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REPORT ON MARINE ACCIDENT ON BOARD THE MOTOR FERRY MF RØST - LDWE, NEAR SKROVA ON 18 MAY 2013

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This report has been translated into English and published by the Accident Investigation Board Norway (AIBN) to facilitate access by international readers. As accurate as the translation might be, the original Norwegian text takes precedence as the report of reference.

Photo of ferry on the Norwegian west coast: Bente Amandussen

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NOTIFICATION OF THE ACCIDENT

On 18 May 2013, the Accident Investigation Board Norway (AIBN) was notified by the Joint Rescue Coordination Centre Northern Norway (JRCC-N) of a fatal work accident on board the motor ferry *MF Røst* en route from Skrova to Svolvær. A member of crew had fallen 8–10 metres from the radar mast to the deck. The AIBN arrived in Svolvær on Sunday 19 May to look into the circumstances surrounding the accident and, on 21 May, it decided to initiate an investigation of the accident.

On 23 May, the AIBN conducted interviews with the management of the shipping company Torghatten Nord AS in Tromsø. Technical examinations on board the vessel and interviews with the crew were conducted in Svolvær on 5 and 6 June.

Figure 1: The accident occurred in the Fyrsundet sound, southwest of Skrova in Lofoten. Source: AIBN

SUMMARY

The shipping company Torghatten Nord AS had just deployed *MF Røst* in the Svolvær-Skutvik-Skrova ferry service. The crew had been given a verbal message from the shipping company not to sail through Fyrsundet sound until further notice, as the aft mast was assumed to be too high for *MF Røst* to pass under the overhead high-voltage cables. However, the captain and chief mate on duty at the time of the accident believed that it would be possible for *MF Røst* to pass under the cables.

On 18 May 2013, they therefore intended to verify the distance between the vessel's aft mast and the overhead cables. The nautical charts showed a safe vertical clearance of 20 metres, while the signs ashore showed 22 metres. The shipboard management had measured the vessel's air draught to be 20.7 metres from the waterline to the top of the aft mast.

On reaching Fyrsundet, the chief mate climbed into the fore mast. The fore mast was slightly lower than the aft mast. He wished to observe the passage under the overhead cables from the fore mast and to check the margin between the mast and the cables using a fishing rod that he had taken with him. His intention was to use the fishing rod to simulate the height of the aft mast, which they had already calculated would pass under the overhead cables with a clearance of 90 cm. However, as the vessel passed under the last of the three high-voltage cables, the fishing rod came in contact with the high-voltage field around the cable, or in contact with the high-voltage cable itself. The chief mate received an electric shock and died as a consequence of falling down from the fore mast.

The shipping company had in place a basically well-documented safety management system, but no risk assessment for *MF Røst* in its new service or any pertaining fairway description was available at the time of the accident.

In the AIBN's opinion, the information flow was inadequate, both as regards the communication of safety-critical information before switching vessels, and as regards the division of responsibility between the vessel and the shipping company. A safety recommendation is submitted to the shipping company in this connection.

The AIBN found that the difference between the vertical clearance for the power cables shown in the charts and the figure shown on the signs ashore is connected with lack of routines for reporting of chart data and the continuous updating of navigational charts. Further the investigation show that the power cables hung lower than recorded at the last modification. In the AIBN's opinion, keeping nautical charts up to date, unambiguous information on signs ashore and follow up of power cables height, are all areas that need to be reviewed and quality assured so as to provide clear and unambiguous information to seafarers. The AIBN submits a safety recommendation to the Norwegian Coastal Administration on this point.

The investigation established that the crew was not familiar with the requirement for a safety margin in relation to overhead cables carrying high voltage. Two safety recommendations are issued to ensure that seafarers can be provided with practical advice and recommendations in this area: one for the Norwegian Hydrographic Service and one for the International Chamber of Shipping (ICS).

The Accident Investigation Board Norway proposes four safety recommendations as a result of the investigation.

1. FACTUAL INFORMATION

1.1 Details of the vessel and the accident

Details of the vessel

Vessel's name and call signal	:	MF Røst – LDWE
Shipping company/responsible for ISM	:	Torghatten Nord AS
Home port	:	Svolvær
Flag state and flag	:	Norway – NOR
Year built	:	1991
Construction material	:	Steel
Length overall	:	66.2 m
Breadth	:	13.4 m
Draught	:	4.7 m
Mast height	:	21.4 m
Gross tonnage	:	2,053
Engine power	:	3,676 KW
Service speed	:	17.2 knots
Passenger capacity	:	250

Details of the accident

Time and date	:	18:50, 18 May 2013
Site of accident	:	Fyrsundet
Persons on board	:	8 crew and 2 passengers
Cargo/goods on board	:	1 private car
Injured/dead	:	One crew member died

Figure 2: 'MF Røst' (owned by Torghatten Nord AS). Photo: Victoria Lovise Solaas

1.2 Chain of events

1.2.1 Taking over the ferry service

In February 2013, by agreement with the county administration, Torghatten Nord decided that *MF Røst* by the end of April that year would take over operation of the Skutvik–Skrova–Svolvær ferry service from *MF Vågan*. After a routine yard stay, *MF Røst* sailed

northwards from Ålesund and arrived in Svolvær as planned on 18 April. The crew were familiar with the fairway, but as *MF Røst* had not previously operated on this route, sea trials and vessel checkout were carried out. Special priority was given to the vessel's procedures and testing of the ferry landings.

MF Røst made its first official voyage in the new service on 29 April.

When the service was operated by *MF Vågan*, it had used Fyrsundet[1] as an alternative to the regular route between Skrova and Skutvik. There is an overhead span of three high-voltage power cables across the sound in Fyrsundet. The power company Lofotkraft raised the overhead cables in 1993 at the request of the company that operated *MF Vågan* at the time, so that the cables did not interfere with the safe passage of the vessel, whose air draught (greatest mast height) is stated to be 18.9 m. According to Nautical Chart No 73, Fyrsundet has a safe vertical clearance of 20 metres, while the warning signs posted ashore at the sound indicate 22 metres.

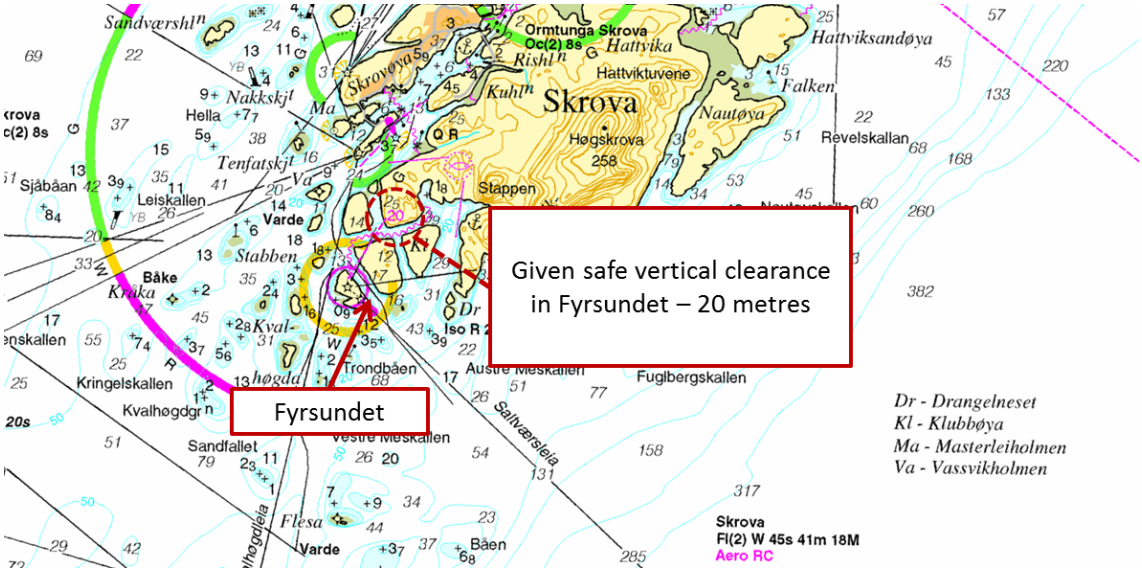

Figure 3: Detailed map section from the Norwegian Mapping Authority's Nautical Chart No 73 (corrected as of the date of 'Etteretning til sjøfarende' (Efs)[2] No 16/13 covering Skrova, Skrova lighthouse and Fyrsundet, indicating a safe vertical clearance of 20 metres.
Source: the Norwegian Hydrographic Service

1.2.2 Chain of events on 18 May 2013

In the early morning of 18 May, while the ferry was berthed at Skrova, the crew used the ferry's workboat to sail out to Fyrsundet to measure the height of the lowest of the three cables that lead to the lighthouse. They did so by using a water-filled plastic bottle attached to a string that they threw over the cable, and then measuring the string after retrieving it. Calculations from the measured distance at actual tidal water and up to the cable, showed a physical vertical clearance of 21.6 metres at the highest astronomical tide (HAT).

[1] The place name on the chart is 'Saltværsundet', while the place name 'Fyrsundet' is used in the shipping company's documentation and generally when the sound is referred to in that company.
[2] Etteretning for sjøfarende (Eft) = Norwegian notice to mariners

Later that day, while berthed at Svolvær, they measured the physical distance to the sea from the highest point on the ferry, which was the top of the aft mast, at the vessel's draught at the time. The measurement showed an air draught of 20.7 m. This formed the basis for calculations and led to the conclusion that there was a clearance of 90 cm (21.6 – 20.7 m) from the aft mast on *MF Røst* to the overhead cables at HAT.

On their next return journey from Skutvik, the captain decided that they would sail through Fyrsundet in order to verify safe passage. The chief mate volunteered to climb up the fore mast of the vessel, which is approximately 1.4 m shorter than the aft mast. The reason for climbing up the fore mast was that he from the top of the mast would be able to visually observe whether their calculations provided the expected safe distance between the aft mast and the overhead cables. In addition he was to report on status in this respect as they progressed.

The mast could not be seen from the captain's position at the centre console on the bridge, and crew were therefore positioned aft on both sides of the bridge to observe the person in the mast. They were intended to act as a communication link with the captain.

MF Røst arrived at Fyrsundet just before 19:00 on Saturday 18 May and approached the overhead cable span at the minimum steering speed. The low speed was chosen so that it would be possible to reverse the engines and go astern out of the tight sound in the unexpected event that the observations should show that there was insufficient clearance for the aft mast.

The chief mate had donned a simple safety belt without shoulder straps (Figure 6). He took with him a 2.7-metre long fishing rod for simulating the height difference between the forward and aft masts. The fishing rod was mainly made of carbon material. The chief mate stood at the highest point in the mast while holding the fishing rod in his right hand and extending his arm.

The crew on deck saw that *MF Røst* passed under two of the three cables with sufficient clearance to the fore mast, before observing a strong flash of light as the ferry passed under the third and lowest cable. The chief mate fell straight out to the left of the mast and fell 8-10 metres to the deck below, head first. He still had his safety belt on after the fall. Lofotkraft registered a transient short circuit in its power cables at 18:50:01 on 18 May, lasting 162 milliseconds.

Witness observations of a strong flash of light, the burn mark found on one of the power cables (Figure 4), the short circuit registered by the power company and burn marks at the tip and lower end of the fishing rod are all consistent with that there having been momentary direct contact between the fishing rod and the high-voltage power line.

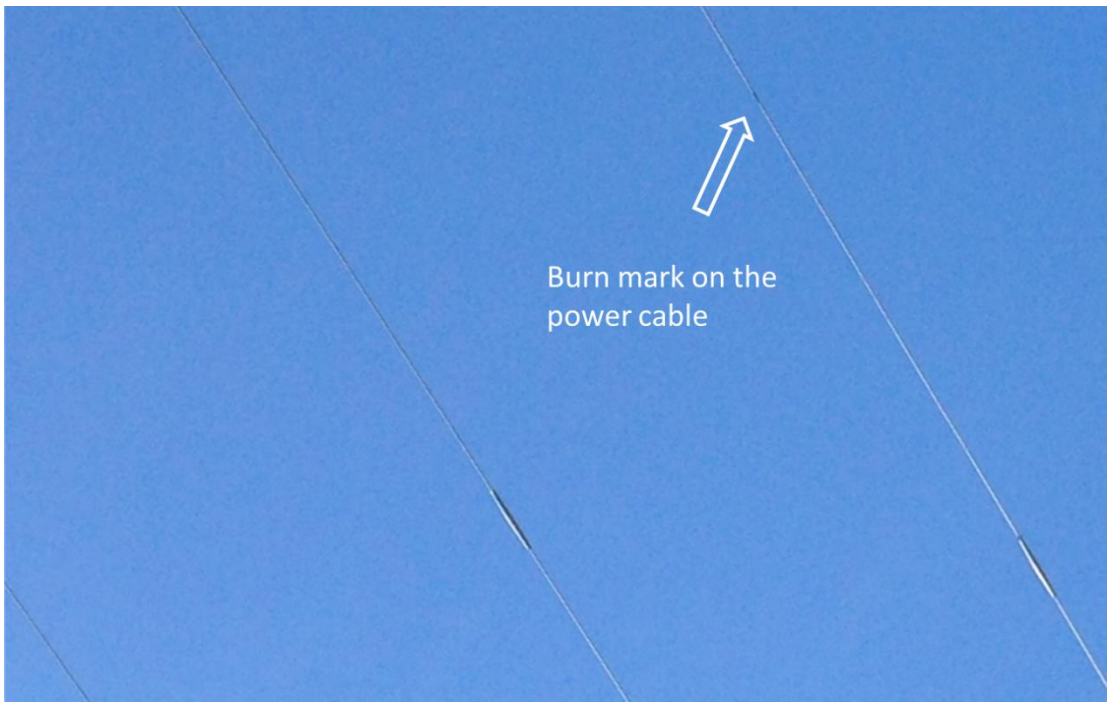

Figure 4: The three overhead high-voltage cables across Fyrsundet. On the upper right, a burn mark can be observed on the cable where it probably came into contact with the fishing rod. Two of the cables in the photo have 'connecting sleeves' from previous repairs. Photo: Lofotkraft

First aid was immediately administered to the chief mate, while the ferry continued through Fyrsundet. The aft mast had clearance to the high-voltage cables. The captain set course for Svolvær at maximum speed. Meanwhile, the crew were in continuous contact with the Emergency Medical Communication Centre (AMK). Medical personnel from an ambulance boat boarded the ferry en route and took over the treatment of the chief mate at the accident site. After several attempts at resuscitation, and before *MF Røst* reached Svolvær, the chief mate was declared dead.

The conclusion in the post-mortem report was that he died from the head injuries sustained when he fell from the mast. He was also found to have physical injuries consistent with having been in contact with high-voltage electricity.

1.3 Crew

On the day of the accident, there was a crew of eight on board: the captain, chief mate, two able seamen, a cook, a catering assistant and an apprentice. Even though the crew had sailed on *MF Røst* for a relatively short period in the new service, most of them had been with the shipping company for a long time and had local knowledge of the area.

The captain and chief mate who served on board at the time of the accident were both on a fixed rotation schedule on *MF Røst* (3 weeks on and 3 weeks off), and they had come on board to start their shift on 7 May.

Mandatory certificates, safety training, medical certificates etc. were in order for all members of crew. The captain and chief mate held valid competence certificates and had completed several safety courses of relevance to the performance of their shipboard functions.

In interviews with the AIBN, the crew informed that they did not have knowledge about the need for a safe distance from power cables carrying high voltage.

1.4 Safety equipment for work at height

1.4.1 Skid rail and pertaining fastening arrangement

Ladder skid rails and pertaining fastening devices (Figure 5) for climbing up into both the fore and aft masts were available on board *MF Røst*. In the event of a fall, an automatic locking mechanism in the fastening arrangement between the safety harness and the skid rail would prevent the user from falling down. This particular equipment was not used by the deceased in connection with his task in the fore mast.

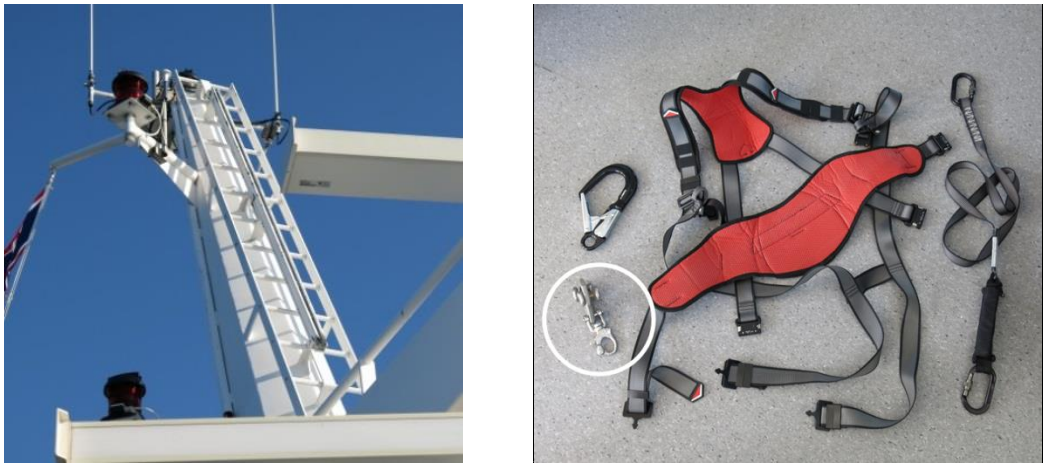

Figure 5: Left: ladder and skid rail in the fore mast. Right: harness and fastening device for the skid rail (ringed in). Photo: AIBN

1.4.2 Safety belt

A safety belt worn around the hips with a strap and snap hook for easy securing to fixed points was also available on board (Figure 6). When the hip belt is correctly and safely secured to a fixed point, the equipment can prevent the user from falling.

Figure 6: Safety belt with snap hook. Photo: AIBN

It was the equipment shown in Figure 6 that was used in connection with the task in the fore mast. The belt was still in place around the deceased's hip after the fall, and how well he had fastened/secured the strap and snap hook, if at all, is thus uncertain. The strap and snap hook did not show signs of stress or damage of any kind, and appeared to be in good condition after the accident. The fastening device for the skid rail shown in Figure 5 can also be used with the hip belt.

All the safety belts on board *MF Røst* were in accordance with the Norwegian Maritime Authority's (NMA) Regulations of 1 January 2005 No 8 concerning the working environment, health and safety of workers on board ships (the Working Environment, Health and Safety Regulations).

1.5 Shipping company

1.5.1 The company

MF Røst belonged to the shipping company Torghatten Nord AS, which is a wholly owned subsidiary of the transport group Torghatten ASA, which has its head office in Brønnøysund.

Torghatten Nord AS operates marine public transport services by express boats and ferries in the counties of Nordland and Troms. The company is bound by tender agreements and framework contracts with the Norwegian Public Roads Administration and the Nordland and Troms county authorities.

In 2009, the company acquired 45 vessels from Hurtigruten ASA, one of which was *MF Røst*. The company operates scheduled services from Brønnøysund in the south to the border with Finnmark county in the north. Most of the company's 625 employees are maritime personnel with positions on board the company's vessels, and onshore employees at the branch offices in Stokmarknes and Tromsø and at the express boat terminal in Bodø.

During the first quarter of 2013, the company renewed its fleet, with gas ferries serving on two of its regular ferry services. There were technical problems associated with putting these ferries into service. The operations department for the established ferry services was involved in the construction of the new ferries, which were built in Poland. Organisational changes had also been made to the operating organisation for the relevant ferry service during the same period.

1.5.2 The shipping company's safety management system

The safety management part of the shipping company's quality system is in accordance with the requirements laid down in the Regulations of 14 March 2008 No 306 relating to safety management systems on Norwegian ships and mobile units (the Safety Management Regulations), and have been approved/certified by the NMA.

The shipping company's safety management system is documented in the Administration Manual (AHB) as well as in the Ship Manual (FHB). The following are excerpts from some of the procedures and instructions that the AIBN deem to be relevant to the accident:

1.5.2.1 The captain's responsibility and authority (AHB-S.05-1):

The captain has overriding authority and is responsible for decisions relating to the safety of the vessel and pollution prevention and for requesting assistance from the company as necessary. The captain is obliged to take such action as he considers necessary to avoid undesirable incidents, regardless of the instructions in this manual. The captain is responsible for implementing the company's safety and environmental policies.

The captain shall motivate the crew to comply with these policies and issue appropriate orders and instructions in a clear and easily understandable manner. The captain shall verify that stipulated requirements are complied with and shall review the safety management system and report any deficiencies to the company's management.

1.5.2.2 *Work at height (AHB-S.07-3):*

A risk assessment shall be completed before commencement of the work, the safety harness/work belt shall be correctly donned and shall have the correct length to prevent personnel from falling to a level below.

The captain is responsible for making this procedure known to the target group. Personnel who are to carry out work at height are themselves responsible for complying with the procedure.

1.5.2.3 Risk assessments (AHB-S.06-11 and AHB-S.06.1-3/1-4):

The shipping company is responsible for ensuring that risk assessments are carried out of voyages and manoeuvring procedures. Such risk assessments shall be based on the prepared fairway descriptions, manoeuvring procedures, emergency manoeuvring procedures (including operational limitations) and a review of critical ship systems and components.

The service routes shall be risk assessed in both directions and with regard to both departure and arrival. The risks associated with the various phases of the voyage and that arise during manoeuvring shall be identified on the form. The risk shall be described together with the causes and consequences of potential incidents. Actions to reduce the risk shall be documented, and a new risk assessment shall be carried out to document the reduced risk. If necessary, actions shall include revision of the prepared fairway descriptions, manoeuvring procedures, operational limitations and the review of critical ship systems and components. The risk analysis shall be kept on board.

1.5.2.4 Fairway descriptions (AHB-FF.07-5):

The fairway description is intended as a guide for navigators of vessels in the applicable service area. It is not intended as a 'course book' or a template for navigation along the service route. It aims to provide information about circumstances and hazards to which particular attention should be given.

As a minimum, the fairway description should include [information about]: Radar navigation, traffic, fishing gear, ice conditions, sea conditions, winds/currents, ports of calls /quays, areas with possible beaching sites (where possible).

The captain is responsible for ensuring that the fairway description is kept up-to-date at all times for the relevant service area and service routes.

1.5.3 Fairway description for Svolvær-Skutvik-Skrova (THN-08855)

In addition to a risk assessment of the fairway for the vessel in question, risk assessments are carried out by each individual vessel serving on the relevant route and included as a supplement to the fairway description.

The shipping company's written fairway description for the Svolvær-Skutvik-Skrova service, dated 2 April 2013, was available on board *MF Røst*.

Among other things, the following is stated concerning sea conditions:

Skrova – Skutvik: Fyrsundet towards Øksnesodden point is a good course in SW winds. It is possible to cross to the other side of the fjord if necessary. At Skrovabakken, the vessel will often be exposed to higher seas abaft the beam than mid fjord when approaching Skrova.

And concerning Skrova ferry landing:

Skrova has three arrival and departure routes. All are equally clearly marked. In strong SW winds, fresh gale or higher, all the fairways are closed by high seas. Fyrsundet should only be used in fair weather, with good visibility and at a speed appropriate to the conditions.

At the time of the accident, the shipping company had initiated a risk assessment of *MF Røst* in connection with the preparation of a new fairway description for Svolvær-Skutvik-Skrova, which was scheduled for completion at the end of May 2013. At the time of the accident, the fairway description did not specifically mention the height limitations in Fyrsundet.

1.5.4 Passage under bridges and overhead cables

The shipping company's quality management system contained the general provision that the captain has overriding authority and is responsible for decisions relating to the vessel's safety, and that the captain is obliged to take such action as he considers necessary to avoid undesirable incidents (see 1.5.2.1).

1.5.5 Communication

There is no evidence that the shipping company initiated any form of dialogue with the crew on board *MF Røst* concerning the passage through Fyrsundet at any time after the ferry started operating the service on 29 April. Nor is it there any evidence that the crew on board *MF Røst* contacted the shipping company concerning Fyrsundet at any time.

According to the captain, the chief mate contacted the Norwegian Mapping Authority to obtain more detailed information about the height of the overhead cables across Fyrsundet, but did not succeed in getting such information. Nobody contacted the power company that operate the overhead cables.

The captain who handed over *MF Røst* after the yard stay at the end of April had conveyed a verbal message from the shipping company's operating department during the sea trials for the new service. The verbal message was that *MF Røst* should not use the route through Fyrsundet until further notice, as the aft mast was deemed to be too high to pass under the overhead cables.

The captain and chief mate on board at the time of the accident nevertheless believed it possible for *MF Røst* to make this passage, which is why they wanted to verify the actual height of the overhead cables in relation to the height of the ferry's aft mast.

The captain and the chief mate who were off duty at the time of the accident had taken note of the verbal message from the shipping company and thus they did not, on their watch, consider this route to be an option for *MF Røst*.

The AIBN was told during interviews that a formal written notice stating that *MF Røst* must not sail through Fyrsundet would probably have been complied with by both shipboard management teams.

1.6 Scheduled service route

Figure 7: Map section with the route Skutvik–Skrova–Svolvær drawn in. Source: the Norwegian Mapping Authority

1.6.1 *MF Røst* deployed in new service

MF Røst operated the ferry service between Lofoten and Bodø at the mouth of the Vestfjord for several years until it was replaced by Torghatten Nord's new gas ferry.

The following statements by Torghatten Drift in connection with the plan to redeploy *MF Røst* in a different ferry service are quoted from the newspaper Lofotposten dated 23 April:

'We aim to put "Røst" into service this weekend. We look forward to this, and it will represent a great improvement for our users and employees alike. Also, the service will now be operated by a highly seaworthy vessel with unique manoeuvring capabilities. This

will greatly improve the regularity of the service' - 'The company puts safety first, so before "Røst" is put into regular service, the crew will be drilled in applicable procedures for this vessel.'

1.6.2 The voyage through Fyrsundet

The shipping company's representatives told the AIBN that sailing through Fyrsundet reduced the travel time between Skrova and Skutvik (Figure 8) by 10 minutes in both directions. It was also stated that Fyrsundet and Saltværsleia inlet were the most favourable starting point for setting course across the Vestfjord. Furthermore, under unfavourable weather conditions, this could also make the passage more comfortable for the passengers on board.

The AIBN was told that *MF Vågan* had regularly used this route option when operating the ferry service.

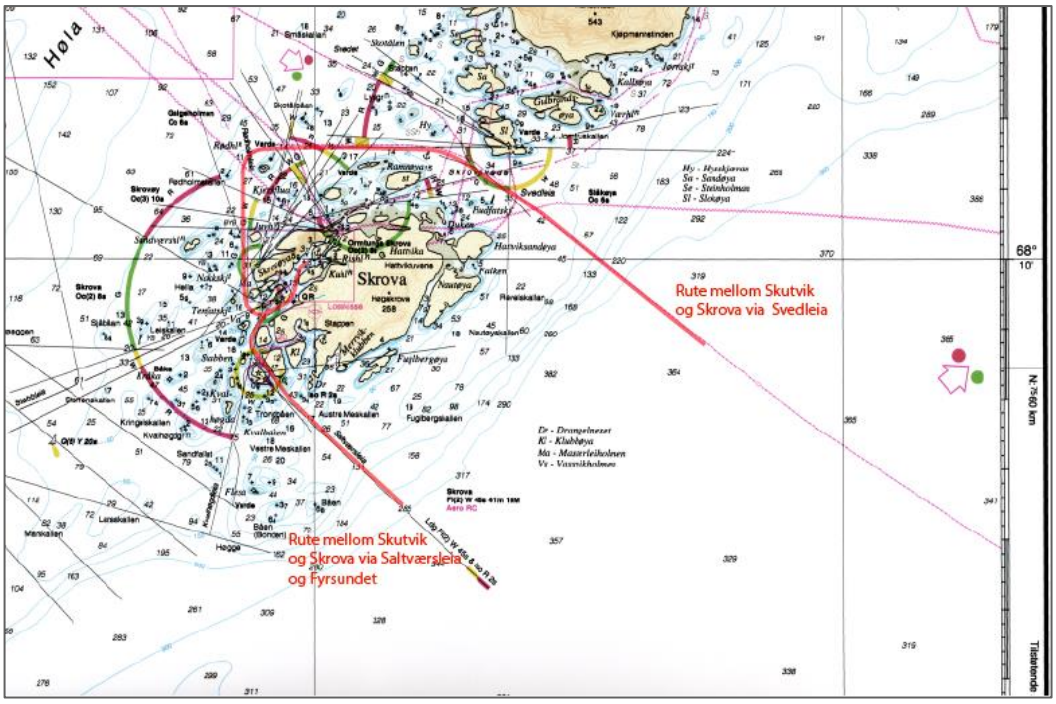

Figure 8: Map section with the route via Svedleia and the alternative route via Saltværsleia and Fyrsundet drawn in. Source: Nautical Chart No 73 from the Norwegian Hydrographic Service

1.6.3 Adjusting the height of the top of the aft mast

In the shipping company's documented vessel information for *MF Røst*, received by the AIBN just after the accident, the top of the aft mast was stated to be 19.9 metres above sea level. The physical measurement of the aft mast carried out by the shipboard management while docked in Svolvær on 18 May, showed a height of 20.7 metres above sea level. Based on the divergence between the stated heights, the AIBN was informed, after contacting the shipping company once again, that the correct height of the aft mast was 21.4 metres above sea level.

In an email of 22 April 2013 addressed to the consulting company Nordnorsk Skipskonsult (NSK), the shipping company asked whether it was possible to adapt the height of the top of the aft mast on *MF Røst* so that the vessel could pass safely through Fyrsundet.

NSK had previously carried out several technical assignments for the shipping company and had access to relevant drawings of *MF Røst*. In this case, they were particularly interested in verifying the height of the aft mast in relation to the ferry's lantern setup. By agreement with the shipping company's operations manager, they therefore contacted the vessel directly by telephone in order to have the height measurements confirmed. The plan was for NSK to subsequently, on behalf of the shipping company, submit an application to the NMA for approval of a possible modification of the aft mast and related lantern setup.

According to the shipping company, the plan to reduce the height of the aft mast was later rejected when they realised how much work it would involve. The vessel was to begin operating the regular service in May, and it was concluded that there would not be sufficient time to get the required paperwork in place.

1.7 Safe vertical clearance in Fyrsundet

1.7.1 General

In Norwegian nautical charts, the safe vertical clearance under fixed obstacles such as bridges and overhead cables are stated as the distance from sea level measured at HAT, and up to the lowest point on the obstacle. Correspondingly, the level of reference for depths marked in Norwegian nautical charts north of Utsira are concurrent with the lowest astronomical tide (LAT).

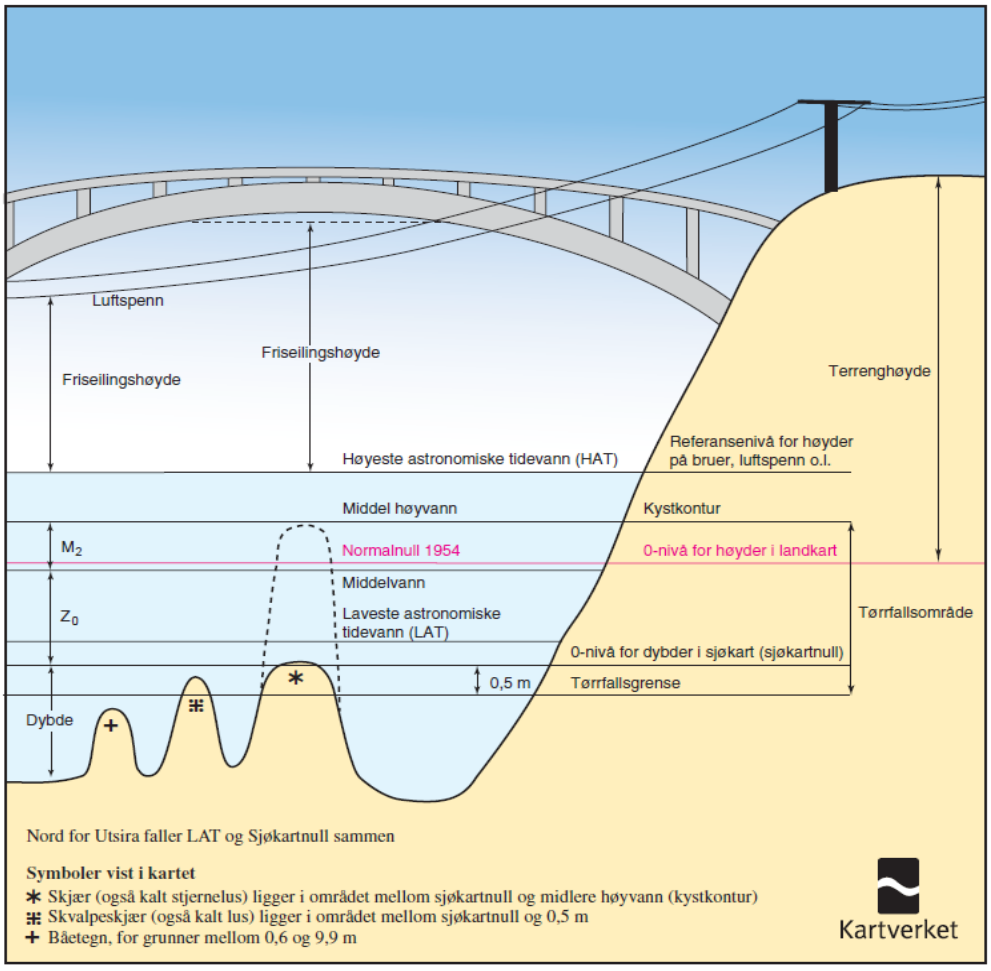

Figure 9: Illustration of navigational limitations. Source: the Norwegian Hydrographic Service

Neither the illustration in Figure 9 nor the legends on the 143 nautical charts in the Norwegian Hydrographic Service's main series, which covers the Norwegian coast in the scale 1:50 000, state that a safety margin has been added to the safe vertical clearances under overhead cables carrying high voltage.

The International Hydrographic Organisation (IHO)[3] defines a Safe Vertical Clearance that is shorter in relation to HAT than the physical distance from cables carrying high voltage. The safety margin from a conductor carrying high voltage varies from 2 to 5 metres, depending on the voltage. The colour magenta is used to mark the authorised safe distance (the physical distance minus the safety margin) on the nautical charts[4]. Heights marked in magenta thus indicate that the figure shows the safe vertical clearance, and that a safety margin must be added (Figure 10).

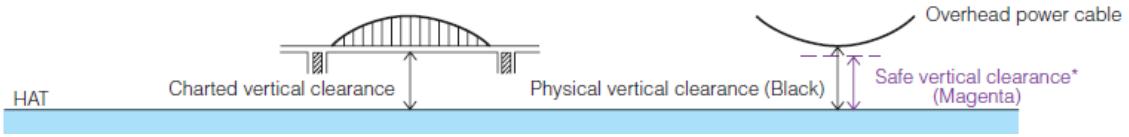

Figure 10: Illustration of safety margins for safe vertical clearances under bridges and overhead high-voltage cables. Source: IHO Publication S-4

1.7.2 Nautical chart for Fyrsundet

Norwegian Nautical Chart No 73 shows a safe vertical clearance of 20 m for passing under the overhead cables in Fyrsundet. The figure is shown in magenta. The chart indicates to seafarers that the water level may be above the reference level for safe vertical clearances, and refers to the most recent January edition of *Etteretning for sjøfarende* (Efs[5] No 1).

The map legend states the following about subsea and overhead cables and reference levels for safe vertical clearances:

> *1) Subsea and overhead cables: Both subsea and overhead cables can carry high voltage. Seafarers must therefore exercise great caution when navigating in their proximity. Likewise, it is important to keep in mind the possible presence of subsea and overhead cables that are not marked on the charts. Subsea and overhead cables established after the date on which the chart was printed are also not shown.*
>
> *2) Reference level for safe vertical clearances: Users must keep in mind that the water level along the coast from Hordaland up to and including Finnmark county can exceed the reference level for safe vertical clearances (spring tide at autumnal equinox). Safe vertical clearances can therefore be lower than shown on the chart.*

[3] The International Hydrographic Organisation (IHO) is the UN's competent authority for mapping and hydrography.
[4] IHO Resolution 3/1919 as amended in 2008.
[5] Etterretninger for sjøfarende, www.kartverket.no

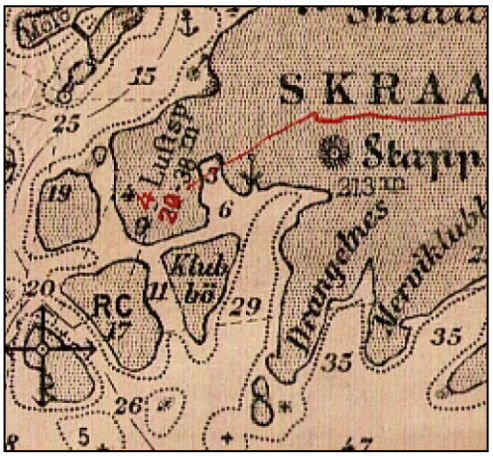

Figure 11: Section of Nautical Chart No 73, 1951-59 Source: the Norwegian Hydrographic Service

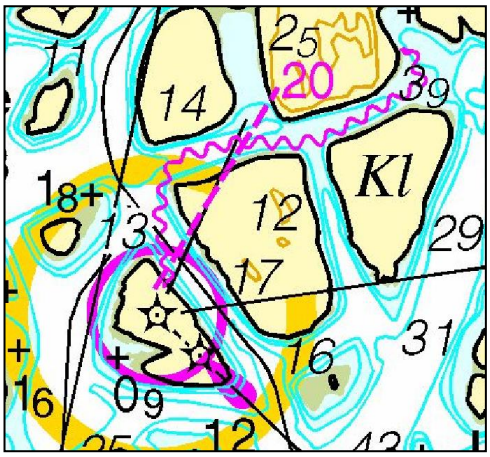

Figure 12: From Nautical Chart No 73 (2008). 20 metres safe vertical clearance shown in magenta. Source: the Norwegian Hydrographic Service

1.7.3 Signs posted ashore at Fyrsundet

At the time of the accident, the overhead cables across Fyrsundet were marked by yellow signs posted ashore below the span on both sides of the sound. The signs carried the text: *'Life-threatening danger, power cable 22 m above high tide'.*

Figure 13: Signs with information about the overhead cables posted by the cable masts on both sides of Fyrsundet. The white circles show where the signs are located. Photo: Lofotkraft

1.7.4 Changed safe vertical clearance in Fyrsundet

According to Lofotkraft, the cables spanning Fyrsundet were raised to a higher level in 1993 at the request of the shipping company that operated *MF Vågan* in the service at the time. The overhead cables were raised by installing new, higher pylons on either side. Control measurements on completion of the work showed an actual physical vertical distance of 25.0 metres from the waterline to the cables. According to the power company, there is a safe vertical clearance of 22 metres after deduction of a 2.0-metre safety margin. It is not clear whether the measurement was adjusted in relation to the HAT reference level. If this was done, the correction made was under 1.0 m. According to the power company, the most unfavourable operating conditions in terms of temperature and ice load are not taken into account. Nor is any 'sagging' of the cables over time taken into account.

The most recently updated list of cables crossing fairways ('*farvannskryssliste*') from 2003, which Lofotkraft claims to have sent to the Norwegian Hydrographic Service, shows a minimum safe vertical clearance of 22 metres, which is the height indicated on the two signs ashore on either side of the sound. The nautical charts, however, show a clearance of 20 m both before and after the overhead cables were raised in 1993 (Figures 11 and 12).

In July 1999, the power cables were damaged by a sailing boat with a mast height of approximately 30 metres. The cables were repaired and restored to the same height. In summer 2013, another sailing boat came into contact with the cables, and two of the phases were damaged. Following the most recent repairs, the power company measured the actual minimum physical vertical clearance to be 22.7 metres in relation to HAT. This is at least 1.3 metres less than the corresponding figure measured after the cables were raised in 1993. The AIBN has not been given any explanation of the difference.

1.8 Navigational qualifications and guidelines for seafarers

1.8.1 STCW and navigational qualifications

The curriculums of the Norwegian maritime educational institutions are based on the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (the STCW Convention).

Certificates of competence for taking charge of the various functions on board a ship are acquired through meeting mandatory minimum requirements described in the STCW Convention. Among the minimum requirements for being awarded a navigator certificate is to have completed an approved programme of education/training and to have demonstrated a minimum standard of competence as specified in the tables in the mandatory Part A of the Convention.

Mandatory minimum requirements for certification of navigators on ships of 500 gross tonnes or more are described in Table A-II/1 “Navigation at the operational level” and in Table A-II/2 “Navigation at the management level”.

1.8.2 The Norwegian Pilot Guide (Den norske los)

The fairway descriptions in the Norwegian Pilot Guide (*Den norske los*) are published by the Norwegian Hydrographic Service. The books contain information about the fairways,

large and small ports and harbours, currents, climatic conditions etc. For vessels subject to flag registration, keeping the publication on board as a nautical aid is mandatory. *Den norske los* was available on board *MF Røst* at the time of the accident.

Volume 1 'General information' contains information of general interest for navigating in Norwegian waters. It describes the following about safe vertical clearance on page 16;[6]

"Safe vertical clearance, heights to bridges and overhead obstacles;
Under bridges, high-voltage power cables and other ship-related overhead obstacles, the stated height is measured from the lowest level of the overhead obstacle/bridge down to a level Z_0 above middle water (2x Z_0 above navigational chart zero)."

It is pointed out in *Den norske los* that overhead cables can carry high voltage, and that seafarers must exercise great caution when navigating in their proximity. However, *Den norske los* does not describe the safety margin that is taken into consideration in the given safe vertical clearance under overhead cables carrying high voltage. Nor is any explanation given of what the magenta colour signifies. The illustration in Figure 9 shows that HAT is to be used as the reference level for safe vertical clearances.

1.8.3 Symbols and abbreviations in Norwegian navigational charts

The publication *Symbols and abbreviations in Norwegian navigational charts* gives an overview of symbols and abbreviations used in Norwegian and international navigational charts. It is published by the Norwegian Hydrographic Service. The publication is also called INT1 or Norwegian INT1.

The publication explains all relevant matters in navigational charts. The publication does not describe the safety margin that is taken into consideration in the given safe vertical clearance under overhead cables carrying high voltage. Nor is any explanation given of what the magenta colour signifies.

It is not a mandatory requirement for vessels subject to flag registration to carry the publication on board. The publication was not available on board *MF Røst* at the time of the accident.

1.8.4 ICS Bridge Procedures Guide

The *Bridge Procedures Guide* is published by the International Chamber of Shipping (ICS) [7]. The guide describes good seamanship, primarily with a view to improving the safety of navigation and protecting the marine environment. The guidelines are intended to reflect the best navigational practice on board today's marine vessels, in all waters and for all types of carriage.

The guidelines provide good descriptions of vessel draughts, advice on how to avoid grounding and information about underkeel clearance[8]. Concerning vessel height (air draught) the guidelines contain only one reference, namely to the Master/Pilot Exchange

[6] The reference is dated 2 May 2014 and copied from the website of Norwegian Hydrographic Service; www.kartverket.no/Kart/Nautiske-hjelpemidler/Den-norske-los/
[7] The International Chamber of Shipping (ICS) is a voluntary organisation comprising the national shipowners' associations, together representing more than 70% of the world's merchant tonnage.
[8] 'Underkeel clearance' means the clearance between a vessel's maximum draught and the seabed.

Card[9]. Air draught limitations, passing under overhead cables and bridges, safe vertical clearances, safety margins etc. are not mentioned in the guidelines.

The *Bridge Procedures Guide* is not mandatory on board ships, but is widely used in the industry. It was not available on board *MF Røst* at the time of the accident.

1.9 Reporting of basic data to the Norwegian Hydrographic Service

In the guidelines to the Norwegian Ports and Fairways Act, the Norwegian Coastal Administration (the NC Administration) has laid down two mandatory conditions for establishing or altering overhead cable spans:

- The developer is obliged to post and maintain warning signs in accordance with the NC Administration's standards.
- The developer shall report new safe vertical clearances to the Norwegian Hydrographic Service so that the nautical charts can be updated.

A copy shall be sent to the NC Administration, and the installation cannot be put into operation until the report has been submitted. Both the Norwegian Hydrographic Service and the NC Administration have pointed out in this connection that the procedures for ensuring satisfactory reporting of changes in the coastal zone by owners of chart data are generally unsatisfactory.

In summer 2012, the Norwegian Hydrographic Service sent a letter to the municipal authorities in all coastal districts, in which reference was made to the NC Administration's practice and all municipalities were urged to comply with that practice. Information on how cases can be reported is also available on the Norwegian Hydrographic Service's website (under Efs).

1.10 Rules and regulations

1.10.1 Safety Management

Requirements for safety management systems are regulated by the Regulations relating to safety management systems. The international standard for the safe management and operation of ships and for pollution prevention (the ISM Code) is appended to the Regulations.

Pursuant to Section 2 of the Regulations, all shipping companies shall have a safety management system for its organisation and on board for each individual vessel in accordance with the ISM Code.

The following requirements cited from the ISM Code are considered relevant to the accident under consideration:

- *Instructions and procedures to ensure safe operation of ships.... (1. 4. 2)*

[9] The 'Master/Pilot Exchange Card' is a form containing information for the pilot. Up-to-date information is entered on the form by the master or deck officer in charge of the watch before the form is given to the pilot.

- *Defined levels of authority and lines of communication between, and amongst, shore and shipboard personnel (1.4.3)*

- *The company should define and document the responsibility, authority and interrelation of all personnel who manage, perform and verify work relating to and affecting safety and pollution prevention (3.2)*

- *To ensure the safe operation of each ship and to provide a link between the company and those on board, every company, as appropriate, should designate a person or persons ashore having direct access to the highest level of management… (Nr. 4.0)*

- *The company is responsible for ensuring that adequate resources and shore-based support are provided.… (3.3)*

- *The company should clearly define and document the master's responsibility with regard to implementing the safety and environmental protection policy of the company (5.1.1)*

- *Development of plans for shipboard operations… (7)*

1.10.2 Overhead cables spanning fairways

1.10.2.1 *Administrative responsibility and authority*

The purpose of the Act No 9 of 17 April 2009 No 9 relating to ports and fairways (the Ports and Fairways Act) is, *inter alia*, to facilitate good navigability, the safety of maritime traffic and acceptable use and administration of Norwegian territorial waters and internal waters; see Section 1. Sections 7 and 9 regulate the administrative responsibility and authority of the state and municipal authorities, respectively.

1.10.2.2 *Permission*

Which measures require permission is regulated on the basis of Section 27. The Regulations of 3 December 2009 No 1449 concerning measures requiring permission from the Coastal Administration were issued pursuant to Section 27 third paragraph of the Act. The Regulations describe a number of types of measures that must always be considered by the NC Administration, regardless of where the development is to take place. Overhead cables are mentioned in Section 1(e) of the Regulations. The NC Administration has published guidelines with general information about the Ports and Fairways Act. The guidelines describe, *inter alia*, that it is the developer who is obliged to submit an application (see Section 7.4) and what the application must include (see Section 7.5). The application process for power lines across fairways is also described in a letter of 9 February 1982 from the Norwegian Coastal Authority (NC Authority) to the NC Admin.

1.10.3 Official mapping authority

The Regulations of 4 December 2009 No 1458 relating to official mapping authority (the Official Mapping Authority Regulations) were adopted by Royal Decree pursuant to Section 11(1) of the Ports and Fairways Act. The Norwegian Hydrographic Service was appointed official authority for hydrographic services. Pursuant to Section 11(1) of the

Ports and Fairways Act, it is the official hydrographic authority that issues or approves official nautical charts and nautical publications. Both official authorised nautical charts and unauthorised nautical charts are produced. The provision defines the legal authority to publish and approve Norwegian nautical charts and publications.

1.10.4 Signage in connection with overhead cables across fairways

At the time of the accident, the overhead power cables across Fyrsundet were marked with signs in accordance with the repealed Regulations of 15 January 1993 No 82 relating to localisation, design and technical requirements for beacons, seamarks and fairway signs issued by the former Norwegian Ministry of Fisheries and Coastal Affairs. According to the Regulations, such signs shall be located immediately above the high tide level and be easily visible to seafarers.

The Regulations do not specify whether the figures stated on such signs shall be understood to signify safe vertical clearances or whether seafarers are expected to add a safety margin. However, the power company's calculations show that a safety margin must have been reckoned with (see section 1.7.3). The margin of 2 metres is in accordance with the letter from the NC Authority in 1982.

There are no provisions relating to how the height of the power cables is to be secured or maintained.

Figure 14: Warning sign where overhead cables span the fairway. Source: Regulations relating to beacons, seamarks etc. Annex A4

With effect from 1 January 2013, the abovementioned Regulations were replaced by the Ministry of Transport's Regulations of 19 December 2012 No 1329 relating to fairway signs and navigational installations (the 'Regulations relating to Fairway Signs etc.'). Chapter 7 in Annex 1 to the Regulations use the term *'limited height* in connection with the new fairway warning signs under bridges and overhead cables. HAT is used as the reference level, and it is stressed that the water level often exceeds that level. The Regulations refer to the most recent January edition of *Etteretning for sjøfarende* (Efs. No 1), which provides further information on safety margins whereby the 'limited height' will be reduced.

As far as overhead cables are concerned, it is specified in Section 7.2.1 of the above-mentioned Annex 1 to the Regulations that the 'limited height' is calculated as the vertical distance to the lowest point within the navigable breadth of the fairway, with the deduction of a safety margin depending on the voltage carried by the cable in question. For the voltage carried by the cables across Fyrsundet, the margin is stated to be 1.5 m, see Table 8. This safety margin comes in addition to what is described in the previous

paragraph. A square sign with a red frame and black digits on a white background indicates safe vertical clearance (Begrenset høyde) above HAT; see Figure 15.

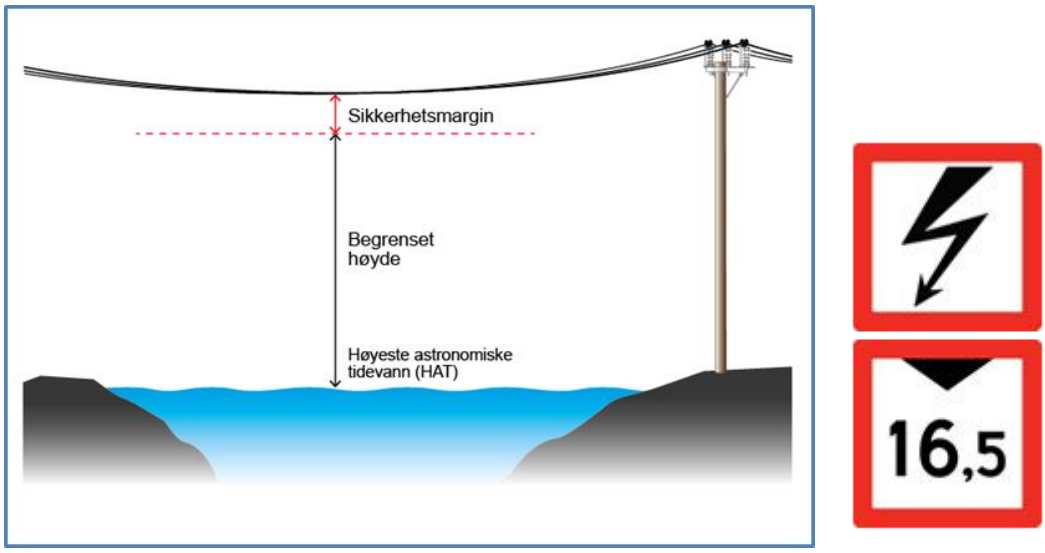

Figure 15: Limited height under overhead cables and signage. The signs indicate 'Life-threatening danger, electric cable' (above) and 'limited height' (below). Reproduced from the Regulations relating to Fairway Signs etc. Annex 1 Chapters 7 and 8

The Ministry of Justice and Public Security's Regulations of 20 December 2005 No 1626 relating to electrical power installations (Regulations relating to electrical power installations) require overhead cables to be installed at a sufficient distance from the surroundings to avoid exposing the general public and material assets to risk; see Section 6-4. The guidelines to the Regulations include a specification of '*additions to safe vertical clearances'* for spans across fairways. A minimum addition of 2.22 metres is specified for the power line in question; see Tables 6-1 and 6-2. The guidelines stress that any warning signs shall indicate the safe vertical clearance only. The guidelines also state that signs shall be produced in accordance with the standards of the NC Authority.

In the NC Administration's draft fairway standard (*farledsnormal*) of 25 November 2013, the term *Begrenset høyde (limited height)* is replaced by *safe vertical clearance*. The standard refers to the Regulations relation to electrical power installations for determination of safety margins.

The Regulations relating to fairway signs etc. state that signs must be placed so that they are clearly visible to seafarers and in immediate proximity to the danger they warn of.

1.11 Implemented measures

After the accident, the AIBN has received documents from Torghatten Nord AS showing changes that have been implemented as compensatory measures:

- Fairway description for service area – sailing handbook for ferries (*Rutehåndbok ferger* – doc. ID: AHB-FF.07-5):

  In the fairway description for the Svolvær-Skutvik-Skrova service, issued on 31 May 2013, the following text had been added:

International rules for the prevention of collisions at sea (Rules of the Sea) must always be observed. Note in particular Rule 2 – Responsibility.

A new revised version of the fairway description for the Svolvær-Skutvik-Skrova service was issued on 11 November 2013, in which the following text had been added:

Overhead cables and bridges (height limitations) – Account must be taken of the overhead cables that span Fyrsundet, with a safe vertical clearance of 20 metres.

2. ANALYSIS

2.1 Introduction

The most probable chain of events is used as the starting point for the first part of the analysis. It serves as the basis for identifying several safety problems. A systematic presentation of the chain of events is provided in Figure 16. The figure provides an overview of activities that played key roles in the chain of events, and the safety problems that were identified and served as the basis for the further analysis of the accident.

The AIBN has identified a total of seven central safety problems, defined as nonconformities with safe or expected functions. These safety problems are reviewed in more detail in section 2.2, with a discussion of those factors that the AIBN believes contributed directly to the accident.

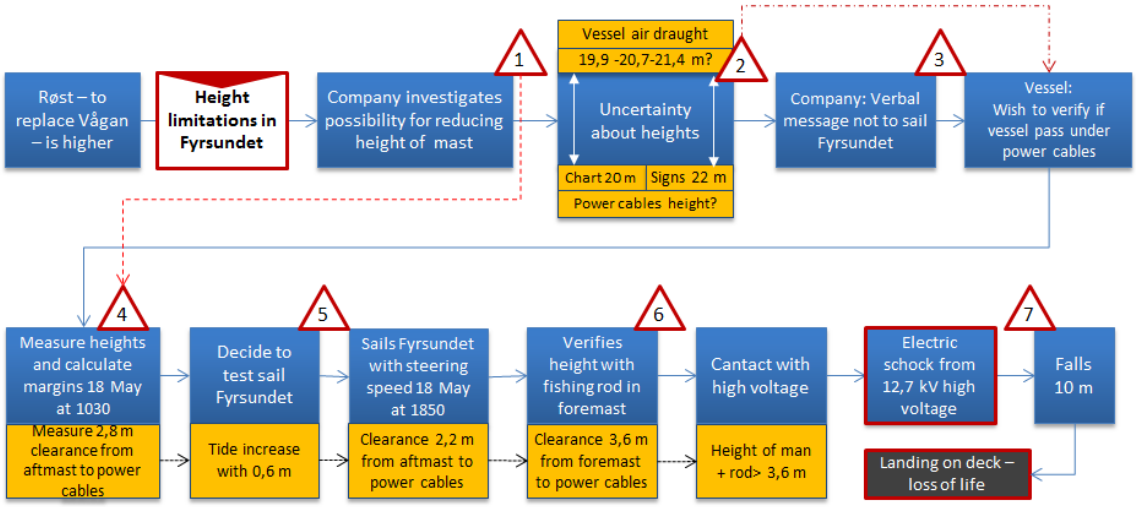

Figure 16. Schematic diagram of how the accident came about. Identified safety problems are marked as warning triangles. Source: AIBN

Sections 2.3, 2.4 and 2.5, discuss what the AIBN believes to be the main elements of the accident and points where there is a potential for improving safety, as illustrated by the analysis of the chain of events and safety problems. These points are the shipping company's role and safety management, control and communication of safe vertical clearances, and navigational competence and seamanship. Under each of these elements, the factors assumed to be immediate causes, underlying causes and areas where there may have been insufficient management and control are discussed.

2.2 Safety problems

The identified safety problems (SP) have a varying degree of severity, and some of them thus had a greater impact on the chain of events than others. The safety problems also vary in terms of where measures to improve safety and prevent future accidents can be implemented. In the following a description is given of the safety problems listed in Figure 16.

2.2.1 Lack of communication with the power company (SP 1)

A height limitation applied in Fyrsundet due to the overhead power cables that supplied the lighthouse. Because of the vessel's air draught, the shipping company recognised a need to reduce the height of the mast if the vessel was to pass through Fyrsundet at safe margins. The shipping company therefore contacted a consultancy firm in order to explore this possibility. Contact was not established with the power company in that connection, something the AIBN consider as a safety problem (SP 1). In the AIBN's opinion, this also gave rise to a subsequent safety problem that influenced the chain of events at a later stage with the (ref. SP 4). This is discussed in more detail in section 2.3 'The shipping company's role and safety management'.

2.2.2 Uncertainty about heights (SP 2)

The aft mast was the highest point on the vessel. During its investigation, the AIBN has received three different figures for the vessel's air draught. There was also divergence as regards safe vertical clearance under the overhead cables, since the charted safe vertical clearance did not tally with the safe vertical clearance indicated on the signs. The figures show that there was uncertainty as to whether the vessel would be able to pass safely under the overhead cables. In the AIBN's opinion, this uncertainty constituted a safety problem (SP 2). This is discussed in more detail in section 2.3 'The shipping company's role and safety management'.

2.2.3 Communication of messages (SP 3)

Due to the uncertainty about safe vertical clearances and margins, it was stated that the vessel should refrain from using Fyrsundet as a navigation channel until further notice. The message was communicated verbally from the shipping company to the captain of *Røst*. At the same time, the shipping company had a management system under which the captain had the authority to decide in matters relating to navigation, and a fairway description that permitted sailing through Fyrsundet. In the AIBN's opinion, the important verbal message was not sufficiently formalised to clarify the level of authority at which it was issued, so that this constituted a safety problem (SP 3). The AIBN discusses this finding in more detail in section 2.3 'The shipping company's role and safety management'.

2.2.4 Measurements and handling of high voltage (SP 4)

The captain on the shift in question believed that the vertical clearance was probably sufficient for the ferry to pass through Fyrsundet. Together with the crew, he decided to take measurements of the vessel and the overhead cables. This was carried out without involving the onshore organisation or the power company. The overhead cables were therefore measured while live. In the AIBN's opinion, there was an imminent risk of

making contact with the high-voltage cables, and this therefore constituted a safety problem (SP 4).

The AIBN believes that it can partly be explained as inadequate handling of safe vertical clearances on the part of both the shipping company and the authorities. The AIBN will discuss this in more detail in section 2.3 'The shipping company's role and safety management' and section 2.4 'Control and communication of safe vertical clearances'.

2.2.5 The decision to sail through the sound with a small safety margin (SP 5)

The crew calculated a clearance of 90 cm between the aft mast of the vessel and the overhead cables at HAT and a clearance of 2.8 metres at the prevailing tidal level. Pursuant to the Regulations relating to electrical power installations, a safety margin of 2.22 metres shall be taken into account for these overhead cables, and this was not done in the calculations carried out by the crew. None of the crew appeared to have the requisite knowledge about the risks associated with high-voltage electricity as prescribed in the Regulations relating to electrical power installations.

The publication *Den norske los* urges seafarers to reckon with sufficient margins in connection with power lines, but does not specify what margins are required by the Regulations or what margins should be used as the basis for signage and hydrographic information. Seen in isolation, it is a safety problem (SP 5) that the crew did not possess the knowledge of the safe margin that could have caused them to decide to refrain from sailing through Fyrsundet. The AIBN discusses this in more detail in section 2.3 'The shipping company's role and safety management'.

2.2.6 Verification of the margin (SP 6)

In order to verify the clearance to the overhead cables, the chief mate took a fishing rod with him up into the fore mast. The chief mate stood at the highest point in the mast while holding the fishing rod in his right hand and extending his arm above his head. According to the AIBN's own calculations, there was a probability that the fishing rod would come into contact with the high-voltage cable, given that the tide had risen by 0.6 m since measurements were carried out previously on the same day.

The fishing rod was made of an electrically conductive carbon material. The observed burn marks and the voltage drop recorded by the power company at the time when *Røst* sailed through Fyrsundet show that electricity found earth through the fishing rod. This constitutes another safety problem (SP6). The AIBN cannot determine whether the chief mate would have died as a result of the injuries sustained from high-voltage exposure alone. The AIBN has chosen not to analyse this finding further.

2.2.7 Incorrect use of fall protection equipment (SP 7)

The contact between the earth potential and one of the phases produced a voltage potential of 12.7 kV. The AIBN assumes that it instantly incapacitated the chief mate. The chief mate was found with the safety belt fastened around his body. The fastening device on the belt was intact. The AIBN therefore believes that he had not attached the safety belt to the mast when he raised his arm towards the overhead cable. The AIBN does not rule out the possibility that he may have disconnected the safety belt from the mast in order to be able to reach higher or for some other reason. The post-mortem report shows that the injuries sustained when he fell from the mast were fatal.

Hence, the fact that he was not securely attached to the mast constitutes a safety problem (SP 7). The AIBN has chosen not to analyse this finding further, as all the relevant equipment, systems, procedures etc. appear to have been satisfactory on the part of the shipping company.

2.3 The shipping company's role and safety management

2.3.1 Introduction

As far as the AIBN has been able to ascertain, the shipboard management had doubts concerning the information on safe vertical clearance in Fyrsundet, as the charted safe vertical clearance and the safe vertical clearance stated on the warning signs in proximity to the overhead cables ashore did not tally. Different heights had also been given for the aft mast on board the vessel. The different heights and vertical clearances stated for the vessel and the overhead cables suggested to the crew a possibility of safe passage through Fyrsundet. The AIBN believes that the diverging information contributed to the shipboard management's decision to verify the height of the overhead cables in Fyrsundet.

The shipping company had an important role in what is described above insofar as it is expected to provide support to the vessel and captain. The shipping company's work on a risk assessment of *MF Røst* in the service that was new to the vessel, the associated fairway description and the verbal form used to communicate the safety-critical circumstances in Fyrsundet are discussed below. We go on to consider the internal information flow within the shipping company, as it is assumed to have had a certain impact on the chain of events. Finally, we discuss the diverging heights that were stated for the aft mast and the process that the shipping company initiated to adapt this height to the level of the overhead cables in Fyrsundet.

2.3.2 Risk assessment, fairway description and verbal message communication

The work on the risk assessment of *MF Røst* in the new fairway, and the possible modification of the aft mast had not got properly under way when *MF Røst* began to operate the service. As far as the AIBN can ascertain, the shipping company had therefore decided that, until further notice, *MF Røst* should not use Fyrsundet as a navigation channel, and a verbal message to that effect was communicated to the shipboard management. In the AIBN's opinion, there were clear drawbacks associated with the verbal communication of the message, as it was more likely to be misunderstood and perceived as less binding than a message or instructions issued in writing.

The AIBN takes the view that the shipping company should have issued a temporary message or instructions to *MF Røst* in writing concerning the height limitations through Fyrsundet.

2.3.3 Information flow between vessel and shipping company

The building of new gas ferries and technical challenges in connection with putting them into service, together with organisational changes to the operating organisation, are understood by the AIBN to have involved extra work for shipping company's operating organisation as a whole. The AIBN believes that this may have had consequences for the day-to-day follow-up of the operation of *MF Røst* on the part of the onshore organisation.

2.3.4 Ambigities as regards the height of *MF Røst's* aft mast and the safe vertical clearance under the overhead cables in Fyrsundet

As far as the AIBN is able to ascertain, diverging information about the height of the aft mast – stated as being 19.9 metres in the shipping company's documented vessel information and measured as being 20.7 metres by the shipboard management – contributed to the shipboard management's decision to verify the height of the overhead cables across Fyrsundet. When the AIBN subsequently requested information from the shipping company, the height of the aft mast was stated to be 21.4 metres.

According to the AIBN's information, the shipping company was not clear about and had not checked the height of the aft mast at the time of the accident.

2.4 Control and communication of safe vertical clearances

2.4.1 Introduction

The raising of the overhead cable in 1993 was intended to give a safe vertical clearance of 22 metres through Fyrsundet. The power company therefore put up new warning signs indicating a clearance of 22 metres. However, the safe vertical clearance stated on the charts remained 20 metres.

Measurements carried out by the power company in 2013 showed a lower safe vertical clearance than stated when the overhead cables were raised 20 years previously. The reduced safe vertical clearance happens to be the same as the safe vertical clearance still stated on the chart. The AIBN would therefore like to stress that the reason why the calculated figure and the charted figure correspond is that two deviations, both of which can be critical, have cancelled each other out.

Disagreement about the safe vertical clearance in Fyrsundet is therefore a result of several factors discussed in the following chapters.

2.4.2 Reporting of basic data for charts

The investigation has shown that information about the increased safe vertical clearance after the overhead cable was raised in 1993 never reached the Norwegian Mapping Authority. The Norwegian Hydrographic Service has pointed out that the procedures for ensuring satisfactory reporting of changes in the coastal zone by owners of chart data are unsatisfactory. On this basis, the AIBN believes that there is room for improvement in the procedures to ensure that such data are communicated.

There are divergences between the requirements for adding safety margins to safe vertical clearances. The Ministry of Justice and Public Security's Regulations relating to electrical power installations require a margin of 2.22 metres for the voltage level in question. The Regulations regarding Fairway Signs etc. require a margin of 1.5 metres, while a margin of 2 metres was prescribed in a letter from the NC Authority in 1982. In the AIBN's opinion, it is necessary to clarify what constitutes applicable requirement in the area.

2.4.3 Follow-up of height

In 2013, the overhead cable was measured to be approx. 1.3 metres lower than the corresponding measurement after the cable had been raised 20 years previously. The

properties of the material, together with several collisions and repairs, may in fact have contributed to reducing the height of the overhead cable. There are currently no requirements for follow-up and control of the height of overhead cables. In the AIBN's opinion there is a need for regular checks and for verifications in connection with repairs or other modifications.

2.4.4 Warning signs

The warning sign for the overhead cable in Fyrsundet bore the text: *'Life-threatening danger, power cable 22 metres above high tide'*. The sign does not make it clear whether the stated height refers to the safe vertical clearance or the physical distance from the waterline to the high voltage cable. The term 'high tide' is also equivocal.

In the AIBN's opinion, the doubt about the safe vertical clearance caused by this sign may have contributed to the initiative taken by the crew of *Røst* to clarify whether the vessel could safely sail through the sound (see also section 2.3.1).

According to the Regulations regarding Fairway Signs etc., heights shall be stated in metres on new signs. The stated height is to be understood as the safe vertical clearance above the highest astronomical tide (HAT), and in the new draft fairway standard the term 'height' is replaced by the term 'safe vertical clearance' to bring it into line with the terminology used by the Norwegian Hydrographic Service. The AIBN believes that this change will make the message to seafarers less equivocal.

The warning signs were placed on shore on both sides under the overhead cable. This is in accordance with both the old and the new regulations. On this basis, the AIBN believes that, in addition to careful planning of the voyage by the captain, it may be expedient if warning signs are also located so as to give prior warning of safe vertical clearance limitations well before vessels pass under the overhead cables.

2.5 Navigational competence and seamanship

2.5.1 Introduction

Based on his knowledge and experience of the fairway in question, the captain clearly believed that it would be possible for *MF Røst* to pass under the overhead cable in Fyrsundet. In the AIBN's opinion, the uncertainty about the vessel's actual air draught and equivocal information about the safe vertical clearance contributed to the captain's wish to verify the margin between the overhead cable and the vessel's air draught and that it would be safe for *MF Røst* to pass.

Furthermore, the investigation has established that the crew was not familiar with the requirement for a safe margin in relation to overhead cables carrying high voltage. The AIBN has therefore looked more closely at sources of knowledge about safe vertical clearances and safety margins.

With more than 6,000 overhead cables in Norway alone, the AIBN considers it likely that the clearance information available to seafarers could also be equivocal in other places than Fyrsundet.

In addition to relevant theoretical instruction in navigation, good seamanship and practical navigation experience is gained through necessary experience. These make up

the qualifications that a captain and navigator must be expected to possess in order to make correct assessments and decisions.

Established sailing directions in which good navigational practice is described (such as *Den norske los*), together with guidelines based on experience and good seamanship (such as the *Bridge Procedures Guide*), provide guidance and recommendations for shipowners and seafarers. The AIBN consider the above to be practical reference books for seafarers in situations where ambiguities can occur and uncertainties arise while sailing.

2.5.2 Navigational instruction

The tables in Part A of the STCW Convention are function-oriented. The specifications in the tables thus give no detailed information about safety margins in connection with passing under overhead cables carrying high voltage.

The Convention states that one must have thorough knowledge of and ability to use navigational charts and publications, and that one must be able to interpret and make use of information obtained from charts. The AIBN is of the opinion that the navigation curriculums are adequate in the area 'safety margins to high-voltage overhead cables' because such publications as the sailing directions in *Den norske los* are included together with nautical charts as part of the curriculum in the general part of the navigation training.

As regards possible experience feedback following this accident, the AIBN therefore sees no need to introduce new requirements or revise the existing navigation curriculum requirements.

2.5.3 Reference books and navigational aids for the voyage

The heights given in charts shall indicate the safe vertical clearance. This is also stated on the chart sheets and in navigation literature.

The AIBN believes that inadequate information about safe margines and the meaning of magenta colour to indicate safe vertical clearances under overhead high-voltage cables, compared to the prompt to exercise great caution near power lines, contribute to create uncertainty about required safety margins and applicable rules.

In the AIBN's opinion, the definition of/information about safe margins to power lines under normal sailing conditions should be a task attended to in a satisfactory manner by the relevant authorities, so that seafarers can trust the information they are provided with en route during the voyage.

During its review of the reference book *Den norske los,* and the publication *Symbols and abbreviations in Norwegian navigational charts,* the AIBN found no description of safety margins in connection with passing under high-voltage overhead cables. In the AIBN's opinion, *Den norske los* gives misleading information when it describes safe vertical clearance under high-voltage overhead cables as equal to the height from the lowest point on the cables to a level Z_0 above mean sea level (see Figure 8). This information does not correspond with the Regulations relating to Fairway Signs etc. or IHO's publication S-4, which specify safety margins and use HAT as the reference level.

During its review of the international guidelines ICS Bridge Procedures Guide, the AIBN found no information under route planning about height limitations and safety margins for passing under high-voltage overhead cables. Although this publication is not mandatory and not available on board *MF Røst*, the AIBN is of the opinion that, generally speaking, it is an important aid to professional seafarers across the world.

3. CONCLUSION

3.1 Chain of events and immediate causes of the accident

a) Height limitations applied in Fyrsundet due to overhead cables, and it was therefore necessary to reduce the mast height of the vessel to have a safe margin for passage. The shipowners had therefore verbally instructed the crew of *MF Røst* to avoid Fyrsundet.

b) During its investigation, the AIBN has received three different figures for the vessel's air draught. There was also divergence as regards the height of the overhead cables, since there was a difference between the heights stated on the chart and on the sign. The AIBN believes that this was the reason why the crew wished to verify for themselves whether the vessel could safely pass under the overhead cables.

c) The crew's verification of the safe vertical clearance was carried out without involving the onshore organisation or the power company. The overhead cables were therefore measured while live, with the consequences this implies.

d) The crew of *MF Røst* were unaware of the hazards associated with high voltage, which, according to the Regulations relating to electrical power installations, require a safety margin of more than two metres to the overhead cables in question, but nonetheless decided to sail under the overhead cables with little calculated clearance.

e) The chief mate, who was in the fore mast without being secured, intended to verify the height with a fishing rod. The observed burn marks and the voltage drop recorded by the power company at the time when *Røst* sailed through Fyrsundet show that electricity found earth through the fishing rod.

f) The chief mate received an electric shock and died as a result of the fall to the deck below. The AIBN is unable to determine whether the chief mate would have died as a result of the injuries caused by high voltage alone.

3.2 Contributory causes of the accident

g) The shipping company had what was basically a well-documented safety management system, but no risk assessment for *MF Røst* in its new service or fairway description for the route in question was available at the time of the accident.

h) In the AIBN's opinion, the information flow was inadequate as regards communication of safety-critical information.

i) There was justified uncertainty about actual safe vertical clearance in the sound. The height shown on the charts differs from what is shown on the signs ashore, and publications contain misleading information about safety margins in relation to high voltage.

3.3 Other safety factors of relevance to the accident

j) Norwegian rules and regulations on quality assurance of the maintenance of navigational charts, reporting of map data, safety margins and the positioning of signs on land are areas that should be reviewed.

k) National nautical guidelines urge seafarers to exercise caution when navigating near power lines, but provide no information about the safety margins that are required in addition to the safe vertical clearance stated on the charts.

4. SAFETY RECOMMENDATIONS

The investigation of this marine accident has identified the following four areas in which the AIBN deems it necessary to submit safety recommendations for the purpose of improving safety at sea.[10]

Safety recommendation MARINE No 2014/05T

The investigation of the accident on board *MF Røst* on 18 May 2013 has shown that no risk assessment was available for *MF Røst* in the new service at the time of the accident and that the communication of safety-critical information, concerning the limitations in the service, was inadequate. The consequence of this was that the crew on board *MF Røst* ignored the instructions given by the shipping company.

The Accident Investigation Board Norway recommends that Torghatten Nord AS review and improve its internal procedures for communication between the shipping company and vessels, as well as the procedures for carrying out risk assessments before starting to operate a new service or a new vessel.

Safety recommendation MARINE No 2014/06T

The investigation of the accident on board *MF Røst* on 18 May 2013 has shown that there was justified uncertainty about the safe vertical clearance in the sound. Differences have been found between the safe vertical clearance shown in the charts and the figure shown on the signs ashore. In addition the actual signs were unclear about safety margins in relation to high voltage. Further, the investigation has shown that the power cables in 2013 were lower than the last recorded modification. The consequence of this is that seafarers cannot with certainty know what the correct safe vertical clearance is.

The Accident Investigation Board Norway recommends that the Norwegian Coastal Administration take steps to ensure that the correct safe vertical clearances are unambiguously communicated so that they are clear to seafarers.

[10] The investigation report is submitted to the Ministry if Trade Industry and Fisheries, which takes necessary measures to ensure that due consideration is given to the safety recommendations.

Safety recommendation MARINE No 2014/07T

The investigation of the accident on board *MF Røst* on 18 May 2013 has shown that national nautical guidelines urge seafarers to exercise caution when navigating near power lines, but contain no information about the safety margin that is taken into consideration for the safe vertical clearances shown in the charts and on signs ashore when high voltage is involved. One consequence of this may be that seafarers challenge the shown safe vertical clearance and by this comes into the danger zone from high voltage.

The Accident Investigation Board Norway recommends the Norwegian Hydrographic Service to clarify in relevant publications about the national requirements that applies for the safety margin that is taken into consideration when stating the safe vertical clearance under power cables that carry high voltage.

Safety Recommendation MARINE No 2014/08T

The investigation of the accident on board *MF Røst* on 18 May 2013 has shown that national nautical guidelines urge seafarers to exercise caution when navigating near power lines, but contain no information about the safety margin that is taken into consideration for the safe vertical clearances shown in the charts and on signs ashore when high voltage is involved. One consequence of this may be that seafarers challenge the shown safe vertical clearance and by this comes into the danger zone from high voltage.

The Accident Investigation Board Norway recommends that the International Chamber of Shipping incorporate into its *Bridge Procedures Guide* practical and relevant advice on height limitations in general, about the safety margin and the safe vertical clearance under power cables that carry high voltage.

Accident Investigation Board Norway

Lillestrøm, 14 May 2014