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

Investigation Report 255/08

Serious marine casualty

Collision CMV MARFEEDER with CMV APL TURQUOISE on the Outer Weser on 1 June 2008

1 February 2010

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 - 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.

The present report should not be used in court proceedings or proceedings of the Maritime Board. Reference is made to art. 19 para. 4 SUG.

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

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1 Summary of the marine casualty

At 0601 on 1 June 2008[1], the container vessel MARFEEDER, sailing under German flag, collided with the container vessel APL TURQUOISE, sailing under Singapore flag, in visibility of less than 1000 m in the fairway of the Weser. The scene of the accident is situated approximately 1000 m south-east of the river bend at the 'Robbennordsteert Light'. Both vessels had a pilot and were also assisted by radar pilots from Vessel Traffic Service (VTS) Bremerhaven. After the collision, the MARFEEDER sailed on to the Stromkaje at Bremerhaven and the APL TURQUOISE anchored at the anchorage, Neue Weser N-Reede. The accident did not lead to any injuries. The MARFEEDER was severely damaged on the port side and lost her rescue boat during the collision. The APL TURQUOISE had a crack on the port forecastle above the water line and was able to continue her voyage on the following night. No pollutants escaped.

[1] Unless otherwise stated, all times shown in this report are local = Central European Summer Time = UTC + 2

2 Scene of the accident

Type of event:	Serious marine casualty, collision
Date/Time:	1 June 2008/0601
Location:	Outer Weser
Latitude/Longitude:	φ 53°41.5'N λ 008°20.6'E

Excerpt from nautical chart 4, BSH

MARFEEDER → Encounter ← APL TURQUOISE

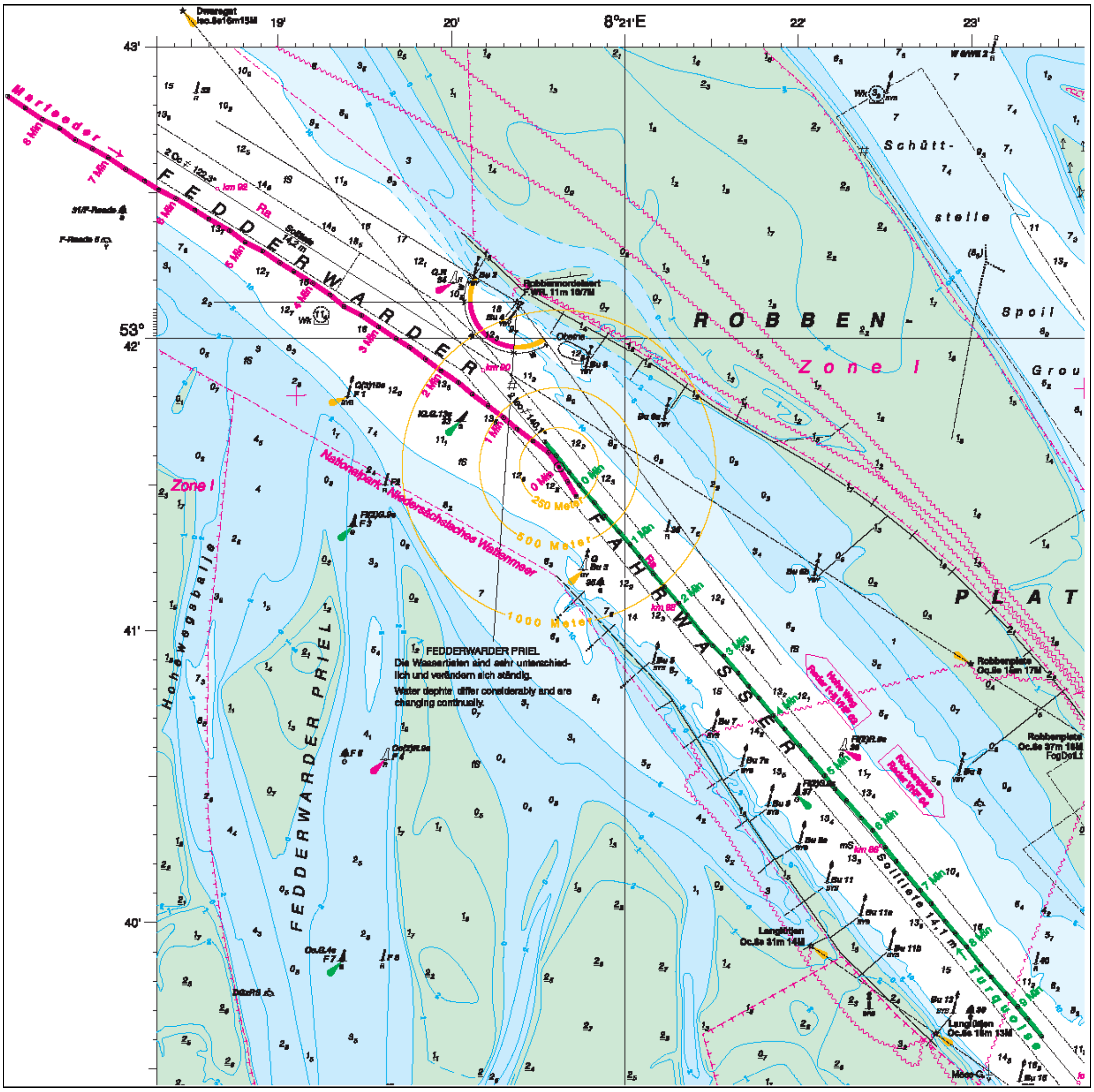


Figure 1: Nautical chart

3 Ship particulars

3.1 Photo MARFEEDER

Figure 2: Photo

3.2 Particulars

Name of vessel:	MARFEEDER
Type of vessel:	Container vessel
Nationality/flag:	Germany
Port of registry:	Hamburg
IMO number:	9123324
Call sign:	DHMA
Owner:	MarConsult Schiffahrt GmbH & Co KG
Year built:	1996
Shipyard/yard number:	Peters Schiffbau/654
Classification society:	Germanischer Lloyd
Length overall:	116.40 m
Breadth overall:	19.40 m
Gross tonnage:	4,986
Deadweight:	6,506 t
Draught at time of accident:	Fore: 4.64 m, aft: 5.80 m
Engine rating:	5,940 kW
Main engine:	Wärtsila 9L 38
(Service) Speed:	16 kts
Hull material:	Steel
Hull construction:	Double hull
Number of crew:	13
Weser pilot:	1

3.3 Photo APL TURQUOISE

Figure 3: Photo

3.4 Particulars

Name of vessel:	APL TURQUOISE
Type of vessel:	Container vessel
Nationality/flag:	Singapore
Port of registry:	Singapore
IMO number:	9082348
Call sign:	9VVY
Owner:	APL Bermuda Ltd.
Year built:	1996
Shipyard/yard number:	Imabari Shipbuilding Co. Ltd./2060
Classification society:	American Bureau of Shipping
Length overall:	294.11 m
Breadth overall:	32.20 m
Gross tonnage:	52,086
Deadweight:	81,881
Draught at time of accident:	12.30 m
Engine rating:	40,526 kW
Main engine:	Mitsubishi Sulzer 10 RTA 84 C-UG
(Service) Speed:	24.5 kts
Hull material:	Steel
Hull construction:	Double hull
Number of crew:	29
Weser pilot:	1
Deep-sea pilot:	1

4 Course of the accident

At 0601 on 1 June 2008, the feeder vessel MARFEEDER, sailing from Hamburg, collided with the container vessel APL TURQUOISE, sailing from Bremerhaven, in visibility of less than 1,000 m south-east of buoy 33 on the fairway of the Weser. The scene of the accident is situated approximately 1,000 m south-east of the river bend at the 'Robbennordsteert Light'. A pilot was on board each vessel and they were also assisted by radar pilots from VTS Bremerhaven. In addition, the Master, Officer on Watch and helmsman were situated on the bridge of the APL TURQUOISE and two Officers on Watch, who were about to hand over their watch keeping duties, were situated on that of the MARFEEDER at the time of the accident. The Master of the MARFEEDER went to the bridge immediately after the collision and through an astern manoeuvre prevented the MARFEEDER, which was broached to in the direction of the fairway, from running aground on the Robbenplate. The MARFEEDER then sailed on to the Stromkaje at Bremerhaven and the APL TURQUOISE anchored at the anchorage, Neue Weser N-Reede. The accident did not lead to any injuries. The MARFEEDER was damaged severely on the port side and lost her rescue boat during the collision. The APL TURQUOISE had a crack on the port forecastle above the water line and was able to continue her voyage on the following night. No pollutants escaped.

The APL TURQUOISE cast off from the Stromkaje at Bremerhaven at 0500 and was sailing for Felixstowe, United Kingdom. The Master, harbour pilot, fourth officer, lookout and helmsman were situated on the bridge. Visibility was initially 2-3 nm. Subsequently, fog patches formed. At 0524, the harbour pilot left the vessel and the sea pilot took over. With a draught of 12.30 m, the APL TURQUOISE remained in the middle of the fairway on the leading light or radar reference line. The pilot did not register an explicit right of way by radio; however, the APL TURQUOISE met the necessary criteria and she was recorded by the VTS as a vessel with an exceptional draught. On the Weser, it is reportedly customary for vessels of this size to stay in the middle of the fairway to reduce the risk of running aground posed by the constantly changing water depths (morphology of the sea floor). It is only possible to manoeuvre within the approx. 200 m wide fairway. Accordingly, the lights were set to those of a right-of-way vessel. Moreover, the APL TURQUOISE was permanently assisted by a radar pilot from Vessel Traffic Service Bremerhaven.

The pilot was briefed on the characteristics of the vessel by the Master of the APL TURQUOISE before departure. The berth was departed at low tide. The tide (about 1 kts) then ran against the vessel off the Robbenplate. The fog became more and more prevalent on this voyage. The pilot used the starboard radar equipment and set it to a range of 1.5 nm OFF CENTRE. This provided him with a view ahead of 2.5 nm. Occasionally, he also set the radar to 3 nm and identified the MARFEEDER between buoys 29 and 31. In the process, he established that the MARFEEDER was remaining close to the buoy line. Furthermore, he had no doubts as regards the manner in which she was operated or the proper course alteration at buoy 33. After 0600, he heard an urgent request by the radar pilot that the MARFEEDER move further to starboard. He therefore assumed that she was already changing her course. At that point, at a manoeuvring speed of 15 kts the APL TURQUOISE had neither the possibility nor the time to execute energetic engine and helm manoeuvres to deviate from her track. A speed reduction, e.g. 'full astern', would have caused her to run aground. The foreseeable collision was no longer avoidable.

The MARFEEDER was sailing from Hamburg downstream on the Elbe under pilot assistance. At about 0300, the Elbe pilot left the vessel at the pilot boarding place and switched to the tender BORKUM. The Officer on Watch was now alone with his watch keeper and sailed the MARFEEDER to pilot boarding place Weser/Jade Pilot. At 0440, the Weser pilot, who was met on the pilot ladder by the watch keeper, boarded the vessel and went to the bridge. At that point, visibility stood at 4-5 nm and there was an E wind of 2-3 Bft.

The MARFEEDER was being steered on autopilot, both radar and VHF equipment were in use and the local radio channel was monitored. The Officer on Watch briefed the pilot about the faulty starboard radar equipment. A service technician, who was only able to repair the radar equipment partially, was reportedly on board in Hamburg and had arranged to visit the vessel again in Bremerhaven. Reportedly, only buoys that were astern were clearly identifiable. The port radar was reportedly set to a range of 3 nm and operated on display mode 'True Motion/Off Centre'. The image was reportedly initially good. The electronic chart equipment (ECS) was switched off because there were problems with the UPS (uninterruptible power supply). The problems with the ECS and starboard radar equipment were reportedly discussed with the pilot.

An attempt was reportedly made to switch on the ECS and adjust the starboard radar to achieve a better image. Visibility deteriorated to 11 cbl at the Hoheweg lighthouse. At about 0553, halfway between buoys 29 and 33, the APL TURQUOISE was identified on the radar screen between buoys 38 and 40. The radar pilot of the VTS was informed that the radar assistance was monitored and the MARFEEDER would keep to the right. That was confirmed by the radar pilot at 0557. At that point, buoy F1 was reportedly at a distance of 4 cbl on the starboard side and not visible.

Following that, the port radar equipment was reportedly set to a range of 1.5 nm; however, the image ahead within the inner 3 rings (7.5 cbl) was reportedly only vague and buoys F1 and 33 at the river bend could not be identified with the radar equipment. After that, the pilot requested radar assistance. At 0600, the radar pilot made the MARFEEDER aware of the close proximity to the APL TURQUOISE in terms of the passing distance and urgently requested her to move further to starboard. He also advised that buoy 33 was reportedly astern and that the distance to the APL TURQUOISE, which was moving along the radar reference line, was 500 m. The course set on the autopilot was reportedly then immediately altered to180° and the MARFEEDER reportedly turned with a rudder position of 15° to starboard; the helm was reportedly then switched to manual. Reportedly, no changes were made to the rate of speed because a reduction from 'full ahead' to ‘dead slow’ causes this type of vessel to lose her steerability.

The alteration of course from 122° to 140° planned in accordance with the nautical chart was too late and the APL TURQUOISE collided with the port side and superstructure of the MARFEEDER. In the process, the rescue boat of the MARFEEDER was torn from her mounting and went overboard. Due to the collision, the vessel turned hard to port and was positioned transversely to the direction of the fairway. Hard rudder and engine manoeuvres enabled the vessel to be kept in the fairway and returned to her course. One of the officers then addressed the settings of the starboard radar equipment and was able to produce a better image of what lay ahead. It was not possible to significantly improve the image of the port radar equipment.

4.1 Damage

The shell plating, the area of the bulwark and small sections of the deck were dented on the port side of the MARFEEDER's forecastle. Some of the hatch cover mountings were damaged. The bulwark in front of the superstructure was dented and the cell guide of the container slots deformed. Containers were torn open. The boat deck was destroyed along a length of 10 m, as was the davit and the rescue boat. The chambers on deck 2 and 3 were destroyed on the port side. The rescue boat was salvaged at buoy 33 by the police boat Visura and taken to Geestevorhafen. A life raft, which also went overboard, was salvaged by the rescue cruiser HERMANN RUDOLF MEYER.

The APL TURQUOISE had a crack below the panama fairlead on the port side of the forecastle and the bulwark was dented. Parts of a container were stuck to the anchor. A 1.2 m long and 20-30 cm high crack was located about 5 m above the water line. Paint abrasions existed at various places.

There were no personal injuries or water ingress and no pollutants escaped. Each vessel was able to continue her voyage unaided.

Figure 4: Damage MARFEEDER

Figure 5: Damage APL TURQUOISE

5 Investigation

5.1 Evaluation of the VDR

The table shows a synchronised summary of the VDR recordings of the MARFEEDER and radio recordings of VTS Bremerhaven. The track of the each upcoming vessel is shown in Fig. 1. While the APL TURQUOISE, the right-of-way vessel, remained consistently on the leading light and radar reference line indicated on the chart, the MARFEEDER initially stayed on the outer edge of the fairway. The course of each track shows that their encounter on the radar reference line up to the collision only became apparent from the river bend at Robbennordsteert. While there were no irregularities on the bridge of the APL TURQUOISE and the navigational equipment and equipments were operable, there were problems on the MARFFEDER. The bridge was manned only by officers, without a helmsman or lookout, the electronic chart could not be switched on and one radar equipment was only partially operable due to deficient tuning. Furthermore, a change of watch had begun just at the time at which the decisive course alteration to stay on the track at the edge of fairway should have taken place. This caused a general distraction from the need for permanent electronic track and traffic monitoring in visibility of less than 1,000 m (see table at Fig. 6). Fog signals pursuant to the Regulations for Preventing Collisions at Sea (COLREGs) could not be heard on the two VDR recordings.

Time Radar	Star-board Radar	GYH-DG	COG	SOG AIS	SOG GPS	OOW = Officer on Watch, BL = pilot on board, RL = radar pilot
044413	6	107.1	106.0	12.8	12.6	Message to Bremerhaven Weser Traffic, passed buoy 3a
044614	6	110.2	111.0	14.8	14.7	OOW to BL, poor radar reception on starboard equipment
045059	6	107.4	109.0	15.6	15.6	OOW reports ECS problems, no password, equipment does not start, time of arrival of harbour pilots at buoy 49 approx. 0615
050412	6	102.1	104.0	15.2	15.2	BL expects a moderate head current
050712	6	112.3	116.0	15.5	15.3	BL establishes bearing for lighthouses Roter Sand and Alte Weser at 65°, it should be 69°, compass check
051813	6	138.3	141.0	15.6	15.5	Hohewegrinne
051858	6	138.4	141.0	15.6	15.6	BL requests radar ranges 3 and 1.5 nm respectively, local fog in sight, MELINDE reports good visibility on AIS bearing 348.8° at distance of 8.0 nm
053013	6	139.2	141.0	16.1	16.1	Harbour pilot, buoy 49, requested for 0630, short pulse and long pulse settings configured on the radar menu
053512	6	130.2	131.0	16.2	16.2	LICA MAERSK reports 2,000 m visibility on AIS bearing 117° at distance of 7.5 nm
054457	6	122.3	123.0	16.3	16.3	Second OOW on the bridge, ECS defective
055159	6	120.2	122.0	16.2	16.2	Discussion concerning problem with ECS and radar continues
055543	6	120.2	121.0	16.3	16.3	Fog, APL TURQUOISE can be seen clearly at distance of 3 nm, crew awoken
055643	6	121.5	122.0	16.2	16.2	Situation report, APL TURQUOISE downstream on Weser, radar reference line, buoy 38 passed
055728	6	121.3	122.0	16.2	16.2	RL confirms MARFEEDER will keep to right (buoy

						line)
055744	6	121.9	123.0	16.1	16.2	BL and RL end discussion via VHF
055757	6	123.0	124.0	16.1	16.1	BL doubts whether buoy F1 is abeam
055813	6	123.4	125.0	16.1	16.1	Large upcoming vessel identified at a distance of 1.5 nm
055828	6	123.3	125.0	16.0	16.1	OOW asks about upcoming vessel
055842	6	123.8	125.0	16.0	16.0	Radar problems, buoy 33 reportedly disappeared
055858	6	124.2	126.0	16.0	16.0	OOW identifies a buoy
055913	1.5	124.6	126.0	16.0	16.0	BL seeks buoys F1 and 33
055929	1.5	126.0	127.0	16.0	16.0	Next buoy identified, one buoy missing
055943	0.75	126.4	128.0	16.0	16.0	OOW reports buoy abeam
055959	0.75	126.4	128.0	16.1	16.1	BL requests advice from radar pilot, APL T. at 0.75 nm
060014	0.75	126.3	128.0	16.0	16.1	RL advises MARFEEDER and APL TURQUOISE
060026	0.75	126.3	127.0	15.9	16.0	OOW reports buoy 33 astern, approx. 500 m distance to APL TURQUOISE (bow to bow)
060042	0.75	130.9	128.0	15.7	15.9	Decisive course alteration to starboard with autopilot; situation recognised on the TURQUOISE
060057	0.75	141.5	137.0	15.3	15.6	Turn of approx. 20.6°/min
060113	0.75	151.4	151.0	14.4	15.3	Collision, loud noises
060127	0.75	141.2	142.0	13.4	14.6	Manual helm, Master on the bridge – is informed
060142	0.75	149.6	146.0	13.2	13.4	MARFEEDER turns to starboard
060158	0.75	143.1	151.0	12.9	13.3	Collision is reported, turn to port begins
060214	0.75	125.8	146.0	12.1	12.8	MARFEEDER brought under control with full astern manoeuvre
060229	0.75	108.4	121.0	9.0	11.4	Turn to port, crossways to fairway
060243	0.75	093.3	115.0	8.3	9.7	BL reports radar problems, one equipment reportedly
060258	0.75	083.1	107.0	7.4	8.2	useless, the other is completely inoperable
060412	0.75	049.5	144.0	0.5	2.1	RL advises MARFEEDER

Figure 6: Log of the MARFEEDER as per the VDR recordings

The times refer to the recorded radar image of the starboard radar equipment and may deviate from the system time by 15 s. GyHDG = gyro heading, COG = course over ground and SOG = speed over ground based on the AIS and GPS. The VDR did not record the entire radar image. The bottom menu bar is not visible. With regards to tuning, it could not be ascertained whether the automatic frequency control (AFC) or the manual tuning was selected. The AFC was reportedly defective. Anticlutter sea (ACS, STC) and rain (FTC) were set manually. The second radar image was not recorded.

5.2 Navigational equipment

The APL TURQUOISE was equipped, inter alia, with two X-Band radar equipments and one S-Band radar equipment from Japan Radio Co. (JRC), a Tokimec EC 7500 electronic chart system with AIS overlay, GPS receivers, a Tokimec PR-8000 gyrocompass, a JRC JFE 570 S echo sounder, a Furuno MF 220 speed log, and a JRC JCY 1850 VDR. The equipment and systems were operable.

The MARFEEDER was equipped, inter alia, with one Kelvin Hughes Nucleus 5000 T/X radar equipment and one Northrop Grumman Sperry Marine Bridgemaster 251 E radar equipment, a Transas Navisailor electronic chart system, an Elac LAZ 5000 echo sounder, one Magnavox MX200 GPS receiver and one MX500 Northstar GPS receiver, a C. Plath Naviknot III speed log, a Raytheon Anschütz Standard 20 gyrocompass, a Raytheon Anschütz Nautopilot D autopilot, a Sam Electronics 4330 S-VDR, and a Furuno FA-100 AIS Minimum Key Display. At the time of the accident, the electronic chart system was defective and the Bridgemaster 251 E radar equipment was only partially operable.

5.3 Manoeuvre characteristics and behaviour, MARFEEDER

The manoeuvre characteristics shown in Fig. 7 were measured during a sea trial under ballast and in deep water before the vessel was put into operation in 1996. According to that, the MARFEEDER would have entered a turning circle after 52 s with a 'hard starboard' and 'full astern' manoeuvre after 2.2 cbl at a speed of 8.4 kts. The turning circle diameter would be 1.4 cbl. At 'full astern' and the helm amidships she would have moved slightly off her track to starboard after 1.57 min and 2.5 cbl. The speed would then be approx. 1.2 kts. Controlled manoeuvres would have been possible with the installed left-hand controllable pitch propeller. The risk of an uncontrolled 'running out of rudder' is therefore rather improbable. The MARFEEDER veered to port and turned across the fairway only after the collision. There would have been sufficient room on the river bend for a turning circle through starboard without running aground. The BSU is not in possession of rudder recordings. The shallow water effect and the flow of the rudder were not further investigated. In the hour before the collision, the tide turned from a moderate head current to an aft current.

The BSU is not in possession of manoeuvre characteristics for the APL TURQUOISE. Due to her dimension and mass, a 'full astern' and 'hard starboard' manoeuvre in a time frame of 1 minute and with a bow to bow distance to the MARFEEDER of 500 m would most likely have been ineffective.

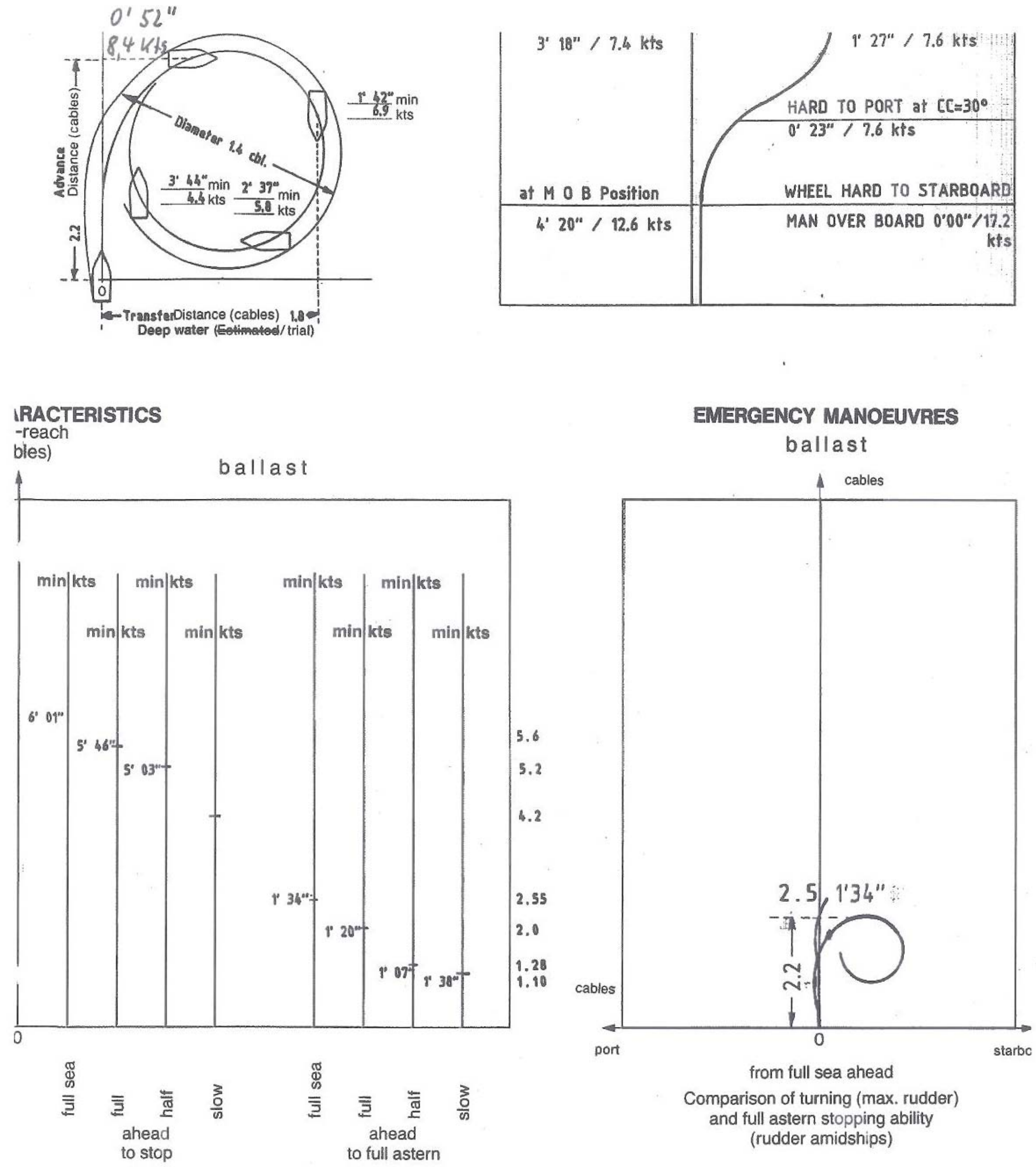


Figure 7: Manoeuvre characteristics MARFEEDER

5.4 Expert opinion by the BSH

Radar investigations on the collision

Bases for the investigation

1. VDR recordings from TURQUOISE
2. VDR recordings from MARFEEDER
3. Service report, MARFEEDER, 31 May 2008
4. Service report, MARFEEDER, 1 June 2008

Radar equipment TURQUOISE

Radar equipment configuration according to VDR recording

Radar equipment	: X-Band, JRC (Japan Radio)
Stabilisation	: Ground stabilisation, stabilisation sensor GPS
Range	: 1.5 nm
Mode of operation	: Relative Motion, North Up
Tuning	: Auto tuning
Amplification	: Manual, approx. 80%
Anticlutter sea	: Manual, 3 of 10
Anticlutter rain	: Off
Image processing	: 3
Interference suppression	: On
Time	: Local time, every minute in 15 s intervals

Description of the radar image

Jetties, groynes and buoys are clearly visible; moderate clutter is visible next to the port side of the vessel; it can therefore be concluded that the amplification of the receiver was adapted to meet the circumstances.

Observations in the time sequence shown

055245 (see Fig. 8)
Preset range is 1.5 nm; the trail time (trail, plot-trail) is set at 1 min. The trails are displayed in true motion. This makes it impossible or difficult to establish visually that the risk of a collision exists. However, it is possible to distinguish between static and dynamic targets, since dynamic targets emit a trail where static targets do not.

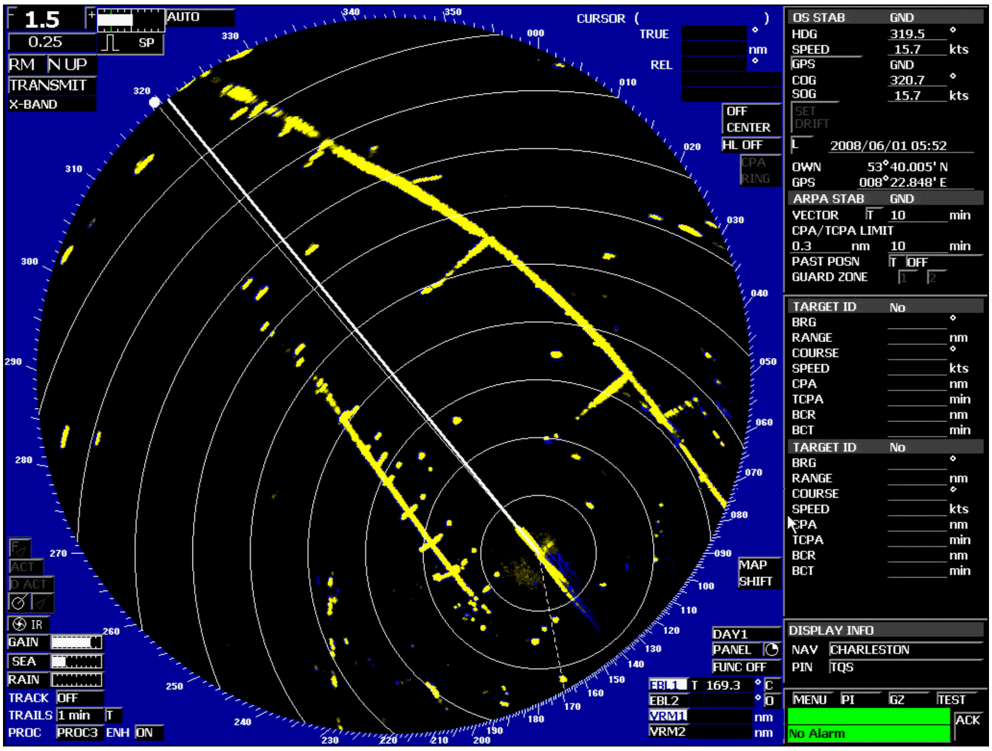


Figure 8: Radar image, TURQUOISE 055245

055545 (see Fig. 9)

The other vessel involved in the collision enters the PPI (plan position indicator, radar screen/all-round view). At that point, it is the only upcoming vessel for the TURQUOISE. Based on the trails, we see that the upcoming vessel does not alter her course during the approach.

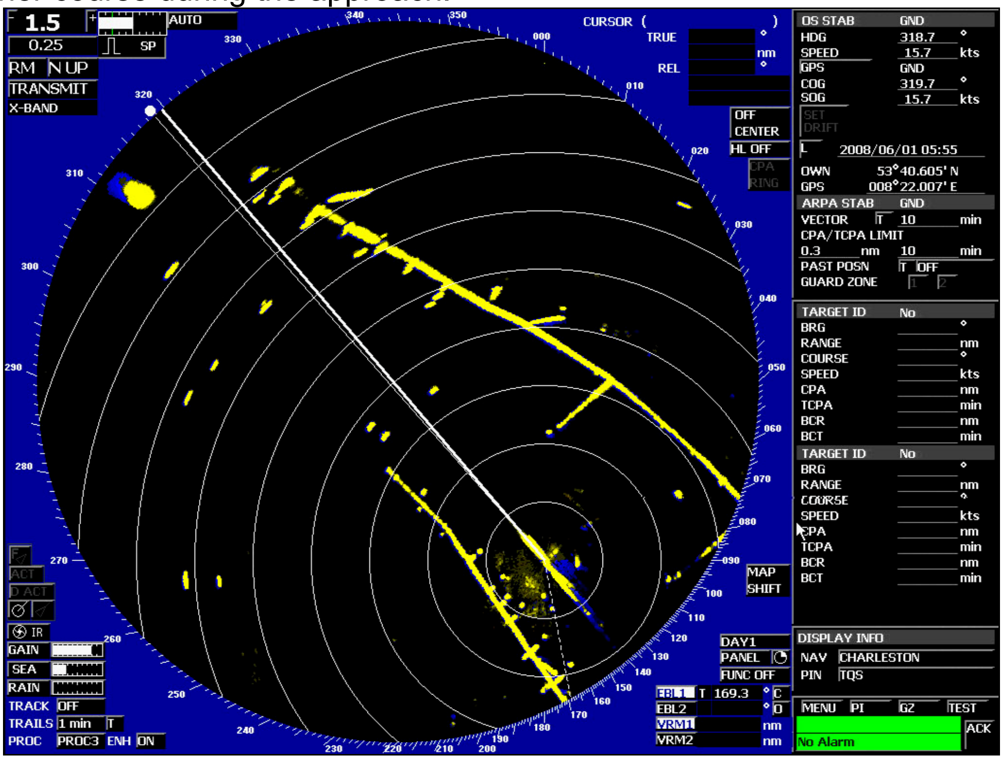


Figure 9: Radar image, TURQUOISE 055545

055900 (see Fig. 10)
MARFEEDER on a collision course

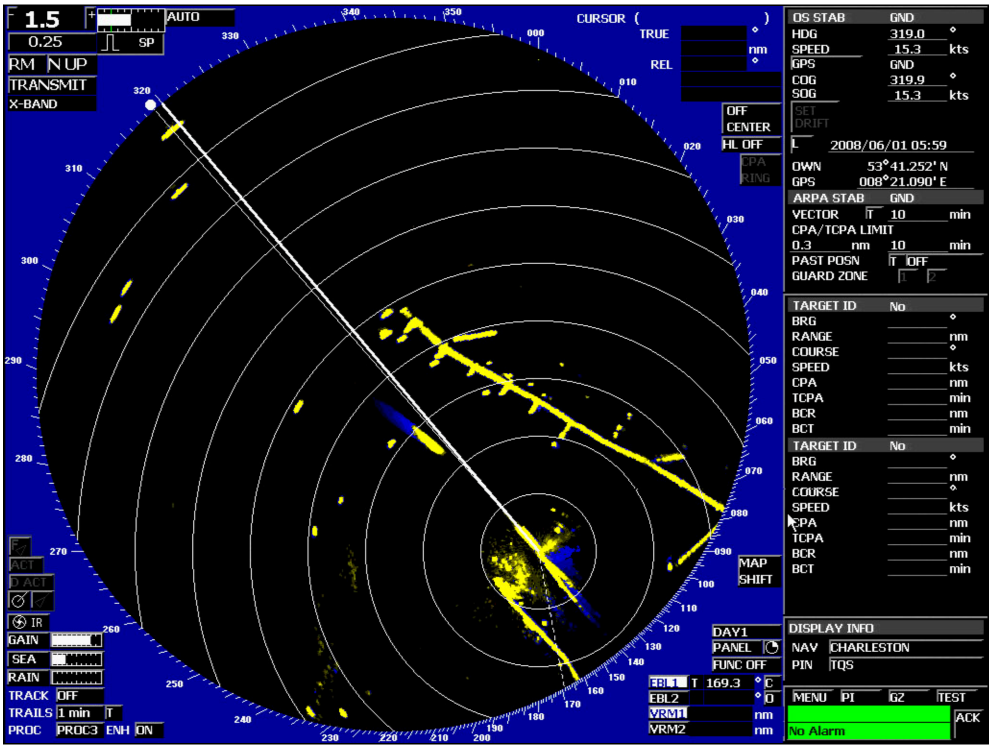


Figure 10: Radar image, TURQUOISE 055900

060000 (see Fig. 11)
The collision occurs.

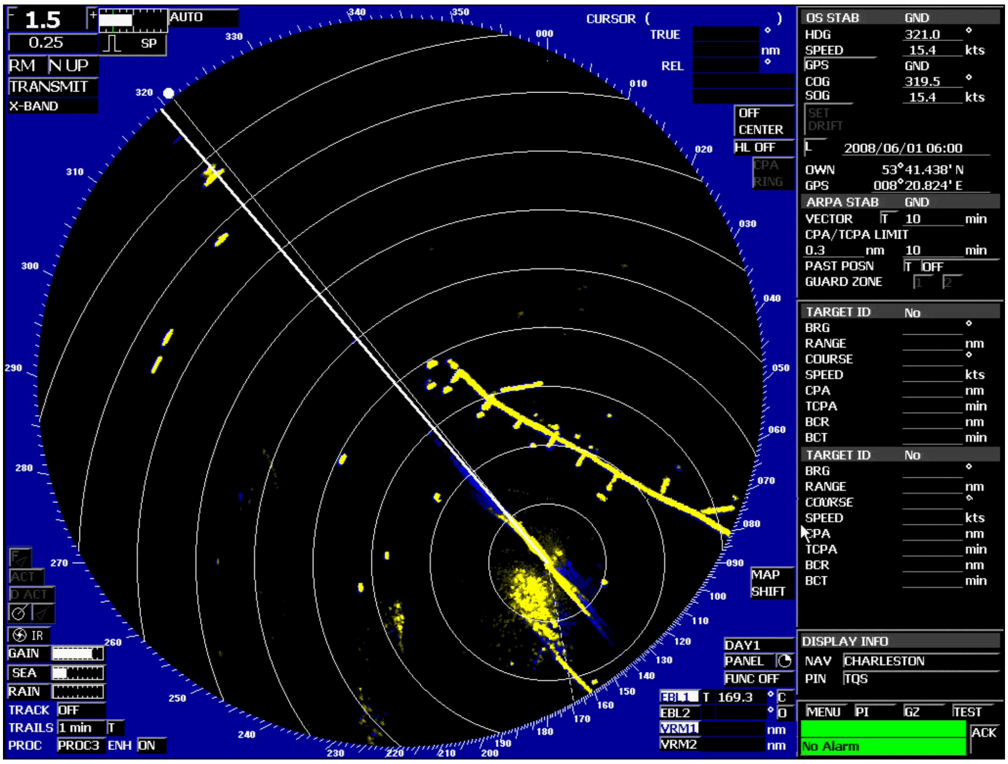


Figure 11: Radar image, TURQUOISE 060000

Radar equipment, MARFEEDER

Radar equipment configuration according to VDR recording

Radar equipment	: X-Band, Sperry Bridgemaster 251 E
Stabilisation	: Ground stabilisation, stabilisation sensor GPS
Range	: 6 nm
Mode of operation	: Relative Motion, North Up
Tuning	: No information (VDR recording error, see Figs. 12 and 13, bottom 2 lines, inter alia, tuning deficient)
Amplification	: Manual, approx. 50%
Anticlutter sea	: Manual, 30%
Anticlutter rain	: Off
Target expansion	: On
Interference suppression	: No information
Vectors true	: 10 minute
Plot-trail length	: No information on the length
Plot-trail length	: Local time, every second in 15 s intervals, as compared with the APL TURQUOISE approx. 1 min 15 s ahead

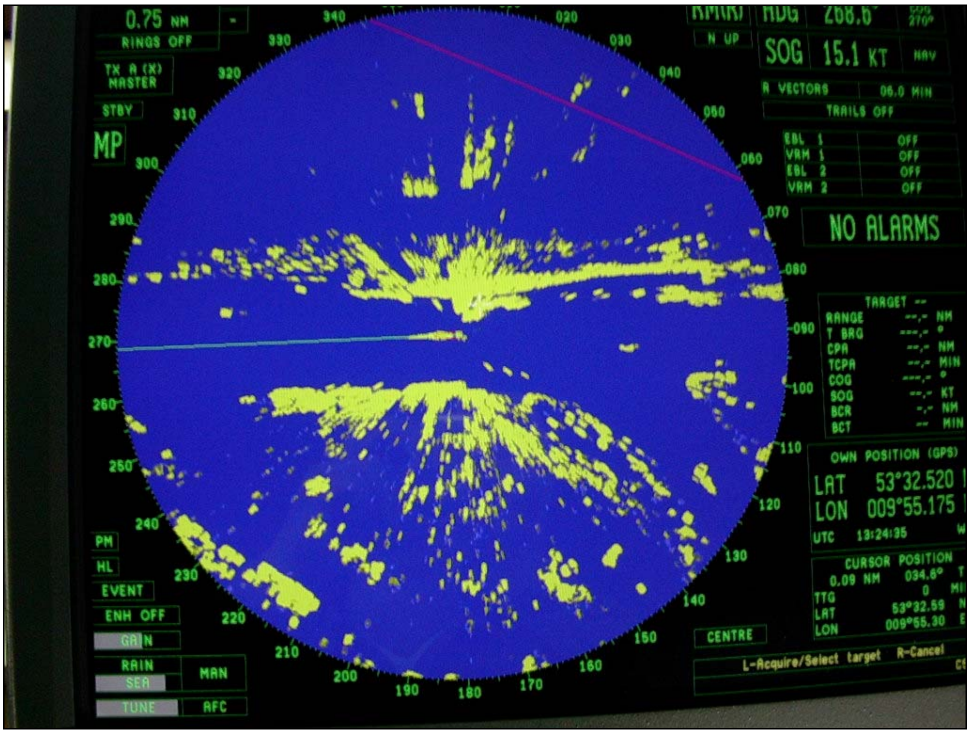


Figure 12: Photo of radar image taken on 10 July 2008

Description of the radar image

Targets in close proximity are shown up to approx. 1.5 nm, point targets up to approx. 3 nm, such as buoys, can be seen only faintly. Groynes and jetties are not displayed on the screen. No clutter can be seen on the radar screen. The display indicates inadequate performance in terms of what the receiver provides the detector for analysing. To the extent that the automatic frequency control was used, the fault outlined in the service reports in relation to it being reportedly defective would explain this.

The service reports of Sperry Marine ServiceNet dated 31 May 2008 and 1 June 2008 noted that the automatic frequency control was reportedly defective, but that the manual tuning was operable.

Observations in the time sequence shown

055244 (see Fig. 13)
The other vessel involved in the collision is shown at approx. 6 nm at 120°. She is the only object shown at that distance. Since an image is recorded only every 15 seconds, it is not possible to determine the stability of the target.

055858 (see Fig. 14)
The target is permanently displayed on the radar image after the above recording.

055913 (see Fig. 15)
The radar is adjusted to a range of 1.5 nm. In addition to the other vessel subsequently involved in the collision, the fairway buoys are also shown on the radar screen on the starboard side of the MARFEEDER.

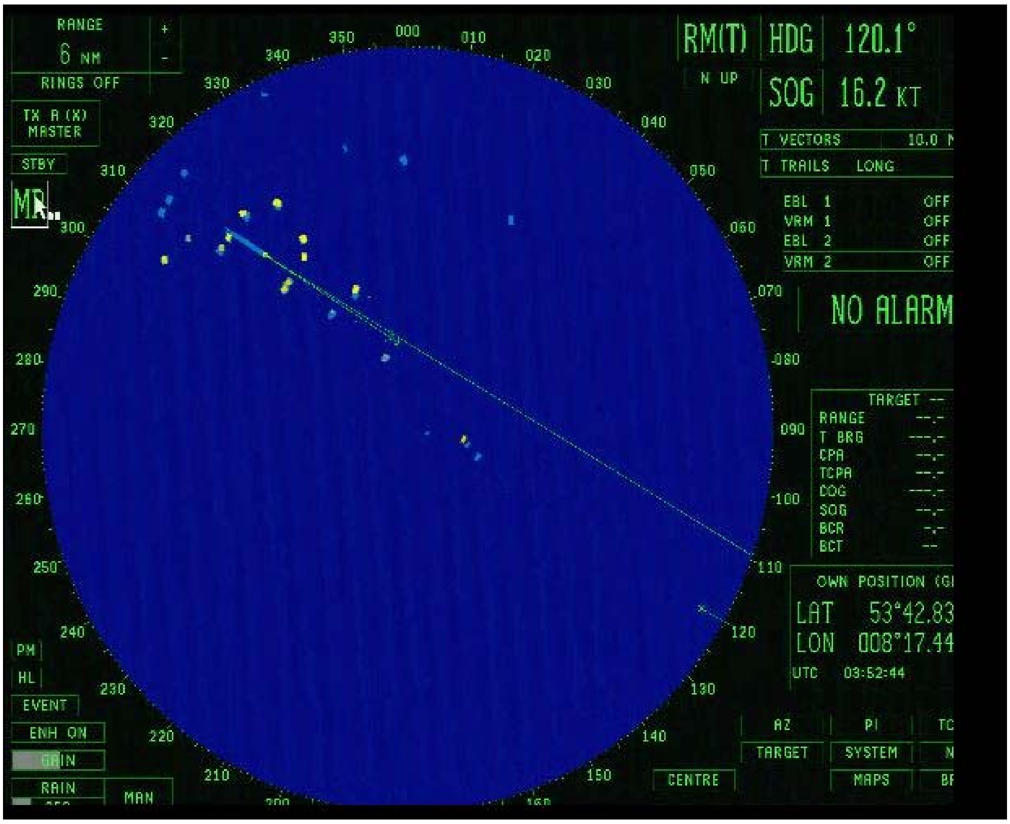


Figure 13: Radar image, MARFEEDER 055244

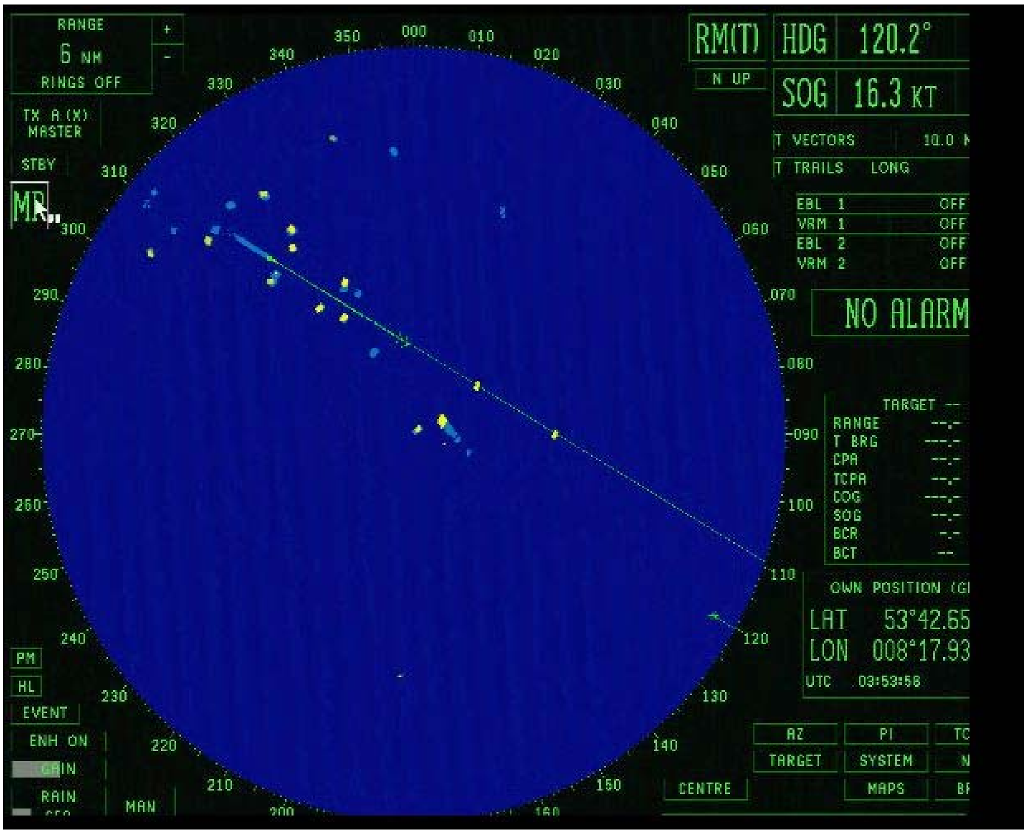


Figure 14: Radar image, MARFEEDER 055858

Figure 15: Radar image, MARFEEDER 055913

055943 (see Fig. 16)
The radar is adjusted to a range of 0.75 nm.

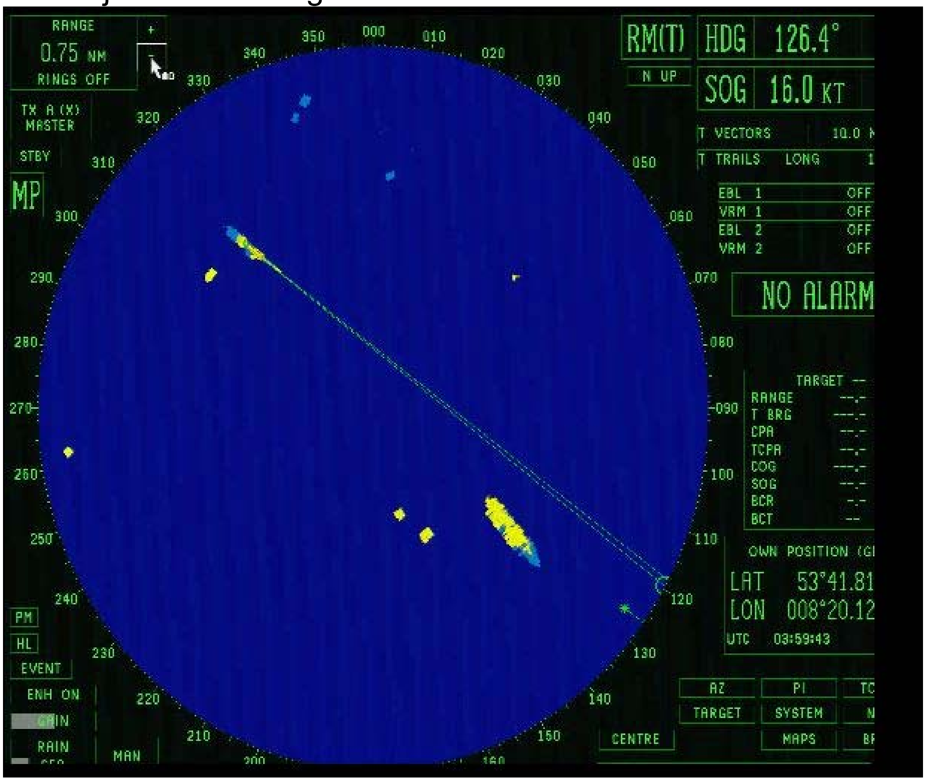


Figure 16: Radar image, MARFEEDER 055943

060113 (see Fig. 17)
This collision occurs.

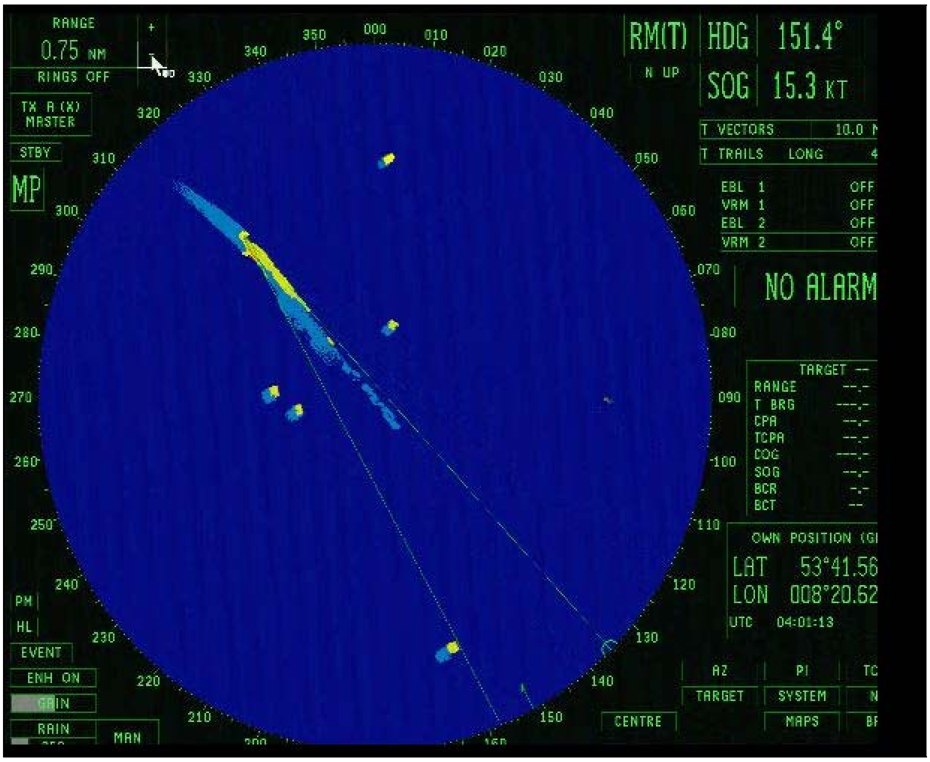


Figure 17: Radar image, MARFEEDER 060113

Notes on the initial setting of a radar equipment

A radar equipment has to be initially set before it can be configured:

1. Tuning of the receiver
2. Setting the amplification of the receiver
3. Setting the anticlutter sea
4. Setting the anticlutter rain

1) Manually tuning the receiver

a) Using targets to tune the receiver
A range of 12 or 24 nm is selected if targets are present. At that range, the long pulse is used by the radar equipment; with this pulse energy is emitted only in the low frequency range. If the tuning of the receiver is altered, the appearance and disappearance of targets can be observed on the radar. The equipment must be configured so that targets can be identified on the radar with maximum possible intensity.

b) Configuring the receiver with the aid of the tuning display
The radar equipment is set at a range of 12 nm or 24 nm; when changes are made to the tuning control one can observe how the level varies on the associated display. The equipment must be tuned so that the level on the display is as high as possible.

c) Setting the receiver using the performance monitor (PM)
IMO radar equipments are delivered with a performance monitor. This has a small transmitter which is tuned to the radar's magnetron frequency. With most radar equipments, adjustments are made using the performance monitor at a range of 12 nm or 24 nm. Details can be taken from the manufacturer's manual. When the PM is switched on, a test target, e.g. a circular segment, is displayed within a given range. When changes are made to the tuning, one can observe how the representation, e.g. of the intensity or the size of the test target, varies. The equipment must be tuned so that the test target is as clear as possible. The user manual for the radar equipment must always be referred to in order to ensure that the function can be used properly.

2) Setting the amplification of the receiver
After modern radar equipments that are not delivered with automatic image processing functions are tuned properly, the amplification must be adjusted. Usually, at a range of 6 nm or 12 nm the amplification control is rotated slowly to the right until a light, steady noise is visible on the radar screen; the amplification should then be slightly reduced just to the point at which the noise is no longer visible. That is the input amplifier's optimum operating range.

This setting option can no longer be used on many modern radar equipments because the noise is eliminated by filtering processes. The radar manual of the manufacturer is to be referred to in such cases. The manufacturer's recommendations should be followed to obtain optimum detection results.

3) Setting the anticlutter sea

One can observe clutter in the area around the ship; this is brought about by sea conditions and wind. The size and shape is based on the sea conditions, wind force and wind direction in relation to the ship and height of the radar equipment – this effect is limited to a range of 2 to 4 nm around the ship. In order to be able to see targets within this range, radar equipments are made less sensitive within this range; therefore, only targets can be observed which reflect more energy than that reflected by the waves. This method has proven itself over many years. The Officer on Watch must be aware that the filtering processes may suppress small targets, due to which they may not be displayed on the radar. If sea reflections are observed, the controller for anticlutter sea should be increased until only moderate clutter can be seen.

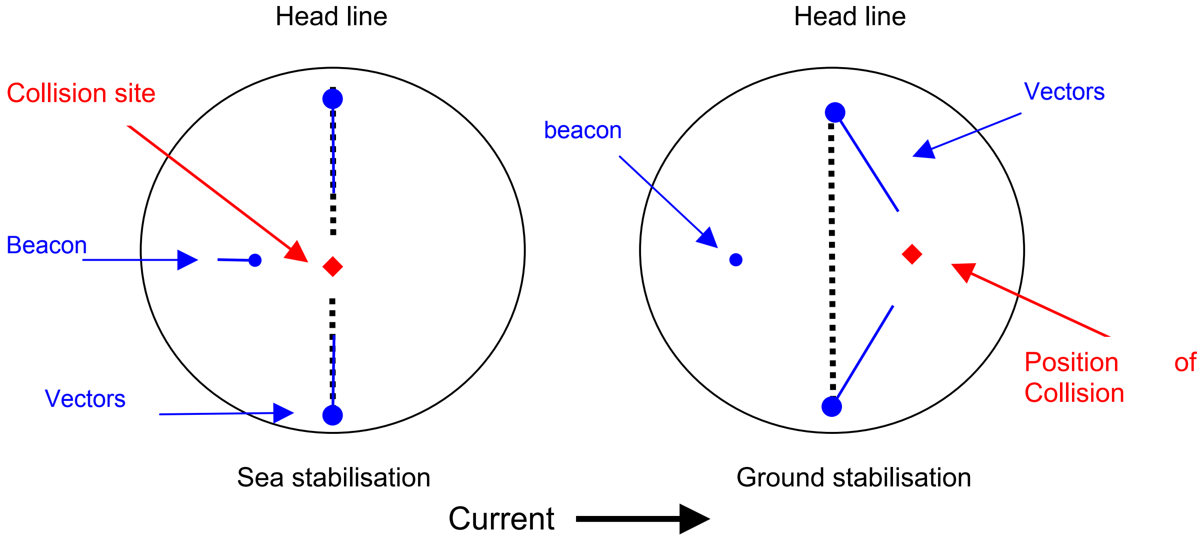
4) Setting the anticlutter rain

The capability of radar is limited during rainfall, especially during heavy showers or monsoon rains. An S-Band radar equipment should be used in these cases if one is on board because the S-Band is less susceptible to rain. The use of short pulses also returns better detection results on the X-Band during rainfall. With classical radar equipments, the reflected signals were differentiated, due to which only the edges of objects such as areas of rainfall or targets were displayed during rain. A controller has been necessary so that the differential element can be adapted to the pulse length used.

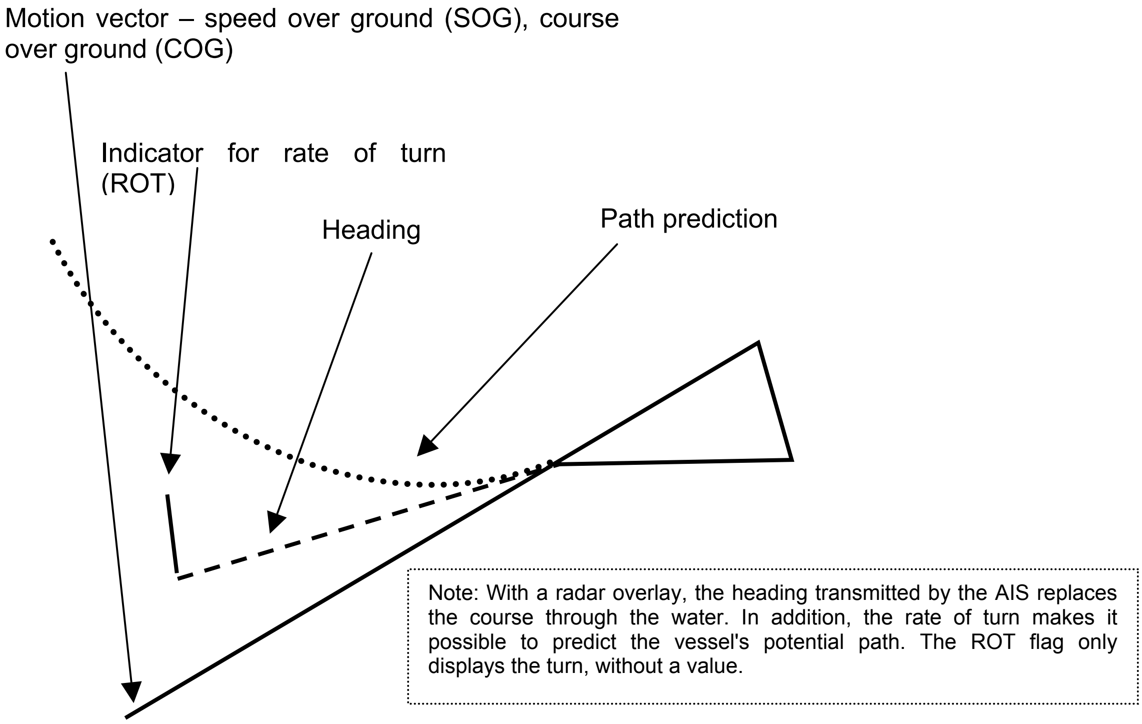
If a radar equipment is delivered with automated features for tuning, amplification, anticlutter sea, anticlutter rain or another automated noise suppression or equipment feature, the radar manual must always be referred to in order to achieve the best possible image enhancement with the settings and procedures specified therein. The improved efficiency of automated features compared to the manual settings should be reviewed periodically by switching over.

5.5 Sea and ground stabilisation on the radar screen and AIS

Sea and ground stabilisation on the radar screen with and without AIS



AIS



With respect to sea stabilisation (speed through water – water track – WT), the position of the vessels and vectors in relation to one another is displayed as in real life. The position of collision would lie ahead and it would be shown geographically inverted. However, a fixed target, such as the beacon receives the vector of the setting current. With respect to ground stabilisation (speed over ground – bottom track – BT), the vectors are shown offset. The aspect of the vessels in relation to one another is not displayed as in real life. The position of collision would be offset, but displayed in a geographically correct manner and fixed targets, such as the beacont, do not have a current vector. Both types of stabilisation have advantages and disadvantages. Ground stabilisation seems to be currently preferred in the shipping sector. It is particularly advantageous when AIS signals can be displayed on the radar screens. Information pertaining to the speed over ground (SOG), course over ground (COG) and heading with rate of turn (ROT) flag would then be available and both aspects are accounted for. A path prediction would also be possible due to the transmitted rate of turn. It should be noted that when choosing the speed measurement sensors for the radar equipment, the sensors for WT and BT must meet the requirements of a speed log. In particular, the accuracy of GPS information is lacking when changes are made to the course or speed.

The advantages of AIS can only be exploited effectively in terms of preventing collisions if the data can be displayed on an electronic chart or radar equipment. Separate representation on a minimum key display is inappropriate. The APL TURQUOISE had the possibility to overlay with the electronic chart system. That would have made the course alterations of AIS targets identifiable almost in real time. The minimum key display on the MARFEEDER was not taken into account. A situational analysis in conjunction with the nautical chart or radar equipment would not have been possible in real time.

5.6 Vessel Traffic Service VTS

At 2150 on 31 May 2008, the watch was handed over to the nautical supervisor and two nautical assistants. At 0445 on the following morning, the MARFEEDER, sailing from Hamburg, registered with the VTS; the APL TURQUOISE, sailing for Felixstowe, did the same at 0455. The APL TURQUOISE was advised by a radar pilot from 0508 onwards. At 0523, the hourly situation report about the traffic conditions was transmitted. A second radar pilot advised the incoming APL HONG KONG from 0540 onwards. A third radar pilot was on duty for the stretch upstream the Weser river from Geestemünde from 0545 onwards because of the deteriorating visibility. Change of watch for the nautical supervisor and one assistant took place at 0550. The Unterweser workstation was not manned. According to the watch log, the collision was reported off fairway buoys 35/36 at about 0555. Only property damage was reportedly reported, there were no injuries or water ingress.

After that, administrative measures were reportedly taken until 0900 in accordance with the alerting plan and reports were submitted to MRCC Bremen, the waterway police, the Central Command for Maritime Emergencies in Cuxhaven, the Port Operations Office and the head of WSA Bremerhaven.

At 0615, the MARFEEDER sailed on to Bremerhaven. A second radar pilot advised on the Outer Weser from 0620 onwards. At 0630, the APL TURQUOISE was instructed to anchor at the anchorage, Neue Weser N-Reede.

5.6.1 Recordings of the visibility measurement installation Hoheweg

Visibility measurements of the stations along the Weser are displayed in the VTS as a bar chart. Visibility is displayed using red bars, which ascend from the top (good visibility) to the bottom (poor visibility). The display's visual scale ranges from > 10,000 m to < 100 m.

Data storage is not supported by the computer equipment of WSA Bremerhaven; therefore, recordings of the visibility measurement installation cannot be made available.

After a deterioration of visibility was detected above Bremerhaven during the situation analysis at 0520, a radar pilot was requested by Pilot Station Weser I to advise on visibility < 2,000 m on the Unterweser. The requested radar pilot went on duty in the VTS at 0545. There was no indication of deteriorating visibility below Bremerhaven up to the end of the night shift, neither according to visibility measurement equipment nor vessel reports.

The radar pilot responsible for advising the APL TURQUOISE first became aware of the deteriorating visibility during the request for radar assistance made by the MARFEEDER at about 0600. According to the morning shift, there was no sign of deteriorating visibility on the visibility measurement equipment at that time or until about 0800. Pilot Station Weser II/Jade requested an additional radar pilot for the Outer Weser after the request by the MARFEEDER. The requested radar pilot went on duty in the VTS at 0620.

5.6.2 Regulations for the handling of vessels during encounters at Robbennordsteert

Throughout the Outer Weser, encounters of right-of-way vessels, which together exceed a width of 65 m, must be coordinated with Vessel Traffic Service 'Bremerhaven Weser Traffic'. Encounters among right-of-way vessels are not permitted en route on the stretches between fairway buoys 39/40 and 43/44 (Wremer Loch) or between fairway buoy 59 and the ferry pier at Blexen.

For the Fedderwarder fairway stretch, at the course alteration point at Robbennordsteert, there are no particular prohibitions in addition to the encounter of right-of-way vessels; general shipping traffic regulations apply.

It is possible to sail safely on low tide with a draught of < 10 m on the marked section of the Outer Weser according to the Regulations for Navigable Waterways (SeeSchStrO) (Appendix I B. 11 and B. 13). Vessels with a draught of >10 m are, depending on the actual draught and the tides, limited to the fairway's dredged channel (LAT -13.47 m at km 68 to LAT -14.49 m at km 127).

The APL TURQUOISE was classified as a right-of-way vessel within the meaning of the notice of the Waterways and Shipping Directorate (WSD) North West. The right of way was not specifically indicated by the vessel; however, with a draught of 12.30 m, she satisfied one of the requirements of Notice No. 3.2 Weser.

Consistent adherence to the radar reference lines/leading lights by certain vessels is not required on the Weser; general shipping traffic regulations apply. For reasons of safety and ease, exceptionally deep vessels use the radar reference line/leading light between the course alteration points as a reference line. In the specified dredged channel, this reference line is usually only left to safely pass other vessels that are possibly also dependent on the dredged channel.

It has hitherto been the case that the radar assistance vessels (as per the Törnordnung (marine ordinance) of LB Weser II/Jade, seawater draught > 10.50 m and length > 270 m) have been considered by the pilots and the Vessel Traffic Service to be vessels which use the deepest part of the fairway - in general and especially on straight stretches, the right side of the dredged channel.

Right of way is assumed by the Vessel Traffic Service for vessels with a draught of > 12.30 m without an explicit indication by the vessel. This fact may explain why the right of way was not specifically indicated. These vessels often use the radar reference lines/leading lights, i.e. the middle of the dredged channel. Leading lights and the associated radar reference lines are aids of navigation; however, they are not prescribed as a mandatory track.

Notification for these vessels, and all other vessels that make use of radar assistance, occurs via the hourly situation report of the Vessel Traffic Service and via specific information either from the Vessel Traffic Service or the advising pilots in the respective radar assistance sections. This information applies analogously for the coordination and encounter of these vessels on the stretches set aside for changing course when the total breadth is > 65 m. In individual cases or for draughts of < 12.30 m, right of way is not granted by the Vessel Traffic Service, but according to the regulation a decision on the use and corresponding indication remains with the vessel.

5.7 Weather and current conditions

In Germany's National Meteorological Service marine forecast for the North Sea and Baltic Sea issued on 31 May 2008 at 1800 UTC and 2100 UTC as well as on 1 June 2008 at 0000 UTC, NW wind of 3-4 Bft, with a subsequent turn to the east and local fog patches, is predicted for the western part of the German Bight. At 0300 UTC, the forecast is updated to E wind of 4 Bft, later circulating, sea 0.5 to 1 m with local fog patches.

Weather situation

On 1 June 2008, low-pressure systems crossed south-east Europe, south-west Europe, the western Mediterranean Sea and the Norwegian Sea. A high-pressure system crossed Scandinavia and the Baltic States, another one crossed Scotland. A frontal system stretched from the Norwegian Sea depression in a wide arc over Spitsbergen, western Norway and the German Bight to Hungary. The frontal system was practically stationary over the North Sea until the following day.

Weather and sea conditions

During the night of 1 June 2008, the southern part of the German Bight was overcast with scattered clouds in places and no rainfall. The night-time air temperature was 16 °C. The water temperature in the German Bight stood at 13 °C and in the Outer Weser at 16 °C.

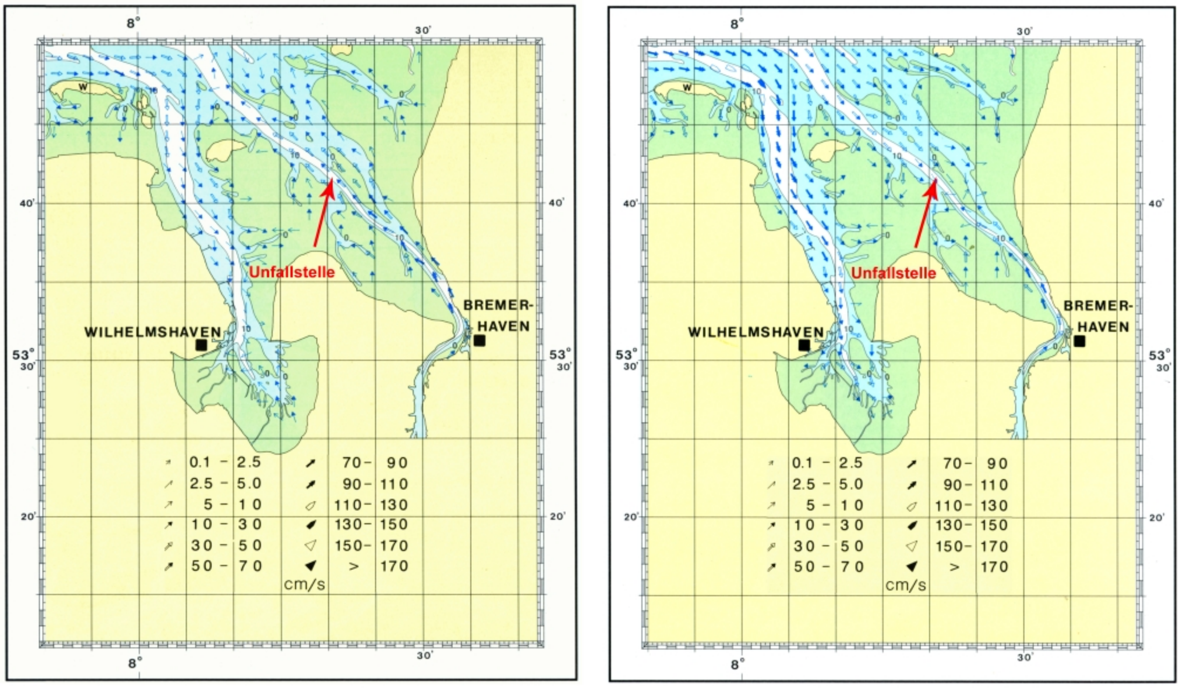
The horizontal visibility was initially close to 10 km. In the early morning hours, the horizontal visibility decreased to less than 5 km inland and on the East Frisian coast; at 0600, local fog prevailed with visibility of less than 1 km. The measurements in Bremerhaven on 1 June 2008 were 10 km at 0400, 5 km at 0500, 1.1 km at 0600, 0.9 km at 0700, 0.8 km at 0800, 2.2 km at 0900, and 3.2 km at 1000. No fog was reported in the German Bight or in the Elbe estuary.

In the southern part of the German Bight the wind blew steadily from E to ENE during the night with a mean strength of 4 to 5 Bft, gusts were not measured. In the early morning hours, the wind gradually veered to ESE, but retained the mean strength of 4 to 5 Bft. With a mean strength of 3 to 4 Bft, the wind was much lower in the Outer Weser.

Observations of wave height in the southern part of the German Bight or Outer Weser from other shipping were not available. Nevertheless, it is possible to estimate the significant wave height of the sea from the ratios between wind force, effective wind duration and fetch length. A mean wind from a stable direction sustained over 6 hours at a force of 4 Bft can generate a wind sea with significant wave heights of 1.0 m with periods of 4 s when deep water conditions are undisturbed. However, taking into account the observed E wind direction in the area of the Outer Weser under review, it cannot be assumed that undisturbed conditions prevailed. The significant wave heights of the wind sea would have been lower than 0.5 m.

The sea plots of the weather forecast models for 0200 and 1400 on 1 June 2008 showed no swell in the southern part of the German Bight. However, depending on the model, predicted wave heights of more than 1.0 and more than 2.0 m are initially shown. Moreover, even with the newest models the coastal areas can still only be insufficiently accounted for. The 'Helgoland' measuring buoy, located at position 54°09.60' N 007°52.08' E at a water depth of 20 m, measured significant wave heights of between 0.2 and 0.6 m during the course of 1 June 2008.

The tide turned between 0500 and 0600 (see Fig. 18). Initially, a moderate head current was detected on the MARFEEDER. According to the tidal stream atlas of the BSH, 0.2-0.6 kts could be expected before and after the tide turned and thus a marginal drift.



5 h vor Hochwasser Helgoland

4 h vor Hochwasser Helgoland

Figure 18: Current conditions at 0500 and 0600

5.8 Time sheets

Evaluation of the time sheets for the crew of the MARFEEDER was carried out by the Occupational Safety and Health Administration in Hamburg, Port Authority/Shipping (see Figs. 19-23). Supporting documents for the APL TURQUOISE were not submitted to the BSU after being requested by its law firm.

In general, the supporting documents are written very schematically according to the required watch keeping plan and there are doubts as to whether the working hours have been recorded properly. The MARFEEDER operates in feeder service between the North Sea and Baltic Sea and regularly serves the ports of Bremerhaven and Hamburg as well as the Baltic ports of Gothenburg, Kristiansand/Moss on a weekly tour. Therefore, daily casting off and berthing manoeuvres with short travel times and extreme stress are quite normal for the 13 man crew.

The work and rest periods of the officers and able bodied seamen differ from the rules only in the 7 daily values and are evenly distributed. The Master's records are somewhat different. Here we see a distinctly different pattern of recording, which roughly corresponds to the port rotation set by the schedule. At 90 hours in 7 days, the hours worked are expectedly high and the rest periods are often interrupted by brief tasks. The statutory maximum of 14 working hours was exceeded on several occasions.

Arbeits- und Ruhezeiten des Kapitäns

Tag	Zeit	0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18	18–19	19–20	20–21	21–22	22–23	23–24	366	7 Tage Arbeitszeit (25)	7 Tage Ruhezeit (0)
Do	1	x x								x x	x x	x x	x x		x x	x x	x x	x x	x x			x x	x x	x x	x x	14		
Fr	2	x x	x x	x x	x x	x x	x x								x x	x x						x x	x x	x x	x x	12		
Sa	3	x x	x x	x x	x x	x x	x x			x x	x x	x x	x x									x x	x x	x x	x x	14		
So	4	x x	x x							x x	x x	x x	x x		x x	x x	x x	x x				x x	x x	x x	x x	14		
Mo	5	x x	x x						x x		x x	x x	x x		x x	x x						x x	x x	x x	x x	12		
Di	6	x x	x x							x x	x x	x x	x x		x x	x x						x x	x x	x x	x x	12	-	-
Mi	7	x x	x x					x x	x x		x x	x x	x x		x x							x x	x x	x x	x x	12	90	78
Do	8	x x								x x	x x	x x	x x				x x	x x	x x			x x	x x	x x	x x	12	88	80
Fr	9	x x	x x							x x	x x	x x	x x					x x				x x	x x	x x	x x	11	87	81
Sa	10									x x	x x	x x	x x		x x	x x	x x	x x				x x	x x	x x	x x	12	85	83
So	11									x x	x x	x x	x x		x x	x x	x x	x x				x x	x x	x x	x x	12	83	85
Mo	12									x x	x x	x x	x x		x x	x x	x x	x x				x x	x x	x x	x x	12	83	85
Di	13	x x	x x	x x	x x									x x	x x	x x						x x	x x	x x	x x	11	82	86
Mi	14	x x							x x	x x		x x	x x		x x	x x	x x	x x				x x	x x	x x	x x	13	83	85
Do	15	x x							x x		x x	x x	x x									x x	x x	x x	x x	9	80	88
Fr	16	x x								x x	x x	x x	x x		x x	x x	x x	x x			x x	x x	x x	x x	x x	14	83	85
Sa	17	x x						x x	x x	x x	x x	x x	x x									x x	x x	x x	x x	11	82	86
So	18									x x	x x	x x	x x		x x	x x	x x	x x						x x	x x	10	80	88
Mo	19						x x	x x		x x	x x	x x	x x									x x	x x	x x	x x	10	78	90
Di	20						x x	x x		x x	x x	x x	x x									x x	x x	x x	x x	10	77	91
Mi	21						x x	x x		x x	x x	x x	x x									x x	x x	x x	x x	10	74	94
Do	22									x x	x x	x x	x x		x x	x x	x x	x x				x x	x x	x x	x x	12	77	91
Fr	23									x x	x x	x x	x x		x x	x x	x x	x x				x x	x x	x x	x x	12	75	93
Sa	24	x x	x x	x x				x x	x x		x x	x x	x x		x x	x x	x x	x x		x x		x x	x x	x x	x x	17	81	87
So	25	x x	x x	x x			x x	x x							x x	x x	x x	x x	x x							10	81	87
Mo	26						x x	x x		x x	x x	x x	x x									x x	x x	x x	x x	10	81	87
Di	27	x x	x x							x x	x x	x x	x x									x x	x x	x x	x x	10	81	87
Mi	28						x x	x x		x x	x x	x x	x x									x x	x x	x x	x x	10	81	87
Do	29						x x	x x		x x	x x	x x	x x		x x	x x	x x	x x	x x					x x	x x	13	82	86
Fr	30	x x	x x							x x	x x	x x	x x				x x	x x	x x			x x	x x	x x	x x	13	83	85
Sa	31	x x	x x							x x	x x	x x	x x		x x	x x	x x						x x	x x	x x	12	78	90

Figure 19: Work and rest periods of the Master

Rest periods according to art. 84a (2) SeemG (Seaman's Law) were not maintained in the fields highlighted in orange. In the fields highlighted in purple, the hours worked exceeded 14 hours. The next figure shows the number of officers working simultaneously with the Master. In the period under review, 15 ports were entered and the Kiel Canal was transited 5 times. In spite of that, both nautical officers were on duty at the same time as the Master only on three occasions. Furthermore, working hours were not recorded on the morning of 26 May 2008. This underlines the careless management of the time sheets.

TO — Arbeitszeiten eingeblendet von allen Offizieren plus Kpt.

Tag	Zeit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Do	1																								
Fr	2																								
Sa	3																								
So	4																								
Mo	5																								
Di	6																								
Mi	7																								
Do	8										Keine Daten														
Fr	9																								
Sa	10																								
So	11																								
Mo	12																								
Di	13																								
Mi	14																								
Do	15	2 2	1 1	1 1	1 1	1 1	1 1	1 1	2 2	1 1	2 2	2 2	2 2	1 1	1 1	1 1	1 1	2 2	1 1	1 1	1 1	1 1	1 1	1 1	1 1
Fr	16	2 2	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	2 2	2 2	2 2	2 2	1 1	1 1	2 2	2 2	2 2	2 2	2 2
Sa	17	2 2	1 1	1 1	1 1	1 1	1 1	2 2	2 2	2 2	2 2	2 2	2 2	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	2 2	2 2	2 2
So	18	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	2 2	1 1	1 1	1 1	1 1	1 1	2 2	2 2
Mo	19	1 1	1 1	1 1	1 1	1 1	2 2	2 2	1 1	2 2	2 2	2 2	2 2	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1
Di	20	1 1	1 1	1 1	1 1	1 1	2 2	2 2	1 1	2 2	2 2	2 2	2 2	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	2 2	2 2	2 2	2 2
Mi	21	1 1	1 1	1 1	1 1	1 1	2 2	2 2	1 1	2 2	2 2	2 2	2 2	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	2 2	2 2	2 2	2 2
Do	22	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	3 3	1 1	1 1	1 1	1 1	1 1	1 1	1 1
Fr	23	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	2 2	1 1	1 1	1 1	2 2	3 3	2 2	2 2	1 1	1 1	1 1	1 1	1 1	1 1	1 1
Sa	24	2 2	2 2	2 2	1 1	1 1	1 1	2 2	2 2	1 1	2 2	2 2	2 2	1 1	2 2	2 2	2 2	2 2	1 1	2 2	1 1	1 1	1 1	1 1	1 1
So	25	2 2	2 2	2 2	1 1	1 1	2 2	2 2	1 1	1 1	1 1	1 1	1 1	1 1	2 2	2 2	2 2	2 2	2 2	1 1	1 1	1 1	1 1	1 1	1 1
Mo	26						1 1	2 2	1 1	3 3	3 3	3 3	3 3	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	2 2	2 2	2 2	2 2
Di	27	2 2	2 2	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	2 2	1 1	1 1	1 1	2 2	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1
Mi	28	1 1	1 1	1 1	1 1	1 1	2 2	2 2	1 1	2 2	2 2	2 2	2 2	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	2 2	2 2	2 2	2 2
Do	29	1 1	1 1	1 1	1 1	1 1	2 2	2 2	1 1	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	2 2	2 2	1 1	1 1	1 1	1 1	2 2	2 2
Fr	30	2 2	2 2	1 1	1 1	1 1	1 1	1 1	1 1	1 1	2 2	1 1	1 1	1 1	1 1	1 1	2 2	2 2	2 2	1 1	1 1	1 1	1 1	1 1	1 1
Sa	31	2 2	2 2	1 1	1 1	1 1	1 1	1 1	1 1	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	1 1	1 1	1 1	1 1	1 1	2 2	2 2	2 2

Figure 20: Number of officers working simultaneously with the Master

The next figure shows that all 4 seamen rarely worked at the same time, which is common practice when sailing into/out of ports or through locks.

TM — Arbeitszeiten eingeblendet von der Decksbesatzung

Tag	Zeit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Do	1																								
Fr	2																								
Sa	3																								
So	4																								
Mo	5																								
Di	6																								
Mi	7																								
Do	8										Keine Daten														
Fr	9																								
Sa	10																								
So	11																								
Mo	12																								
Di	13																								
Mi	14																								
Do	15	1 1	1 1	1 1	1 1	1 1	2 2	2 2	2 2	3 3	3 3	3 3	3 3		3 3	3 3	3 3	3 3					1 1	1 1	1 1
Fr	16	1 1	1 1	1 1	1 1	1 1				3 3	3 3	3 3	3 3		2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2
Sa	17	1 1	1 1	1 1	1 1	1 1	1 1	2 2	2 2	3 3	3 3	3 3	2 2	2 2	3 3	3 3	3 3	3 3	1 1	1 1	1 1	1 1	1 1	1 1	1 1
So	18	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	2 2	2 2
Mo	19	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2		4 4	4 4	3 3	3 3						1 1	1 1
Di	20	1 1	1 1	1 1	1 1	1 1	2 2	2 2	2 2	3 3	3 3	3 3	2 2	2 2	3 3	3 3	3 3	3 3	2 2	1 1	1 1	1 1	1 1	1 1	1 1
Mi	21	1 1	1 1	1 1	1 1	1 1	2 2	2 2	2 2	3 3	3 3	3 3	2 2	1 1	2 2	3 3	3 3	3 3				1 1	2 2	1 1	1 1
Do	22	1 1	1 1	1 1	1 1	1 1	1 1	1 1	2 2	3 3	3 3	3 3	2 2	2 2	3 3	3 3	3 3	3 3						1 1	1 1
Fr	23	1 1	1 1	1 1	1 1					3 3	3 3	3 3	3 3		4 4	4 4	3 3	3 3				1 1	1 1	1 2	2 1
Sa	24	1 1	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	1 1	1 1	1 1	1 1	1 1
So	25	1 1	1 1	1 2	2 2	2 2	2 2	2 2	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1
Mo	26	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	3 3	3 3	3 3	3 3	1 1	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	1 1
Di	27	1 1	1 1	1 1	1 1					3 3	3 3	3 3	3 3		4 4	4 4	3 3	3 3					1	1 1	1 1
Mi	28	1 1	1 1	1 1	1 1	1 1	1 1	2 2	2 2	3 3	3 3	3 3	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	1 1
Do	29	1 1	1 1	1 1	1 1	1 1	1 1	1 1	2 2	3 3	3 3	3 3	3 3		2 2	3 3	2 2	2 2	2 2	2 2	2 2	2 2	2 2	1 1	1 1
Fr	30	1 1	1 1	1 1	1 1					3 3	3 3	3 3	3 3		3 3	3 3	3 3	3 3		1 1	1 1	1 1	1	1 1	1 1
Sa	31	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2

Figure 21: Number of simultaneously working seamen

			Norway			Sweden / Finnland / Poland / Baltic States																							Finnland - Rotterdam			Russia			
WEEK			ICE BIRD	MARFEEDER	ROGALAND	ANTJE	BARBARA	BELIEVER	BUXTEHUDE	CONCEIVER	ELISABETH	GOTLAND	LAPPLAND	MARIS	NORRLAND	NYLAND / TBN	PANTONIO	PERCEIVER	RAGNA	SPICA	TUCANA J	VÄRMLAND	WERDER BREMEN	Euro Storm	Caplanus J / WMS Groningen	Maike D	BELUGA SENSATION	BELUGA STIMULATION	GÖTALAND	ANDROMEDA J	ANNALAND	BIRKALAND	LIVLAND
		TEU	686	547	707	658	352	535	868	535	658	822	658	508	508	330	686	535	508	749	972	707	700	686	686	668	750	750	822	962	868	868	868
	FR	25. 04.	HAM		OSL	HEL	GDY			GOT	BRV	YARD	HAM	STO		NRK	BRV		HAM	RAU	BRV	KTK		GDY						STP/FCT	BRV	GVX	
17	SA	26. 04.	BRV	HAM	OSS		GDY	HAM	BRV		HAM	YARD	BRV	GVX	TLL	AHU	HAM	HAM	HAM		BRV			GDN					HAM				STP/PLP
	SU	27. 04.		BRV	KRS			BRV	HAM	BRV		YARD					HAM	HAM			BRV								RTM	STP/FCT			STP/PLP
	MO	28. 04.	OSL	BRV	BRV	HAM	HAM	HAM	HAM	HAM		YARD	STO			HAM			GOT	BRV				BRV	BRV		KTK	KTK	RTM		GDY	HAM	
	TU	29. 04.	OSL	KRS	HAM	HAM	BRV		HAM	HAM	HEL	HAM	GVX	HAM	HAM	BRV (3)	RIX	KLA	AHU	HAM	KLA	HAM		HAM	HAM		KTK	HEL	BRV	STP/PLP	GDN	HAM	
	WE	30. 04.	BVK	OSS	HAM			GOT	GDY					BRV	BRV		RIX	KLA	AHU		KLA					TLL		RAU		STP/PLP	RAU	HAM	HAM
18	TH	01. 05.			OSL	HAA			GDY	GOT			HAM							TKU											RAU		HAM
	FR	02. 05.	HAM	HAM	OSL	HEL	NRK	BRV		GOT	BRV	GVX	HAM	GDY			BRV		BRV	RAU	BRV	KTK		GDY	RIX		BRV		KTK		RAU	GDY	HAM
	SA	03. 05.	BRV	BRV	OSS		AHU	HAM	HAM		BRV		BRV	GDY	TLL		BRV	HAM	HAM		BRV	KTK		GDN	KLA	BRV	HAM	RTM	HEL	HAM			BRV
	SU	04. 05.			KRS				HAM	BRV	HAM						HAM	HAM			BRV					HAM		RTM		HAM	HAA	STP/PLP	BRV
	MO	05. 05.	OSL	GOT	BRV	HAM	BRV	GOT		HAM	YARD	HAM	STO	BRV					AHU	BRV				BRV	BRV			RTM		BRV	HEL	STP/PLP	
	TU	06. 05.	OSL	KRS	HAM	HAM	HAM		GDY		YARD	BRV	AHU	BRV	BRV		RIX	KLA	GVX	HAM	KLA	HAM	BRV	HAM	HAM		KTK	BRV	BRV		HEL		HEL
	WE	07. 05.	BVK	KRS/OSS	HAM			HAM	GDY	GOT	YARD		AHU		HAM		RIX	KLA			KLA					TLL	RAU		RTM		.		STP/PLP
19	TH	08. 05.		GOT	OSL	HAA					YARD	STO	BRV	GDY				KLA		TKU			KLA						RTM	STP/FCT		BRV	STP/PLP
	FR	09. 05.	HAM	HAM	OSL/OSS	HEL	NRK	GOT	HAM	BRV	BRV	GVX	HAM	GDY			BRV	GDN (2)	HAM	RAU	BRV	KTK	GDY	GDY	RIX			HEL	HAM	STP/FCT	HAM	HAM	KTK
	SA	10. 05.	BRV	HAM	KRS		AHU		HAM	HAM	HAM		HAM	GDY	TLL		HAM		BRV		BRV		GDY	GDN	KLA	BRV	HAM	KTK			HAM	HAM	
	SU	11. 05.																HAM								HAM	RTM				HAM		
	MO	12. 05.	OSL	GOT	BRV	BRV	BRV	HAM		GOT		HAM	STO	HAM				HAM	SOT	BRV		BRV	BRV	BRV	BRV		RTM		KTK	BRV	HAM	GDY	BRV
	TU	13. 05.	OSL	KRS	HAM	HAM	HAM		GDY		HEL	BRV	GVX	HAM	BRV		RIX	HAM	AHU	HAM	KLA	HAM	BRV	HAM	HAM		BRV	ZEE	KTK	HAM	HAM		HAM
	WE	14. 05.	BVK	KRS/OSS				GOT	GDY	HAM				BRV	HAM						KLA					TLL		ZEE/RTM	RAU	HAM	HAM	STP/PLP	HAM
20	TH	15. 05.		GOT	OSL	HAA			GDN			STO	HAM					KLA	BRV	TKU			KLA					RTM			BRV	STP/PLP	
	FR	16. 05.	HAM	HAM	OSL/OSS	HEL	NRK	BRV		GOT	BRV	GVX	HAM	GDY		BRV	BRV	GDN (2)	HAM	RAU	BRV	KTK	GDY	GDY	RIX		KTK	HAM				STP/PLP	
	SA	17. 05.	BRV	HAM			AHU	HAM	BRV		HAM		BRV	GDY	TLL	HAM	HAM		(3)		BRV			GDN	KLA	BRV	HEL		HAM	STP/PLP	GDY		STP/FCT
	SU	18. 05.		BRV					HAM	BRV								HAM			BRV					HAM			RTM	STP/PLP			STP/FCT
	MO	19. 05.	OSL	GOT	BRV	HAM	BRV	GOT		HAM		HAM	STO	HAM						BRV		HAM	BRV	BRV	BRV			KTK	RTM		STP/PLP	BRV	
	TU	20. 05.	OSL	KRS	HAM	HAM	HAM		GDY		HEL	BRV	GVX	HAM	BRV	AHU	RIX	KLA		HAM	KLA	HAM	(3)	HAM	HAM		BRV	KTK	BRV	HAM	STP/PLP	HAM	

Figure 22: Schedule-1 MARFEEDER

			Norway			Sweden / Finnland / Poland / Baltic States																					Finnland - Rotterdam			Russia			
WEEK			ICE BIRD	MARFEEDER	ROGALAND	ANTJE	BARBARA	BELIEVER	BUXTEHUDE	CONCEIVER	ELISABETH	EURO DISCOERY	GOTLAND	LAPPLAND	MARIS	NORRLAND	NYLAND	PANTONIO	PERCEIVER	RAGNA	SPICA	TUCANA J	VÄRMLAND	Euro Storm	Cepheus J7 / WMS Groningen	Maike D	BELUGA SENSATION	BELUGA STIMULATION	GÖTALAND	ANDROMEDA J	ANNALAND	BIRKALAND	LIVLAND
		TEU	686	547	707	658	352	535	868	535	658	907	822	658	508	508	330	686	535	508	749	972	707	686	686	668	750	750	822	962	868	868	868
	FR	09. 05.	HAM		OSL/OSS	HEL	NRK	GOT	BRV	HAM	HAM		GVX	HAM	GDY			HAM	GDY	HAM	RAU	BRV	KTK	GDY					HAM	HAM	HAM	BRV	KTK
19	SA	10. 05.	HAM	HAM	KRS		AHU		HAM	HAM	HAM			HAM	GDY	TLL		BRV		HAM		BRV		GDN					HAM				
	SU	11. 05.	OSL	HAM				HAM																								KLA	
	MO	12. 05.	OSL	BRV	BRV	BRV	BRV	HAM	GDY	GOT	HEL		HAM	STO	BRV			RIX		SDT	BRV		HAM	BRV	BRV		RTM	ZEE	KTK		GDY	KLA	BRV
	TU	13. 05.	OSL	BRV	HAM	HAM	BRV/HAM	HAM	GDY	HAM	HEL		BRV	AHU	BRV	HAM		RIX	HAM	GVX	BRV/HAM	KLA	HAM	HAM	HAM		HAM	RTM	KTK	HAM	RAU		HAM
	WE	14. 05.	BVK	KRS/OSS	HAM			GOT	GDN	HAM						BRV			HAM	GVX		KLA		HAM		TLL	BRV	RTM	RAU	YARD	RAU	STP/PLP	HAM
20	TH	15. 05.	HAM		OSL	HAA		GOT			BRV		STO	BRV	HAM			BRV	KLA		TKU	BRV		HAM				RTM		YARD	HAA	STP/PLP	HAM
	FR	16. 05.	HAM	HAM	OSL/OSS	HEL	NRK	HAM	BRV	GOT	HAM		GVX	HAM	GDY		BRV			HAM	RAU	BRV	KTK/HAA		RIX			HAM		HAM		KTK	
	SA	17. 05.	HAM	HAM			AHU	HAM	HAM		HAM			HAM		TLL	HAM	HAM		HAM		BRV		GDY	KLA	BRV	KTK		HAM	BRV	GVX		
	SU	18. 05.	BRV	BRV				BRV	HAM				HAM											GDN		HAM	HEL	TLL	RTM				STP/FCT
	MO	19. 05.	OSL	BRV	HAM	HAM	BRV	GOT		HAM			HAM	STO	HAM		SDT		HAM		BRV		BRV		BRV			TLL	RTM			HAM	STP/PLP
	TU	20. 05.	OSL	KRS	HAM	HAM	HAM	GOT	GDY		HEL	BRV	BRV	GVX	HAM		AHU	RIX	HAM	KTK	HAM	KLA	HAM	BRV	HAM			KTK	BRV	GDY	BRV	BRV	
	WE	21. 05.	BVK	KRS/OSS		BRV			GDN	GOT		HAM.			BRV	HAM						KLA	.	HAM		TLL	RTM	RAU					.
21	TH	22. 05.		GOT	OSL			HAM					STO	HAM		YARD			KLA		TKU		HAA				RTM			STP/PLP			HAM
	FR	23. 05.	HAM	HAM	OSL/OSS		NRK	GOT	BRV	BRV	BRV	GDY	GVX	HAM	GDY	YARD	BRV	BRV		OSL	RAU	BRV	HEL	GDY	RIX		HAM		KTK	STP/PLP	KLA	STP/FCT	HAM
	SA	24. 05.	BRV	HAM	KRS	KTK	AHU	GOT	HAM	HAM	HAM	GDY		BRV	GDY	YARD	HAM	HAM		OSL		BRV			KLA	BRV		HAM	HEL		GDY	STP/FCT	BRV
	SU	25. 05.		BRV				BRV	HAM							YARD			HAM	HAM		BRV				HAM		RTM					
	MO	26. 05.	OSL	GOT	BRV		BRV	HAM		GOT		BRE	HAM	STO	HAM	YARD	SDT			(3)	BRV		HAM	BRV	BRV		KTK	RTM		BRV	RAU		
	TU	27. 05.	OSL	KRS	HAM	HAM	HAM		GDY		HEL	BRE	BRV	GVX	HAM	BRV	AHU	RIX	KLA		HAM	KLA	HAM	HAM	HAM		KTK	BRV	BRV	HAM	(2)	HAM	GDY (2)
	WE	28. 05.	BVK	KRS/OSS				GOT	GDN	HAM		(3)			BRV	HAM			KLA			KLA				TLL	RAU		RTM			HAM	STP/PLP
22	TH	29. 05.		GOT	OSL	HAA							STO	HAM					KLA		TKU		HAA						RTM			BRV	STP/PLP
	FR	30. 05.	HAM	HAM	OSL/OSS	HEL	NRK	BRV	BRV	GOT	BRV		GVX	HAM	GDY		BRV	BRV	GDN (2)		RAU	BRV	KTK	GDY	RIX			KTK	HAM	STP/FCT			
	SA	31. 05.	BRV	HAM	KRS		AHU	HAM	HAM		HAM			BRV	GDY	TLL	HAM	HAM				BRV		GDN	KLA	BRV	HAM	HEL		STP/FCT			
	SU	01. 06.		BRV					HAM	BRV									HAM			BRV				HAM	RTM						
	MO	02. 06.	OSL	GOT	BRV		BRV	GOT		HAM			HAM	STO	HAM		SDT				BRV		HAM	BRV	BRV		RTM		KTK			STP/PLP	BRV
	TU	03. 06.	OSL	KRS	HAM	HAM	HAM		GDY		HEL		BRV	GVX	HAM	BRV	AHU	RIX	KLA		HAM	KLA	HAM	HAM	HAM		BRV	BRV	KTK	BRV		STP/PLP	HAM

Figure 23: Schedule-2 MARFEEDER

6 Analysis

Overall, many aspects, which suddenly culminated, facilitated and led to the accident. Both vessels entered fog banks unexpectedly. The amount of time the Officers on Watch had to respond was limited. Although both vessels were manned by pilots and advised by VTS Bremerhaven, the vessels were unable to pass as planned at a sufficient distance. The MARFEEDER missed a course alteration in due time at the 'Robbennordsteert Light' and collided in the middle of the fairway with the upcoming right-of-way vessel APL TURQUOISE. This occurred at an inopportune moment during the change of watch on the MARFEEDER. Furthermore, in contrast with the safety management system (SMS), due to being insufficiently manned, organisation on the bridge was lacking and adversely affected by partially inoperable navigational equipment, such as a radar equipment and the defective electronic chart system (ECS). Hence, at about 0600 in the morning, the officers were distracted and could not concentrate on the situation fully. Fog signals may have increased the attention on the bridge of the MARFEEDER. The advising pilot on the MARFEEDER was unable to implement his required radar settings. With minimum key display (MKD), the AIS could not be evaluated for collision prevention in real time and was situated out of the pilot's sight on the starboard side of the conning position (see Fig. 24).

Figure 24: Bridge of the MARFEEDER

The APL TURQUOISE sailed consistently on the radar reference line; while following the direction of traffic the MARFEEDER remained well to the starboard side of the fairway before the intended course alteration at buoy 33. According to the voice recordings, the two pilots on board did not coordinate with one another directly; the two vessels were to pass on the starboard side of the fairway without communication and with radar assistance.

At the scene of the accident, the dredged channel is approx. 220 m wide and the fairway approx. 400-500 m wide. To the NE of buoy 33, a depth outside of the dredged channel of 11.3 m is plotted on the nautical chart and of 12.3 m to the SE. To that extent, on account of the tidal conditions and the squat effect, the APL TURQUOISE was dependent on the dredged channel, which has a nominal depth of 14.5 m above the chart datum there. The APL TURQUOISE therefore had room to remain well to the right of the dredged channel by some 3 ship widths. The MARFEEDER had about 12 ship widths room to the edge of the fairway. Both vessels could have passed one another with sufficient room. Consistent action should have been taken at the latest at a distance of about 1,000 m from each other in order to possibly prevent the collision. That would have been about 1 minute before the collision and at the point at which the MARFEEDER would have had to carry out her planned course alteration (see Fig. 25). In the given situation, the ship's command of the APL TURQUOISE must have relied on the fact that the MARFEEDER would also remain at the edge of fairway during the course alteration and in the river bend and that this alone would have sufficed for passing one another safely, especially since her own proposed course alteration to port was to take place at the river bend 2 minutes after passing the MARFEEDER and she had right of way in terms of remaining in the middle of the fairway.

As the MARFEEDER requested radar pilot assistance at 0600 and she was informed that buoy 33 was reportedly astern and that the distance to the APL TURQUOISE was 500 m, she made an energetic course alteration to starboard; on the APL TURQUOISE it was realised that MARFEEDER was still heading for her. For the APL TURQUOISE, it was too late to take effective action to create more room between the vessels. The pilot of the MARFEEDER initially carried out the course alteration with the autopilot. That delayed the turn. It would have been possible to switch immediately to follow-up steering or even better to non-follow-up and steer a turning circle with a diameter of about 2 cbl with 'full astern'. That would probably have prevented the collision. This manoeuvre should have been initiated by the Officer on Watch. We are unable to understand the concerns of the pilot that the vessel would lose her steerability with this manoeuvre. Furthermore, in light of the knowledge that the navigational equipment was not fully functional, on recognising the deteriorating visibility it remains unclear why the speed was not promptly significantly reduced to gain more time to evaluate the situation.

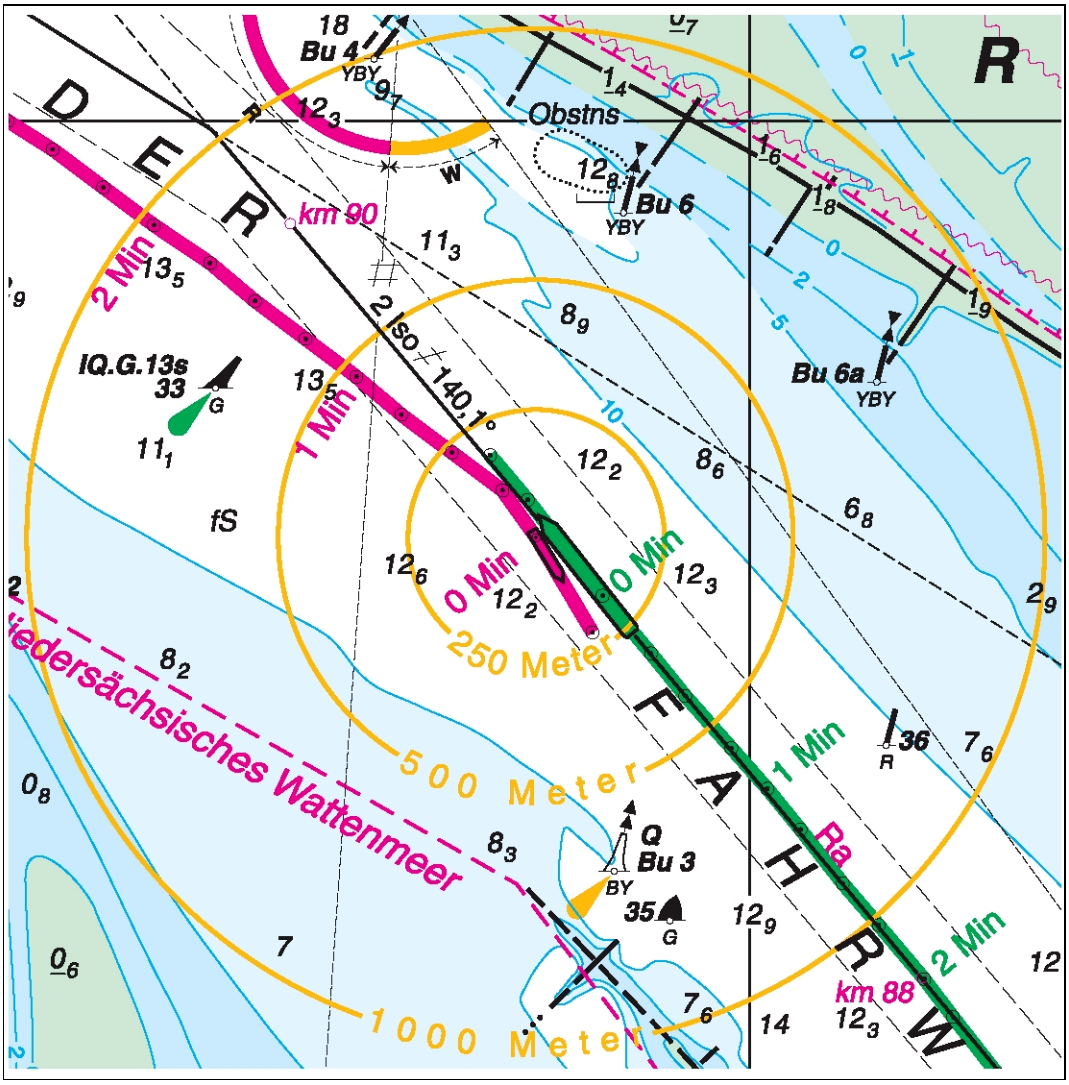


Figure 25: Scene of the accident with spacing rings

The Officer on Watch is experienced, knows the vessel type and had been deployed by the shipping company on three occasions. He operated in global service as Officer on Watch from 12 December 2004 to 12 October 2005 and on the MARFEEDER in North European service from 1 February 2006 to 21 January 2007 and 19 November 2007 until the day of the accident and beyond. The cruise times are relatively long. That may lead to fatigue. The time sheets do not provide sufficient evidence as to the actual working hours. Due to the schedule and daily port rotation in feeder service, as suspected by the Occupational Safety and Health Administration in Hamburg, the work and rest periods must have been much more irregular. With a crew of 13, the MARFEEDER satisfies the formal requirements for manning set out in the Minimum Safe Manning Document. However, it is questionable whether this minimum manning was adequate for this trading area.

According to the Officer on Watch's time sheet, he took over the watch at 0000 while sailing from the Elbe into the Weser. At 0300 and 0440, a pilot change took place on the Outer Elbe and the Outer Weser. According to the audio recordings, the Officer on Watch was alone on the bridge at those times and on the crossing to the Weser.

In each case, a watch keeper met the pilots and prepared for their transfer by deploying or fitting the pilot boarding arrangement. It remains unclear from the audio recordings whether a watch keeper was on the bridge at all during this period. There was probably no lookout or helmsman on the bridge until the next change of watch.

Such practice conforms to neither the procedural instructions of the SMS, nor the STCW[2] and SOLAS[3] requirements. The procedural instructions of the SMS include extensive check lists, inter alia, on handover of the watch, Master's directives, bridge equipment, navigation in restricted visibility, navigating in coastal waters, voyage planning, pilot transfers and entering a port. Each list contains 10-20 requirements for implementation.

During the hand over of watch, information on the traffic conditions, navigational hazards, course and speed as well as compass errors should be provided. The Master should be informed in the event of irregularities such as reduced visibility, malfunctions, and unclear traffic conditions. Beyond that, standing orders also exist. The bridge equipment should be fully checked before departure and weather reports, sailing directions, electronic chart system and paper nautical charts prepared for the voyage. In restricted visibility, a helmsman and lookout should be appointed and the signal system checked. The vessel should be in a position to reduce speed, stop and evade at all times. In coastal waters the position should be reviewed periodically, the current and tide accounted for, and checks made as to whether the radar head line is set. Reference is also made to the helmsman and lookout. The voyage plan should be recorded and waypoints and pilot transfers entered.

The pilot card is to be kept up-to-date. Deployment of the pilot boarding arrangement for the transfer of pilots and the embarking and disembarking of a pilot must be supervised by a responsible officer. That officer must have a communication link to the bridge and must also ensure that the pilot is accompanied to the bridge and back via a safe route. People tasked to deploy and operate mechanical equipment must be instructed in the safe procedures to be determined and the equipment must be tested before use. Once the pilot is on the bridge, he should be informed about the heading, speed, draught, engine settings and life saving appliances.. The voyage plan must be coordinated with the Master with respect to radio communications, watch keeping on the bridge and the traffic conditions. Pilot instructions must be monitored by the Officer on Watch and Master. Signals, such as flags and lights, must be displayed. When sailing into port, it must be ensured that the anchors, winches, mooring lines, engine and rudder are operational and that the helmsman is ready on time.

Fulfilment of these tasks according to SMS, STCW and SOLAS presupposes sufficient manning. In this case, the Master, Officer on Watch and two watch keepers would be necessary on the deck/bridge. The voices of one Officer on Watch, one pilot and one watch keeper can be heard on the VDR recordings between 0300 and the change of watch at 0545.

[2] STCW Code A and B, Chapter VIII, standards relating to watch keeping duty
[3] SOLAS Chapter V, Regulation 23, facilities for the transfer of pilots

According to the time sheets, watch keeping on the bridge was divided between the Master and two Officers on Watch in the following manner: one Officer on Watch 0-6 and 12-18, the second Officer on Watch 6-12 and 16-20 and the Master 20-24. One watch keeper was assigned to each officer. Two able bodied seamen were assigned to the watches 0-6, 12-18 and 6-12, 18-24. The other three seamen were assigned to daily service between 06-12 and 13-18 as well as occasionally at night-time for mooring/singling up when entering or leaving a port. One engineer, one electrician, a general-service seaman and one mechanic were employed in the engine room. In addition, one cook was on board. Essentially, it is a two-watch system, which is commented on especially by MAIB (Marine Accident Investigation Branch), the British investigative agency, in their reports and which leads to considerable strain on watch keepers. A three-watch system significantly reduces the risk of fatigue and burn out as well as the risk of accidents.[4]

Taking into account the maximum number of working hours provided for by corresponding legislation and that pertaining to occupational safety to be complied with by the crew, the shipping company must find a balance between the prescribed minimum manning as per the Minimum Safe Manning Document and the number of deployed crew members. According to the Minimum Safe Manning Document, which prescribes the minimum level of manning pursuant to the relevant international rules, the total number is set at 10 seamen. 13 seamen were recorded on the crew list. To that extent, manning on the MARFEEDER complied with the rules formally. In the case of this accident, the under-manning on the bridge during the pilot transfer and on the estuary as well as the improper management of the time sheets are conspicuous. That is something that the shipping company has a duty to remedy.[5]
The BSU is not in possession of time sheets for the APL TURQUOISE. With a crew of 30, including a deep-sea pilot, Master, 4 nautical watch officers, chief and 3 engineers, and the crew member on duty at the time of accident, there is no evidence of under-manning or doubt as to the observance of legislation pertaining to working hours and occupational safety. Due to the actual manning on the MARFEEDER, it was not possible to organize the bridge management satisfactorily. In the audio recordings and communication between the Officer on Watch and pilot, voyage planning and vessel characteristics were hardly discussed. At 0507, the pilot reportedly checked the compass with an alignment bearing on the lighthouses Roter Sand and Alte Weser of 065° instead of 069°. The equipment on which this difference of 4° was established could not be verified.

[4] MAIB Report on the investigation of the grounding and loss of the JAMBO No. 27/2003, Fatigue Offshore Study, Seafarers International Research Centre Cardiff University.

[5] Due to her size, a three-watch system should have been operated on the MARFEEDER according to art. 85 SeemG, which states that the working hours of crew members tasked with actual watch keeping duties must not exceed 8 hours per day. According to art. 138 SeemG, a two-watch system is only permissible for vessels up to 2,500 GT. The manning proposal of the shipping company when the Minimum Safe Manning Document was issued was based on and consistent with a three-watch system according to the Seeberufsgenossenschaft (See-BG). With effect from 1 January 2010, the See-BG and the BGF (German road vehicle maintenance employers' liability insurance association) have merged to form the Ship Safety Division (BG Verkehr).

It was only when the pilot gradually became familiar with the bridge equipment that the Officer on Watch mentioned problems with one radar equipment and the electronic chart system (ECS). The 3 or 1.5 nm ranges requested by the pilot at 0519 were at least configured on the radar equipment recorded by the VDR immediately prior to the collision. This radar equipment initially remained at 6 nm and did not show all the radar targets due to the deficient tuning. There were no recordings for the port radar equipment. The ECS could not be activated because the uninterruptible power supply (UPS) was defective. At 0545, the relieving Officer on Watch entered the bridge and further attempts were made to improve the radar equipment settings and start the ECS. In the process, the servicing of navigational equipment and systems as well as the burden of extensive documentation of the ship safety management system was also discussed. At 0555, visibility deteriorated unexpectedly and fog formed. The crew was awakened. VTS Bremerhaven was not aware of the problems with the navigational equipment. It was therefore unable to order radar assistance at an early stage. The radar assistance, which was already available to all vessels in any case because of the deteriorating visibility, was requested too late by the pilot.

The APL TURQUOISE was clearly visible on the starboard radar equipment and in the situation report of the VTS at 0556 it was heard that she had passed buoy 38 on the radar reference line. At 0557, the pilot reported to the VTS that the MARFEEDER would keep to the right. At 0558, the pilot reportedly had doubts as to whether buoy F1 was abeam and the large upcoming vessel was identified at a distance of 1.5 nm. In that respect, when changing to the 1.5 nm range, the image within the inner 3 rings (7.5 cbl.) on the port radar equipment was reportedly completely blurred. An Officer on Watch asked about the upcoming vessel and an attempt was made to identify buoy 33 for the upcoming course alteration. At 0559, the starboard radar equipment was switched to 1.5 nm and a buoy was detected by the Officer on Watch. The pilot tried to find buoys F1 and 33 on the radar screen. One buoy was reportedly not visible. That was confusing and at 0600 radar assistance was requested from the VTS. It was not possible to reliably determine what radar equipments were used to assess the situation during the previous three minutes and by whom the equipment was operated. Presumably, the pilot was situated behind the seats and the two Officers on Watch in front of the radar equipment. The pilot reportedly oriented himself only on the port radar. At that point, the APL TURQUOISE was 0.75 nm away. The radar pilot reported that buoy 33 was astern and the distance to the APL TURQUOISE was reportedly only 500 m (bow to bow). Following that, the course was altered to starboard with the autopilot and, according to the VDR, a calculated rate of turn of about 20°/min. The collision took place at 060113. The helm was then switched to manual and the subsequent broaching-to brought under control by engine manoeuvres. The pilot reported the collision to the VTS and requested that radar assistance be continued because of radar problems. In the meantime, the Master had entered the bridge, was informed of the situation and took command.

During the course of the accident, the records and statements indicate that little attention was given to the AIS. The minimum key display was positioned to the right of the starboard radar equipment and could not be seen by the pilot.

There are also no reports from the Officers on Watch concerning AIS data. In contrast, an AIS overlay with the electronic chart system was installed on the APL TURQUOISE. That enabled the advantages of AIS to be exploited. However, with the exception of monitoring the turn of the MARFEEDER on the screen, the APL TURQUOISE was unable to take any effective measures in terms of preventing the collision. Presentation of AIS targets on the minimum key display is unsuitable for making an assessment in real time. That has already been noted in the BSU reports on the collisions involving the LYKES VOYAGER/WASHINGTON SENATOR, Ref.: 126/05, SVEN/KOMET, Ref.: 476/05, and HANJIN GOTHENBURG/CHANG TONG, Ref.: 450/07. Prompt recognition of the situation in real time can only be achieved effectively if the AIS targets are overlaid adequately, i.e. with the radar or electronic chart system. Otherwise, the benefits of AIS are not exploited. In traditional radar navigation, changes in the movement of another target can only be realised with a time delay of at least 3 minutes. That is how long it takes to reliably plot a target. Therefore, as with the APL TURQUOISE, fixed radar rings are used. The images and settings of the other radar equipments of the two vessels could not be verified because there are no corresponding records. In the VDR recordings it was noted that the radar image of the MARFEEDER had not been completely recorded. Therefore, it could not be verified whether automatic or manual tuning was selected. In that respect, an installation error relating to the video signal is present. Installation problems through to total recording failures have already been seen with the licence holder in BSU investigations Ref.: 450/07 and Ref.: 510/08. The licence holder has since clarified the setting instructions in the manual 'Initial Survey/Annual Survey'. The settings will be checked during future annual inspections of the S-VDR 4330.

VTS Bremerhaven manned the vessel traffic service with radar pilots in a timely manner. The APL TURQUOISE had been advised by a radar pilot since departing from Bremerhaven and treated as a right-of-way vessel. With a vessel of that size, it is reportedly customary to keep to the middle of the fairway so that a safe draught can be maintained in the dredged channel. Here, leading lights can be used as a reference for steering. In sufficient visibility, it is of considerable benefit for helmsmen to use landmarks as a steering aid in addition to the steering compass. In poor visibility, there is no comparable electronic means for aiding steering except for the steering compass. That can lead to the vessel quickly leaving the intended track due to inaccurate steering or course alterations at the wrong time. Every encounter conceals a potential risk of collision[6]. That risk is further increased at river bends because tracks must be observed during the encounter so that the vessels pass one another at a sufficient distance. In the same area at Wremer Loch, the last serious collision occurred between the dry bulk cargo vessel YU LIN and the feeder vessel ROBERT on 22 December 1990, in which both vessels locked together and the ROBERT sank off Robbennordsteert during the salvage attempt.

[6] See John Kemp: When do Collision Regulations begin to apply?, The Journal of Navigation 2009, 62, S. 167: When two ships are on converging courses towards a collision point or a close quarters situation, there is a risk of collision which increases continuously until courses begin to diverge. In rivers and harbours, where vessels frequently have to alter course, risk of collision may only be considered to exist at relatively short distances.

On the Weser, only encounter prohibitions are currently issued for right-of-way vessels on defined stretches. Entcounters between other vessels are generally permitted and not coordinated in advance. That would only be possible with traffic flow control.

The weather forecast at 0300 UTC predicted an E wind of 4 Bft, later circulating, sea 0.5 to 1 m with local fog patches in the western part of the German Bight. Specification of fog patches with a vague geographical reference is very limited in terms of its usefulness for voyage planning. The measurements in Bremerhaven on 1 June 2008 were 10 km at 0400, 5 km at 0500, 1.1 km at 0600, 0.9 km at 0700, 0.8 km at 0800, 2.2 km at 0900, and 3.2 km at 1000. No fog was reported in the German Bight or in the Elbe estuary. Germany's National Meteorological Service states that for the foreseeable future there is no way to improve the forecasts for fog formation.

7 Safety recommendations

The following safety recommendations do not attribute a presumption of blame or liability in respect of type, number or sequence.

7.1 Operators

7.1.1 Crew

The BSU recommends that, having regard to the traffic area and degree of automation on their vessels, owners and operators of feeder vessels find a balance between required minimum manning levels and actually required manning, so that legislation pertaining to working hours and occupational safety can be observed. In the case of pilot changes alone, two deck officers and at least two able bodied seamen are required. Long cruise times and watch systems with six hour intervals increase the risk of fatigue and exhaustion.

7.1.2 AIS

The BSU recommends that owners and operators of sea-going vessels configure navigational equipment in a manner that facilitates a comprehensive evaluation of AIS targets in real time. It should be noted that in terms of collision prevention it is only effective if overlaying with the electronic chart or radar equipment is made possible. Minimum key displays alone are unsuitable.

7.2 Ship's commands

The BSU recommends that the Master of a vessel in feeder service ensures that time sheets are carefully managed and correspond with the actual working hours. Where there is doubt as to whether the rest and work periods prescribed by the Arbeitszeitgesetz (act regulating working hours) can be adhered to, the operator must be informed in order to ensure the situation is remedied through increased manning. It must be possible at all times to man the bridge in a manner that when exposed to heightened risk, such as in fog or heavy traffic, as well as in harbour mode, sufficient manning is available. Only then is it possible to comply with occupational safety legislation and for bridge management to be operated according to the procedures of the ISM Code. In unclear traffic situations speed must be reduced significantly so that more time is available to assess the situation.

7.3 Ship Safety Division[7]

The BSU recommends that when setting the minimum manning levels for the Minimum Safe Manning Document, the Ship Safety Division accounts for manning levels which correspond to the practical demands of the traffic area and the port rotation. In particular, according to IMO Resolution A. 890 (21), a three-watch system should be adopted and supervised and it should not be necessary for the Master to keep regular watches. Art. 138 SeemG states that for vessels sailing under German flag a two-watch system is currently only permissible up to 2,500 GT.

7.4 Waterways and Shipping Directorate North West

The BSU recommends that, having regard to all possible factors and integral implementation of a consequence analysis, the Water and Shipping Directorate North West reviews whether the potential to improve multi-vessel traffic in the area of course alterations exists. That may lead to an improvement of the existing traffic strategy.

7.5 Manufacturers, licence holders and VDR distributors

The BSU recommends that SAM Electronics GmbH, L3 Group, implements better quality control during the installation of VDRs. Within one year, the BSU has noted three improperly installed systems. The procedural instructions for quality control have since been clarified.

7.6 Nautical colleges and operators of ship handling simulators

The BSU recommends that training establishments give more attention to the failure of sensors or the setting of navigational equipment, in particular, radar equipment and electronic chart systems, in their courses and provide training on how faults or unfavourable navigational equipment settings should be adequately addressed within the scope of bridge management.

The BSU recommends that training establishments provide training on turning circles and stop manoeuvres at river bends for relevant vessel sizes, i.e. vessels in feeder service in ship handling simulators, and incorporate the collision involving the MARFEEDER and APL TURQUOISE into their programme. To what extent pilots perform such manoeuvres remains the responsibility of the competent Officer on Watch and is part of the organisation on the bridge.

[7] With effect from 1 January 2010, the See-BG and the BGF (German road vehicle maintenance employers' liability insurance association) have merged to form the Ship Safety Division (BG Verkehr).

8 Sources

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- Witness accounts by the pilots and crew

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- Documents
  - See-Berufsgenossenschaft (See-BG)
    - Minimum Safe Manning Document
    - Statement
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  - Hasenpusch, WSP Bremerhaven and Wilhelmshaven, BSU