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

Investigation Report 415/06

**Serious marine casualty**

# Capsizing of the Pilot Tender ELBE 3 while casting off from MV DELTA ST. PETERSBURG on 23 August 2006 north of Elbe Buoy (Elbetonne) 1

1 August 2007

www.bsu-bund.de

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 200.

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

This report is not to be used in court proceedings or proceedings of the maritime court investigation. Reference is made to § 19 Paragraph 4 SUG.

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At about 12:15[1] h on 23.08.2006, approx. 0.5 nm north of Elbe Buoy 1, the Pilot Tender ELBE 3 heeled so far to port on casting off from MV DELTA ST. PETERSBURG that it capsized and floated upturned.

All three persons on board were rescued.
One of the persons was injured and was admitted to the municipal hospital Cuxhaven, where he was treated as an in-patient.

The pilot tender was salvaged and set into operation again after extensive repairs. There was no visible damage to DELTA ST. PETERSBURG.
No environmental damage was reported.

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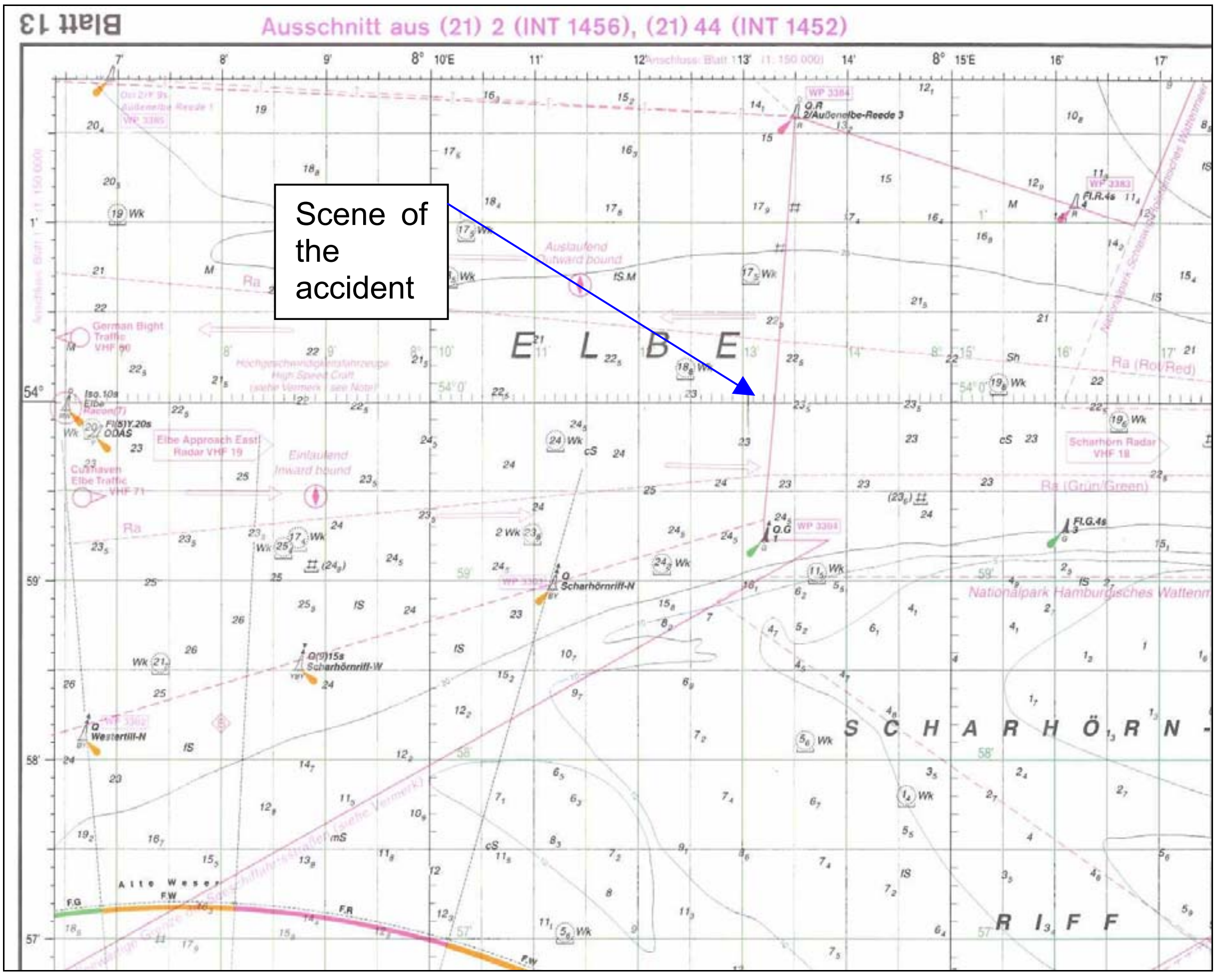
[1] All times in CEST - Central European Summertime = UTC + 2 h

## 2 Scene of the accident

| | |
|---|---|
| Nature of the incident: | Serious marine casualty, one injured person |
| Date/Time: | 23 August 2006, approx. 12:15 h |
| Location: | Elbe, off buoy 1 |
| Latitude/Longitude: | φ 54°00.00’N λ 008°13.02’E |

Section of Chart 3014, sheet 13 Federal Maritime and Hydrographic Agency



+Figure 1: Chart

# 3 Vessel particulars

## 3.1 DELTA ST. PETERSBURG

Figure 2: DELTA ST. PETERSBURG

(Photo : Hasenpusch)

## 3.2 Main particulars

| | |
|---|---|
| Name of vessel: | DELTA ST. PETERSBURG |
| Type of vessel: | Container vessel |
| Nationality/Flag: | Gibraltar |
| Port of Registry: | Gibraltar |
| IMO Number: | 9301093 |
| Call sign: | ZDHG 8 |
| Vessel operator: | Beluga Shipping GmbH |
| Year built: | 2006 |
| Building yard/location: | Vollharding Shipyards, Netherlands |
| Classification: | Germanischer Lloyd |
| Length over all: | 154.85 m |
| Length between perpendiculars: | 144.89 m |
| Width over all: | 21.50 m |
| Gross tonnage: | 8,971 |
| Draft at time of accident: | Df = 6.70 m, Dm = 6.90 m, Da = 7.10 m |
| Displacement: | approx. 10,600 t |
| Service speed: | 18.7 kn |
| Engine rating: | 7,999 kW |
| Main engine: | MaK 8M 43 C |
| Rudder: | Flap rudder, type Becker's rudder |
| Number of crew: | 15 |

## 3.3 Pilot Tender ELBE 3

Figure 3: Pilot Tender ELBE 3

## 3.4 Main particulars

| | |
|---|---|
| Name of vessel: | ELBE 3 |
| Type of vessel: | Motor boat, pilot tender |
| Nationality/Flag: | German |
| Port of Registry: | Cuxhaven |
| Operator: | Lotsbetriebsverein Hamburg e.V. |
| Year built: | 2002 |
| Building yard/location: | Fr. Fassmer GmbH & Co.KG / Berne |
| Length over all: | 7.50 m |
| Width over all: | 2.60 m |
| Draft at time of accident: | approx. 1.00 m |
| Displacement: | approx. 4.8 t |
| Service speed: | 18 kn |
| Engine rating: | 157 kW |
| Main engine: | MTU 6 R099 TE 91 |
| Number of crew: | 2 + max. 5 pilots |

# 4 Course of the accident

On 23.8.2006 the Container Vessel MV DELTA ST. PETERSBURG was proceeding downstream the river Elbe on a voyage from Hamburg to Rotterdam. One hour before reaching the Pilot Station Vessel ELBE, DELTA ST. PETERSBURG was informed that due to the low freeboard of 2 m, the smaller Pilot Tender ELBE 3 was designated to collect the pilot.

A WNW wind force 3 and a light north-west swell prevailed in the Elbe estuary, so that the pilot ladder was rigged on the port side, the lee side of the vessel. On passing Buoy 6 the Station Vessel ELBE was informed that it was planned to collect the pilot on the port side.

Shortly before reaching the station vessel the Master of DELTA ST. PETERSBURG was instructed by the pilot to reduce speed to approx. 6 kn for the approaching collection manoeuvre and after passing the station vessel to turn to a southern course in order to make lee[2] and ensure safe collection.
The vessels rate of speed was reduced and on passing the station vessel the pilot bid his farewells to the bridge and made his way to the main deck. When he was on the port side next to the pilot ladder, DELTA ST. PETERSBURG was already on a southern course with good lee.

There were two crew members on the main deck by the pilot ladder.

The Pilot Tender ELBE 3 manned with a boatswain and a seaman came alongside close to the pilot ladder and the pilot climbed over without any problems and together with the seaman went into the forward superstructure.

At this time the Master of DELTA ST. PETERSBURG was informed via radio channel 17 by one of his men at the pilot ladder "pilot is off" and 5 - 15 seconds later he was informed by his Second Mate who was standing on the port side of the bridge and observed the casting off manoeuvre: "pilot boat away". He thereupon increased the propeller pitch and began to turn over his starboard bow in order to reach his outgoing course of 275°. Shortly after this he was informed via channel 17 from the main deck that something was wrong with the pilot boat, whereupon he immediately reduced the pitch again.

On this occasion the casting off from DELTA ST. PETERSBURG proved difficult for the boatswain of ELBE 3, as the pilot tender did not get clear from the ship’s side and after a little time slipped ever further aft towards the stern of the container vessel with an increasing list to port. The boatswain still tried to get away from DELTA ST. PETERSBURG by increasing the engine speed to "full ahead" and setting the helm from port to starboard. After a short time, however, the list to port increased considerably so that the boatswain called to the persons in the superstructure to leave the interior. At this moment the pilot tender capsized.

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[2] When it "makes lee" the vessel is placed crossways to the wind so that on the side turned away from the wind, the lee side, there is an area protected from the wind, with lower wave height too.

The interior quickly ran full of seawater. During the capsizing incident the seaman and the pilot were able to pull themselves through the entrance hatch and dive to the surface of the water. On the surface of the water they swam to the completely capsized pilot boat that was lying upturned and helped the boatswain who was also swimming on the surface and losing strength and who threatened to slip out of his life jacket.

The Master of DELTA ST. PETERSBURG saw the capsized pilot boat at the stern and sounded the general alarm, notifying the crew that they should get the life boat ready. The turning manoeuvre was resumed in order to help the capsized pilot tender. The vessel notified the Station Vessel ELBE of this intention by radio. Station Ship ELBE declined this assistance as they had observed the capsizing and immediately launched an inflatable boat that picked up the three persons at the scene of the accident after about 8 minutes.
DELTA ST. PETERSBURG was instructed to stop the turning and to maintain its position.

All three persons in the water were wearing automatically inflatable life jackets.

The pilot tender lying in a stable, upturned floating position was subsequently picked up by MV VOGELSAND and taken to Cuxhaven.

# 5 Investigation

The BSU was notified of the accident by fax from the Waterways Police Cuxhaven at 18:45 h on 23 August 2006 and immediately started the investigation.

## 5.1 Weather Expertise by Germany's National Meteorological Service (DWD)

On behalf of the BSU the German Meteorological Service (DWD) issued an official expertise on the weather and sea conditions.
A shallow ridge of high pressure extended over the North Sea between a low pressure area moving eastwards over the Baltic Sea and another moving northwest of Scotland. The cloudiness was variable and partly cleared up and there were only very isolated, light showers of rain. At the time of the accident westerly winds (240° to 280°) prevailed, force 3 to 4 bft. The wave height of the sea was about 1 m with sea periods of about 6 sec. and a weak swell from a northerly direction. At 12.00 h a flood stream was running from a westerly direction at approx. 1.2 kn. The air temperature was between 13° and 14° and the water temperature was 19°.

## 5.2 Crews

At the time of the accident the crew of DELTA ST. PETERSBURG held all the necessary qualifications. The German Master sails this section of the Elbe generally twice a week. There were 15 crew members on board.

The boatswain of ELBE 3 holds a certificate of competence as Master in Baltic Sea fishing - B2 from the German Democratic Republic and has been a member of the pilots association (Lotsbetriebsverein) since 1999. The command of the pilot tender is assumed responsibly, alternating with the second crew member holding a seaman's certificate. The qualification for commanding the pilot tender is regulated by service regulations of the Lotsbetriebsverein.

## 5.3 DELTA ST. PETERSBURG

### 5.3.1 Inspection of the vessel

The BSU inspected DELTA ST. PETERSBURG for the first time in Hamburg on 2 September 2006.

No visible damage or paint abrasion was ascertained. DELTA ST. PETERBURG has a closed bridge. Visibility downwards to the pilot transfer station is easily possible through appropriately arranged light lattices. The Master stated that neither he nor a crew member had observed the capsizing of the pilot tender directly.
In other pilot operations it was normal for the pilot vessel to proceed ahead, only this time it had “sagged” off.

### 5.3.2 Pilot transfer facilities

The specifications for pilot transfer facilities are described in SOLAS Chapter V, Rule 23. It is stated under 2.2 in Rule 23:

”*The rigging of the pilot transfer arrangements and the embarkation of a pilot shall be supervised by a responsible officer having means of communication with the navigation bridge who shall also arrange for the escort of the pilot by a safe route to and from the navigation bridge.*”

The arrangement of the pilot ladder is described under 3.3 as follows:

*Safe and convenient access to, and egress from, the ship shall be provided by either:*

*3.3.1 a pilot ladder requiring a climb of not less than 1.5 m and not more than 9 m above the surface of the water so positioned and secured that,*
*3.3.1.1 it is clear of any possible discharges from the ship;*
*3.3.1.2 it is within the parallel body length of the ship and, as far as is practicable, within the mid-ship half length of the ship; ....*"

The pilot station with pilot ladder is arranged well aft on DELTA ST. PETERSBURG. From the transom to the pilot ladder is about 1/5 of the ship's length (34 m).
In this area the shell plating is still just parallel above the water surface. In the underwater area and also a few metres further aft in the above-water area the frame contours already fall inwards considerably.
The arrangement of the pilot ladder in the straight midships part halfway along the vessel would be approx. 77 m from the stern.

### 5.4 Recording of the marine casualty

The recording of the Vessel Traffic Services Centre (VTS) Cuxhaven and the Voyage Data Recorder (VDR) on board DELTA ST. PETERSBURG were used to evaluate the marine casualty. No other recordings, e.g. VDR data from other vessels in the vicinity or AIS data were available.

### 5.4.1 Vessel Traffic Service

The course of the voyage and the radio traffic of DELTA ST. PETERSBURG were evaluated on the basis of the data recorded by VTS Centre Cuxhaven. The course of the voyage of smaller craft, such as e.g. the Pilot Tender ELBE 3, is not plotted and recorded with the rest.

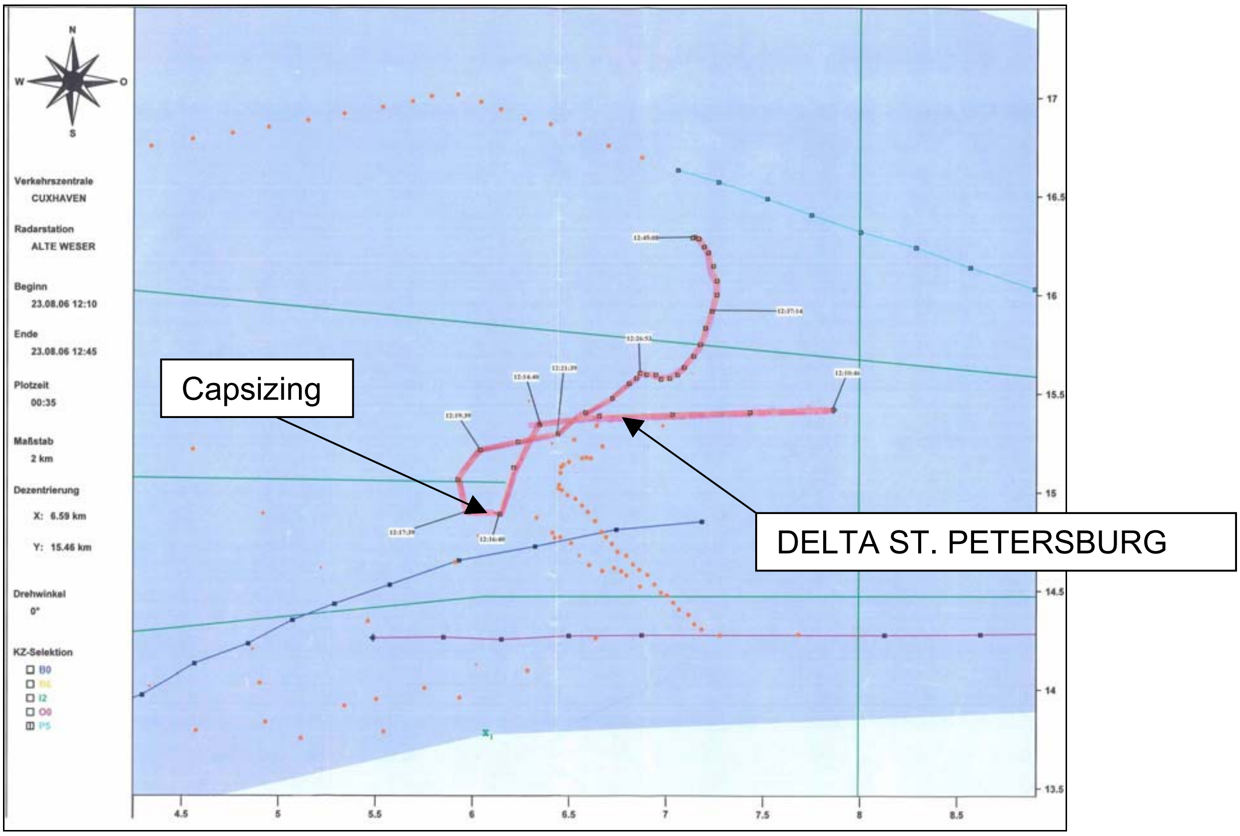


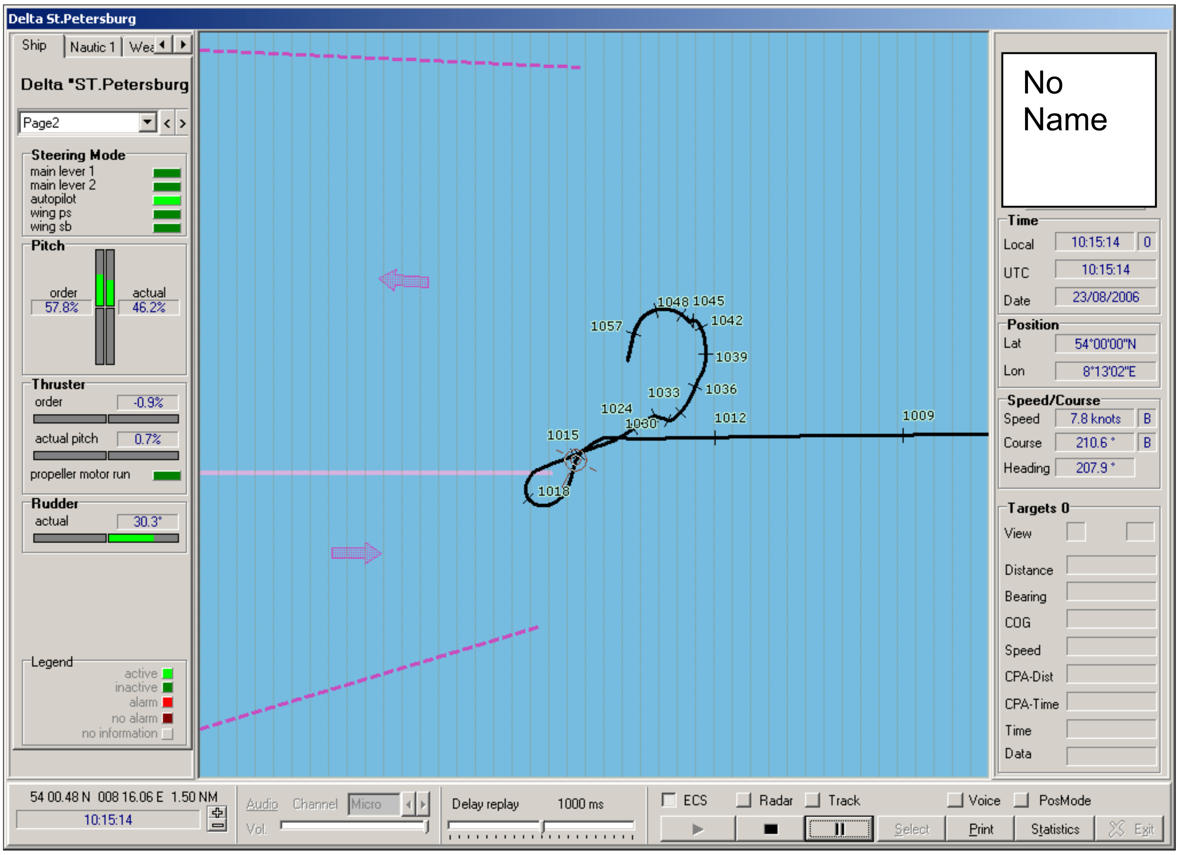
Figure 4: Radar plot of VTS Cuxhaven

The course of the voyage shows a distinct southerly course as of 12:14:40 and a reduction of speed down to 7.7 kn at 12:16:40, as well as subsequently a tight turning circle over the starboard bow.

### 5.4.2 Voyage Data Recorder (VDR)

DELTA ST. PETERSBURG is equipped with a Voyage Data Recorder (VDR) from a German manufacturer. After the marine casualty the Master immediately pressed the emergency back-up button. The analysis revealed that the recording of the radar was not working because of a defective video output on the radar device. Nor were any data of the speed-log recorded, as faulty values were supplied due to a defective sensor. The audio data of the 6 bridge microphones were unsuitable for use due to noise.

The echo sounder was operational, but no data were recorded as this device was switched off. There were also faults in the allocation values of rudder and bow thruster.



Delta St.Petersburg

Delta "ST.Petersburg

Page2

**Steering Mode**
main lever 1 🟩
main lever 2 🟩
autopilot 🟩
wing ps 🟩
wing sb 🟩

**Pitch**
order 57.8%
actual 46.2%

**Thruster**
order -0.9%
actual pitch 0.7%
propeller motor run 🟩

**Rudder**
actual 30.3°

Legend
active 🟩
inactive 🟩
alarm 🟥
no alarm 🟥
no information ☐

54 00.48 N 008 16.06 E 1.50 NM
10:15:14

No Name

**Time**
Local 10:15:14 0
UTC 10:15:14
Date 23/08/2006

**Position**
Lat 54°00'00"N
Lon 8°13'02"E

**Speed/Course**
Speed 7.8 knots B
Course 210.6 ° B
Heading 207.9 °

**Targets 0**

Delay replay 1000 ms

☐ ECS ☐ Radar ☐ Track ☐ Voice ☐ PosMode

Figure 5: Plot of the course from VDR DELTA ST. PETERSBURG

The course of DELTA ST. PETERSBURG recorded by the VDR and shown above is almost identical with the recordings of the Vessel Traffic Service Cuxhaven. Up to approx. 10:15:12[3] the vessel sailed a south-south-west course and according to the GPS data the speed over ground dropped to 7.8 kn. After this the vessel proceeded through a turning circle with a diameter of 320 to 360 m.

The following recordings of the VDR data show that at 10:15:30 speed was increased and the course changed more to a westerly and later to an almost northerly direction. The southernmost course achieved was 193.5° and the turning circle sailed was clearly recorded in accordance with GPS measurements. The highest speed in the turning circle was achieved at 10:16:02 with 8.9 kn over ground.

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[3] UTC = CEST -2h

The report that the pilot tender had capsized came over the radio channel recorded at 10:16:10.

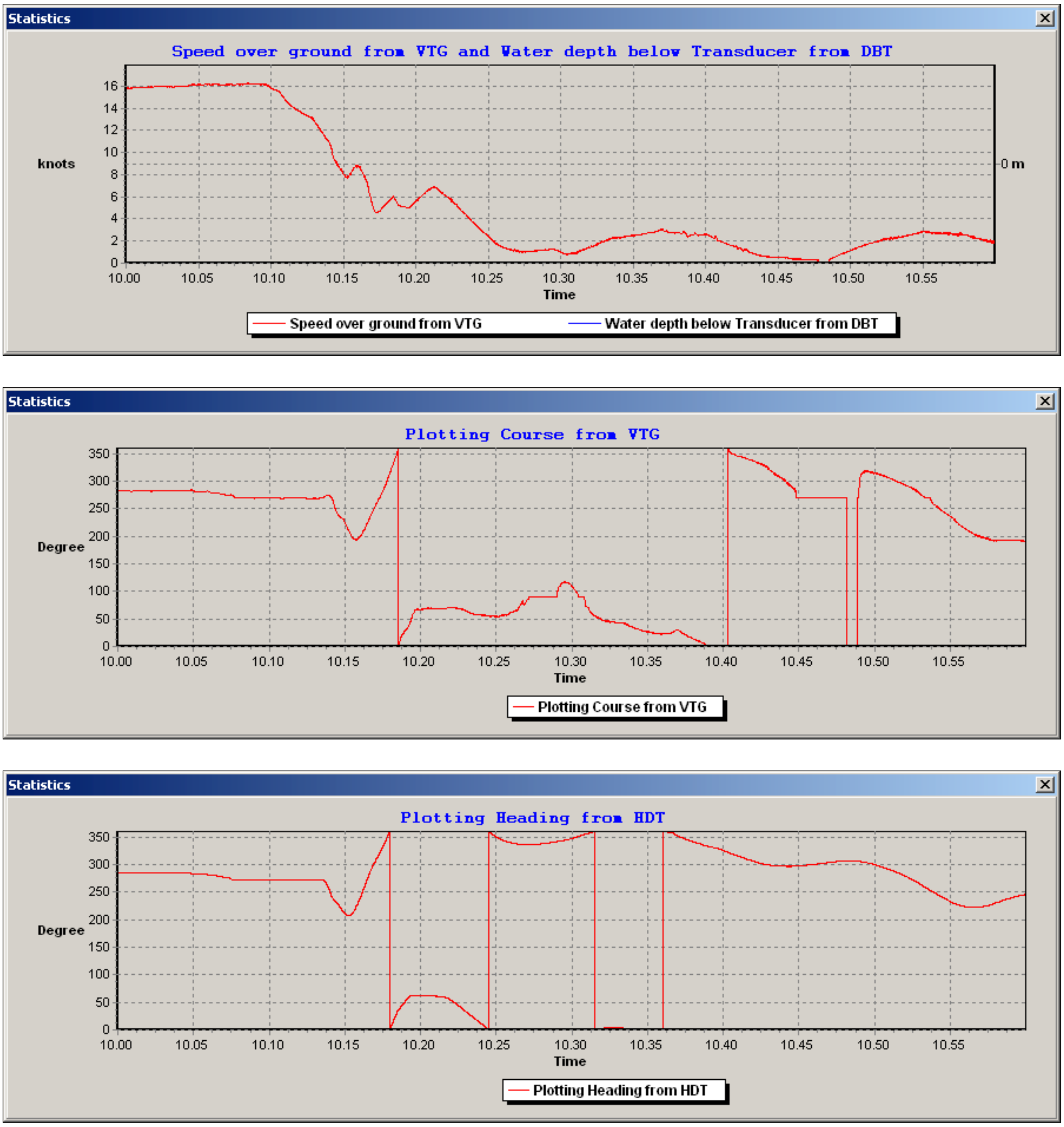


Figure 6: Speed and course according to VDR

The rudder angle and the change of the propeller pitch were also recorded by the VDR and analysed. According to the data up to 10:12:30 the rudder lay midships, and was then moved for about 2 minutes to port with 29.7° and as of 10:15:00 to starboard with 30.4°. The pitch was reduced as of 10:12:30 to 44.4%, from 10:14:30 to approx. 10:14:45 further to 25%, and from 10:15:12 the vessel ran with a pitch of 57.8 %. The starboard rudder position of 30.4° and the pitch of 57.8% were maintained until approx. 10:17:00, in other words until after the report that the pilot tender had capsized.

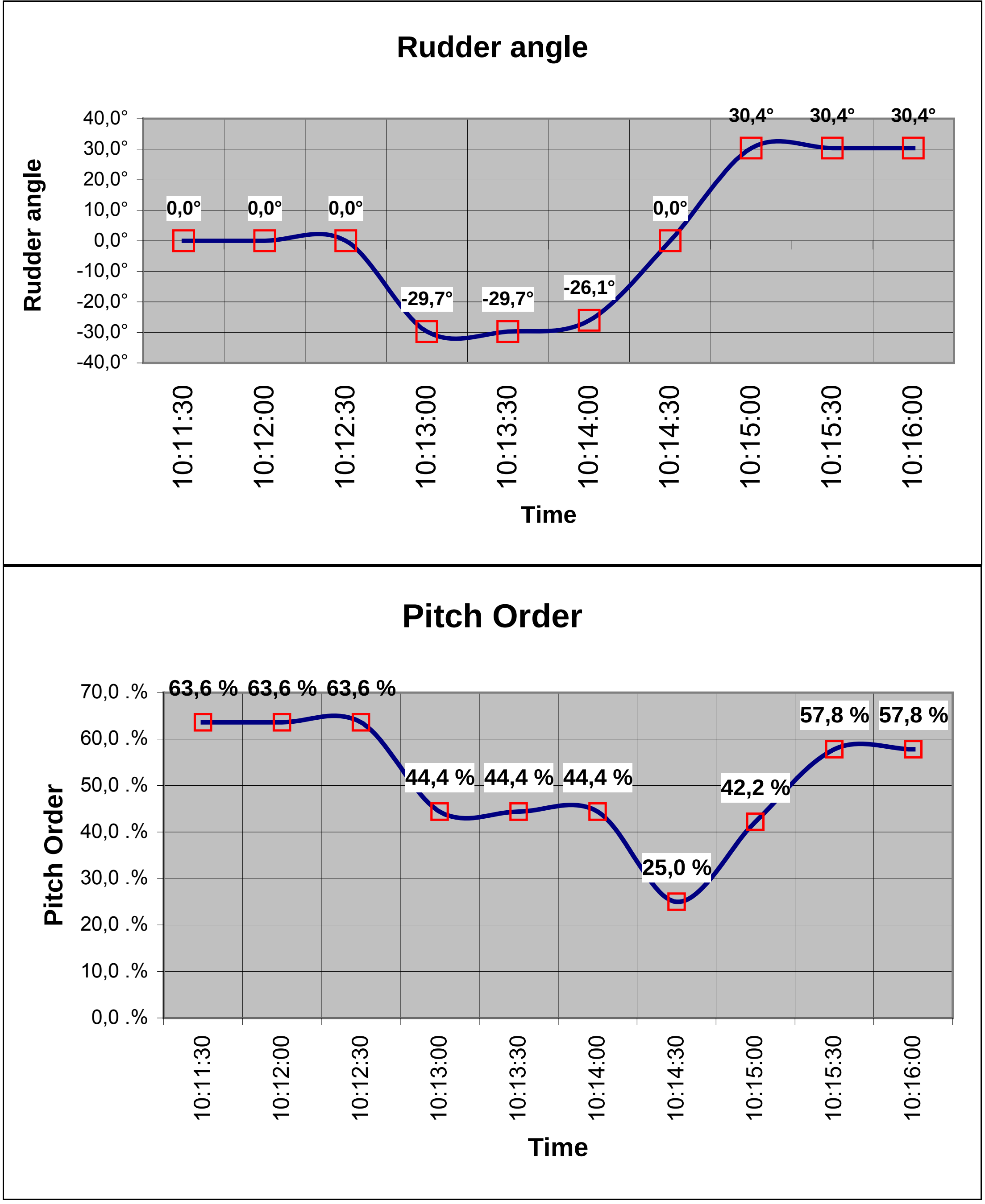


Figure 7: Rudder angle and propeller pitch according to VDR

## 5.5 Pilot Tender ELBE 3

### 5.5.1 Inspection of the vessel

The Pilot Tender ELBE 3 was inspected on shore lying in a hall in Cuxhaven on 29 August 2006. The evident damage to the hull and the surrounding fender was sustained on salvage and/or before the accident in normal operation and is not to be seen in connection with the capsizing. No damage to the conning position and the aerials resulting e.g. from contact with DELTA ST. PETERSBURG could be seen.

The Pilot Tender ELBE 3 was built as third copy of vessels "of the same design" in 2002 at the Fassmer yard as a "self-righting boat with open conning position". The hull and engine of the vessels are all the same. Only the superstructures were modified in accordance with findings gained during work assignments to allow even safer transfer of the pilots.

A basic requirement for pilot tenders made by the public authority carrying out the tendering procedure in 1997 was a self-righting and self-draining design. According to the requirements the boat must have positive righting moments over a range of 180° range of stability. In the text of the tendering procedure in 2001 for repeat construction this requirement was changed to an "unsinkable design". Sufficient fendering to absorb the collision energy was also to be provided so that in rough seas it would be possible to go alongside vessels. The rudder was to be extended as in the prototypes ELBE 1 and ELBE 2.

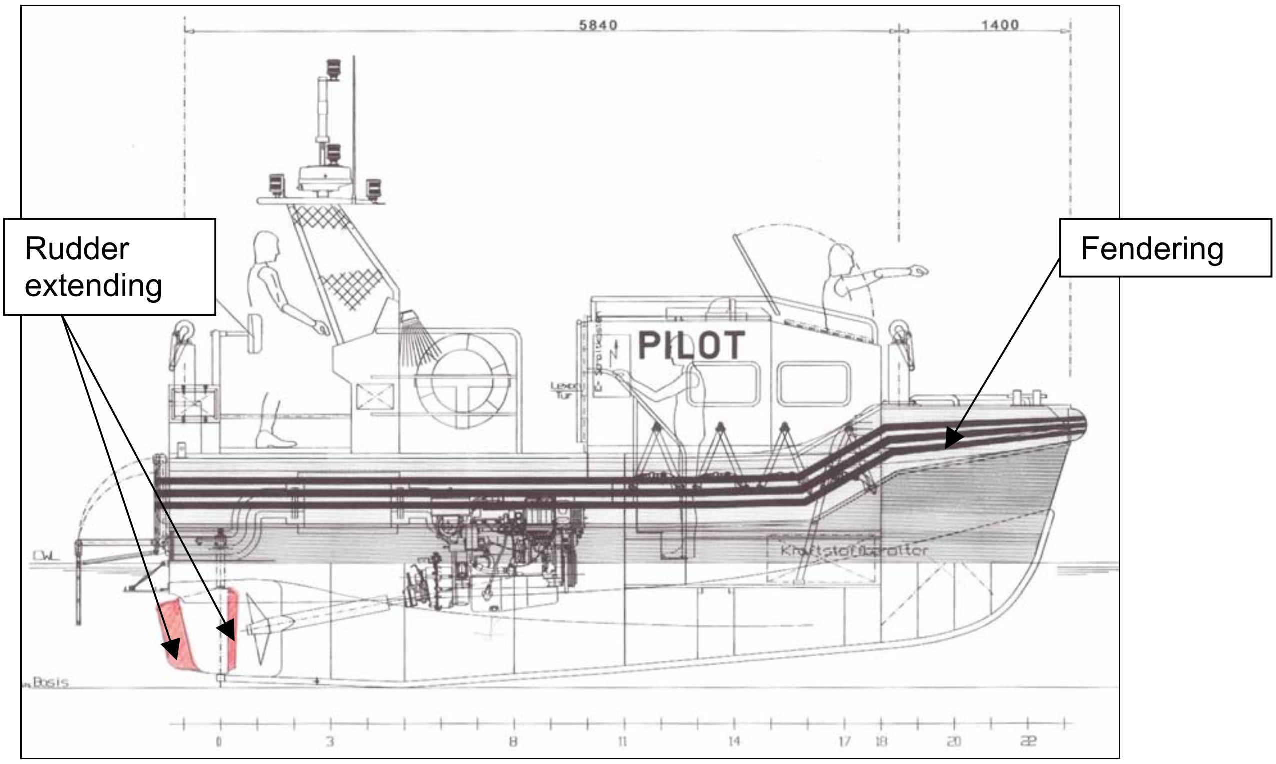


Figure 8: Side view ELBE 3

### 5.5.2 Hydrostatics and heeling test

In order to obtain reliable statements about the stability of the pilot tender and the course of the accident an expert opinion was commissioned from the firm Ship Design & Consult GmbH (SDC). The vessel shape was digitised using the lines drawing and the hydrostatic form values were calculated with the "NAPA" programme system. The calculations take into account free heeling, free trim and the effect of the free surfaces in partly filled tanks. A comparison of the data from 1999 and 2002 drawn up by two different firms with the data now produced revealed only slight differences in the displacement and centre of gravity values that can be neglected for the calculation. Thus all three firms calculated the hydrostatic values practically with the same geometry model.

In the course of the further examination a heeling test was conducted with ELBE 3 in Cuxhaven on 7.12.2006 and evaluated.

| Test date | Vessel | Weight | VCG | LCG |
|---|---|---|---|---|
| 16.12.1999 | ELBE 1+2 | 4.3 t | 1.43 m | 2.60 m |
| (15.3.2002 | ELBE 3 | 4.5 t | 1.52 m | 2.46 m) |
| 07.12.2006 | ELBE 3 | 5.0 t | 1.51 m | 2.43 m |

The differences in the weights and the centres of gravity are already remarkable. In the heeling test in 2002 the weight of the vessel was determined with crane scales and not by reading the drafts. The results of this experiment have therefore been placed in parentheses due to this type of execution and other discrepancies.

The weight of the empty vessel ELBE 3 has increased by 0.7 t compared to the preceding buildings ELBE 1 and ELBE 2, and the centre of gravity VCG is 8 cm higher.

This change is plausible and can lie in the modified superstructures, the enlargement of the rudder and subsequent mounting of the fendering.

The difference in weights and centres of gravity is not crucial for the course of the accident as the maximum righting moment is almost the same, although clearly with a different, smaller angle of heel.

In order to be able to assess to what extent a change in the empty vessel weight as shown in the above table influences the stability, the loading case at the time of the accident was calculated once with the empty ship's weight of 1999 (‚C01’) and once with the empty ship's weight determined in 2006 (‚C02’).

It was assumed that at the time of the accident there was approx. 20 l fuel on board, two persons were sitting in the cabin and one person was standing at the helm.

The comparison of the two load cases shows that as a result of the different empty vessel weights the characteristics of the respective statical stability curves differ.

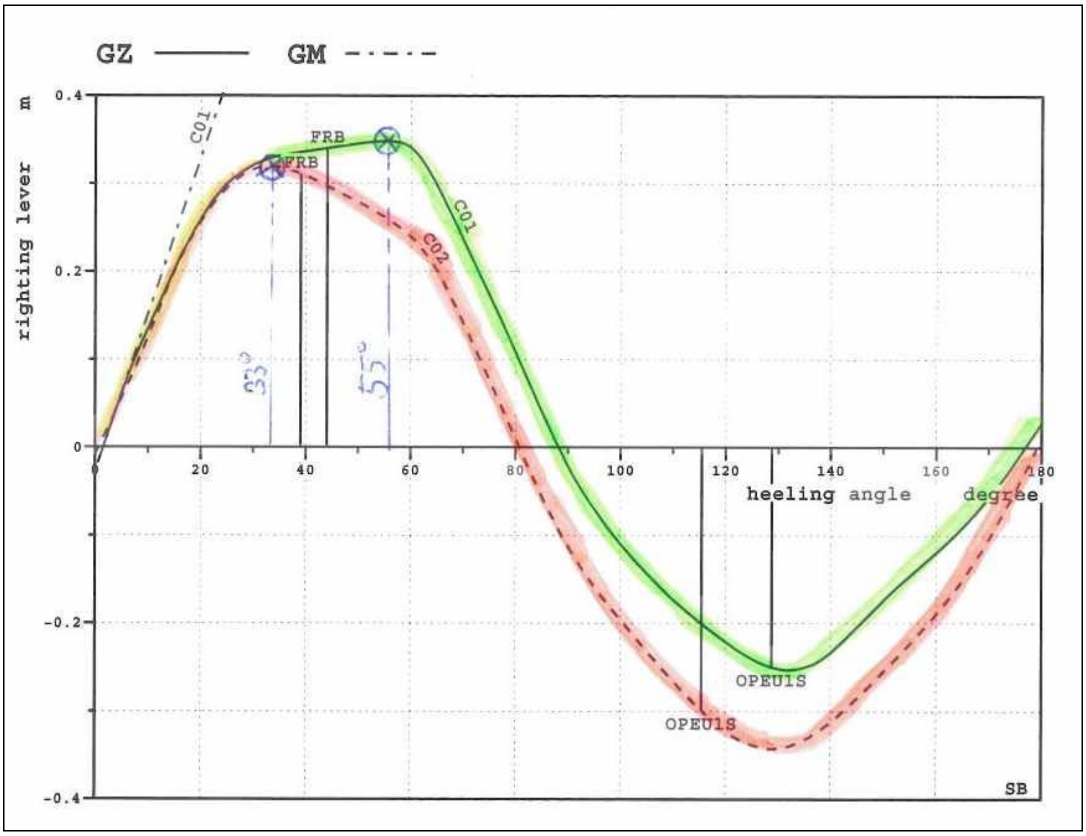


Figure 9: Uprighting statical stability curves with different ships weights

In case C01 (empty ship's weight of 1999, green curve) the maximum of the statical stability curve is approx. 55° and amounts to approx. 0.35 m.
In Case C02 (empty ship's weight of 2006, red curve) the maximum of the statical stability curve is approx. 33° and amounts to approx. 0.32 m.
The difference of 3 cm in the righting moment is not critical for the stability. However, the fact that the maximum of the statical stability curve has shifted from 55° to 33° and the range of stability has been reduced to 80° is significant.

However, the two cases still fulfil all the stability criteria in accordance with IMO Res. A167.

The modifications of the superstructure and other changes in the repeat construction of the vessel and the resulting increase of the empty vessel weight and height of the centre of gravity can be ruled out as a cause of the accident.

### 5.5.3 Righting moment

The righting moment of the boat at the time of the accident is calculated as follows:

Ma = Gzmax * Disp
For load case C01 this results in 4.56 t * 0.35 m = 1.6 tm
For load case C02 this results in 5.22 t * 0.32 m = 1.7 tm

Despite the differing statical stability curves almost the same value is obtained for the maximum righting moment.
In the following it is assumed that an external moment greater than 1.7 tm or 16 KNm would cause the boat to capsize.

### 5.5.4 Influence of wave crest and wave trough

The influence of the stern wave of DELTA ST. PETERSBURG on the statical stability curve of Pilot Tender ELBE 3 was examined.
In order to obtain an approximate impression of the wave pattern the departure of DELTA ST. PETERSBURG was filmed on the Elbe off Blankenese on 21.11.2006. On this occasion the function of the VDR on board was also checked.

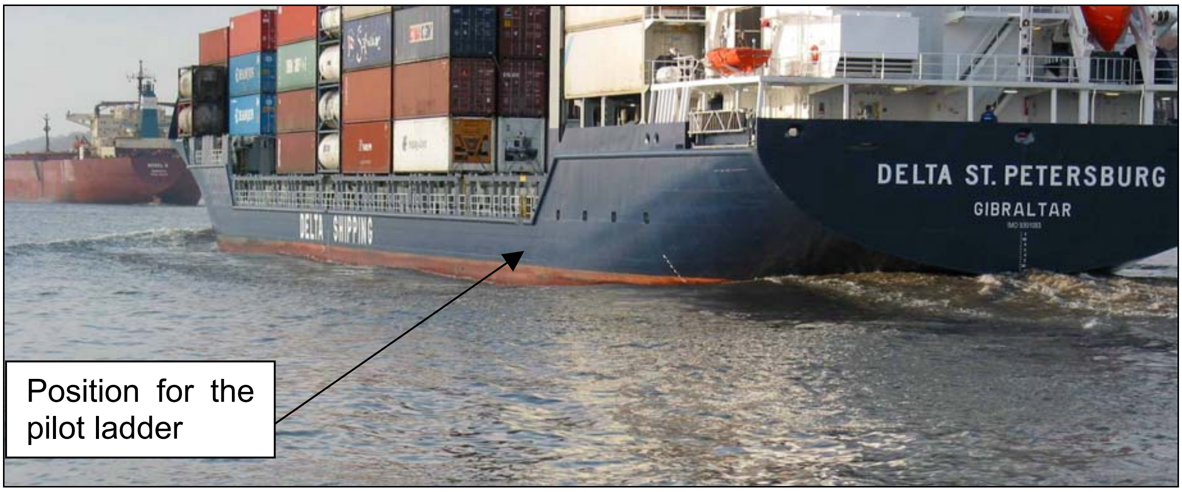


Figure 10: Wave pattern of DELTA ST. PETERSBURG

The video recordings of the voyage of DELTA ST. PETERSBURG show that at a speed of 8 to 9 kn over ground the length of the wave at the aft shoulder is at least twice the ship's length of the pilot boat and max. 0.4 m high.

This results in a calculated difference of the maximum righting moment between wave crest and wave trough of not more than 2 cm.
Even if the wave were only the length of the pilot boat, corresponding to the worst case, there would only be a difference of approx. 4 cm.

In addition film records still present at the Hamburgische Schiffbau- Versuchsanstalt (HSVA) - (Hamburg Ship-building and Testing Institution) of the model towing experiments were studied. These recordings did not indicate any abnormal wave pattern in the stern area even at much higher speeds.

The stern wave of DELTA ST. PETERSBURG can thus be ruled out as the main cause of the accident.

### 5.5.5 Watertight Integrity

The companionway to the forward superstructure is arranged on the starboard side and is closed by a non-water-tight door made of Lexan (perspex) with two bolts and a Lexan sliding hatch. At the time of the accident this companionway was open. This non watertight condition is not the cause of the accident, as the companionway only comes to the water surface at an angle of heel greater than 100°, while the positive stability range is only approx. 80°.

### 5.5.6 Moment caused by putting the helm

The Pilot Tender ELBE 3 has an installed engine rating of 157 kW. When the helm is set a force is generated resulting from the diversion of the propeller jet. This depends on the effectiveness of the rudder (rudder angle and area of the rudder blade) and the propeller thrust (engine rating).
The rough calculation shows that the moment caused by setting the helm of the pilot tender does not exceed the righting moment of 16 KNm in any of the calculated cases. It can be concluded from this that the enlargement of the rudder area and the setting of the helm cannot have been the cause of capsizing.

### 5.5.7 Self-uprighting boat

The pilot tender capsized completely in the accident and remained lying in a stable upturned position. As a result of this accident the hypothetical calculations that the boat does not upright itself and remains stable upturned were confirmed.

Figure 11: Upturned position

The boat's safety can be increased if the boat were to upright itself again after capsizing.

In order to convert this boat to a self-righting boat it would be necessary to take measures ensuring that the statical stability curve always remains positive up to 180°.

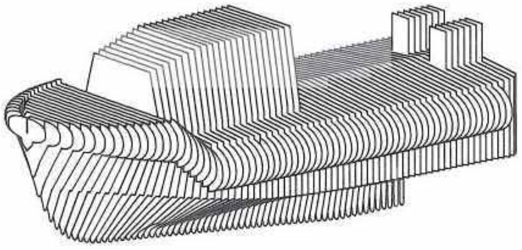
The Lotsbetriebsverein (pilots association) in Cuxhaven conducted practical tests on a conversion as self-righting boat on 13.10.2006. Various buoyancy bodies were installed on the cabin roof and the boat was turned through 180° with a crane.

Figure 12: Experiment with buoyancy bodies

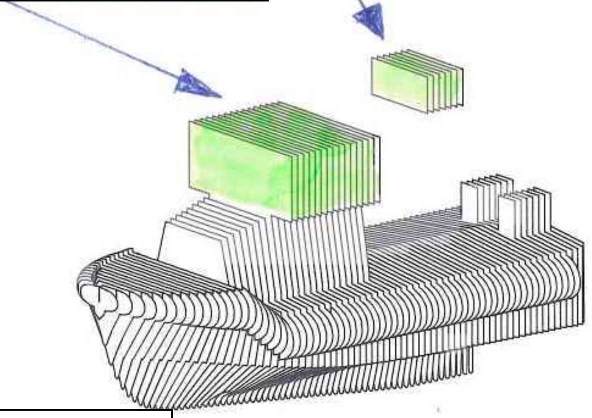
The following results were obtained by Messrs. SDC by calculation:
If a buoyancy volume of approx. 3.0 m³ is installed on the cabin roof and 0.4 m³ on the signal mast that inflate when subjected to water pressure, a positive righting moment up to 180° is achieved. However, this consideration does not take into account the fact that these buoyancy bodies also weigh a certain amount and shift the centre of gravity of the entire boat upwards. On the other hand, the stability is improved if the compressed air cylinders and release unit for the buoyancy bodies are installed below the centre of gravity.

A further prerequisite is that the water-tight integrity of the entire boat must be ensured.

Boat in the present condition



Example as self uprighting boat:
Volume on the signal mast: 0.36 $m^3$
Volume on the cabin cover: 2.97 $m^3$



Comparison of the statical stability curves:

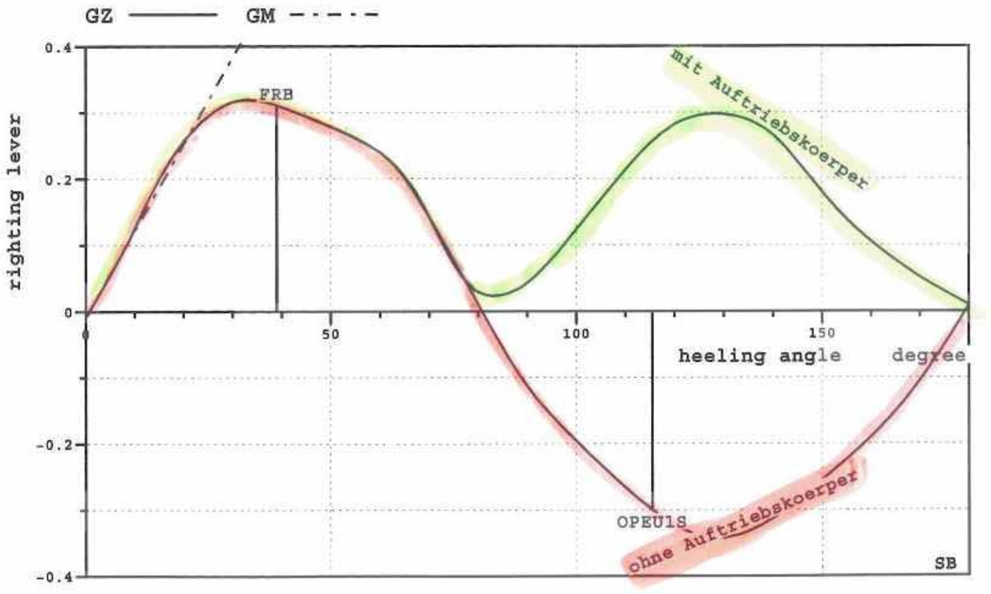


Figure 13: Comparison of the statical stability curves

### 5.5.8 Damage stability calculation

Even if it was not necessary for ascertaining the cause, the stability of the pilot boat in damaged condition was also to be examined within the scope of this investigation.

The boat is divided into two watertight compartments by a bulkhead at construction frame No. 11.

For the damage stability calculated here the aft compartment, the engine room, was assumed to have a permeability of 0.85 and the forward compartment, the cabin, a permeability of 0.95.

The calculations are based on loading case C02, i.e. loading as at the time of the accident and an empty ship's weight according to the heeling test in 2006.

The damage stability calculations of Messrs. Fassmer take into account a buoyancy body of 1.0 m³, but this is not shown on the drawings submitted.
During the first examination of the pilot tender on shore, dismounted buoyancy bodies consisting of construction foam were found lying under the hull. BSU did not determine the volume and the possible arrangement in the hull of the vessel.
This buoyancy is therefore not taken into account in the first calculation. Moreover in the calculations of Messrs. Fassmer the watertight bulkhead at frame 10 was assumed. In the calculation of Messrs. SDC the bulkhead is assumed at frame 11 as shown in the drawings available here and as it was in fact installed. A change of the bulkhead to frame 10 was also calculated.
For the second calculation a buoyancy volume of 1.0 m³ arranged in the engine room at the transom was included in the calculations, independently of the technical feasibility of this.

The results of the calculations conducted can be summarised as follows:

Case - flooding of the engine room:

- Without additional buoyancy in the engine room the boat is trimmed at almost 90° and floats on the hatch to the companion-way (that is currently not executed as watertight).

- With additional buoyancy in the engine room the deck is only slightly under water aft.

- The assumption of a bulkhead at frame 10 or 11 has no major effects on the result of the calculation in damaged condition.

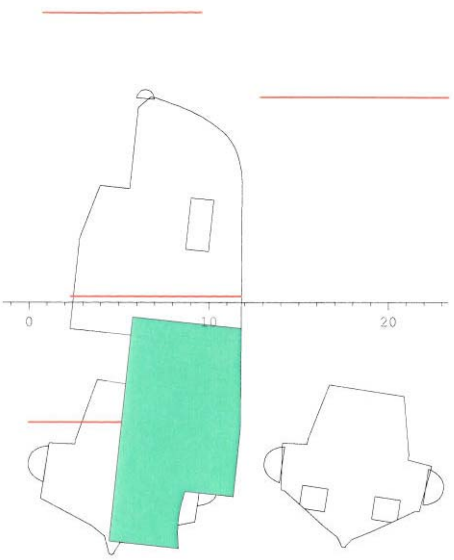
Case - flooding of the cabin:

- The flooding of the cabin leads to forward trimming, but without the deck coming into the water.

Cargo case CO2, Leakage case ER flooded

```
RESULTS

------------------------------------------
CASE         STAGE          T       TR   HEEL
                            m        m degree
------------------------------------------
I1/D1        1          0.929 -71.765    -8.6
------------------------------------------
```



Cargo case CO2, Leakage case ER flooded,
1m3 buoyancy

```
RESULTS

------------------------------------------
CASE         STAGE          T       TR   HEEL
                            m        m degree
------------------------------------------
I1/D1.2      1          1.211  -1.517    -0.7
------------------------------------------
```

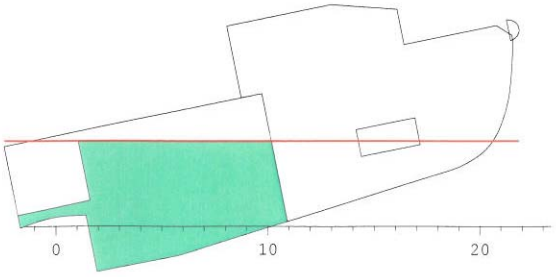


Figure 14: Floating positions in damaged condition

## 5.6 Course of the accident

### 5.6.1 Description of the accident situation

A 7.5 m long pilot tender runs next to a 155 m long container vessel approx. 34 m from the stern. The vessels touch one another, accelerate and the large vessel sets the helm, starts a turning circle, and its stern pushes against the pilot tender.

The statements by witnesses that the boat capsized approx. one minute after the pilot had transferred confirm the assumption that the vessel can already have been in the turning circle. It is evident from the plots of the VTS Centre Cuxhaven that the vessel went into the turning circle at the latest at 12:16:40. These data are confirmed by the VDR recordings of the course of the vessel. It is therefore assumed that the vessels were already moving in the turning circle at the time of capsizing.

The situation in movements through a turning circle is extremely complex in hydrodynamic terms and cannot be solved numerically within the scope of this investigation.

However, in order to determine an indication for the cause of the accident the situation was strongly simplified mathematically.

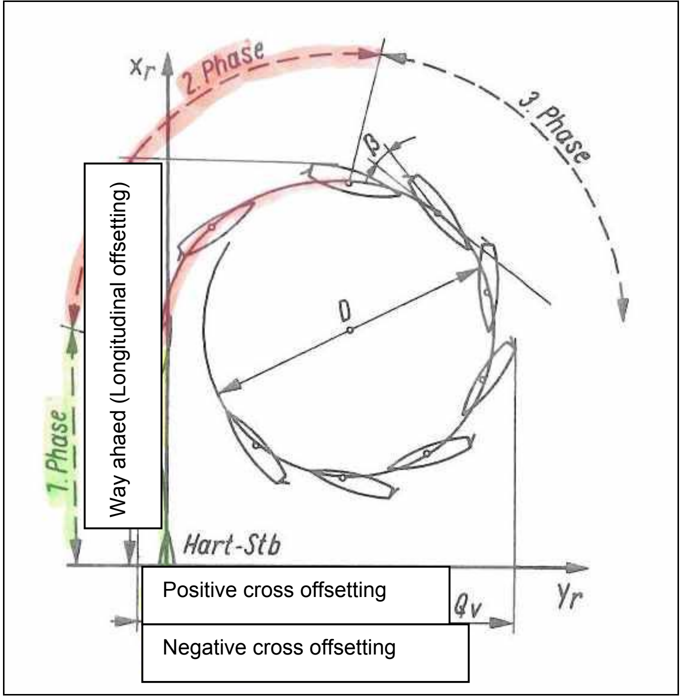


Figure 15: Sketch of turning circle[4]

In the first phase of the turning circle movement the vessel does not immediately begin to turn perceptibly because of the mass moment of inertia and the hydrodynamic mass. The upper sketch shows that initially a "negative cross offsetting" of the centre point of the vessel starts. Although the helm was set to starboard, the vessel first migrates to port and the cross offsetting can be up to two

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[4] From "Seemannschaft 3", Verlag für Verkehrswesen

ships widths. In this first phase the stern of DELTA ST. PETERSBURG moves approx. 40 to 50 m to port.
In the second phase, that is practically non-stationary, the pushing angle β increases as a consequence of the centrifugal forces generated. The speed of course change or curvature of the track increases, while the speed of the vessel decreases.
The third phase of the turning circle movement is stationary. The pushing angle β, the change or course speed and the ship's speed are almost constant.

The effect of the acceleration of the vessels at the start of the turning circle is neglected.
The centrifugal forces depend on the ship's speed and increase quadratically as the ship's speed rises.

The evaluations of the data from the Vessel Traffic Services in Cuxhaven and the VDR data have shown that a speed of DELTA ST. PETERSBURG at the time of the accident of approx. 8 kn over ground was measured. It should be noted here that this was a circular track and not the direct route.

### 5.6.2 Heeling moments

The calculation of the heeling moments is carried out in accordance with the rough formula set out below.
It is assumed that the total heeling moment Mk is made up of three components:

Cross resistance
The moment generated by the pure transverse speed of the pilot tender, caused by pushing of the large vessel in the turning circle. This force depends on the square of the transverse speed ($\sim V_y^2$).

Transverse drive, lift
The moment generated by the oblique flow towards the pilot tender, corresponding to drifting, and also caused by pushing of the large vessel in the turning circle. This transverse force depends on the product Vx*Vy.

Propeller/rudder moment
The moment caused by setting the helm of the pilot tender, depends on the propeller thrust and the rudder angle.

The fact that the existing transverse speed acting on the boat is very much smaller than determined geometrically due to the presence of the large ship is roughly taken into account by a damming up correction $k_{ST}$ .

Accordingly the sum of the heeling moments is calculated in accordance with the following rough formula:

Heeling moment when ship and boat turn away

| **Ship:** | | **Pilot Boat:** | | **Assumptions:** | |
|---|---|---|---|---|---|
| Loa | 154 m (FT-AT) | L | 7,5 m | $H_{Rud}$ | 0,7 m |
| $X_{Lots}$-AT | 34 m fom AT | T | 1,0 m | $D_{Prop}$ | 0,6 m |
| $X_{Takt}$ | 128 m from FT | $A_{Lat}$ | 4,9 m² | 1-t | 0,9 |
| $X_{Lots}$ | 94 m | $A_{Rud}$ | 0,5 m² | $\eta_D$ | 0,7 |
| $R_{Drehkr}$ | 180 m | | | $P_D$ | 157 kW |
| Vs | 8,5 kts | | | $\delta_R$ | 30 ° |
| | | | | $k_{Quer}$ | 0,7 |
| | | | | Cdy | 1,0 |
| | | | | $k_{St}$ = | 0,5 Staukorr. |

**Speeds:**

Longitudinal speed $Vx = Vs =$ 4,4 m/s

Turning speed $\omega = Vx/R =$ 0,024 1/s

Transv. Speed $Vy = \omega * X_{Lots} =$ 2,3 m/s

**Lever arms:**

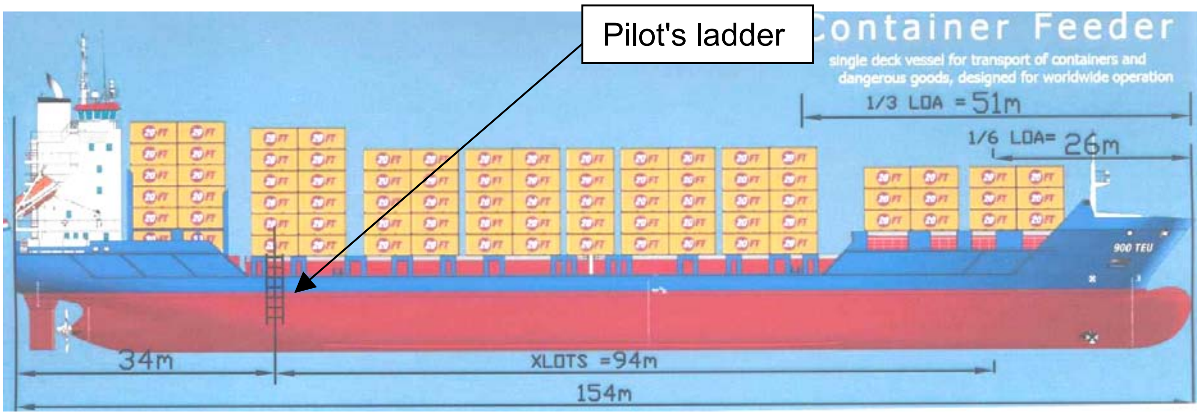
| | |
|---|---|
| Fender-Hull | 1,5 m |
| $h_{Fender-Prop}$ | 1,0 m |

Propeller thrust: $Tp = Pd\ \eta d / (Vx\ (1-t)) =$ 27,9 kN

| **Transverse forces:** | | | **Heeling moments:** | |
|---|---|---|---|---|
| Transv. Resistance | $Dy = \rho/2\ k_{St}^2\ Vy^2\ A_{Lat}\ Cdy =$ | 3,2 kN | $Dy * h_{FR} =$ | 4,8 kNm |
| Transverse drive | $Cy = \rho\ Vx\ k_{St}\ Vy\ \pi/2\ T^2 =$ | 7,9 kN | $Cy * h_{FR} =$ | 11,8 kNm |
| Transverse thrust | $Tpy = Tp \sin(\delta r)\ k_{Quer} =$ | 9,8 kN | $Tpy * h_{FP} =$ | 9,8 kNm |
| sum transverse forces | $Fx = Dy + Cy + Tpy =$ | 20,9 kN | $\Sigma Mk =$ | 26,4 kNm |

The length $X_{pilot}$ is the distance between the x-position of the pilot ladder at which the pilot boat is taken on to and the so-called tactical pivot about which the vessel apparently turns.

This point can be between 1/3 and 1/6 of the ship's length from the bow and is assumed here to be at 1/6, as shown in the following sketch.



### 5.6.3 Assessment of stability

It can be concluded from the comparison of the sum of the heeling moments from the calculation described above and the righting moment of 5.5.3 of 16 kNm that the transverse forces were in any case always large enough to cause the pilot tender to capsize.

As differing data were recorded on the speed ahead (ship's speed) and differences in the turning circle diameter, two input parameters, speed ahead and turning circle radius, have been varied in the calculation of the heeling moments:
(The red figures in the preceding table are the variable input parameters.)

$k_{ST}=0.5$

| V [kn] | $R_{\text{Turning circle}}$ = 180 m | $R_{\text{Turning circle}}$ = 160 m |
|---|---|---|
| 8.5 | 26.4 kNm | 29.2 kNm |
| 7.5 | 24.0 kNm | 26.2 kNm |
| 6.5 | 22.5 kNm | 24.1 kNm |
| 5.5 | 22.1 kNm | 23.2 kNm |

It is evident from the above table that even distinctly lower speeds would have been sufficient to bring the pilot tender to capsize under the above conditions.
However, the table also shows that the turning circle, i.e. the rudder position of the DELTA ST. PETERSBURG, has a very large influence on the heeling moment, especially at higher speeds.

In addition the damming up correction factor was then reduced from 0.5 to 0.3, i.e. due to the presence of DELTA ST. PETERSBURG next to the Pilot Tender ELBE 3, only 30% of the transverse speed/transverse resistance act on the smaller vessel instead of 50%.

for $k_{ST}=0.3$

| V [kn] | $R_{\text{Turning circle}}$ = 180 m | $R_{\text{Turning circle}}$ = 160 m |
|---|---|---|
| 8.5 | 18.6 kNm | 19.9 kNm |
| 7.5 | 17.9 kNm | 19.0 kNm |
| 6.5 | 17.9 kNm | 18.7 kNm |
| 5.5 | 18.8 kNm | 19.4 kNm |

The moments produced by transverse resistance and transverse drive are the critical quantities here too, without which the boat would not have capsized according to this calculation.
The pilot tender would have capsized at lower speeds too.

The calculations conducted within the scope of this investigation to determine the heeling moments must be considered cautiously, as the accident situation was greatly simplified and the hydrodynamic effects were only considered/assumed roughly. A more precise numerical computation, e.g. with a RANS[5]-simulation procedure for both vessels in a stationary turning circle movement with non-stationary occurrences could allow further conclusions and bring more reliability. Within the framework of this investigation the BSU refrained from this as the result would merely increase the precision of the calculations, but would not change anything in the actual course of the accident and the cause determined for the accident.

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[5] **R**eynolds **A**veraged **N**avier-**S**tokes = Statistical turbulence model from numerical flow mechanics in which all turbulance scales are modelled with a stationary process and not calculated directly.

# 6 Analysis of the serious marine casualty

## 6.1 Pilot tender

The stability of the pilot tender is in line with the stability criteria of the IMO Res.A167. The stability is sufficient for this vessel, and during trials in open water the boat did not encounter any stability-endangering situations.
Applying "full speed" and a “hard rudder position” alone do not lead to capsizing of the boat according to these calculations in the situation described.
The stability calculations have also shown that an error made by the boatswain in running the vessel can therefore be ruled out.

The manoeuvres of the pilot tenders demand some skilfulness from the boatswain, and the pilots association (Lotsbetriebsverein) is itself responsible for the qualification and deployment of these staff. The boats are not tied up with lines to the vessels receiving piloting services, but approach very close to these vessels so that the pilot can transfer safely. For this manoeuvre it is advantageous to have a hull with a long, largely straight contact surface. However, for casting off from the other vessel a hull that is drawn in towards the stern and in which the contact area ends well before the rudder axis to facilitate turning away is better.

The pilot tender is not a self-righting craft. On the contrary, the stability curve and also the floating position on the day of the accident show that in the "upturned floating position" the stability is more than twice as high as in the upright floating position. The additional installation of self-inflating buoyancy bodies that become effective in the event of capsizing create self-righting of the boat. However, this has a negative influence on the centre of gravity of the vessel and increases the weight of the boat, so that the stability curve for the upright floating position would deteriorate further.

The calculations have revealed that the stability in damaged condition and safety in damaged condition can only be produced by installing approx. 1 m³ additional buoyancy bodies in the engine room. This buoyancy is also urgently necessary if, for instance, the 3 mm thick aluminium shell plating is damaged in a collision, as in the accident of Pilot Tender ELBE 2 on 16.12.2002 (BSU Ref. 209/02).

Figure 16: Accident ELBE 2

After this accident the Pilot Tender ELBE 2 was able to reach a port in time and as can be seen on the above photo could be prevented from foundering by being secured ashore.

In a letter of 1 September 2006 to the Lotsbetriebsverein, the BSU pointed out that the pilot tenders should only be used with the necessary care in similar manoeuvring, sea and wind conditions.

## 6.2 DELTA ST. PETERSBURG

DELTA ST. PETERSBURG was called upon by the pilot to take a southern course to "make lee" just in front of the Traffic Separation Scheme (TSS) "Elbe Approach". The vessel proceeded into the southern eastbound fairway and subsequently had to cross the dividing line/dividing zone from south to north during the turning circle in order to come back on the old, outbound course of 275°.

The examinations and calculations have revealed that the cause for the capsizing of the pilot tender was the change of course into the turning circle in conjunction with the pilot transfer station being arranged well aft.

A view onto the pilot transfer station was possible without restrictions, despite the fact that the bridge was closed. There was a reporting connection from the pilot transfer station to the bridge.

The arrangement of the pilot ladder in the aft part is not in line with the regulations of SOLAS Chapter V, Rule 23.

## 6.3 VDR data recording

According to the IMO Performance Standards on developing VDR devices it must be possible to record at least one video channel of a radar set. In the present case the radar images were indeed picked up, but in such poor quality that it was not possible to analyse them. According to the manufacturer of the VDR, the reason for this was a defective video output in the radar. To eliminate the problem the radar manufacturer exchanged the video card in the radar set.

The audio data from the bridge microphones from the day of the accident and also from the speed measurement on the Elbe on 21.11.2006 are available in extremely poor quality after the technician was on board.
The BSU issued concrete recommendations to the manufacturer of this VDR and to the BSH as responsible body for testing the system already on 15 July 2005 under Ref. 343/04. Similar and/or the same problems in evaluating the VDR were complained of in connection with the marine casualty at that time.
Problems were also ascertained in a further marine casualty with an evaluation of data of the same VDR manufacturer.
The problem of the poor audio quality has also been mentioned by other investigative bodies in the past. The poor quality in all cases appears to lie in interference noise resulting from vibrations in the cable shafts and bridge cladding. Naturally these vibrations are not as strong when the ship's engine is running during appropriate tests, but the vessel is not actually moving.
The inspection of the microphones of DELTA ST. PETERSBURG took place with the main engine not running. In this case the quality of the recordings was in order and in line with the Performance Standards. It is plausible that in practice it is not always possible to test and accept audio recordings in sea service, e.g. during a sea trial, for reasons of time. In these cases, it is however possible as an alternative to use the recording and replay options available in the VDR. Data back-up carried out in "genuine operation" can provide reliable results here on the quality of the sensor information recorded, especially the audio quality.

It would also be possible to achieve distinctly improved evaluation of audio data if the selection of individual audio channels were possible.

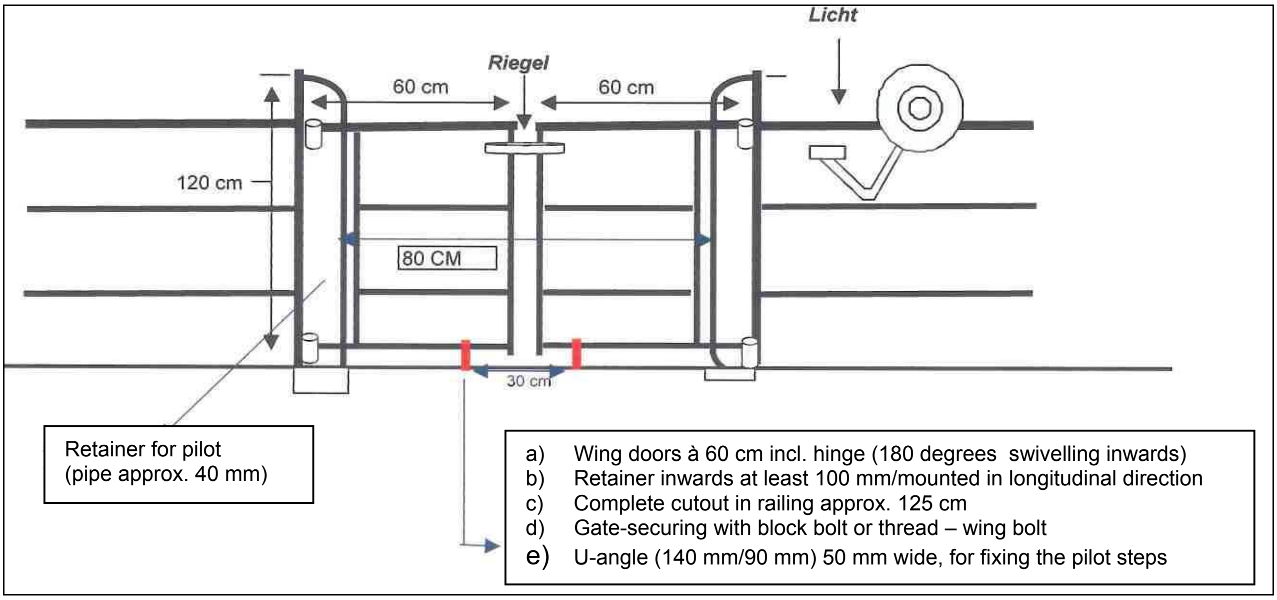
According to the IMO Regulations VDR devices should be installed on ships in order to allow qualified and comprehensive analysis of a particular incident by an authorised investigation organisation and thus make it possible to issue recommendations to avoid similar incidents in the future. This requirement is rendered more difficult in the case of the VDR described here by the problems described above.

The accumulation of problems in analyses by investigating authorities with a VDR from this manufacturer indicates that although considerable improvements have been made to these appliances, especially as regards the audio part too, they still do not completely satisfy the requirements of the IMO Performance Standards.

# 7 Measures already taken

In the draft of the present report the BSU recommended to the operator of DELTA ST. PETERSBURG that the arrangement of the pilot transfer station be shifted on the vessels more to the vessel pivot point at halfway along the ship's length.

The operator informed the BSU in its comment on this that a draft design for a pilot ladder had been submitted to Germanischer Lloyd for approval. The following sketch shows the arrangement of the pilot gate midships:



a) Wing doors à 60 cm incl. hinge (180 degrees swivelling inwards)
b) Retainer inwards at least 100 mm/mounted in longitudinal direction
c) Complete cutout in railing approx. 125 cm
d) Gate-securing with block bolt or thread – wing bolt
e) U-angle (140 mm/90 mm) 50 mm wide, for fixing the pilot steps

After approval of the drawing the modification is to be implemented on all 4 vessels of the "M Class" of this operator. The new pilot station would then be in the middle of the vessel where the rubbing strakes are interrupted.

The SeeBG (Marine Insurance and Safety Association) too sees need for action regarding the alignment of the transfer arrangements, not only in relation to the marine casualty of DELTA ST. PETERSBURG. With reference to the regulations of the SOLAS Convention that are to be observed, the flag state administrations and classification societies are also called upon to act here. The SeeBG will therefore approach the recognised classification societies in order to find a general solution for the problem.

# 8 Safety recommendations

The following safety recommendations shall not create a presumption of blame or liability, neither by form, number nor order.

The BSU recommends the public authority responsible for procurement that in the case of new procurement or conversion of the pilot transfer vessels, care should be taken to ensure that the intact stability and floatability satisfies the requirements of use in the Elbe estuary in the event of damage. It should be reviewed whether it is possible by changing the form of the vessel to achieve greater positive range of stability up to 180°, or at least to ensure far-reaching self-righting of the vessels by means of appropriate technical measures.
These recommendations are to be considered in particular against the background of what happens when these vessels are integrated in the rescue concept of the station vessel.

The BSU recommends that pilots should point out more intensively in advising vessels that the course and speed specified by the pilot should be retained until the pilot has transferred safely to the pilot transfer vessel and this has moved at least 2 to 3 boat's widths away from the ship’s side.
Advice of a course always presumes sufficient sea area and sufficient distance from other vessels or navigational signals.

The BSU recommends that the manufacturer of the VDR device on board DELTA ST. PETERSBURG should optimise the hardware and software so that the data recorded are available in sufficient quality after marine casualties and can be analysed.

By way of reminder the following recommendations from Investigation Report 343/04 on the VDR system are printed again here:

> *The BSU recommends that the manufacturer of the voyage data recorder system should analyse the technical inadequacies of the appliance that have occurred in close cooperation with the BSH as federal authority responsible for type testing for vessels under German flag and ensure complete functionality of the system and the required quality of the data to be recorded in future in line with the requirements of the IMO and the European standard. Furthermore, the possibility of appropriate notification of the vessel command in the event of inadequacies within the unit should be reviewed and if appropriate be implemented in practice. This applies in particular for the lack of sensor data specified for recording.*
>
> *The BSU recommends that the BSH as responsible body should examine the audio data to be recorded in sea operation for their reproduction quality more strongly for superimpositions and interference noise when checking the system prior to use on board.*

*The BSU requests the Federal Ministry for Transport, Construction and Housing*[6] *to propose in the relevant IMO committees that the VDR performance requirements specify a separate audio track for each microphone*[7]*.*

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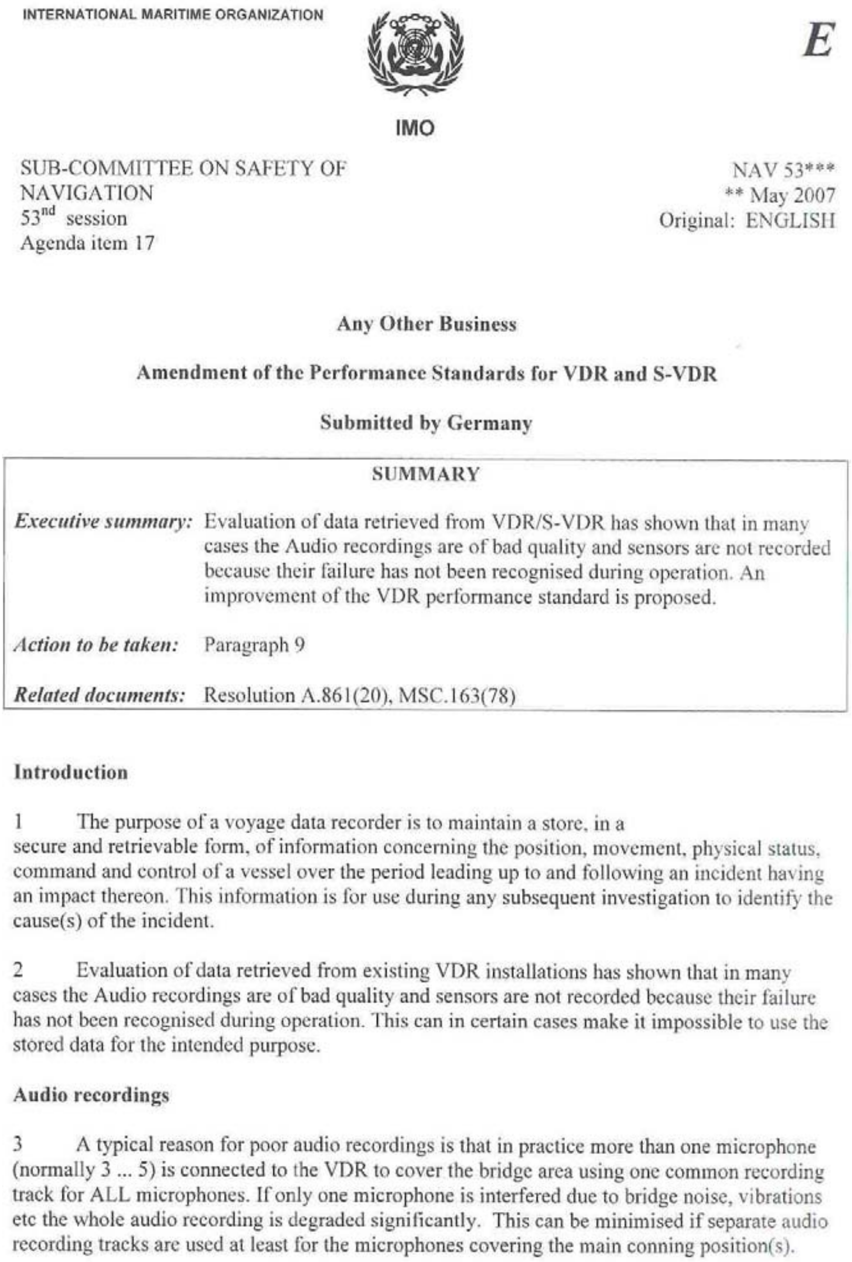
[6] Now: Federal Ministry for Transport, Building and Urban Affairs

[7] With reference to the recommendations to BMVBS and BSH a corresponding proposal was submitted in 4/2007 as a supplement to the IMO-Performance Standards for the Sub-Committee NAV 53 of IMO (see Annex).

# 9 Sources

- Investigations of the Water Police (WSP)
- Recordings of the Vessel Traffic Services Cuxhaven
- Official Weather Expertise by the Germany’s National Meteorological Service (DWD)
- Charts of the BSH
- VDR data from on board DELTA ST. PETERSBURG
- Statements by witnesses
- Calculations by the firm Ship Design & Consult GmbH (SDC), Hamburg
- Photos by Hasenpusch Schenefeld, WSP, BSU
- Seemannschaft 3, Schiff und Manöver (Seamanship 3, Ship and manoeuvre)
  Transpress VEB Verlag für Verkehrswesen

# 10 Annex



INTERNATIONAL MARITIME ORGANIZATION

IMO

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SUB-COMMITTEE ON SAFETY OF
NAVIGATION
53nd session
Agenda item 17

NAV 53***
** May 2007
Original: ENGLISH

## Any Other Business

## Amendment of the Performance Standards for VDR and S-VDR

**Submitted by Germany**

**SUMMARY**

| | |
|---|---|
| ***Executive summary:*** | Evaluation of data retrieved from VDR/S-VDR has shown that in many cases the Audio recordings are of bad quality and sensors are not recorded because their failure has not been recognised during operation. An improvement of the VDR performance standard is proposed. |
| ***Action to be taken:*** | Paragraph 9 |
| ***Related documents:*** | Resolution A.861(20), MSC.163(78) |

### Introduction

1 The purpose of a voyage data recorder is to maintain a store, in a secure and retrievable form, of information concerning the position, movement, physical status, command and control of a vessel over the period leading up to and following an incident having an impact thereon. This information is for use during any subsequent investigation to identify the cause(s) of the incident.

2 Evaluation of data retrieved from existing VDR installations has shown that in many cases the Audio recordings are of bad quality and sensors are not recorded because their failure has not been recognised during operation. This can in certain cases make it impossible to use the stored data for the intended purpose.

### Audio recordings

3 A typical reason for poor audio recordings is that in practice more than one microphone (normally 3 ... 5) is connected to the VDR to cover the bridge area using one common recording track for ALL microphones. If only one microphone is interfered due to bridge noise, vibrations etc the whole audio recording is degraded significantly. This can be minimised if separate audio recording tracks are used at least for the microphones covering the main conning position(s).

4 It is proposed to amend Resolution A.861(20) and MSC.163(78) as follows:

5.4.5 Two or more microphones positioned on the bridge should be placed so that conversation at or near the conning stations, radar displays, chart tables, etc., are adequately recorded. As far as practicable, the positioning of microphones should also capture intercom, public address systems and audible alarms on the bridge.
Two separate recording tracks should be provided for two microphones installed near the conning stations; additional microphones should use at least one separate track.

**Sensor failure**

5 Data retrieval failed in several cases because sensors had not been recorded due to their failure was not recognised during operation. As an example, after RADAR maintenance the video connection to the VDR had not been re-installed properly. Because there is no requirement for an internal integrity test and appropriate alarms, this had not been brought to the attention of the user. After an incident the data evaluation of the recorded RADAR data failed.

6 It is proposed to amend Resolution A.861(20) and MSC.163(78) as follows:
Add new para 7.2:
A clear indication should be given to the user if the interface to a connected sensor fails or if data are unavailable.

**AIS recordings**

7 Recording of AIS data is not required for the VDR and a possible addition to radar recordings for the S-VDR. AIS is a reliable data source for other ship's data and can also act as own ships information source providing data in digital form that is easy to store and retrieve.

8 It is proposed to amend Resolution A.861(20) and MSC.163(78) as follows:
Add new para 5.4.16 to A.861(20) / modify para 5.4.8 of MSC.163(78):
AIS target data should be recorded as a source of information regarding other ship's. If AIS also provides own ship data, this may replace the connection of dedicated sensors.

**Action requested of the Sub-Committee**

9 The Committee is invited to note the above information and decide as deemed appropriate.