Statens haverikommission
Swedish Accident Investigation Authority





Final report RL 2020:09e

Accident at Visby Airport, Gotland County, on 30 October 2019 involving the helicopter SE-JRM of the type AW139, operated by the Swedish Maritime Administration.

File no. L-156/19

7 October 2020

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 30 October 2019 that a serious incident involving a helicopter with the registration SE-JRM had occurred at Visby Airport, Gotland County, the same day.

The accident has been investigated by SHK, which was represented by Mikael Karanikas, Chairperson, Stefan Carneros, Investigator in Charge, Tony Arvidsson, Technical Investigator, Alexander Hurtig, Investigator Behavioural Science and Tomas Ojala, Investigator specialising in Fire and Rescue Services.

Fabio Di Caro, Agenzia Nazionale per la Sicurezza del Volo (ANSV), has participated as an accredited representative of Italy.

Magnus Axelsson has participated as an adviser for the Swedish Transport Agency.

The following organisations have been notified: The International Civil Aviation Organization (ICAO), the European Union Aviation Safety Agency (EASA), the European Commission, ANSV, The Transportation Safety Board of Canada (TSB Canada) and the Swedish Transport Agency.

Investigation material

Interviews have been conducted with the crew and the passenger, the aviation manager and the head of the helicopter unit. A reference flight in a simulator was performed at the type certificate holder’s premises in conjunction with a fact-finding meeting.

A fact finding presentation meeting with the interested parties was held on 9 June 2020. At the meeting SHK presented the facts discovered during the investigation, available at that time.

Statens haverikommission
Swedish Accident Investigation Authority

Final report RL 2020:09

Aircraft:	
Registration, type	SE-JRM, AB139/AW139
Model	AW139
Class, airworthiness	Normal, Certificate of Airworthiness and valid Airworthiness Review Certificate (ARC)[1]
Serial number	31597
Owner	Swedish Maritime Administration
Time of occurrence	2019-10-30, at 13:23 hrs in daylight Note: All times are given in Swedish daylight saving time (UTC[2] + 1 hour)
Location	Visby Airport, Gotland County, (position 57º39'17N 018º20'26E, 41 metres above mean sea level)
Type of flight	Schooling
Weather	According to SMHI's analysis: wind approx. west/5 knots with gusts up to 8 knots, visibility >10 km, no cloud below 5000 feet, temperature/dew point +5/-2°C, QNH[3] 1028 hPa
Persons on board:	3
Crew members including cabin crew	2
Passengers	1
Personal injuries	None
Damage to the aircraft	Substantially damaged
Other damage	None
Instructor:	
Age, licence	59 years, ATPL(H)[4]
Total flying hours	7,979 hours, of which 823 hours on type
Flying hours previous 90 days	37 hours on type
Number of landings previous 90 days	68 on type
Student:	
Age, licence	42 years, ATPL(H)
Total flying hours	6,500 hours, of which 4,000 hours on type
Flying hours previous 90 days	26 hours on type
Number of landings previous 90 days	150 on type

[1] ARC – Airworthiness Review Certificate.
[2] UTC – Coordinated Universal Time.
[3] QNH – altimeter set so that the altitude above mean sea level is obtained when on the ground.
[4] ATPL(H) – Airline Transport Pilot Licence Helicopter.

SUMMARY

In conjunction with an exercise in take-off from confined areas with simulated one engine inoperative, the rate of descent became too high and the landing was hard, which resulted in structural damage to the helicopter. None of those on board suffered any physical injuries.

The cause of the accident was that the exercise was performed too far outside of the exercise profile without the risks of this being identified.

A contributing factor was that there were no clear criteria indicated when and how the exercise was to be aborted.

An underlying cause at the systemic level was that the ancillary aviation safety organisation, including the safety and monitoring functions, did not have sufficient insight into how various elements were to be practised and had not conducted any assessment of risks in conjunction with the performance of the exercise as a result of a lack of staff and staff turnover, including the nominated persons.

Safety recommendations

In the light of the accident, the Swedish Maritime Administration has implemented a number of measures of both an aeronautical and management nature (see section 1.18.2). Considering the measures taken by the Swedish Maritime Administration, the Accident Investigation Board refrains from making any special safety recommendations.

1. FACTUAL INFORMATION

1.1 History of the flight

1.1.1 Circumstances

The flight was one of the air exercises that pilots who have just been employed by the Maritime Administration perform and that conclude the flight training before they are able to begin serving as standby crew as a co-pilot under supervision. The student pilot was experienced, both as a helicopter pilot and on the helicopter type. However, the student pilot had not practised the take-off profile in question previously, except in a simulator in the week prior to the occurrence.

Representatives of the Maritime Administration have stated that there is an insufficient number of helicopters to maintain operations at all five bases at the same time throughout the year. Nor does the training organisation have access to a specific helicopter for training purposes. Consequently, the helicopter that was being used for the training flight in question was, in accordance with the usual procedures, also on standby for SAR[5] operations, with a separate crew on standby. In order to maintain readiness during the training flight, the helicopter was equipped with materiel and fuel for a potential mission. In addition, it was necessary for the exercise to take place close to the standby crew so that the helicopter could be handed over quickly in the event of a potential mission.

The exercise was what is known as a familiarisation flight, the aims of which include to provide the student pilot with knowledge of the pertinent take-off and landing profiles, in this case *confined areas*[6]. The student pilot had previously performed the exercise in a simulator. Nevertheless, the simulator that was used did not have a full visual field downwards through the lower windows (‘chin windows’), which is necessary if it is to be possible for the exercise to be performed in accordance with the type certificate holder’s rotorcraft flight manual (RFM).

The exercise is normally not particularly dramatic and does not require the rapid monitoring and manoeuvring that are characteristic of, for example, emergency landing and autorotation exercises. Nor is the exercise deemed to lead to an increased risk that requires the emergency services to adopt a higher state of readiness.

The flight profile is used in twin-engine helicopters during take-off from confined areas with obstructions in front of the take-off site and involves the helicopter climbing vertically from the site to an altitude of 40 feet and then commencing a climbing reverse manoeuvre that continues until the helicopter has reached a ‘decision altitude’ This means that, from there, the pilot is able to dive to increase speed and fly

[5] SAR – Search And Rescue.
[6] Take-off from confined areas.

over obstacles ahead in the event of the failure of one engine (see Figure 1). Should an engine failure occur before the take-off decision point has been reached, the intention is for it to be possible to land the helicopter at the original take-off site. It is important that the pilot maintain visual contact with the take-off site until such time as the TDP[7] has been passed in order not to lose sight of the take-off site and risk not being able to abort the take-off in a safe manner.

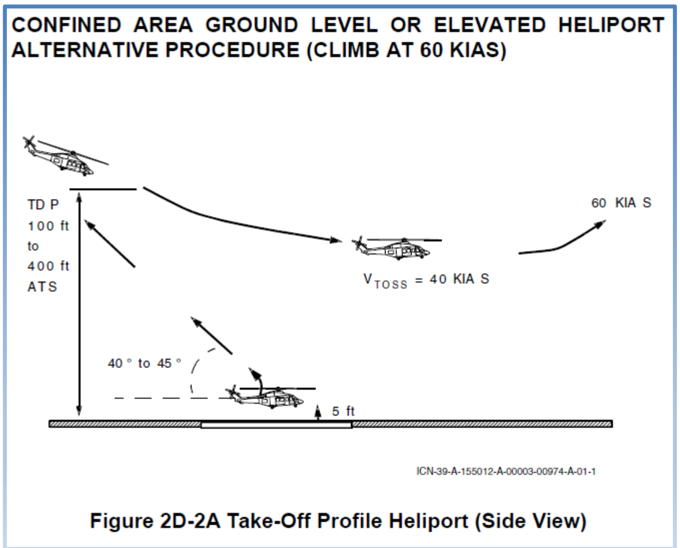

Figure 1. 2D-2A: Description of the take-off profile in the rotorcraft flight manual.

The exercise is based on maintaining a visual reference to the take-off site through the chin window and on maintaining a climbing movement throughout the entire sequence. If the engine failure occurs before the decision altitude has been reached, the pilot has to immediately utilise the climb gradient using what is termed a 'ballooning effect' and transition to forward movement in order to reach and land at the site from where they took off.

The flight profile is described in detail in the RFM, which contains images of the pilot's visual impression through the chin window at various altitudes. It is also governed clearly by specifying how much engine output is to be increased from hover prior to take-off and then from the state at which the helicopter transitions from climbing vertically to climbing backwards up to the TDP.

So that it is possible to monitor the flight profile by means of visual references and maintain continuous contact with the take-off site through the chin window, the pilot flying the helicopter has to yaw it once they reach 40 feet. If they are sitting on the left, the helicopter has to be yawed 10–15 degrees to the right. If they are sitting on the right, the helicopter has to be yawed 10–15 degrees to the left (see Figures 2–4).

[7] TDP (take-off decision point) – is determined prior to take-off and consists of an altimeter reference.

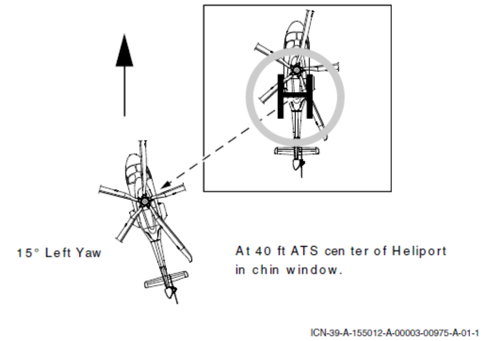

Figure 2D-2B Take-Off Profile Heliport, PF in RH Seat (Top View)

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Figure 2. 2D-2B: The images illustrate how the yaw is to be performed in order to maintain the references to the take-off site when the pilot is flying from the right seat.

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Figure 2D-13 Take-Off - View LH Seat TDP 100 ft ATS

Figure 3. The image illustrates the pilot’s visual impression through the chin window from the left side, 100 feet above the take-off site.

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Figure 2D-14 Take Off - View LH Seat TDP 150 ft ATS

Figure 4. The image illustrates the pilot’s visual impression through the chin window from the left side, 150 feet above the take-off site.

The exercise had been run through carefully during the simulator training and an alternative to the initial yaw had been discussed at that time. The student pilots had been given the opportunity to move sideways instead, i.e. the helicopter was moved in the opposite direction from the crew member who had control. The reason for this was that the yaw itself may overload the student pilot and because there were certain limitations with regard to downward vision in the simulator, which were accentuated when yawing the helicopter.

No specific abort criteria were discussed during the exercise.

1.1.2 Sequence of events

The training began with the student having to handle practiced engine failure from hovering at heights 5, 10, 20 and 30 feet for the purpose of verifying a good handling of the collective pitch to obtain a soft settlement on the ground.Thereafter the instructor demonstrated a take-off and landing of the flight profile involving an exercise in one-engine failure, the intention of which is to land with one engine (simulated) in the same place from where the helicopter took off. The exercise was demonstrated over the northern end of runway 03 at Visby Airport. Following this, they moved to the southern section of the runway, over the ‘03’ runway marking, having been asked to do so by air traffic control which had other traffic on the northern section of the field.

Once there, the student pilot began performing an equivalent take-off and landing profile involving a simulated failure of one engine. The exercise was performed perpendicular to the runway direction because the wind was westerly and and the exercise requires headwind or very limited crosswind component.

During the exercise, there was a tendency for the helicopter to land a little too far forward. Consequently, the instructor decided to perform an additional exercise.

During the introductory demonstration by the instructor take-off began with a 13-degree yaw. FDR data from the demonstration also shows that the take-off profile was performed by the book, with the engine output and attitude being adapted during the climb. During the student pilot’s first exercise, the yaw was slightly lower and began at a later stage than specified in the manual.

There was no yaw during the student pilot’s second attempt. During the preparations in the simulator, the student pilot had practised performing the yaw as described in the RFM where, by turning the helicopter, the starting position is maintained in the field of view during the take-off process, but was also shown that it was possible to replace the instructions described in the RFM with a sideways movement.

The initial reverse became problematic immediately. The reversing profile shows that the climb was steep, and the student pilot has stated that he lost his view of the landing site. Several attempts were made to correct the profile and the reverse speed during the climb. However, both the instructor and the student pilot felt that the profile was acceptable and that they, at least temporarily, got a good view of the landing site.

Nevertheless, the student pilot was not able to maintain a constant visual reference of the landing site in the chin window in accordance with the description in the RFM.

During the continued reversing climb towards the TDP, the instructor made the assessment that the angle had become too sharp to allow the helicopter to return to the take-off point in the event of an aborted take-off. As a result, the instructor extended the procedure slightly in order to give the student pilot the opportunity to correct the angel and return to the intended flight profile. This resulted in the helicopter continuing past the maximum recommended altitude of 400 feet up to 430 feet. When they reached the decision altitude, the rate of climb had decreased slightly and when the decision was made to simulate one engine inoperative, the helicopter was not climbing but descending a little while continuing to reverse.

When the instructor activated the training mode for simulating flight with one engine inoperative, the indicator for engine output showed a simulated loss of power in one engine. The student pilot reported ‘torque split’ and pushed the collective forward so that the nose was dropped markedly with the aim of transitioning from reverse motion to forward motion. The rate of descent increased and soon after the pilot raised the nose markedly, up to 20 degrees nose up, in order to reduce the effect of the preceding manoeuvre. At this stage, the student pilot again lost sight of the landing site. Immediately after this, the crew felt a large and unexpected descent (see Figure 5).

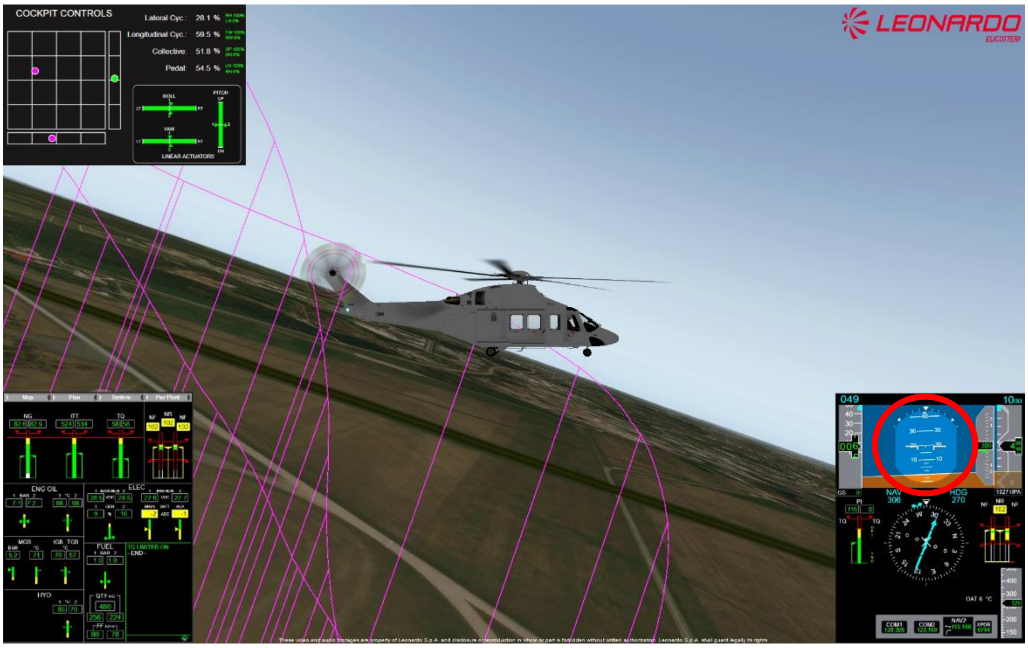

Figure 5. The helicopter's attitude immediately prior to the large vertical descent that followed the high nose position, the low speed and the limited power output. Source: FDR data and animation from Leonardo Helicopters.

In conjunction with the descent, the instructor had his left hand on the collective. There is a button on the collective called the 'torque limiter', which reinstates the power output from the engine when pressed. The instructor has stated that the way he was gripping the collective did not allow him to activate this function and that he made an immediate instinctive decision to focus on manoeuvring the helicopter using the limited engine output that was available. He did not want to move his gaze to the collective to look for the button, which under the prevailing circumstances could result in a loss of valuable seconds.

FDR data indicates that, just before the collision with the ground, the power output increased and the rotor RPM decreased in accordance with the logic that is to simulate the power obtained from only one engine. When the rotor speed fell to 87 %, a safety function took over and engaged full output so that the power from two engines could be used. The same data indicates that when the power output increased further with two engines, the rate of descent decreased. Nevertheless, the helicopter continued descending, which resulted in a collision with the ground.

The crew perceived the contact with the ground as a hard touch-down, but not so hard that it was felt to be damaging. The intention was to take-off once again when the student pilot in the cabin noticed that the helicopter's lifeboat had been released and was visible out of the wind-screen on the left cabin door. When the student pilot attempted to open the door to investigate what had happened, it was not possible to open the door and the door on the other side had to be used instead. The crew then shut down the engines and informed the tower of what had happened. No rescue operation was deemed necessary. The leak from the helicopter’s landing gear hydraulics that was later detected was cleaned up by the airport’s fire and rescue service in conjunction with the removal of the helicopter.

The flight profile that shows the final part of the flight, from take-off to collision with the ground, is shown in Figure 6.

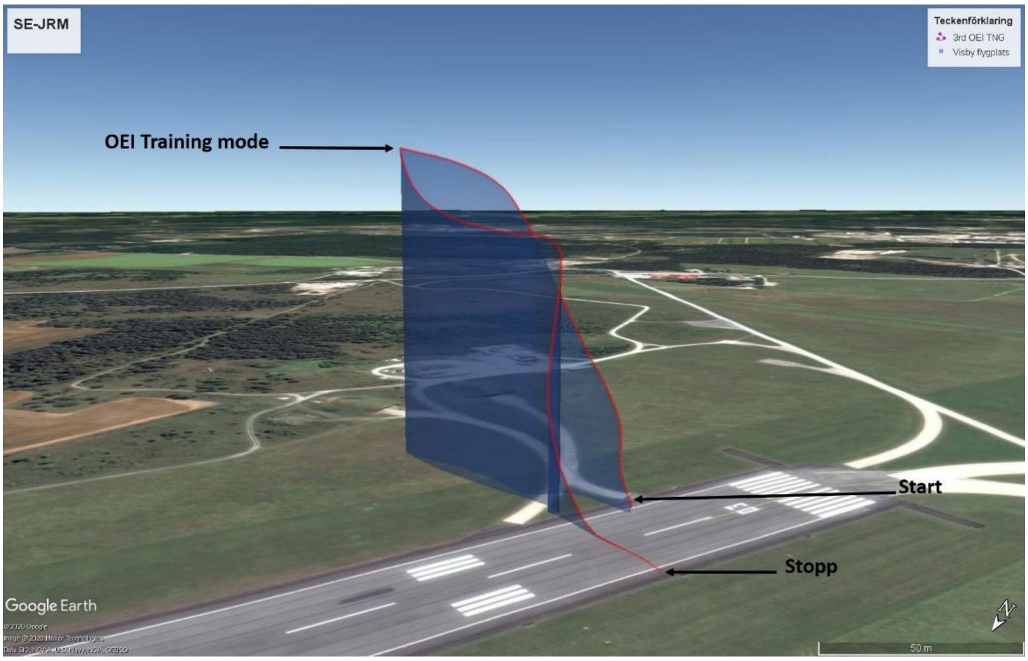

Figure 6. The red line shows the movement of the helicopter during the flight based on data from the FDR. Source: Leonardo Helicopters and Google Earth.

The flight lasted a total of half an hour and the fuel consumption was approximately 400 kg per hour during this type of operation.

The accident occurred at position 57º39’17N, 018º20’ 26E, 41 metres above mean sea level in daylight.

1.2 Personal injuries

	Crew members	Passengers	Total on board	Others
Deceased	-	-	-	-
Serious injuries	-	-	0	-
Minor injuries	-	-	0	Not applicable
No injuries	2	1	3	Not applicable
Total	2	1	3	-

1.3 Damage to the aircraft

Substantially damaged.

1.4 Other damage

None.

1.4.1 *Environmental impact*

A small oil spill occurred on the runway, which was cleaned up by the airport fire and rescue service following the occurrence.

1.5 Personnel information

1.5.1 *Qualifications and duty time of the pilots*

Instructor

Instructor was 59 years old and had a valid ATPL(H) with flight operational and medical eligibility. At the time, the instructor was PM[8].

Flying hours				
Latest	24 hours	7 days	90 days	Total
All types			37	7979
On type			37	823

Number of landings, on type – last 90 days: 68.
Type rating concluded on 1 June 2013.
Latest PC[9] conducted on 11 September 2019 on the AW139 simulator.

Student

Student was 42 years old and had a valid ATPL(H) with flight operational and medical eligibility. At the time, The pilot in command was PF.

Flying hours				
Latest	24 hours	7 days	90 days	Total
All types			26	6400
On type			26	4000

Number of landings, on type – last 90 days: 150.
Type rating concluded on 26 August 2010. Experience on the helicopter type has subsequently been built up abroad to encompass 4,000 hours over the course of various foreign postings in the period 2010–2019. Skill test and type rating according to EASA requirements conducted on 6 October 2019.

Latest PC conducted following the Swedish Maritime Administration's flight training on 21 November 2019 on the AW139.

Cabin crew

There were no cabin crew during the exercise but one other pilot student pilot was present in the cabin as a passenger as part of their own training.

[8] PM – Pilot Monitoring.
[9] PC – Proficiency Check.

1.6 Aircraft information

The AgustaWestland 139 is a twin-engine transport helicopter with a conventional configuration consisting of a five-blade main rotor, a four-blade tail rotor and three retractable wheeled landing gear.

1.6.1 Helicopter

TC-holder	LEONARDO S.p.A	
Model	AW139	
Serial number	31597	
Year of manufacture	2014	
Gross mass (kg)	Maximum take-off/landing mass 6,800, max. for the exercise 5,850, recommended 5,650, actual 5,809	
Centre of gravity	Within limits. CG 5,342 mm, min. 5,098, max. 5,537	
Total operating time (hours)	1946	
Operating time since latest inspection (hours)	80	
Number of cycles	3005	
Type of fuel uplifted before the occurrence	JET-A1	
Engine		
TC-holder	PRATT AND WHITNEY CANADA	
Type	PT6C-76C	
Number of engines	2	
Engine	No. 1	No. 2
Serial number	PCE-KB1632	PCE-KB1668
Total operating time (hours)	1828	1946
Operating time since latest inspection (hours)	270	270
Hold item list	Not relevant to the occurrence.	

The aircraft had a Certificate of Airworthiness and a valid ARC.

1.6.2 Training mode

The *training mode* function is used to simulate flying with one engine inoperative in a safe manner. Instead of reducing output, or shutting down one engine and allowing the other to take over propulsion, flying on one engine can be simulated by activating the *training mode* function. In *training mode* both engines supply power but a simulated performance and control logic results in the performance corresponding to flying on only one engine. This makes the helicopter feel less powerful and like it has poorer performance, while allowing the exercise to be performed in complete safety. When training mode is activated, it appears to the pilots as if there was an actual fault in which the combined torque of both engines is separated when one engine stops supplying power. This is reported by the pilot who detects it by saying 'torque split'.

The function is activated with a three-position switch "OEI TNG" on the center console between the pilots where you can choose which of the engines to simulate that it reduces the power (see Figure 7).

The RFM does not specify any limits for when training mode may be activated in conjunction with the exercise in question.

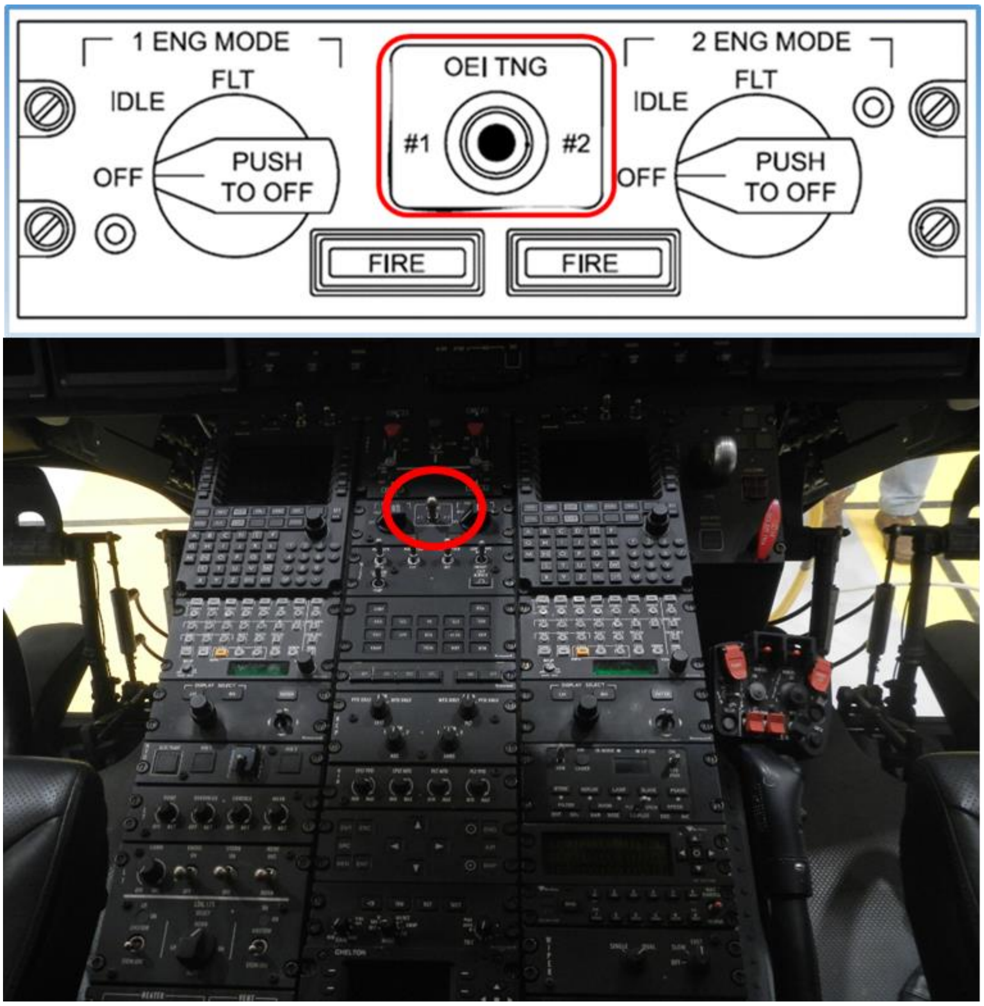

Figure 7. The red circle shows the design of the training mode switch. The panel is located on the centre console between the pilots.

Training mode is inactivated automatically if an actual fault with either motor occurs. The function is also deactivated if the switch is moved back to the central position, the output is altered with the collective such that the rotor speed falls to 87 % or by pressing a button, 'torque limiter' (TQ LIM), which is easily accessible on both pilots' collectives.

On the basis of the exercise that was being performed when the occurrence took place, from a design perspective, these functions can be said to provide redundancy in respect of one another. Should an unexpected occurrence take place during an exercise, it is possible to reinstate full engine output by simply pushing the training mode switch or torque limiter button. It should also be possible to activate the torque limiter button without the pilot needing to release the collective. As mentioned above, the torque limiter button is located on both collectives, the intention being for it to be activated using the thumb of the left hand. (see Figure 8).

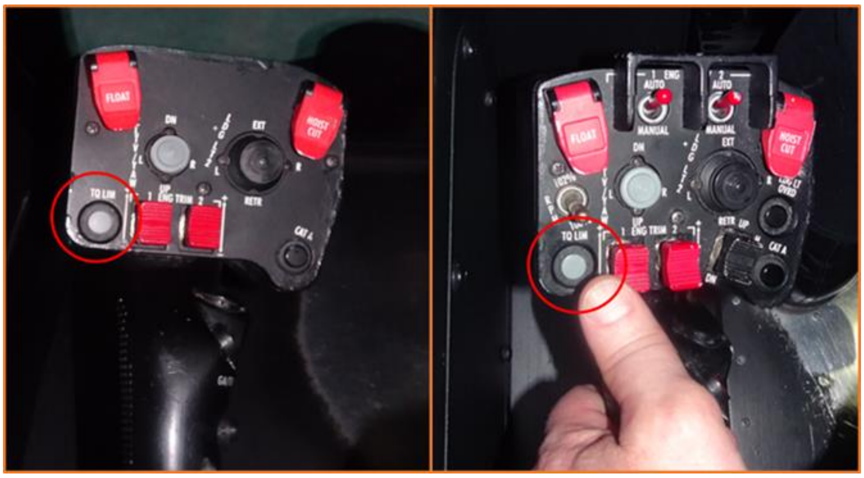

Figure 8. Head of the collective with the torque limiter (TQ LIM) button circled.

The torque limiter button has a distinctly different tactile design compared to the surrounding buttons. This makes it possible to find and activate this function without the pilot needing to search for it visually or to think about where it is located. Accordingly, the intention is for the design to reduce the visual and cognitive workload for the pilots.

1.6.3 Rotorcraft flight manual and recommendations

The exercise in question is described in the type certificate holder's manual AW139 RFM part D Confined area take-off procedures.

The manual states that the type certificate holder recommends that the exercise be initiated with a reduced mass of 5,650 kg, i.e. 200 kg under the maximum training mass. Furthermore, it emphasises the importance of maintaining visual references in the chin window throughout the entire sequence in order to ensure safety and maintain references to the landing site in the event of an aborted take-off. The recommended reduction in the mass was known to the instructor when the flight took place. With the prevailing wind, it was not deemed necessary to reduce the flight weight according to the recommendation. This was verified during the demonstration shown before the student's exercise.

It emerged during interviews with the instructor that the implementation of the exercise has been adapted to the Maritime Administration's operations.

As an alternative to the initial 10–15 degree yaw described in the RFM, the student pilot can instead make a sideways movement in the opposite direction to the side of the helicopter on which they are sitting, i.e. a sideways movement to the right if the pilot is sitting on the left side or vice versa. The reason for this is that the component in which the helicopter is yawed using the foot pedals increases the workload on student pilots. The alternative to the description in the RFM has thus been introduced in order to make the exercise easier for student pilots.

During the investigation, SHK has not seen any documentation in writing from the Maritime Administration to indicate that the alternative procedure is used or that describes the way in which it is to be performed.

1.6.4 Certification requirements for main landing gear and nose landing gear

The main landing gear and nose landing gear were originally certified by the EASA in accordance with the requirements in JAR[10] 29, amendment 3, paragraphs 29.725 and 29.727 for the limit drop test and reserve energy absorption drop test.

A combination of full-scale drop tests, simulations and analysis have been used in order to comply with the relevant certification requirements up to the maximum mass of 6,800 kg.

In particular, the most critical corners of the mass and balance diagram have been covered. In one-point, two-point and three-point landing configurations at maximum take-off mass (MTOM) and a vertical speed of up to 2.2 m/s for a normal landing and 2.8 m/s for a hard landing or reserve energy landing. This is done with the mass adjusted in order to take into account the remaining rotor lift in accordance with JAR 29.

A comparison between these figures and those recorded during the accident involving SE-JRM shows that the final recorded vertical speed prior to contact with the ground was approximately 1,200 feet/min., or 6.1 m/s. Data also show that the helicopter landed in a one-point configuration, with the remaining vertical speed far above the design characteristics of the main landing gear.

The actual mass of 5,850 kg was significantly lower than the maximum mass of 6,800 kg. However, the 13.9 per cent reduction in mass cannot itself compensate for the 218 per cent increase in vertical speed when compared with the design scenario. This is because the kinetic energy that the main landing gear and its attachments to the fuselage are subject to increase by the square of the vertical speed.

[10] JAR – Joint Aviation Requirements (-2013).

1.7 Meteorological information

According to SMHI’s analysis: Wind approx. west/5 knots with gusts up to 8 knots, visibility >10 km, no cloud below 5000 feet, temperature/dew point +5/-2°C, QNH 1028 hPa.

1.8 Aids to navigation

Not pertinent.

1.9 Radio communications

Not pertinent.

1.10 Aerodrome information

The airport had status in accordance with AIP[11] Sweden.

1.11 Flight recorders

The helicopter was equipped with a combined flight data recorder and cockpit voice recorder that was recording data and sound throughout the entire flight. SHK has analysed data and communications from the exercises in question.

1.11.1 Flight data recorders FDR[12]

The combined flight data recorder and cockpit voice recorder was a Penny & Giles Multi-Purpose Flight Recorder, PN: D51615-142, SN: A09638-002.

The flight data analysed indicate that the helicopter was hovering at an altitude of 6 feet with a power index (PI) of 2x83 %.

The procedure began with increased power and a relatively intense vertical climb that varied from 400–1,250 feet/min. over the period from take-off to the top. At 93 feet above the ground, the first ground speed (GS) above zero was recorded, which then varied from 2 to 14 knots and the vertical speed was at most 1,776 feet/min. during the reversing climb. Data indicate that the heading was constant following the vertical take-off and that no distinct 10–15 degree yaw to the right was performed during the climb in this exercise.

The entire climb took 42 seconds and the helicopter was at 430 feet when the OEI training switch was activated in order to simulate one engine inoperative. At this stage, the climb had ceased and there was no additional gain in altitude.

[11] AIP – Aeronautical Information Publication.
[12] FDR – Flight Data Recorder.

The rotor speed (Nr) fell to a minimum of 93.5 % following activation of OEI, 7 seconds after which the speed was back to 102 % at 353 feet. The pitch angle during this phase was decreased to nose down -10.55 degrees, before recovery took place and the pitch angle increased to 21 degrees nose up at 315 feet above the ground. The ground speed has varied during the approach, reaching up to 20 knots, until such time as the raising of the nose resulted in the speed falling to zero at 298 feet above the ground.

The rotor speed of 102 % was maintained down to 270 feet and the vertical speed (V/S), ‘the descent’, increased to 1,650 feet/min. For a short time the vertical speed increased to over 2,000 feet/min. A nose-down movement was initiated, which resulted in vertical speed of over 3,000 feet/min., at the same time as some forward motion was being obtained. The collective was raised and the rotor speed fell to 87.1 %, which causes the OEI training mode to deactivate automatically, at that same time, the FDR data recorded that the rotor speed was low (‘Rotor Low’).

The altitude was approximately 70 feet when the nose was raised, at the same time as the collective continued being raised in order to increase power. The vertical speed decreased in the final seconds to approximately 1,200 feet/min. before the helicopter made contact with the ground and bounced before the forward motion generated was checked.

The initial contact with the ground took place with the left main wheel and the vertical acceleration at that time was 3.38 G.

The FDR records radar altitude (RA) with a delay of one second.

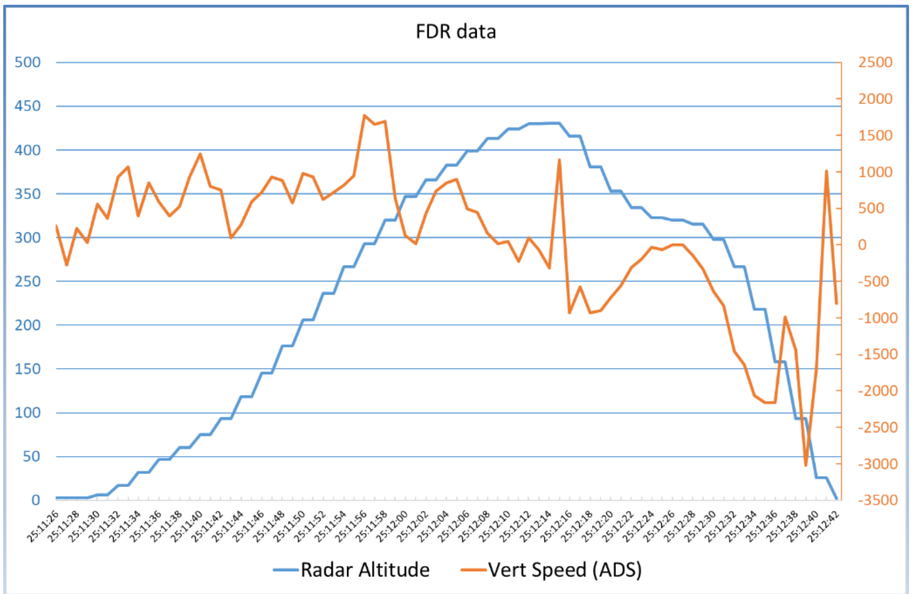

Figure 9. Shows how the radar altitude and vertical speed varied from take-off to the accident.

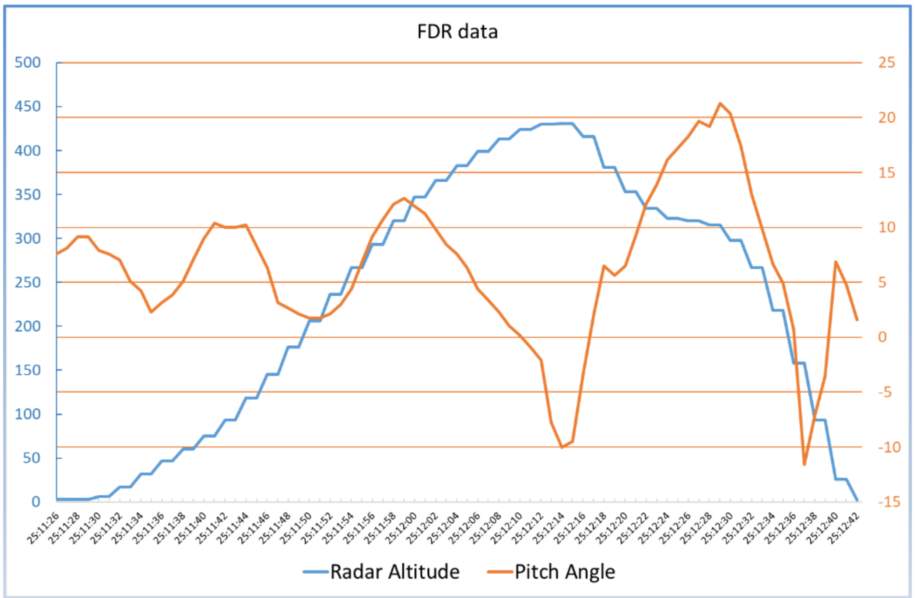

Figure 10. Shows how the radar altitude and the pitch angle (nose up and nose down) varied from take-off to the accident.

1.11.2 Cockpit voice recorder (CVR[13])

The voice recording indicates that communication has functioned as intended during the flight but that the dialogue between the pilots ceased during a critical element immediately prior to the accident. It has not been possible to record control of the helicopter being taken over.

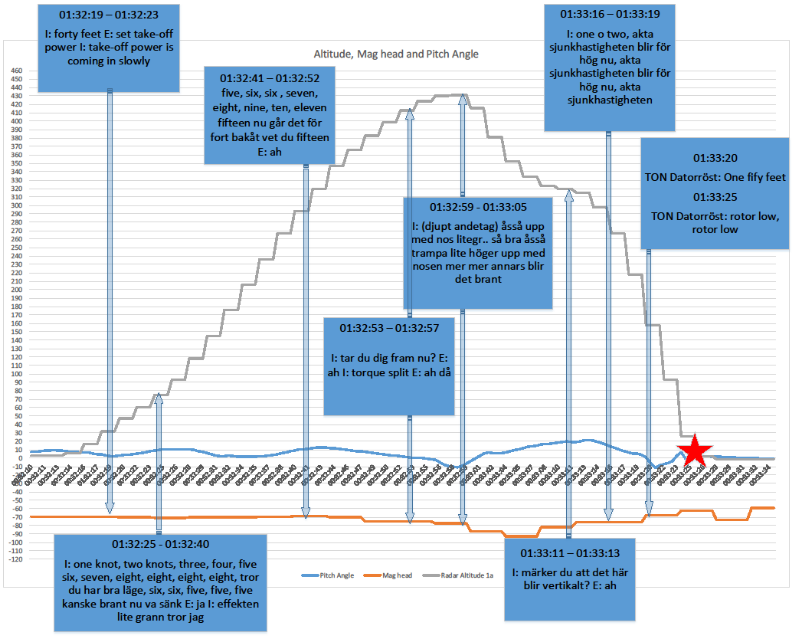

Figure 11. Shows the communication in the cockpit from the final take-off to the hard touch-down.

[13] CVR – Cockpit Voice Recorder.

1.12 Accident site and aircraft wreckage

1.12.1 Site of occurrence

The accident occurred at Visby Airport at the level of the marking for runway 03.

Figure 12. Part of runway 03 at Visby Airport, the approximate final position is marked by SHK. Source: Google Earth.

Figure 13. The helicopter's position after the occurrence.

1.12.2 Aircraft wreckage

The damage sustained by the helicopter was substantial. Following the occurrence, the helicopter was standing on its landing gear but leaning to the left. Structural damage occurred to the left landing gear and its attachments to the fuselage. Damage also occurred to panels and beams around the fuel compartment in the cabin. All of the structural damage was between fuselage stations 5700 and 7200, which is the area that begins behind the cabin door and ends at the beam for the rearmost attachment of the landing gear.

Figure 14. Right image: The damaged main landing gear and surrounding structure.
Left image: Structural damage from the inside of the fuel compartment.

1.13 Medical and pathological information

There is nothing to indicate that the mental and physical condition of any of the crew was impaired before or during the flight.

1.14 Fire

No fire broke out.

1.15 Survival aspects

1.15.1 Rescue operation

No rescue operation was initiated. The crew of the helicopter called the tower to inform them of what had happened. The helicopter, which remained on the runway with its nose wheel outside of the marked runway edge, was then towed away by its owner.

The emergency locator transmitter (ELT[14]) of the type HR Smith, PN: 503-16 was not activated at the time of the occurrence.

1.15.2 Position of crew and passengers and the use of seat belts

The instructor was sitting in the right front seat and the student pilot was sitting on the left, both were using the installed safety belts.

The accompanying student pilot was sitting on a bench by the front wall of the cabin, without a safety belt.

1.16 Tests and research

Not pertinent.

[14] ELT – Emergency Locator Transmitter.

1.17 Organisational and management information

The Swedish Maritime Administration is responsible for search and rescue (SAR) in Sweden. The helicopter in question is part of this organisation.

The Maritime Administration is led by a board. The Director General is the head of the authority and is also a member of its board. The Maritime Administration's operational management team consist of the Director General and the heads of the departments of planning and controlling, business, communication, shipping management, development and expertise, legal affairs, search and rescue, and icebreaking.

The Head of Search and Rescue (SAR) is responsible for leading and organising that department's capacity such that planning, implementation, follow-up, investigation, analysis and the implementation of measures leads to its activities being conducted in accordance with relevant domestic and international requirements. The Maritime Administration's rules of procedure state that this responsibility also includes producing guidelines for its activities, establishing requirements for the Joint Rescue Coordination Centre (JRCC), the helicopter unit and the search and rescue units, to ensure that the set goals for its activities are fulfilled, and ensuring that the helicopter operations have the correct resources for planned activities and that these are conducted in a safe manner.

There are three units that are under the supervision of the Head of Search and Rescue: SAR System Management, the JRCC and the helicopter unit.

1.17.1 The helicopter unit and the training organisation

The unit is responsible for accomplishment of the helicopter-based part of search and rescue, which therefore entails responsibility for the Maritime Administration's aviation operations, which are state aviation, and airworthiness in accordance with applicable regulations. The head of unit is responsible for ensuring it is possible to finance its activities and that its work can be performed in accordance with the conditions in respect of aviation safety imposed by the supervisory authority.

The civil aviation regulations stipulate that an aircraft operator shall have certain specifically appointed post holders that are approved by the supervisory authority, who are called nominated persons (NPs). Corresponding rules are also applied to the Maritime Administration's air operations.

The head of unit has a separate post as accountable manager (AM) and is approved by the supervisory authority, having been appointed by the Director General of the Maritime Administration. The AM reports directly to the Director General with regard to aviation safety and airworthiness and shall report and notify of circumstances of major importance within this field without delay. In addition, the AM shall set up and maintain a management system, corporate manual (CM), and be responsible for other appointed post holders that have specific requirements placed on them by the supervisory authority and are subject to its approval. These are the flight operations manager, the training manager, the ground operations manager, the unit's safety manager, the manager for continued airworthiness and the compliance monitoring manager (CMM).

The head of unit had been in post since April 2019. The flight operations manager at the helicopter unit has previously been the safety manager, but took up the post of acting flight operations manager when the then manager left his post in August 2019.

The current head of unit is the third person to hold this post since 2016. During the same period, two training managers (TMs) and safety managers (SMs) have left or changed their posts. The unit has not had any permanent instructors aside from the instructor in question, who is also the TM, since 2018.

In its final report RO 2019:01 (Thematic Investigation: Search and Rescue Operations with Helicopters Operated by the Swedish Maritime Administration), SHK addressed the conflicts that occurred within the Maritime Administration's organisation and the consequence of these, including a reduction in the number of reported discrepancies in the discrepancy management system used by the helicopter unit. According to information from interviews with personnel from the helicopter unit, there was a perceived lack of security, the consequences of which included that the pilots did not always report discrepancies. This is expressed through, among other things, the fact that very few reported occurrences involve mistakes on the part of the individual reporting them. To a certain extent, however, discrepancies did continue being reported, but not to the same extent as in the past. This is also confirmed by the Swedish Transport Agency's investigation[15] of the safety culture at the Maritime Administration's helicopter unit.

Training organisation

The training manager (TM) is responsible for the training of helicopter crews until such time as they become part of an SAR stand-by crew. From that point on, this responsibility passes to the aviation manager, who is responsible for flight operations, which also includes regular proficiency checks, known as line checks. When a pilot begins their employment, a training programme tailored to the operator begins, the aim of which is to allow the pilot to be part of an SAR crew as first officer under supervision. The training programme ahead of beginning

[15] TSL 2018-7675.

stand-by duty involves both training elements that are common to the whole unit and those that are specific to the crew. A large portion consists of flight operations training, which takes place partly in a flight simulator and partly in a helicopter. In addition to the training of new personnel, all categories of crew member also undergo repetitive training and regular operational checks.

Those who conduct the training of crew members are instructors who have been specifically appointed as instructors through decisions. The ability to complete the tailored training programme and the required repetitive training programme requires the air operator to have a suitable training organisation with access to instructors for the various crew categories and helicopters with which to undertake its activities. The training organisation is shown in Figure 15.

The Maritime Administration had intended to change the conditions for instructors' service in 2018 and 2019. The change to the conditions led to the majority of the instructors no longer being instructors. The chief instructor and two instructors remained, one of whom was in training, where the latter two periodically supported the training organization. As a result, only the chief flight instructors continued his training and examination roll in helicopters and simulator. Consequently, this instructor, who had been one of three experienced pilots that made up the introduction group that first trained themselves on the new helicopter type AW139, became uniquely qualified in his role. It was also the introduction group that, in the period 2013–2015, drew up the descriptions indicating how the various procedures were to be performed.

Attempts were made to employ new instructors in 2018 and 2019. However, the recruitment process was terminated in late summer 2019 due to the parties' failure to agree on terms. Since 2018, and up until the time of the occurrence, no new instructors have been recruited.

Consequently, in 2019 the chief instructor's principal duty became the training of new pilots on both the simulator and in the helicopter. Formally, however, he was still the deputy training manager, despite having no instructors to manage. In autumn 2019, the instructor's principal duties consisted of training three newly employed pilots up to the level of co-pilot under supervision. This means that he was responsible for both training and examination of the pilots in both the simulator and the helicopter. The workload that these duties resulted in led to the instructor's working hours being limited to four days a week during the training periods. With this limitation applied, the work situation was deemed acceptable. It has also been possible to complete the required training programmes during the period with the prioritisations that have been made.

It has emerged during interviews that the limited availability of instructors has resulted in difficulties for training operations. One person has kept training operations running almost single-handedly. At the same time, there has been limited insight into the details of training components for those not directly involved in day-to-day training. The training components have not been evaluated or risk assessed. Nor has any audit or similar been conducted in order to see how closely the training components adhere to the descriptions that have been drawn up or the specified curriculum. Nevertheless, opinions have been gathered in order to find out how well the student pilots thought the training programme lived up to the reality of live operations. In this respect, the feedback suggests that the training programme had prepared the prospective pilots for their future duties in a good way.

Provision of new instructors

The Maritime Administration has made various attempts to plan to get new qualified instructors approved by the Swedish Transport Agency. It has repeatedly been difficult to get this planning to correspond to the testing sessions arranged by the Transport Agency. According to the Maritime Administration, there have been too few of these sessions and they have been too infrequent.

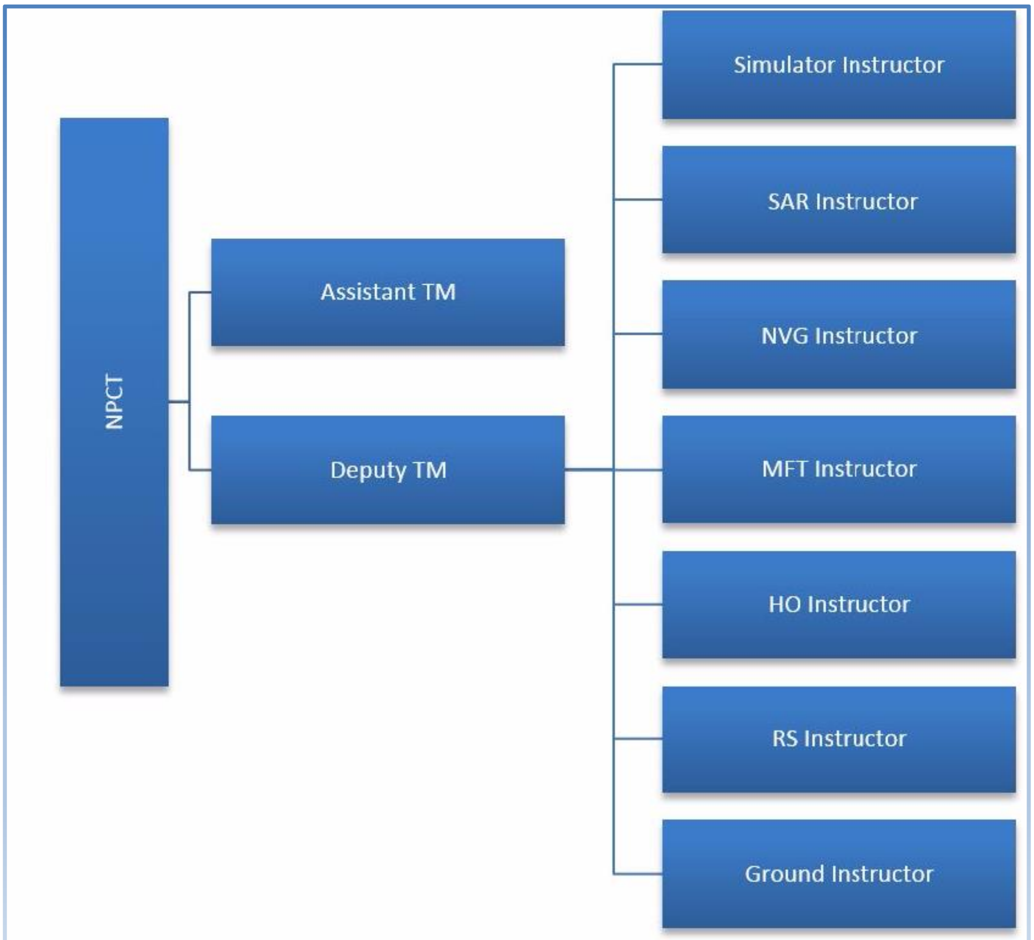

Figure 15. The training organisation in the Swedish Maritime Administration's helicopter unit. Source: Swedish Maritime Administration.

Training documents

The air operations described within the helicopter unit are documented in the operationally tailored operations manual (OM) that has been produced by the Maritime Administration. The air operations activities that include training are classified under OM-D. OM-D is based on the RFM[16]-D that the type certificate holder Leonardo Helicopters has published. Verbal information obtained by SHK indicates that the training programme is based on the RFM published by Leonardo. The RFM is a document that is based on the extensive test flight programme and tests that lead up to the type certificate being awarded. If an operator is to make a change to something that is described in the RFM, this should be preceded by a documented risk assessment and a decision by the person responsible, e.g. the aviation manager. No such changes, with the associated risk assessments, have been documented.

1.17.2 *Perception of time pressure in the Swedish Maritime Administration's training programme for new pilots*

During the investigation, information has been provided to the effect that the training programme that prospective pilots undergo is perceived as intensive. The time frame provided in which to go through all the training components is said to be tight, which also resulted in there having been limited scope if the need to practice certain specific components were to arise. In this respect, reference has also been made to the fact that the pilots have been added to the rota prior to having completed the final examination in advance of approval.

The student pilot in question has stated that the training components proceeded very well. The student pilot has also stated that the extensive experience he had of flying the helicopter type resulted in it being possible for him to be examined on the various components quickly and efficiently. Furthermore, the student pilot has stated that he did not perceive any time pressure during the training period or during the session in question.

For reasons of continuity, the Swedish Maritime Administration plans for the COPUS phase to begin immediately after SAR training has ended. The management of the helicopter operations has stated that if more time is needed for SAR training, the schedule can be revised. The working time agreement means that the schedule must be presented to the students two months in advance, which means that the students are scheduled as COPUS[17] even though the SAR training has not been completed and the starting point is for the training to be completed within the set time. The management of the helicopter operations has stated that all flying personnel are aware of the design of the working time agreement and this should therefore not cause stress.

[16] RFM – Rotorcraft Flight Manual.
[17] COPUS – Copilot Under Surveillance.

1.18 Additional information

1.18.1 Judging distance and binocular clues in conjunction with flight

Judging distance is dependent on various ‘binocular clues’, i.e. correctly judging distance requires visual clues to be processed by both eyes. These visual clues include relative sizes and relationships between different objects longitudinally. When the distance to a visual reference is unclear, it becomes harder to interpret the visual clues, the consequences of which include the uncertainty of the assessment increasing.

In its description of the exercise in question, the type certificate holder has emphasised the importance of maintaining the visual references that have been chosen for the performance of the exercise in the chin window. At a greater distance, judging distance is largely just as effective, regardless of whether one or two eyes are used. A correctly executed climb results in it being possible to observe the visual references through the chin window and good judgement of distance is thus maintained in relation to the movements of the helicopter. In addition, the uncertainty in the judgement of distance due to the distance to the visual references can be minimised when a procedure of this type is used.

1.18.2 Actions taken

Following the internal investigation of the incident carried out at the Swedish Maritime Administration Helicopter Unit, the investigators gave a number of recommendations. Based on these, the following measures have been taken;

- Current exercise is not carried out in the helicopter (immediate action after the incident, which has now also been introduced in the long term). Continued only in simulator at TR and also semi-annually at PC/OPC.
- Review and reworking of operational manuals OM-A, OM-B and OM-D is ongoing. This work is expected to be completed in September.
- New NPCT[18] has been recruited and appointed since 2020-04-01.
- Instructors in sufficient numbers for the training activities have been recruited and appointed in all crew categories since 2020-05-01. There are currently 4 instructors among the pilots and 2 each for HO[19] and RS[20].
- AM and Aviation Manager have quarterly reviews of the flight safety situation with the Director of Maritime Affairs and Air Rescue and the Director General.

[18] NPCT – Nominated Person Crew Training.
[19] HO – Hoist Operator.
[20] RS – Resque Swimmer.

1.19 Special methods of investigation

None.

2. ANALYSIS

2.1 Sequence of events

The type certificate holder's RFM states that the helicopter is to be yawed 10–15 degrees from the original orientation once it has left the ground. This yaw makes it possible for the pilot who is manoeuvring the helicopter to maintain their visual references in the chin window throughout the entire procedure. This is important because the exercise is based on it being possible to land in the same site from where the helicopter took off. The longer the distance to the visual references becomes, the harder it becomes to judge the distance. By fixing the visual references in the chin window throughout the entire exercise, spatial orientation and the ability to judge distance are maintained. The increase in engine power specified in the RFM from hover to climb means it is possible for the rate of climb to vary in proportion to the actual take-off mass, which affects the angle of climb. A more dynamic tailoring of the power to the prevailing conditions should make it easier to follow the described flight profile by means of the visual impression through the chin window.

During the student pilot's second attempt, there was no yaw and the student pilot has stated that they lost the visual references during the initial reversing climb. This resulted in impairment to their spatial orientation, which in turn had an impact on their chances of finding an acceptable reversing profile. This resulted in the reversing climb being too steep. It has emerged that the student pilots are offered an alternative to the initial 10–15 degree yaw and instead perform a sideways movement in order to capture the visual references. However, this did not take place during the training component.

Prior to the session in question, the instructor and the student pilot had not discussed or established conditions for when the exercise could be aborted. Nevertheless, there was always a basic pattern for aborting an exercise. When the instructor says 'my controls', the student pilot has to hand over control to the instructor or commander. No such takeover of control took place during the session in question.

The student pilot was very experienced on the helicopter type and felt confident in the cockpit. He was well acquainted with the handling of the instruments and controls. The instructor also had great confidence in the student pilot's ability to complete the training component. In advance, there was nothing to suggest that the student pilot would have any specific difficulties completing the component in question.

Both the student pilot and the instructor have stated that the reversing climb was perceived as acceptable and that during the session in question, they did not believe there was any need to abort the exercise. However, it is possible to establish following an analysis of the FDR data that the helicopter was outside of the exercise profile in question throughout pretty much the entirety of the reversing climb. During this part of the flight, the instructor also gave the student pilot several instructions with the aim of trying to correct the profile and speed.

When they reached the decision altitude, the climb had decreased slightly, even though the helicopter had already passed 400 feet, which is the recommended upper limit for performing the exercise. At this stage, the instructor asked the student pilot whether he thought he was able to take the helicopter down, which the student pilot responded to in the affirmative. When the instructor activated training mode in order to simulate one engine inoperative, the helicopter was not climbing but descending slightly while still reversing. In addition, it was difficult at this stage for the student pilot to make an accurate assessment of where the landing site was because he had lost visual references to the take-off site during the climb.

The fact that the exercise continued at this stage may be explained by the confidence the instructor had in the student pilot, with his extensive experience of the helicopter type, being able to correct the abnormal profile. The student pilot had completed the previous exercises in an excellent and rapid manner. The instructor also concluded prior to the start of the exercise that it was not a sufficiently difficult challenge for the student pilot to perform the exercise in line with the direction of the runway without a predetermined place to try to land. This suggests that the instructor wanted the exercise to be more challenging, which it is when performed perpendicular to the direction of the runway. At the same time, it was natural to carry out the exercise in that direction with regard to the prevailing wind.

When “training mode” was activated and the nose was immediately dropped markedly in order to transition to forward motion, at a stage where there was no longer upward movement, the height gain (‘ballooning effect’) in which the kinetic energy upwards is utilised during the transition, and on which the procedure is based, was absent. Instead, the descent and the speed increased in an undesirable way. In order to correct this, the nose was raised markedly, which resulted in a nose-up attitude of approximately 20 degrees. With the nose as high as this, with close to the maximum mass for the exercise and one engine in training mode, the result was a sudden and rapidly accelerating descent.

The silence in the communication between the instructor and the student pilot that occurred and the failure to inactivate training mode indicates that the crew was not prepared for the manoeuvre to have this outcome. Both the student pilot and the instructor have stated that it was only at this time that they felt the exercise went outside of what was expected, but neither the student pilot nor the instructor felt the nose-up attitude was as radical as it actually was.

The instructor had his left hand on the collective, but was not prepared to quickly inactivate training mode by, for example, pressing the torque limiter button. Once the descent had started, the instructor did not want to look down at the collective and instead intended to try manoeuvring the helicopter out of the situation. Activating the torque limiter or inactivating the training mode switch at an early stage would probably have resulted in a safe end to the exercise.

At a late stage, when the pilots increased the collective pitch in order to reduce the rate of descent close to the ground, and the rotor speed fell to 87 %, training mode was inactivated through the inbuilt safety function. The rate of descent decreased but the altitude was too low to avoid a hard landing. The fact that the rate of descent decreased with the increased power output and lift confirms that this was not a vortex ring state[21] into which the helicopter had been flown.

2.1.1 Abort criteria and positive training

Based on the available descriptions of how the procedure was to be practised and the interviews conducted by SHK, it is possible to conclude that there were no explicit abort criteria for the exercise at the time, with the exception of the call ‘my controls’, which meant that the commander is able to take over control of the helicopter.

As stated in section 2.1, there were several occasions when it would have been reasonable to abort the exercise given how the exercise was intended to be performed in accordance with the RFM. However, it is easy to draw this conclusion in retrospect, especially given the outcome. Nonetheless, the lack of abort criteria has resulted in it not being as easy for the pilots to identify them.

It is not SHK’s job to specify which abort criteria are appropriate for exercises performed by the Maritime Administration’s helicopter unit. It is however SHK’s opinion that ahead of every exercise component, there is a need to run through which abort criteria that should apply and how various situations are to be managed.

From an educational perspective, there is reason to point generally to the importance of building up student pilots’ skills in a positive way. It may be relevant here to talk about *positive learning*. That means practising in a way that builds up skills at a low tempo and where the levels of difficulty are well balanced in order to make the exercise more difficult at a suitable tempo until such time as the desired proficiency is achieved. This may involve components of an exercise being split up and practised one by one, or the exercise being simplified initially, e.g. for the exercise in question to initially be performed at a lower weight.

[21] Vortex ring state – name for a state during flight in which the engine is driving the rotor system and the helicopter gets stuck in its own downdraught and descends in an uncontrolled manner and where increased lift results in an increased rate of descent.

When the student pilot has completed all partial components, the component can be put together or the weight gradually increased. What is key to this concept is thus that the exercise is practised in a representative way, i.e. that procedures are adhered to and the established limits are not exceeded.

The opposite, i.e. negative experiences in training, involve ending up in situations that are perceived as overwhelming and that lead to the student pilot not successfully completing the exercise in one way or another. When a student pilot is faced with components that have negative connotations, their thoughts are that they do not want to experience the same thing again. In such a case, the learning takes place with negative consequences, i.e. the student pilot does not necessarily learn what they were supposed to. It is beneficial to perform components such as this in simulator environments where factors including the extremities of various exercises can be explored. While it is certainly true that overcoming situations that may be perceived as overwhelming can lead to better self-confidence, this does not necessarily lead to the correct behaviour being learned.

Furthermore, the accident investigation commission considers it good practice to begin performing the exercise without practicing one-engine-inoperative until the student pilot has good command of the flight profile. Only after this should one move on to practicing the procedure under one-engine-operative conditions.

In this respect, among others, it is important to abort the exercise at a suitable juncture when the positive experiences change into negative ones.

2.1.2 Departures from the procedure described in the RFM

As mentioned previously, an alternative had been introduced in the exercise that involved the helicopter being moved to the side instead of being initially yawed 10–15 degrees. This entailed a departure from the procedure specified in the RFM. This alternative was not being used at the time of the accident, but there is still reason to address this issue from the perspective of aviation safety.

As far as SHK is aware, this departure has not been documented in any way. Irrespective of how the alternative procedure affects the potential to maintain visual references in the chin window in a way that is similarly effective, a change to the procedure should be analysed, risk assessed and documented before being used.

2.1.3 Overall view based on the performance of the exercise

The overall view of the performance of the exercise is that it has not been performed in accordance with the RFM and that there were no set abort criteria in the event of excessive departures from the procedure being practised. In addition, an alternative exercise component has been introduced, which had not been analysed, risk assessed and documented.

The Accident Investigation Commission therefore opine that the Swedish Maritime Administration should review how the procedures are described in the training documents and identify if and in such a case what deviations occur in relation to the type certificate holder's flight manual, RFM. Such a review should include the current education and focus on whether concrete interruption criteria need to be formulated, both from a learning and a safety perspective.

2.2 Aviation safety organisation

The Swedish Maritime Administration's aviation safety organisation has recently been covered in an investigation by SHK and has been subject to an investigation of its safety culture by the Swedish Transport Agency. Based on the occurrence in question, there are still grounds to briefly address certain matters linked to the aviation safety organisation. These relate to the lack of instructors, the turnover of personnel in senior positions in the aviation safety organisation and the lack of helicopters and how this affects training activities.

As stated in section 1.17.1, in recent years, there has been a lack of instructors which has meant that the educational organization has had a strained situation for a long time.

There has also been a high turnover of personnel in senior positions. In addition, the reporting of discrepancies has decreased. Naturally, these are circumstances that risk having an impact on aviation safety.

A safety and training organisation shall normally have the scope to continually evaluate and challenge the way in which the organisation has chosen to undertake training components. This takes place partly through discussions between the post holders in the training organisation, i.e. the instructors, and partly through insight from the safety and monitoring functions in the aviation organisation. The chances of conducting adequate work of this nature is of course impaired by a lack of personnel and staff turnover, and by a reduction in the reporting of discrepancies.

It is SHK's opinion that this may be one explanation why the hazardous circumstances described in section 2.1 have not been identified and rectified previously.

Against this background, the Accident Investigation commission wishes to emphasize the importance of the measures taken to ensure that there is an organization that is staffed in relation to the requirements of the activity by ensuring that instructors are available to a sufficient extent and that particularly required positions such as Nominated persons, NP, are appointed over time. There are also certain in-built conditions with regard to availability of helicopters for training activities. It is not optimal that training takes place using a helicopter that is simultaneously on stand-by for rescue operations. Nor is it uncommon for this to be the case because the availability of helicopters is a limiting factor within the Maritime Administration. The result is therefore increased pressure on the training crews to adapt to the stand-by requirements. Consequently, certain flying sessions that should be performed with a relatively light helicopter may be performed at an increased mass, depending on the stand-by requirements of the helicopter. In the case in question, it was necessary to fly around for a time and perform landings outside of the field in order to get the mass down to the maximum permitted mass before it was possible to perform the intended exercise. To get down to the type certificate holder’s recommended mass, it would have been necessary to consume additional fuel equivalent to about half an hour of flying. All in all, this entails a potential conflict between the stand-by requirements and the need for training activities, which may result in exercises being performed under greater time pressure and more difficult conditions that is appropriate.

3. CONCLUSIONS

3.1 Findings

a) The pilots were qualified to perform the flight.
b) The helicopter had a certificate of airworthiness and a valid Airworthiness Review Certificate.
c) The helicopter landed in a one-point configuration, at a vertical speed far above the design characteristics of the main landing gear.
d) Training activities have been suffering from a lack of instructors for a long time.
e) Differences between the type certificate holder's RFM and the Swedish Maritime Administration's operations manual are not documented to a sufficient extent.
f) The recommended reduction in mass for the exercise was known to the instructor.
g) The exercise was not performed in accordance with the description that appears in the RFM.
h) The exercise was aborted at a late stage.
i) There are no limits specified for when training mode should be used in conjunction with the exercise in question.
j) A safety function intervened and deactivated the simulated one engine inoperative training mode when the rotor speed fell to 87 %.
k) Deactivation of the training mode resulted in increased lift, which reduced the rate of descent prior to the collision with the ground.

3.2 Causes/contributing factors

The cause of the accident was that the exercise was performed too far outside of the exercise profile without the risks of this being identified.

A contributing factor was that there were no clear criteria indicating when and how the exercise was to be aborted.

An underlying cause at the systemic level was that the ancillary aviation safety organisation, including the safety and monitoring functions, did not have sufficient insight into how various elements were to be practised and had not conducted any assessment of risks in conjunction with the performance of the exercise as a result of a lack of staff and staff turnover, including the nominated persons.

4. SAFETY RECOMMENDATIONS

In the light of the accident, the Swedish Maritime Administration has implemented a number of measures of both an aeronautical and management nature (see section 1.18.2). Considering the measures taken by the Swedish Maritime Administration, the Accident Investigation Board refrains from making any special safety recommendations.

On behalf of the Swedish Accident Investigation Authority,

Mikael Karanikas   Stefan Carneros