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

Investigation Report 94/15

Serious Marine Casualty

Collision between the SAINT GEORGE and a lock gate at Brunsbüttel on 20 March 2015

21 March 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 1 of 22 November 2011, BGBl. (Federal Law Gazette) I p. 2279.

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

The Cyprus-flagged general cargo ship SAINT GEORGE was en route from Amsterdam to Lübeck via the Kiel Canal when she reached Brunsbüttel at about midday on 20 March 2015. Apart from the master and pilot, the bridge was manned by the third officer and a helmsman for the entry into the Neue Nordschleuse lock. The ship sailed into the lock chamber at low speed with engine stopped. When the SAINT GEORGE was supposed to be brought to a halt in the lock, she accelerated unexpectedly. Even though both anchors were dropped, a collision with the lock gate was unavoidable. Heavy material damage was caused to the ship and lock gate. There were neither injuries nor environmental pollution.

2 FACTUAL INFORMATION

2.1 Photo of ship

Figure 1: Photo of the SAINT GEORGE

2.2 Ship particulars

Name of ship:	SAINT GEORGE
Type of ship:	Cargo ship
Nationality/Flag:	Cyprus
Port of registry:	Limassol
IMO number:	9452323
Call sign:	5BDY3
Operator:	Pacific and Atlantic Shipmanagers Inc.
Owner:	Great Options Investments Ltd.
Year built:	2008
Shipyard:	Fujian New Shenghai Shipbuilding
Classification society:	Lloyds Register
Length overall:	131.55 m
Breadth overall:	18.80 m
Gross tonnage:	6,680
Deadweight:	8,737 t
Draught (max.):	6.90 m
Engine rating:	3,824 kW
Main engine:	8PC25-L
(Service) Speed:	14.3 kts
Hull material:	Steel
Hull design:	Double bottom
Minimum safe manning:	12

2.3 Voyage particulars

Port of departure:	Amsterdam
Port of call:	Lübeck
Type of voyage:	Merchant shipping, international
Cargo information:	Ballast
Manning:	18
Draught at time of accident:	Df = 3.85 m, Da = 5.24 m
Pilot on board:	Yes
Canal helmsman:	No
Number of passengers:	None

2.4 Marine casualty or incident information

Type of marine casualty:	Serious marine casualty; collision with lock gate
Date, time:	20/03/2015, 1225
Location:	Brunsbüttel
Latitude/Longitude:	φ 53°53.6'N λ 009°08.7'E
Ship operation and voyage segment:	Harbour mode/berthing
Place on board:	Fore section
Human factors:	Yes, human error
Consequences:	Heavy damage to the bulbous bow and lock gate. There were neither injuries nor environmental pollution

Excerpt from nautical chart 46, Federal Maritime and Hydrographic Agency (BSH)

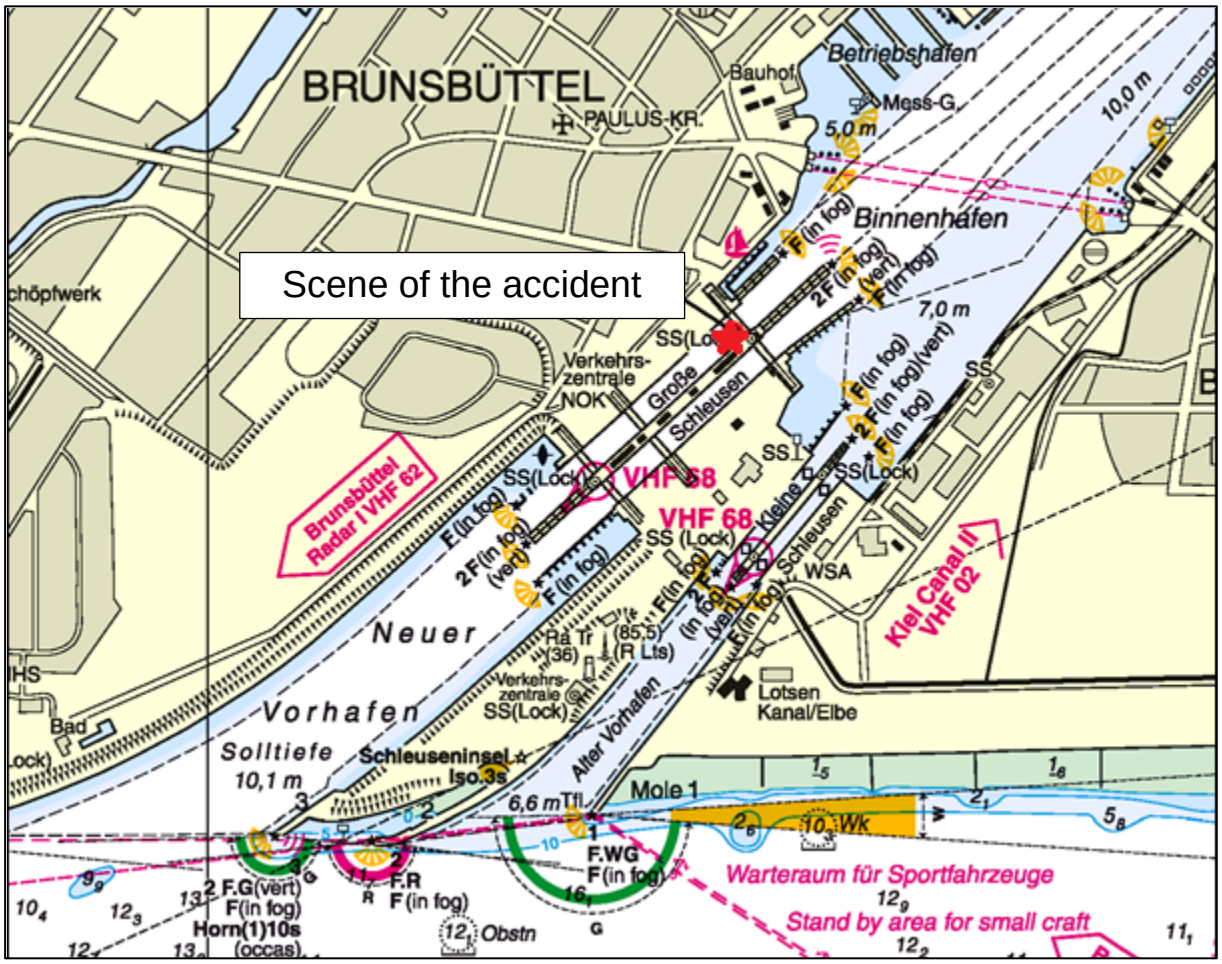

Figure 2: Nautical chart

2.5 Shore authority involvement and emergency response

Agencies involved:	Federal Waterways and Shipping Agency (Norther Region Office), Waterway Police (WSP) Brunsbüttel
Resources used:	None
Actions taken:	Scene investigated
Results achieved:	Repairs to the ship and lock gate facilitated

3 COURSE OF THE ACCIDENT AND INVESTIGATION

3.1 Course of the accident

The Cyprus-flagged general cargo ship SAINT GEORGE sailed out of Amsterdam in ballast. Her next port of loading was Lübeck. While en route there, she was scheduled to transit the Kiel Canal. The SAINT GEORGE arrived at the Nordwest-Reede roadstead off Brunsbüttel on 20 March 2015. A scheduled pilot change took place there at 1204[1]. The canal pilot[2] embarked and the Elbe pilot[3] was released after a brief handover. Apart from the pilot and master, the third officer and a helmsman were also on the bridge. The engine control room (ECR) was manned by the chief engineer officer and the electrician.

The vessel traffic service (VTS) cleared the Neue Nordschleuse lock for entry at 1150. The SAINT GEORGE was to enter the lock first. Since she is equipped with a left-hand fixed pitch propeller, it was agreed that she would make fast on the centre wall with her starboard side. She turned in on the main line (mole head lights 1 and 2 in line). After the ship had reached a speed over ground (SOG) of about 8 kts at the lowest rate of speed ahead, the engine was stopped.

Shortly before reaching mole 4, an order was issued to set the engine to dead slow ahead again. The SAINT GEORGE turned through the shear zone into the Neue Vorhafen (new outer port) at a speed of about 6.5 kts. The engine was stopped again when mole 3 was abeam to starboard. The helmsman steered the ship in accordance with the pilot's rudder angle recommendations. Her steering characteristics were good even with the engine stopped. The northern guiding jetty was reached at a speed of 3.5 kts.

After the wheelhouse passed the outer gate at 1224, the pilot issued an order to set the engine to dead slow astern. The heaving lines for the mooring lines were passed across. The pilot went to the starboard wing for the berthing manoeuvre. According to information given by the master, the third officer then went to the bridge door on the starboard side, so as to relay the recommendations of the pilot to the master from there. Since the SAINT GEORGE does not have control stands in the wings, the master remained at the main control stand to operate the engine order telegraph.

The speed of the ship did not drop and therefore consecutive orders were issued to set the rate of speed to slow astern, then half astern, and finally full astern. The SAINT GEORGE accelerated, however. The two bow anchors were then dropped as well to prevent a collision with the lock gate. However, this was unsuccessful and the SAINT GEORGE collided with the lock gate at 1226 at a speed of some 5 kts.

[1] All times shown in this report are CET = UTC + 1.
[2] Sea pilot from the Kiel Canal I Pilots Association.
[3] Sea pilot from the Elbe Pilots Association.

3.1.1 Consequences of the accident

Both ship and lock gate were considerably damaged as a result of the collision. The SAINT GEORGE's bulbous bow was severely damaged and there was water ingress via a hole of some 0.8 m x 1.5 m. The fore section was also dented above the waterline. The SAINT GEORGE remained in the lock to begin with an initial investigation. After that, she received a specific approval to proceed under her own power to a shipyard in Rendsburg for repairs.

Figure 3: Damage to the fore section

Figure 4: Hole in the bulbous bow

Due to the force of the collision, the lock gate was almost split in two. Moving it was no longer possible and it could not be repaired at the scene. Since a replacement gate was initially not available, there were major traffic delays on the Kiel Canal.

Figure 5: Damage to the lock gate

Figure 6: Damage to the lock gate

3.2 Investigation

The waterway police notified the BSU immediately after the accident. Prof. Dipl.-Ing. Hark Ocke Diederichs, an expert, produced an opinion aimed at determining the cause of the accident on behalf of the Federal Waterways and Shipping Administration. The BSU considered the opinion in this report.

3.2.1 Propulsion system

The SAINT GEORGE is propelled by a type 8PC25-L non-reversible medium-speed four-stroke diesel engine built by Pielstick (ShanXi Diesel Industry). Its rated power is 3,824 kW at 500 revolutions per minute (rpm). A left-hand fixed pitch propeller is driven via a reversing gear with a reduction ratio of 3.52 : 1.

The propulsion system (engine and gearing) is typically controlled from the ECR by means of a pneumatic remote control. It is not possible to operate the engine directly from the bridge.

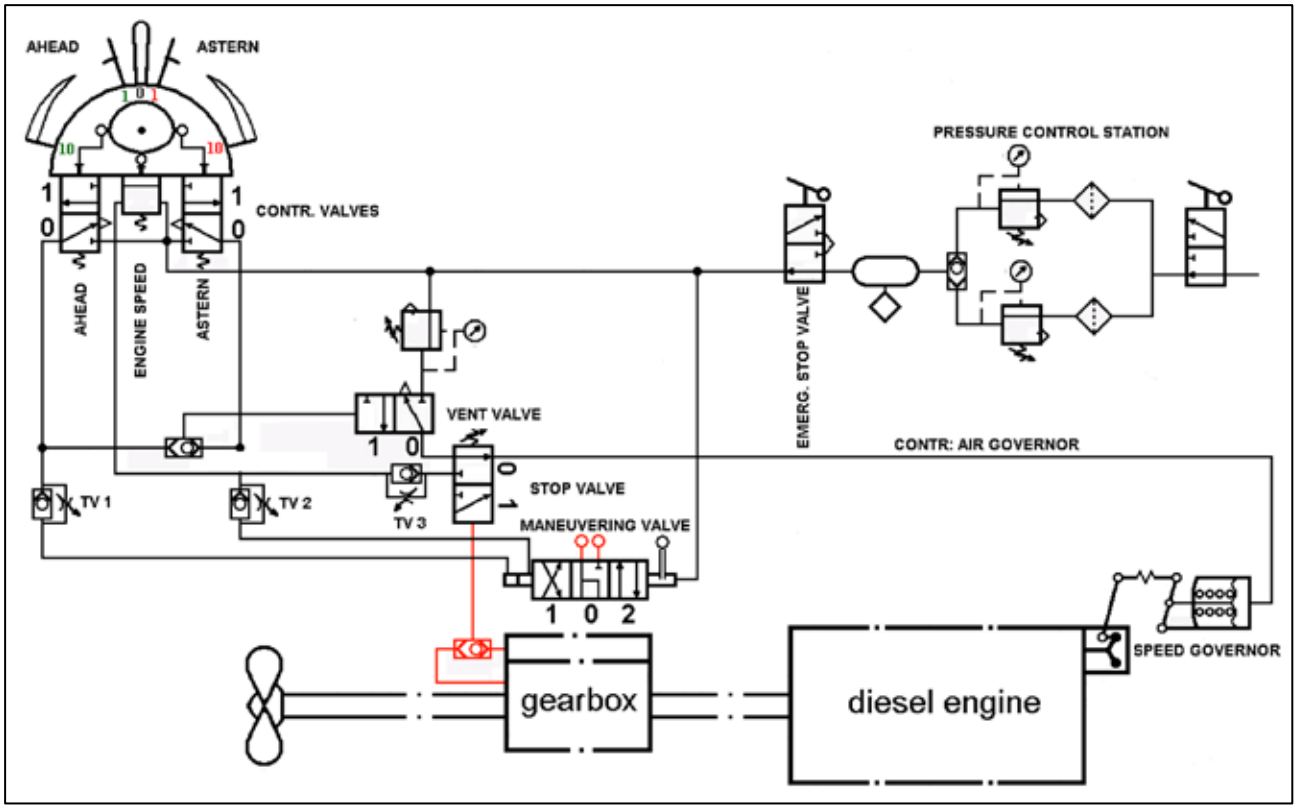

Figure 7: Remote control system circuit diagram

The reversing gear (gearbox) is controlled via the manoeuvring valve. It has three positions:
0 – frictional connection off (disengaged), 1 – ahead, 2 – astern. The clutch couplings in the gearing are operated hydraulically via the manoeuvring valve. In addition to the pneumatic remote control, it is also possible to shift the gearing manually using a hand lever on the gearing (see Fig. 9).

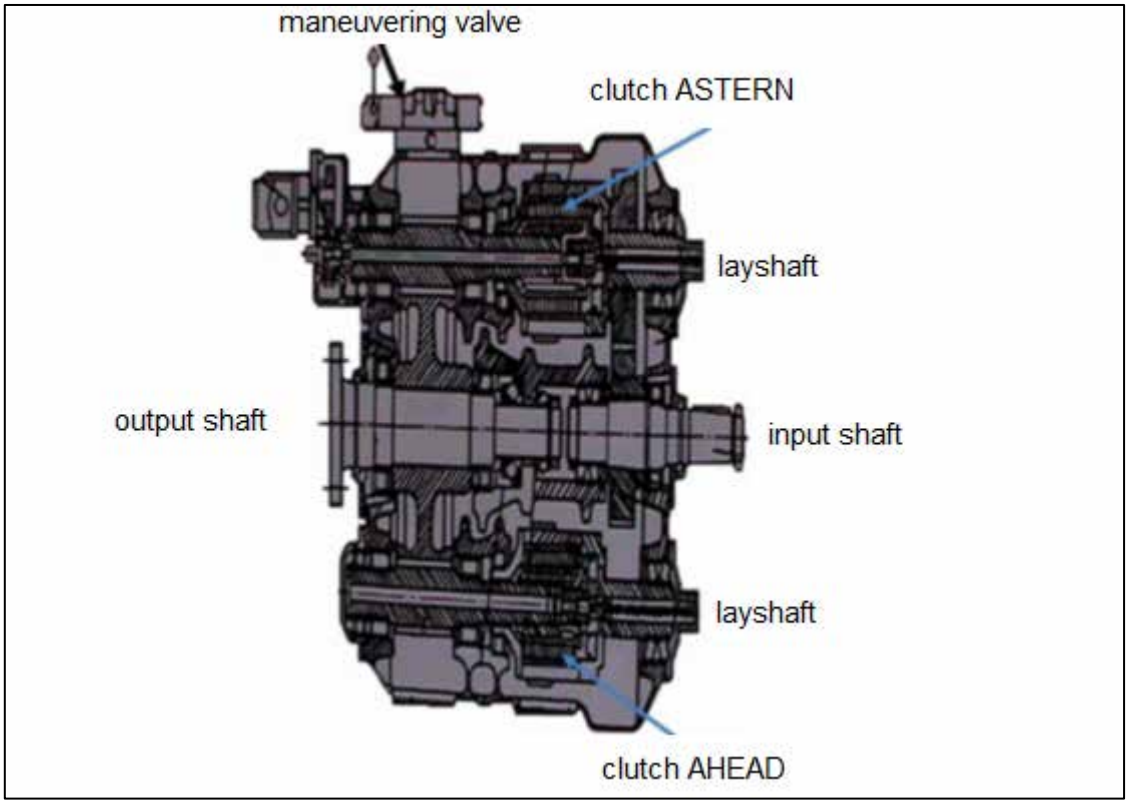

Figure 8: Sectional view of reversing gear

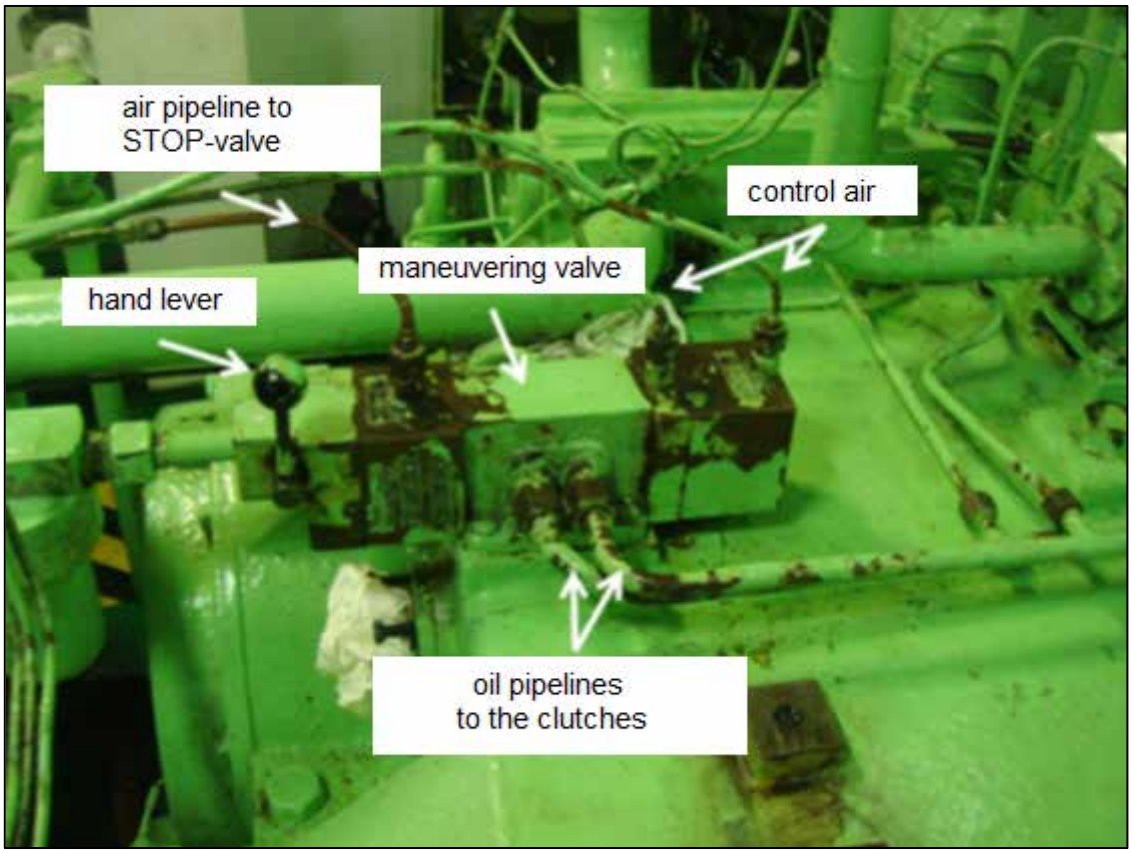

Figure 9: Reversing gear controlling elements on the SAINT GEORGE

After the main engine is started, the control air line to the engine's speed governor is depressurised; the engine turns at the idling speed of 200 rpm when the control lever is in the neutral position. Setting the control lever to position 1 causes one of the two control valves to open, releasing the control air for the manoeuvring valve and vent valve. This causes the engine speed to first increase to shifting speed, after which the manoeuvring valve opens and the shift oil pressure in the gearing closes the relevant clutch coupling and stop valve. The control air from the speed control valve is released when the stop valve (engine speed) is closed.

The engine speed drops briefly during the shift operation because the propeller shaft is accelerated when the coupling closes, which requires more torque. This speed suppression might be evident from a brief darkening of the engine exhaust gases.

After completion of the shift operation, the frictional connection between engine and propeller shaft is established and the engine drives the propeller at idling speed. The required rate of speed is set by moving the control lever through the positions 1 to 10. To achieve this, the control cams on the control lever open the speed control valve, so as to increase the control air pressure to the engine's speed governor and thus the speed and power on the gearing's input shaft.

Placing the control lever in the neutral position (stop engine) closes the relevant control valve; the control air line to the vent valve is then vented without a delay and the control air line to the manoeuvring valve with a delay. This causes the manoeuvring valve to close and shuts off the flow of shift oil to the relevant coupling and the stop valve. Closing the stop valve releases the control air line to the engine's speed governor to the already closed vent valve, via which venting takes place.

After completion of the shutdown operation, the frictional connection between engine and propeller shaft is interrupted; the propeller shaft is driven by the 'turbine effect' of the propeller and continues to turn at the 'drag speed'. The engine runs at the idling speed.

To change the direction of rotation, the control lever must be set to a position in the opposite direction via the neutral position. After completion of the shutdown operation, the power-up process is initiated. The required torque is greater than during a shift operation without a change in the direction of rotation because the propeller shaft is first retarded before it can be accelerated in the opposite direction.

If the required torque exceeds the drive torque available from the engine or the maximum torque that can be transmitted from the clutch coupling, then the power-up operation must be delayed until the shifting conditions are met through reduction of the drag speed.

The time required from completion of the shutdown operation to completion of the power-up operation and the distance covered during this period are dependent upon:

- the design data of the ship (torque characteristics of the engine, shifting power of the coupling), and
- the particular operating conditions (direction of travel, rate of speed and load condition) of the ship.

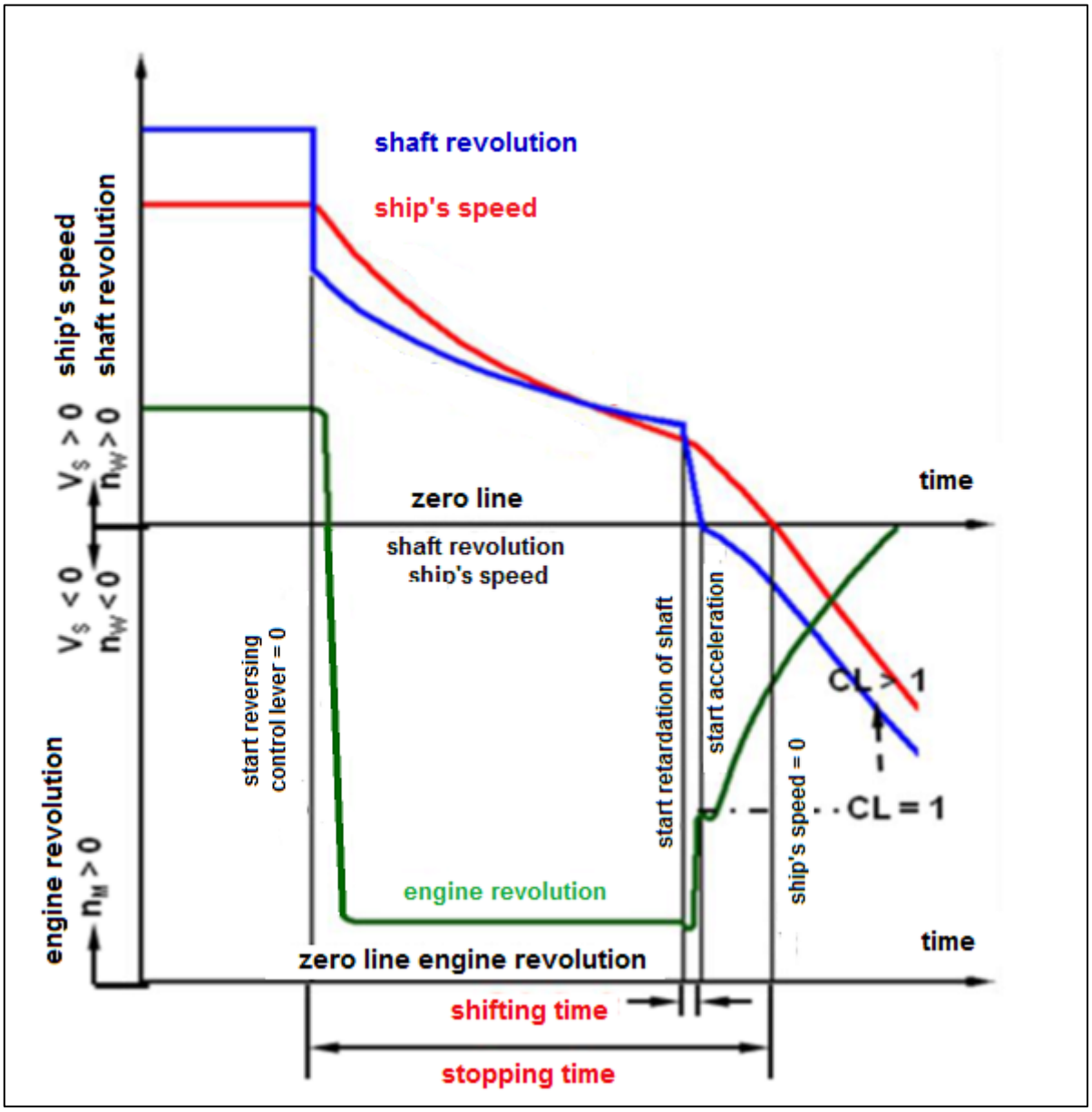

Figure 10: Typical behaviour of the parameters during changes in the direction of rotation

Various valves open if there is a loss of control air (or if the emergency stop valve is operated). As a result, the frictional connection between engine and propeller shaft is interrupted, the propeller shaft continues to rotate at the drag speed and the engine at the idling speed.

If the manoeuvring valve malfunctions (blockage), it does not open when the control lever is set to the neutral position. The control oil pressure for the coupling is not interrupted and the coupling and stop valve remain closed. The frictional connection

between engine and propeller remains intact. The propeller shaft is then powered by the engine at the idling speed. The propeller's direction of rotation cannot be reversed. Regardless of the position of the control lever, the engine rotates according to the direction of rotation determined by the position of the manoeuvring valve.

If TV (throttle valve) 1 or TV 2 (see Fig. 7) is obstructed (no flow), then the manoeuvring valve remains closed. Couplings are not closed and the engine continues to rotate at the idling speed. If this TV fails (full flow), then the manoeuvring valve closes almost simultaneously with the vent valve. There is a risk of speed suppression down to the engine stopping due to the insufficient increase in the engine speed prior to a coupling's shift operation.

If TV 3 is obstructed, then the control air line to the engine's speed governor is closed and the engine continues to rotate at the idling speed even if the coupling is closed. It is possible that there will be rapid variations in the number of revolutions of the engine if this valve fails. There is a risk of the engine being overloaded when it is under acceleration.

The expert did not find any deficiency on the propulsion system during the inspection of the engine room. The machinery's state of repair was satisfactory. The engine room personnel carried out any necessary maintenance work, thus ensuring serviceability and availability of the propulsion system.

3.2.2 Propulsion data

Stopping times, advance distances, and the behaviour of the ship during such manoeuvres are important items of information for the safe operation of the ship. In addition to other manoeuvring characteristics of the ship, they are determined during technical trials at the shipyard. The findings are recorded on the bridge poster and in the summary of manoeuvring information and thus available to the bridge personnel.
The following approximate values for the engine power and available torque can be calculated from the data determined during the ballast condition sea trial.

Rate of speed	Rated speed (rpm)	v (kts)	P (kW)	M (kNm)
Full	500	13	3,415	65.2
Half	460	10	1,554	38.2
Slow	360	6	336	8.9
Dead slow	230	3.5	67	2.8
Idling	200	2	20	0.95

It is also possible to ascertain that a reverse manoeuvre can be initiated at a speed of about 4.7 kts without deceleration or risk to the engine.

Analysis of the stopping distances in ballast condition reveals that it is possible to stop the SAINT GEORGE within a distance of at least some 74 m (0.4 cable) using a full astern manoeuvre if the initial speed is 6 kts (rate of speed: slow).

3.2.3 Controls

In accordance with the relevant construction requirements, the SAINT GEORGE is equipped with two engine order telegraphs for transmission of the required rate of speed and direction of rotation from the bridge to the control stand in the ECR and at the engine.

The two engine order telegraphs are positioned on the bridge at the manoeuvring platform to the right of the main steering position (see Fig. 11). The main engine order telegraph left in the figure only connects the bridge with the control stand in the ECR.

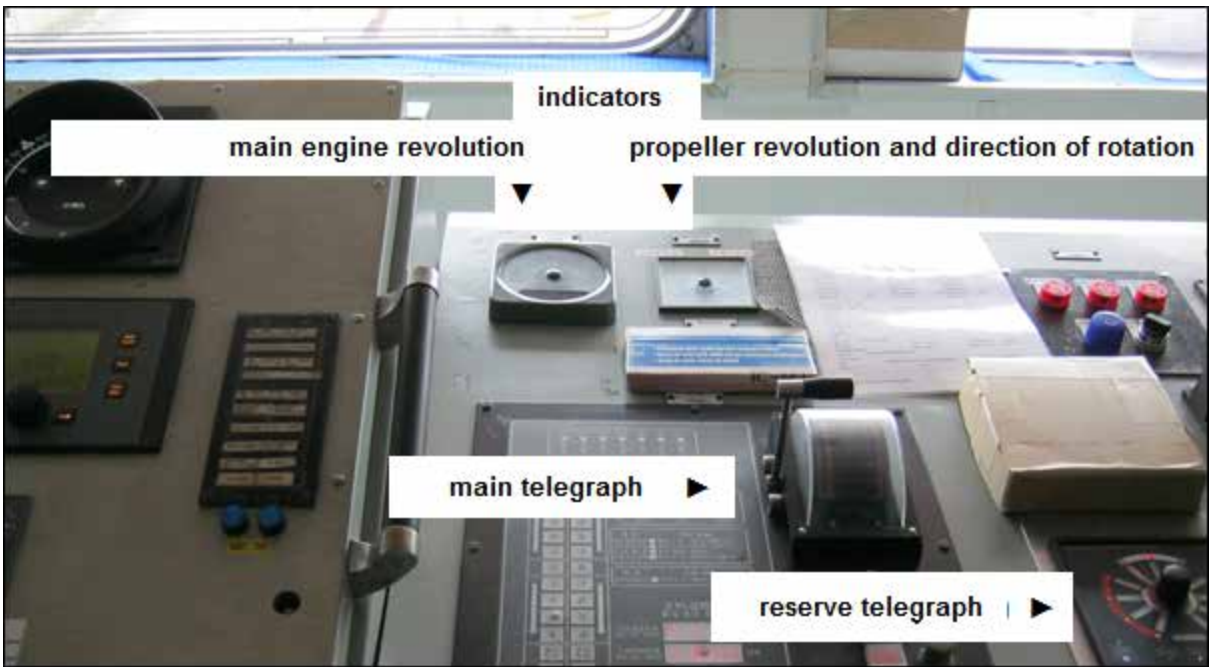

Figure 11: Engine order telegraphs on the bridge

The required direction of rotation of the propeller shaft and rate of speed are set with a lever on the bridge engine order telegraph (main telegraph) and forwarded to the engine order telegraph in the ECR via a synchro transmitter. Pointers and indicator lights display the entered and current command.

The pointers adopt unequal positions when a new command is entered. The indicator light for the new rate of speed starts to flash and an audible signal sounds at the same time. At the moment that the pointers have been brought into an equal position by operating the lever on the engine order telegraph in the ECR, the indicator lights stop flashing (i.e. are on permanently) and the audible signal ceases.

If an order that entails changing the propeller shaft's direction of rotation is issued, then an additional indicator light appears and an additional audible signal sounds.

The second (reserve) engine order telegraph connects the bridge with the control stand in the ECR, as well as with the control stand directly at the engine. This engine order telegraph is disc shaped and smaller than the (main) engine order telegraph discussed above.

Figure 12: Engine order telegraph at the engine's control stand

Rather than a lever, a rotary control at the bridge engine order telegraph is used to set the required direction of rotation of the propeller shaft and rate of speed, which are then forwarded to the engine order telegraph in the ECR (or the engine control stand). The pointer on the rotary control and indicator lights displays the entered and current command. To enter a new command, the rotary control is turned to the required rate of speed. The indicator lights for this rate of speed flash on the two connected engine order telegraphs and an audible signal sounds at the same time. The engine room personnel confirm this command by also turning the rotary control on the engine order telegraph at the engine to the ordered rate of speed. The indicator lights for this rate of speed stop flashing (i.e. are on permanently) and the audible signal ceases on both engine order telegraphs. If an order that entails changing the propeller shaft's direction of rotation is issued, then an additional indicator light appears and an additional audible signal sounds.

A visual and performance test was carried out on the main and reserve engine order telegraphs after the accident. No defects or malfunctions could be found.

The controls for the bow thruster are positioned on the main control stand to the left of the main steering position.

3.2.4 Indicator for propeller speed and direction of rotation

The SOLAS Convention states that indicators for the propeller speed and direction of rotation shall be provided at the navigation bridge, in the ECR, and at the manoeuvring platform.

Such indicators are implemented by means of analogue pointer instruments on the SAINT GEORGE. The indicator on the bridge is positioned in the console above the engine order telegraph (see Fig. 11). In the ECR, a identical indicator is also located in the immediate vicinity of the engine order telegraph.

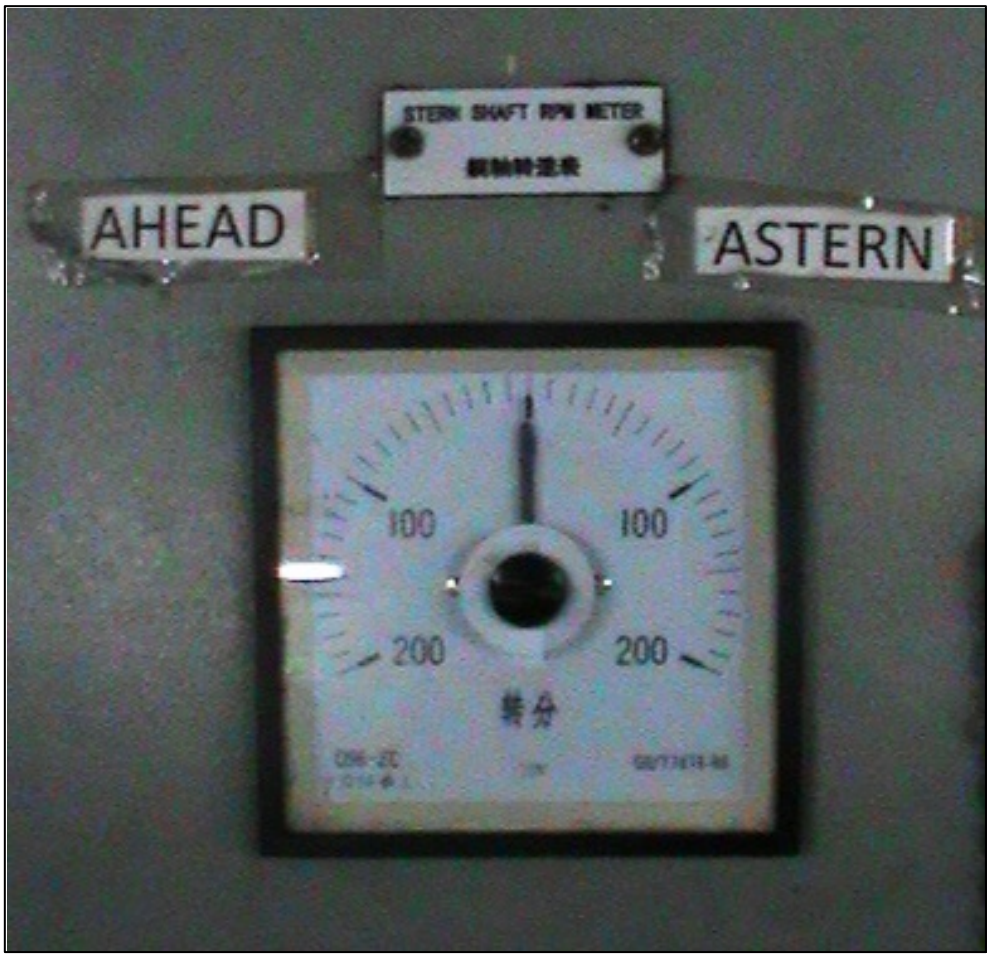

Figure 13: Indicator for rated speed and direction of rotation of the propeller in the ECR

Propeller shaft revolution indicators are also located in the port and starboard wings, positioned next to a rudder angle indicator (see Fig. 14) in each case.

Figure 14: Indicators in the starboard wing

3.2.5 Voyage data recorder

The SAINT GEORGE is equipped with a Kelvin Hughes MDP-A3 voyage data recorder (VDR). The last annual performance test was made on 18 December 2014 in Rotterdam. An emergency backup was made after the accident, meaning the data of relevance were available for the investigation.

The SAINT GEORGE is equipped with an X-band and an S-band radar unit. In accordance with the relevant performance standards, only the radar images from the X-band radar unit were recorded on the VDR. This radar unit was initially operated at a range of 3 nm. The unit was switched to standby mode when the SAINT GEORGE reached the outer port of the lock at Brunsbüttel.

The recorded data from the position sensor (Furuno GPS GP 150) and speed log (Furuno DS 80) are reproduced in the following table.

Time	Position		STW	SOG	Time	Position		STW	SOG
	Latitude N	Longitude E				Latitude N	Longitude E		
122000	53°53.3956	9°08.2215	5.2	4.7	122504	53°53.5941	9°08.5958	3.4	2.6
122010	53°53.4032	9°08.2357	5.2	4.6	122507	53°53.5955	9°08.5979	3.4	2.7
122020	53°53.4109	9°08.2523	5.1	4.5	122511	53°53.5973	9°08.6013	3.4	2.7
122030	53°53.4184	9°08.2688	5.0	4.4	122514	53°53.5985	9°08.6041	3.4	2.8
122040	53°53.4263	9°08.2834	4.9	4.3	122517	53°53.5999	9°08.6071	3.4	2.8
122050	53°53.4341	9°08.2982	4.8	4.2	122520	53°53.6014	9°08.6107	3.5	2.9
122100	53°53.4413	9°08.3141	4.7	4.2	122523	53°53.6031	9°08.6140	3.5	2.9
122110	53°53.4484	9°08.3286	4.6	4.0	122526	53°53.6050	9°08.6174	3.6	3.0
122120	53°53.4557	9°08.3423	4.5	4.0	122529	53°53.6068	9°08.6209	3.6	3.0
122130	53°53.4630	9°08.3563	4.4	3.9	122533	53°53.6092	9°08.6256	3.7	3.1
122140	53°53.4701	9°08.3719	4.4	3.8	122536	53°53.6106	9°08.6290	3.9	3.2
122150	53°53.4770	9°08.3855	4.3	3.8	122539	53°53.6118	9°08.6320	4.0	3.3
122200	53°53.4839	9°08.3980	4.2	3.7	122542	53°53.6133	9°08.6355	4.1	3.4
122210	53°53.4907	9°08.4108	4.1	3.7	122545	53°53.6151	9°08.6391	4.2	3.5
122220	53°53.4971	9°08.4242	4.0	3.6	122549	53°53.6176	9°08.6443	4.4	3.6
122230	53°53.5037	9°08.4372	3.9	3.5	122552	53°53.6201	9°08.6486	4.5	3.8
122240	53°53.5103	9°08.4488	3.9	3.5	122555	53°53.6232	9°08.6529	4.6	3.9
122250	53°53.5171	9°08.4597	3.8	3.4	122558	53°53.6252	9°08.6577	4.8	4.1
122300	53°53.5233	9°08.4717	3.8	3.3	122601	53°53.6277	9°08.6624	5.0	4.2
122310	53°53.5293	9°08.4825	3.8	3.3	122604	53°53.6302	9°08.6675	5.2	4.3
122320	53°53.53°56	9°08.4936	3.7	3.2	122607	53°53.6327	9°08.6725	5.4	4.4
122330	53°53.5417	9°08.5044	3.7	3.2	122611	53°53.6359	9°08.6799	5.5	4.6
122340	53°53.5477	9°08.5156	3.7	3.1	122614	53°53.6396	9°08.6851	5.7	4.8
122350	53°53.5540	9°08.5262	3.6	3.0	122617	53°53.6432	9°08.6906	6.0	4.9
122400	53°53.5601	9°08.5360	3.6	3.0	122620	53°53.6465	9°08.6964	6.2	5.0
122410	53°53.5659	9°08.5454	3.6	2.9	122623	53°53.6497	9°08.7021	6.4	5.1
122420	53°53.5714	9°08.5547	3.5	2.8	122626	53°53.6527	9°08.7083	6.6	5.3
122430	53°53.5766	9°08.5638	3.5	2.8	122629	53°53.6559	9°08.7147	6.7	5.3
122440	53°53.5813	9°08.5738	3.5	2.7	122633	53°53.6588	9°08.7220	5.9	5.1
122450	53°53.5865	9°08.5829	3.4	2.7	122636	53°53.6592	9°08.7232	4.6	3.4
122452	53°53.5876	9°08.5847	3.4	2.7	122639	53°53.6588	9°08.7237	3.3	2.4
122455	53°53.5893	9°08.5873	3.4	2.7	122642	53°53.6585	9°08.7238	2.0	1.2
122458	53°53.5908	9°08.5901	3.4	2.7	122645	53°53.6582	9°08.7242	0.5	0.9
122501	53°53.5923	9°08.5929	3.4	2.6	122648	53°53.6578	9°08.7245	0	0.5

Spreadsheet 1: VDR data

Data on orders and responses for the machinery status of the main engine (settings of the engine order telegraph, shaft speeds, directions of rotation, etc.) and thruster were not recorded. The orders and responses for rudder angles and the main alarms (mandatory alarms on the bridge according to the IMO) were not recorded, either.

The audio recording includes discussions on the bridge (four microphones) and the radio traffic directly on the VHF device. The quality of the audio recording is sufficient.

Since the machinery status was not recorded, the pilot's recommendations on the main engine's rate of speed from pilot transfer up until the collision are reproduced in the table below using the audio recording of the VDR.

Time	Engine command
1204	Pilot transfer – engine running at the rate of speed dead slow ahead
120650	Dead slow ahead
121010	Stop engine
121418	Dead slow ahead
121742	Stop engine
122451	Dead slow astern, bow thruster full to starboard
122514	Slow astern
122541	Half astern
122557	Full astern

3.2.6 Manoeuvre recordings

As mentioned in the previous section, the VDR did not record the machinery data. The data were not recorded automatically in the ECR by a manoeuvre printer or similar, either. Instead, a manoeuvre log (bell book) was kept by hand on the bridge and in the ECR. The third officer was responsible for doing this on the bridge. The electrician kept the manoeuvre log in the ECR. Extracts of relevance to the accident from the manoeuvre logs are shown in the following figures[4]. A comparison of the clocks on the bridge and in the ECR with GPS time made after the accident did not reveal any significant differences.

[4] Highlighting in Figs. 15 and 16 added by the BSU.

BRIDGE BELL BOOK

Ship SAINT GEORGE Voyage No. 018 Date 20-03-2015

Port ..... Arrived ..... Departed .....

AHEAD				STOP	ASTERN			
D. SLOW	SLOW	HALF	FULL		D. SLOW	SLOW	HALF	FULL
POB	- 0930		(E) ELBE BOY					
		1110						
	1115							
1120								
1142	1130			1145				
1150				1155				
ELBE	PILOT	OFF	— 1205					
1157				1200				
BRUNS BUTTEL PILOT ON				BOARD	- 1200		BOSP	
1215	1216			1220 OFF THE LOCK	1222	1223	1223	
1225	TOUCH THE GATE, & LET				GO BOTH ANCHOR - 1224			
1230	VESSEL ALONG			SIDE.				
1310	PILOT OFF							

Master/Chief Engineer

Officer on Watch

Figure 15: Extract from the manoeuvre log on the bridge

ENGINE BELL BOOK

Ship SAINT GEORGE Voyage No. Date 20 MAR 2015

Port KIEL CANAL Arrived ✓ Departed

AHEAD				STOP	ASTERN			
D. SLOW	SLOW	HALF	FULL		D. SLOW	SLOW	HALF	FULL
		0917		TRANSIT PILOTAGE				
	0920							
		0931						
			0932					
		1111						
	1114							
1117	1132							
1143				1145				
1152				1156				
1159								
				1200				
1205				1210				
1214				1218				
1225	1225	1226	1226					1227
				1227				
1228				1228				
1228				1229				
M/E STOP - 1241 H - AS PER ORDER FROM BRIDGE								

Master/Chief Engineer

Officer on Watch

Figure 16: Extract from the manoeuvre log in the ECR

3.2.7 Environmental conditions

The SAINT GEORGE sailed into the lock at Brunsbüttel at about 1220 on 20 March 2015. At this point, a force 2 Bft west-north-west wind prevailed. Visibility was good. The next high tide at Brunsbüttel was predicted for 1407. The rising tide on the River Elbe was setting east-north-east at a maximum speed of some 3 kts.

3.2.8 Manning

The minimum safe manning certificate stipulates a minimum crew of 12 people for the SAINT GEORGE. At the time of the accident, the crew consisted of 18 people, including four of Russian or Ukrainian nationality. The other 14 people were from the Philippines.

The 48-year-old Ukrainian master graduated from the Odessa Maritime Academy in 1989, which was followed by periods of service as a watchkeeping officer and chief mate. He was promoted to master in 1998 and has since worked in this position on various ships similar to the SAINT GEORGE. The accident happened toward the end of his six-month service contract.

4 ANALYSIS

The SAINT GEORGE's entry manoeuvre into the Neue Nordschleuse lock at Brunsbüttel began at 1204 on 20 March 2015 when the canal pilot boarded the ship. The VTS had already cleared the lock for entry at 1150. At this point (two hours before high tide, spring tide), the rising tide had reached its maximum speed, which is specified at 3.11 kts[5] at buoy 58a.

It is possible to trace the entry manoeuvre using data from the VDR and automatic identification system (AIS). These data did not exhibit any inconsistencies.
The ship was running at dead slow ahead during the pilot transfer. This rate of speed was maintained initially. The SAINT GEORGE was first turned in on the main line. The engine was stopped at 1210 when the SOG stood at 7.9 kts. An order to set the engine to dead slow ahead again was issued at 1214 to gain the required ability to steer when entering the outer port and passing through the shear zone[6]. At this point (see Fig. 17), the SAINT GEORGE's SOG stood at 5.7 kts.

Figure 17: AIS display at 121417

[5] Page 110 of the BSH's Nordsee-Handbuch Südöstlicher Teil (North Sea sailing directions; south-easterly section).
[6] Transition between the current on the River Elbe and the outer port, which is not affected by a current.

The engine was stopped again at 1217 after the SAINT GEORGE had completely passed the line joining mole 3 and mole 4 (see Fig. 18). Her SOG now stood at 6.5 kts.

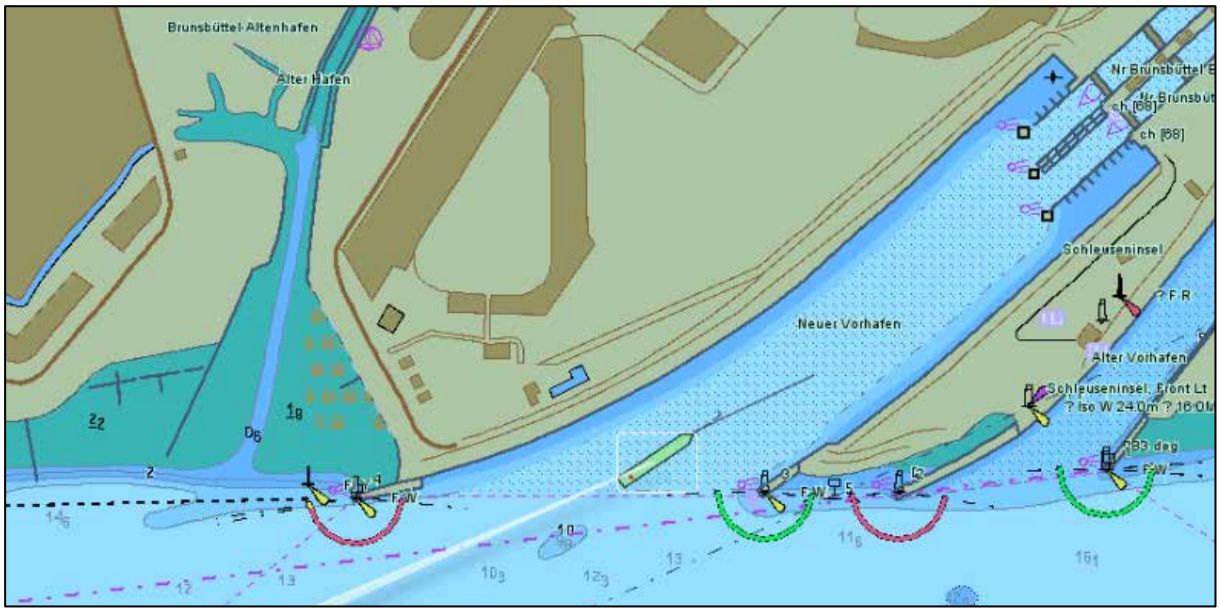

Figure 18: AIS display at 121746

The SAINT GEORGE then sailed first into the northern berthing jetty with engine stopped. The fore section passed the outer gate of the Neue Nordschleuse lock at 122327 (see Fig. 19); the SOG was 3.2 kts.

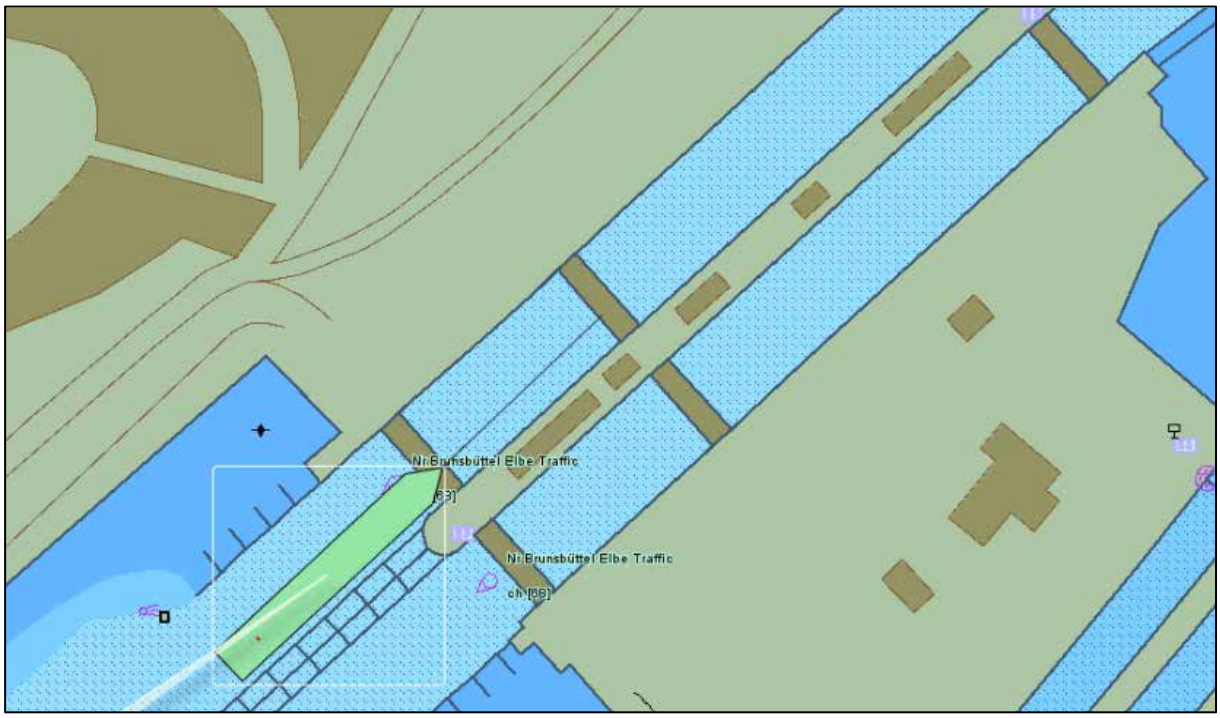

Figure 19: AIS display at 122327

At 122451, after the SAINT GEORGE had entered the lock completely (see Fig. 20), the pilot issued an order to set the engine to dead slow astern and bow thruster to full to starboard. The SOG was 2.7 kts at this point and the distance to the lock gate about 200 m. The SAINT GEORGE's manoeuvring characteristics indicate that she could be stopped safely before reaching the lock gate.

Figure 20: AIS display at 122446

Since the speed reduction required for stopping did not materialise, the pilot issued an order to set the engine to slow astern at 122514. The SOG was 2.8 kts and the distance to the lock gate about 170 m. Instead of slowing down, the SAINT GEORGE now clearly accelerated. An order to set the engine to half astern was issued at 122541. At this point, the lock gate was about 100 m away and the ship ran at 3.4 kts SOG. An order to set the engine to full astern was eventually issued at 122541. The SOG had now increased to 4 kts and the distance to the lock gate was about 100 m.

An order to drop the port anchor was issued a few seconds later. Due to the hectic atmosphere, the crew on the forward manoeuvring station immediately dropped both anchors. This manoeuvre was destined to fail because the SAINT GEORGE continued to accelerate. Consequently, the SAINT GEORGE collided with the lock gate at 122633. Her SOG had now increased to 5 kts. After the collision, the SAINT GEORGE freed herself without assistance and was able to moor safely in the lock.

The analysis of the entry manoeuvre revealed that rather than slowing down, the SAINT GEORGE constantly accelerated in the lock.

Corresponding statements of the two people working in the ECR indicate that the rates of speed (from dead slow ahead to full ahead) entered in the manoeuvre log (engine) were ordered from the bridge and the chief engineer officer set the engine accordingly. Orders to set the engine from full ahead to full astern were not issued until the very end. The two people had full view of the engine order telegraph. The entries in the engine's manoeuvre log were largely consistent with the speed and audio recordings. The engine room personnel had no means of tracing the actual position of the ship in the ECR.

The crew members working on the bridge (helmsman and third officer) did not monitor operation of the engine order telegraph by the master. The expert tested the engine order telegraphs after the accident and no malfunction was found. On the merits of the case, the BSU assumes that the master set the engine order telegraph to the wrong direction inadvertently. The mandatory VDR could have provided absolute certainty in this regard. Despite being required according to the VDR performance standards[7], the position of the engine order telegraph was not recorded. The scope of the data recorded corresponded only with the standards for a simplified voyage data recorder (S-VDR). S-VDRs may only be installed on ships that had their keel laid before 1 July 2002[8], however. The SAINT GEORGE's keel was laid on 31 December 2005.

The reserve engine order telegraph was used during the entry manoeuvre. The crew claimed that it had never used the main telegraph. This was justified by the fact that previous crews had reported faults not specified in greater detail. The crew had no experience with the main telegraph.

Operation of the main engine order telegraph is carried out instinctively, i.e. the lever is pushed forward for moving ahead and pulled backward for moving astern. By contrast, the rotary control for the reserve engine order telegraph is turned to the left or right. A stipulation that the rates of speed ahead are set in a clockwise direction and astern in an anti-clockwise direction is necessary. The propeller's direction of rotation is shown in the opposite direction to the emergency telegraph on all the indicators (bridge, ECR, wings) on the SAINT GEORGE (see Fig. 21). Such a display contradicts the stipulation, which is also reflected in the relevant technical regulations[9]. These state that a ship's ahead movement should be shown in a clockwise direction.

[7] IMO Resolution A.861(20) of 3 December 1997.
[8] SOLAS Chapter V Regulation 20.
[9] ISO 22554: Ships and marine technology - Propeller shaft revolution indicators. Section 4.3.3.

Figure 21: Comparison between the engine order telegraph and indicator showing the direction of rotation

Even though – as in the SAINT GEORGE's case – the direction of rotation is marked clearly on the indicator, a display contrary to the norm can lead to misinterpretations.

The pilot claimed that he explained to the master the entry manoeuvre in the outer port in rising tide at the start of the pilotage assignment. Such an explanation cannot be inferred from the audio recording from the VDR. The pilot merely noted that they were sailing with the current. The master was of the opinion that the ship was reportedly still very fast after she had passed the shear zone. He voiced his concerns to the pilot when the SAINT GEORGE sailed into the lock's berthing jetty. The pilot replied that he intended to start the astern manoeuvre only after the outer gate was passed, so as to maintain the ship's ability to steer and prevent any damage.

The first astern command was issued about one minute after this conversation. Up to this point, the manoeuvre had passed with no complications whatsoever and there was no indication that it might still be unsuccessful.

The diagram showing the SAINT GEORGE's speed curve during the entry manoeuvre illustrates how the speed was initially more or less constant after the dead slow astern command. The speed first rose moderately after the slow astern command and then sharply after the half astern command (see Fig. 22).

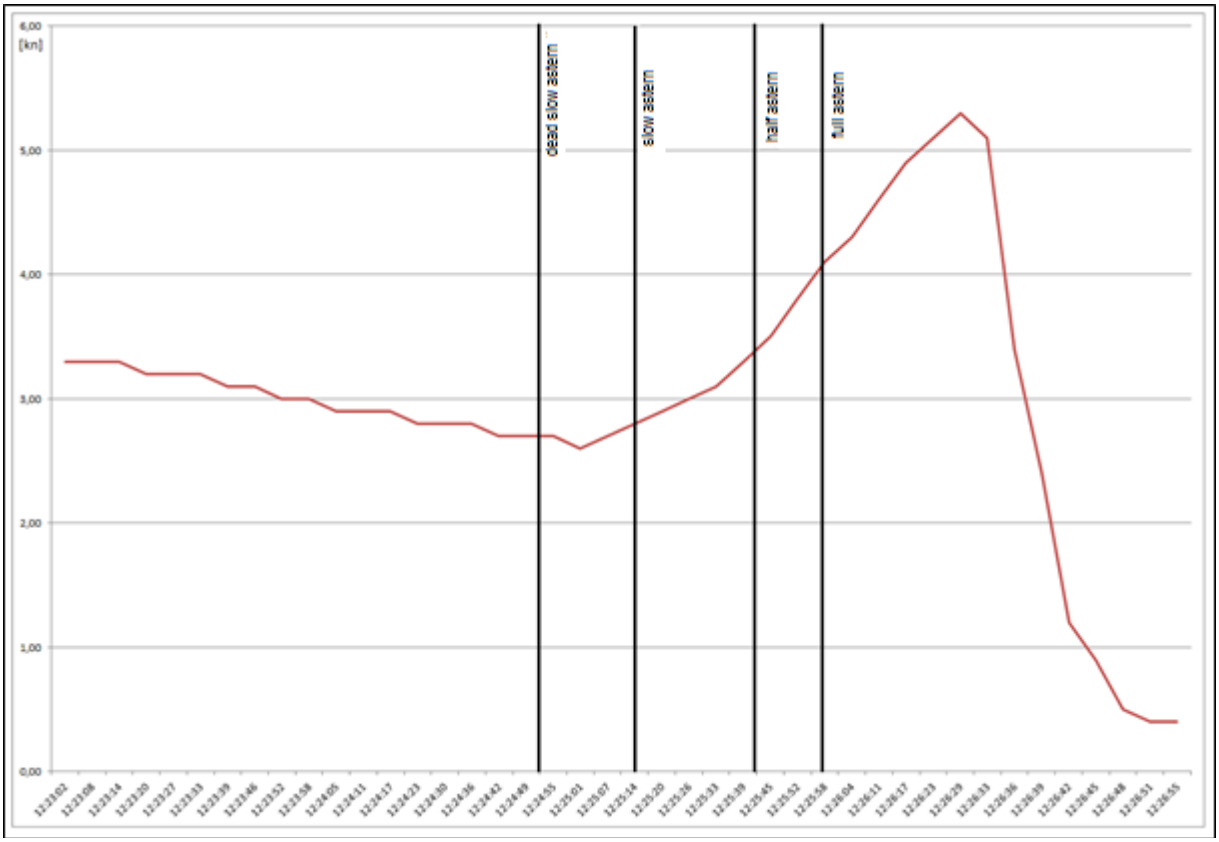

Figure 22: Diagram showing the speed curve

The pilot went to the starboard wing after the first astern command. He believed that the SAINT GEORGE's position and course were as they should be. Since it seemed to him that the reduction in speed was insufficient, he issued the slow astern command. This rate of speed should have caused the ship (in ballast condition) to come to a standstill rapidly. Since this did not materialise, he issued the half astern command. Immediately afterwards, the pilot noticed that the SAINT GEORGE was accelerating. He then returned to the wheelhouse and ordered that the rate of speed be set to full astern. The master did not acknowledge the two previous engine commands in the usual manner by repeating them, but rather with the following words: "Already, already!" and "That's why I told you!". This implies that the master had not noticed the increase in speed, but rather assumed that a very strong astern manoeuvre was now necessary due to the initial speed, which he believed was very high. It was not until after the anchors had been dropped that the pilot informed the master of his observations vis-à-vis the increase in speed. Neither the third officer on the bridge nor the two other officers on the manoeuvring stations, who were able to communicate with the bridge using handheld transceivers, indicated to the master that the SAINT GEORGE had accelerated.

5 CONCLUSIONS

It was possible to reconstruct the course of the entry manoeuvre using the technical and written recordings, as well as the witness testimony. Fortunately, in spite of heavy material damage, nobody came to physical harm as a result of the SAINT GEORGE colliding with the lock gate.

The SAINT GEORGE's entry manoeuvre happened as the rising tide reached its maximum level. As a result, the speed when entering the lock was toward the upper limits of the norm. Consequently, the window of time available, which was narrow in any case, for preventing a collision with the lock gate after the occurrence of a fault by making a correction reduced further.

A technical failure of the machinery or its control system can be ruled out.

In all probability, the accident was caused by an error in operating the engine order telegraph on the bridge. The BSU is of the opinion that this momentary lapse was facilitated by the use of the reserve engine order telegraph. Due to the technical design (lever ahead or astern), an error in operating the main engine order telegraph is less likely. The risk of confusion on the SAINT GEORGE was increased further by the opposing displays on the reserve engine order telegraph and indicator showing the direction of rotation.
Moreover, the arrangement of the bow thruster and engine order telegraph controls to the left and right of the main steering position, respectively, was rather ineffective. It causes the operator to have to walk around the helmsman repeatedly.
However, it should be noted at this point that the master has extensive experience and was sufficiently familiar with the local conditions on the SAINT GEORGE.

In the bridge management practised on the SAINT GEORGE, the third officer was entrusted only with keeping the log book and relaying commands during the entry manoeuvre. Monitoring or verifying commands, inputs, and the movement of the ship was not carried out and not required, either.
Given that a particularly strong rising tide prevailed at the time of entry, the exchange of information between the master and pilot might have been more detailed.

6 SAFETY RECOMMENDATIONS

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

6.1 Ship's command of the SAINT GEORGE

The Federal Bureau of Maritime Casualty Investigation recommends that the ship's command of the SAINT GEORGE use the main engine order telegraph whenever possible. In the event of a fault, an inspection and repair should be carried out without undue delay.

6.2 Ship's management of the SAINT GEORGE

The Federal Bureau of Maritime Casualty Investigation recommends that the ship's management of the SAINT GEORGE modify the indicators for the propeller's speed and direction of rotation, so that the display conforms to the norm.

6.3 Ship's management of the SAINT GEORGE

The Federal Bureau of Maritime Casualty Investigation recommends that the ship's management of the SAINT GEORGE implement an appropriate retrofit on the VDR installed on board the ship, so as to ensure that the data required by the VDR performance standards are recorded at minimum.

7 SOURCES

- Investigations of WSP Brunsbüttel

- Written statements
  - Ship's command
  - Pilot

- Witness testimony

- Opinion of Prof. Dipl.-Ing. Hark Ocke Diederichs

- Nautical charts and ship particulars: Federal Maritime and Hydrographic Agency (BSH)

- AIS recordings, VTS