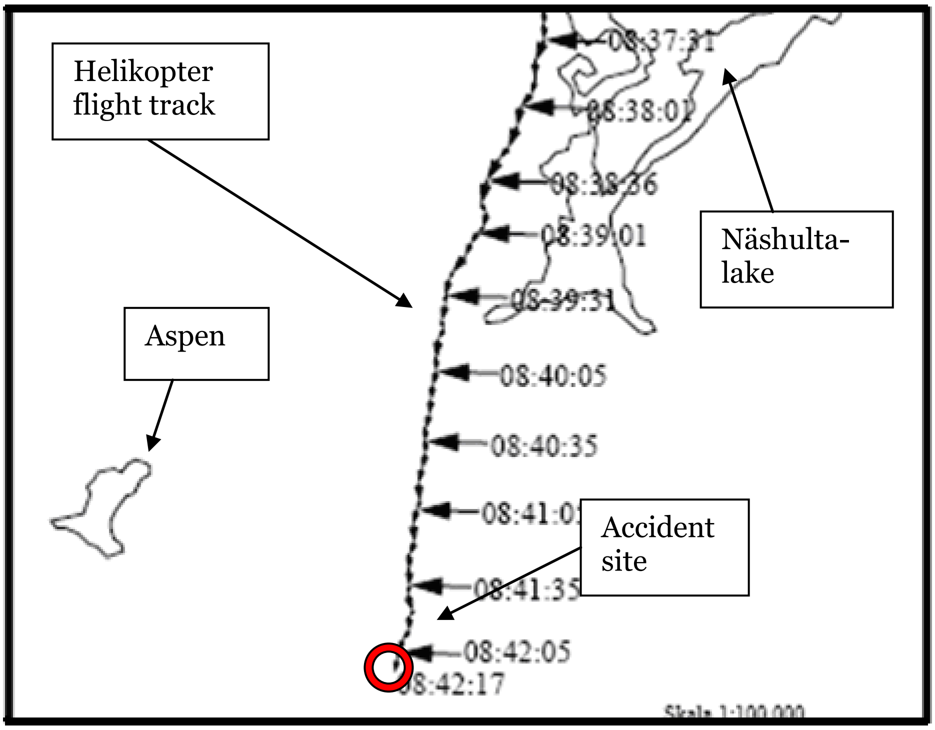

Fig.11. Part of the radar plot from FM.

The illustration at Figure 11 does not contain every return, for presentation purposes. The sampling time[8] for that particular radar station is six seconds. The graphic shown above can therefore be supplemented by the penultimate recording of a return at 08:42:11, when the helicopter still maintained its altitude at 240 metres (790 feet). At the instant of the final recorded return at 08:42:17.95 – rounded off to 08:42:18 – the helicopter had descended to 180 metres (590 feet).

According to the radar returns the flight had mostly followed the planned route until just after 08:42 when the helicopter suddenly departed from its former altitude and started a descent. With the available radar data the rate of descent can be calculated as about 1650 ft/minute, given that the descent began at 08:42:11. If the descent began later, the calculated descent rate increases in proportion. The course change that the helicopter made to enter the cleared area where the accident took place is not recorded on the radar images since at that altitude it had gone below the particular radar coverage in the area.

1.18.5 *GPS*

The helicopter was equipped with a permanently installed GPS of Garmin type. This type of GPS also has a memory unit, in which certain data from the most recently performed flights is stored. The unit was found in the wreckage in damaged and burnt condition.

[8] Sampling time: The time interval between radar sweeps.

Fig.12. The helicopter's GPS. Photo: BEA

SHK sent the GPS to the British Aircraft Accident Investigation Branch, the AAIB, for examination. After a preliminary examination the unit was however forwarded to the French accident investigation authority, the BEA, for further examination, since the internal components and memory circuits were also fire damaged.

With the aid of special methods it was however possible to extract data from the memory unit for analysis. The data from the accident flight showed close agreement with the radar data that had been recorded. The GPS unit has its greatest accuracy in lateral navigation. The altitude readings from the unit do not have the same accuracy and have therefore in this report not been used for any purpose other than comparative studies.

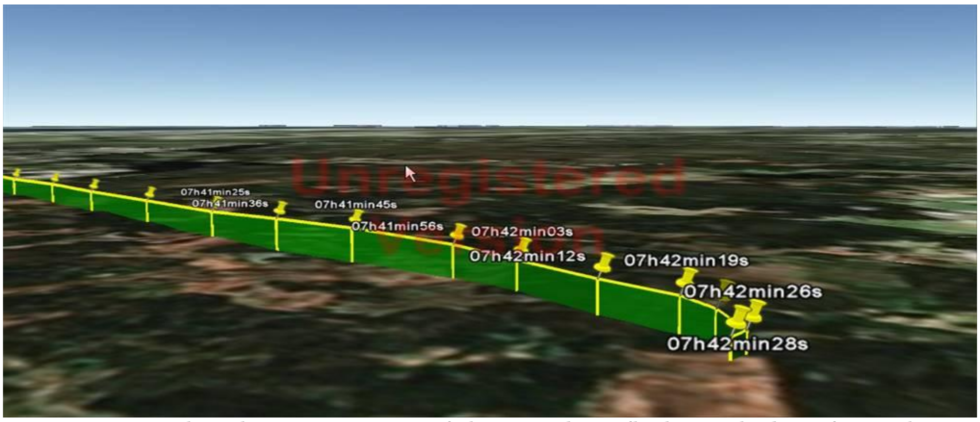

Fig. 13. Graphical presentation of the accident flight with data from the GPS.

Analysis of the data from the accident flight showed that take off took place at 08:17 (GPS time) and began according to plan until 08:42 when the helicopter started to descend. The helicopter began a mild course change to the right for less than 10 seconds and then started to turn right more definitely. The last data that was recorded from the GPS was at 08:42:28. The time from when the descent began until the power to the GPS was cut off by the accident was 16 seconds.

Note
The times given by the GPS cannot be confirmed as exact and in the investigation have only been used in Δt format, i.e. measurements between intervals.

1.18.6 Helicopter accidents - general

In 2007 the Swedish Civil Aviation Authority published a study called “The Helicopter Flight Safety Project”. The reason for this study was that a negative trend had been observed in Sweden in respect of accidents and other events within both commercial and private helicopter operations, see Figure 14 below. The study was based on events that had been reported and/or investigated during the previous 10 years.

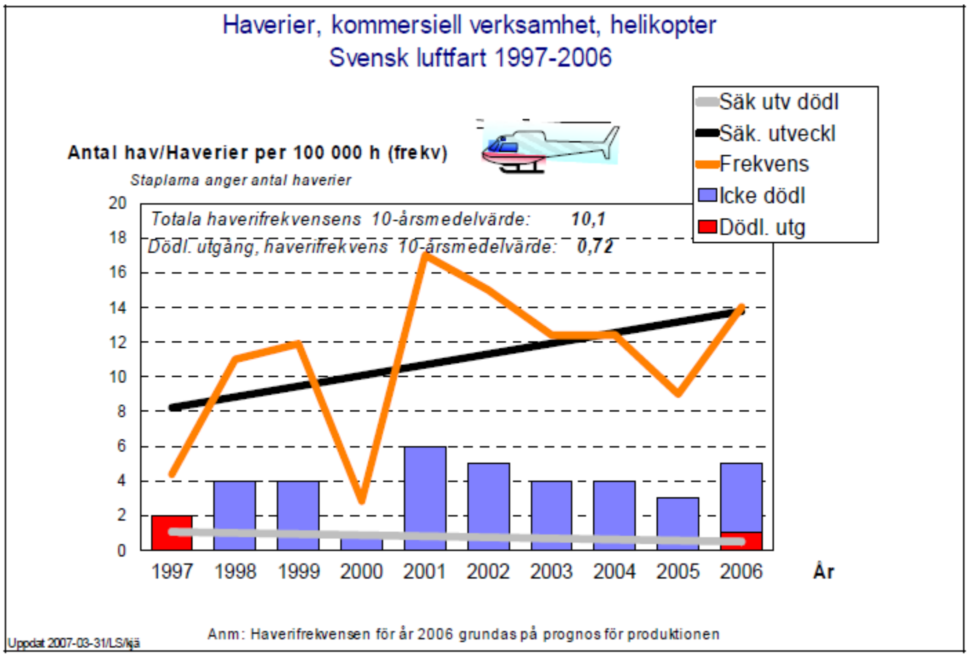

Fig. 14. Helicopter accidents in Sweden within commercial operations, 1997-2006. (Graphic:Lfs)

In a comparison with commercial aviation for aircraft of less than 5,700 kg, it was found that the accident frequency for helicopters was considerably higher; per 10-year average value the total number of helicopter accidents was 10.1 per 100,000 flying hours, while the equivalent figure for aircraft was 3.6.
The survey also showed which types of causes had been most frequent in connection with helicopter accidents during a 15 year period in the Nordic countries. The table below shows the percentage of causal factors.

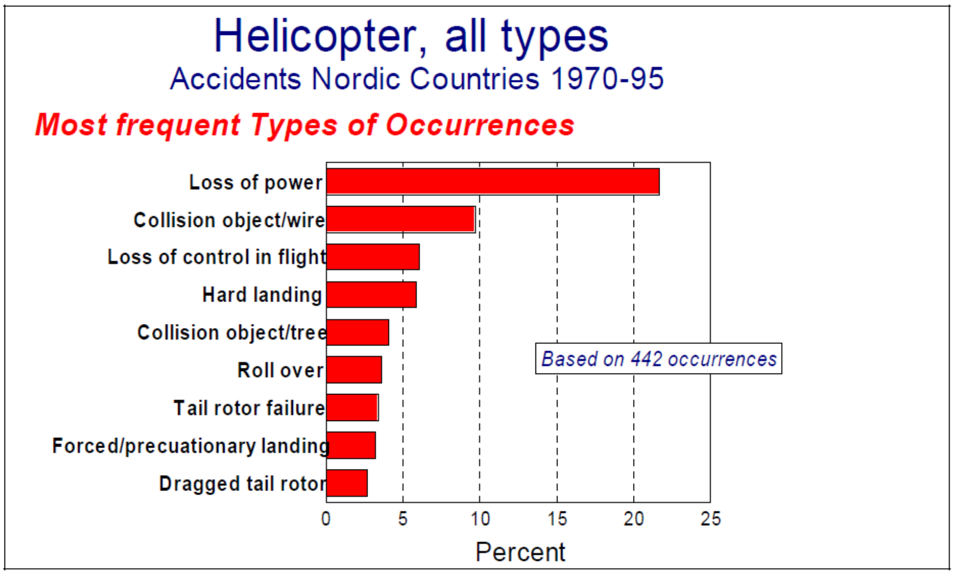

Fig.15. Nordic accident analysis based on types of event (Graphic Lfs)

The results clearly show that the dominant causes of accident occurrence were some kind of loss of power, and collisions of various types. The analysis was based on a relatively large number of accidents and could therefore be considered as providing a relevant factual basis for cause analysis. The report also mentions that the number of engine-related accidents would probably reduce in future, as the number of helicopters powered by turbines increases. The accident helicopter had a piston engine.

The report from the Swedish Civil Aviation Authority dealt with a number of other safety-related areas in helicopter operations, including disturbance reporting and questionnaires of both operational and business character. The report concluded with a comprehensive proposal for measures with the aim of raising the level of flight safety for Swedish helicopter flying.

1.18.7 Fuel on board aircraft

The jerry cans that were found in the wreckage were, according to information from the company, filled with fuel. The reason why they were being carried in the helicopter was that the location of the lifting task did not offer access to fuel. According to the regulations in LFS 2007:49, §§ 22 – 27, it is permitted, under certain conditions, to carry fuel as freight aboard aircraft on flights within Sweden. As far as SHK could ascertain these rules were complied with.

2 ANALYSIS

2.1 The flight

2.1.1 General

The accident to SE-JGX occurred in an uninhabited forest area. There were no survivors or witnesses to the accident itself. The few radio messages sent from the helicopter did not indicate any problems or conditions that could throw any light on the sequence of events. Hindering factors were also that the conditions for the investigation were severely limited due to the status of the wreckage, with an almost completely disintegrated aircraft that had been subjected to fire for a long time.

The analysis by the SHK resulting in this report is based on the limited facts that could be obtained from radar images, the aircraft's electronic units on board, together with the examination of the wreckage and accessible components. The investigation cannot therefore claim, to definitively describe the exact events of the accident and/or the reasons for it, but presents what SHK believes to be the most probable sequence of events and the reasons that led to the accident.

2.1.2 Conditions pertaining to the flight

The flight on this particular day was a routine flight to ferry the helicopter to a location where lifting would commence. There was nothing in the preparations for the flight to indicate that there were any residual or expected problems. The technical status of the helicopter was unblemished and it has not been possible to find any other events that could have had any effect on the continued sequence of events.

The general status of the pilot is not assessed to have been diminished. According to information received he had a good night's rest and had not been required to wake abnormally early. He was a very experienced helicopter pilot and can also be deemed to have been in good flying practice.

The weather conditions probably did not cause any difficulties. The wind speeds were low, there was good visibility and a cloud base at a minimum of 1200 feet, which can be considered good conditions for the VFR flight that was planned. The flight took place without the submission of a flight plan, meaning that tracking by air traffic control was not available. In this particular case signals from the helicopter's emergency transmitter were received after the crash, which resulted in activation of search and rescue units. SHK considers that submission of a flight plan to ATC should be routine, in the case of point-to-point flights, particularly those of a commercial nature. The fact that no flight plan was submitted to ATC did not however affect the rescue efforts since the emergency transmitter activated in this case, but it should encourage the company concerned to review their procedures in respect of ATC flight plans.

2.1.3 The first phase of the flight

From take off and the first part of the flight no information was available. The communication that took place was of a normal nature and did not indicate that anything was amiss.

According to the radar data the continued flight followed the planned route, with few deviations. The height varied somewhat but followed a pattern that could be seen as quite normal for VFR flight in a helicopter without an autopilot in the present weather conditions.

For the first 25 minutes of the flight everything indicated that flying progressed normally in accordance with planning and without any disturbances. The penultimate radar return that was recorded at 08:42:11, showed the helicopter at a normal altitude and on course. Six seconds later, at 08:42:17, the altitude had reduced to about 180 metres (590 feet) which was also the last radar indication that was recorded.

Using this data the average rate of descent during that interval can be estimated as being about 1650 feet per minute. This indicates that this was not a normal altitude variation in accordance with the earlier pattern of the flight, rather an indication that the pilot had quickly commenced a descent. Analysis of the subsequent events was made without the support of radar data, but with the assistance of other information a probable sequence of events could be reconstructed.

2.1.4 *Problems*

As mentioned above it is probable that something caused this rapid reduction in altitude. It is conceivable that the change was initiated by the pilot since its commencement appears to have been controlled, with the course maintained followed by a right turn into an open area. The disturbance – that caused the pilot to begin this manoeuvre – could have had several causes:

- Engine disturbance
- Power transmission or rotor problems
- Bird strike
- Fire on board
- Carburetor icing
- Medical reasons
- Other causes

The probabilities of the causes are covered in a later section. The most likely theory in the opinion of SHK is that the pilot for some unknown reason entered autorotation of the helicopter. The pilot had practised autorotation in connection with the PC that had been carried out with an inspector. He had not however done this on the particular type of helicopter. The Robinson R 44 is a small helicopter with a relatively light main rotor. Autorotation means that one utilises the stored kinetic energy of a rotor that is still turning, so that at the landing stage by means of resetting the blades this energy can be converted into a lifting force to provide a controlled landing. On helicopter types with light rotors it is therefore important to rapidly control the blade angle to be able to retain a high rotor speed up to the point of touchdown.

Quickly arising faults in the engine or power transmission – on a Robinson R 44 this may be the drive line to the main rotor – necessitate an emergency landing with the aid of autorotation. The known part of the sequence of events, with a loss of altitude and a turn towards an accessible open area, strongly indicate that the pilot initiated autorotation of the helicopter at 08:42:11 (or immediately thereafter).

2.1.5 *The accident*

The route of the flight passed by the left side of the cleared area where the accident occurred. The cleared area was the only open space in a relatively large surrounding forested area. Since the pilot was sitting on the right side of the helicopter it is probable that he noted this area passing by. After the assumed disturbance, a gradual change of course to the right could be identified, according to the GPS data. The recorded right turn first took place about 10 seconds later, at an altitude of 180 metres (590 feet).

The direction of the main wreckage found in the cleared area indicated an impact facing about 300°. This indicates that the pilot made at least one right turn to enter the open area represented by the clear-cut area. A witness at this point saw the helicopter just before it disappeared from view and claimed that it made a number of turns.

Considering the calculated descent rate and the appearance of the wreckage – that indicates a high sink rate on impact – SHK believes that it is most probable that the helicopter only made one turn of about 110° in towards the cleared area. Using a conservative calculation of a continued rate of descent of 1650 feet/minute from the last recorded height, this gives a time of 21 seconds to impact. This is not enough time to make more than one turn to arrive at the final course that led to the point of impact.

It is probable that the pilot consciously began a turn in towards the intended emergency landing location while performing autorotation. If an autorotation for some reason is not performed correctly, i.e. energy from the spinning rotor is taken too soon, it can lead to an early reduction of rotor speed and less likelihood of a survivable emergency landing. If the rotor speed is too low, the centrifugal force will be too low and the rotor blades than bend upwards with an increasing descent rate.

2.2 Technical investigations

2.2.1 Examination of the engine

As stated earlier the ability to perform a complete examination of the engine and its associated systems was limited a great deal due to the character of the accident. The examinations that could however be performed in respect of the basic engine condition did not reveal any identifiable fault or incorrect operation. According to the analysis of the fuel remains on the spark plugs that was carried out there were no signs of problems with the fuel.

SHK can say however that there were certain facts in the examination that indicated that the engine had stopped – or had been stopped- during the final part of the flight.

The magneto selection key was broken in its "OFF" position.
It is entirely possible – and not unusual – for the positions of controls to change due to the considerable forces exerted during an impact. It is however less likely that the magneto key would due to these influences both be turned to "OFF" and then broken off. The best indication is that the pilot turned the key to "OFF" and that the key subsequently broke due to impact forces. It is entirely possible that a sudden engine disturbance could have made the pilot change magnetos and in connection with this inadvertently set the selector to its OFF position.

Another possibility is that the pilot, in the case of a disturbance – possibly in connection with strange noises and/or vibration – decided with the aid of the magneto system to shut off the engine and therefore deliberately turned the key to OFF.

<u>*The oil pressure warning lamp was probably lit*</u>
The lamp that indicates low oil pressure was probably lit. Theoretically this could be due to some leakage or pipe break, but most probable is that the pressure fell due to the engine stopping. Both the oil pressure warning lamp and the position of the magneto key bear witness however to the engine probably not delivering power during autorotation and landing. Even though the engine examination was not able to prove damage or faulty functions in the engine, SHK believes it is clear that some kind of disturbance occurred that affected the helicopter's engine. The probability of such an event occurring is also supported by the helicopter accident statistics, where the most common accident cause is loss of power of some type.

2.2.2 Examination of the power transmission

The main transmission was relatively free from external damage, but analysis of the pinion shaft showed that the damage it had suffered had probably been caused by the impact forces. The breakage was most probably caused by the forces that arose when the entire drive package pressed against the pinion shaft at impact.

Most of the drive belts were destroyed by the fire. The small amount that remained showed however no signs of abnormal wear, so there is no reason to suspect that a fault occurred in this part of the power transmission. On examination of the other parts of the drive line no other damage or faults were found that could have affected the sequence of events.

2.2.3 Examination of the rotors

Both the main and tail rotors showed clearly identifiable traces of slow rotation at impact. Neither of the blades showed signs of rotation damage. The damage that had occurred was breaks, probably caused by the impact forces.

The main rotor bending damage with upwards coning is a clear sign of the forces that arise when there is slow or no rotation.

Fig.16. Parts of the main rotor at the accident site.

The damage to the tail rotor also indicates that it was hardly rotating on impact. The overall damage picture shows, according to SHK, that on impact the helicopter rotors were at a low rotation speed, but that they were probably fully functional.

2.3 Bird strike

The risk of a bird strike is greater for helicopters than aircraft, due to their generally lower operating altitudes. At the time of the accident autumn migration of birds was still to some extent in progress, therefore a bird strike cannot be entirely excluded.

No damage or other signs of a bird strike could be seen on the rotors. If a large bird had collided with the glass canopy of the helicopter during cruise flight it is probable that this would have resulted in widespread damage. Such an event would probably have left certain traces – feathers, skeletal remains, blood, etc. – that despite the fire would to some extent have been detectable in the wreckage or nearby.

No such signs or traces were however found, so SHK therefore considers it unlikely that a bird strike occurred during flight.

2.4 Fire on board

No trace of any fire starting on board before the impact could be found. The engine fire warning lamp was probably unlit at impact. The intact parts of the aircraft fuselage that could be examined, such as the tail boom, showed no sign that the fire damage that was present was caused by anything other than the fire after impact.

The jerry cans that were found had been emptied of their contents. In the case of a fire that started in connection with impact it is probable that the contents of the helicopter's normal fuel tanks would be enough for a powerful development of the fire. In their upside down state the seals on the jerry cans probably melted so that the fuel inside could leak out and further reinforce the fire. The object that forced its way through one of the cans is not considered to have had much effect on the course of the fire.

Altogether there are no signs that fire could have broken out in any part of the helicopter before impact.

2.5 Carburetor icing

2.5.1 General

The general meteorological conditions on that particular day could be regarded as good for flight operations. However the relationship between temperature and dewpoint were such that there was a risk of severe carburetor icing at all power settings.

The probability that ice could build up in the carburetor cannot be specified in exact figures or terms. If carburetor icing arises it is the result of several variables, air humidity and temperature, current power setting and the design of the carburetor. It should also be mentioned that just a few degrees change in temperature of the surrounding air can quickly change the conditions for carburetor icing.

2.5.2 Conditions during the flight

At the time of the accident flight all the meteorological conditions favoured the build-up of carburetor icing. Since the weather for flying was otherwise good without precipitation, it is possible that the pilot saw no reason to use carburetor heating for the first part of the flight. In a situation where the pilot is for example studying a map or busy doing something else, there is a risk that he will not observe the commencement of ice build-up in the carburetor.

On the R 44, with an activated governor function, the system compensates automatically for an increasing amount of carburetor icing by gradually opening the throttle valve to maintain speed. If the pilot is not holding the collective it is only the scale on the CAT instrument that acts as a warning of the start of ice build-up.

According to the warnings issued by the manufacturer the governor system can mask carburetor icing, with a resultant engine stoppage. If the engine stopped during flight this could have surprised the pilot. In such a case it is however probable that in connection with the disturbance he saw the CAT and then pulled out the heating control. From a height of about 790 feet this does not however permit enough time for the ice to melt.

SHK cannot rule out the possibility that carburetor icing caused the engine to misfire or stop during this particular flight.

2.6 Probable cause of disturbance

The overall analysis of the initial events leading to the accident indicates that there was a disturbance in the engine. The lack of signs of technical defects or malfunctioning of the engine, power transmission and rotors indicates that other circumstances rather than purely technical defects probably caused the engine to misfire or stop.

2.7 Medical status

2.7.1 Status at the time of the accident

Nothing in the post mortem showed signs of any illness in the pilot that could have directly affected the accident. No trace of any medicines or drugs were found. The low level of carboxyhaemoglobin in the blood indicates that the pilot had not been exposed to carbon monoxide and/or fire gases.

2.7.2 Medical Investigations

As far as the pilot’s medical status was concerned, SHK has found that the pilot had hypertension on several occasions, most recently during the year of the accident. On two of those occasions the values were very high, indicating that the pilot had a blood pressure condition that was untreated at the time of the accident.

SHK has not been able to determine why the visits to the doctor's clinic, where hypertension was verified and treatment introduced, are not found in patient records from the aviation medical examinations.

It has not been possible to clarify whether the pilot was aware that his high blood pressure might make him unable to safely exercise his powers in accordance with his license and that he, when medication was initiated, should have without delay consulted Swedish Transport Agency, Civil Aviation Authority medicine unit or an aviation medical examiner.

2.7.3 Increased medical risks

In the case of untreated hypertension there is an increased risk of heart disease or a stroke and the blood pressure, in association with, for example, stress, can rise to critically high levels and provoke severe headaches, dizziness and fatigue, but also visual problems, nausea, confusion and even unconsciousness.

SHK has not been able to establish the precise sequence of events during the final stage of the flight, which means that it cannot be excluded that the pilot found himself in a pressed situation with increased psychic stress and the risk of increased blood pressure.

2.8 The probable accident sequence

2.8.1 The beginning

After an engine stoppage – that probably occurred at about 790 feet height above ground level – the first thing to do according to the checklist on board was to initiate autorotation. This meant immediately lowering the collective to maintain rotor speed. Next according to the list is to determine a place to land, and to push the mixture control in, to obtain a full rich mixture.

There is nothing to indicate that these measures were not taken in accordance with the list. According to the GPS data the helicopter then turned in towards the cleared area while losing height. What the pilot did after this is unknown, but if the carburetor heating had not been applied before this, it is probable that the pilot pulled its control all the way out. The emergency checklist has no items regarding switching magnetos, but this is a natural action by an experienced pilot in the case of a misfiring engine. At this stage – while probably under great stress – the pilot could have inadvertently placed the magneto key in the OFF position instead of to the left magneto.

The reason why the switch for the clutch (manual release of the rotor shaft) was recovered in position "Disengage" and the clutch was probably activated has no obvious explanation. The freewheel would disconnect automatically if the engine speed was less than the rotor speed. The operation of the freewheel was tested and found to work properly. However the freewheel did show some chafing. It is not unlikely that this – despite the unit working properly – caused some kind of unusual noise from the coupling that caused the pilot to believe that it was not working properly and he therefore performed a manual release via the clutch control. This action however did not alter the function of the rotor compared to a normally released rotor.

2.8.2 The autorotation

At 08:42:11, or immediately thereafter, autorotation of the helicopter was probably initiated. The calculated descent rate of 1650 ft/min – compared with the tested rate of 1450 ft/min in stable autorotation in the same conditions – is not unrealistic considering that it takes some time to stabilise a helicopter during this manoeuvre. However the manoeuvre could not be completed in the intended manner but led to a collision with the ground. After analysis of the position of the wreckage and the damage to the rotor it is very probable that the final phase of the flight took place without any power from the engine and at a very low rotor speed.

There are several reasons why an autorotation is unsuccessful. If the collective is not lowered quickly enough the normal rotation speed of the rotor cannot be maintained. From the relatively low altitude of 790 feet there is in such a case little chance or regaining rotor speed, instead the descent rate will increase and the ability to control the helicopter reduces.

What counts against the pilot having failed to maintain rotor speed is his experience. With over 13,000 flying hours and experience of flying a number of different helicopter types, it is not reasonable to think that he would have completely failed to execute an autorotation.

What however might have contributed to the negatively affecting factors is the actual altitude in relation to the distance to the landing surface, i.e. the cleared area. Taking into account that the helicopter after the engine stoppage more or less continued on track during the initial height loss, it is possible that the pilot began the right turn too late to reach the cleared area with the necessary height margin. The wreckage was found only 50 metres into the clearing, with a relatively high line of trees just behind. It is entirely possible that the pilot, during the final part of the approach realised that the margin to the trees before the clearing was insufficient and therefore used part of the kinetic energy from the rotor to lift the helicopter over the edge of the forest.

In such a case the rotor speed would have reduced dramatically and the helicopter would have gone into a steep dive with an increasing descent rate. Nor would the pilot have been able to obtain any help from the wind, since the approach was made with an almost direct crosswind.

2.8.3 *Autorotation in combination with medical effects.*

The medical records from visits to clinics showed that the pilot suffered from very high blood pressure. The aviation doctor’s examinations that were carried out during the same time period did not however show equivalent results. The doctor who had issued the pilot’s medical certificate had – although for other reasons – his aviation medicine certificate withdrawn. During its investigation into this accident, SHK did not examine more closely the presence of irregularities in connection with the pilot’s medical checks.

It did however come to light that at the time of the accident the pilot probably suffered from untreated hypertension. The post mortem did not reveal any intake of medicine that would lower his blood pressure. As mentioned earlier in the analysis, this condition can lead to serious medical consequences. In situations with a high level of stress blood pressure can rise further and thereby increase the risk of such consequences as headache, blurred vision, confusion and even unconsciousness.

The known medical facts mean that SHK cannot exclude the possibility that the pilot suffered some kind of reaction in connection with the accident sequence. The highly stressful situation that results from engine stoppage in a helicopter at low altitude could have meant that a correctly entered autorotation could not be completed because the pilot became medically incapacitated at some stage.

The final phase of the flight – which ended in a steep impact angle – can be explained by the pilot no longer having the capacity to control the helicopter during the approach and landing.

2.8.4 Summary

The available facts have not been shown to be sufficient to provide a certain analysis of the sequence of events or their causes. On the basis of such evidence as exists, SHK believes the following sequence of events is the most probable.

During the flight the pilot could have been taken unawares by an engine stoppage, probably caused by ice build-up in the carburetor. The pilot initiated autorotation and turned towards the place he had chosen for an emergency landing. However the autorotation could not be completed – perhaps with medical effects as a contributory factor – and the helicopter struck the ground at a steep angle.

3 CONCLUSIONS

3.1 Findings

a) The pilot was qualified to perform the flight.
b) The helicopter had a valid Certificate of Airworthiness.
c) The pilot was found to suffer from high blood pressure during examinations at clinics.
d) An aviation doctor's examination had been performed, with approved results.
e) The current aviation doctor's authorization was revoked in 2006.
f) There was a high risk of carburetor icing.
g) The governor system permitted carburetor icing to develop without being noticed by the pilot.
h) The manufacturer had warned of the risk of *g)* above.
i) The helicopter impacted at a steep angle.
j) Fire broke out in connection with the impact.
k) The rotor speed was very low on impact.
l) No technical faults were found on the helicopter.
m) The magneto selection key was broken in its "OFF" position.
n) The oil pressure warning lamp was probably lit.
o) The clutch was probably manually disconnected.
p) The *carb heat assist* system to the carburetor was activated
q) The radar data showed that the helicopter commenced a rapid descent.
r) The GPS data showed that the helicopter began to turn right soon after the start of the descent.
s) Two jerry cans were found in the wreckage.
t) No ATC flight plan had been submitted for the flight.

3.2 Causes of the accident

In the investigation of this accident SHK has not been able to determine sufficient facts to make a certain analysis of the sequence of events or the causes of the accident.

4 RECOMMENDATIONS

None.

ROBINSON
HELICOPTER COMPANY

Safety Notice SN-25

Issued: Dec 86 Rev: Nov 99

CARBURETOR ICE

Carburetor ice can cause engine stoppage and is most likely to occur when there is high humidity or visible moisture and air temperature is below 70°F (21°C). When these conditions exist, the following precautions must be taken:

During Takeoff - Unlike airplanes, which take off at wide open throttle, helicopters take off using only power as required, making them vulnerable to carb ice, especially when engine and induction system are still cold. Use full carb heat (it is filtered) during engine warm-up to preheat induction system and then apply carb heat as required during hover and takeoff to keep CAT gage out of yellow arc.

During Climb or Cruise - Apply carb heat as required to keep CAT gage out of yellow arc.

During Descent or Autorotation -

R22 - Below 18 inches manifold pressure, ignore CAT gage and apply full carb heat.

R44 - Apply carb heat as required to keep CAT gage out of yellow arc and full carb heat when there is visible moisture.

ROBINSON
HELICOPTER COMPANY

Safety Notice SN-31

Issued: Dec 96

GOVERNOR CAN MASK CARB ICE

With throttle governor on, carb ice will not become apparent as a loss of either RPM or manifold pressure. The governor will automatically adjust throttle to maintain constant RPM which will also result in constant manifold pressure. When in doubt, apply carb heat as required to keep CAT out of yellow arc during hover, climb, or cruise, and apply full carb heat when manifold pressure is below 18 inches.

Also remember, if carb heat assist is used it will reduce carb heat when you lift off to a hover and the control may require readjustment in flight.