aibn Accident Investigation Board Norway

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REPORT SL 2019/08

REPORT ON AIR ACCIDENT 10 KM NORTH-WEST OF GRIMSTAD, AUST-AGDER COUNTY, NORWAY ON 21 JUNE 2018 INVOLVING HUGHES HU 369 D, OH-HNX, OPERATED BY HELIWEST OY

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As accurate as the translation might be, the original Norwegian text takes precedence as the report of reference.

Photos: AIBN and Trond Isaksen/OSL

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AIR ACCIDENT REPORT

Aircraft information:	Hughes HU 369 D
Nationality and registration:	Finnish, OH-HNX
Owner:	Heliwest OY, Helsinki-Malmi Airport, Finland
Operator:	Same as owner
Crew:	Commander and systems operator, both unharmed
Passengers:	None
Location:	In forested terrain between Stalleland and Valborgland, 10 km north-west of Grimstad, Aust-Agder County, Norway (58° 23' 36″ N, 008° 25' 01″ E)
Accident time:	Thursday, 21 June 2018 at 10:48

All times given in this report are local time (UTC + 2 hours), unless otherwise stated.

ACCIDENT NOTIFICATION

On 22 June 2018, at 13:00, the Civil Aviation Authority (Norway) notified the Accident Investigation Board Norway's (AIBN) on-duty officer that a Finnish-registered helicopter had been involved in an air accident or serious aircraft incident as it was inspecting power lines in Southern Norway. A short time later, it was confirmed that an HU 369 helicopter belonging to Heliwest with registration OH-HNX had severed a power line during laser scanning. The AIBN then contacted Heliwest directly, and decided based on available information to initiate an investigation.

Pursuant to ICAO Annex 13, "Aircraft Accident and Incident Investigation", the AIBN informed the authorities in the State of manufacture, the US, and the State of registration, Finland. The European Aviation Safety Agency (EASA) was also notified. The US and Finland both appointed an accredited representative. The representative from Finland has provided substantial contributions during the investigation.

SUMMARY

The Finnish helicopter company Heliwest was contracted by Agder Energi Nett to map and document the condition of 22 kV power distribution lines and surrounding areas. During this work north-west of Grimstad, the helicopter collided with a 132-kV power line that crossed over the 22-kV line. The main rotor cut all three conductors in the 132-kV line, but the helicopter was controllable, and the commander flew back to the base at Arendal Airport Gullknapp. After landing, it was ascertained that three main rotor blades were damaged at the tips. The helicopter was flying 40 – 50 m above the line to be mapped at a speed of 80 – 100 km/h when the collision occurred.

Due to a lapse, the crossing line was not registered during the pre-flight preparations. Due to a software error, data concerning crossing lines also could not be entered in the Vimap system that was used as a reference during the flight. The crew were thus dependent on visually discovering crossing lines in time to avoid collision. The AIBN is aware of three incidents in the Agder Counties involving crossing lines over a period of six months in 2018. What these three incidents

have in common is that safe flight was largely dependent on the crew discovering crossing lines in time. Warning signs that are physically mounted on the pylons, and which inform that a crossing line is coming up, will constitute an extra safety barrier against such collisions. The AIBN therefore recommends that the Civil Aviation Authority introduce a requirement for physical marking of crossing lines in Norway.

1. FACTUAL INFORMATION

1.1 History of the flight

1.1.1 The helicopter company Heliwest was contracted by Agder Energi Nett to map and document the condition of the power lines in the company's 22 kV distribution nett, including vegetation in the surrounding area. The documentation was carried out photographically and using laser scanning (LIDAR)[1]. The helicopter OH-HNX arrived in Norway on 6 June 2018 and the crew, which consisted of a pilot and a systems operator, conducted the first inspection flight on 8 June. The helicopter used Arendal Airport Gullknapp (ENGK) as base.

1.1.2 The evening before the accident occurred, the crew planned the flight by e.g. drawing the power lines to be inspected the next day on a paper map. Due to a lapse, the crossing line in question with which the helicopter later collided, had not been registered or drawn on the map. The crew had only planned to fly one sortie this day because they were going to fly back to the base at Helsinki-Malmi that afternoon in connection with Midsummer's Eve, which was to be celebrated on Friday evening. A fuel truck would normally be driven out to areas where the work would take place, but since only one sortie was planned, a decision was made to fly in an area near Gullknapp, thus rendering use of the fuel truck unnecessary.

1.1.3 The crew lived in Mandal. On the morning of 21 June, they ate breakfast before driving approx. one hour and 20 minutes to Gullknapp, where they arrived at approx. 07:20. They then completed a pre-flight check on the helicopter, prepared the equipment and signed a dedicated checklist for line inspection flights prepared by Heliwest. This checklist contained multiple safety-related items, including the item *"Daily risk analysis"*.

1.1.4 The helicopter took off at 08:45. It was flown by the commander in the left seat[2]. Apart from the helicopter's instruments, he used an iPad with the application (app) Air Navigation Pro for general navigation. The systems operator was in the right seat. There was a navigation display in front of him to the left. The display used the software Vimap and showed a map with the power lines to be inspected. There was a large screen (main screen) in front and to the right of the systems operator which showed the results from the photography and scanning. They also had the paper map the crew had prepared the evening before. On this map they e.g. marked the lines they had documented.

1.1.5 They flew 40 – 50 m above the line to be inspected at a speed of 80 – 100 km/h (43 – 54 kt). On their way north in the area north-west of Grimstad, the commander suddenly

[1] Long-range measurement technique utilising ultraviolet, visible or infra-red light to collect data. By measuring the time between or changes in the wave phase between an emitted laser signal and a reflected light, one can calculate the distance to, and other properties of, the object.

[2] The commander normally sits in the left seat in HU 369. This as opposed to most other helicopters, which are flown from the right seat.

discovered a crossing power line at the same altitude as the helicopter and immediately effected an evasive manoeuvre to the left (see Figure 4). At this time, the systems operator was looking at the *main screen* and heard the commander yell *crossing line*. When he looked up, he saw the power line pass above.

1.1.6 The two people on board have stated that they were unsure whether or not they had hit the power line. They did however notice vibrations in the helicopter and aborted the inspection. Once he ascertained that he had full control of the helicopter, the commander decided to fly approx. 21.5 km back to Gullknapp, where they landed at 10:58. The crew on OH-HNX did not notify the AFIS officer in the tower that something abnormal had occurred.

1.1.7 After the landing, the helicopter was put in the hangar and the crew notified the helicopter company. The helicopter company reported it as what they called a "nära på fall" (close call - trans.) to Agder Energi Nett at 15:33. At this point it was already clear that a power line outage had occurred at 10:48 and Agder Energi Nett had initiated an extensive effort to find the cause of the line fault.

1.1.8 Closer investigations of the helicopter revealed damage to the tips of three rotor blades. It became clear that the helicopter had cut all three conductors in a 132-kV power line belonging to Agder Energi Nett.

1.1.9 The commander has explained that the windows in the helicopter were clean and that glare was not a factor. However, they were flying with baseball caps on their heads that blocked the upward view. In addition to the fact that the power lines were very difficult to spot against the dark background, the use of caps may have been a factor contributing toward not spotting the line.

1.2 Injuries to persons

Table 1: Injuries to persons

Injuries	Crew	Passengers	Others
Fatalities			
Serious			
Minor/none	2		

1.3 Damage to aircraft

Damage to the tips of three main rotor blades meant that all five main rotor blades had to be replaced. The damage to the main rotor also resulted in extensive replacements and overhauls of components in the main rotor, the main rotor transmission and the engine.

Figure 1: The damage to the tip of one of the rotor blades. Photo: Heliwest

1.4 Other damage

1.4.1 All three conductors in the 132-kV line belonging to Agder Energi Nett were cut. Each line was 30 mm thick and consisted of a 10 mm thick spun steel core wrapped in aluminium strands.

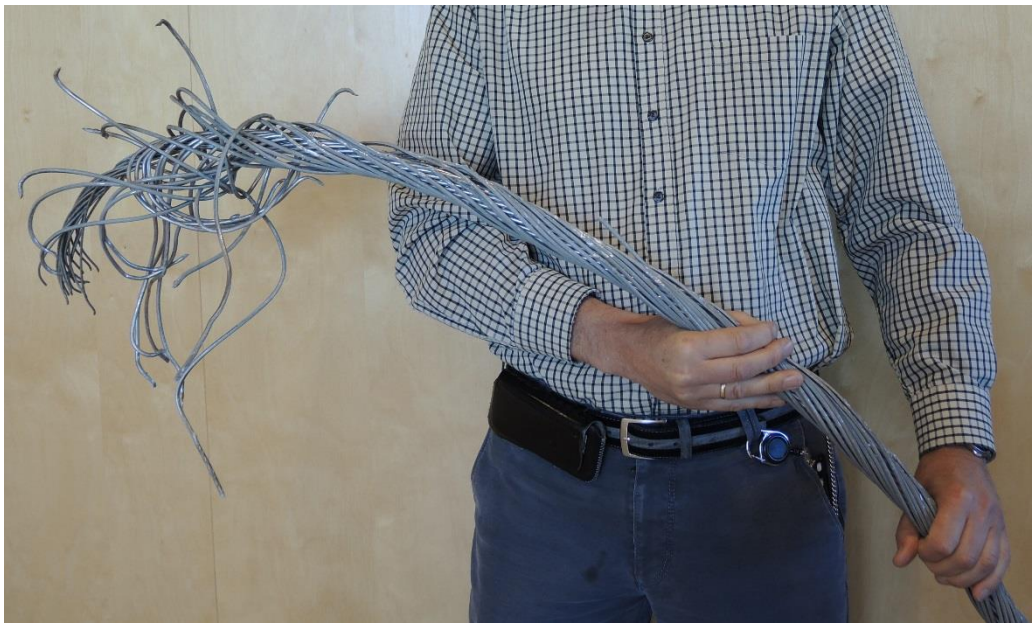

Figure 2: The end of one of the live conductors that was cut. Photo: AIBN

1.4.2 The line was part of a "ring structure", which is why no customers lost power. According to Agder Energi Nett, splicing of the just over 500 m long air span was resource-intensive and complicated.

1.5 Personnel information

1.5.1 Commander

1.5.1.1 The commander was 60 years of age and a Finnish citizen. He had flown helicopters since 1989. He held a commercial pilot licence for helicopters (CPL(H)) and approx. 6 000 hours of experience with flying line inspections, including with LIDAR equipment. He was also entitled to fly helicopters with under-sling loads (HESLO 3).

1.5.1.2 The commander had ratings to fly Robinson R44 and HU 369. His rating to fly HU 369 were validated on 20 April 2018 and was valid until 30 April 2019. The commander had a class 1 medical certificate with the restriction VML *"Correction for defective distant, intermediate and near vision"*. This certificate was valid until 16 December 2018. The commander had Level 4 English language skills, valid until 31 October 2019.

1.5.1.3 Due to poor weather, the commander had not flown during the period from 16 June to 21 June. He felt ready and rested before the flight started.

1.5.1.4 After the incident, the commander was on sick leave for two weeks, and then took two weeks' vacation.

Table 2: Flying hours commander

Flying hours	All types	Relevant type
Last 24 hours	2:12	2:12
Last 3 days	2:12	2:12
Last 30 days	74	74
Last 90 days	134	134
Total	11 870	6 876

1.5.2 Systems operator

1.5.2.1 The systems operator was 34 years of age and a Polish citizen. He worked for the sub-supplier Vimap. He held a commercial pilot licence for helicopters (CPL(H)), had instructor rights for sailplanes (SPL(FI)) and a private pilot licence (PPL(A)). The systems operator had flown a total of approx. 2 200 hours in addition to the time he had flown as systems operator.

1.5.2.2 Due to poor weather, the systems operator had not flown during the period from 16 June to 21 June. He felt ready and rested before the flight started.

1.6 Aircraft information

1.6.1 Introduction

1.6.1.1 Hughes HU 369 is a light single-engine helicopter with an Allison 250-C20B turbine engine. The helicopter is also called McDonnell Douglas MD 500 D. The equipment used during the assignment was installed in a Viking Helicopters Ltd. Cargo Pod mounted under the belly of the helicopter.

Manufactured 1977

Serial number: 47-0112D

Maximum allowed take-off mass: 1 157 kg

Fuel type: Jet A-1

Figure 3: The helicopter photographed in the hangar at Gullknapp the day after the accident. The inspection equipment is mounted in the white pod under the belly of the helicopter. Photo: Agder Energi Nett

1.6.1.2 The helicopter has a five-bladed rotor with a diameter of 8.05 m that rotates counter-clockwise, as viewed from above. The rotor's RPM is 487 – 492 revolutions per minute. Each rotor blade consists of an extruded aluminium spar encased in a single piece of laminated aerodynamic aluminium. The blade tips have an end piece and weights to balance the blades.

1.6.2 Equipment on board the helicopter

1.6.2.1 The mapping equipment on board was calibrated with focus at a 45 m distance. The mapping was therefore optimal if they flew 40 – 50 m above the power line. The equipment could function at speeds up to 120 km/h. Heliwest had determined that the optimal speed for quality weighed against the desired efficiency was 80 – 100 km/h.

1.6.2.2 The mapping systems on board were operated by the systems operator. He saw the power lines to be mapped on the navigation display. When the accident occurred, there was a problem with the Vimap software to the effect that it was not possible to enter digital map information about crossing power lines. According to the systems operator, the software issues were solved after the accident. Further, both the navigation display and *main display* also got audio warnings and visual warnings when they approached a crossing line entered in the system.

1.7 Meteorological information

Terminal Aerodrome Forecast (TAF) is not issued for Arendal Airport Gullknapp (ENGK). The relevant TAF was therefore obtained from Kristiansand Airport Kjevik (ENCN).

TAF ENCN 210800Z 2109/2118 32014KT CAVOK TEMPO 2109/2117 32015G25KT=

METAR ENGK 210850Z 34010KT 310V030 CAVOK 14/03 Q1004=

1.8 Aids to navigation

The commander used an iPad with the Air Navigation Pro app for navigation. The 132-kV power line in question, which the helicopter hit, was presented on the electronic map.

1.9 Communications

There was periodic two-way radio communication during the flight between the commander of OH-HNX and the air traffic services at Gullknapp.

1.10 Aerodrome information

Not applicable

1.11 Flight recorders

Not mandatory and not installed

1.12 Incident site

1.12.1 The incident occurred in hilly forested terrain 200 m north of Austertjenn lake approx. 10 km north-west of Grimstad (58° 23' 36″ N, 008° 25' 01″ E). The incident site is approx. 21.5 km south-west of Arendal Airport Gullknapp. At the intersection, the 22-kV line was 7.4 – 7.9 m above the terrain and the 132-kV line crossed 60 m above the 22-kV line. The pylons for the 132-kV line were on two peaks 584 m apart. Both of these peaks are approx. 200 m above sea level, while the lowest point of the valley between the two peaks is approx. 125 m. Due to elevation differences in the terrain, a corridor in the forest was not needed under the 132-kV line.

1.12.2 The 132-kV power line was not visually marked. Neither was it subject to a marking requirement because less than 100 metres of the line was more than 60 metres above the terrain[3]. The 22-kV power line was not marked with signage to inform about the crossing overhead line running above the power line, which is also not a requirement in Norway.

[3] FOR-2014-07-15-980 forskrift om rapportering, registrering og merking av luftfartshinder (BSL E 2-1). (Regulation No. 980 of 15 July 2014 relating to reporting, registration and marking of aviation obstacles)

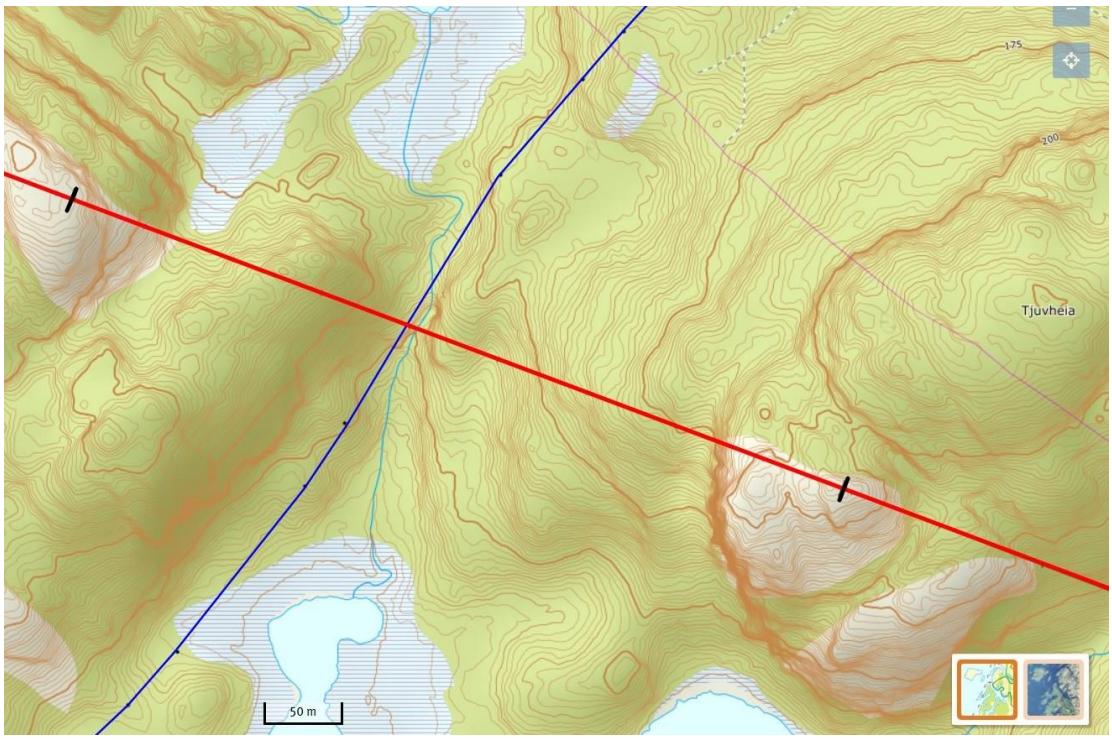

Figure 4: Area where the power lines crossed. The 132-kV line is indicated in red and the 22-kV line is indicated in blue. The northern part of Austertjenn lake is visible at the bottom of the image. Map: © Norwegian Mapping Authority

1.13 Medical and pathological information

Not relevant.

1.14 Fire

No fire occurred.

1.15 Survival aspects

The crew did not use helmets. After the accident, Heliwest introduced a requirement to use helmets during equivalent operations.

1.16 Tests and research

Not relevant.

1.17 Organizational and management information

1.17.1 Heliwest

1.17.1.1 Heliwest OY has its main base at Helsinki-Malmi Airport in Finland. The company has specialised in supplying helicopter services geared toward the energy sector. In this context, they had extensive experience with cutting power corridors in forests and laser scanning (LIDAR) of power lines. They were familiar with the conditions in Norway and had previously flown for both TrønderEnergi Nett and Hafslund Nett.

1.17.1.2 In its Operations Manual for Aerial Work Operations, Heliwest lists seven executive positions in the company (Nominated Postholders). Six of these positions are covered by

two people. At the time of the accident, Heliwest had three HU 369 helicopters and three Robinson R44 helicopters. The company outsourced technical services (CAMO and Part 145).

1.17.1.3 In connection with the inspection and mapping of power lines, Heliwest had an agreement with the Polish sub-supplier Vimap Sp.z.o.o. Equipment for photography and LIDAR were permanently mounted on the helicopter. Vimap also provided systems operators to operate the equipment on board the helicopter.

1.17.1.4 Heliwest used the Flyspect software for flight following and to plan operations. Using this system, the helicopter company could follow the helicopter operations at all times from the base at Helsinki-Malmi.

1.17.1.5 Heliwest has a number of manuals describing the company's operations in general and line inspections in particular. The procedures also describe how planning shall take place and how risks shall be mitigated or avoided. The following is stated in the company's operations manual for *Power Line Inspections and Photogrammametry* (OM SOP) under chapter (F)(1)(ii) *Preflight preparations*:

> *Checked powerlines are checked from maps. Any potential danger areas/obstacles/high ground/congested areas should be marked and noted. Especially 110 kV and higher voltage lines should be noted.*

1.17.1.6 Heliwest has stated that, on an annual basis, they had approx. 25 internal reports on non-conformances. These were continuously addressed by the company's internal reporting system. When asked by the AIBN whether the error in the Vimap software mentioned in section 1.6.2.2 had been reported, the company stated that it had not.

1.17.1.7 The Finnish Transport and Communications Agency carries out oversight with Heliwest. They conducted an audit of Heliwest on 14 and 15 May 2018. This was the first audit carried out at the company following introduction of the European regulations for aviation operators (Organisation Requirements for Air Operations – Part-ORO) and special operations (Special Operations – Part-SPO). The audit report describes a number of observations, 4 comments and 6 minor non-conformances. In the assessment of the Accident Investigation Board, none of these findings are directly related to the accident.

1.17.1.8 Heliwest reviewed the accident in a meeting on 29 June 2018. This included a review of the company's risk assessments of *Aerial Work* (document Aerial Work Risk Assessment AWRA-3). The risk matrix did not contain a dedicated item on the risk of colliding with crossing power lines during implementation of line inspections. In connection with this meeting, the following items were noted, among others:

- *Check material for crossing lines (Vimap crossline alert system)*
- *Checklist – every day, before every flight – crossing lines – paper maps*
- *Pilot iPad – crossing lines info*
- *Speed during inspection (reduce by approx. 10 %)*[4]

[4] From the original 80 – 100 km/h

1.17.2 Agder Energi Nett

1.17.2.1 Agder Energi Nett is part of Agder Energi, which is owned by municipalities in the Agder Counties and Statkraft Holding. Agder Energi Nett owns and has operating responsibility for the electric power regional and distribution network in the Agder Counties, a total of 20 600 km of lines. The company provides electric energy to 199 000 customers. At the time of the incident, the company had 157 employees.

1.17.2.2 In a meeting with the AIBN, Agder Energi Nett stated that they had increasingly begun to use helicopters in connection with inspection and maintenance of the power distribution network. The largest part of this work, estimated at approx. 80%, occurred in connection with planned work. However, following a period of considerable wind and snow in Southern Norway, substantial problems had arisen involving damaged power lines, power outages and the need for helicopter services was considerable. In order to be prepared for such sudden needs, Agder Energi Nett had entered into framework agreements with two helicopter companies.

1.17.2.3 Agder Energi Nett was of the opinion that it was the helicopter company's and pilot's responsibility to avoid aviation obstacles. However, the company was aware of the risk associated with such line inspections and they want to strengthen their procurement expertise regarding helicopter services.

1.17.2.4 Agder Energi Nett had considered marking all power lines with signs before crossing lines. However, they were somewhat reluctant to start posting signs for fear of potential subsequent legal requirements introducing new standards that required marking with other types of signs. After the accident, the company decided to mark all power lines.

1.17.3 Tender and contract formation

1.17.3.1 In connection with the inspection and documentation of the power distribution network, Agder Energi Nett invited a tender competition. It required the use of a helicopter with a turbine engine and adherence to the industry guidelines for "Helikoptertransport i kraftnæringen" (helicopter transport in the power industry). Four helicopter companies submitted tenders and two of them could deliver with the preferred equipment from the Polish sub-supplier Vimap. Price was weighted by 50%. Heliwest was preferred and "A-00853 Rammeavtale, Inspeksjon og skanning av høyspentlinjer" (Framework agreement, Inspection and scanning of high-voltage lines) was signed by Agder Energi Nett and Heliwest on 24 May. The agreement included inspection of up to 45 000 pylon points.

1.17.3.2 The framework agreement contained a so-called simplified SHA plan[5] prepared by Agder Energi Nett. The plan contained a form for risk assessment (SJA)[6] where no items were relevant for the inspection assignment in question. One annex to the framework agreement was Heliwest's performance description. Under the HSE[7] chapter, reference was made to the fact that the helicopter company's quality system was approved by the Norwegian aviation authorities. It was also pointed out that personnel from the sub-supplier Vimap were approved by the aviation authorities.

[5] Safety, Health and Working Environment Plan
[6] Safe Job Analysis
[7] Health, Safety and the Environment

1.17.3.3 On assignment from the Ministry of Transport and Communications through the Flight Safety Forum, Safetec was engaged to map and elucidate risk areas and potential measures for inland helicopter operations. The result was published in February 2013 in the report *Sikkerhetsstudie innlands helikopter*. (Inland helicopter safety study) The report e.g. concerns tender systems and price emphasis. One of the measures deemed to yield significant safety gains is the professionalisation of clients[8]:

> *The objective is for safety concerns to be emphasised to a greater extent in connection with tenders. This measure is presumed to entail a certain change in client preferences in connection with choosing a helicopter supplier.*

1.17.4 The Civil Aviation Authority

The Civil Aviation Authority stipulated the current Regulation[9] relating to reporting, registration and marking of aviation obstacles (the Marking Regulations, BSL E 2-1). This only establishes minimum requirements for marking aviation obstacles. The part of the Regulation that concerns registration and reporting has been published for consultation and is nearly ready for stipulation. The Civil Aviation Authority has stated to the AIBN that one should also consider revising the part of the Regulation that concerns marking. In connection with this, the Civil Aviation Authority has signalled that they take a positive view of a potential safety recommendation regarding a requirement for signage in connection with crossing lines.

1.18 Additional information

1.18.1 Marking in Sweden and Finland

1.18.1.1 Owners of power lines in Sweden and Finland have been required to mark power line pylons before crossing lines. In Sweden, the last three pylons before the crossing must bear signage. There is also extra signage if more than one line is crossing, if the crossing line is more than 10 metres above the line to be inspected, or if lines run close to each other. Heliwest has stated that they had good experiences with such signage.

[8] Measure T32 on p. 90 of the report
[9] FOR-2014-07-15-980 (Regulation No. 980 of 15 July 2014)

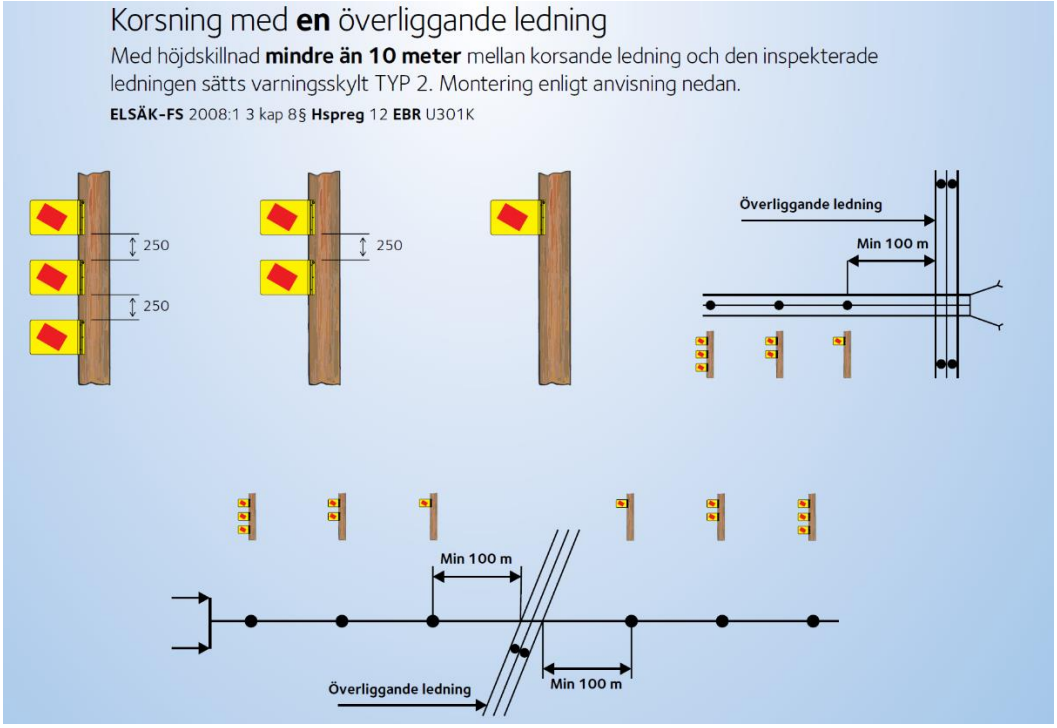

Figure 5: Example of signage in Sweden. Source: Sales catalogue from the company Hammarprodukter

1.18.1.2 In Norway, Helgeland Kraft has already marked all their lines. This signage is simpler than that in Sweden.

Figure 6: Signs on Helgeland Kraft's power distribution network notifying of an upcoming crossing line ahead. Photo: Pegasus AS

1.18.2 Similar incidents

1.18.2.1 On 18 January 2018, a helicopter from Pegasus Helicopter AS was close to colliding with a crossing power line in Marnardal municipality in Vest-Agder County. The helicopter

(LN-OST) was flying line inspections for Agder Energi Nett. The serious aircraft incident is described in the AIBN's report 2019/07.

1.18.2.2 On 13 February 2018, a helicopter from Fonnafly AS was close to colliding with a crossing power line during line inspections for Agder Energi Nett. The power line was marked and known, but attention lapsed for a moment and an evasive manoeuvre became necessary to avoid the crossing line. This incident was not reported as serious and was thus not forwarded to the AIBN. It was therefore not subject to a dedicated investigation by the AIBN.

1.18.2.3 The AIBN sees similarities between all three incidents and the report following the serious aircraft incident on 18 January 2018 is published alongside this report.

1.19 Useful or efficient investigation methods

No methods qualifying for special mention have been used in this investigation.

2. ANALYSIS

2.1 Introduction

2.1.1 The incident is classified as an air accident because the damage to the helicopter entailed replacement of all main rotor blades and extensive replacements and overhauls of components in the main rotor, the main rotor's drive train and the engine.

2.1.2 The risk of collision with crossing lines is very real in connection with helicopter work at low altitude along power lines. This is e.g. illustrated by the fact that, over a six-month period, Agder Energi Nett had three somewhat serious incidents in connection with work along the company's power distribution net. What these three incidents have in common is that safe flight was largely dependent on the commanders discovering crossing lines in time. Failure in this one barrier triggered the situations and only coincidences prevented a far worse outcome. The course of events is analysed in the chapter below. In Chapter 2.3, causal links and how the barriers can be strengthened is analysed, and in Chapter 2.4, signage for crossing lines is analysed.

2.2 The course of events

2.2.1 The AIBN believes that OH-HNX was very close to a total loss when it hit the crossing power line. The commander started a turn to the left to avoid the collision. The rotor disc tilt to the left entailed that the main rotor blades on the right were somewhat higher and hit the three conductors. The fact that the three blades sustained roughly the same damage indicates that the helicopter was flying in a relatively straight line when it hit. Had the main rotor disc remained horizontal, there is a chance that the helicopter could have passed under the conductors without touching them.

2.2.2 The power line consisted of three thick conductors. At a speed of 80 – 100 km/h, any contact between the conductors and the helicopter will normally entail significant damage to the helicopter and loss of control. The fact that the helicopter did not crash in this instance was due to the conductors being struck by the very tips of the main rotor blades. Rotation speed at the tips is approx. 743 km/h. When the rotor hit the conductors, the relative speed between the blade tips and conductors was 823 – 843 km/h. This meant

that the rotor blades had enough kinetic energy to cut the conductors without the rotor system sustaining immediate critical damage.

2.2.3 The AIBN can understand that the two were frightened by the thought that they could have hit the power line. The fact that the helicopter was controllable could be interpreted such that they had only touched a conductor. However, the AIBN believes it was unfortunate that they continued to fly approx. 21.5 km before landing and inspecting the damage, and that they did not notify the AFIS officer in the tower at Gullknapp about a possible emergency situation. The area was forested and rugged, but on their way to Gullknapp they passed multiple fields and open plains that could have been used as emergency landing sites. It is understandable that, following inspection of the damage, they could not imagine that all three conductors had been cut. This could help explain why it took almost 5 hours for Heliwest to notify Agder Energi Nett.

2.2.4 The AIBN has no reason to believe that potentially dirty windows, or that the commander had an obstructed view, were factors in this accident. The helicopter flew in a northerly direction, so glare was also not a factor. Overhead cables are generally very difficult to spot when they are viewed against terrain or other dark backgrounds. The power line in question was not physically marked, which also was not a requirement. The overhead cables were so high over the terrain that a power corridor had not been cut in the forest and the pylons were far to the sides of the helicopter's route. These factors may have contributed toward the limited visibility of the overhead cables.

2.3 Causal links

2.3.1 The risk of colliding with crossing lines is very real and must be prevented with barriers at multiple levels. At the overarching level, both the clients and the helicopter companies must be aware of this risk. Necessary attention must be given to helicopter safety when entering into framework agreements and contracts. *Sikkerhetsstudie innlands helikopter* (inland helicopter safety study) (see Item 1.17.3.3) is a good guideline in this context.

2.3.2 The helicopter companies are subject to extensive regulations, and are aware of the fact that flying at low altitudes entails an increased risk of accidents. However, clients appear to have a tendency to presume that their expected safety is safeguarded as long as the company or the person flying is approved by the authorities. In this context, it is important to point out that the helicopter companies are approved based on an assessment undertaken by the individual aviation authorities. One of the grounds for such approval is the company's safety system (Safety Management System - SMS). Even though the system is in place, it can be demanding to verify the appropriateness when the system is applied. The AIBN believes that the client (procurer) must have the necessary competence and undertake its own safety assessments of important parameters such as the suitability of the helicopter type, adaptation of equipment, experience and language and cultural differences when agreements are entered into. In other words, the nett companies can have a significant impact on the safety of helicopter operations, and one must continuously work to ensure that safety margins are as extensive as possible. This is particularly relevant for nett companies in instances where personnel from the nett companies are on board the helicopter.

2.3.3 One important point before work starts along power lines is that all necessary map information must be made available and used. Crossing lines can be marked on paper maps, but with various automatic notification systems available, it is important that data

can be transferred electronically. This may constitute an important barrier in addition to the commander's observation from the cockpit.

2.3.4 In the instance in question, the Vimap company was unable to enter crossing lines in the database due to a software error. In the opinion of the AIBN, this entailed the loss of a safety barrier that should have been reported as a non-conformance internally in Heliwest. If the crossing line had been in the database, the systems operator could have notified the commander that they were approaching a crossing line. He could then have reduced the speed and potentially undertaken a fly-over at a safe altitude to obtain an overview of the situation before he continued mapping the 22-kV line.

2.3.5 The commander had information about the crossing power line on his electronic maps on the iPad. However, when flying at high speed at low altitude over the terrain, the commander must direct his attention out of the cockpit to the greatest possible extent. Excessive focus on details on the moving map can thus have a negative impact on safety. However, the AIBN believes that the information from Air Navigation Pro would have been highly beneficial during planning of the flight and drawing on the paper map.

2.3.6 The AIBN believes that, in this instance, the crew exposed themselves to significant risk by flying at low altitude along the power line without assuring themselves that they had a full overview of crossing lines. Neither did they have any form of warnings about crossing lines. A software error and a lapse during the planning therefore entailed that safety depended solely on the commander spotting any crossing lines in time.

2.3.7 Heliwest has designated a 10% reduced flight speed as a measure following the accident. The AIBN believes that this will provide a marginally improved reaction time and reduced workload on board, but could hardly have prevented the accident from occurring. In the view of the AIBN, the fact that Vimap has subsequently been upgraded to warn about crossing lines is an important contribution toward improving safety, given that data about all relevant lines is available.

2.3.8 The crew on OH-HNX operated over a longer period of time while being physically separate from the company. This was very often the case for Heliwest crews and must be considered to be the company's normal operating pattern. However, this poses certain challenges as regards follow-up and safety management. The AIBN sees no direct connection between the accident and the fact that, in reality, the crew was operating in a highly independent manner. However, it is common knowledge that, as regards people or branches that operate independently while separate from the organisation's headquarters, deviations between procedures and relevant execution may occur gradually over time. This phenomenon is called *Drift into Failure* and is e.g. described by Scott A. Snook in the book *Friendly Fire* and Sidney Dekker in the book *Drift into Failure.* In such a context, Heliwest should consider whether the company has an adequate overview of the operations that take place out of view of the company's management.

2.4 Marking of crossing lines

The risk of colliding with crossing lines is very real and must be prevented with barriers at multiple levels. The recent incidents and the accident involving OH-HNX have shown that the measures that have so far been implemented are largely based on people not making mistakes. In connection with work along power lines, both people and sensor equipment will primarily aim their attention at the power line and associated pylons and

poles. Warning signs that are physically mounted on the poles, and notify that a crossing line is coming up, will most likely be easier to notice. The AIBN believes that such warning signage could constitute an important safety barrier and is issuing a safety recommendation concerning this.

3. CONCLUSION

In connection with helicopter work along power lines, the risk of colliding with crossing lines is very real and must be prevented with safety barriers on multiple levels. In the instance in question, safe flight depended solely on the commander visually spotting crossing power lines in time. When this did not occur, the helicopter collided with a 132 kV power line, which very nearly led to a total loss. The AIBN believes that warning signage about crossing overhead cables may constitute an important safety barrier and is issuing a safety recommendation to this effect.

3.1 Investigation results

a) In this investigation, the AIBN has not uncovered faults or irregularities in the helicopter that could have had an effect on the course of events.

b) The crew had valid licences and rights to serve on board the helicopter.

c) The weather was not a factor in the accident.

d) The digital map system Vimap was used to display the power lines to be inspected. A software error entailed that crossing power lines could not be entered in the map system.

e) The commander used an iPad with the Air Navigation Pro software for planning and general navigation.

f) The Air Navigation Pro database contained information about the power line that was hit.

g) The crew planned the assignment and e.g. drew the power lines to be mapped on a paper map. Due to a lapse, the crossing power line was not discovered or drawn in during the planning.

h) The crossing power line was shown on the digital map in Air Navigation Pro, but at high speed and low altitude, the commander had to devote attention outside the helicopter and the line was not spotted in time.

i) The AIBN believes that the crew exposed themselves to significant risk by flying at low altitude along the power line without ensuring themselves that they had a full overview of crossing lines.

j) The crossing line was not subject to a marking requirement and was not marked.

k) There was no corridor in the forest below the crossing line and the distance between the pylons was 584 m. It could thus be difficult to spot the line visually.

l) The commander discovered the crossing power line so late that he did not have time to complete an evasive manoeuvre before the helicopter collided.

m) Three blades on the main rotor cut all three conductors in the crossing power line.

n) No customers lost power as a result of the damage, but splicing of the power line was resource-intensive and complicated.

o) The AIBN believes that the helicopter was very close to a total loss when it hit the crossing power line.

p) The helicopter experienced vibrations, but the commander chose to fly back to Arendal Airport Gullknapp before landing and inspecting the damage.

q) The accident in question was the third incident in six months for the same nett company in connection with helicopter assignments and crossing power lines. This shows that the risk of collision is very real.

r) Following the accident, the software error in Vimap has been corrected and the system has an audio warning and visual warning when approaching a crossing line.

s) The software error in Vimap was not reported as a non-conformance in Heliwest's internal reporting system.

t) The client did not stipulate special safety requirements for the helicopter company.

u) The helicopter companies are approved according to a general standard, e.g. based on the company's safety system. Even though the system is in place, it can be demanding to verify the appropriateness when the system is applied.

v) Both clients and helicopter companies should facilitate to ensure that helicopter flights can be as safe as possible in connection with work on power lines.

w) As opposed to Norway, Sweden and Finland have introduced requirements for physical marking of power lines before they are crossed by overhead cables.

x) The AIBN believes that physical marking of power lines could, to a substantial extent, prevent the risk of collision.

4. SAFETY RECOMMENDATIONS

The Accident Investigation Board Norway (AIBN) makes the following safety recommendation:[10]

Safety recommendation SL no. 2019/01T

On 21 June 2018 OH-HNX, a helicopter from Heliwest hit a crossing power line and cut all three conductors. The risk of collision with crossing lines is very real in connection with helicopter work at low altitude along power lines. This is e.g. illustrated by the fact that, over a six-month period, Agder Energi Nett had three incidents in connection with work along the company's power distribution network. Sweden and Finland have introduced requirements for physical marking of power lines before they are crossed by overhead cables. The AIBN believes such marking could, to a substantial degree, prevent the risk of collision.

The Accident Investigations Board Norway recommends that the Civil Aviation Authority introduce requirements for physical marking of crossing lines in Norway.

Accident Investigation Board Norway

Lillestrøm, 25 June 2019

[10] The Ministry of Transport and Communications ensures that safety recommendations are presented to the aviation authorities and/or other relevant ministries for assessment and follow-up, cf. Section 8 of the Regulations relating to public investigation of air traffic accidents and incidents in civil aviation.

APPENDICES

Appendix A: Relevant abbreviations

APPENDIX A: RELEVANT ABBREVIATIONS

AFIS	Aerodrome Flight Information Service
BSL	Bestemmelser for sivil luftfart (Norwegian Civil Aviation Regulations)
CAMO	Continuing Airworthiness Management Organization
kt	knot(s) –Nautical Mile(s) (1 852 m) per hour
kV	kilovolt
LIDAR	laser scanning utilising ultraviolet, visible or infra-red light
N	North (North latitude)
rpm	Revolutions Per Minute
TAF	Terminal Aerodrome Forecast
UTC	Coordinated Universal Time
E	East