Bundesstelle für Seeunfalluntersuchung
Federal Bureau of Maritime Casualty Investigation
Federal Higher Authority subordinated to the Ministry of Transport,
Building and Urban Affairs

Investigation Report 47/08

15 January 2009

Serious marine casualty

Collision of the MV SCHLESWIG-HOLSTEIN with the Skanseodde Lighthouse in Fredericia on 31 January 2008

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The investigation was conducted in conformity with the law to improve safety of shipping by investigating marine casualties and other incidents (Maritime Safety Investigation Law/Seesicherheits-Untersuchungs-Gesetz, SUG) of 16 June 2002.

According to this, the sole objective of the investigation is to prevent future accidents and malfunctions. The investigation does not serve to ascertain fault, liability or claims.

This report should not be used in court proceedings or proceedings of the Maritime Board. Reference is made to § 19 paragraph 4 of the SUG.

The German text shall prevail in the interpretation of the Investigation Report.

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Table of Contents

1 SUMMARY OF THE MARINE CASUALTY 5
2 SCENE OF THE ACCIDENT 6
3 VESSEL PARTICULARS 7
3.1 Photo 7
3.2 Particulars 7
4 COURSE OF THE ACCIDENT 8
5 INVESTIGATION 11
5.1 Damage report 11
5.2 Voyage planning 16
5.2.1 Pilot transfer 16
5.2.2 Sailing directions and current 18
5.3 Statements of the masters of the SCHLESWIG-HOLSTEIN, the pilots and tug masters 23
5.3.1 Onboard survey 25
5.3.1.1 Navigational equipment 27
5.4 Recordings from the Danish authorities 28
5.5 VDR recordings 29
5.6 Weather expertise 39
6 ANALYSIS 40
7 ACTION TAKEN BY THE VESSEL OPERATOR 44
8 SOURCES 45

Table of Figures

Figure 1: Chart 6
Figure 2: Photograph of the vessel 7
Figure 3: Keel plate 11
Figure 4: Shell 11
Figure 5: Engine room 11
Figure 6: Separator room 11
Figure 7: Tragten pilot transfer 17
Figure 8: Section showing natural conditions in the Baltic Sea, BSH 19
Figure 9: Section from the Kattegat Manual Part I, BSH 20
Figure 10: DMI model 22
Figure 11: Control positions 24
Figure 12: Tandem operation 24
Figure 13: Navigational equipment 27
Figure 14: AIS place of collision 28
Figure 15: AIS course of voyage 29
Figure 16: Configuration of the pod drives 30
Figure 17: VDR-X band radar 17:40:08 system time 31
Figure 18: VDR-S band radar 17:40:08 system time 32
Figure 19: VDR with ECS display 17:40:08 33
Figure 20: Sketch of drift at 17:40:08 34
Figure 21: VDR-X band 17:42:00 system time 35
Figure 22: VDR-S band 17:42:00 system time 36
Figure 23: VDR with ECS display 17:42:00 36
Figure 24: VDR-X band 17:44:00 system time 37
Figure 25: VDR-S band 17:44:00 system time 38
Figure 26: VDR with ECS display 17:44:00 38
Figure 27: Sketch of the Fredericia leading light line and the Skanseodde sectors.. 41

1 Summary of the marine casualty

On 31 January 2008 at 17:42[1] the German double-end ferry SCHLESWIG-HOLSTEIN, proceeding with pilot advice and tug assistance, collided with the Skanseodde lighthouse after leaving floating dock II at Fredericia/Denmark and destroyed the lattice work. The vessel suffered a leak and had to return to a safe berth at Fredericia. There were no passengers on board and there were no casualties. Since the early morning hours, the wind had been blowing from south-southwest to south with an average force of 6 to 7 Bft, in gusts of 9 Bft. Sleet and rain obstructed visibility. The current set northeast at 1.5 to 3 kn. The SCHLESWIG-HOLSTEIN was at times drifting at 4 to 5 kn transverse to port in the direction of the lighthouse. The collision finally occurred when the master in charge gave lee for the pilot boat by changing course and reducing speed as the pilot intended to disembark.

[1] The times stated in this report refer to Central European Time (CET) = UTC+1h

2 Scene of the Accident

Type of event:	Collision with the Skanseodde lighthouse
Date/time:	31. January 2008, 17:42
Location:	Fredericia, Denmark
Latitude/longitude:	φ 55°33.3'N λ 009°46.4'E

Section from chart 21, Federal Maritime and Hydrographic Agency (BSH)

Figure 1: Chart

3 Vessel particulars

3.1 Photo

Figure 2: Vessel Photo

3.2 Particulars

Name of the vessel:	SCHLESWIG-HOLSTEIN
Type of vessel:	Train/car ferry
Nationality/flag:	Germany
Port of registry:	Puttgarden
IMO number:	9151539
Call sign:	DMLM
Vessel operator:	Scandlines Deutschland GmbH
Year built:	1997
Shipyard:	Van der Giessen-de Noord B.V.-Krimpen
Classification society:	Lloyd's Register
Length overall:	142 m
Breadth overall:	25.4 m
Gross tonnage:	15187
Deadweight:	2836 t
Draught at time of accident:	6 m
Engine rating:	15840 kW
Main engine:	2 MAK 8M32, 3 MAK 6M32
(Service) Speed:	18.5 kn
Hull material:	Steel
Crew:	25

4 Course of the accident

On 31 January 2008 at 15:00, the double-end ferry SCHLESWIG-HOLSTEIN intended to undock from floating dock II, Fredericia Shipyard Ltd. in Jylland/Denmark in order to resume the ferry traffic from Puttgarden to Rødbyhavn. Due to technical problems on the newly installed pod drive thruster 2, undocking was delayed by about two hours. The second master on duty travelled from his residence to Fredericia, which he had visited briefly during the time in the shipyard, for the onward journey to Puttgarden and boarded the vessel at 13:00 to relieve his colleague according to the duty schedule. The other master on duty was at work from 06:00 to 13:00 and was in charge of dock watch. Around 15:00 it was „stand by fore and aft", and the manoeuvring stations were manned at the 'south forecastle' by the chief mate and at the 'north forecastle' by the second officer, as well as two ship's mechanics each. Both masters and the pilot (who boarded at 15:40) were at the south bridge[2]. During the day, the wind increased constantly, and at the time of undocking it freshened up to 8 Bft from the south with steady rain and partial sleet.

The pilot informed the master in charge of sailing who had just arrived and was standing at the chart table in front of a paper chart, that the forward tug SVITZER MENJA and the aft tug FRIGGA would fasten for departure. There was no particular discussion about the manoeuvring characteristics of the SCHLESWIG-HOLSTEIN and the current in the Snaevringen fairway in front of Fredericia, generated by a strong wind, though requested by both masters. The pilot did not consider this a problem as long as all pod drives were working. Both masters informally made ready to sail and switched on the navigation equipment. Both were familiar with the area. First of all the radar antennas were not switched on in order to protect dock personnel.

Both tugs were on the spot at about 16:00. Undocking was delayed by another hour until thruster 2 was declared clear and generators 2 to 5 were started up. Generator 1 was switched off. At 17.12 the tugs fastened and on the north and south forecastle manoeuvring stations they began to single up the lines. Subsequently the ship floated free from the blocks. At 17:24, all lines were singled up and the SCHLESWIG-HOLSTEIN left the dock at 17:29. Then the S band radar antenna was switched on. Both tugs were released at about 17:35. During this manoeuvre the ship drifted northeast and got close to the Kastelshavn pier. No distances were communicated by the manoeuvring stations. Only the tug crews tried to call the pilot on VHF channel 13 and draw his attention to the dangerous drift. According to observations of the tug crews, the SCHLESWIG-HOLSTEIN manoeuvred forcible with the pod drives and gathered speed again on a south easterly course.

[2] The SCHLESWIG-HOLSTEIN is a double-end ferry with two fully equipped bridges that are designated with the prefix 'north' and 'south'; analogously, the manoeuvring stations are designated as 'north forecastle' and 'south forecastle'.

At the same time, the ship drifted further parallel along the oil pier of Skanseodde-havn. During this phase, the master in charge was at the conning position on starboard side steering the four pod drives predominantly in tandem operation with two wheels. The second master, was amongst others, engaged in filling in the pilot papers, communicating with the officers at the manoeuvring stations by hand-held radio sets and preparing the transfer of the pilot who wanted to disembark. The shipside door on the starboard windward side was made ready because the other side had been reported unready. At 17:38 the pilot left the bridge and was accompanied by the second officer to the starboard shipside door. The master reduced speed for the transfer. Once at the shipside door, the pilot asked the second officer to make more lee.

Up to this point, only the S band radar was switched on at the right-hand conning position on the bridge; it was centred on North UP relative motion and relative vectors (RM)R in the 0.5 nm range . The racon[3] (T) (3 cm) of the Skanseodde lighthouse could therefore not be displayed by the S band radar. The X band radar antenna was not yet switched on. Only AIS targets were visible on the associated monitor. On the third monitor midships from the conning position, technical data was displayed such as rudder, rate of turn, pod operation, drift and speed. Echo sounder and electronic chart were not displayed on the monitors. The German chart 21 (Snaevringen and Kolding Fjord) laid on the chart table. The master in charge was engaged in controlling the pod drives and was navigating by sight. According to his statement, he steered 160° and initially was in the green sector of Skanseodde lighthouse which then changed to red. Shortly afterwards, the light on the port site came out of sight so it was no longer visible from the starboard conning position. The second master had also lost sight of the light that would have only been visible from the bridge wing and the manoeuvring stations while the SCHLESWIG-HOLSTEIN drifted towards the Skanseodde lighthouse. When the pilot left the bridge at approx. 17:38 the X band radar antenna at port was switched on. At first the setting was centred on Head Up relative motion and relative vectors (RM)R in the 0.75 nm range and several filters were selected. Somewhat later, the radar image was adjusted to be decentred with a larger ahead range. The Skanseodde racon was not identifiable with these settings.

At 17:42 the ship heeled and the second master heard noises on the bridge. The south forecastle look-out used the hand-held radio set to report that there had been a collision with an unknown object on the port side at water line level. The pilot was ordered back to the bridge. At 17:45 water ingress in the separator room was reported. It could be controlled by closing the bulkheads and taking bilge measures (see expertise). The water penetrating in the engine room could be observed from the bridge by the camera system. At 17:53 all bulkheads were closed and generator 5 was switched off as a precaution followed by generator 4 at 18:19. The SCHLESWIG-HOLSTEIN turned to the south and steered back to the port while the second master requested tugs. At 18:17 the aft tug SVITZER MENJA was fastened, followed at 18:55 by the forward tug FRIGGA. At 19:30 the SCHLESWIG-HOLSTEIN moored at berth 17 in Vesthavn and water was pumped out of the engine room by means of extra external measures and pumps supplied. Around 22:00 the ship manoeuvred into the dock.

[3] Racon: Radar beaCON

5 Investigation

5.1 Damage report

After the accident the ship was surveyed by Survey Association Ltd. Copenhagen acting on behalf of the hull underwriter.

Following damages noted:

Hull:

Damage is located at frame 12 and include the keel plate and up to the shell plate strake G.

There is a penetration of approx. 100 x 500 mm into the separator room in East side.

There is a penetration of approx. 100 x 4000 into the sludge tank in East side.

Furthermore indentations are present in the range of the void space 106 and electrical stores.

Oil is leaking from the sludge tank.

Paint scratches are found on the keel between frame 42 and 62 an on the east side of the keel.
The tanks have been inspected and no damage has been noted.

Figure 3: Keel plate

Figure 4: Shell plating

Engine room Section 5:

The complete compartment has been floated with water and mixed with sludge from penetrated sludge tank in separator room.

Approx. 20 pieces of electrical motors are damaged.

4 pieces of oil heaters have been submerged.

Approx. 400 meter of insulation and approx. 70 pads are damaged.

Approx. 400 meter of el tracing on insulated fuel pipes are damaged.

Approx. 10 pieces of thermostats have been submerged.

Approx. 12 pieces of actuators have been submerged.

Approx. 10 pieces of switches have been submerged.

Approx. 10 pieces of connection boxes have been submerged.

Water/oil has entered lower part of the main generators number 4 and 5.

Water/oil has entered into lubrication oil sump tank for main engine no. 4 and 5 (approx. $8m^3$)

Approx. 40 m^2 insulation in the bulkhead between engine 4 and 5 is damaged.

Spare parts and tools need cleaning and preservation.

Azimuth thruster North East:

Scratches can be seen on the blades.

There has not been any contact between the thruster housing and the foundation of the light house.

Necessary repairs:

Hull repair:

To crop and replace the following amount of steel (Grade A):

<u>Keel plate:</u>

A + B plate strake	4000 x 2000 x 14 mm
C plate strake	6000 x 2000 x 12 mm
D plate strake	1800 x 2000 x 14 mm
E plate strake	2600 x 2000 x 14 mm
F plate strake	2000 x 2000 x 18 mm AH36
G plate strake	3000 x 2000 x 12 mm

<u>Internals:</u>

Floor plates	3000 x 3000 x12 mm
Frame –12	4000 x 1000 x12 mm

Stringer 3700	2000 x 1000 x10 mm
Longitudinal frames	HP200 x 9 x 18000 mm
Frames	HP240 x 11 x 1200 mm
Bilge keel	HP340 x 12 x 4000 mm
Bilge keel	4000 x 60 x 12 mm
Deck/tank cover	4000 x 2000 x 8 mm

In order to replace the steel in the keel it is necessary to remove 3 keel blocks.

Necessary staging, lighting, ventilation and access.

Engine room repair Section 5:

Pumping out of seawater and sludge from tank top in engine room section 5.
Cleaning of compartment from approx. 60-70 cm above the gratings and all the way to tank top. (s. fig. 5 and 6)

Figure 5: Engine room

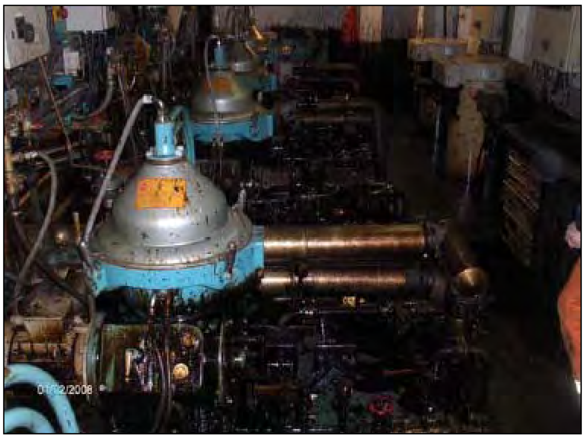


Figure 6: Separator room

Main engine 4 & 5.
To inspect the internal of the engines.
To repair/replace the elmotor for the pre-lubrication pump and pre-heater pump.

Main generator no 4 & 5.
To clean out the salt and oil by freshwater, arrange heating for at least 3 days and megger readings to be taken.

Separators:
Replacement of all el motors, sensors and switches.

Electrical motors:
All submerged el motors to be dismantled and brought to workshop for dismantling, cleaning and possible repair. Non repairable motors to be replaced with new.

Actuators:
All submerged actuators to be dismantled for cleaning and possible repair. Non repairable units to be replaced with new.

Switches:
All submerged switches to be dismantled for cleaning and possible repair. Non repairable units to be replaced with new.

Azimuth thrusters North East:

The oil to be drained into clean drums (approx. 6.000 litres)

End cover on the lower unit to be removed for inspection of gear wheels.

Inspection cover on the upper unit to be dismantled for inspection of the gear wheels.
The slewing motors (2 pcs) to be removed for inspection.

The scratches on the propeller blades to be ground and polished.

Alignment check of the coupling to the electrical motor.

Cause of the incident:

At this stage it is not possible to conclude the cause for the damage, but further investigations are carried out and a conclusion will be included in the next report.

The master has informed that all propulsion machinery was in operation and all equipment were working to his satisfaction.

Additional information:

The Svitzer tugs Menja and Fenja were used for the assistance to port.

The Svitzer tugs Menja and Frigga were used for assistance when docking the vessel.
The cleaning of the main generators is carried out by Siemens Hamburg.

Recommendations:

None for the time being.

Outstanding:

The extent of the damage to the light house and possible repair has not yet been clarified, but will be surveyed with the next days.

A more detailed report with additional photos will be forwarded within the next days.

Main engines 4 and 5:
Inspect the installed parts of the engines.
Repair/replace the electric motor for the lube oil pump and preheating pump.

Main generators No. 4 and 5:
Wash out salt and oil with heated fresh water, arrange for 3 days of heating and read off resistance meter.

Separators:
Replace all electric motors, sensors and switches.

Electric motors:
Dismantle all flooded electric motors and clean them in the workshop, repair if necessary. Motors that cannot be repaired are to be replaced with new ones.

Control elements:
All flooded control elements are to be dismantled for cleaning and possible repair. Units that cannot be repaired are to be replaced by new ones.

Switches:
All flooded switches are to be dismantled for cleaning and possible repair. Units that cannot be repaired are to be replaced by new ones.

Northeast pod drive:

The oil is to be pumped off into clean containers (about 6000 litres).
End cover of bottom unit is to be removed for inspection of the gear unit.
Cover on the top unit must be dismantled to inspect the gear unit.
Two adjustable oil motors are to be removed for inspection.
The scratch marks on the propeller blades are to be ground off and polished.
Check the adjustment of the electric motor coupling.

5.2 Voyage planning

For the voyage from Fredericia to Puttgarden, the masters of the SCHLESWIG-HOLSTEIN had nautical charts issued by the BSH as ECDIS and in paper format as well as hard copy nautical publications such as the Nautischer Funkdienst books (marine radio signal books), sailing directions, tide tables and list of lights.

5.2.1 Pilot transfer

Apart from a few exceptions the Danish pilot service is provided by state pilots.

Requests for regional and port pilots for Fredericia are to be directed to the Lillebælt Pilot Station.

The Danish pilot law also contains the following conditions:

When consideration of public safety, military reasons, navigational safety, maintenance of order, prevention of danger, consideration of the environment or other significant public interests support this, the Danish Pilotage Authority can decide that there is an obligation to use a pilot.

Ships may only accept official Danish pilots in Danish ports and in Danish territory, unless this has been ordered otherwise by contract.

Even outside territorial waters, ships that want to accept Danish pilots are only entitled to an official pilot who has been approved for the respective route.

If there is no official pilot available although the vessels command has requested a pilot, then it is up to the vessels command to find any person with knowledge of the fairway as a stand-in pilot (Kendtmand) and to pay him according to their agreement.

Such a stand-in pilot is obliged to inform the vessels command immediately that he is not an official pilot and that the pilot signal must continue to be displayed until either a pilot comes on board or the ship comes to anchor.

In Danish waters pilots may only embark or disembark either when the ship is in port, by a jetty, in a roasted, etc., or at pilot embarkation points as approved by the Danish Minister of Defence, unless special circumstances apply. The pilot transfer position is marked on the chart as NE of Tragten (see Fig. 7).

Section from the chart 18, Federal Maritime and Hydrographic Agency (BSH)

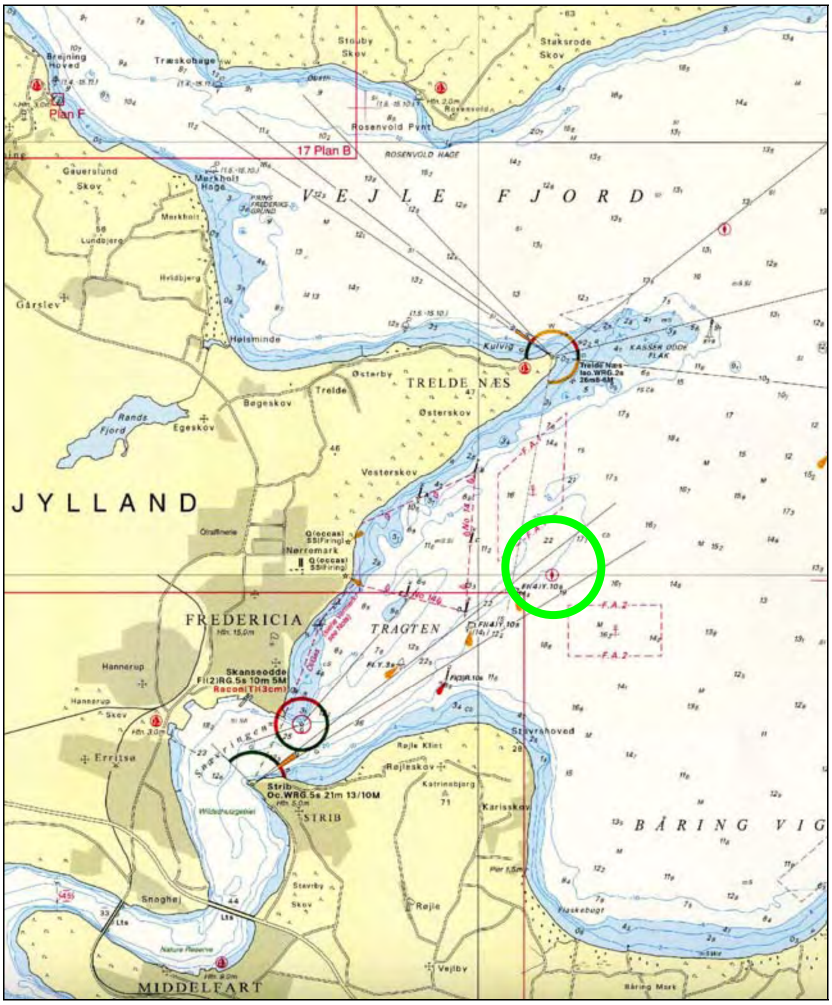


Figure 7: Tragten pilot transfer position

In this instance, with the prevailing strong southerly winds, the pilot had decided to transfer west of Skanseodde lighthouse (Snævringen). This decision was conveyed to the master only just before, without any special indication of the risks from wind, current and drift.

5.2.2 Sailing directions and current

Lillebælt (Little Belt) is the name of the westerly connection between the Baltic Sea and Kattegat. The passage is narrow and meandering especially between the Danish mainland and the island of Fyn, as well as at some points of the central section; however, the main fairway through the Lillebælt is well marked for daytime and night-time sailing and also allows ships with a greater draught to steer through. In Tragten, the NE entry to Lillebælt NE from Fredericia, the water depths over level ground are between 12 m and 16 m.

Snævringen, the waters between Bredningen and Tragten, is about 4 to 5 kbl wide at the narrowest points. The harbour towns of Middelfart and Fredericia lie along this passage. The fairway through the funnel shaped, tapering NE entrance to Tragten has the lowest water depth with approx. 12 m to 16 m.

Fredericia (55°34'N 009°45''E) is on the west side of the NE entrance of Snævringen. Vessels with maximum dimensions of up to 300 m long and a 13.3 m draught can call at the port.

Entering ships have right of way. Before entering and leaving, a VHF message on channel 71 must be transmitted to the port authority.

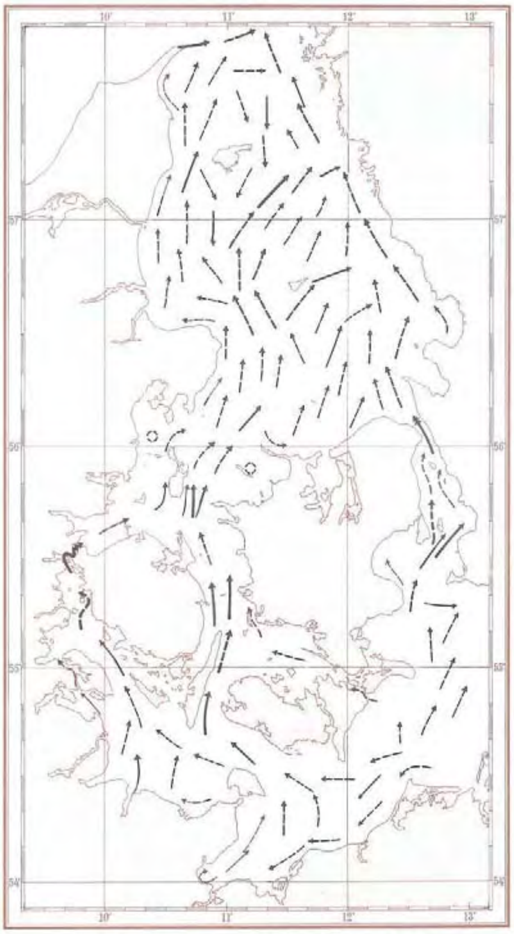
The surface currents through the Belt and the Strait are more sloping and drift currents. The greatest current speeds (more than 2 nm/h on a daily average) occur with W and E winds, i.e. where there are especially high wind-generated differences in water level between the Kattegat and the SW Baltic Sea.

Depending on weather conditions, there are essentially two current directions in the Belt and Strait: With winds from southwest via west to northwest, the current sets into the Baltic Sea, i.e. there is an incoming current; with winds from northeast via east to southeast it sets out of the Baltic Sea, i.e. there is an outgoing current. The S wind also generates an outgoing current as the outflow from the Baltic Sea is reinforced by the thrust of the wind; however, in general the current speeds are lower than with E and W wind conditions. Incoming and outgoing current conditions can change quickly, where outgoing current conditions last longer and predominate on average over longer periods of time.

At lower levels, the current does not depend so much on weather conditions. In general there is an incoming current characterised by the salt-rich and therefore heavier North Sea and Kattegat waters pushing beneath the low-salt, lighter Baltic Sea water. In winter and spring, when there are sustained winds from the east (if there is no temperature layering) the outgoing current can cover the entire water column so that even low-salt Baltic Sea water at depth is drawn north. The current speed is however much lower at depth than on the surface.

In individual cases, surface currents of 4 nm/h can occur in the principal current lines of Storebælt and Strait; and surface currents of 3 to 4 nm/h speed can occur in Lillebælt. The current speed is higher with W winds than with an E wind of the same force. – Weaker winds give similar current distributions. However, the current speeds only reach 1 to 1.5 nm/h on daily average with a wind force of 3; mostly they are under 1 nm/h, and frequently there is even a virtual current standstill. – When the wind is still there is essentially a weak outgoing current.

Figure 8: Section showing natural conditions in the Baltic Sea,
Federal Maritime and Hydrogaphic Agency (BSH)



Oberflächenströmung bei S-Wind, Stärke 6 Bft
Abb. B 5.2 a

Erläuterung zu der Darstellung der Oberflächenströmungen

Stromgeschwindigkeit in sm/h
(gilt für die Mitte des Pfeilschaftes)

<0,2
0,2–0,5
0,5–1,0
1,0–1,5
1,5–2,0
>2,0

Häufigkeit der Stromrichtung in %

>75
50–75
25–50

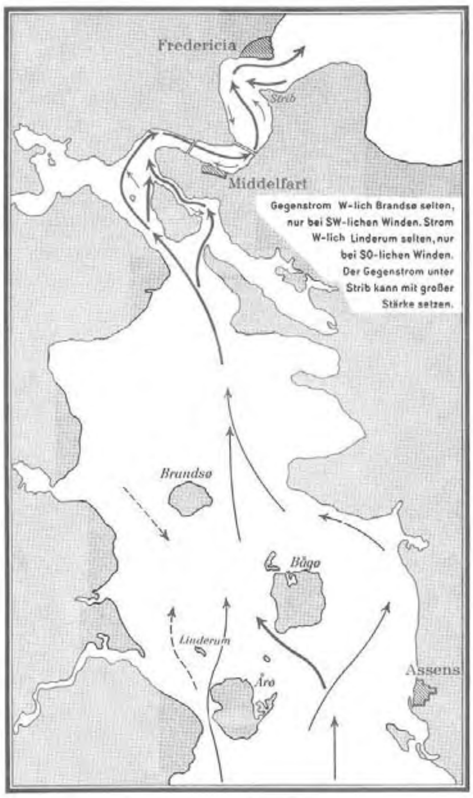
Unterbrochene Stromsignaturen
stützen sich nicht auf Beobachtungen
.......10-m-Tiefenlinie

Deviations from the average conditions shown in Fig. 8 (B 5.2 a) must be accepted around the complexly structured coastlines and when the shallows are flooded; there are also eddy currents along the coast.

The tidal wave penetrating from the North Sea spreads through the easterly Kattegat and Strait more rapidly than through the westerly Kattegat and the Belt. However, as tides and tidal currents are already insignificant in Skagerrak, they become hardly noticeable in the region of the Belt and Strait. The more powerful tidal current is in Storebælt and can be maximum 0.3 nm/h. The remaining region experiences maximum tidal currents mostly below 0.2 nm/h.

Surface currents can reach a major force in Lillebælt, specifically in the narrow Snævringen fairway. They do not always set in the direction of the fairway but partially move transverse to it. There is a countercurrent close to shore at individual areas along the coasts which can be used to great advantage by small vessels sailed by local commanders. As a consequence of the windings of the fairway, there are areas of different land protuberances where smaller vessels can anchor outside the current area or where the current is much less forceful than in the fairway. These particular anchorages are stated in the coastal description.

In spring, a northerly current predominates; at times it can run in this direction for several days consecutively without being influenced by local wind conditions. Later in the year, both the duration and strength of this current depend more on prevailing winds over the North Sea and Baltic Sea. A southerly current primarily occurs in autumn and then sets with much greater force than the northerly current. The current chart shows the normal progression of currents in the northerly section of Lillebælt (see Fig. 9).



N-Strömung in Lillebælt
Abb. C 2.1.3 a

Figure 9: Section from the Kattegat Manual Part I, BSH

In front of Fredericia port the current almost always sets eastwards even if there is a southerly current predominating in Lillebælt.

Tab. B 6.3 b Maximale Abweichungen vom mittleren Wasserstand in m mit Angabe der vorherrschenden Windrichtung und -stärke

	Lillebælt			Storebælt			Sund		
	Strib	Kolding	Assens	Kalund-borg	Korsør	Nyborg	Helsingør	Kopen-hagen	Dragør
Höchster Wasserstand (1916–1940)	1,25 NNW 7	1,10 SW 3	1,20 W 3	1,36 NW 8	1,19 NW 8	1,36 N 9	1,76 WNW 10	1,57 NNW 9	1,10 NNW 3
Niedrigster Wasserstand (1916–1940)	–1,08 W 9	–1,03 W 9	–1,50 WNW 8	–0,72 SSW 7	–0,73 WSW 10	–1,00 WSW 10	–0,46 S 7	–0,71 S 7	–0,60 S 7

Table B 6.3 b gives an overview of the extreme water conditions in the area of the Belt and the Strait, stating the local wind. According to this, the entries for water level drops do not reach that of the water level peaks. Extreme water levels only occur rarely, more frequently in winter than in summer. In general, water level fluctuations are minimal. For example, in Copenhagen an increase in water level of 0.4 m and more above mean water level was only observed in 10 % of cases; an increase of 0.75 m and more was observed in only roughly 1 % of cases; a drop of 0.4 m and more only ever occurs in 5 % of all cases.

The water level in the Little Belt fluctuates in calm weather as a consequence of the tides by about ± 0.2 m. However, it is very much influenced by the duration, direction and force of the wind. Gales can create bigger differences in the water level in the narrow, irregular fairways. In general, when there are NW to NE gales and a S current, the water in the northern section of Lillebælt is about 0.6 to 1 m above mean water level and drops by the same amount with SW to S gales and a N current.

The "Danmarks Meteorologiske Institut, Center for Ocean og Is (DMI)" has published daily animations of winds, wave heights and surface currents on its website http://ocean.dmi.dk. A northerly setting current at 1.5 kn was forecast on the early afternoon of 31 January 2008. Around 17:00 the current turned and set in a southerly direction until midnight. Subsequently it moved in a northerly direction again. However, the model calculations could not be verified on this day because there were no current measurements for the Lillebaelt from the "Miljoecenter Ribe". Since there is the constantly recurring setting of incoming and outgoing currents in Snaevringen (Fredericia), the model calculations are generally reliable presupposing that the input parameters from the weather model with the predicted gale were correct. A critical factor would be the time when the current turns. Fig. 10 shows a typical animation with a SW weather state from 27 June 2008 which shows the surface current, wind direction and wave height.

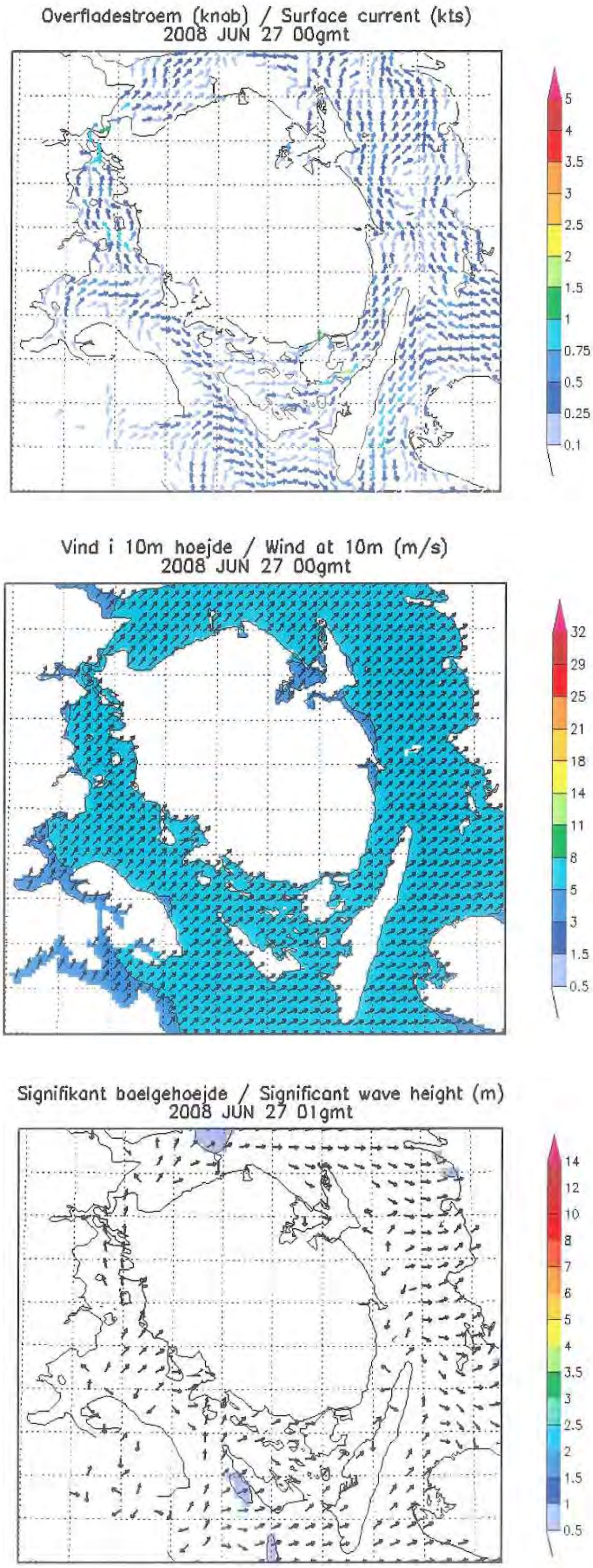


Figure 10: DMI model

5.3 Statements of the masters of the SCHLESWIG-HOLSTEIN, the pilots and tug masters

Once the pilot was on board about 15:40, the first master on duty who had arrived from his residence at 13:00 discussed the voyage plan with the pilot. Meanwhile the second master (who had dock watch since 06:00 in the morning and was relieved at 13:00 according to the duty schedule) had been working informal through the "un-docking" check list with the second officer since 15:00. The wind force had been growing continuously over the day, and during the undocking procedure there were wind forces of at least 8 Bft from the S with steady rain, partially mixed with snow. Visibility was 3 nm. Due to the weather conditions, the masters considered undocking the main problem for the voyage.

The undocking manoeuvre and pilot transfer position were discussed in detail between the first master and the pilot. The first master was said to have questioned the pilot several times about current conditions at the Skanseodde lighthouse. The pilot was of the opinion that sailing at 4 kn with slow turning onto the planned route would not pose any major problem as long as all drives were working. Work had been carried out on the second pod drive (thruster 2) since 16:00. At 17:00 all 4 pod drives were declared clear. Meanwhile the first master had to check frequently whether the actual values for all drives correspond to the reference values, relating to speed and azimuth. Therewith he wanted to make sure that he had not overlooked anything in assessing the availability of the drives in tandem and single operation.

At 17:12 the forward tug and aft tug were fastened and at 17:13 the dock's own mooring lines were cast off. At 17:18 the SCHLESWIG-HOLSTEIN floated and by 17:24 all mooring lines were singled up and hauled in. The vessel left floating dock II in Fredericia at 17:29. At 17:35 the hawser lines were cast off. The propellers were at standstill during heaving-in. At this point in time, the vessel was still in relative proximity to the floating dock with a course of 160°and speed of 6 kn.

The S band radar was switched on and the second officer was called to the bridge to accompany the pilot to the shipside door. When the pilot left the bridge at 17:37, the lighthouse was viewed in the green sector of Skanseodde approx. 3 points to port; it passed through until it disappeared out of sight of the first master standing at the conning position. The chief mate at the N forecastle manoeuvring station was asked if there were any objects astern. The pilot boat was only ahead to port and then shifted to the starboard side (west side of the vessel). Then the x band radar antenna was switched on. Having arrived at the shipside door, the pilot asked for more lee. Consequently a starboard manoeuvre with reduced speed was carried out.

At 17:42 the vessel collided with the lighthouse and the pilot was called back to the bridge with the second officer. The pilot said that it could not be a collision.

At 17:45 water ingress in the separator room was reported. While the first master was engaged in manoeuvring the ship, the second master called the dock master on VHF channel 13 and ordered both tugs back. At 17:49 the bulkheads were closed and the interring system was switched on to stabilise the ship with ballast and to prevent the ship from listing[4]. Only by observing the video monitor they noticed water ingress in the separator room. It was clear that the SCHLESWIG-HOLSTEIN had to be docked immediately. The first master manoeuvred against current and wind to a position where the tugs could fasten. At 18:12 the aft tug SVITZER MENJA was fastened approx. 1 kbl S of Skanseodde followed by the forward tug FRIGGA at 18:15. The SCHLESWIG-HOLSTEIN then reached berth 17 at Vesthavn with tug assistance at 19:30.

According to the pilot's files, the pilot was on board at 15:50. At 16:50 the master reported that the SCHLESWIG-HOLSTEIN was clear to undock. At 17:20 she was free from the dock with the assistance of the forward tug SVITZER MENJA and aft tug FRIGGA. At 17:35 the tugs were released. At 17.40 the hawser lines were dropped. SVITZER MENJA was to accompany the SCHLESWIG-HOLSTEIN until passing the Skanseodde lighthouse. Shortly afterwards, when the Skanseodde lighthouse had been passed at a distance of 0.15 nm, the tug was released and the pilot left the bridge in agreement with the master to disembark while it could still be done safely in view of the bad weather. At this point, the heading was set for 120° and speed was about 5 kn. The master gave the impression that he would have no trouble in continuing navigation.

At 17:42 the pilot went to the car deck to transfer to the pilot boat with the aid of a crew member. At 17:46 he was ordered back to the bridge on instruction of the crew member. At 17:50 he was back on the bridge and the master informed him that he had stricken something. At this point, the SCHLESWIG-HOLSTEIN was on its planned route and the pilot explained that there were no obstacles on this route. It was established that neither the tugs nor the pilot boat or other vessels posed a danger, however the Skanseodde lighthouse disappeared and could not be located. The tugs were ordered back to assist the SCHLESWIG-HOLSTEIN in mooring at berth 17. The wind came from SSW at speeds of 15 to 20 m/s and in gusts of up to 25 m/s. Visibility was good. The current set NE at 1.5 to 2.0 kn. In this respect it must be noted that in the pilot's experience, the current can change quickly and unpredictably altering its direction and force in both directions. There are no measuring devices to determine the current.

According to statements of the tug crews, their job was to assist the SCHLESWIG-HOLSTEIN in undocking with forward and aft tugs and to assist in the Lillebælt. The observed and measured wind came from the SW with a force of 20 to 23 m/s, and the current set NE in Snævringen at 3 kn. At the same time the SCHLESWIG-HOLSTEIN was drifting NE at approx. 4.5 kn. The dock master and pilot were asked by VHF whether it made sense to undock in this bad weather. Irrespective of this, undocking was continued with the comment that as long as all 4 pod drives were working, undocking would be continued.

After an unproblematic undocking, the forward tug SVITZER MENJA and the aft tug FRIGGA were cast off and the SVITZER MENJA was ordered to accompany the vessel until the pilot had disembarked. FRIGGA prepared for the next order which was to assist the TANAGER which was waiting S of Fredericia to come into port.

[4] According to the VDR recordings central locking was effected at 17:53, corresponding to a board time of 17:51. Locking the bulkheads takes about 90 s.

Originally, the pilot had intended to disembark on port side. Instead, the SCHLESWIG-HOLSTEIN turned to starboard through the wind to make lee for disembarkation on this side. As a consequence she shifted greatly to the NE in shallow water. Attention was drawn to this hazardous situation several times via VHF channel 13. The pod drives were working intensively. Initially it looked as if the SCHLESWIG-HOLSTEIN could hold her position until she drifted eastwards. Shortly afterwards she struck the Skanseodde lighthouse with her port side. Then both tugs were ordered back by the pilot when a leak was discovered. By 19:30 she was moored at berth 17 in Vesthavn.

5.3.1 Onboard survey

In presence of both masters of the SCHLESWIG-HOLSTEIN, the superintendent of the vessel operator and the BSU carried out a round trip on the south bridge and north bridge of the SCHLESWIG-HOLSTEIN from Puttgarden to Rodbyhavn and back. There were further discussions with representatives of the vessel operator and the office for the Federal Railways Fund (Bundeseisenbahnvermögen - BEV) in the conference hall of the SCHLESWIG-HOLSTEIN. The Danish pilot involved on the day of the accident was not present and referred to his report.

The course of the accident was reconstructed on both bridges. The first master in charge arrived on the day of the accident. The second master supervised the work in the dock in Fredericia and had been working from early morning onwards. The bridge was ready at 15:00. The pilot embarked at 15:40. All 4 pod drives were tested in dock and were fully working by 17:00. Only the response display on pod 2 was not working. Using the paper chart, a short voyage plan was discussed between the first master in charge and the pilot. The pilot did not regard the strong S wind of Bft 8 and the current a problem, as long as all pod drives were working. Apart from this, two tugs were ordered. There were no special arrangements between the two masters. Both were familiar with the area. The first master operated the pod drives in tandem operation and stood on the right side in front of the S band radar (see Fig. 11 and 12). The second master also stood in front of the X band radar on the left side. The antenna for the S band radar was activated on leaving the lock. The antenna for the x band radar remained off initially. The monitor only displayed AIS targets. The central conning display showed the rate of turn, the cross off-set, ahead and astern speed and the drift. The German chart No. 21 (Snaevringen and Kolding Fjord) lay on the chart table. The electronic chart (ECDIS) was not displayed on any of the screens or was overlaid to the radar image.

At 17:27 the SCHLESWIG-HOLSTEIN left floating dock II in Fredericia. The first master sailed by sight and oriented himself with the sectors of the Skanseodde light. At 17:35 the tugs were released and at 17:38 the pilot left the bridge. The SCHLESWIG-HOLSTEIN steered a set course of 160° and reduced speed so that the pilot boat could approach on the lee side. The second master was busy filling in the pilot card and was communicating with the forward and aft manoeuvring stations by hand-held radio set. The second officer was to accompany the pilot down. The antenna for the X band radar was switched on. No targets were acquired on either radar. At the time the pilot left the bridge, the colour of Skanseodde had changed from red to green. Shortly afterwards, the light on the port side came out of sight so it was no longer visible from the starboard conning position. The second master had also lost the light from view; it was now only visible from the bridge wing.

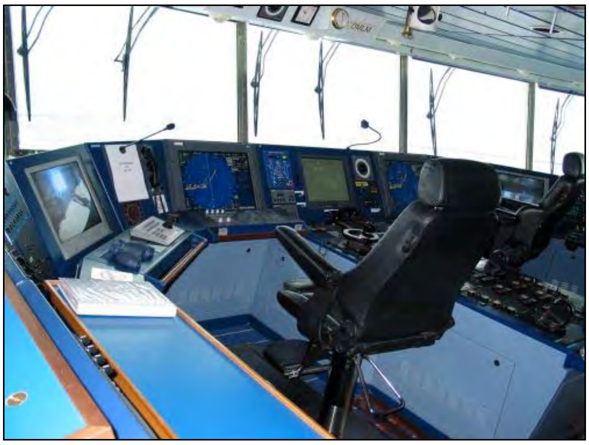


Figure 11: Conning positions

Figure 12: Tandem operation

Around 17:42 the SCHLESWIG-HOLSTEIN drifted towards Skanseodde and struck the light. The noise was heard by the second master. The pilot was ordered back to the bridge. At the same time, water ingress in the separator room was reported; it could be controlled by pumping out the water and leveling. The SCHLESWIG-HOLSTEIN sailed a port turning circle to the south and ultimately returned to the port with tug assistance.

Subsequently the course of the accident was analysed at the shipping company by means of VDR recordings in the presence of both masters, the superintendent and the BSU. At the same time it was established that insufficient arrangements and allocation of tasks had been made between the masters. A look-out or helmsman (as another rank) was not on the bridge. The electronic chart was not used. The X band radar antenna was switched on just before the collision. No targets were detected. The navigation was neglected once the Skanseodde light was out of sight. The first master was engaged in manoeuvring; and the second master was busy with administration duties, disembarkation of the pilot and communicating with the manoeuvring stations. The local knowledge of both masters regarding the wind-generated current was inadequate. The pilot did not sufficiently inform the masters about the potential off-set generated by the weather conditions. The chosen pilot transfer position west of Skanseodde lighthouse with S winds and NE setting current of approx. 3 to 4 kn and 2 kbl distance was very risky. After reducing speed and preparing for the pilot transfer, the SCHLESWIG-HOLSTEIN drifted out of control towards the light. Pilot transfer in the protected S region of the Belt would have been safer.

5.3.1.1 Navigational equipment

Both bridges of the SCHLESWIG-HOLSTEIN have a redundant navigational system that exceeds the basic required equipment. This also includes the electronic chart ECDIS and a track control system (see Fig. 13). The sensor data can be read off three screens. The screens can be differently configured. The radar image can be overlaid with ECDIS.

	Navigational equipment	Holder of approval	Equipment type name
1	AIS	SAM Electronics GmbH	UAIS DEBEG 3400A
2	Track control system	STN Atlas Electronics GmbH	ATLAS NACOS "XX"-3
2	ECDIS	SAM Electronics GmbH	CHARTPILOT 93XX
2	Echo sounder	STN Atlas Electronics GmbH	ATLAS 9205
2	Speedlog	STN Atlas Electronics GmbH	DEBEG 4675
1	Remote compass	RAYTHEON Anschütz GmbH	TMC 20
2	Airband transceiver (121.5 + 123.1 MHz)	none[5]	AR 4201
2	Bell	none	BELL
2	GNSS	STN Atlas Electronics GmbH	NT 200 D
2	Gong	none	GONG
2	Gyro compass	RAYTHEON Anschütz GmbH	STANDARD 20 PLUS
2	Track control system, gyroscope	none	TRACKPILOT 9401
2	Magnetic compass	Cassens & Plath GmbH	REFLECTA 2
2	Morse signal light	none	MORSE SIGNAL LIGHT
1	NAVTEX receiver	STN Systemtechnik Nord	DEBEG 2900
2	Whistle	none	WHISTLES
2	navigation lights	none	Navigation lights
4	Radar system/ARPA	SAM Electronics GmbH	MULTIPILOT 1000
2	Radar transponder	STN Systemtechnik Nord	DEBEG 5900
2	Satellite EPIRB 406 MHz (COSPAS/SARSAT)	HAGENUK GmbH	TP 2
2	Daylight signal	none	DAYLIGHT SIGNAL
2	VHF/DSC encoder	STN Atlas Electronics GmbH	DEBEG 3817
2	VHF/DSC encoder with watchkeeping receiver	STN Atlas Electronics GmbH	DEBEG 3817R
4	VHF radiotelephone system	DMT Marinetechnik GmbH	DEBEG 6348 VHF RADIOTELEPHONE
10	VHF radiotelephone (transmitter/receiver), portable, for survival crafts	STN Atlas Electronics GmbH	DEBEG 6701
2	Bearing repeater	none	PEILTOCHTER 133-406

Figure 13: Navigational equipment

[5] The equipment with the designation „none“ is largely liable to registration

5.4 Recordings from the Danish authorities

The department for the investigation of marine casualties of the DANISH MARITIME AUTHORITY provided the BSU with extensive data material (AIS, ENC)[6] as well as statements of the tug masters involved and the pilot. The radio communication between the pilot and the tug masters was not available. According to the AIS recordings, at 17:44:11[7] the SCHLESWIG-HOLSTEIN was sailing on a heading of 134°, course over ground (COG) of 042.3°, with speed over ground of 3.5 kn and rate of turn (ROT) of 720°/min to port, which is not plausible (see Fig. 14[8]). The difference of 92° between heading and COG is conspicuous. The tug SVITZER MENJA is located to starboard aft of the SCHLESWIG-HOLSTEIN. Fig. 15 reveals that the vessel drifted immediately to the north after having left the floating dock, without having reached the plotted line of leading lights.

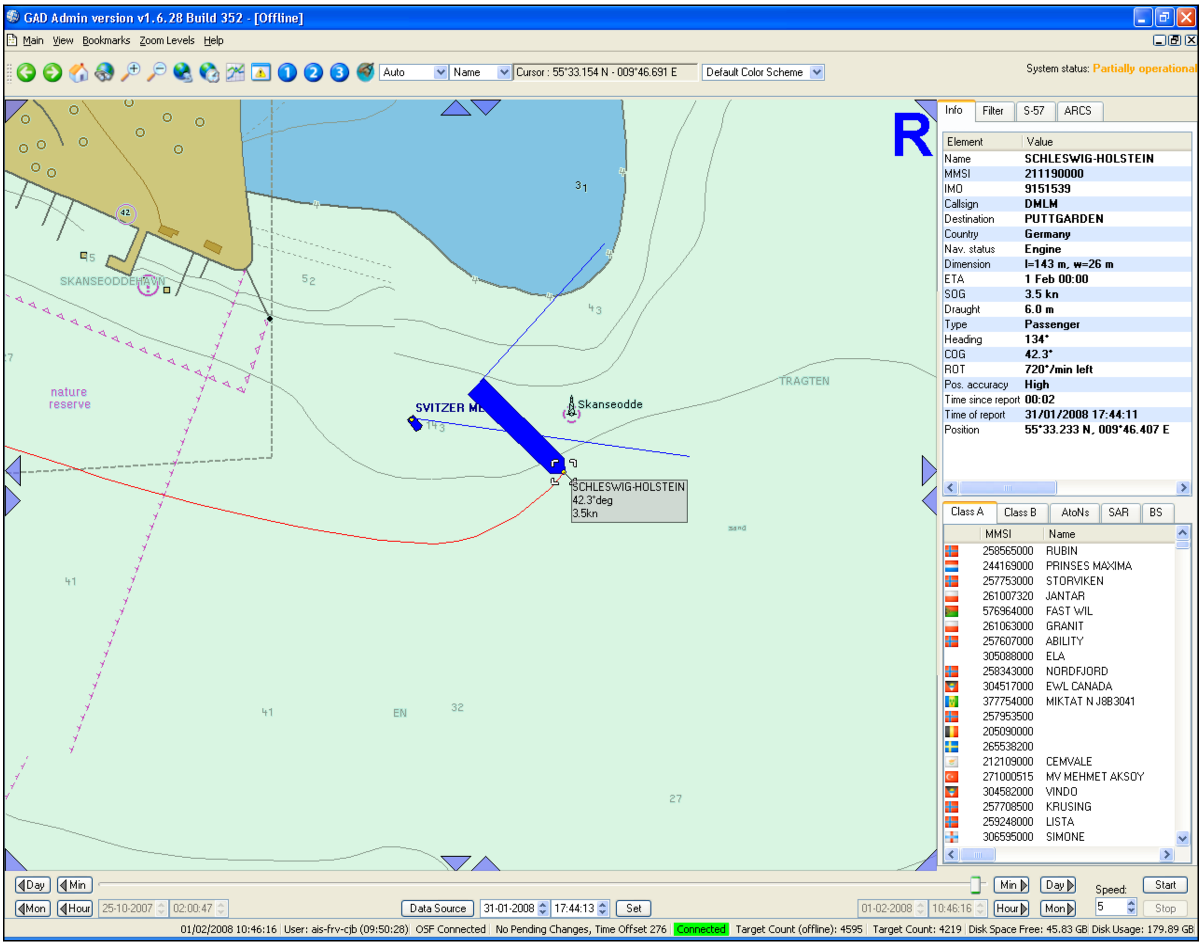


Figure 14: AIS place of collision

[6] AIS - Automatic Identification System, ENC - Electronic Navigational Chart (data record according to the S-57 standard of the IHO for ECDIS systems)

[7] Time deviates by about 2 mins. from the statement

[8] The AIS-input of the raw data should be correct: The AIS date „127“ for ROT on the introduction of AIS in a former version meant „720°/min“. Meanwhile this magnitude is only used in case, no approved ROT Sensor is available and a turning rate deviated from the heading of more than 5°/30 s is determined. Here, the display software of the Port Authority must be adjusted.

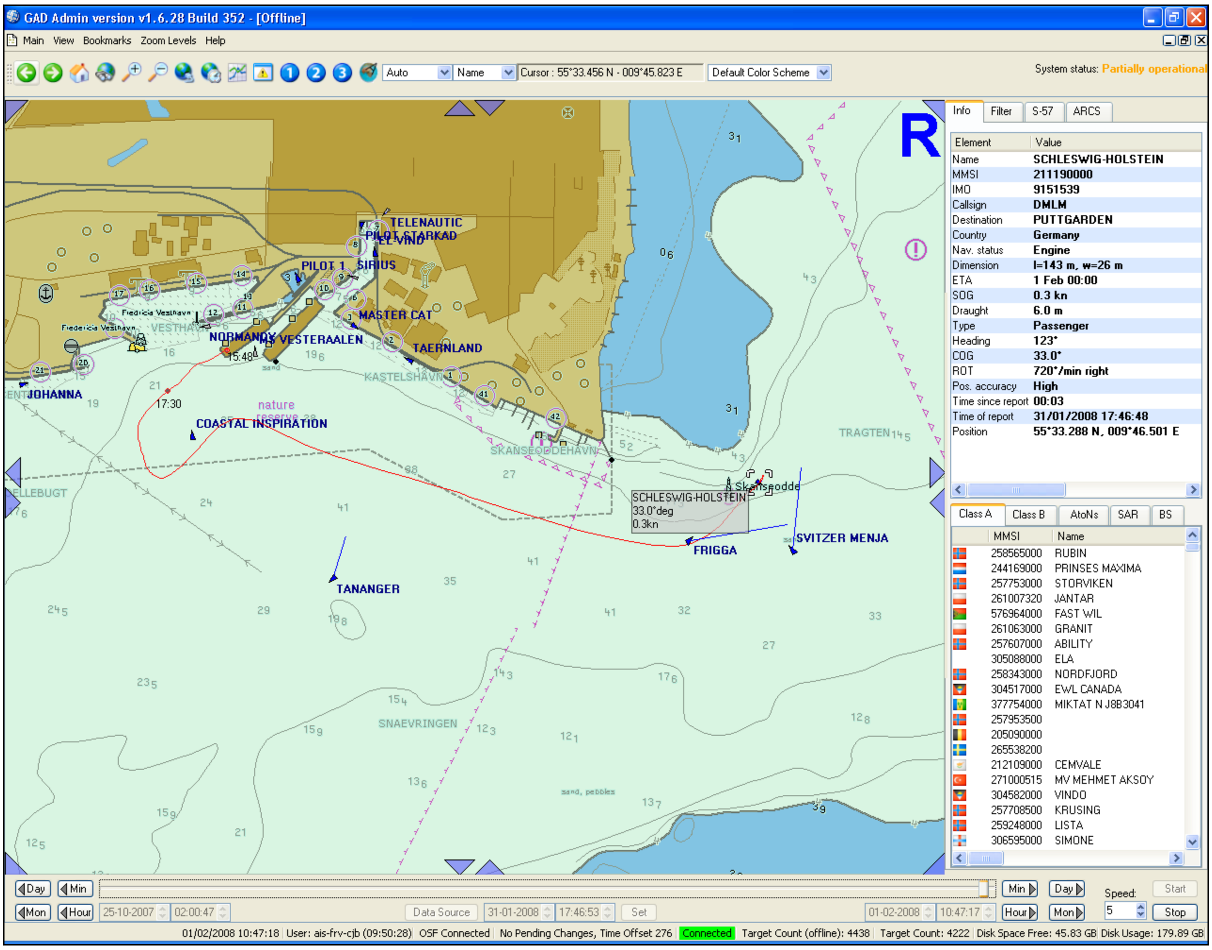


Figure 15: AIS course of voyage

5.5 VDR recordings

The VDR recordings made it possible for the BSU to extensively reconstruct the course of the accident from a technical perspective. It must however be noted, that the times shown (as on the AIS recordings) are about 2 minutes ahead and differ from the statements of crew members. Unfortunately no voice recordings could be secured due to an operating error by the crew when backing up the data. Instead of pressing the record button, only the locking key for the record button was operated after the accident, which did not trigger data back-up. The video data was backed up later by a shipping company inspector. Of course, data is also available for longer periods beyond the basic requirements through the VDR installed on board, however, due to a company agreement and for data protection purposes, video data is backed up separately without audio data for internal purposes. At the latest after one week all data is overwritten and can no longer be reproduced. Consequently, the VDR manufacturer's technician (who was requested too late) was unable to save any data.

Regarding the following VDR recordings, please note that the displays for the pod drives do not correspond to the configuration on the bridge (see Fig. 16) and that pod drive No. 2 had[9] no response display (R) after the dock stay. The effective directions of the Pod drives thruster 1 and thruster 2 are displayed in the VDR replayer with different prefix in comparison with thruster 3 and thruster 4 in the images 22, 27 and 31, i.e. minus must be interpreted as plus, since the values delivered by the automation are interpreted without prefix-consideration. If the north forecastle makes headway, then forward is zero (0°) with a semicircular numbering system and the direction of rotation to starboard is designated with minus (-) and to port with plus (+). If the south forecastle makes headway, then forward is designated with 180° while the prefix for the semicircular numbering system is maintained. The maximum rotations for the pod drives are 130 rpm each. The thruster-scheme made available for the configuration of the VDR (s. fig. 17) leads in the figures 23, 28 and 32 with regard to the prefix rule to the same effective directions as with the plus/minus display, that means the displayed effective directions in figure 28 are as regards the heading of the complete image with a forward speed of 5,9 kn are not counter-turning.

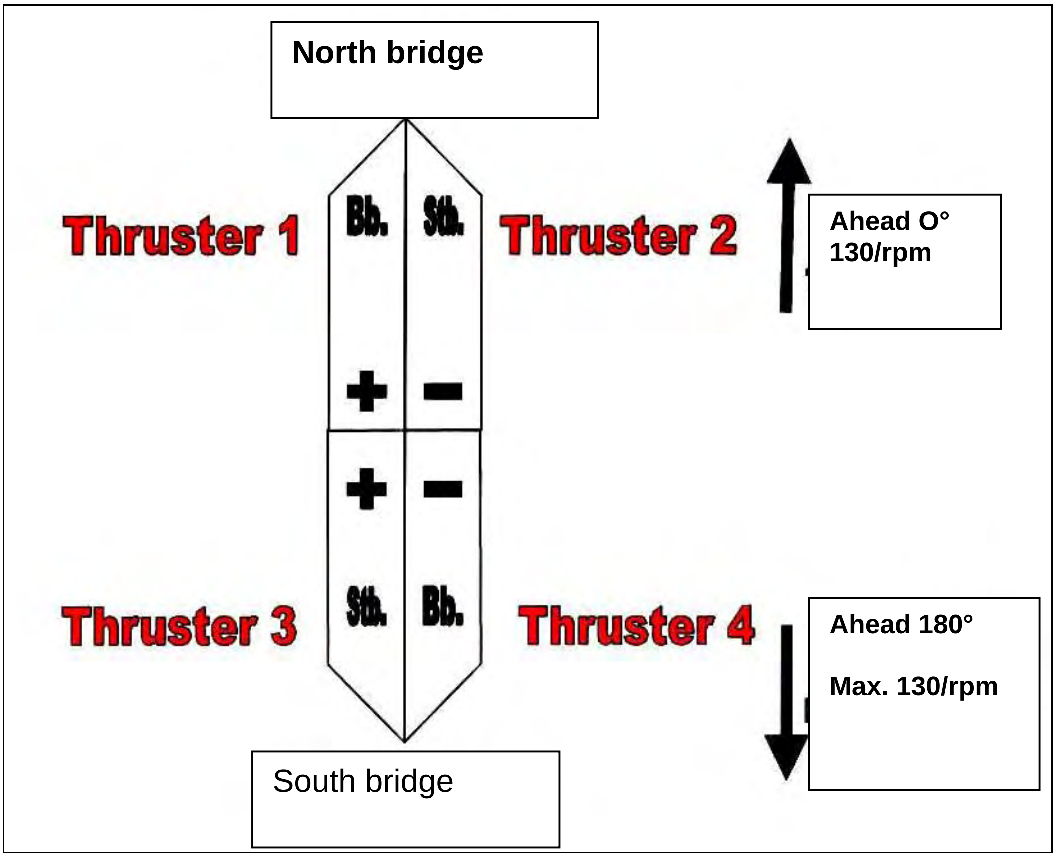


Figure 16: Configuration of the pod drives

[9] According to the statement supplied by the VDR manufacturer will be inspected on the next annual maintenance date. An adjustment in the display of the VDR Replayer should be effected if necessary. After ship yard periods and maintenances on systems, which transfer data to the VDR, it should be checked if the VDR is working properly.

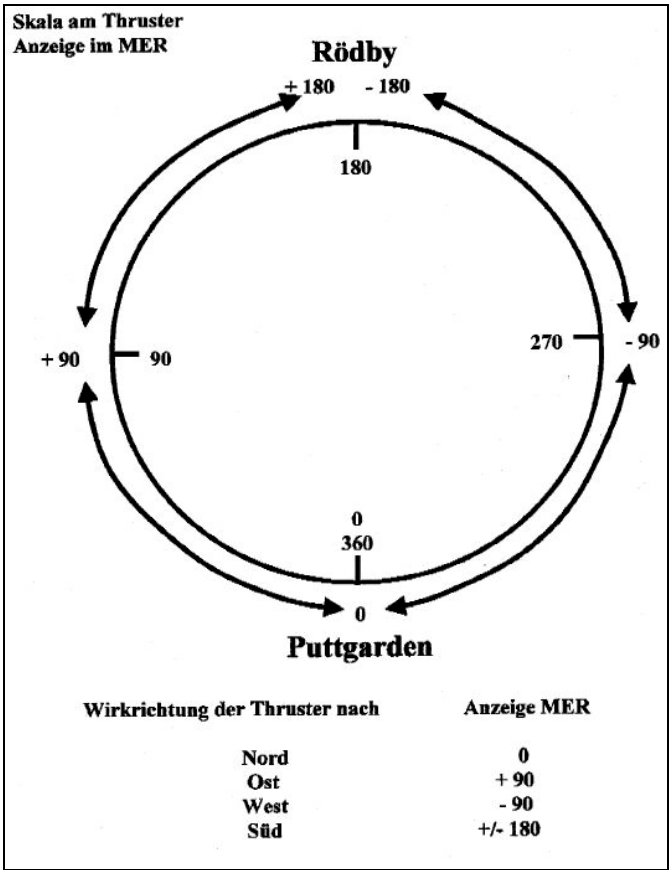


Figure 17: Thruster-Scheme Automation

With regard to the ENC data: sectors of the Skanseodde lighthouse were not completely shown as a full circle (s. figure 18). However, no entry error was identified in the Danish ENC data following an examination by the BSH. There was a change of scale at those areas where the sectors are invisible. This means there is currently no other way (according to the S-57 standard[10]) to show the sectors differently if larger and smaller detection scales are adjacent to each other at this point. Contour lines are also shown offset. The Navionics company displays the sectors in the electronic chart as a full circle (s. figure 19).

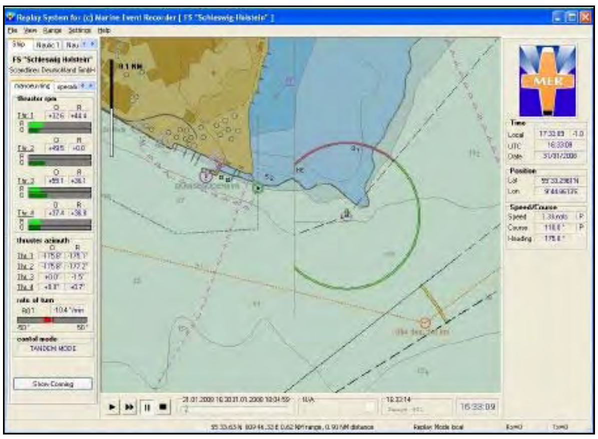


Figure 18: Official Danish Chart

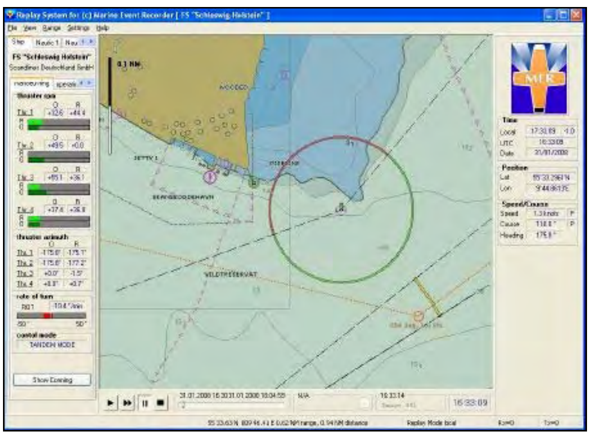


Figure 19: Navionics Chart

[10] S57- Special Publication 57 of the International Hydrographic Organization to digitise official maritime chart data (ENC) for the electronic nautical chart display and information system ECDIS

Clutter can occur with poor weather conditions like those on the day of the accident, i.e. showers, snow, rough sea and significant wave heights of 2 m. Without filtering the signal, a circular excentric area pulled in wind direction with differing brightness would form in the centre of the screen. Rain and sleet dampen the radar impulses on the X band radar and lead to echoes in the form of milky areas, whereas there are virtually no damping losses on the S band radar and even targets behind the rain are also detected. Effective targets can be weakened so that they might only be displayed every 3rd or 4th antenna sweep, or even not at all. In this case, the RACON signal was shown distorted (if at all) with characteristic "T" and wave length of 3 cm on the X band radar (see Fig. 17). The S band radar with a wave length of 10 cm was technically unable to display the RACON signal with a 3 cm wave length.

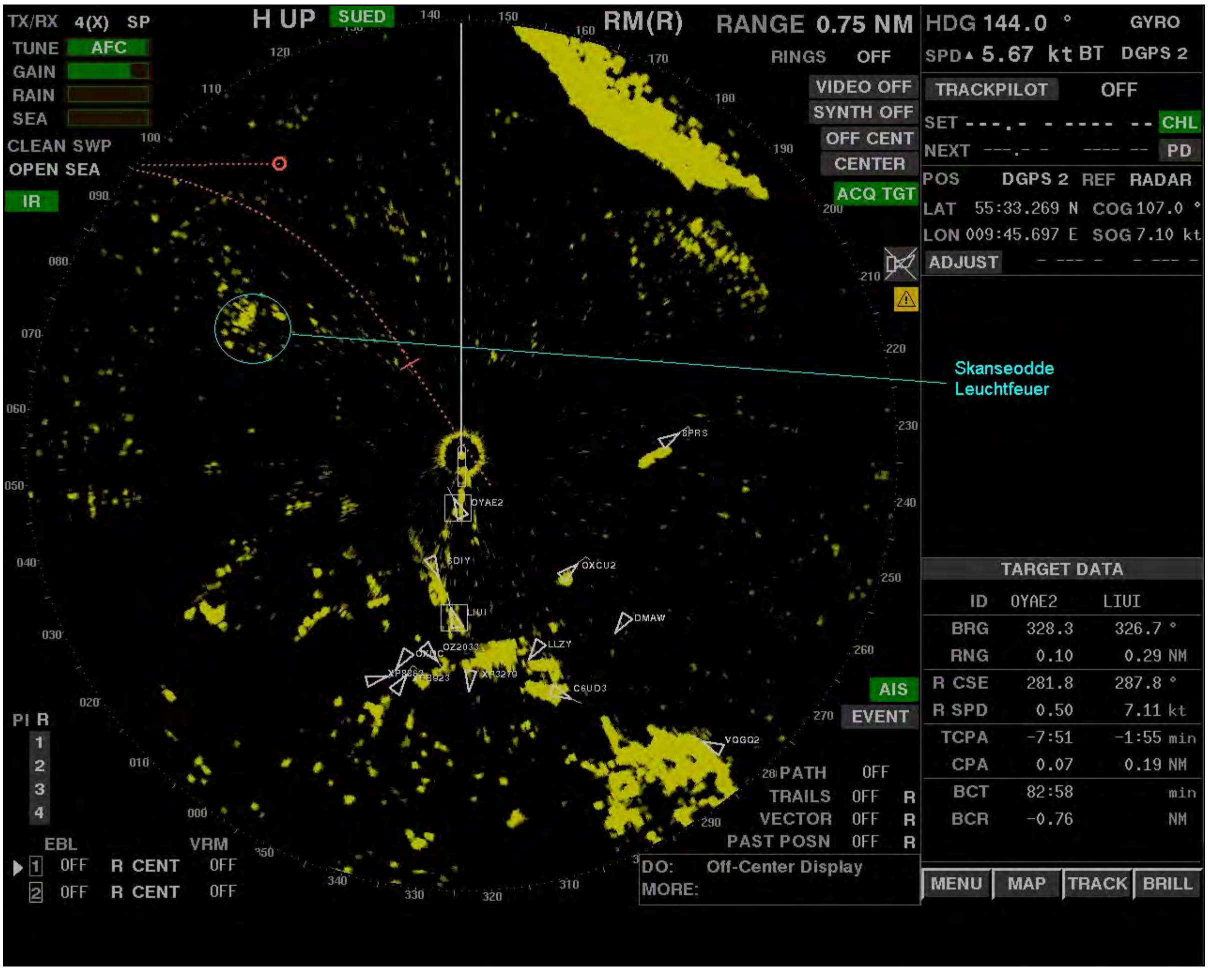


Figure 20: VDR-X band radar 17:40:08 system time

Figure 21: VDR-S band radar 17:40:08 system time

Regarding sensor data for course and speed, only the speed over ground (SOG), course over ground (COG) and heading (gyro compass) were recorded. The speed through water (STW) of the electromagnetic speedlog DEBEG 4675 was not recorded or was not available while manoeuvring with POD drives. Consequently the setting current could not be calculated in retrospect from the vessels data. With the drift and large differences between heading and COG, it must be noted that according to the recordings the pod drives were constantly working.

The times shown on the radar images can differ when compared to the times shown with the electronic chart as background by maximum 15 s because the radar images are recorded only at intervals of 15 s according to basic requirements for the VDR. Nevertheless, the difference in the display of geographic positions is to large. The second fraction in length is shown incorrect for the ECDIS display (cf. Fig. 17 to 19). This is obviously a software error by the VDR manufacturer. The ship's symbol is however shown in the correct place[11]

[11] The VDR replay system is able to display the geographic positions in the mode degree/minutes/seconds and in the mode degree/minutes/decimal quota. As regards the longitude the angular second was displaced about 1 position to the right and displayed with prefix of zero. This error was said to have been remedied by now.

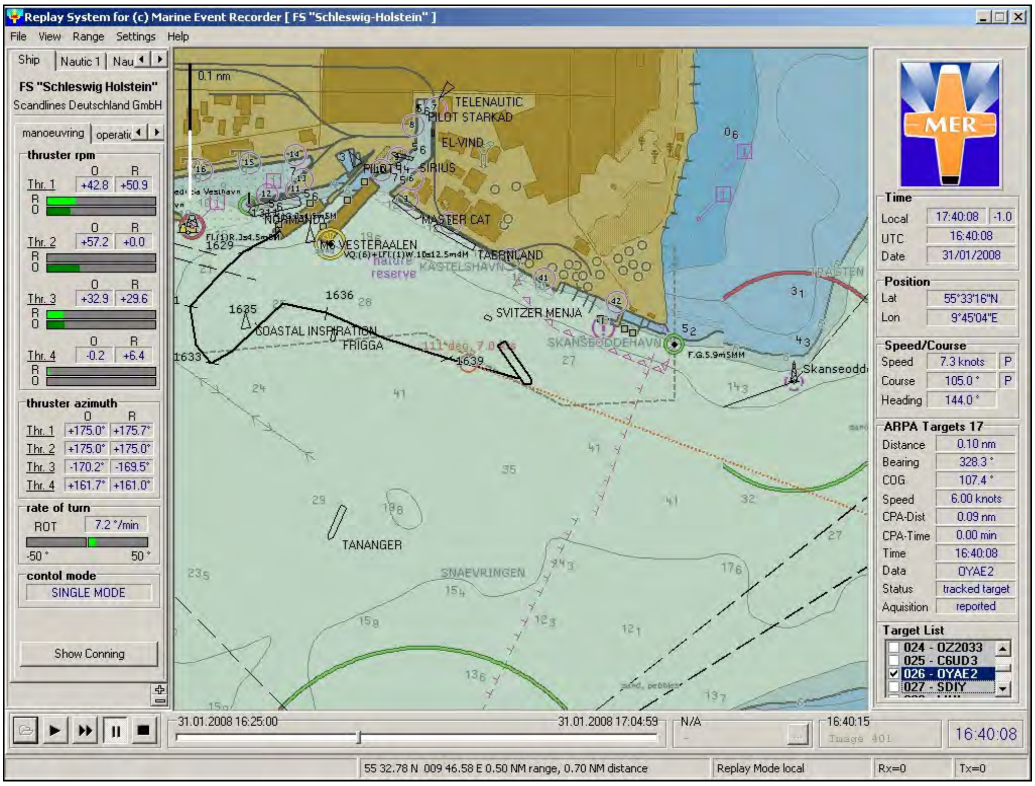


Figure 22: VDR with ECS display 17:40:08

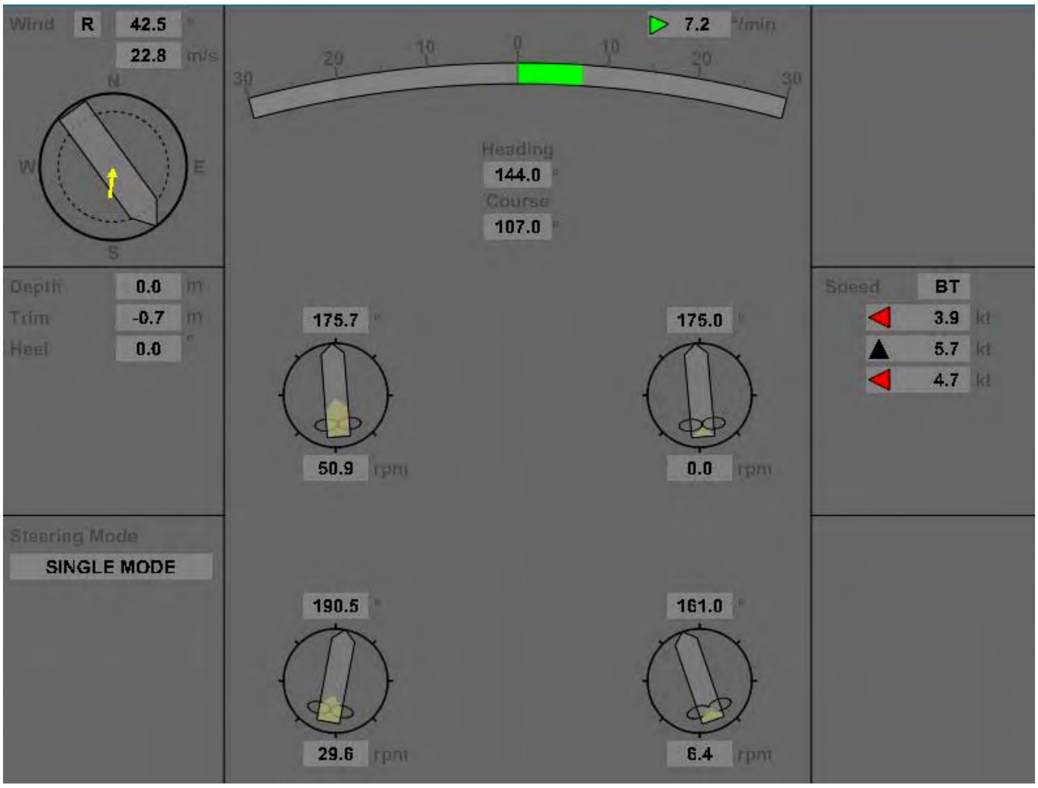


Figure 23: Positive direction of the pod drives 17:40:08

The radar sets are able to work ground- and sea stabilised. They were set that way on SCHLESWIG-HOLSTEIN that they used the speed over ground of the GPS and showed the speeds SOG (SOG-Speed over Ground) as well as the speed ahead (BT – Bottom Track) calculated out of this. Apart from this, the course over ground (COG) and the heading were shown by the gyro compass. The installed GPS receivers of type DEBEG NT 200D are not type approved by the administration according to the new GPS performance requirements which dictate that COG and SOG also have to be tested. However, no significant errors have been observed with this constellation. GPS was chosen as speed sensor because the measurements of the speedlog would be disrupted by the pod drives. According to the performance requirements for radars, the proper speed should stem from an approved sensor that corresponds to IMO requirements for the corresponding stabilisation mode ground or sea. The accuracy of COG and SOG can therefore not be verified. Inaccuracies can arise in particular when there are quick changes of movement. Overall, the drift appears plausible.

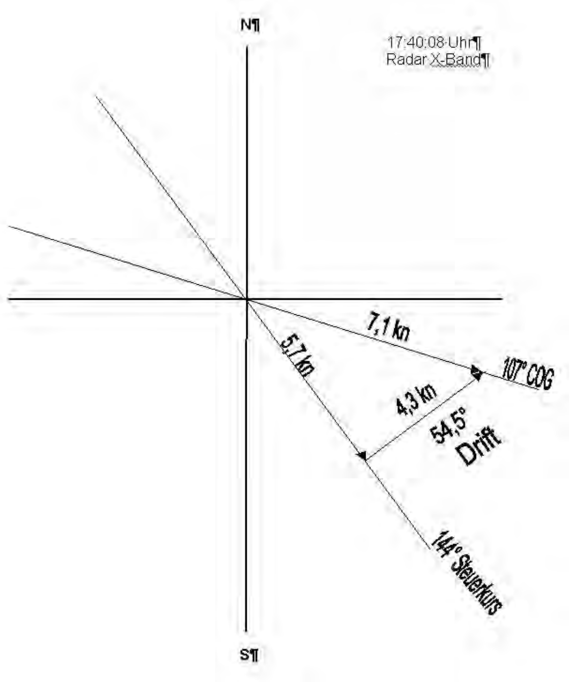


Figure 24: Sketch of drift at 17:40:08

The AIS targets are overlaid on the radar images of the S band and X band radars. The tugs SVITZER MENJA and FRIGGA are identified by their call signs OYAE2 and OXCU2. The pilot boat could not be verified on the radar images. The Skanseodde lighthouse can still be seen on the radar images at 17:40 (see Fig. 17 and Fig. 18). The red dotted track shows the direction and curve of the planned track. The curve passes approx. 2 kbl S of Skanseodde. Based on the values shown on the X band radar system (HDG=144.0°, SPD=5.67 kn, COG=107.0°, SOG=7.10 kn) this gives a drift of 054.5° at 4.3 kn (s. fig. 20). This drift would have been appeared on the central screen (conning) on the bridge console (see Fig. 20). There are no recordings for this. Due to the position of the pod drives, a resultant rate of turn of 7.2°/min to starboard is achieved (see Fig. 19).

Two minutes later the echoes of the Skanseodde lighthouse disappear from both radars (see Fig. 21 and 22). The RACON with code "T" is also not clearly apparent at any time on the X band radar system. At 17:42 the values on the X band system show HDG=134.0°, SPD=5.89 kn, COG=104.0°, SOG=6.80 kn. This gives a drift of 044° at 3.3 kn. Due to the position of the pod drives, a resultant rate of turn of 6.4°/min to port is achieved (see Fig. 23).

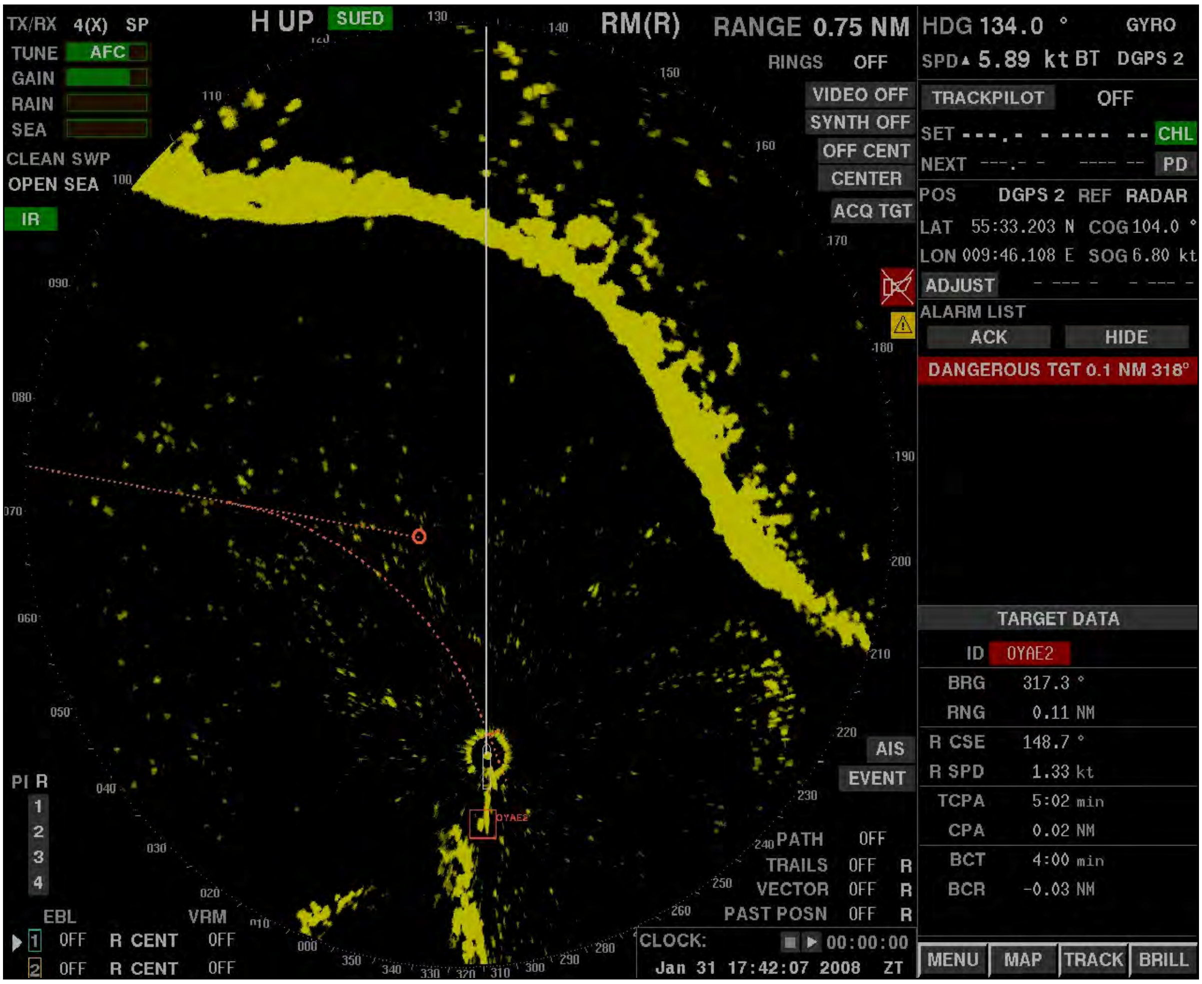


Figure 25: VDR-X band 17:42:00 system time

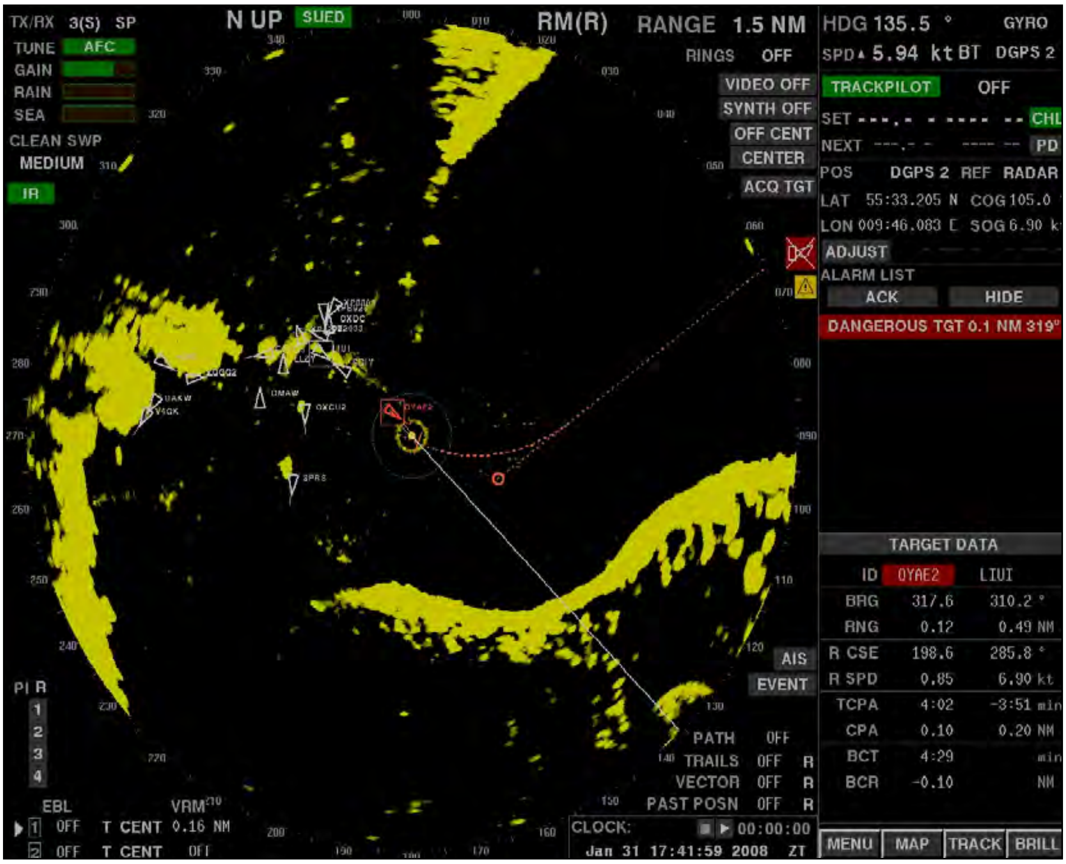


Figure 26: VDR-S band 17:42:00 system time

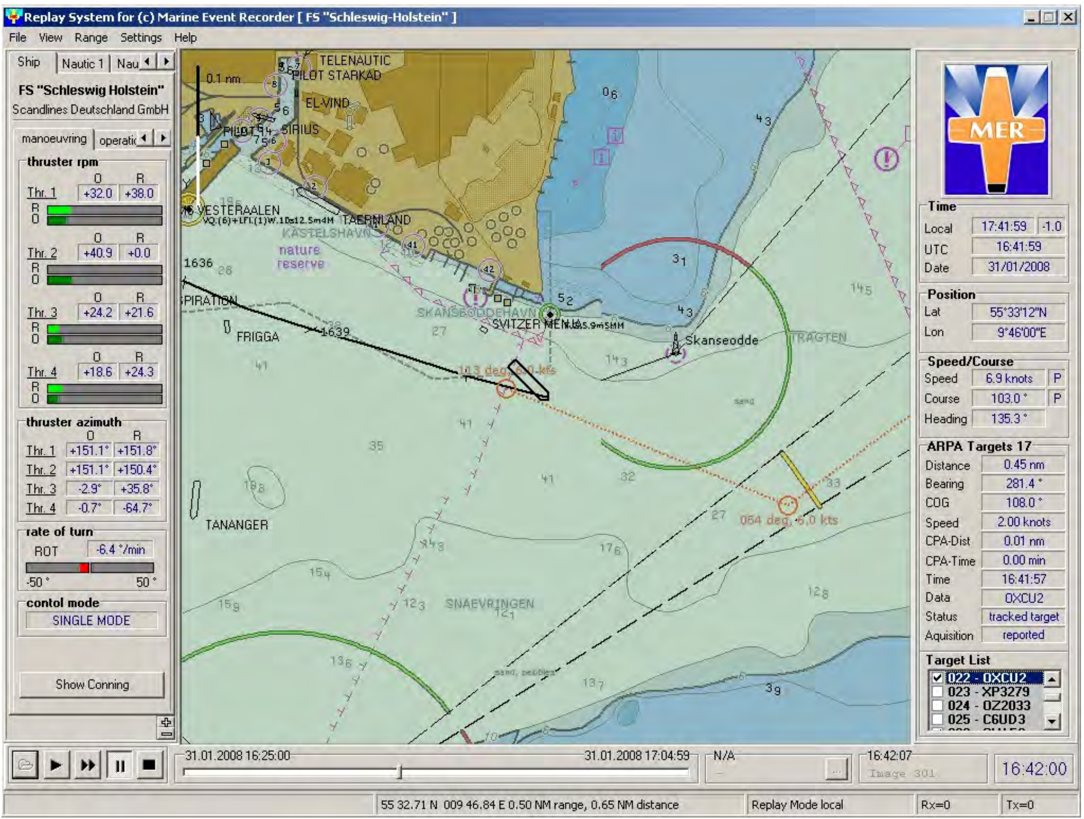


Figure 27: VDR with ECS display 17:42:00

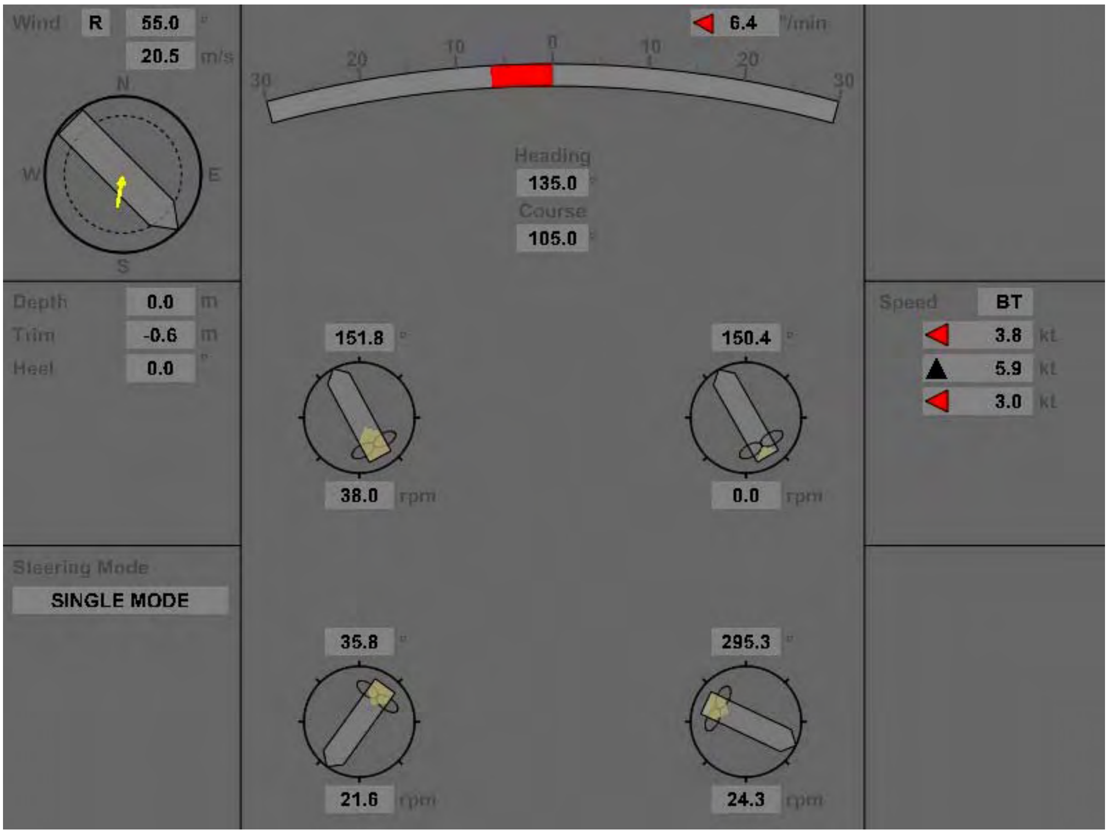


Figure 28: Positive direction of the pod drives 17:42:08 (pods below not counter-turning)

Around 17:44 the SCHLESWIG-HOLSTEIN collided with the Skanseodde lighthouse. Shortly before the collision, the values on the X band system show HDG=134.3°, SPD=0.08 kn astern, COG=43.0°, SOG=3.4 kn (see Fig. 29). This gives a drift calculated by the system, that corresponds approximately to COG and SOG since speed amounts to zero. Due to the position of the pod drives, a resultant rate of turn of 13.9°/min to port is achieved (see Fig. 26). The steel structure of the lighthouse was destroyed by the collision.

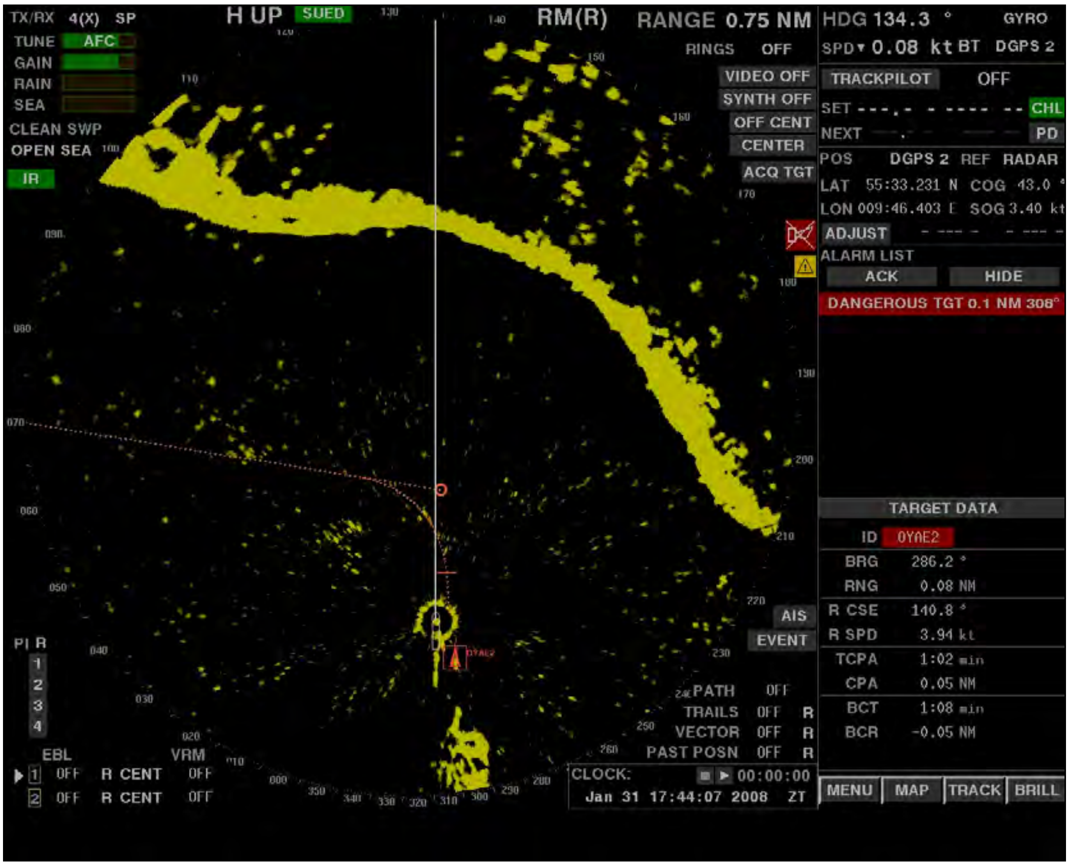


Figure 29: VDR-X band 17:44:00 system time

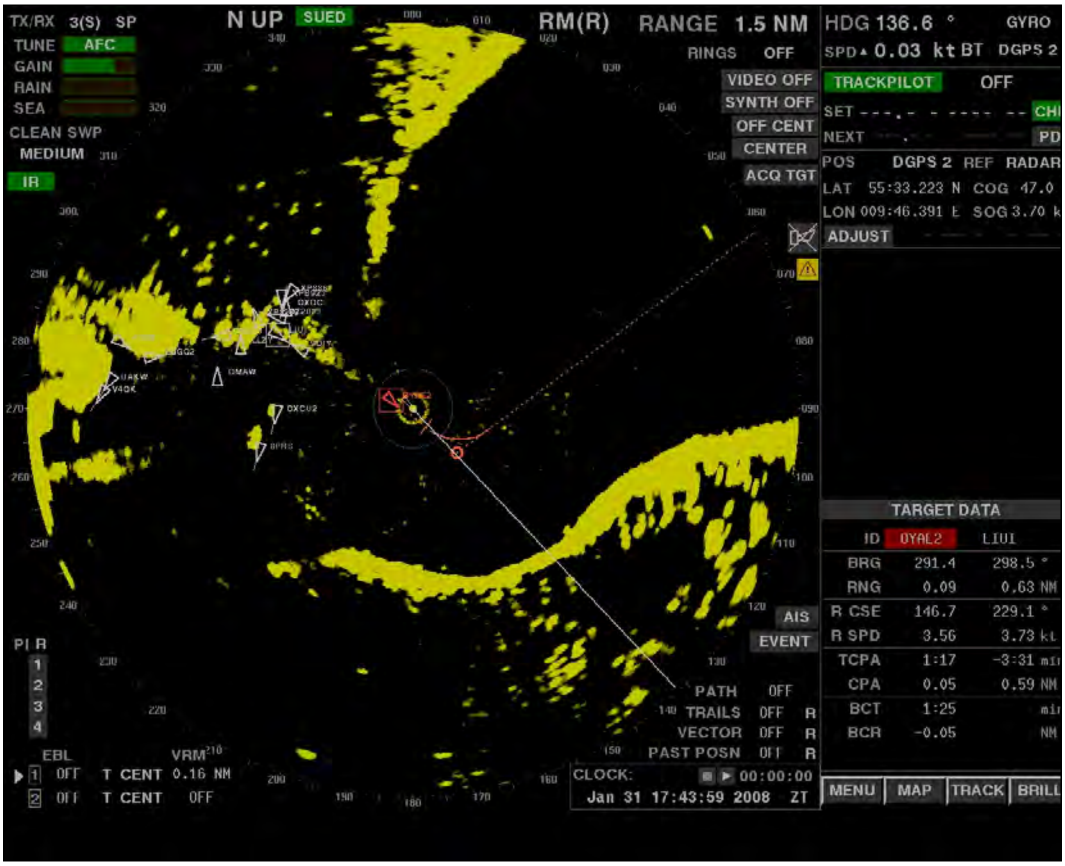


Figure 30: VDR-S band 17:44:00 system time

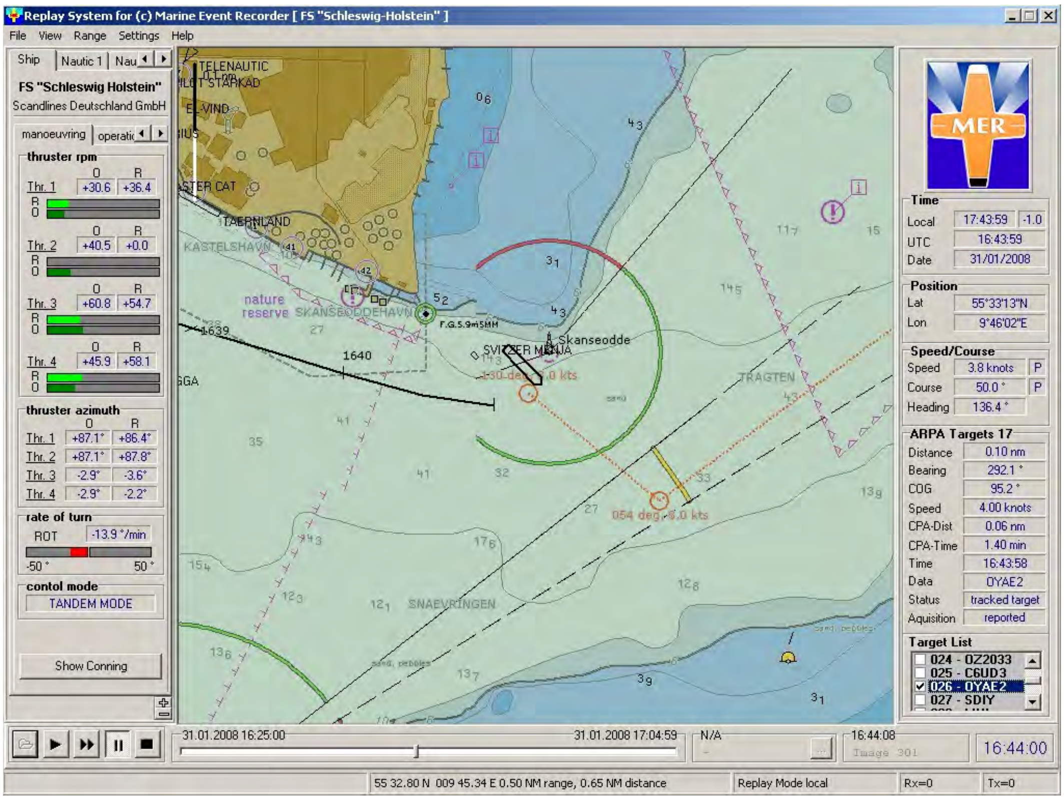


Figure 31: VDR with ECS display 17:44:00

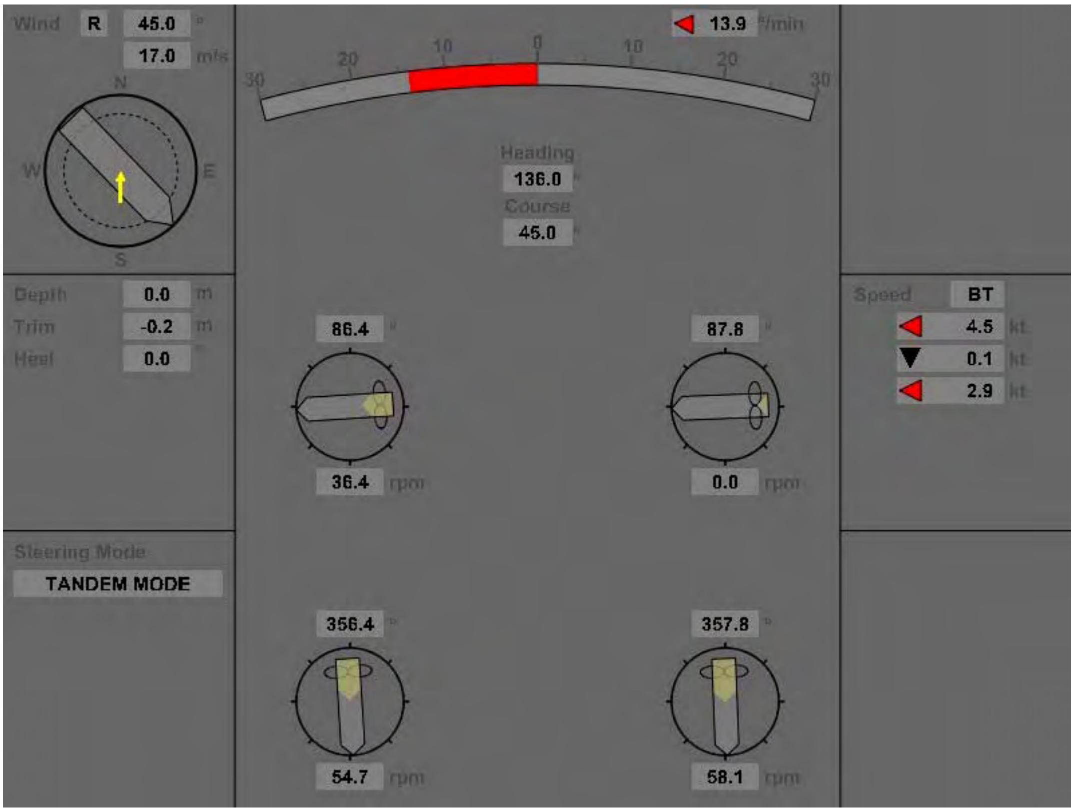


Figure 32: Positive direction of the pod drives 17:44:00

5.6 Weather expertise

On 30.01.2008 an intensive low-pressure system developed very rapidly from a low near Iceland. In the course of the day of 31.01.2008 this intensive low-pressure system "Resi" relocated moving eastwards over the British Isles. Its very active weather front system pushed over the North Sea towards the Baltic Sea, and in the night to 01.02.2008 it crossed Denmark from the West.

In the afternoon of the 31.01.2008 it was severely overcast in the west area of the Baltic Sea, and there were repeated showers partially mixed with snow, and brief localised thunderstorms. The horizontal visibility for the relevant sea area, the "Little Belt", was between 3 and 8 km; during showers (in particular sleet) it dropped temporarily to clearly below 3 km. The air temperature was 2°C, and water temperature was 5°C.

Since the early morning hours, the wind had been constantly blowing from south-southwest to south with an average force of 6 to 7 Bft, in gusts of 9 Bft. In Toroe (southwest Funen) an average wind of 8 Bft was blowing from south-southwest and in the Odense gusts of up to 10 Bft were also measured for several hours over midday and during the afternoon.

The wind force values in Beaufort (Bft) refer to the 10 minute average of wind speeds, measured at a height of 10 m.

There are unfortunately no ships observations of wave heights from the Little Belt region. Nevertheless, we can estimate the significant wave height of the sea from the ratios between wind force, effective wind duration and fetch length. An average wind from a stable direction sustained over 6 hours at a force of 6 to 7 Bft can generate a wind sea with significant wave heights of 2.5 m with periods of 5 s when deep water conditions are undisturbed. Taking into account the observed south-southwest to south wind direction in the relevant area of the Little Belt between Fredericia and the Strib peninsula, it cannot be assumed that undisturbed marine conditions prevailed. The sustained strong south wind created an eastward setting current south of Fredericia which turned abruptly to the northeast at the east of Skanseodde. This current modified the wind sea so that significant wave heights probably lay nearer 2.0 m. The sea will have been very choppy.

6 Analysis

The SCHLESWIG-HOLSTEIN has progressive navigational equipment that exceeds equipment requirements by having an electronic chart on both bridges because of the double-end design. Apart from this, she also has excellent manoeuvring characteristics due to four pod drives.

During berthing and departing, the master in charge mainly takes over manoeuvring with the pod drives at the conning position and must at the same time navigate the ship. In this function he is both helmsman and watch officer in charge at the same time. As helmsman, he has to operate four pod drives which can be operated either individually or in tandem operation. At the same time, he has to observe the navigational equipment monitors and adjust if necessary, and navigate by sight. On leaving the floating dock, the S band radar on the right side of the conning position was switched on first and then the central screen with the vessels command data (conning display) was switched on. It could not be established which form of display was selected. It is probable that the drift angle or the ahead and lateral speed were displayed from which the offset angle could be calculated, e.g. with a tangent or for an angle <10°, reduced from the formula for transverse speed multiplied by 60 and divided by the longitudinal speed, or which could be estimated from the heading and course over ground. The setting current force would have only been reliably determined from the difference between the speed through the water and the speed over ground, taking into account the pod drives. There were no recordings detailing the speed through the water.

The observation of the navigational data reveals that the SCHLESWIG-HOLSTEIN drifted quickly to the north after having left the dock and releasing the tugs. The drift was not sufficiently counteracted to clear the port facilities and to keep to the centre of the Belt near Snævringen. The ship was navigated by sight to reach the planned track. The sectors of the Skanseodde lighthouse were the deciding reference points for the manoeuvring master to keep safe fairway. According to his own statement, the sector changed from green to red. However, according to evaluations of the AIS and VDR recordings, they never left the red sector of the light marked on the paper chart. It is possible that the master was confused by the solid green light of the Shell oil pier on the SE dolphin of the refinery 5 kbl NW of the Skanseodde lighthouse which is stated in the lighthouse directory with a nominal range of 4 nm.

It would have been better to navigate by sight and keep to the Fredericia Anlægsværk II leading light with leading light line 305° and the green sector of Skanseodde on bearing 070.4°-220.4° (see Fig. 27). However, this would have not been possible for the master alone who was manoeuvring at the same time because he had no visibility aft from the conning position. It would have been helpful here to use the installed electronic nautical chart (ECDIS) to gather quickly more information about the situation.

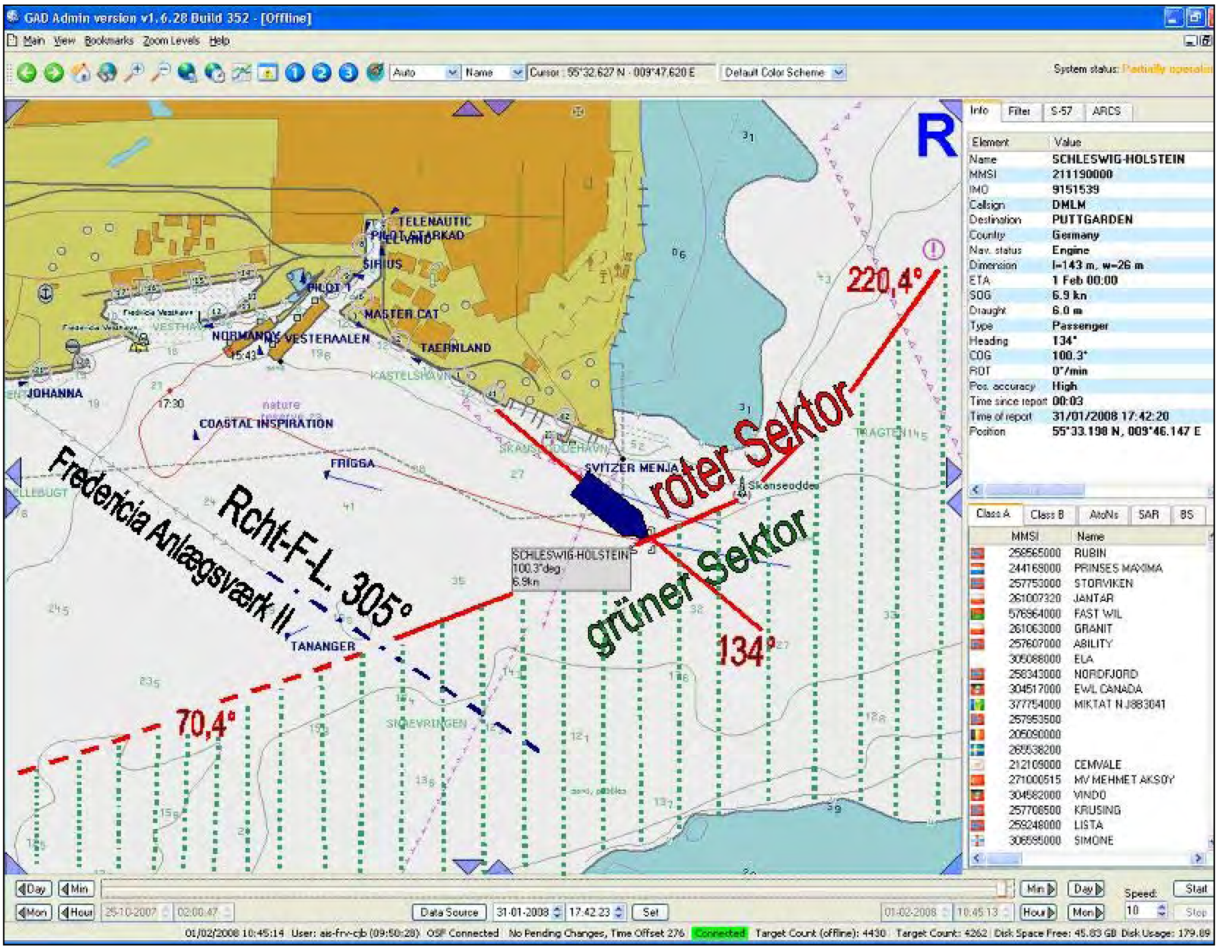


Figure 33: Sketch of the Fredericia leading light line and the Skanseodde sectors

Instead of the ECDIS, the X band radar image was switched on the third monitor available on the left side of the conning position at the time the pilot left the bridge. Consequently, two radar images and the vessel's navigating data were displayed. It must be considered that poor weather conditions with wave heights of 2 m and S winds of 7 Bft, in gusts of 9, prevailed and visibility was reduced due to rain and sleet. Attention also had to be paid to traffic (see Fig. 17 and 18, AIS targets). Under such conditions, radar navigation is only beneficial when the radar images are continuously evaluated. As a result of the filters applied which were used due to the weather conditions, the Skanseodde racon (T) (3 cm) was not identifiable on the X band radar based on the VDR recordings. A clear echo of the frame tower was visible only on the S band radar system. This echo last appeared at 17:40:08 on a bearing of 092° and at a distance of 0.4 nm.

It was not possible to observe the radar continuously because the first master was busy with manoeuvring the pod drives and the second master was busy with administration (filling in the pilot card) and he was communicating with the manoeuvring stations during the planned pilot transfer.

At this point in time, no other watchman was available on the bridge to look out for the lighthouse. The north and south forecastle manoeuvring stations did not report any dangerous approach of the Skanseodde lighthouse either. This would have required the clear allocation of a "look-out" function.

Considering the prevailing weather conditions with a strong wind from the S and most likely a NE setting current at 2 kn the transfer of the pilot at about 17:40 N of Snævringen was very risky. No one could subsequently explain why this position had been selected. It is possible that the reason is the pilot boat which was not identifiable on the radar recordings. The transfer position marked on the chart was in Tragten outside of Snævringen (see Fig. 7). The transfer position may differ from this under special circumstances. In consideration of the NE drift of the SCHLESWIG-HOLSTEIN of 4 to 5 kn, any pilot transfer in the S section of Snævringen and in line of the leading light would have been significantly less risky.

The masters employed on the SCHLESWIG-HOLSTEIN are experienced and familiar with the natural conditions in the Baltic Sea and in the Lillebælt. Surface currents can reach a major force in Lillebælt, specifically in the narrow Snævringen fairway. They do not always set in the direction of the fairway but partially move transverse to it. Individual areas of countercurrents are found close to shore along the coast. The currents cannot be determined precisely even with the latest models. The Danish meteorological service, DMI, had predicted a southerly current for the period of the accident whereas the pilot and tug masters observed a NE setting current at 1.5 to 3 kn. Current measuring devices were not used. During the voyage planning between master and pilot the current was not considered a risk.

The voyage was planned between the first master in charge and the pilot using the paper chart in the chart room, while the second master was busy with making ready for undocking. Attention was focused on undocking with tug assistance. As long as all 4 pod drives were working, there was considered to be no particular risk from the prevailing natural conditions. No one responded to warnings from the tug masters. It is possible that the warnings were not sufficiently communicated by the pilot. The pilot transfer position at Snævringen S of the refinery had also not been considered during voyage planning. The master was informed relatively late about the pilot transfer position, i.e. only after the tugs had cast off.[12]

Procedures to operate the bridge equipment were formless. There were no special arrangements between the two masters. It was agreed that the master who had arrived from his residence on the same day would take over his duty for undocking and beginning the voyage according to the regular watch routine. The radar antennas were only switched on and the radar systems tuned after leaving the dock so that dock personnel were not endangered. There was no explanation as to why the electronic nautical chart was not used. An additional monitor would have perhaps been helpful or even the option of overlaying of the radar image with the electronic chart.[13]

[12] The BSU does not know if the pilot transfer position initially agreed on by the master and the pilot has been changed in the course of the voyage.
[13] The overlaying with the radar image and the sole display of the electronic chart in the multipilot respectively is not equivalent with ECDIS in the Chartpilot or the paper chart. According to the Type Approval Certificate for Atlas NACOS „XX“-3 system BSH Nr. 31013 this display may only be used in connection with official charts

Helmsman and look-out were dispensed with. The first master in charge assumed the function of helmsman on the SCHLESWIG-HOLSTEIN because in this instance helm and engine revolutions are both operated simultaneously by the pod drives. The second master took over the function of look-out which included the function of a second watch officer and therefore of controlling the course. The job of controlling the course and the function of a look-out were partially lost to administrative duties and communicating with the manoeuvring stations. When the red sector of Skanseodde drifted so far to port that it was no longer visible from the conning positions, there was no one keeping visual watch at the bridge wing. A look-out was missing. The situation could only be monitored by 3 screens. The first master in charge was engaged in manoeuvring and could not leave his position. Consequently he was fully occupied and reliant on the help of his colleague to be able to navigate. Finally, neither of the two masters had an overview of the whole situation just prior to the collision with the lighthouse.

The responsibilities between the first and second master, as well as the pilot, were disadvantageous and unclearly defined. They needed someone to be in charge of maintaining an overview of the whole situation. The officer in charge of the watch must be able to leave his position at the conning position, without simultaneously being occupied with manoeuvring the pod drives and being liaison for the pilot. A watch man employed explicitly with the function as a look-out would have perhaps been able to see the dangerous approach in good time.

7 Action taken by the vessel operator

After the accident, the vessel operator conducted a detailed internal analysis of the accident with all the masters in the shipping company and revised their ship safety management system. An anonymous version of the investigation report has been forwarded to the remaining officers on board for educational purposes and training.

In the vessel operators own simulator and on the ship handling simulator at Wismar University, department for maritime studies, scenarios are developed for masters and officers which deal with voyage planning, docking and navigating in poor weather conditions with pilots and tugs as well as inspection of the vessels command.

The manuals for the ship safety management system and procedural instructions for docking, making ready for sea and voyage planning are being revised. The responsibilities of officers supporting manoeuvring are being re-regulated with pilots advice.

Due to the ongoing improvement of the ship safety management system by the vessel operator and the extensive training options in their own ship handling simulator, the BSU doesn't consider a further safety recommendation necessary.

8 Sources

- Investigations of the Danish Maritime Authority, Division for Investigation of Maritime Accidents (DMA)
- On-board inspection by BSU
- Written statements
  - SCHLESWIG-HOLSTEIN vessel's command
  - Scandlines Deutschland GmbH vessel operator
  - Danish Pilotage Authority
- SCHLESWIG-HOLSTEIN witness statements
  - Pilot
  - Tug masters
  - Vessel's command
- Reports/expert opinions
  - Survey Association Ltd. Copenhagen
  - Denmark's Meteorologiske Institut, Center for Ocean og Is (DMI)
  - Official weather expertise by the German National Meteorological Service (DWD)
  - Federal Maritime and Hydrographic Agency/Bundesamt für Seeschifffahrt und Hydrographie (BSH)
- Paper charts, books of sailing directions and vessel particulars from BSH
- Electronic nautical chart data
  - Kort & Matrikelstyrelsen Denmark
- Photos
  - BSU
  - Hasenpusch
  - Survey Association
- Radar plots by Vessel Traffic Services (VTS)/Vessel Traffic Centres
  - DMA
  - Voyage data recorder