Bundesstelle für Seeunfalluntersuchung
Federal Bureau of Maritime Casualty Investigation
Federal Higher Authority subordinated to the Ministry of Transport
and Digital Infrastructure

Investigation Report 16/15

Serious Marine Casualty

Collision between the MV RED7 ALLIANCE and a lock gate at Brunsbüttel on 17 January 2015

15 January 2016

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, amended most recently by Article 16 of 19 October 2013, BGBl. (Federal Law Gazette) I p. 3836.

According to said Law, the sole objective of this investigation is to prevent future accidents and malfunctions. This investigation does not serve to ascertain fault, liability or claims (Article 9(2) SUG).

This report should not be used in court proceedings or proceedings of the Maritime Board. Reference is made to Article 34(4) SUG.

The German text shall prevail in the interpretation of this investigation report.

Issued by:
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1 Summary

On the morning of 17 January 2015, the special purpose ship RED7 ALLIANCE, sailing under the flag of the Bahamas, arrived at the locks in Brunsbüttel to transit the Kiel Canal during her voyage from Great Yarmouth (GB) to Mukran (D). Apart from the pilot, the master and the second officer were on the bridge for the approach manoeuvre when Neue Südschleuse (new south lock) became available at shortly after 0900[1]. Just after the fore spring and stern line had been placed over the quayside bollards, it was a case of finally bringing the RED7 ALLIANCE to a halt. Instead, she continuously accelerated and despite all measures to prevent a collision, rammed the closed lock gate with such velocity at 0942 that exiting again under her own steam was impossible.

Assisted by the tug BUGSIER 21, she was finally hauled out of the lock sternwards and, supported by a second tug, the WAL, towed through Neue Nordschleuse (new north lock) into the inland waterway port at Brunsbüttel.

There was extensive damage to both her bow and the lock gate. Nevertheless, there was no environmental pollution and nobody came to physical harm.

[1] Unless stated otherwise, all times shown in this report are local = UTC +1.

2 FACTUAL INFORMATION

2.1 Photo

© Hasenpusch Production

Figure 1: Photo of the ship

2.2 Ship particulars

Name of ship:	RED7 ALLIANCE
Type of ship:	Supply ship
Nationality/Flag:	Bahamas
Port of registry:	Nassau
IMO number:	8304799
Call sign:	C6LC9
Owner:	DSV ALLIANCE AS
Year built:	1984
Shipyard/Yard number:	EB Industri OG Offshore AS/135
Classification society:	DNV
Length overall:	78.30 m
Breadth overall:	18.01 m
Gross tonnage:	3,700
Deadweight:	1,959 t
Draught (max.):	5.58 m
Engine rating:	9,480 kW
Main engine:	Bergen KVGB-12
(Service) Speed:	12.0 kts
Hull material:	Steel
Hull design:	Double hull
Minimum safe manning:	11

2.3 Voyage particulars

Port of departure:	Great Yarmouth, Great Britain
Port of call:	Mukran, Germany
Type of voyage:	Merchant shipping/ international
Cargo information:	No cargo
Manning:	48
Draught at time of accident:	F: 5.40 m, M: 5.20 m, A: 5.30 m
Pilot on board:	Yes
Canal helmsman:	No
Number of passengers:	0

2.4 Marine casualty or incident information

Type of marine casualty:	SMC, collision
Date, time:	17 January 2015, 0942
Location:	Brunsbüttel, Neue Südschleuse lock
Latitude/Longitude:	φ 53°53.39'8"N λ 009°8'49"E
Ship operation and voyage segment:	Harbour mode/berthing
Place on board:	Fore section
Consequences (for people, ship, cargo, environment, other):	Considerable damage in the area of the stem post and the lock gate. No physical injuries or damage to the environment

Excerpt from Nautical Chart INT 1366, BSH

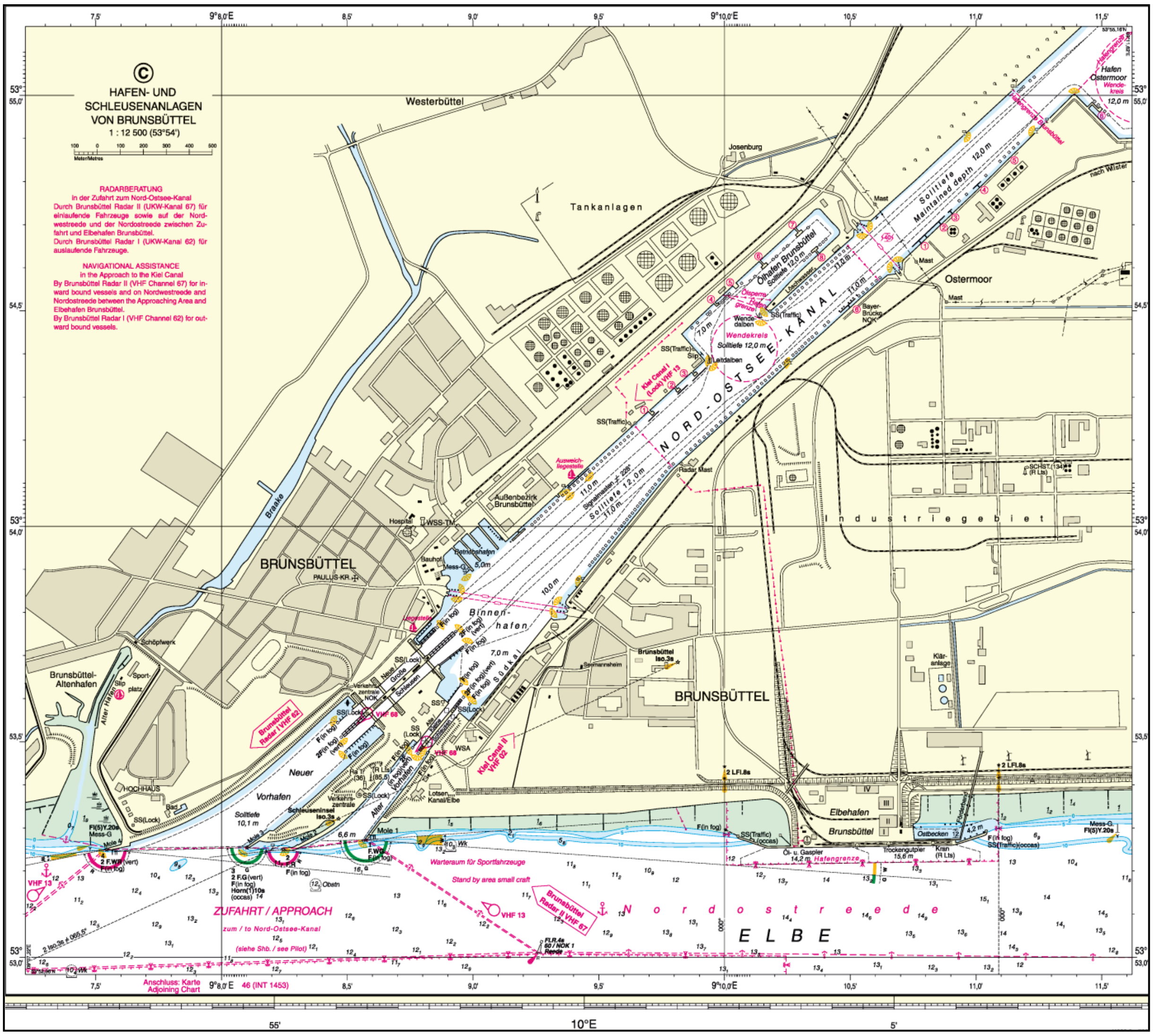

Figure 2: Nautical chart – overall view

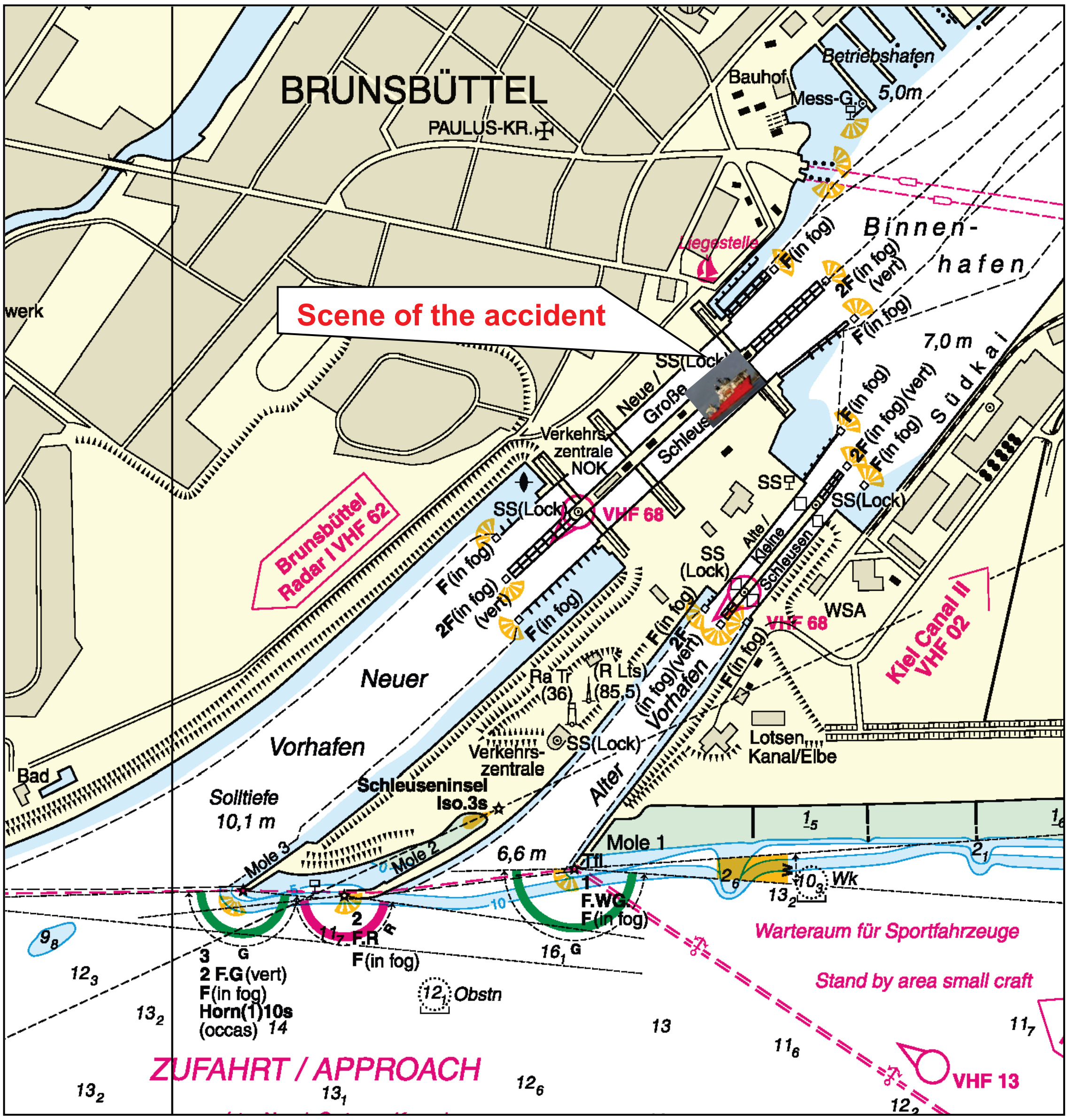

Figure 3: Scene of the accident

2.5 Shore authority involvement and emergency response

Agencies involved:	Directorate-General for Waterways and Shipping, Outstation North (GDWS Outstation North), Waterway Police Brunsbüttel
Resources used:	The tugs BUGSIER 21 and WAL
Actions taken:	Hauled free and made fast at the Brunsbüttel inland waterway port
Results achieved:	Prevention of further damage and facilitation of repairs to the lock gate and ship

3 COURSE OF THE ACCIDENT AND INVESTIGATION

3.1 Course of the accident

The special purpose ship RED7 ALLIANCE, sailing under the flag of the Bahamas, was proceeding to Mukran when she arrived at the Nord-West-Reede roadstead off the Kiel Canal locks at Brunsbüttel on the morning of 17 January 2015. The Kiel Canal pilot was on board at 0804. The master and the second officer were still on the bridge.

The lockmaster stated on VHF channel 13 that the Alte Schleuse lock's north chamber was ready for the RED7 ALLIANCE to enter. The pilot did not accept this, as he believed visibility from the bridge was insufficient, however. The helicopter deck forward of the superstructure causes a large blind spot. This gave rise to a one-hour wait until the next large lock was available. The pilot and master discussed the lock manoeuvre in detail and all the propulsion and steering systems were tested during this period and was determined that they worked properly.

It was reported that the Neue Südschleuse lock was ready shortly after 0900. The RED7 ALLIANCE was to enter before the other ships and then make fast at the eastern end of the outer wall. She turned on the main line (pier lights 1 and 2 in a line) at 6 kts speed over ground (SOG). Upon reaching mole 4, the ship was turned through the current shear zone into the Neue Vorhafen (new outer port) at unchanged speed. Her speed was then reduced to 4 kts and the lock course just south of the centre axis steered. Her speed was reduced to 2 kts when she approached the pier and then to 1 kt within the pier. She passed the Neue Südschleuse lock's outer gate at 0936. Co-operation between pilot and ship's command was reportedly very good. While the master set the speed in accordance with the advice of the pilot, the pilot operated the ship's steering directly using a tiller[2]. The heaving lines for fore spring and stern line were handed ashore after she passed the middle gate. The pilot recommended that the ship be traversed starboard up to the fender using her thrusters and brought to a halt. He then handed over the tiller to the second officer and went to the starboard wing, from where it was clear to him that the RED7 ALLIANCE was slowing down steadily. The distance to the forward gate was still about 50 m. The fore spring and stern line were placed over their bollards. The ship suddenly picked up speed unexpectedly. The pilot reportedly called into the bridge: "Captain, full astern and hold fast the lines." The master reportedly relayed the command to the stations forward and aft. Although the two control levers appeared to be set to full astern, the ship continued to accelerate.

At 0942, the RED7 ALLIANCE rammed and became wedged with the lock gate.
All the propulsion units were switched off immediately and a damage assessment initiated. There was significant damage to the bow and lock gate but neither physical injury nor environmental pollution.

The ship was wedged so tightly that ensuing manoeuvres carried out to release her unassisted in a sternward direction were unsuccessful. The Federal Waterways and

[2] Tiller: Small lever for steering the ship directly

Shipping Administration, waterway police, ship's command, and pilot liaised and a decision to haul the RED7 ALLIANCE sternward with the help of the tug BUGSIER 21 made, which was ultimately successful. Vessel Traffic Service NOK Brunsbüttel then decided to shift the ship to the inland waterway port. Since it was apparent that the ship's own propulsion units could not be relied on, a second tug, the WAL, was made fast forward to tow the RED7 ALLIANCE through the Neue Südschleuse lock. The ship was finally made fast on the south quay at 1400.

3.2 Investigation

Prof. Dipl.-Ing. Hark Ocke Diederichs, an expert, produced an opinion aimed at determining the cause of the accident. The BSU considered the opinion in this report.

3.2.1 Azimuth thrusters

The RED7 ALLIANCE is a special purpose ship that supplies divers when they operate in very deep water. She is approved for use anywhere in the world but operates mainly in the Mediterranean area, as well as in the North Sea and Baltic Sea.

Her role as a base ship for divers means she must have excellent manoeuvrability. To achieve this, she is equipped with two rudder propellers for forward thrust and four thrusters for traversing.

The rudder propellers are manufactured by Rolls-Royce and equipped with CPPs[4] and Kort nozzles. The rated power of each is 1,840 kW.

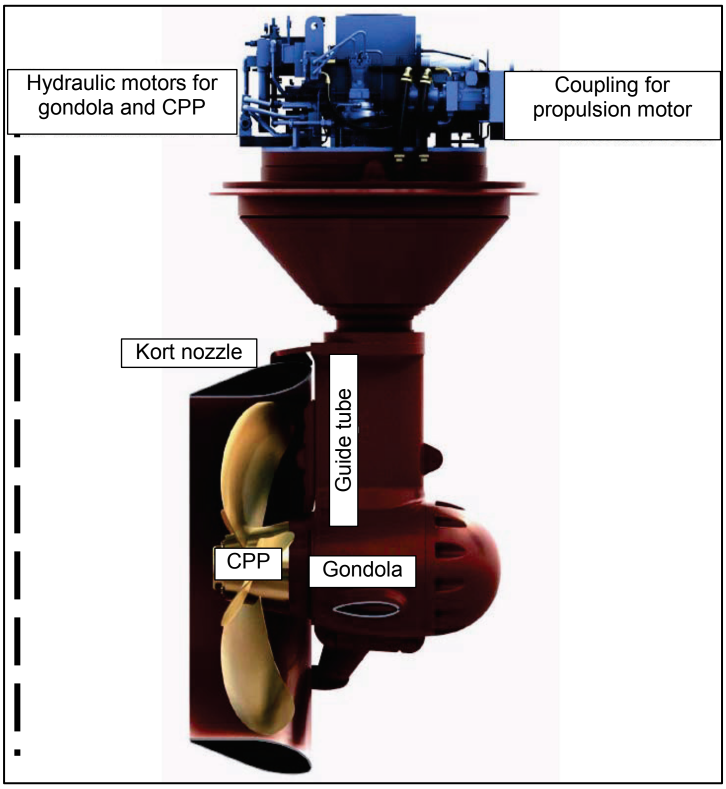

Figure 4: Azimuth thruster

[4] CPP: Controllable pitch propeller

A rudder propeller combines a ship's propulsion and steering in a single unit. The propeller's thrust can be aligned as necessary by rotating the gondola around the guide tube. This means that a rudder blade is not needed to steer the ship.

The Kort nozzle is a profiled ring similar to a hydrofoil. It surrounds the propeller and tapers away from the vessel. The Kort nozzle reduces flow losses at the propeller and produces a higher mass flow rate, resulting in increased efficiency when the ship is moving ahead.

When the ship is moving astern, the inflow of water to the propeller is disturbed by the smaller inlet cross-sectional area and the outflow of water by the larger outlet cross-sectional area and guide tube. Accordingly, the mass flow rate, efficiency, and thrusts differ when moving ahead or moving astern.

The actuators of the two Gondola (Figs. 5 and 6) and associated hydraulic equipment (pumps and valves) were surveyed externally.

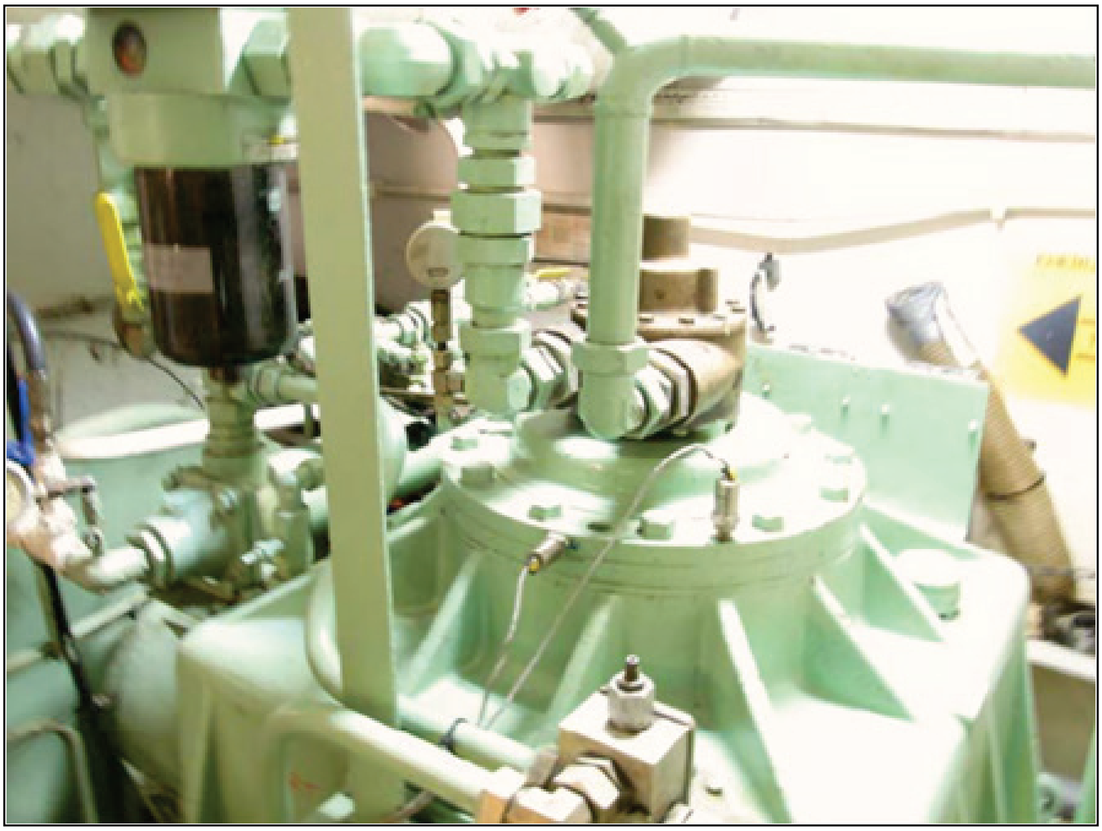

Figure 5: Actuator for the port Azimuth propeller blades

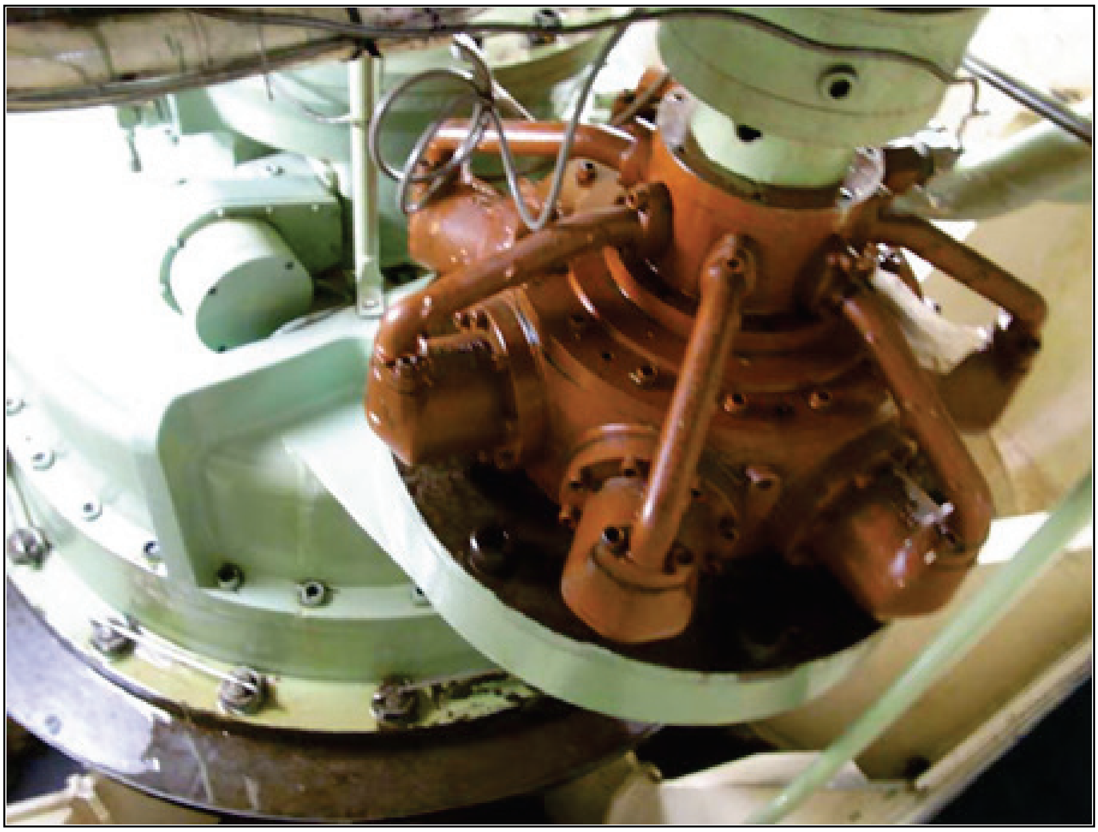

Figure 6: Actuator for the port Azimuth pod gondola

No leaks or traces of a subsequent repair (paint removed from bolted joints, etc.) could be found. Rolls-Royce, the manufacturer, was consulted and found no technical faults after testing every set extensively.

3.2.1.1 Controlling the azimuth thrusters

The hydraulic motors for turning the gondola and adjusting the pitch of the propeller blades can be operated on each thrust column (local control: in the engineroom, right next to the azimuth) of a rudder propeller or from one or several control consoles on the ship (remote control).

A rudder propeller's control console consists of a control lever and indicators for the rudder's position, the pitch of the propeller blades, the current propulsion power, as well as the operating mode and alarm signals.

At each control console, a power supply failure (electric, hydraulic) or a break in the electrical connection (cable break) between the control lever and synchro transmitters or rate control triggers an alarm signal, which is registered and recorded by the monitoring and alarm system.

Figure 7: Rudder propeller's control console

The control lever can be rotated about the horizontal and vertical axis. A rotation about the vertical axis causes the gondola to rotate (rotating control – RC). A rotation about the horizontal axis adjusts the pitch of the CPP (load control – LC).

In the forward conning position (BV), aft conning position (BH), and engine room conning position (MKR), the control consoles of the two propulsion units are combined. Operators can choose between these conning positions at their discretion, but not between the control consoles of different conning positions.

Selection of a conning position is made by a switch with an 'OR' function. This ensures that it is only possible to operate the rudder propellers from one conning position.
Switching between the conning positions must be acknowledged on the conning position selected to make it possible to operate from that conning position. In each case, the active conning position is displayed on the other conning positions.

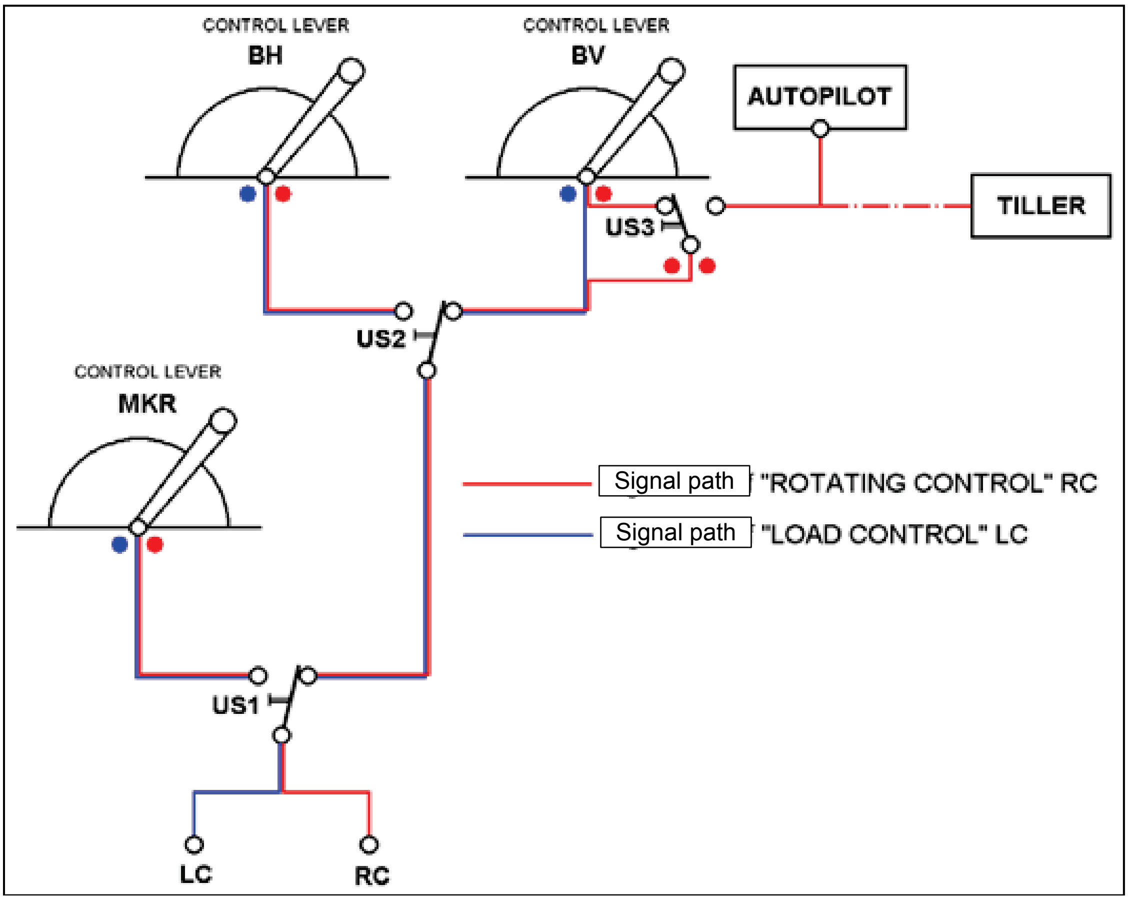

Figure 8: 'OR' link between the conning positions for a control console

3.2.1.1.1 Operating principle of the Rotating Control - System

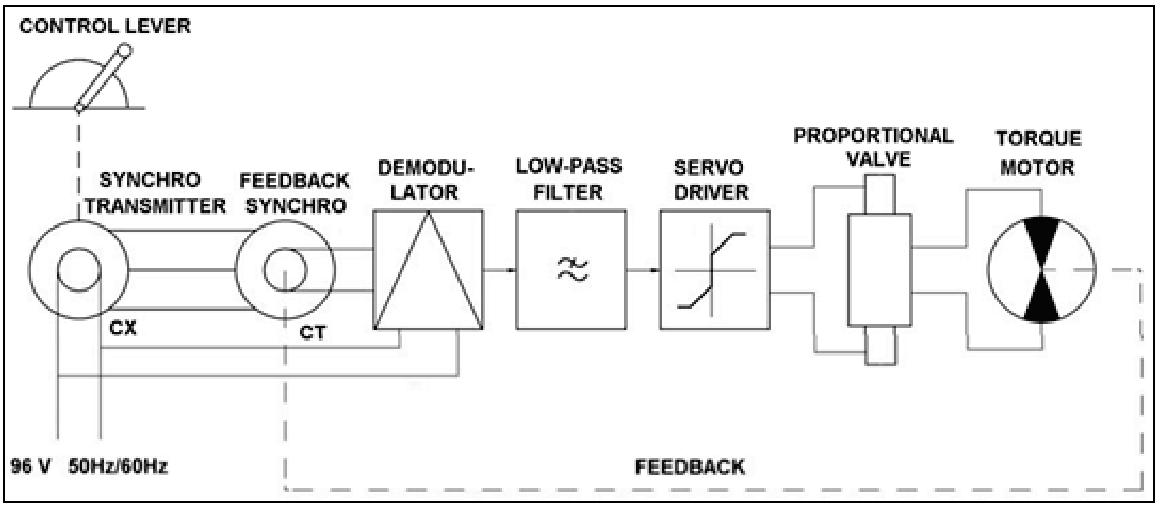

Figure 9: RC controller's wiring plan

This is described in section 6.2.88 of the propulsion system's manual. The control lever's output is an electrical signal that rotates the synchro transmitter's motor.

Rotation of the synchro transmitter produces a 3-phase synchronising signal in accordance with the rotation of the control lever. This signal is transmitted to the control transformer (feedback synchro), which is permanently connected to the swivel column of the gondola.

The control transformer's output signal is a differential voltage according to intensity and direction (phase relationship) between the two transformers. After demodulation and filtering, the controller's output signal is sent via the servo driver to the proportional valve. Depending on the intensity and direction of the output signal, the proportional valve opens and allows hydraulic fluid to flow to the hydraulic motor. The motor rotates the swivel column until the synchronising signal is at zero (set value = existing value according to intensity and direction). The proportional valve then closes and shuts off the flow of hydraulic fluid again, fixing the gondola in that position.

According to the relevant regulations (SOLAS), steering gear must be able to turn the rudder over 65° within a period of 28 s. Accordingly, the maximum period calculated for turning the rudder over 180° is 77.5 s.

3.2.1.1.2 Load Control - System's operating principle

This is described in section 6.2.14 of the manual. The control lever's output is an electrical signal that gets transmitted to a stored program controlled speed control (SPS – rate control).

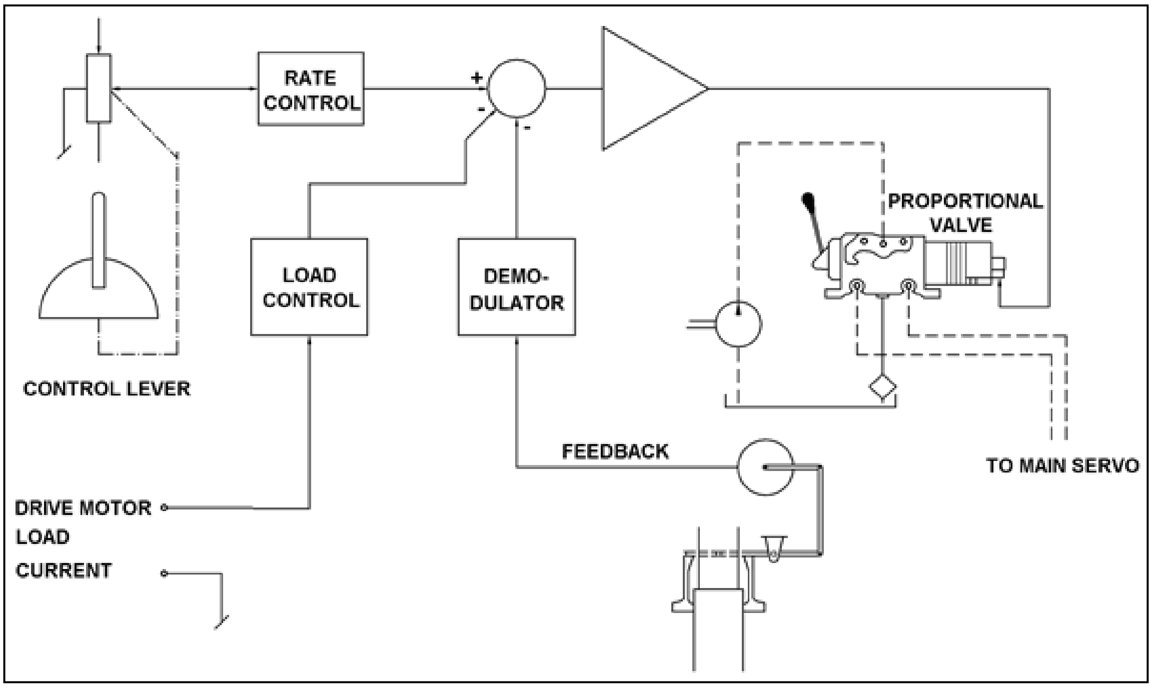

Figure 10: LC controller's wiring plan

The SPS's output signal (+) is compared with a fixed value (-) from the load control and a variable value (-) from the feedback. The difference is an electrical signal that gets transmitted to a proportional valve. This opens and allows the fluid to flow to the hydraulic motor. The propeller blades are rotated until the difference between the electrical signals is zero (set value = existing value according to intensity and direction). The proportional valve closes and shuts off the flow of hydraulic fluid, fixing the propeller blade in the required position.

For optimum manoeuvrability, the SPS system has two stages for the actuator speed:

- manoeuvring;
- free sailing.

The 'free sailing' condition exists when the propeller pitch is greater than 80% of the maximum value when moving ahead. The SPS then reduces the actuator speed automatically to protect the propulsion motor against overloading.

In the 'manoeuvring' condition, the SPS operates at a higher actuator speed, but without overloading the propulsion motor.

3.2.1.2 Operating options of the actuators

With exception to the forward conning position, only manual operation of the Rotating Control- and Load Control-systems is generally possible at the conning positions. At the forward conning position, the RC systems can be switched to autopilot mode. Moreover, manual operation (manual) or automatic (autopilot) can be selected for each control console. The operating mode selected is displayed on the respective control console.

After switching, the input of the respective RC controller (synchro transmitter) is connected with the ship's autopilot (ship tracking) and the control lever is disconnected. The following options are available in autopilot mode:

- 'dynamic positioning' (DP) by manual operation of all propulsion systems (rudder propellers and thrusters) using a central hand lever;
- manual control of one or both rudder propellers using a tiller; the 'steering gear' of both rudder propellers is displayed on a central indicator.

When both rudder propellers operate in autopilot mode, they can be set so that the starboard propeller is used to turn the ship in one direction and the port propeller in the other direction. The assignment of each propeller is permanently configured.

It is also possible to assign a rudder propeller operated in autopilot mode the function of turning the ship in both directions and the other rudder propeller operated in manual mode the function of propulsion without any effect on steering.

Depending on the rudder propeller's operating mode, the ship can be set to move astern as follows:

(1) Both rudder propellers are operated in autopilot mode

The control lever of each rudder propeller is rotated to 'Full astern' (R 10) only about the horizontal axis – the thrust of the two rudder propellers is approximately 70% of the rated value.

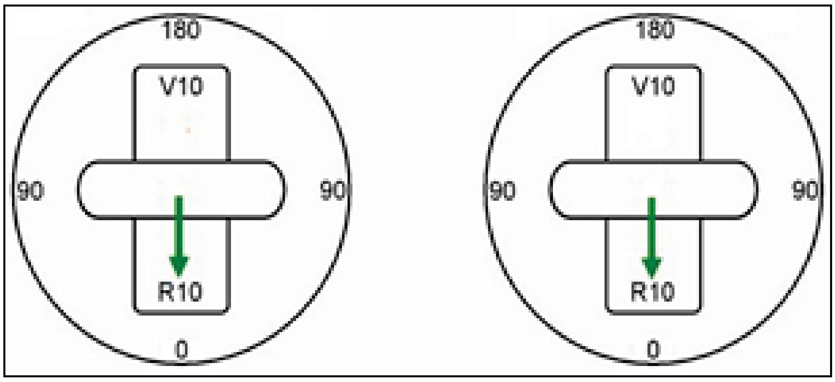

Figure 11: Position of the control levers when moving astern – option 1

(2) Both rudder propellers are operated in manual mode

The control lever of each rudder propeller is rotated about the vertical axis to 180° and simultaneously about the horizontal axis to 'Full ahead' ((V 10) (see Fig. 10)) – the thrust of the two rudder propellers is 100%. During this manoeuvre, the rudder propellers' control levers have to be rotated in the opposite direction to prevent a concurrent response to the helm.

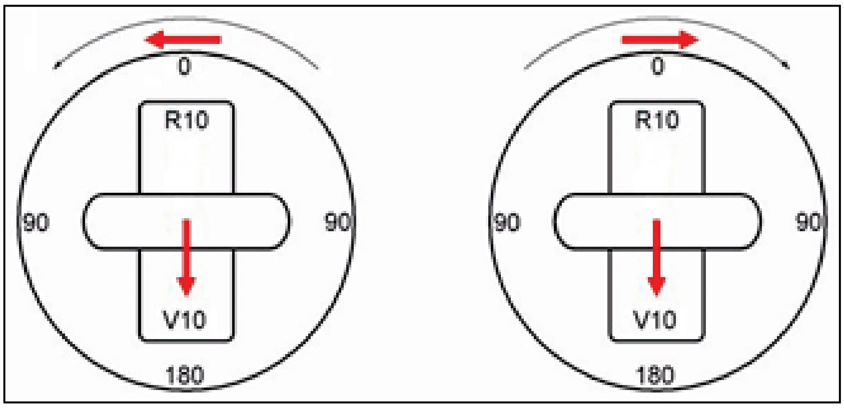

Figure 12: Position of the control levers when moving astern – option 2

(3) One rudder propeller is operated in autopilot mode, the other in manual mode

The control lever of the rudder propeller operated on autopilot is only rotated about the horizontal axis to 'Full astern' (R 10); the control lever of the rudder propeller operated in manual mode is rotated about the vertical axis to 180° and simultaneously about the horizontal axis to 'Full ahead' (V 10). There may be a response to the helm during this manoeuvre because the rudder propeller is operated in manual mode. Furthermore, the thrusts differ.

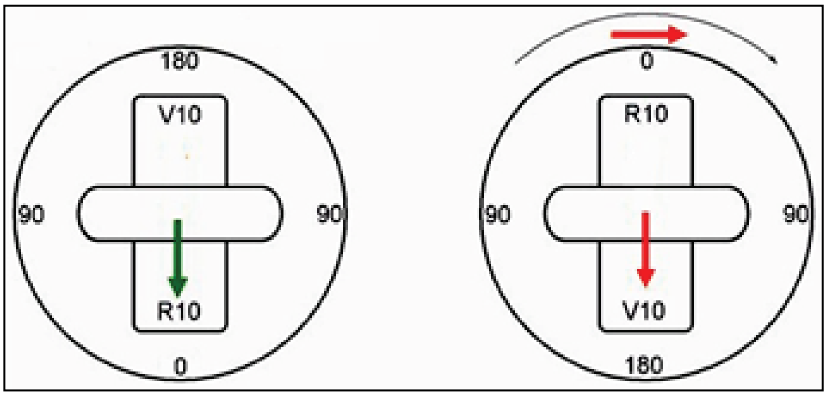

Figure 13: Position of the control levers when moving astern – option 3

The final position of each control lever is the rear position in the case of every manoeuvre. It is not possible to identify which manoeuvre is executed at first glance; further information is required.

3.2.2 Power supply system

Ship operations are powered by electrical energy through an on-board power supply network with various voltages (660 V/440 V/220 V). The four diesel generators have a total power output of 9,450 kW (2 x 2,715 kW and 2 x 2,020 kW) available and feed the power into the system, from which the consumers are supplied, via the two 660 V main power supply networks (PORT and STBD).

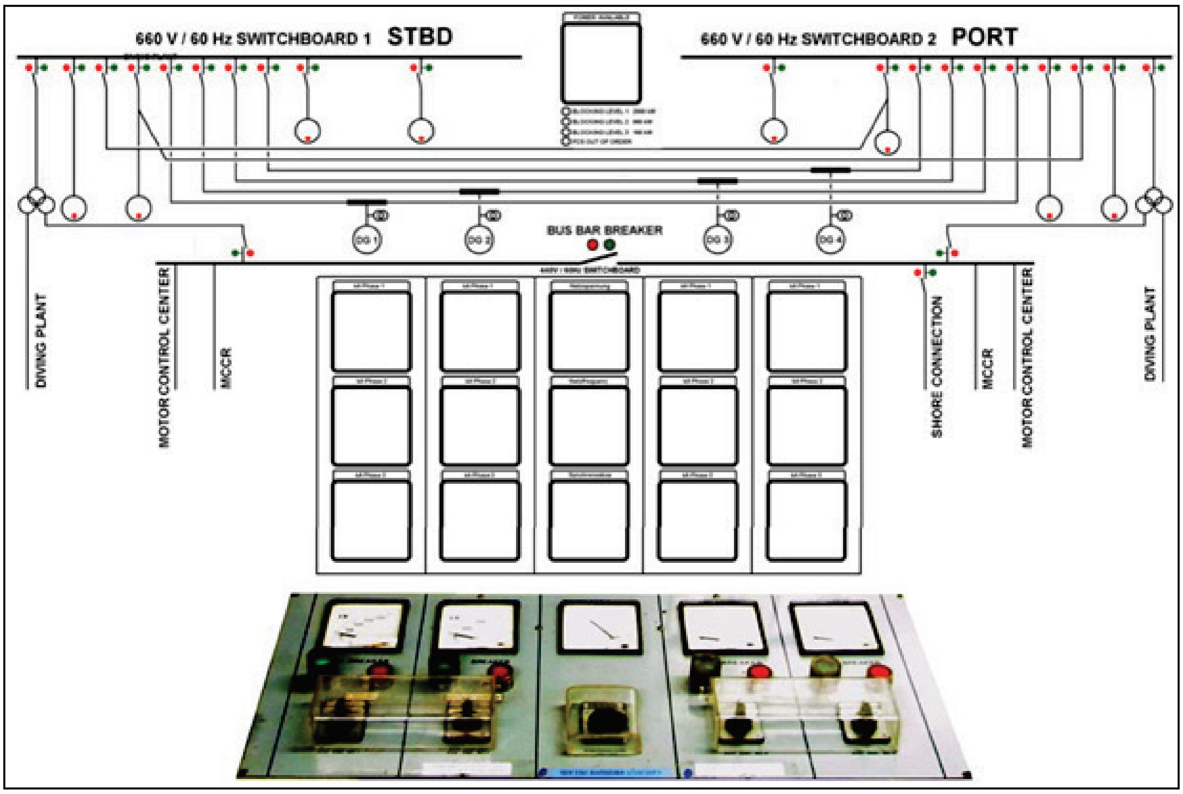

Figure 14: Schematic circuit diagram, monitoring console for the electricity supply system

Large power consumers (Azimuth, thrusters) are supplied directly from the main power supply networks; the other consumers with lower voltage (440 V, 220 V) from the main power supply network via transformers.

The two main power supply networks are monitored by a power control system (PCS), which

- continuously registers the power demand of all the consumers, as well as the maximum power available from the generators in operation;
- automatically switches on/off generators as required, so that enough 'surplus power' (difference between the maximum power available and power demanded) is always available, and
- monitors the uniform loading of the two main power supply networks (unbalanced load).

The system is connected to the central monitor and safety system. If limits are not met or exceeded (unbalanced load too high = surplus power too low), then an alarm is initially triggered. If deviations are substantial, then the propulsion power of the Azimuths is reduced via the safety system. The monitoring system registers and records every process centrally.

3.2.3 Monitoring and safety system

The ship is equipped with an Autronica KM-2 engine control room alarm and monitoring system. The 'List of alarms' contains all the connected measuring points, including

- Alarm name/function (column 1);
- Measured value (column 2);
- Card No. (column 3);
- Alarm Ch. No. (column 4);
- Sensor – make/type (column 5);
- Set point (column 6, pre-set limit);
- Shut down (column 7, intervention of safety system).

The following alarms are registered and recorded under group number 05 and the 'Alarm Ch. No.' for the azimuth thrusters :

Azimuth Thruster Stbd.						
El Motor Water Detector	LAH	42A	202			
El Motor Air Temperature	TIAH	43A	203			
El Motor Bearing Temp.	TIAH	44A	204		90°C	
El Motor Winding Temp. R	TIAH	45A	206		90°C	
El Motor Winding Temp. S	TIAH	46A	207		90°C	
El Motor Winding Temp. T	TIAH	47A	208			
Rotating Oil	PAL	48A	209			
Pitch Oil	PAL	49A	210			
LO Thruster Unit	PAL	50A	211			
Bevel Gear LO pump	XA	51A	212			
Lub Oil Temperature	TAH	52A	213			
Gravity Tank	LAL	53A	214			
Gear Lub Oil	PAL	54A	215			
Gear Lub Oil	TAH	55A	216			
LO p/p Thruster St.by Start	XA	56A	217			
Power System Fail Rem Con	XA	57A	218			
Power Failure Signal System	XA	58A	219			
PLC System Failure	XA	59A	205			

Figure 15: Azimuth thruster alarm signals

The acronyms in this list mean:

T: Temperature
P: Pressure
L: Level
I: Indicator
A: Alarm
X: User definable

It is evident from the list that an alarm is triggered and registered in the event of a remote control (Power System Fail Rem Con), power (Power Failure Signal System) or stored program logical control (PLC System Failure) failure.

PCS system alarm signals are registered under the group number 09.xxx.

The monitoring and safety system did not register or document any alarm signals in the period between 083506 and 084427. The first alarm signal after the collision with the gate is registered at 084604.

```
17/01/15 08:46:04 - 11 -   09.519 BLOCKING LEVEL 1                        - Alarm
17/01/15 08:46:07 - 11 -   09.520 BLOCKING LEVEL 2                        - Alarm
17/01/15 08:46:08 - 11 -   09.018 SKEW LOAD kVAr                          - Alarm
17/01/15 08:46:12 - 11 -   09.019 SKEW LOAD Amp                           - Alarm
17/01/15 08:46:19 - 11 -   05.043 FW PUMPS AZIMUTH THR.STERN THR.         - Alarm
17/01/15 08:46:21 - 11 -   09.519 BLOCKING LEVEL 1                        - Ack
17/01/15 08:46:22 - 11 -   09.520 BLOCKING LEVEL 2                        - Ack
17/01/15 08:46:22 - 11 -   09.520 BLOCKING LEVEL 2                        - Normal
---------------------------------------------------------------------------------
Ship name : CSO Alliance          Project :

Date     Time     - Gr -          ID Description                          - Status
---------------------------------------------------------------------------------
17/01/15 08:46:23 - 11 -   09.018 SKEW LOAD kVAr                          - Ack
17/01/15 08:46:23 - 11 -   09.018 SKEW LOAD kVAr                          - Normal
17/01/15 08:46:24 - 11 -   09.019 SKEW LOAD Amp                           - Ack
17/01/15 08:46:24 - 11 -   09.019 SKEW LOAD Amp                           - Normal
17/01/15 08:46:26 - 11 -   05.043 FW PUMPS AZIMUTH THR.STERN THR.         - Ack
17/01/15 08:46:28 - 11 -   09.519 BLOCKING LEVEL 1                        - Normal
17/01/15 08:46:28 - 11 -   05.043 FW PUMPS AZIMUTH THR.STERN THR.         - Normal
17/01/15 08:46:30 - 11 -   09.018 SKEW LOAD kVAr                          - Alarm
17/01/15 08:46:30 - 11 -   09.251 DG2 kVAr CONVERTER FAILURE              - Alarm
17/01/15 08:46:33 - 11 -   09.251 DG2 kVAr CONVERTER FAILURE              - Ack
17/01/15 08:46:33 - 11 -   09.251 DG2 kVAr CONVERTER FAILURE              - Normal
17/01/15 08:46:34 - 11 -   09.018 SKEW LOAD kVAr                          - Ack
17/01/15 08:46:34 - 11 -   09.018 SKEW LOAD kVAr                          - Normal
17/01/15 08:46:35 -  8 -   04.026 ME4 L.O. ROCKER ARM SYSTEM              - Alarm
17/01/15 08:46:38 -  8 -   04.026 ME4 L.O. ROCKER ARM SYSTEM              - Ack
17/01/15 08:46:45 -  8 -   04.026 ME4 L.O. ROCKER ARM SYSTEM              - Normal
```

Figure 16: Excerpt from the error log

Ship's time	Indicator	Type of message	Type of fault
084604	Blocking Level 1	Alarm	Surplus power in the electricity supply system < 2,000 kW
084607	Blocking Level 2	Alarm	Surplus power in the electricity supply system < 860 kW
084608	Skew Load kVAr	Alarm	Large difference in idle power between the main power supply networks
084612	Skew Load Amp	Alarm	Large difference in amperage between the main power supply networks
084621	Blocking Level 1	Ack	Alarm signal acknowledged
084622	Blocking Level 2	Ack	Alarm signal acknowledged
084622	Blocking Level 2	Normal	Alarm cancelled

Following that, the first alarm (Blocking Level 1) is not signalled until long after the collision, followed by more.

Diesel generator 2 is disconnected from the network (DG2 KVAr Converter Failure) at 084630 and the electric power then available only stands at 4,735 kW. At this point, the rudder propellers must also have been switched off because the 'Blocking Level 1' alarm was already cancelled and the surplus power when operating the rudder propellers at 1,055 kW would have been below the limit value for the 'Blocking Level 1' alarm.

3.2.4 ECDIS-, AIS- and VDR-Recordings

The ship is equipped with an electronic chart display (ECDIS) and an automatic identification system (AIS). Both systems register current voyage particulars, such as the ship's time, course, and speed. There is also a Kelvin Hughes voyage data recorder (VDR). Since the ship's command dispensed with the use of radar equipment during the approach, radar images are not recorded. Although the bridge microphone recordings are difficult to understand, they at least confirm the time of the collision due to a significant noise at 0942. Since the VDR does not have sensors for the controlling elements and propulsion systems, data on set and existing values for system operations are also absent.

The ECDIS shows on a monitor the ship using it on a nautical chart (WGS84) in her direction of travel. Furthermore, important voyage particulars (programmed heading line = set value, current course = existing value, and a speed vector computed using GPS data) are displayed.

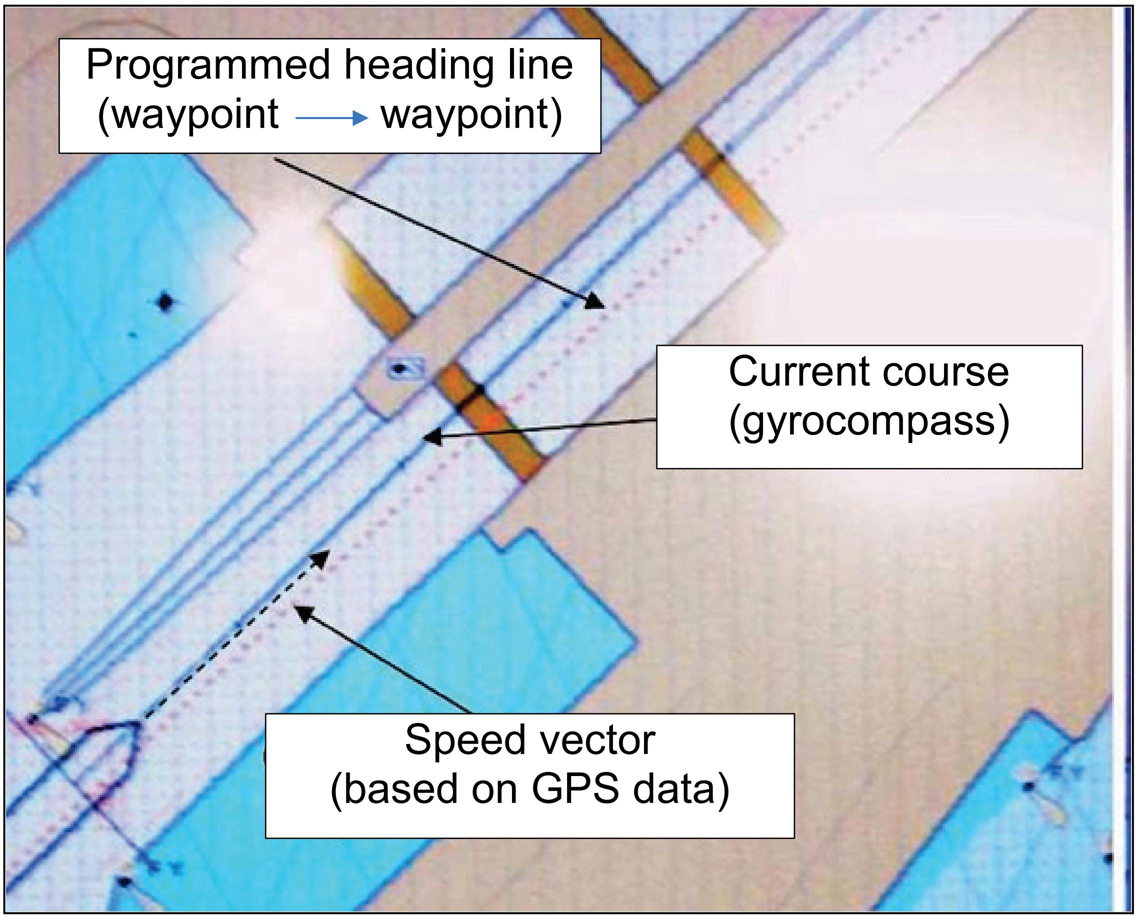

Figure 17: ECDIS display

The AIS stores data on the ship's position, course over ground (COG), speed over ground (SOG), accelerations, and other data like the name, flag State, MMSI number, type, and length of the ship.

Based on the AIS data, the course of the ship's voyage was shown by means of an electronic nautical chart during the investigation.

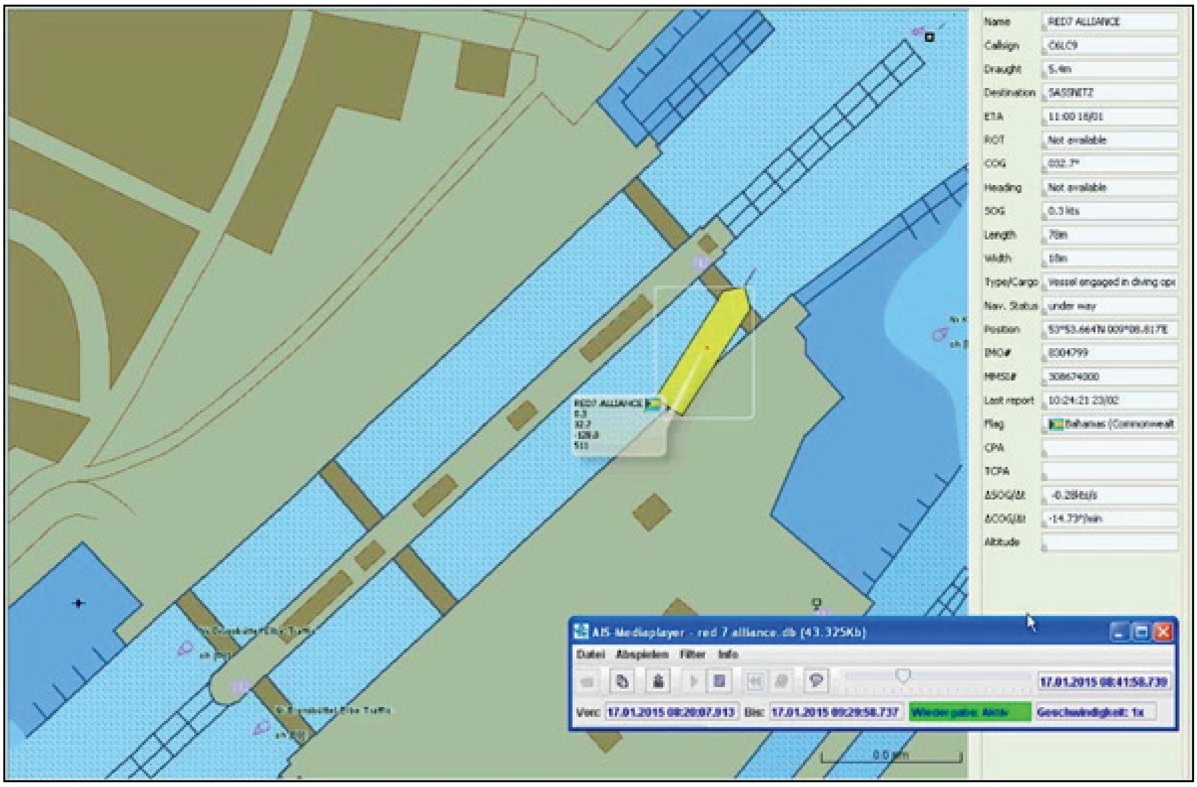

Figure 18: AIS display of the collision

Based on the two data pools, the entire manoeuvre from approaching the pier up until the collision was traced. The key data (ship's time, position, SOG, COG, and accelerations) were summarised on a table for selected positions of the ship.

Ship's time	Position	SOG	ΔSOG/Δt	COG	ΔCOG/Δt
083358	53°53.491N/009°08.474E	2.3 kts	- 0.05 kts/s*	46.6°	- 7.56°/m**
083629	53°53.550N/009°08.585E	2.0 kts	- 0.00 kts/s	47.8°	9.25°/m
083808	53°53.591N/009°08.658E	1.9 kts	- 0.01 kts/s	55.7°	8.08°/m
083929	53°53.617N/009°08.714E	1.7 kts	- 0.00 kts/s	55.2°	8.00°/m
084017	53°53.628E/009°08.748E	1.5 kts	0.00 kts/s	60.5°	10.91°/m
084048	53°53.635N/009°08.765E	1.5 kts	- 0.01 kts/s	46.9°	- 63.00°/m
084058	53°53.638N/009°08.770E	1.5 kts	0.01 kts/s	47.6°	- 19.64°/m
084107	53°53.640N/009°08.775E	1.8 kts	0.00 kts/s	47.3°	4.20°/m
084117	53°53.646N/009°08.784E	2.5 kts	0.03 kts/s	46.9°	- 2.00°/m
084129	53°53.654N/009°08.798E	3.6 kts	0.07 kts/s	46.4°	- 2.40°/m
084137	53°53.661N/009°08.813E	4.3 kts	0.09 kts/s	49.5°	- 2.50°/m
084148	53°53.664N/009°08.818E	1.2 kts	0.09 kts/s	46.8°	23.25°/m
084158	53°53.664N/009°08.817E	0.3 kts	- 0.28 kts/s	32.7°	- 14.73°/m
084207	53°53.663N/009°08.816E	0.1 kts	- 0.09 kts/s	29.1°	- 84.60°/m

* - ΔSOG/Δt = deceleration

** - ΔCOG/Δt = course alteration to port

The tabular summary shows that the ship turns to port immediately before the speed starts to increase, then turns back to starboard, and then while the speed is increasing turns to port continuously until the collision.
The ship initially turns back to starboard at the beginning of the collision. She then turns very heavily to port until she comes to a halt.
The data also show that at the beginning the ship was accelerated at 0.03 kts/s (0.0154 m/s2). This acceleration subsequently increased to 0.07 kts/s (0.036 m/s2) and then remained at a constant 0.09 kts/s (0.0463 m/s2) until the collision.

3.2.5 Damage

A massive cross member in the lock gate damaged the hull level with the water line so severely that water entered the forepeak and the ship lost some of her buoyancy. Furthermore, the end of the upper longitudinal member of the lock gate penetrated the hull level with the bower.

Figure 19: Damage to the bow

Due to the ship colliding with a massive guide beam belonging to the gate, there was a hole in her bow of approximately 1.4 m in height and 3.3 m in length level with the waterline. The shell plating was cut relatively sharp on the upper edge of this hole and turned inwards on the lower edge.

Figure 20: Damage to the lock gate

Figure 21: Damage to the lock gate's walkway

The damage pattern on the hull and that of the lock gate show that the ship must have turned to port after the collision. In the process, huge forces must have acted for the right fracture point of the upper longitudinal beam to penetrate the hull on the ship's starboard side level with the bower.

4 ANALYSIS

Having considered all the evidence, the course of the accident is reconstructed as follows.

According to the pilot, he operated the tiller and steered the ship thus. At the same time, the master set the rate of speed at the two control consoles' control levers in accordance with the specifications of the pilot.

The course of the accident is only possible if the two propulsion units – in accordance with the recommendations in the manual – were operated as follows (see page 20 option 3):

1. **port system** in manual mode; the RC controller was set constantly to 0°; only the position of the propeller blades was altered with the control lever on the control console; This means **only thrust** was generated here.
2. **starboard system** in autopilot mode; the RC controller and thus **course of the ship** were operated using the tiller; only the position of the propeller blades was altered with the control lever here, too.

To improve his angle of visibility, the pilot handed over control of the tiller to the second officer and went to the starboard wing.

Up to this point, the entire manoeuvre passed without any complications.

The master initiated the sternward manoeuvre on the recommendation of the pilot.
In the process, **he must have assumed** that he operated the control levers on both control consoles in manual mode (as per the second option shown in figure 12), and switched **both** control levers by 180°. He thus failed to switch the starboard propulsion, so far working in automatic pilot mode to manual mode.

The outcome of the masters assumption that both propulsion units worked in manual mode was that only the port gondola rotated 180°, as required, but the starboard gondola held its position (0°) and pushed the ship further forward. These unintended forward thrust of the starboard propeller took effect immediately but the required sternward thrust of the port propeller could have only taken effect after the gondola turned completely by 180°.

If the master was aware of the starboard propulsion operating in automatic pilot mode he could have only set the controllable pitch propeller to “astern”, whereas the port Azimuth should have been turned by 180°.

Based on the data, the calculated distance to the lock gate at the beginning of the sternward manoeuvre is about 90 m; the ECDIS indicates a distance of 82 m.

The recordings indicate that approximately 39 s had passed between the start of the sternward manoeuvre and first collision with the lock gate. Based on the rudder taking no more than 78 s to turn over, the port gondola would have turned about 90°. This means that an appreciable sternward thrust could not have been produced before the first collision with the gate.

That explains the behaviour of the ship, as described in section 3.2.5:

1. turn to port immediately before the start of the increase in speed;
2. ship turns to port throughout the increase in speed until the collision, and
3. increase in speed with an acceleration of 0.03 kts/s up until the collision, by which time 0.09 kts/s had been reached.

Accordingly, the ship must have collided with the lock gate under forward thrust and no sternward thrust. That explains the behaviour of the ship during the collision:

4. another slight turn to starboard just before the first collision with the gate;
5. strong turn to port during the collision, penetrating the gate with substantial one-sided thrust to starboard.

The recording of the conversations on the bridge indicate that immediately after the collision the master apparently assumed there had been a "technical failure" in the propulsion units because the systems had not responded as he had expected.
That the systems were forced to respond in the manner they did because of the failure to switch the starboard propulsion unit to manual mode had yet to be recognised at that point.
According to the chief engineer, three diesel generators with a total power output of 7,450 kW available operate at all times when manoeuvring.
After deducting the maximum total power output of both rudder propellers (3,680 kW), 3,770 kW of power is still available for the remaining on-board operations, including the thrusters.
For lack of knowledge of the situation and the erroneous assumption that in the absence of alarm signals it concerned a short-term fault and both propulsion units were operating in a sternward direction, an attempt to release the ship from the gate under her own steam was apparently made after the collision. In the process, the aft thruster was also used to 'swing' the hull. This manoeuvre was destined to fail because the port propulsion unit had turned 180° in the meantime and the pitch of the propeller blades on both the propulsion units had now reached its limit (100% ahead). The propeller thrusts cancelled each other out due to the 'misalignment' of the two propulsion units. Nevertheless, each unit's propulsion power stood at 100%.
The failed attempt to release the vessel unassisted already discussed explains the high power demand immediately after the collision and the alarm signals

- Blocking Level 1 and Blocking Level 2, and
- Skew kVAr and Skew Amp.

After the failed attempt, further use of the propulsion units was dispensed with and the propulsion motors for the propellers switched off on the recommendation of the pilot. This decreased the demand on the power supply network, resulting in the disconnection of one of the large diesel generators from the network due to the transformers being shut down via the generator's safety system (protection against the intake of electrical power by the DG's reverse power protection system). This explains the alarm signals 'DG2 kVAr Converter Failure'.

5 CONCLUSIONS

It was possible to reconstruct the course of the manoeuvre. Activities on the bridge and the alarm signals could be clearly reconciled with the chronological sequence of the manoeuvre and the ship's manoeuvring behaviour.

A technical failure in the control system can be ruled out with certainty.

Consequently, the accident was caused by an error in operating the starboard propulsion since the master assumed that this Azimuth already operated in manual mode. If he had been aware that this unit operated in the automatic pilot mode he should not have turned the gondola but instead only switched the pitch on “astern” to achieve a stop effect.

It should be noted that in addition to special training for these propulsion units, the ship's command also has extensive experience with this ship. The manufacturer was requested to check whether the avoidance of such operator errors is technically feasible.

The period of time between the sternward manoeuvre being initiated and the collision with the lock gate was very short. A subsequent correction of the operator error would not have prevented the collision.

The accident would not have happened if the propulsion unit controls were operated, **having regard to the different operating modes** (auto mode and manual mode). Moreover, it would have been helpful if the technical equipment had indicated the operator error or possibly even prevented it.

6 SAFETY RECOMMENDATIONS

The following safety recommendations do not constitute a presumption of blame or liability.

6.1 Rolls-Royce Marine A/S

The Federal Bureau of Maritime Casualty Investigation recommends that Rolls-Royce Marine A/S develop technical modifications to the propulsion unit controls, to avoid operating errors as the found here.

6.2 Ship's command of the RED7 ALLIANCE

The Federal Bureau of Maritime Casualty Investigation recommends that the ship's command of the RED7 ALLIANCE be continuously aware of the complexity of controlling the Azimuths and avoid routine in the sense of habitual practice.

6.3 DSV Alliance AS, the ship's management

The Federal Bureau of Maritime Casualty Investigation recommends that the ship's management of RED7 ALLIANCE continue training its ship's commands in operating the Azimuths on a regular basis.

7 SOURCES

- Enquiries of Waterway Police (WSP) Brunsbüttel, including photographs
- Written statements
  - Ship's command
  - Owner
  - Classification society
- Witness testimony
- Expert opinion of Prof. Dipl.-Ing. H.O. Diederichs (on behalf of GDWS Outstation North), including photographs
- Nautical charts and ship particulars, Federal Maritime and Hydrographic Agency (BSH)
- Photograph of the RED7 ALLIANCE on page 6 by Hasenpusch Production
- Recordings of Vessel Traffic Service Brunsbüttel NOK
- Documents, Ship Safety Division (BG Verkehr)
  - Accident Prevention Regulations (UVV See)
  - Guidelines and codes of practice
  - Ship files