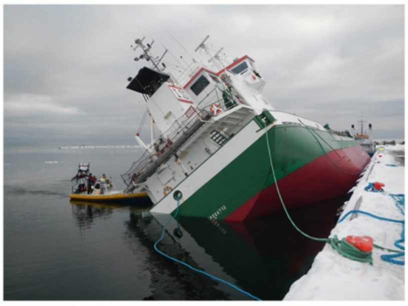
Statens haverikommission
Swedish Accident Investigation Authority



Final report RL 2017:07e

Accident at Åre Östersund Airport, Jämtland county on 13 June 2016 involving the helicopter SE-JVP of type AS 350, operated by a private person.

File no. L-59/16

13 June 2017

SHK investigates accidents and incidents from a safety perspective. Its investigations are aimed at preventing a similar event from occurring in the future, or limiting the effects of such an event. The investigations do not deal with issues of guilt, blame or liability for damages.

The report is also available on SHK´s web site: www.havkom.se

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General observations

The Swedish Accident Investigation Authority (Statens haverikommission – SHK) is a state authority with the task of investigating accidents and incidents with the aim of improving safety. SHK accident investigations are intended to clarify, as far as possible, the sequence of events and their causes, as well as damages and other consequences. The results of an investigation shall provide the basis for decisions aiming at preventing a similar event from occurring in the future, or limiting the effects of such an event. The investigation shall also provide a basis for assessment of the performance of rescue services and, when appropriate, for improvements to these rescue services.

SHK accident investigations thus aim at answering three questions: *What happened? Why did it happen? How can a similar event be avoided in the future?*

SHK does not have any supervisory role and its investigations do not deal with issues of guilt, blame or liability for damages. Therefore, accidents and incidents are neither investigated nor described in the report from any such perspective. These issues are, when appropriate, dealt with by judicial authorities or e.g. by insurance companies.

The task of SHK also does not include investigating how persons affected by an accident or incident have been cared for by hospital services, once an emergency operation has been concluded. Measures in support of such individuals by the social services, for example in the form of post crisis management, also are not the subject of the investigation.

Investigations of aviation incidents are governed mainly by Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation and by the Accident Investigation Act (1990:712). The investigation is carried out in accordance with Annex 13 of the Chicago Convention.

The investigation

SHK was informed on 13 June 2016 that an accident involving a helicopter with the registration SE-JVP had occurred at Åre Östersund Airport, Jämtlands county, the same day at 09:55 hrs.

The accident has been investigated by SHK represented by Mrs Helene Arango Magnusson, Chairperson, Mr Stefan Carneros, Investigator in Charge and Flight operations Investigator until 29 March 2017, Mr Christer Jeleborg, Technical Investigator, and, from 30 March 2017, Investigator in Charge and Mr Agne Widholm, Flight operations Investigator from 30 March 2017.

The investigation team of SHK was assisted by Mrs Annika Wallengren as an expert on Fire and Rescue Services.

On behalf of France Mr Nicolas Courjaud from BEA[1] has participated as an accredited representative.

Mr Pascal Hérate and Mr Marc Lever from BEA, Mr Vincent Lassus from Airbus Helicopters (AH) and Mr Xavier Azema from Safran Helicopter Engines (SHE) have participated as advisors to France's accredited representative.

On behalf of the Swedish Transport Agency, Mr Magnus Axelsson has participated as advisor.

The following organisations have been notified: The International Civil Aviation Organisation (ICAO), the European Aviation Safety Agency (EASA), the European Commission, the Swedish Transport Agency and the French accident investigation authority, BEA.

Investigationmaterial
Interviews have been conducted with the pilot, air traffic control and rescue service personnel at Åre Östersund Airport and witnesses who were at the site during the accident. SHK has also interviewed two pilots with experience of the helicopter type and has performed a reference flight with a helicopter of the same model.

A meeting with the interested parties was held on 1 December 2016. At the meeting SHK presented the facts discovered during the investigation, available at the time.

[1] BEA (Bureau d'Enquêtes et d'Analyses pour la securité de l'aviation civile) – the French authority for safety investigations in the field of civil aviation.

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Aircraft:	
Registration, type	SE-JVP, AS 350/EC 130
Model	AS 350 B3
Class, Airworthiness	Normal, Certificate of Airworthiness and valid Airworthiness Review Certificate (ARC)[2]
Serial number	8199
Owner	Roator AB
Time of occurrence	13 June 2016, 09:55 hrs. in daylight Note: all times are given in Swedish daylight saving time (UTC[3] + 2 hrs.)
Place	Åre Östersund Airport, Jämtlands county, (position 63°11′ N, 14°29′ E, 373 metres above mean sea level)
Type of flight	Private
Weather	According to SMHI's analysis wind 310 degrees/12 knots, visibility more than 10 km, cloud base above 5 000 feet, temperature/dewpoint +9/+2 °C, QNH[4] 1008 hPa
Persons on board:	1
Crew including cabin	1
Passengers	None
Injuries to persons	1 person with minor injuries
Damage to aircraft	Substantially damaged
Other damage	Damage to adjacent buildings, personal property and vehicles by flying pieces of wreckage
Pilot:	
Age, licence	69 years, PPL(H)[5]
Total flying hours aeroplane	4,175 hours
Total flying hours helicopter	1,010 hours, of which 48 hours on type
Flying hours previous 90 days	13 hours, of which 12 hours on type
Number of landings previous 90 days	21, of which 13 on type

[2] ARC – Airworthiness Review Certificate.
[3] UTC – Coordinated Universal Time.
[4] QNH – atmospheric pressure at mean sea level.
[5] PPL(H) – Private Pilot Licence.

SUMMARY

The accident occurred in connection with landing after a flight from Tullinge, south of Stockholm to Åre Östersund Airport.

The pilot received permission to land at FATO[6] A and then hover to the helicopter pad “Mitt” outside the hangar of the company Storm Heliworks. After landing, the pilot was directed by a person on the ground to hover in for touch down in front of the hangar. The area of the apron where the helicopter was to touch down inclines approximately 4 degrees towards the hangar, and the helicopter was to touch down transverse to the incline with the left side downwards.

In conjunction with the first contact with the ground, the helicopter began to bounce uncontrolled between the skids. The pilot aborted the touch down, increased the collective lever displacement markedly and quickly lifted off from the ground with a low nose position, after which an uncontrolled situation arose. The helicopter lifted and rotated two turns counter clockwise before it hit the ground. The impact was first with the tail rotor and then with the main rotor blades. After having rotated another turn, the helicopter came to rest standing on its skids in an upright position. A fire broke out in the engine bay, but was extinguished by personnel from an adjacent helicopter company. The pilot received help to evacuate from the helicopter and was taken to hospital by ambulance. The helicopter sustained substantial damage.

Extensive examination of the helicopter including the power plant system shows that all systems were operating as per design until the impact. However, the investigation shows that the touch down of the helicopter was made on a rigid and unforgiving surface that sloped to the left with a hovering position that inclined to the right. The investigation further shows that the helicopter neither touched down and unloaded nor hovered free from the ground in conjunction with the touch down and that the manoeuvring quickly went to an overcompensation of the steering displacements, which increased the helicopter's movements. When the decision to abort the landing was made, control was already on its way to being lost. The large collective lever displacement that was given at this stage, in combination with the absence of compensatory steering displacements using pedals, led to the situation becoming uncontrolled.

The accident was caused by the fact that the sloping and hard surface at the touch down site made the degree of difficulty of the touch down too high in relation to the pilot's experience of the helicopter type and his current flight proficiency.

Regarding the rescue operation, the investigation shows that the alerting service and collaboration between units involved functioned well from an overall point of view, but that it took a relatively long time for the airport's first fire fighting vehicle to get to the accident site. Admittedly, the response time was within the requirements for non-commercial air traffic. However, the airport's rescue services must be designed to also meet the requirements for

[6] FATO – Final Approach and Take off area.

commercial operation. It is noted that the present rescue routes are primarily designed to facilitate operations at the main runway. The investigation shows that the sharp turns on the response routes mean that the drivers must maintain a very low speed in the turns. SHK is therefore of the opinion that Swedavia should consider to take measures to assure that they can meet the existing response time requirements of three minutes, e.g. should the rescue routes be redrawn with smoother turns or, alternatively, be supplemented with direct rescue routes in order to facilitate response with heavy fire fighting vehicles to FATO A.

The analysis further shows that there may be reason to investigate whether personnel should have the task of assisting in engine start of passenger aircraft and on the same time be on duty as a firefighter. If both tasks are still to be handled at the same time, the emergency functions should, according to the SHK, be supplemented so that they can be clearly observed from all locations. In such a case, there may also be a need for instructions on how to cancel an engine start of a passenger airplane in case of an alarm.

The investigation shows that since the accident occurred Swedavia has begun the process to of reviewing the functions that should be manned by employees while in the same time serving as fire fighters. Therefore SHK refrain from issuing any safety recommendation to Swedavia. It is expected that The Swedish Transport Agency will follow up on this work in its oversight and will ensure that Åre Östersund airport complies with the prescribed response time requirements for rescue services.

It is noted that deficiencies identified in the investigation have not been acted on in the Swedish Transport Agency`s oversight role. The Swedish Transport Agency is therefore recommended to evaluate how well this type of deficiencies can be identified in the Agency's oversight process.

Safety recommendations:

The Swedish Transport Agency is recommended to:

- Evaluate their oversight process for airports. *(RL 2017:07 R1)*
- Assure that Åre Östersund airport complies with the Swedish Transport Agency`s regulation and general advice (TSFS 2010:29) regarding preparedness for rescue and emergency services at airports. *(RL 2017:07 R2)*

1. FACTUAL INFORMATION

1.1 History of the flight

1.1.1 Circumstances

The accident occurred during a private flight upon touch down after approach to Åre Östersund Airport. The flight was conducted under Visual Flight Rules from Tullinge, south of Stockholm to Östersund. The weather entailed no limitations, and the flight planning with performance, weight and balance calculations showed that the flight could be performed with the requisite margins. The pilot had prepared with half an hour's local flying two days before the flight to Östersund. The helicopter had no deferred remarks.

1.1.2 Sequence of events

The flight from Tullinge to Östersund took two hours and 20 minutes. The pilot requested and received clearance from the air traffic controller to enter the Åre Östersund Airport's control zone and also permission to land towards FATO A and then air-taxi to the "Mitt helicopter pad" outside the hangar of the company Storm Heliworks. Both the Mitt helicopter pad and FATO A are located near the air traffic control tower. The flight activity at Åre Östersund was somewhat lower than normal, but preparations were in progress for the departure of a passenger aeroplane.

After approach and hovering towards FATO A, the pilot was directed by a person on the ground to hover in to a site for touch down of the helicopter.

The site where the helicopter was to touch down inclines approximately 4 degrees towards the hangar, and the helicopter was to touch down transverse to this incline with the left hand side towards the hangar. The pilot was alone on board and was sitting on the right hand side in the helicopter.

The entire course of events was recorded by one of the airport's surveillance cameras. The film shows that the approach and the hover over FATO A, as well as the hovering to the touch down site on the helicopter pad Mitt, were performed in one go. The pilot turned up against the wind and hovered sideways towards the person who was showing where the helicopter was to touch down. The film, which at the time of touch down shows the helicopter from behind, shows that the hovering height first decreases at a low speed to then in the final part decrease at an abnormally high speed for touch down.

In conjunction with the touch down and after the first ground contact, a situation arose where the helicopter came to bounce with the right and left skids against the ground in a manner that was perceived as uncontrolled. The pilot aborted the touch down, increased the collective lever input markedly and quickly lifted off from the ground, first with a low nose position. The helicopter then climbed sharply, now with a high nose position, and yawed two turns counter clockwise before it hit the ground, first with the tail rotor and tail boom and then with the main rotor blades. After having rotated another turn, the helicopter stopped and remained on its skids in the upright position. A fire broke out in the engine bay, but it could be extinguished by personnel from Storm Heliworks using five hand-held fire extinguishers. The pilot received help to evacuate from the helicopter and was taken to hospital by ambulance.

1.2 Injuries to persons

	Crew members	Passengers	Total on board	Others
Fatal	-	-	0	-
Serious	-	-	0	-
Minor	1	-	1	-
None	-	-	0	-
Total	1	0	1	-

1.3 Damage to aircraft

Substantially damaged, see figure 1.

Figure 1. The helicopter after the accident. Photo: SHK.

1.4 Other damage

Hangars and other buildings, vehicles and other equipment were slightly damaged by parts that came loose from the helicopter upon ground contact.

1.4.1 Environmental impact

Minor leakage of oil and fuel was observed at the crash site.

1.5 Personnel information

1.5.1 Pilot

The pilot, 69 years old, had a Private Pilot Licence (PPL, H) with flight operational and medical competence.

Flying hours				
Latest	24 hours	7 days	90 days	Total
All types	2	2	13	1 010
Actual type		2	12	48

Number of landings actual type previous 90 days: 13.
Type rating on AS 350 (B2) concluded on 17 May 2013.
Latest PC[7] conducted on 23 May 2016 on the type.

The pilot has flown helicopters privately for about ten years and has 1,010 hours' total helicopter flying time. He has previously flown, among others, helicopters of the types Robinson R 44 and EC-120. The pilot also has about 4,000 flying hours from private flying of aeroplanes.

Flight training on the AS 350 was conducted about three years before the accident and the pilot have since then flown 48 hours on the type.

1.5.2 The pilot's duty schedule

The pilot has stated that his sleep was good the night before the accident and that he was well rested before take-off. Nothing has emerged during the investigation which gives reason to question this information.

1.5.3 Other personnel affected

Not applicable.

1.6 Aircraft information

General
Airbus Helicopters AS 350 B3 is equipped with a turbine engine. The helicopter is eleven metres long and three metres high. The three-blade main rotor has a diameter of almost eleven metres. The two-blade tail rotor has a diameter of just less than two metres.

[7] PC – Proficiency Check.

1.6.1 *Helicopter*

TC-holder	AIRBUS HELICOPTERS
Model	AS 350 B3
Serial number	8199
Year of manufacture	2016
Gross mass, kg	Max start/landing mass 2 250, actual mass 1 490
Centre of gravity	Within limits.
Total flying time, hours	21
Flying time since latest inspection, hours	Not applicable.
Type of fuel uplifted before the occurrence	Jet A1

Engine	
TC-holder	Safran Helicopter Engines
Type	Arriel 2D
Number of engines	1
Serial number	50834
Total operating time, hours	21

The aircraft had a Certificate of Airworthiness and a valid Airworthiness Review Certificate (ARC) and had no deferred technical remarks.

1.6.2 *System for control of main and tail rotors*

The helicopter's rotor system is used to steer the helicopter during flight. The collective lever is used to change the angle of the main rotor blades collectively in order to increase or decrease the lift. The cyclic stick is used to change the lift on the rotor blades cyclically and thereby change the direction of the lift from the main rotor in order to steer the helicopter's pitch and roll angle. The tail rotor is used to compensate for the main rotor’s torque and to steer the helicopter in the yaw axis. The two position sensors in figure 2 send information on the position of the collective lever and the pedals to the Digital Engine Control Unit, DECU[8], where these data are saved. These values have been used in SHK’s analysis of the accident (see also Section 1.6.3).

Displacements with collective lever and pedals affect the power required from the engine, which is described in Section 1.6.3.

[8] DECU – Digital Engine Control Unit.

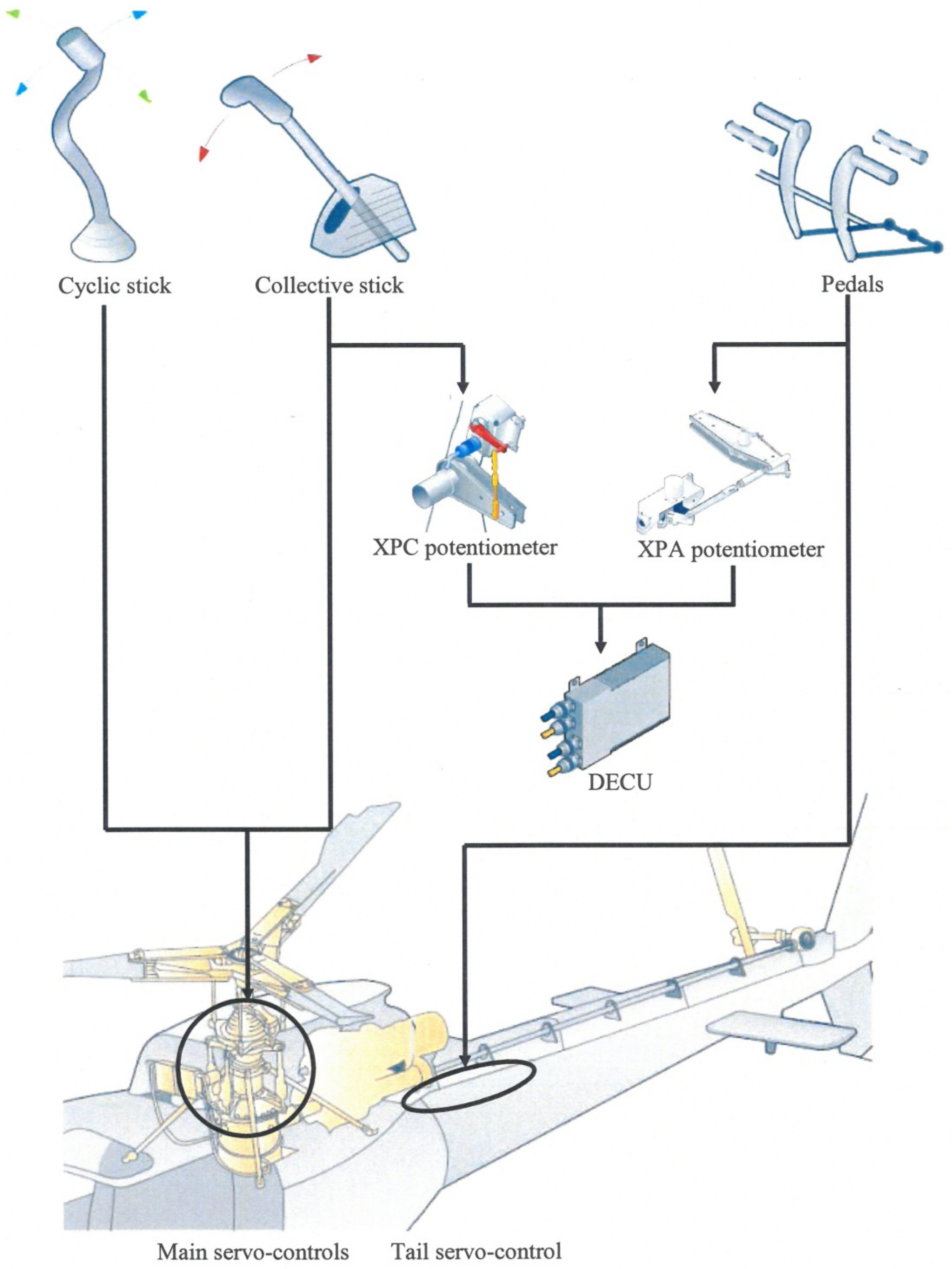

Figure 2. Schematic steering system for the rotors.

1.6.3 Engine system

The engine's main task is to drive the helicopter's rotor system with main rotor and tail rotor. The engine consists primarily of a gas generator, a free turbine with drive shaft and a gear box and auxiliary apparatus. The engine's primary purpose is, regardless of power needs, to drive the rotor system and thereby keep the drive shaft and thus the rotors within a constant rpm range as possible.

System for engine control (FADEC[9])

The helicopter is equipped with a digital fuel control system, FADEC. The pilot's commands affect the control system, which then regulates the fuel supply to the engine. The main components in the system are the Digital Engine Control Unit (DECU) and the memory unit for engine values (EDR)[10].

The DECU uses digital and analogue inputs to regulate the rotor speed. There are two analogue position sensors, one for pedal position and one for the collective lever's position. These positions are saved continuously in the DECU once per second.

The helicopter's EDR mainly records the same parameters as the DECU but has larger recording capacity. The values are recorded 50 times per second but are normally not saved. However, in case of certain incidents, for example if critical parameters are exceeded, all values are saved in the EDR from 4 seconds before to 4 seconds after the exceedance or discrepancy.

The collective lever and pedal position sensors function as preventive information to the FADEC of a future increased need for power so that the gas generator can increase the gas flow so as to keep the rotor speed within prescribed values. The pedal position is recorded for displacement above 70 % of the right pedal (XPA parameter). The reason why only large displacement from the right pedal is an input to the FADEC is that the main rotor rotates clockwise and the counter-acting moment turns the helicopter counter clockwise. By means of steering displacements from the right pedal, the pilot counteracts this turning, which is done using power from the tail rotor. This further increases the load on the free turbine. This means that the engine needs an increased fuel supply in order to maintain the speed of the rotors. The sensor for the collective lever supplies a continuous position signal between 0 and 100 %.

1.6.4 Appareo Vision 1000

The helicopter is also equipped with a camera system in the cockpit. The system films the crew and the instruments from behind and is intended to be used as a support for training. However, it can also be used in investigations of events, but the camera is not crash protected. The system saves heading, roll and pitch angles, longitude, latitude, ground speed, vertical speed and altitude based on GPS data. Furthermore, video recordings and audio from the cockpit are saved. Recorded video and other values are saved in the internal memory and in the portable SDHC[11] card.

The accident flight was registered but no data from the flight was saved in the memory. It has therefore not been possible to use any data

[9] FADEC – Full Authority Digital Engine Control.
[10] EDR (Engine Data Recorder) – Memory unit for engine values.
[11] SDHC – Secure Digital High Capacity.

from the system as facts in the investigation. Data not being recorded is however not a security issue and does not imply any restrictions on the use of the helicopter.

1.7 Meteorological information

According to SMHI's analysis: Wind 310 degrees/12 knots, visibility more than 10 km, cloud base above 5 000 feet, temperature/dewpoint +9/+2 °C, QNH 1008 hPa.

According to the airport´s anemometer, the wind direction was 310 degrees and the wind speed 10 knots at the time of the accident. The event occurred in daylight.

1.8 Aids to navigation

Not relevant.

1.9 Communications

Not relevant.

1.10 Aerodrome information

The airport had operational status in accordance with the Swedish AIP[12].

1.11 Flight recorders

The helicopter was not equipped with crash-protected flight recorders, nor is this a prescribed requirement. However, there were several units on board, which were not crash-protected, but which record certain data (see Section 1.6.3–4).

1.12 Site of occurrence

1.12.1 Accident site

The accident site is located on a pad of concrete that is in front of a hangar at the airport. The touch down site in question inclines about four degrees downwards towards the hangar.

As previously stated, the area was monitored by a video camera that recorded the entire sequence of events. The film from the surveillance camera has been used as a basis in the investigation.

[12] AIP – Aeronautical Information Publication.

Figure 3. The accident site market with a red ring and located approximately 50 meters from the intended parking site. Photo: Swedish Police.

1.12.2 Examination of the Helicopter

Under SHK's supervision, the wreckage has been examined by personnel from both the type certificate holder for the engine and for the helicopter. The following parts have been examined in particular:

- Skids and dampers.
- Structure and fuselage.
- Tail boom with drive shafts.
- The pilot's seat.
- All rotor blades.
- Main and tail rotor gearbox.
- Tail and main rotor hubs.
- Drive shaft connection, engine and main rotor gearbox.
- Rotor system controls.
- Fuel system.
- Engine system and engine mounts.

The damage to the engine's compressor indicates that parts from the helicopter have entered the engine through the air intake in conjunction with the impact. On the free turbine there is a notch with the purpose to separate the turbine blades in the event of high over speed on the free turbine. As a consequence of the rupture of the drive shaft between the engine and the main gearbox during the sequence of the accident, all blades from the free turbine have separated at the notch. This occurs at about 140 % free turbine speed.

Nothing has emerged in the investigations to indicate that the helicopter, before the impact, had any technical faults which might have affected the sequence of events.

1.13 Medical and pathological information

Nothing indicates that the mental and physical condition of the pilot was impaired before or during the flight.

1.14 Fire

A fire broke out in the engine compartment. It did not spread and could as stated be extinguished by personnel from the nearby helicopter companies using a total of five hand-held fire extinguishers with powder extinguishant.

1.15 Survival aspects

1.15.1 Rescue operation

Regulations on rescue services

Regulations on rescue services are found primarily in the Civil Protection Act (2003:778) and the Civil Protection Ordinance (2003:789), in the following referred to by use of their acronyms in Swedish, LSO and FSO respectively.

According to Chapter 1, Section 2, first paragraph of LSO, the term “rescue services” denotes the rescue operations for which central government or municipalities shall be responsible in the event of accidents or imminent danger of accidents, in order to prevent and limit injury to persons and damage to property and the environment. The respective municipality is responsible for rescue services within the municipality insofar as it is not a matter for central government rescue services (Chapter 3, Section 7, LSO). In this case, the responsibility for rescue services was with the municipality.

Rescue services at airports

Special regulations on airport rescue services are contained in the Swedish Transport Agency’s regulations and general advice (TSFS 2010:29) on preparedness for air rescue operations and on airport rescue services.

According to these regulations, the operator of an airport shall provide rescue services for commercial air transport. The primary task is to conduct operations to save lives in the event of aviation accidents occurring within the airport or in its vicinity. Fire fighting operations shall be conducted to facilitate emergency evacuations in the event of fire in conjunction with aviation accidents.

According to the regulations, the rescue team should be led by a rescue leader who, on behalf of the municipal rescue services, leads the rescue operation until its management is assumed by the municipal rescue services.

According to the above-mentioned regulation, the response time for the airport's rescue services shall not exceed three minutes to every point on runways in use during daytime, in good visibility and when the planned operation routes are free from water, ice or snow. The response time is defined as “time between the first call to the airport’s rescue services and that extinguishant can be applied at a discharge rate of at least 50 per cent of the discharge rate for the aerodrome category in question”.

According to the AIP[13] for Åre Östersund Airport, Section 2.6, the response time at the airport for non-commercial air transport shall not exceed eight minutes.

Alerting services and air traffic control

Alerting services are a part of air traffic services and are defined in the Swedish Transport Agency’s regulations and general advice (TSFS 2015:51) on alerting services and air rescue services as “activities with a task to inform units when an aircraft needs rescue services and, to the necessary extent, to support these activities”. According to Chapter 5, Section 4, an air traffic control unit conducting alerting services in the vicinity of an airport shall, inter alia, have issued a checklist for accidents with known crash site, which is designated red checklist. According to Chapter 3, Section 19 of the Swedish Transport Agency’s regulations and general advice (TSFS 2016:34) on air traffic services (ATS), the tower shall also have access to a device that makes it possible to immediately trigger accident alarms and warning alarms.

[13] AIP – Aeronautical information publication – A collection of facts containing information for aviation.

General information on Åre-Östersund Airport

The statistics from Åre Östersund Airport show that the airport has had just over 10,000 movements (take-off and landings) at the airport per year in 2014 and 2015. Just over 600 of these have been commercial helicopter movements at the helicopter pad Mitt and FATO A.

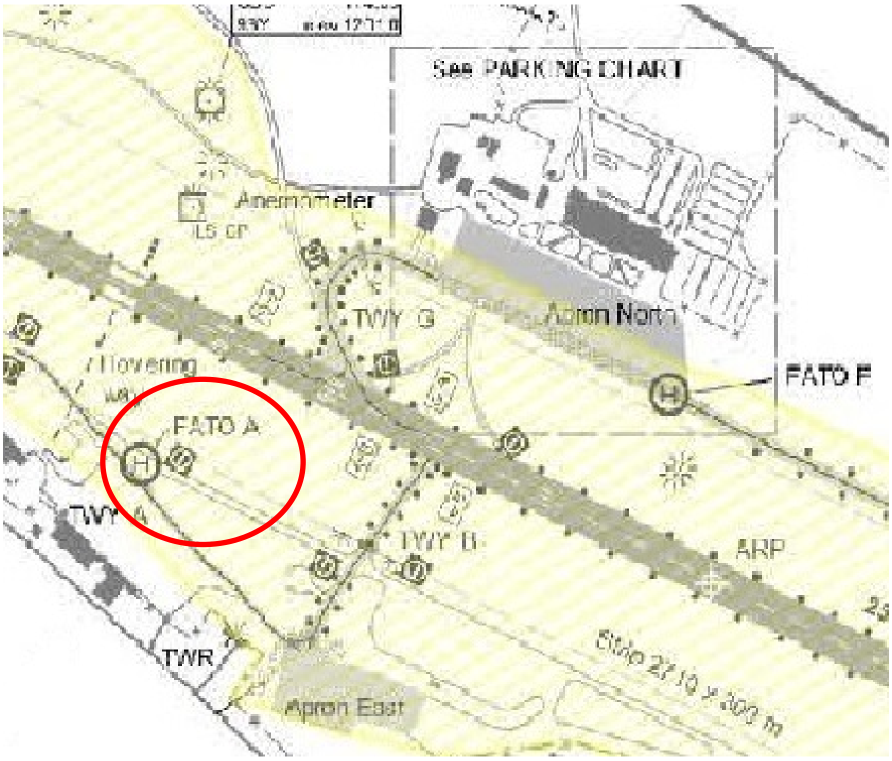

Figure 4. A schematic of the airport, and FATO A marked with a red ring.

Extensive helicopter activities are conducted in connection to the helicopter pad Mitt. These include the extensive service of ambulance helicopters.

The airport has about 40 approved fire fighters, whereof 9 also can be rescue leaders. The rescue personnel are divided into four fire and rescue service teams. Each team includes at least five fire fighters. At the same time as they are divided into such a team, the personnel perform several other tasks in conjunction with airport operations, such as check-in, security checks, loading and unloading of baggage, aircraft refuelling and assisting with the engine start of passenger aircraft.

The response routes from the fire station to FATO A, which is located on the other side of the airport landing runway, see Figure 4, have a number of very sharp turns. The fire fighting vehicles, which fully loaded weigh about 30 metric tonnes, must therefore brake to a very low speed in several turns. Previously, when Åre Östersund Airport was operated by the Swedish Armed Forces, there was a response route that led directly from the fire station to the helicopter pad Mitt. However, this route was removed when the airport went to only civilian activities and the fire brigade station was located to apron “Norr”. At the time when the route was removed there were no helicopter operations at the south side of the airport.

The fire fighters’ training fulfils the formal requirements. However, the fire fighters that are driving the fire fighting vehicles describe that they have limited experience of driving fully loaded fire fighting vehicles at high speed. This is due to the fact that they rarely receive training on this.

All air traffic controllers serving in the control tower regularly exercise different elements of alerting services.

Local aviation safety meetings are conducted three times a year.

Collaboration within the rescue services

Jämtland’s county has a well-established tradition of collaboration between authorities and organisations that conduct rescue services. Representatives from, for example, the police, the municipal rescue services, the county administrative board, SOS Alarm AB, the airport and air traffic services, participate in regular collaboration meetings.

The sequence of events with regard to the rescue services

The air traffic control tower is normally manned by one controller, but at the time of the accident there were two controllers in place as it was time for relieving.

One controller followed the helicopter visually in conjunction with the approach towards FATO A and the subsequent air-taxiing to the intended parking place. When the helicopter's two skids made contact with the ground, the controller perceived the helicopter to bounce up about eight metres from the ground and rotate two turns around its own axis. The controller decided to immediately trigger the accident alarm and follow the red checklist for accident with known accident site. The checklist was available in direct connection to the work station.

When the controller lifted the lid over the accident button, the whole button came loose from its mount. The controller then put his hand down into the space for the accident button and nevertheless succeeded in carrying out the alarm. The broken accident button therefore resulted in only an extremely marginal delay of the alerting.

After the event, the manager for air traffic services decided, in accordance with current procedure, to call in an extra controller to relieve the controllers who had been in position at the time of the accident. This extra colleague arrived at the workplace within 15 minutes.

When the accident alarm was triggered, the personnel who were part of rescue service preparedness were as usual in the process of carrying out various tasks, such as refuelling, check-in, security checks and assisting with the engine start of an aircraft. They were made aware of the alarm by means of portable ground radio and via audio and light signals.

The rescue leader, who was alerted via his portable radio, quickly left his work at the security checkpoint. He saw the black smoke at the accident site and received clearance to cross the runway by passenger car. On his way out to the accident site, he received supplementary information from the tower. He arrived at the accident site exactly three minutes after the alarm. The first fire fighting vehicle arrived at the accident site after three minutes and 15 seconds, the second fire fighting vehicle after three minutes and 55 seconds.

One of the fire fighters on call was at one of the aircraft aprons to assist with the engine start of a passenger aircraft and did not perceive the accident alarm directly. He was using protective headphones and had his back towards the light and audio signals. There are a total of eight light and audio functions at the airport. The nearest light and audio function was located approximately 30 metres from the apron. However, the fire fighter noted the gates to the fire station being opened and the operation leader's car driving away and then understood that an alarm situation had arisen.

When the rescue leader arrived at the accident site, the fire had already been extinguished. The rescue leader grouped the airport's own vehicles and forces according to standard procedure in order to be able to take measures if the situation would deteriorate. After dialogue with the municipality's rescue coordinator it was decided that the rescue leader would continue to lead the operation and coordination at the site. The event eventually developed from rescue service to police cordon.

SOS Alarm, the municipal rescue coordinator and the airport’s rescue leader communicated via a joint talk group in the national communications system Rakel. The control tower, however, had no access to Rakel but communicated with the other functions via telephone and the radio stations used within the air navigation services.

Activities at the helicopter pad Mitt

One of the employees at Storm Heliworks was prepared to direct the helicopter so that it would be parked in a manner that was desirable for their activities. The employee, who was in direct connection to the helicopter, ran quickly off from the helicopter at the time of the accident in direction towards the hangar. Although fragments were spread when the helicopter hit the ground, he escaped getting hit. After the impact, he saw that the helicopter had caught fire. He then ran back to the crashed helicopter and helped the trapped pilot out of the wreckage.

At the time of the accident, there was a break for the employees at Storm Heliworks and Saab Aerotech, and they were in the hangar. They brought portable fire extinguishers that were placed on a trolley in the hangar and ran out to the helicopter wreckage. There they could quickly extinguish the fire. Five powder extinguishers of 5 kg each were used during extinguishing.

When the emergency rescue operation had been concluded, it was noted that spall had hit the outside of the hangar walls and two of the cars parked outside one of the hangars.

The alerting of municipal rescue services, police and ambulance

The alarm to municipal rescue services, police and ambulances in Östersund was secured via the red checklist. Central Östersund is approximately 10 km from the airport. Eleven minutes after the alarm, the first ambulance arrived at the accident site from central Östersund. After thirteen and a half minutes, the second ambulance arrived. The first police car arrived after 14 and half minutes, and a second police car arrived after fifteen and a half minutes. Fire fighting vehicles from the municipal rescue services arrived after 16 and half minutes. After another minute, a larger fire fighting vehicle arrived at the site.

Collaboration of rescue services

Coordination was handled by the rescue leader. However, a controller in the tower on his/her own initiative directed ambulances, municipal rescue services and police via the airport gates closest to the accident site instead of having them drive the longer route that actually constitutes standard procedure.

Liaison

The initial communication between the tower and the rescue leader via the airport's ground radio functioned well. However, the rescue leader had some technical problems with his telephone when he was to contact the municipal rescue coordinator.

The helicopter's ELT[14] of type McMurdo Kannad Integra AP-H was not activated.

1.15.2 Positions and injuries of those on board and the use of belts

The pilot who was sitting on the right side and was using the safety belt sustained multiple but minor injuries. He was treated in hospital for about 24 hours.

The pilot's seat is designed to deform to protect the pilot from personal injuries from the forces that arises in a crash.

[14] ELT – Emergency Locator Transmitter.

1.15.4 The fuel tank

The design of the fuel tank was approved in 1997 in conjunction with the certification of the helicopter type, which was then based on FAR[15] Part 27 Revision 1–10. Airbus Helicopters offered an alternative design with increased crash resistance of the fuel system, a modification designated OP-4605. However, SE-JVP had the original design.

The original design of the fuel system was consequently of a less crash-proof type. Upon impact, the tank was cracked by the main rotor gearbox, and large pieces in its upper part were separated from the tank. The remaining fuel, just over 100 litres, was exposed to the surrounding air and environment with adjacent fire, but remained in the tank and did not leak or take fire.

1.15.5 Other damage

In conjunction with the accident, flying pieces from the helicopter caused damage to the adjacent hangar building and administrative building and to vehicles and fencing.

1.16 Tests and research

Examination of Appareo Vision 1000

In conjunction with other wreckage examination, SHK has performed an examination of the power supply to the Appareo Vision 1000 unit, according to an instruction from the type certificate holder. The power supply functioned in the intended manner. Extensive examinations of the unit, operating program and saved data have been performed with the support of personnel from the French accident investigation authority. However, as previously stated, there was no data of the flight in question saved in the unit.

In contrast, there were previous flights saved in the unit, and recordings made in conjunction with the examinations were saved both in the internal memory in the camera and the SDHC card. In contacts with the accident investigation authorities of other countries, it has emerged that they have had similar experiences of problems with the Vision 1000 system from their investigations.

Examination of the DECU and EDR

The review of data from the DECU and the EDR (see Section 1.6.3.) shows that a low power output from the collective lever was used in the landing attempt, roughly corresponding to hovering in ground effect, which meant that the helicopter only partially made contact with the ground and never stood fully unloaded. The data shows a subsequent power output with the collective lever in 100 % and a displacement of the right pedal of less than 70 %.

[15] FAR 27 (Federal Aviation Regulations) US design requirements for helicopters in the normal category.

1.17 Organisational and management information

Not applicable.

1.18 Additional information

1.18.1 General information on ground resonance

Ground resonance is a form of oscillation that can affect helicopters. This is because the blades can move forwards and backwards in the plane of rotation. This function means that the rotor balances itself in the air. However, problems can arise on the ground when the rotor is rotating. If the rotor blades start moving in this manner on the ground, the rotor disk's centre of gravity will not lie exactly over the rotor mast. This means that the centre of mass and, if lift is being drawn, also the centre of lift rotates outside the rotor mast centre. The helicopter will then begin to rock, which might lead to an undamped, increasing oscillation that causes the helicopter to risk tipping over or vibrating so that damage arises, if the pilot does not correctly perceive the situation in time and take immediate measures.

Ground resonance can arise from several causes. In addition to technical causes, such as faulty oscillation dampers, the phenomenon can be brought about by, for example, landing with only one of the landing gear on the ground, hard or uncontrolled touch down and combinations of these factors in conjunction with landing on an uneven surface. According to the design organisation Airbus Helicopters, one of the criteria for ground resonance to be able to arise is that the helicopter is fully unloaded with its skids on the ground.

The pilot procedure to correct the state in conjunction with take-off is to apply a quick throttle or to increase lift. All the blades will then move towards their rear stop, and the rotor disk will then be back in balance. The method in conjunction with landing is to either lift into the hover again or immediately shut off the engine. Some helicopter types have systems with dampers on their skids in order to counteract this phenomenon. This helicopter had two dampers which were found without remarks after the accident.

1.18.2 General information on pilot-induced oscillation, PIO

Pilot-induced oscillation (PIO) is a state with vibrations or oscillations that arises when the pilot over compensates steering displacements for a perceived imbalance or is too late in applying steering displacements and thus counteracts the desired steering response. This results in an opposite effect to the one desired and instead amplifies the undesirable movements. The consequence is increasing amplitude in the oscillations. PIO can arise in conjunction with flight or hovering and can be initiated by both collective lever and cyclic stick. One way to get out of the situation is to release or freeze the controls affecting the oscillations.

1.18.4 Hovering with marginal ground contact

A state that can be perceived to be ground resonance is the movement pattern that might arise if the pilot is not hovering sufficiently high to be free from the ground, but also does not unload and stand firmly on the ground. The helicopter then gets into an intermediate position where the helicopter bounces against the ground. This is not an undamped state with increasing oscillations as in ground resonance, unless the pilot himself induces an increased oscillation with a varying lift output, as in PIO. The situation requires the pilot to increase the lift and increase the hovering height so that the helicopter hovers free from the ground or touch down the helicopter and unload the rotor system.

1.18.5 AS 350 compared with the pilot's experiences from previous helicopters

The pilot has previous experience from helicopters of the type EC-120 and Robinson R-44 and was relatively experienced on the EC-120. The pilot flew EC-120 also after his type rating on the AS 350.

The AS 350 has a more powerful engine and, according to interviews with a number of experienced helicopter pilots, is more distinct in its flight control response compared with, for example, the EC-120. The AS 350 also has a flatter lower fuselage, which causes the down wash air when hovering at a low height, the “ground cushion”, to affect the fuselage more than on an EC-120. This particularly applies at lower heights in ground effect and means, in simplified terms that the helicopter becomes a little more difficult to precision hover with. The interviews have shown that pilots flying the helicopter type are a little extra vigilant during touch down and lift-off on a hard surface when they are flying for the first time after a hiatus. Consequently, the differences between the EC-120 previously flown by the pilot and the AS 350 can therefore be summarised by saying that, in order to precision hover with the AS 350, a little more is required of a pilot with relatively little routine or low level of flight proficiency. The differences are amplified if the helicopter is lightly loaded.

1.18.6 Actions taken

Actions taken by Swedavia

The airport’s management group conducted a meeting and debriefing for those concerned already the same day the accident occurred. According to those interviewed the meeting and the opportunity to see the accident site facilitated the processing of the event that occurred.

A local aviation safety meeting that discussed experiences from the accident with SE-JVP was held on 27 September 2016. The airport's experiences were then disseminated within Swedavia by the aviation safety coordinator.

The fire fighters invested time in driving vehicles in order to safely orient themselves at the airport and find alternative driving routes. They have also practised driving with rescue vehicles in order to get a feel for how the vehicle behaves in sharp turns and braking. To check the driving times, the response route in question has also been test driven. The fastest time noted with a prepared driver sitting inside the vehicle was 1 minute and 19 seconds. During the days when they were practising driving the vehicle, the driving time was shortened by an average of about 20 seconds.

Discussions have also been conducted on to what extent fire fighters are to staff other functions. A reminder has been issued to the administrative personnel that they have the task of covering positions that personnel in the rescue force leave on account of an alarm.

Actions taken at helicopter pad Mitt

After the accident, the helicopter companies at the helicopter pad have introduced procedures entailing that the hangar doors are always to be closed when this is possible. Saab Helikopterservice has, among other things, decided to have a minimum of personnel on the pad during checks and tests, introduced the procedure to always have hand-held fire extinguishers available on the pad and become more restrictive with vehicles at the hangar door. Storm Heliworks has, among other things, purchased several hand-held fire extinguishers that have been placed near the pad and minimised the number of vehicles outside the hangar.

2. ANALYSIS

2.1 The pilot's experience of the helicopter type

Flight training on the AS 350 was conducted, as stated, about three years before the accident. After that, the pilot had only flown about 48 hours with the actual type. In the last three months, the pilot had flown helicopter for thirteen hours, of which twelve hours on the type. According to SHK, the overall level of flight proficiency and experience of the helicopter type may thereby be considered to have been low, especially in light of the helicopter type being considered to be a little more difficult to precision hover compared with the EC-120.

2.2 The touch down and the crash

The film, which at the time of touch down shows the helicopter from behind, shows that the hovering height first decreases at low speed to then in the final stage decrease at an abnormally high speed for touch down.

The pilot was sitting on the right side and was alone on board. The helicopter had relatively little fuel remaining and no load other than light personal equipment. The wind was coming from straight ahead and thus did not affect the helicopter's roll angle. The helicopter was therefore inclined a little to the right and was tail-heavy with a nose-up attitude when hovering. The apron, on the other hand, was inclined to the left. This combination meant that the right rear skid made contact first during the touch down.

Data from the engine control system (FADEC) shows that the landing phase was executed with the collective lever in the position for hovering effect. It can thereby be ruled out that ground resonance had arisen since this state presupposes that the helicopter is fully unloaded with its skids on the ground. Data further shows that when the landing was aborted, the collective lever was pulled up to the maximum position while the right pedal was maintained in a position corresponding to less than 70 % steering displacement, hence the uncontrollable flying situation arose. A steering displacement under 70 % is not sufficient to compensate for the collective lever displacement that was applied to maintain the heading. These steering commands resulted in the helicopter yawing markedly counter clockwise while climbing. The aforementioned surveillance video shows that the helicopter's nose when lifting into the hover was pointing in a direction towards the hangar and was in a low position, which resulted in a forward movement. SHK believes that the uncontrolled flying situation arose when the collective lever displacement was increased without compensatory pedal displacement being engaged.

From the helicopter, it can be difficult to determine how much the apron inclines, and such a great incline as 4 degrees can be experienced as surprising on a pad that is otherwise perceived as levelled. In conjunction with the right skid making contact with the ground, the helicopter was manoeuvred distinctly downwards. Since the helicopter was inclined to the right and the pad was inclined to the left, there were 2–3 decimetres remaining on the left side before the left skid also reached the ground. The last part of the touch down was also relatively abrupt, which is shown both by the film and information provided in the interviews.

The surface of concrete is rigid and not dampening like grass or gravel. The quick touch down resulted in the helicopter, after having touched down the right skid, making a rolling movement to the left before it hit the ground with the left skid. The small manoeuvres and fine adjustments that had actually been required for a smooth touch down in the situation in question were not made, and there arose a situation where the helicopter instead bounced alternately between the right and left skids. The pilot's attempts to compensate for the movements led to overcompensations of steering displacements which resulted in heavy oscillations (PIO). The recorded engine values show, as stated above, that the rotor system was not unloaded during the sequence and that the engine power before the aborted touch down corresponded to hovering at a low height.

When the decision was made to abort the touch down and lift into hover, the pilot made a steering command forward. This steering command in combination with a maximum collective lever command meant that the helicopter lifted off with a strong nose-down attitude before counteracting steering displacements were applied during continued climb. The lack of sufficiently compensatory right pedal displacement in combination with the strong collective lever displacement caused the main rotor's moment to turn the helicopter counter clockwise under strong acceleration vertically. This resulted in the helicopter yawing to the left during the following sequence.

2.3 Results from the wreckage examination

All damage noted during the wreckage examination is assessed to have arisen upon impact. SHK has not found any signs of previous technical deficiencies that might have affected the sequence of events.

The compressor damage is assessed to have been caused by parts from the helicopter, and the fact that all blades from the free turbine have separated at the notch indicates a turbine speed over 140 % due to the ruptured drive shaft. These observations show that the engine was in operation and was supplying power upon impact.

The Appareo Vision 1000 system did not operate as intended. This suggests that there is a deficiency in the reliability of this system. That is also confirmed by the experience from other investigations at foreign safety investigating authorities. As a result of the lack of saved data in the system, the system hasn’t been able to contribute to the determination of the sequence of events.

The forces that arose on the helicopter during impact were reduced, as the pilot chair was deformed. Thus did the chair function as intended.

2.4 Rescue operation

Alerting services and air traffic control

The investigation shows that all air traffic controllers serving in the control tower regularly exercise different elements of alerting services. Their actions in conjunction with the event also show that they had good competence and capability to conduct alerting tasks.

The rescue services at the airport

As stated, the rescue leader arrived at the accident site three minutes after the alarm. The first fire fighting vehicle arrived at the accident site after three minutes and 15 seconds and the second fire fighting vehicle after three minutes and 55 seconds. According to SHK, this may be considered to be a relatively long time considering the short driving distance.

The investigation shows that the present rescue routes are primarily designed to facilitate operations at the main runway. Although it would have been possible at the time of the accident to drive the fire fighting vehicles over the dry grass areas, this procedure entails some risks, is rarely possible to use and had also not been exercised. The investigation further shows that the sharp turns on the response routes mean that the drivers must maintain a very low speed in the turns, which is a factor contributing to the relatively long response time. Admittedly, the operation time is within the operation time requirements for non-commercial air traffic. However, the airport's rescue services must be designed to also meet the operation time requirements for commercial operation. SHK is of the opinion that Swedavia should therefore investigate and take a position on whether the existing rescue routes should be redrawn with smoother turns or, alternatively, be supplemented with direct rescue routes in order to facilitate response with heavy fire fighting vehicles to FATO A. Such an improvement would help to reduce risks, reduce the stress for the fire fighters driving the rescue vehicles and improve the opportunities to communicate the information given.

The investigation also shows that the drivers need to be given expanded opportunities for continuously practising driving with fully loaded fire fighting vehicles in order to better learn the vehicles' limitations. This particularly applies to the speed that is suitable when the vehicles are to be manoeuvred in sharp turns while taking their own safety into account. Such exercises have also been carried out after the event. However, it is important that this is also introduced as a recurrent element in the exercises for the rescue force at the airport.

The analysis further shows that there is reason to investigate whether personnel should at the same time have the tasks of assisting with the engine start of passenger aircraft and of on-call fire fighter. If both tasks are to continue to be handled at the same time, the alarm functions should, according to SHK, be supplemented so that they can be clearly perceived from all parking places. In such a case, there is also a need of instructions for how the engine start of a passenger aircraft is to be aborted in the case of an alarm.

The investigation shows that since the accident occurred Swedavia has begun the process to shorten the response time and that, among other things, is discussing alternative routes. There is an ongoing process of reviewing the functions that should be manned by employees while in the same time serving as fire fighters. Swedavia is also at the same time evaluating the alarm function. Fire fighters have also been practicing to drive fully loaded extinguishing vehicles and alternative routes. It is essential that this process is completed and that the employees are scheduled for regular exercises for maintaining experience and competence. Considering the work already being started, SHK assumes that the airport completes the work to ensure that the airport remains in compliance with the prescribed requirements. Considering this, SHK refrain from issuing any safety recommendation to Swedavia. It is expected that The Swedish Transport Agency in its oversight follow up on this work and ensure that Åre Östersund airport complies to the prescribed requirements regarding e.g. rescue service response time.

It is noted that the deficiencies identified in the investigation have not been detected and acted upon by the Swedish Transport Agency in its oversight activities. The Swedish Transport Agency is therefore recommended to evaluate how well this type of deficiencies is being detected in the Agency's oversight process.

Collaboration of rescue services

The driving time for the police and the municipal rescue services from central Östersund to the accident site may be considered reasonable. Since the fire fighting operation had already been concluded when the municipal rescue services arrived at the site, there has been no reason for SHK to further investigate their respective operation.

Coordination was handled by the rescue leader at the airport who was in the first car. Thanks to good local knowledge, the air traffic controller saved driving time for the units that came from central Östersund by directing these to gates that were closer to the accident site than the gates used according to the standard procedure. The initial communication between the tower and the operation leader via the airport's ground radio functioned well. However, the rescue leader had some technical problems with his telephone when he contacted the municipal rescue coordinator. However, this is assessed to only have had a marginal influence on the operation. In summary, the investigation shows that this part of the rescue operation has mainly functioned as intended.

3. CONCLUSIONS

3.1 Findings

The investigation shows that:

a) The pilot was qualified to perform the flight.
b) The helicopter had a Certificate of Airworthiness and a valid ARC.
c) The touch down of the helicopter was made on a – for the pilot – unexpectedly sloping plane to the left with a hovering position that inclined to the right and against a rigid surface.
d) The pilot had limited experience in the helicopter type and a low level of current flight proficiency.
e) The touch down was not performed with the precision required.
f) The helicopter operated as intended and that no technical faults contributed to the accident.
g) The Appareo Vision 1000 system lacked recorded data from the accident flight.
h) The alerting function has mainly functioned well.
i) The rescue operation functioned well, but the response time for the airport's fire and rescue services could be shortened through improvement measures.

3.2 Causes

The accident was caused by the sloping and hard surface at the touch down site making the touch down’s degree of difficulty too high in relation to the pilot's experience of the helicopter type and current flight proficiency.

4. SAFETY RECOMMENDATIONS

The Swedish Transport Agency is recommended to:

- Evaluate their oversight process for airports. *(RL 2017:07 R1)*
- Assure that Åre Östersund airport complies with the Swedish Transport Agency`s regulation and general advice (TSFS 2010:29) regarding preparedness for rescue and emergency services at airports. *(RL 2017:07 R2)*

The Swedish Accident Investigation Authority respectfully requests to receive, **by 13 September 2017 at the latest**, information regarding measures taken in response to the safety recommendations included in this report.

On behalf of the Swedish Accident Investigation Authority,

Helene Arango Magnusson Christer Jeleborg