



Danish Maritime Accident
Investigation Board

MARINE ACCIDENT REPORT

January 2014



DART
Grounding on 1 August 2013

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Front page: Picture of DART. **Source:** Redningsselskapet.

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The Danish Maritime Accident Investigation Board

The Danish Maritime Accident Investigation Board is an independent unit under the Ministry of Business and Growth that carries out investigations with a view to preventing accidents and promoting initiatives that will enhance safety at sea.

The Danish Maritime Accident Investigation Board is an impartial unit which is, organizationally and legally, independent of other parties.

Purpose

The purpose of the Danish Maritime Accident Investigation Board is to investigate maritime accidents and to make recommendations for improving safety, and it forms part of a collaboration with similar investigation bodies in other countries. The Danish Maritime Accident Investigation Board investigates maritime accidents and accidents to seafarers on Danish and Greenlandic merchant and fishing ships as well as accidents on foreign merchant ships in Danish and Greenlandic waters.

The investigations of the Danish Maritime Accident Investigation Board procure information about the actual circumstances of accidents and clarify the sequence of events and reasons leading to these accidents.

The investigations are carried out separate from the criminal investigation. The criminal and/or liability aspects of accidents are not considered.

Marine accident reports and summary reports

The Danish Maritime Accident Investigation Board investigates about 140 accidents annually. In case of very serious accidents, such as deaths and losses, or in case of other special circumstances, either a marine accident report or a summary report is published depending on the extent and complexity of the subject.

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1. SUMMARY

On 31 July 2013 at 0440, DART departed Dusavik, Norway, after having been loaded with drilling mud. The ship was proceeding northwards in sheltered waters along the Norwegian coast towards Floroe, Norway, where it was to be further loaded. On its way towards Floroe, the ship called at Kopervik for maintenance of the electronic chart and display information system (ECDIS). DART resumed its voyage towards Floroe at 1625. When the ship's ECDIS had been serviced, it was observed that the sound alarm inherent in the system did not work. Except for the lacking sound alarm, the voyage proceeded as planned until at 0517 on 1 August 2013, when the ship went aground a rock in the Aafjorden. Ten minutes before the grounding, the ship deviated from the planned route because the mate had fallen asleep immediately before a waypoint.

The Danish Maritime Accident Investigation Board does not propose safety recommendations in connection with the grounding, but has received information from the shipowner about the measures taken to improve on-board safety.

2. FACTUAL INFORMATION

2.1 Photo of ship



Figure 1: DART
Photo: Soltin AS

2.2 Ship particulars

Name:	DART
Type of ship:	Tanker
Nationality	Denmark (DIS)
Port of registry:	Aarhus, Denmark
IMO number:	7423926
Call sign:	OOUV2
DOC company:	Maritime Management ApS
IMO company no. (DOC):	5623661
Year of build:	1976

Shipyard/yard number:	Svendborg Skibsværft/152
Classification society:	Lloyd's Register of Shipping
Length overall:	66.50 m
Breadth overall:	10.67 m
Bruttotonnage:	926
Deadweight:	759 t
Draught max.:	3.32 m
Engine rating:	912 kW
Service speed:	12.5 knots
Hull material:	Steel
Hull type:	Single hull

2.3 Voyage particulars

Port of departure:	Kopervik, Norway
Port of call:	Florø, Norway
Type of voyage:	Archipelago fairways
Cargo information:	Drilling mud
Manning:	7
Pilot on board:	No
Number of passengers:	0

2.4 Weather data

Wind – direction and speed in m/s:	South-easterly 5.5-8 m/s
Wave height:	0.2 m
Visibility:	Good
Light/dark:	Light

2.5 Marine casualty or incident information

Type of marine casualty/incident:	Grounding
IMO classification:	Serious
Date and time:	1 August 2013 at 0517 LT
Position and location:	Groeneskjeret in the Aafjorden, Norway
Position:	61°13.430' N – 004°59.576' E
Ship's operation/voyage segment:	In transit, national
Human factors:	Yes
Consequences:	Damages to the ship's bulb stern as well as leakage between the forepeak and the bow thruster room. No pollution or personal injury.

2.6 Shore authority involvement and emergency response

Involved parties:	Redningsselskapet and the Norwegian Coastguard.
Resources used:	The rescue vessel HALFDAN GRIEG, the Coastguard vessel TOR, the tugs GECO and FASTNET NORE from Florø Port as well as the tanker AMALIE.
Measures taken:	The ship was examined for any risk of pollution.
Results achieved:	The ship was refloated and towed alongside the quay at the Lutelandet.

2.7 Information about relevant crew members

Mate:	Certificate of competency STCW II/2. 68 years old. Has been employed by the shipowner since 2007 and has previously been engaged as a master by the shipowner. Has been at sea for appr. 25 years.
Master:	Certificate of competency STCW II/2. 42 years old. Has been employed by the shipowner since 2008 and has been at sea for appr. 27 years. Master since 2012.

2.8 Place of marine casualty/incident



Figure 2: Position of the grounding in the Aafjorden, Norway
Source: Google Earth

3. NARRATIVE

3.1 Background

At the time of the accident, DART was owned by the Norwegian shipowner SOLTIN AS and registered in the Danish International Register of Shipping with its domicile in Aarhus, Denmark. The technical operation of the ship was performed by the Danish operator Maritime Management ApS. The ship was specialised in the carriage of drilling mud from oil extraction and was typically engaged in voyages between fixed ports along the Norwegian coast and had, in addition, individual voyages to the Netherlands.

When the ship grounded, the ship had a crew of seven persons consisting of two navigation officers, one engineer officer, one motorman, two ABs as well as a cook.

The ship's master and mate, who were on board during the grounding on 1 August 2013, signed on on 14 and 21 July 2013, respectively. They both held a Norwegian so-called "farledsbevis", which meant that they were permitted to sail along the Norwegian coast without having a pilot on board.

All times are given as the ship's local time.

3.2 Sequence of events

3.2.1 The voyage until the grounding

On 31 July 2013 at 0440, DART departed from Dusavik, Norway, after having been loaded with 534 tonnes of drilling mud and headed north towards Floroe to be loaded additionally. Subsequently, the total cargo was to be unloaded in the north in Averøy.

On its voyage towards Floroe, the ship made a short stop in Kopervik at 0715 due to problems with the ship's ECDIS¹, which was used for navigation as well as route and loading planning. The ECDIS consisted of two independent units, one of which was a primary ECDIS used for navigation. The other one was a secondary ECDIS to which a shift should be made in case of malfunction of the primary ECDIS. The problem concerned the ship's primary ECDIS. It had started operating slowly and could not be updated and was, consequently, inspected by a repair company in Kopervik. At 1625, DART resumed its voyage towards Floroe. At this point in time, the mate was the officer of the watch on the bridge.

After appr. ten minutes' sailing, the mate observed that the ECDIS sound alarm had been turned off. Normally, it would sound when the ship was approaching a waypoint if the ship deviated from its planned route. The sound alarm had functioned before the ECDIS was serviced earlier that day.

Since the crew could not configure the sound alarm by themselves for safety reasons, the mate called the master and informed him about the problem. The master contacted the company that had serviced the ECDIS earlier that day and was informed that the company did not have a possibility of sending a repairman to the ship once again that day. Both the mate and the master perceived the communication received from the repair company as un-cooperative. The master decided to continue the voyage and instead contact the ECDIS supplier for assistance the next morning. It was not possible to get in contact with the supplier the same day since it was outside normal office hours.

At 1800, the master took over the bridge watch off the rock Bloksen. The voyage went as planned, and there was a light to moderate breeze and good visibility. At 0000, the mate took over the watch again. Then, the ship was in a position off the Bratholm Light. There was a drizzle, but visibility continued to be good. It started getting light at appr. 0300.

The voyage continued as planned until 0507, whereafter the mate could not remember anything until the ship went aground at 0517. The picture from the ship's ECDIS (figure 3, page 8) shows that the mate had not altered the course at the waypoint passed at 0509. Instead it proceeded on the original course until the ship went aground on the Groeneskjeret at 0517. The mate immediately woke up at the sound of the ship's contact with the rock and set the pitch of the screw at zero. The AB who was keeping the watch on board the ship and the master were both present on the bridge one minute after the grounding.

¹ Electronic Chart Display and Information System.

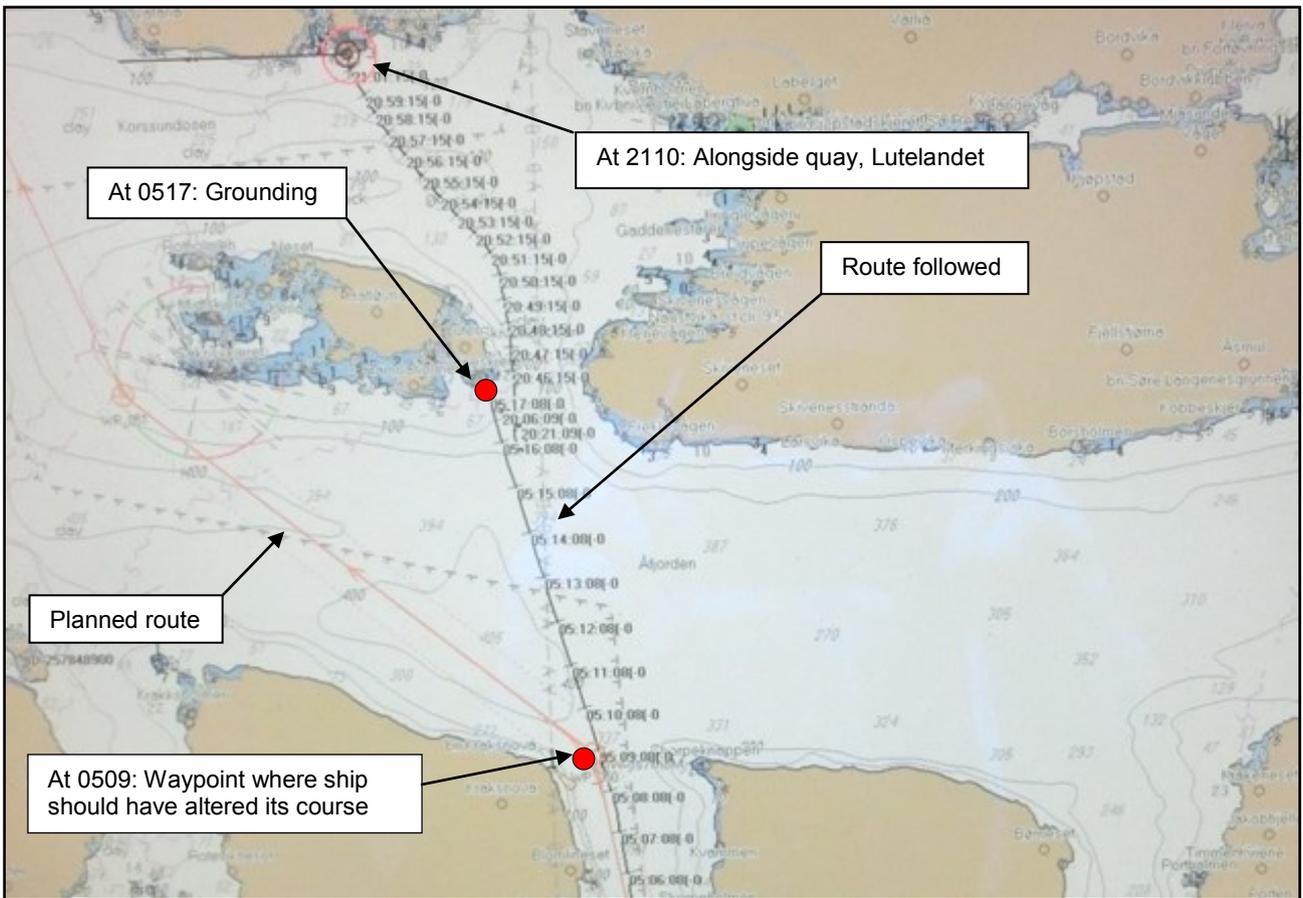


Figure 3: Picture from EDCIS. The red track shows the planned route, while the black track shows the route followed. Source: The Danish Maritime Accident Investigation Board



Figure 4: Grounding on the Groeneskjeret Photo: Maritime Management ApS

3.2.2 *The salvage*

At 0530, the master asked the mate to call Florø Radio and inform them about the grounding and make them take the necessary measures. While the mate was making the call, the master familiarized himself with the SMS² of the ship and called the company Emergency Group. The rest of the crew were tasked with getting an overview of the damages to the ship and sounding the tanks. At 0550, the master had established contact with the Rescue Centre, the Coast Guard, the Norwegian Maritime Authority and the Norwegian VTS.³

The ratings and the chief engineer found a minor crack between the bow thruster room and the forepeak, but no additional damages or leakages. It was ascertained that the ship was standing very firmly on the ground. At 0630, the main engine was stopped.

At 0831, the rescue vessel HALFDAN GRIEG arrived at the scene and attempted to get DART off the rock. The attempt was unsuccessful since it was low tide and, consequently, it was decided to wait until the next high tide and get assistance from tugs. HALFDAN GRIEG positioned itself alongside DART, ready to provide assistance should the need arise to discharge the ship in case of water ingress.

The police arrived at the scene of the accident at 1030 and embarked the ship in order to take statements from the crew and to breathanalyze the mate and the master. The test showed an alcohol per thousand of zero in both cases.

At 1300, the Norwegian Coast Guard vessel TOR arrived at the place of the accident, and two of its crewmembers embarked DART at 1340 to examine the damages to the ship and risk of pollution. The Coast Guard assessed that the risk of pollution was very low. Only the forepart of the ship had been damaged, and the foremost bunker tank was empty. The crewmembers from TOR left DART again at 1400. The ship remained at the place of the accident in case any pollution should arise, but did not provide any further assistance.

The crack between the forepeak and the bow thruster room did not result in ingress of water, but the master decided to stabilize it before the tugs tried to get DART off the ground. He arranged for a shipment of cement to be transported to the ship from Florø, and the chief engineer and an AB managed to close the crack by means of foam rubber, cement and a plate. The intention was to minimize the risk of water ingress when the ship was pulled off the ground.

In order to improve the possibility of getting the ship afloat, the master decided, together with the shipowner, to unload part of the cargo from DART, especially from the foremost cargo tank. Tank no. 1 contained 183 m³ of drilling mud and tank no. 4, which was the aftermost tank, contained 302 m³ of drilling mud. The tanker AMALIE was permitted to take over part of the cargo from DART. AMALIE reached the place of the accident at 1705 and the unloading was initiated 15 minutes later. At 1900, the foremost cargo tank of DART had been emptied and 218 m³ of drilling mud remained in the aftermost tank.

When AMALIE departed at 1915, the tugs GECO and FASTNET NORE from Florø Port were ready to assist DART in getting off the rock. The master ordered all watertight doors to be closed and, subsequently, all men were called to the deck before initiating the towing. At 2003, DART got off the rock by means of the tugs.

The ship's crew inspected the ship for any leakages and sounded the tanks once again. No major leakage was found, but a small amount of water was seeping through the crack between the forepeak tank and the bow thruster room. The water ingress was estimated to 200 litres an hour.

² Safety Management System.

³ Vessel Traffic Service.

By means of the tug FASTNET NORE, DART came alongside the quay at the Lutelandet, Korssund, at 2110. The master asked HALFDAN GRIEG to place itself alongside DART for the duration of the night in case assistance should be needed if the water ingress became worse.

At 1135 the following day, divers examined DART for any pollution risk. They did not find any leakages. HALFDAN GRIEG remained alongside DART until around 1940 when it was assessed that the leakage in the ship was under control.

3.3 Voyage and cargo

DART was typically engaged in voyages between fixed ports on the Norwegian coast and was, in addition, engaged in individual voyages to the Netherlands carrying drilling mud from oil extraction for cleaning. Each individual sea voyage could have a duration of between half an hour and up to four days, and DART called at appr. one port a day.

The planning of the route as well as of the loading and unloading was a matter of routine. Since the ship was engaged on voyages between fixed ports, the routes were stored in the ship's ECDIS, and the ship was always carrying the same type of cargo just as all four tanks were usually fully loaded.

The waters along the Norwegian coast are characterised by many islets, rocks and narrow sounds. The master and the mate had navigated these waters for several years and, therefore, did not consider the area difficult to navigate. They had both acquired the so-called "farledbevis" permitting them to navigate the Norwegian coast without having a pilot on board.

3.4 Alarms

3.4.1 Bridge watch alarm

DART was fitted with a bridge watch alarm the purpose of which was to sound the alarm in case there was no reaction on the bridge. Thus, the bridge watch alarm functioned as a so-called dead man's alarm that could wake up the person concerned or warn the rest of the crew in case the officer of the watch had fallen asleep or felt unwell.

The functioning of the bridge watch alarm fitted on DART was such that a sensor would register any movements on the bridge (figure 5, page 11). For each movement registered by the sensor, a watch would start counting down from five minutes. If no movement was registered during these five minutes, a high tone would sound. The alarm was audible in the master's cabin and, furthermore, throughout most of the accommodation.

It was possible to switch on and off the bridge watch alarm by means of a control device on the bridge (figure 6, page 11). However, the crew never turned off the alarm since it would automatically become active when the engine was running and the ship was at speed.

The bridge watch alarm did not sound prior to the grounding of DART though the mate had been asleep for appr. 10 minutes. The reason for this was probably that the movement sensor was located too close to the chair in which the mate was sitting (figure 7, page 11). This meant that very small movements by the sleeping mate were registered and that the bridge watch alarm, therefore, started counting from the start. The crew on board DART did not realize that there was a problem with the bridge watch alarm prior to the grounding.



Figure 5: Movement sensor
Source: Danish Maritime Accident Investigation Board



Figure 6: Control device for the bridge watch alarm
Source: Danish Maritime Accident Investigation Board



Figure 7: The location of the movement sensor in relation to the chair in which the mate was sitting during the grounding
Source: Danish Maritime Accident Investigation Board

3.4.2 ECDIS

DART was navigated by means of electronic charts and the ship was fitted with an ECDIS, consisting of a primary ECDIS and a secondary ECDIS. The two units were running independently of each other. The primary ECDIS sounded an alarm when it registered that the ship was approaching a waypoint, if it deviated from its route, or if a risk of grounding arose. The alarm was signalled by means of a staccato repetition of a tone from the computer loudspeakers as well as a red, flashing beam on the screen.

Following the departure from Kopervik, the mate observed that the sound alarm of the primary ECDIS did not function. The master was contacted and, since they did not succeed in getting a repairman on board, they decided to proceed towards Florø and get assistance from the supplier the next morning.

According to the ship's SMS, the procedure stipulated that, if one unit of the ECDIS was inoperative, a shift should be made to the other unit. The sound alarm on the secondary ECDIS functioned, but a shift was not made to this unit.

Only the sound alarm was inoperative on the primary ECDIS. The flashing visual alarm signal on the screen continued to be displayed.

3.5 Watchkeeping order – Lookout

When DART grounded, the mate was alone on the bridge without any lookout. The AB who formed part of the watchkeeping team during this period came to the bridge once every hour, but otherwise he had a fixed round of inspection on the ship, keeping an eye out for any dangers such as a leakage or a fire.

*The order on watchkeeping on board ships*⁴ prescribes that an appropriate lookout must be kept on the bridge. The lookout must be fully attentive of the lookout duty and, thus, not assume or be ordered to carry out any other work. Lookout duty and navigation duty are two separate tasks, and the helmsman must not be referred to as a lookout when he is navigating, except on board small ships with an unobstructed view of the entire horizon.

However, the officer of the watch can, pursuant to the order, have the lookout duty alone during daylight. The composition of the bridge watch should be assessed on the basis of, inter alia, the qualifications of the navigating officers and the ratings and the experience and knowledge of the ship's equipment, procedures and manoeuvring capabilities held by the officer of the watch.

The ship's SMS stated that a qualified navigating officer and an AB should always be available for the bridge watch. In accordance with the *watchkeeping order*, the officer of the watch could perform the lookout duty on his own during daylight. The obligations of the lookout consisted in observing the surroundings of the ship and keeping an eye out for elements that may present a danger to the voyage. The description of the ABs' duties did not specifically stipulate that they should form part of the watchkeeping team during the voyage. The watchkeeping duties of the ABs were specifically mentioned in connection with port stays. Lookout duty on the bridge was not specifically mentioned as a responsibility of the ABs.

The operational approach to the watchkeeping AB on board was that he went his rounds of inspection on the ship to check for any leakages or fires. The officer of the watch on the bridge could call for the AB at any time in case he needed a lookout, for example in case of dense traffic or poor visibility. Both the mate and the master preferred to stay on the bridge alone unless special circumstances prevailed. The AB could be disruptive to the concentration of the watchkeeping officer during conversations.

⁴ Order no. 1758 of 22 December 2006 (the watchkeeping order).

Shortly before the grounding of DART, the mate had navigated through the Krakellersundet, which is a narrow fairway requiring concentration. Consequently, he had preferred to perform the lookout duty himself.

3.6 Bridge watchkeeping arrangement

The master and the mate distributed the bridge watch according to a 6/6 shift so that the master had the bridge watch during the periods 0600-1200 and 1800-0000, and the periods between these two watches constituted his rest period. Similarly, the mate had the bridge watch during the periods 0000-0600 and 1200-1800 with intermediate periods of rest of six hours' duration. The master and the operator are responsible for planning the watchkeeping shift so that it is in compliance with the provisions on hours of rest. They are free to arrange another watchkeeping shift than a 6/6 shift.

Because the mate had experience as a master, it was not necessary to call in the master in connection with port calls and loading and unloading operations. Extra tasks such as drills and paperwork could, in general, be handled during the periods spent in ports, and since the ship was engaged in voyages between fixed ports and, more often than not, with a full tank, the route planning was stored in the ship's ECDIS and could be retrieved. This meant that deviations from the watchkeeping form were made only very rarely and, thus, it was also very seldom that watch duties were shifted.

3.7 Safe manning – Hours of rest

The safe manning document issued by the Danish Maritime Authority on 12 February 2003 requires the ship to have a minimum safe manning consisting of a master, a first mate, a chief engineer and three ordinary ship's assistants. The safe manning documents states that "*the above-mentioned ship is to be considered appropriately manned if it, when it leaves port, has a manning corresponding at least to what is stated below and overleaf.*" The operator and the shipowner considered the manning of DART to meet this requirement and, in addition, the ship was manned with a cook.

On board a ship where the safe manning document stipulates two navigating officers, it is normal to arrange the bridge watch in accordance with a 6/6 shift, as was the case on DART. The arrangement of the work on board meant that this watchkeeping scheme observed the provisions on hours of rest applicable according to Danish law at the time of the grounding.⁵

Hours of rest is defined as an uninterrupted period of not less than one hour's duration outside working hours. The provisions on the hours of rest of officers of the watch and ratings forming part of the watchkeeping team stipulate that the hours of rest must, as a minimum, amount to 10 hours during a 24-hour period and 77 hours during a seven-day period. In addition, it is possible to divide the hours of rest into a maximum of two periods, one of which must have a duration of at least six hours, and the period between two consecutive periods of rest must amount to a maximum of 14 hours.

The provisions on hours of rest are a legal construction and concern only the quantity of the hours of rest and not the quality of the hours of rest. Consequently, compliance with the minimum hours of rest requirement is not in itself a guarantee that the seafarer is rested.

3.8 Sleep

The human circadian rhythm is adjusted to the light and darkness cycle of the astronomical circadian rhythm. The circadian rhythm is a biological phenomenon in the human body regulating the

⁵ Order no. 515 of 21 June 2002 (order on seafarers' hours of rest).

time-related occurrence of various body functions, including the sleep process. During the night, a sleeping hormone is emitted, facilitating sleep, and during daytime this hormone is absent in order to facilitate a waking state. This circadian rhythm is not affected by a changed rhythm of sleep.⁶

While a human being is awake, it is building up a sleep requirement that is relaxed during the sleep. Since the circadian rhythm starts processes during the night that facilitate sleep, there are improved conditions for relaxing the sleep requirement during this period. In order not to accumulate a sleep requirement over several days and nights, 6-8 hours' uninterrupted sleep is required.

The mate on board DART had a watchkeeping shift according to which he was on the bridge during the periods 0000-0600 and 1200-1800. During the intermediate period of rest, he had adjusted his sleeping pattern so that he slept for appr. 5 hours during the period 0600-1200 and for appr. 2.5 hours during the period 1800-0000. The mate was comfortable with this arrangement. He did not feel tired, and he awoke by himself without using an alarm clock.

Each of the mate's periods of rest had a duration of six hours. The two times 6 hours are to include meals, baths and social activities. Though the mate went directly to bed after his watch, it would not be possible to get 6 hours of uninterrupted sleep, for which reason a lack of sleep would accumulate during the days and nights when he was forming part of the watchkeeping shift on board the ship. The mate got his main sleep in the morning before noon at a time when the biological circadian rhythm promotes a waking state. This means that the quality of the sleep gained during this period was impaired and that the sleep requirement had less favourable chances of being relaxed. During the night when the mate had the bridge watch, the circadian rhythm would emit sleeping hormones, facilitating sleep and thus impairing the possibilities of staying awake.

The mate fell asleep at appr. 0507, which means that appr. 24 hours had passed since his last main sleep was initiated. At this point in time, his sleep requirement must have approached a maximum during the relevant 24-hour period.

According to the watchkeeping order and the ship's SMS, the officer of the watch was permitted to have the bridge watch only if he was rested. The mate did not feel tired before the grounding, but research shows that it is quite subjective how tiredness is assessed and described. The relation between self-reported tiredness and objective tiredness is characterized by poor coordination, which means that there is not necessarily accordance between the objective tiredness and the degree of tiredness assessed by one self.

The fact that the mate on board DART fell asleep on his watch is not a unique case. A research project⁷ has shown that the risk of dangerous situations at sea is increased in cases where night watches are combined with the 6/6 shift and navigation in narrow fairways and that especially the last part of a night watch is critical in terms of the likelihood of falling asleep.

The same research project also showed that persons forming part of a 6/6 shift rather than an 8/4 shift had a tendency to lack sleep and that a micro sleep⁸ occurred in 45 per cent of the persons in the test group who were on a 0000-0600 watch in a 6/6 shift.

⁶ Jennum, Poul: *Søvn*. Munksgaard, 2013.

⁷ Project Horizon – a wake-up call. Research Report 2012. See: project-horizon.eu.

⁸ Micro sleep means an occurrence of sleep of typically 10-15 seconds' duration and may be caused by a lack of sleep. Persons hit by micro sleep are, in general, not aware that they have been sleeping.

4. ANALYSIS

In connection with accident investigations, human errors are considered to be the starting point in the investigations and are, thus, not considered to be a result of investigations. The purpose of the investigations is to unveil the circumstances behind the human behaviour and decision-making process. In this connection, it must be emphasized that the information that subsequently seems to be decisive was not necessarily available or recognized by those involved. This means that the probability of a specific incident occurring was not necessarily especially clear to those involved beforehand. This basis of the investigations carried out by the Danish Maritime Accident Investigation Board is decisive in order to understand how and why incidents develop. In this manner, the most effective safety learning is achieved.

4.1 The grounding

DART grounded after the watchkeeping mate had fallen asleep immediately before a waypoint. Since the ship did not alter its course, it deviated from the planned route and went aground.

The fact that the mate fell asleep was not considered to be the reason for the grounding in itself, but must be understood as a result of a sequence of events. The safety measures that could have woken him up did not function as intended. In addition, the arranged watch keeping rotation may have affected his sleep balance which resulted in him falling asleep unintentionally.

The nature of the waters may have been of importance to the outcome of the incident since distances are short when navigating sheltered waters and only a few minutes' inattention may lead to grounding.

4.2 Alarms

The bridge watch alarm did not react when the mate was sleeping. The movement sensor has probably registered minor movements by the mate and, thereby, reset itself. The on-board crew did not realize that the bridge watch alarm did not function as intended. In addition, the alarm was a passive measure that did not require intentional action to be de-activated. The design of the bridge watch alarm meant that it was possible to test it only while the ship was at speed and in case of lacking movements on the bridge. Therefore, the routine test of the bridge watch alarm before departure did not reveal the inappropriate location of the sensor in the specific case.

Shortly after departure from Kopervik, where the ship's ECDIS had been serviced, it became clear that the sound alarm of the primary ECDIS did not function. The master decided that DART should proceed towards the planned port of destination, Florø, though the sound alarm was inoperative. A conjunction of several circumstances was probably at the core of this decision. When the master contacted the repair company after departure, the company was dismissive and, therefore, the master would instead ask for assistance from the supplier the following day. Furthermore, the master as well as the mate had several years' experience navigating along the coast and therefore did not feel uncomfortable about the situation.

According to the ship's SMS, the master should see to it that a shift was made to the secondary ECDIS if the primary ECDIS did not function. A shift was not made to the other unit though the sound alarm did not function because the primary ECDIS was not perceived as being out of order. The primary ECDIS functioned in relation to navigation and the alarm signal was displayed on the screen. Only the sound alarm was inoperative. The master and the mate did not perceive the function of the sound alarm as that of keeping the mate awake since that was the function of the bridge watch alarm. Its function was to alarm the officer of the watch if the pre-defined limits on the ECDIS were exceeded. Against this background, the defect in the equipment did not give rise to intensified lookout.

4.3 Lookout

The mate was alone on the bridge just before the grounding. It was quite normal for the officer of the watch on board DART to be alone on the bridge when no special circumstances necessitated the presence of a lookout. The AB who formed part of the watchkeeping team could have a disruptive impact on the bridge since they often conversed when they were together on the bridge. When the ship passed through the Krakellersundet, which is a narrow fairway, immediately before reaching the Aafjorden, the mate would like to remain concentrated and, therefore, the AB went on his rounds of the ship rather than kept a lookout.

The fact that it was normal procedure on board the ship for the officer of the watch to be alone on the bridge did not mean that safety on board was considered lightly. It is rather an expression of the operational safety thinking on board. The concentration of the officer of the watch could be disturbed by the watchkeeping AB if there were no special circumstances such as weather and traffic conditions to be looked out for. In addition, the watchkeeping AB had a safety function when he went on his rounds of inspection on the ship, checking for any dangers on board.

The size of the ship, the fact that it was light and that visibility was good meant that, at the time of the grounding, the mate acted in accordance with the *watchkeeping order* or the ship's SMS when he was alone on the bridge.

4.4 The watchkeeping arrangement

The master and the mate performed the bridge watch in accordance with a 6/6 shift, which is ordinary on ships of this size, and the watchkeeping scheme was in accordance with the provisions on hours of rest. Neither the master nor the mate held the view that the watchkeeping scheme had a negative impact on their sleeping balance and they had both had this shift at sea for several years. There are indications that the provisions on hours of rest were met in practice since the watchkeeping form was only rarely changed or exceeded.

The provisions on hours of rest are a legal construction securing the seafarer a certain quantity of sleep, but they do not concern the issue of the quality of the sleep. Therefore, compliance with the provisions on hours of rest on board DART is not the same as saying that the mate was rested.

The watchkeeping order and the ship's SMS prescribed that the officer of the watch should be rested when forming part of the bridge watch. However, research shows that there is not necessarily any correlation between how tired one feels and how tired one objectively is. The mate did not feel tired on his watch, but it cannot be rejected that he was tired in objective terms. If the coordination between the mate's subjective feeling of tiredness and his objective tiredness was poor, he has probably not been able to realize or react to this tiredness.

The circadian rhythm of the human being is biological and follows the astronomical day and night cycle, where the sleeping process is facilitated during the night and a waking state is facilitated during the day. Since the mate has had the night watch, he has kept awake during a period of the day when the biological processes have facilitated tiredness. Similarly, he had his main sleep during a period of the day when a waking state was facilitated, which may have affected the quality of his sleep.

The mate falling asleep spontaneously may have been a combination of the biological circadian rhythm having set the body in a sleep-facilitating mode and the body simultaneously trying to compensate for an accumulated lack of sleep and sleep requirement.

5. CONCLUSIONS

DART grounded as a consequence of the watchkeeping mate falling asleep during the bridge watch. Additionally, the functional barriers, (i.e. the bridge watch alarm and the ECDIS alarm) intended to wake the mate and warn him about the ship's deviation from the course, did not function at the relevant point in time. The mate falling asleep may have been caused by the fact that the manner in which the watch shift was arranged led to reduced quality of sleep though it was in compliance with the provisions on hours of rest. These factors together constitute an explanation of why the accidental event occurred.

The mate slept for appr. 10 minutes before the grounding. In this connection, the nature of the waters has been of importance since the attentiveness of the officer of the watch is especially required during voyages in sheltered waters because a few minutes' inattention can result in grounding.

6. PREVENTIVE MEASURES

After the grounding of DART, the operator of the ship has ensured that the movement sensor on the bridge has been moved aft. This means that now the movements required to prevent the bridge watch alarm sounding must be of such a nature that they cannot be made unconsciously.

The lacking ECDIS sound alarm turned out to be due to a software problem, which has been remedied.

The operator is evaluating the existing watch shift on the basis of the report analysis. Taking into account the typical trade of the ship in narrow waters, a mandatory lookout on the bridge has been introduced during the period 0000-0600.