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

Investigation Report 537/06

Marine Casualty

Person overboard from MS BELUGA STIMULATION on 27 October 2006 at 08:20 in the German Bight

1 June 2008

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

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

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

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

Issued by:
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1 Summary of the Marine Casualty

Fully laden the container vessel BELUGA STIMULATION left the port of Rotterdam on the evening of 25 October 2006 in order to sail to St. Petersburg via the Kiel Canal. The cruising speed was said to have been reduced that evening since the weather continued to deteriorate. A strong gale from the West developed with gusts of wind measuring 11 Bft and a westerly swell with waves 7 to 8 m in height.

After various alarms from the bunker room between hold 2 and 3 had sounded during the night, the ship command decided to send the Chief and Second engineers to the bunker room to remedy the source of the alarms.

This took place at the start of the day shortly after 08:00[1]. Both engineers refrained from using a safety line so as not to be obstructed by it. Instead they gripped the railing whenever a wave washed over them. One of the waves hurtled the second engineer overboard around 08:25. His immersion suit did not have a flotation device but kept him warm and a fender which also had been torn loose kept him afloat until he was saved.
The ship command promptly informed German Bight Traffic and requested assistance.

On account of the bad weather conditions, the ship command reportedly decided that a return manoeuvre such as the “Williamson Turn” would be too dangerous for the vessel, its crew and cargo. The BELUGA STIMULATION continued onwards without changing its course or speed.

After the second engineer had fallen into the water, he was rescued alive by the rescue vessel BERNHARD GRUBEN and brought to a hospital in Wilhelmshaven. The hypothermia and external injuries were not life-threatening with the result that he was able to resume his work on the vessel just a few days later.

[1] All times in the report are ship’s time = UTC + 2 h (= CEST).

2 Scene of the accident

Type of event: Maritime casualty, Man over board
Date/time: 27 October 2006 – 08:25
Location: German Bight
Latitude/longitude: φ 53° 55.0' N λ 007° 37.8' E

Section from chart 1045, Federal Maritime and Hydrographic Agency (BSH)

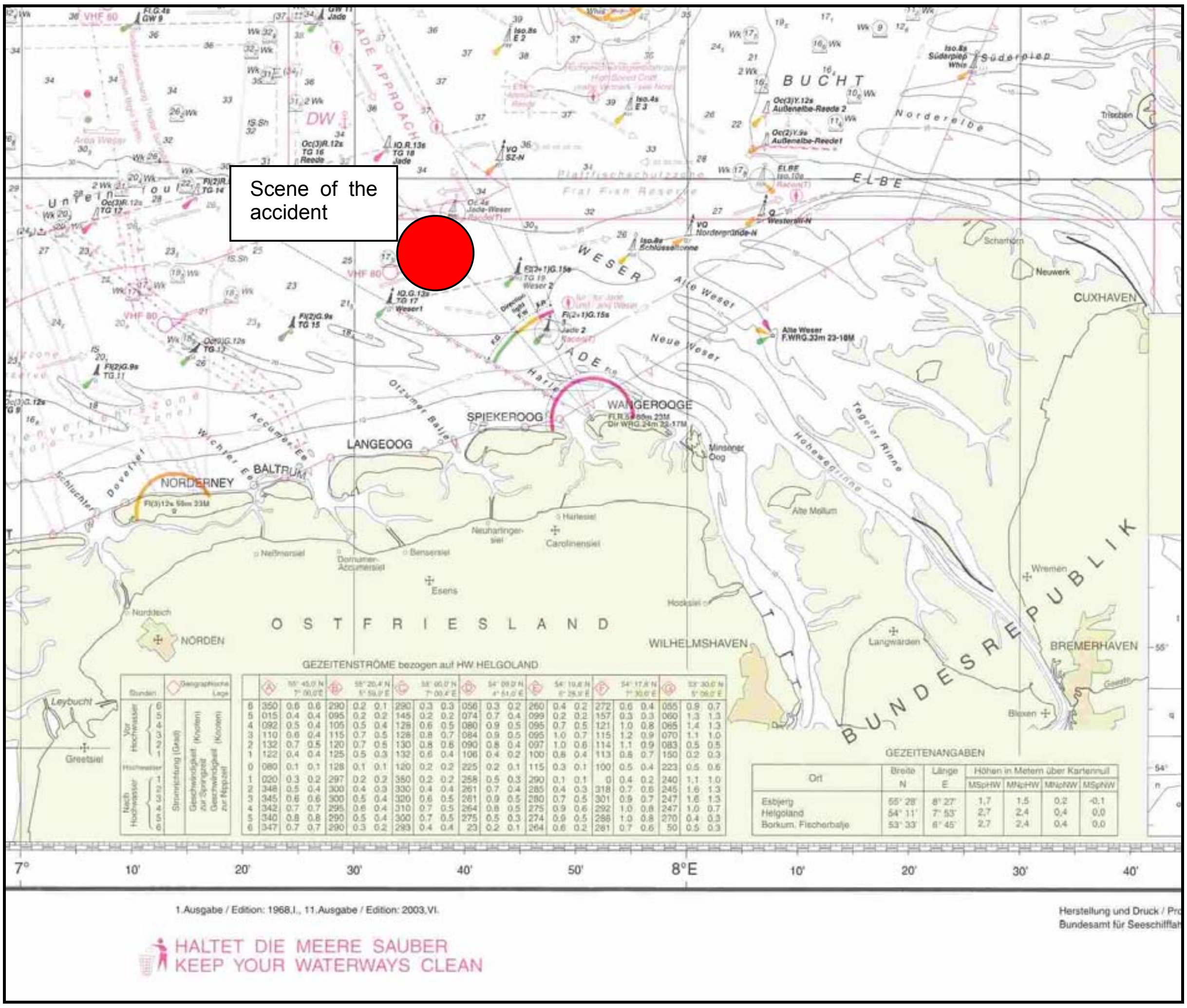

Figure 1: Chart - overview

Section from chart 1456, BSH

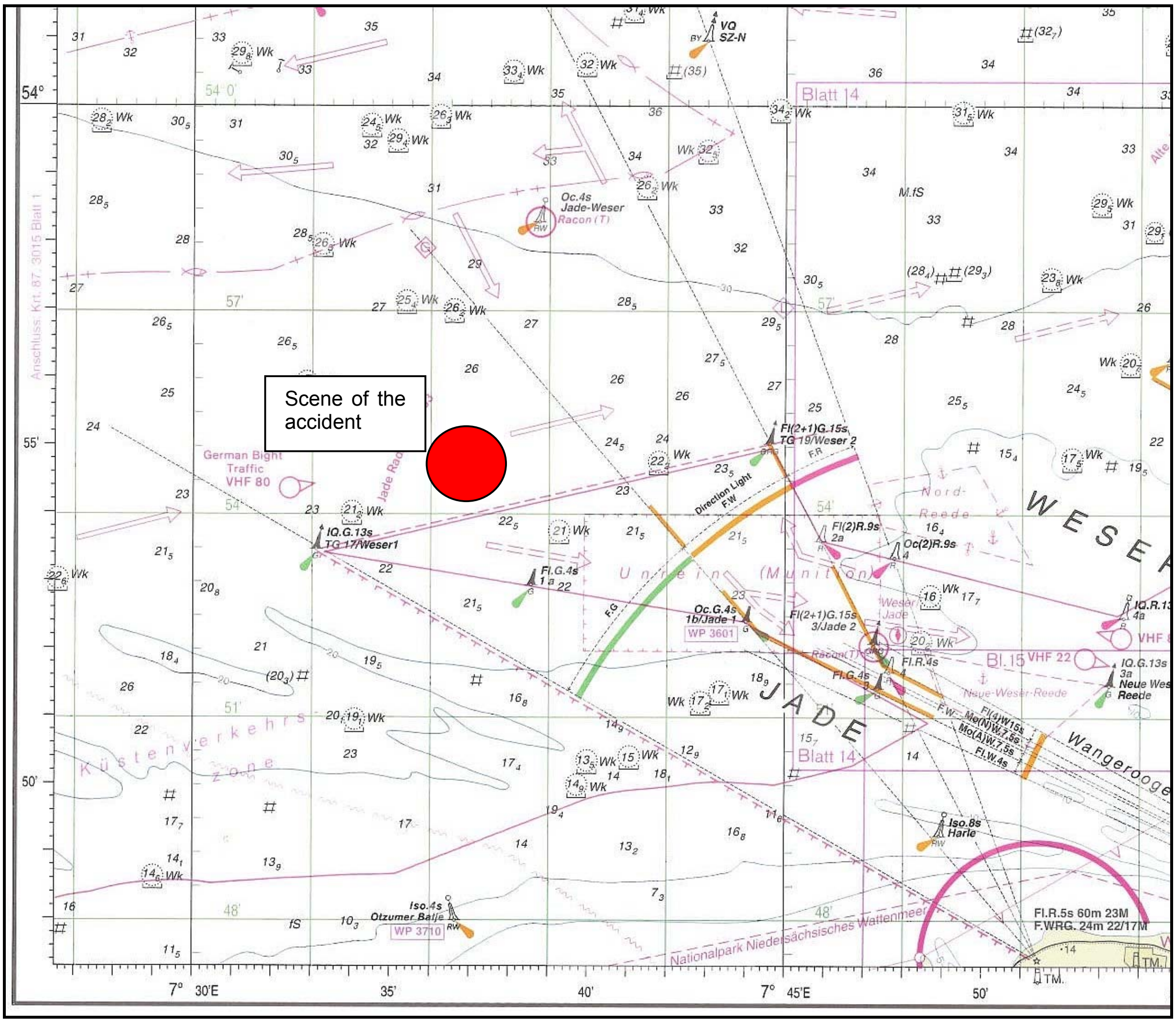

Figure 2: Chart - detailed

3 Vessel Particulars

3.1 Photo

Figure 3: Photo of the vessel

3.2 Particulars

Name of the vessel:	BELUGA STIMULATION
Type of vessel:	Container vessel
Nationality/flag:	Federal Republic of Germany
Port of registry:	Elsfeth
IMO number:	9299513
Call sign:	DLIM
Owner:	Beluga Shipping GmbH & Co. KG
Year built:	2004
Shipyard/yard number:	Bodewes Scheepwerf Vollharding Fox. / 557
Classification society:	GL
Length overall:	134.60
Breadth overall:	21.50
Gross tonnage:	7660
Deadweight:	9180 t
Draught at time of accident:	6.90 m
Engine rating:	7200 kW
Main engine:	Caterpillar Diesel 8 M 43
(Service) Speed:	18.3 kn
Hull material:	Steel
Hull construction:	Double bottom
Number of crew:	14

4 Course of the Accident

The container vessel BELUGA STIMULATION left the port of Rotterdam on 26 October 2006 fully laden with 287 containers to sail via the Kiel Canal to St. Petersburg. Reportedly the vessel was fully prepared for this sea voyage.

The voyage began at 19:36. The cruising speed was said to have been reduced that evening since the weather continued to deteriorate. The forecast had announced westerly winds measuring 8 to 9 Bft and increasing to 10 Bft. A westerly gale was developing over the ocean with wind gusts of 11 Bft and westerly waves of 7 to 8 m in height.

Apparently at around 01:00 in the night the first alarm “water in the bunker room” was displayed in the Chief Engineer’s room. He then went to the engine room and tried to start the bilge pump for the bunker room between holds 2 and 3. However, apparently the pump did not start.

The Chief Engineer was said to have given the Second Engineer instructions to go forward between the containers in order to look for the source of the alarm. The latter then reported that the access hatch to the bunker room was locked and he was no longer able to recognise it.

It was reported that an overflow of heavy oil had led to the suction pipe being stained. The previous Chief Engineer had not noticed this since the suction side of the bilge pump was located underneath. Only after the current incident had happened was the pump removed in order to clean everything underneath it.

The Chief Engineer apparently then remained in the engine room until the morning time to continually pump water from the holds. The bilge pumps seems to worked perfectly.

The Chief Engineer informed the Chief Mate about everything but he, in turn, seemed not to have informed the Captain. Instead, he sent the Bosun forward without consulting the Chief Engineer. The Bosun and the Second Engineer then supposedly met on deck.

Around 07:10 the fire alarm from the bunker room between holds 2 and 3 went off on the bridge and in the Captain’s room. The Captain then reportedly hurried to the bridge immediately where the Chief engineer phoned him to discuss how to proceed. The Chief Engineer requested permission to access the bunker room in order to ascertain the cause of the alarm. The Captain then instructed him to put on a immersion suit and attach a safety line. The Captain said to have been decided to co-ordinate the operation himself and to maintain communication with the bridge via VHF. When the Captain reached the main deck shortly afterwards, the Chief Engineer had already put on the immersion suit and a long safety line measuring about 50 m and was already ready to go forward of the vessel. For reasons of safety, the Captain decided, to ensure his personal safety with the support of two other crew members.

On the instructions of the Captain, the Chief Engineer proceeded to the forward of the vessel along the passageway on starboard since it was too dangerous between the containers. While the Chief Engineer was on his way, the Captain repeatedly observed how the passageway was being washed over with green water. For this reason he was reported to have instructed the crew not to enter the main deck for the duration of bad weather.

When the Chief Engineer returned, he reported that he had opened the entry area to the bunker room and had found the room to be filled with about 70% water. However, he did not discover a fire. The sensor must have set off an alarm message due to the water. He was alleged not to have been able to localise the water ingress but was of the opinion, that water may have entered via the opened goosenecks in the bunker room. He was supposedly not able to reach the goosenecks to close them as there was too much water in this cross passageway with the result that he almost swam to the entry area. He suggested that two of them go to the bunker room together to close the gooseneck openings.

They first had breakfast in order to be able to carry out this plan during daylight. After breakfast the Captain, the Chief and Second Engineer are alleged to have had a discussion. The Captain's initial reservations had been dispelled by the argument that it was necessary to avoid further water ingress.

There seems to have been a misunderstanding, since the two engineers put on immersion suits and went on deck while the Captain reportedly waited in the mess for them to give notice of departure so that he could safeguard them. They refrained from using a safety line in order to avoid the whole length of it buoying upwards like the first time and hooking. Instead, they gripped the railing whenever a wave washed over them. On their way forward they noticed an opened flap for hydraulic control of the hatch cover. After they had closed it, another big wave came over the deck with the result that they had to grip the railing. Suddenly the Second Engineer had the impression that his railing was moving inwards and, when the vessel rolled to starboard, strike the stop on the railing with increasing force. He was thrown over the railing due to the impact and was able to briefly hold on to the outside. He then saw a fender and caught hold of it. However, it became loose and the Second Engineer fell into the water with the fender in his arm. His immersion suit did not have a buoyancy device but kept him warm and the fender kept him afloat until he was saved. The Chief Engineer is said to have returned to the superstructures and thrown a life buoy into the water.

The Captain was apparently still waiting in the mess for the Chief Engineer to start again to the bunker room. In the meanwhile it is alleged that he informed other crew members of the action being taken. Suddenly the Chief Engineer is said to have run in and reported that the Second Engineer had fallen over board.

The Captain promptly informed the Chief Mate on the bridge via VHF about the incident and instructed him to reduce speed. Then he rushed to the bridge and informed German Bright Traffic about the accident. Receipt was acknowledged and the suggestion made that MRCC[2] Bremen should be informed by German Bight Traffic. The person overboard buoy (PoB-Buoy) on the bridge wing was not released.

As a result of the bad weather conditions, the Captain is supposed to have decided that a return manoeuvre, such as the "Williamson Turn", for example, would be too dangerous for the vessel, its crew and cargo. This decision to assign the search for the Second Engineer to the MRCC was said to have been made in consultation with German Bight Traffic and the MRCC. During the vessel continued on its voyage, contact via VHF continued to be maintained with the search units until the Second Engineer had been saved.

[2] MRCC = "Maritime Rescue Co-ordinating Center".

5 Consequences of the accident

After the Second Engineer had fallen into the water around 08:25, he was rescued alive around 10:10 by the rescue cruiser BERNHARD GRUBEN and brought to a hospital in Wilhelmshaven. Hypothermia and external injuries were not life-threatening with the result that he was able to resume work on board the ship a few days later.

6 Investigation

6.1 Inspections of the BELUGA STIMULATION by the BSU

The BELUGA STIMULATION was initially inspected by two employees from BSU in the port of Hamburg on November 4th 2006. The Master made use of his right to refuse to give evidence concerning the facts.
Apart from interviews with crew members, inspection of the conditions of the path of the accident on starboard side of the main deck took place.

The path to and from the scene of the accident lead via the starboard passageway which is separated (see fig.4) on the outside by a 1.05 m high railing and on the inside by partitioned areas – amongst others for stowing lashing material (twistlocks).

Figure 4:Passageway on starboard

A pilot shipside door is located in the railing a few metres away from the superstructures (see fig. 5).
A fender is attached to the railing beside this pilot shipside door with the purpose of cushioning the pilot boat (see fig. 7).

Figure 5:pilot shipside door on starboard

The Second Engineer was wearing a immersion suit without a life jacket when he fell overboard (see fig.6).

He was able to the draw the attention of the rescuers with the aid of a torch that he had on his person.

Figure 6: Immersion suit – similar to the used suit

Figure 7: Fender – similar to the fender that was carried away

The course of the marine casualty investigation required repeat inspection of the BELUGA STIMULATION on September 10th 2007 in the port of Hamburg in order to investigate possible “influences of free surfaces” on the vessel’s deck during bad weather as well as examine the question as to how the water was able to penetrate the bunker room. During this investigation 2 cm of rainfall lay on the cross passageway at the time.

There are two goosenecks in the cross passageway between the holds 2 and 3 where entry to the bunker room is located: one for aerating and the other for de-aerating the bunker room. They are used for active ventilation. The gooseneck for de-aerating is installed at such a height that water could not have penetrated. The gooseneck for aerating was so short at the time of the accident that it was located about 70 cm above the deck. If the level of water had increased to over 70 cm, augmented by the movements of the vessel, then water may have penetrated at this location.

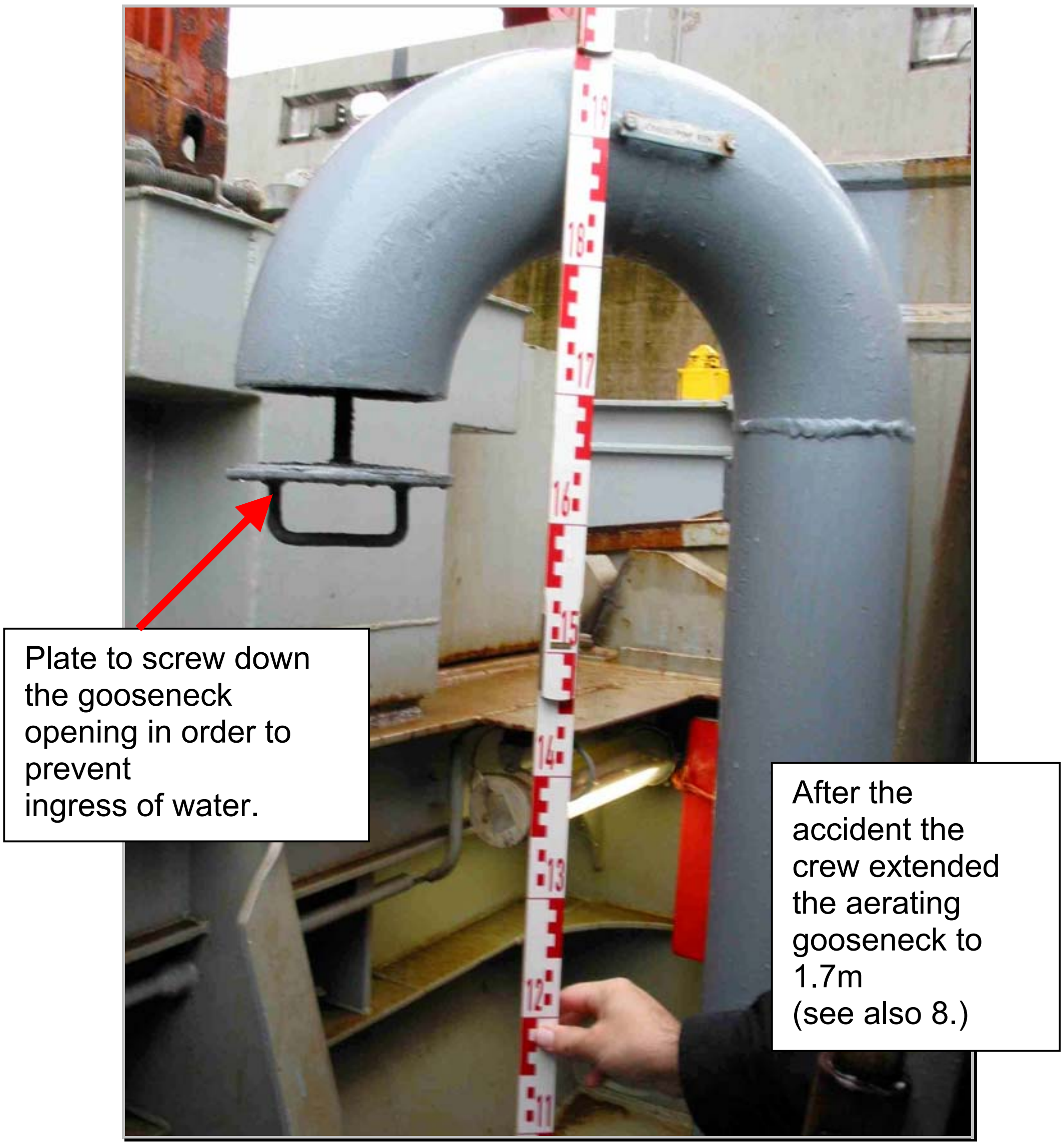

Figure 8: Aerating gooseneck – after extension

The further investigation showed that about 21 t of water was in the bunker room. The impact of free surfaces was negligible due to the construction and liquid level of the bunker room. Up to 13 t water may have collected in the cross passageway. Since there are two cross passageways, it must be assumed that up to 26 t of water collected given the fact that its free surfaces influenced the stability.

The vessel's fuel supply is primarily secured from the engine room.
The tank capacity of both settling tank plus daily tank is large enough to supply the main engine with fuel for 24 hours. As soon as they have reached a set minimum level, the settling tanks are automatically filled with fuel from each connected double bottom tank until it is empty. The valves of the double bottom tanks cannot be controlled from the engine room. It is necessary to enter the bunker room for this.
The journey time from Rotterdam to Brunsbüttel takes approx. 17 hours at a speed of 15.5 knots.

6.2 Environmental conditions

The official meteorological expertise of the Germany's National Meteorological Service (DWD) stated that there was a powerful cyclone centring over Southern Norway during the night of 26-27 October 2006. The frontal system extended in a broad arch over Central Sweden, the Baltic states and the Southern Baltic Sea as far as Central France. There was unsettled weather with squalls in the German Bight during the night and the first half of the day of 27 October. A strong to stormy wind was blowing on 27 October 2006 in the relevant area , initially from Westerly Southwest, and then later from West to North West with an average strength of 7 to 8 Bft and 9 Bft at times. Gusts measuring 10 Bft were reached. A gale that continued over several hours from Westerly directions can produce a wind sea from a Westerly direction with significant waves heights of 3.5 to 5.0 m. The wind came from Southerly directions on the previous day so that no noticeable swell appeared in the relevant sea area which lies 6 nm North of Langeoog and Spiekeroog.
The sky was initially clear at midnight and cloudy later on. There were scattered showers of rain during the morning hours. Horizontal visibility was 10 km throughout the entire period.
The air temperature was 14 ºC, the water temperature approx. 15 ºC. Sunrise was around 08:16 CET, moonrise at 14:38 CET.

The Federal Maritime and Hydrographic Agency (BSH) conducted a swell analysis for the scene of the accident at the time the accident occurred and produced the following results:

Significant wave height:	Hm	= 4.20 m
Average period:	Tm	= 7.7 s
Max. wave height:	Hmax	= 6.93 m
Max. period:	Tmax	= 9.4 s
Average swell direction:	Dir	= 286º
Directional scatter:	Spr	= 13º
Water temperature:	WT	= 15.9 ºC

Measured data for wind velocity and wind direction were not available.

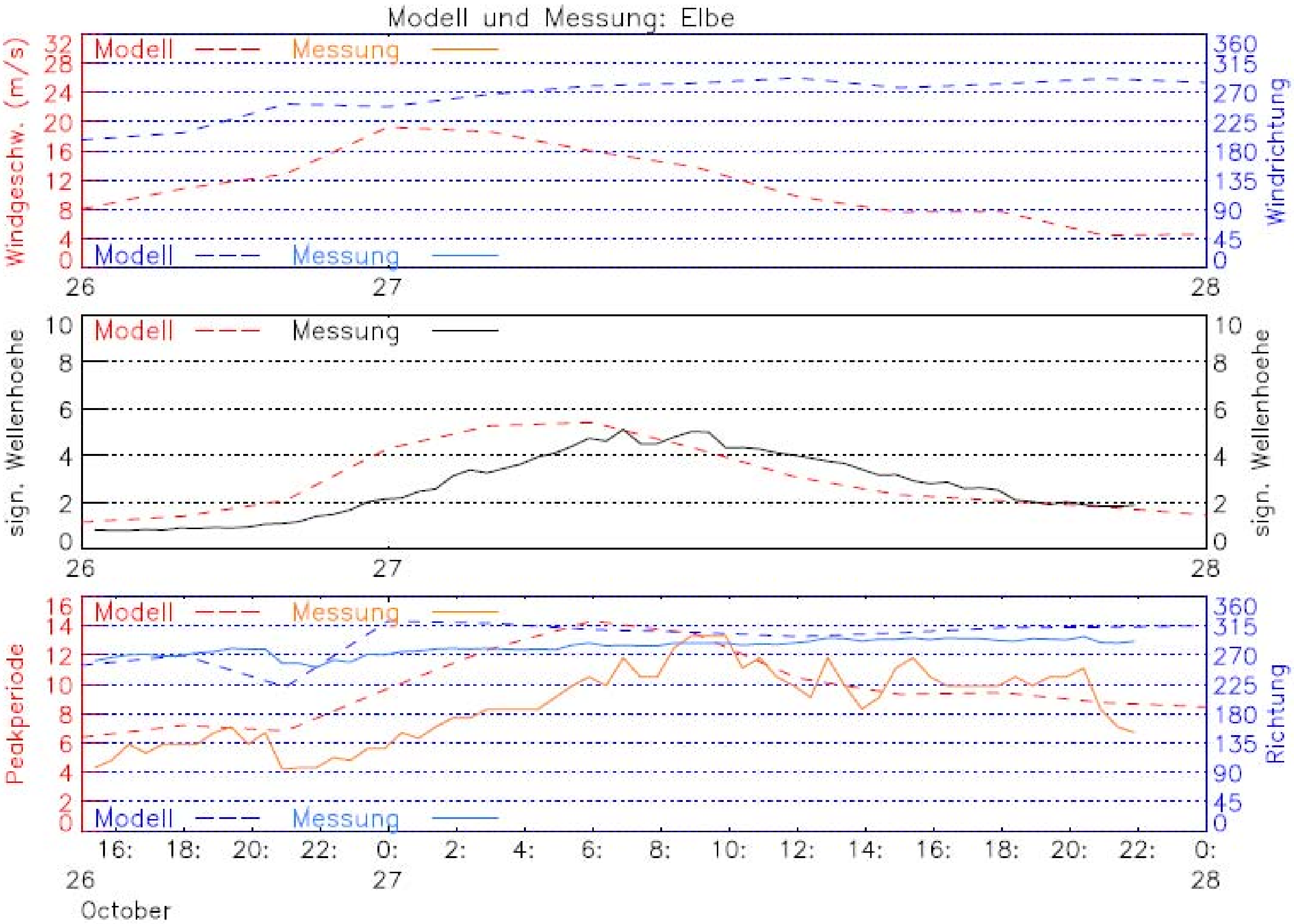

Figure 9: Environmental diagram

6.3 AIS track

Apart from a tabular listing of courses and speeds, the VTS Centre Wilhelmshaven supplied the following plots with the course of the voyage of the BELUGA STIMULATION beginning a half an hour before the accident. The AIS data of the vessel recorded here, confirm that the vessel neither changed its course or speed to make it easier to walk the forecastle prior to the accident or to support rescue measures after the fall overboard.

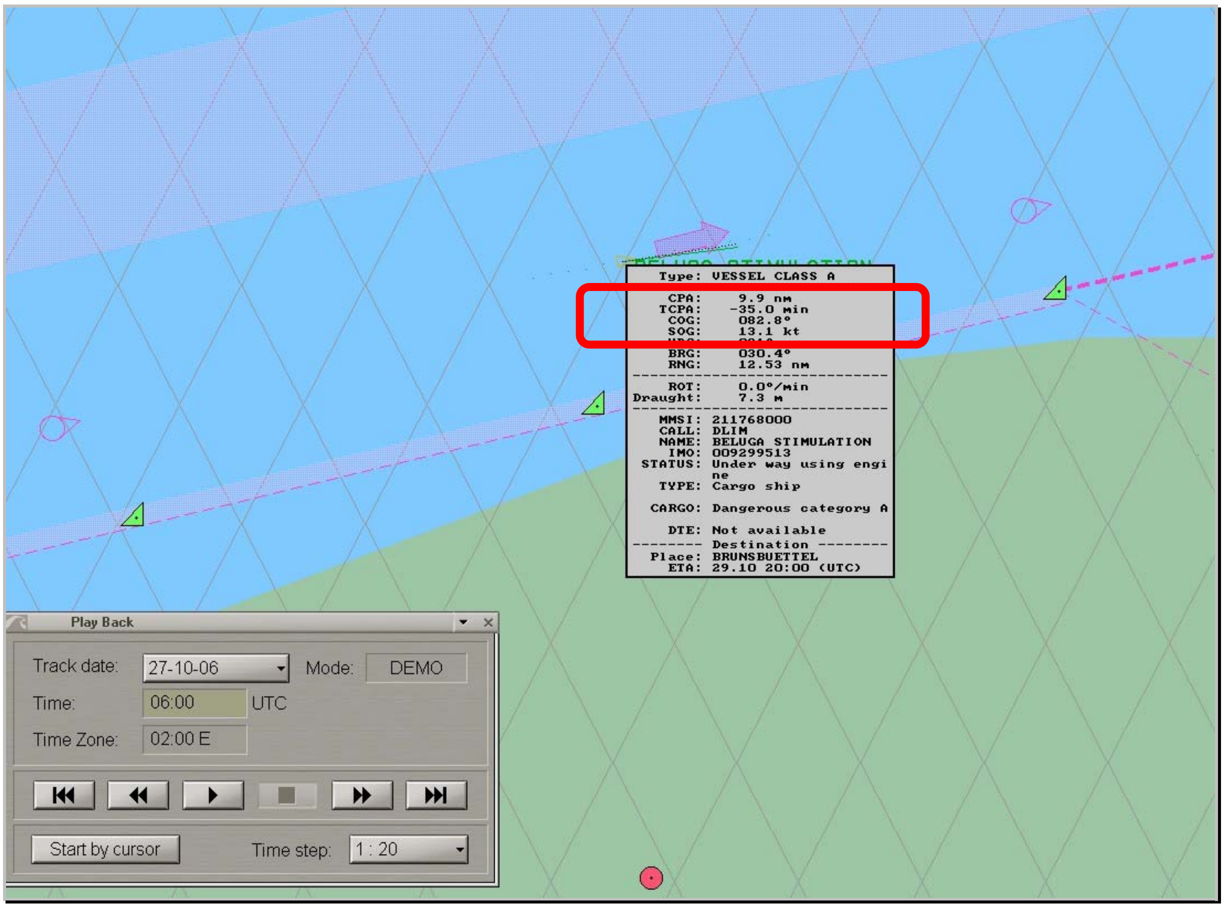

Figure 10: AIS data from 08:00 LT

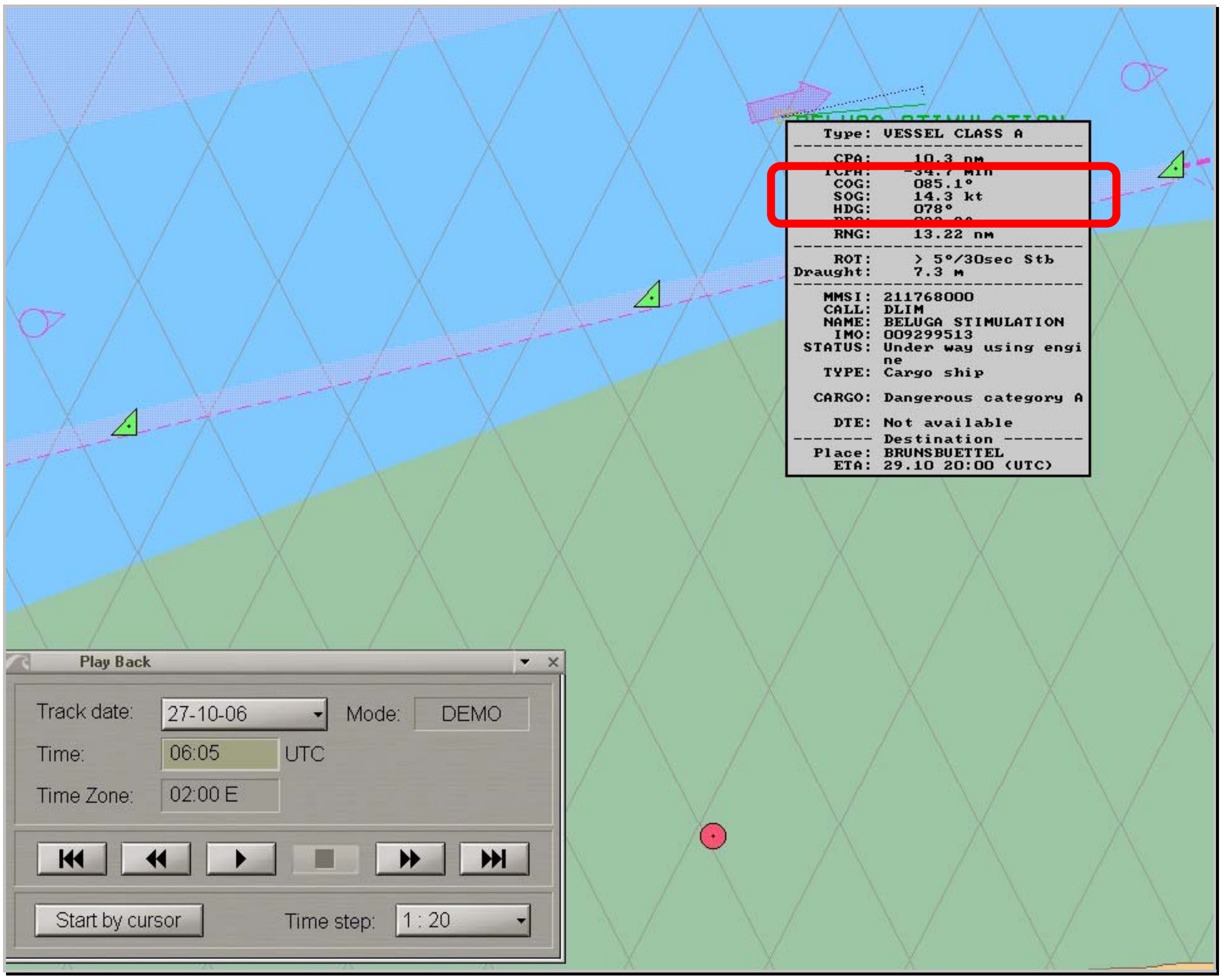

Figure 11: AIS data from 08:05 LT

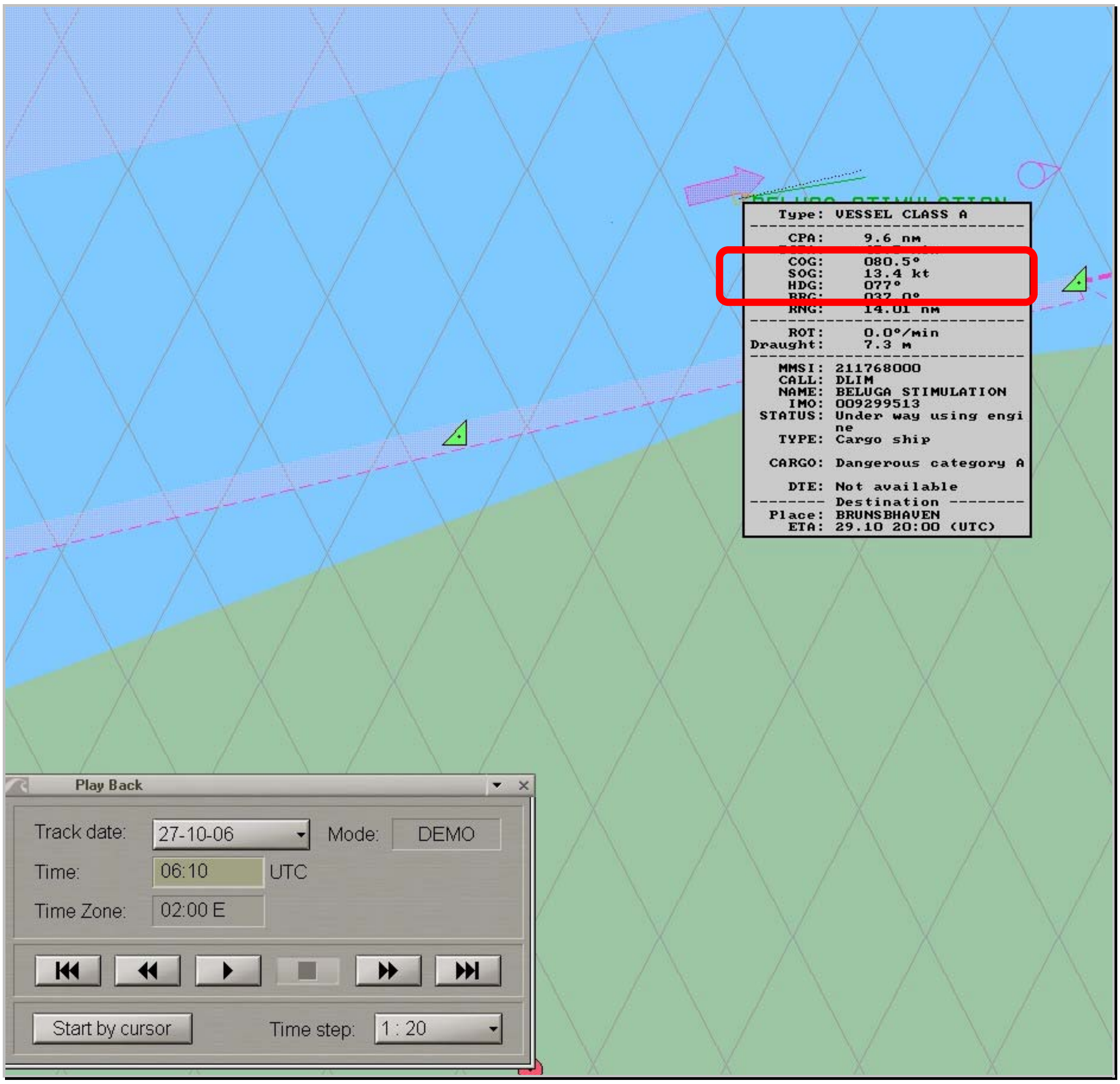

Figure 12: AIS data from 08:10 LT

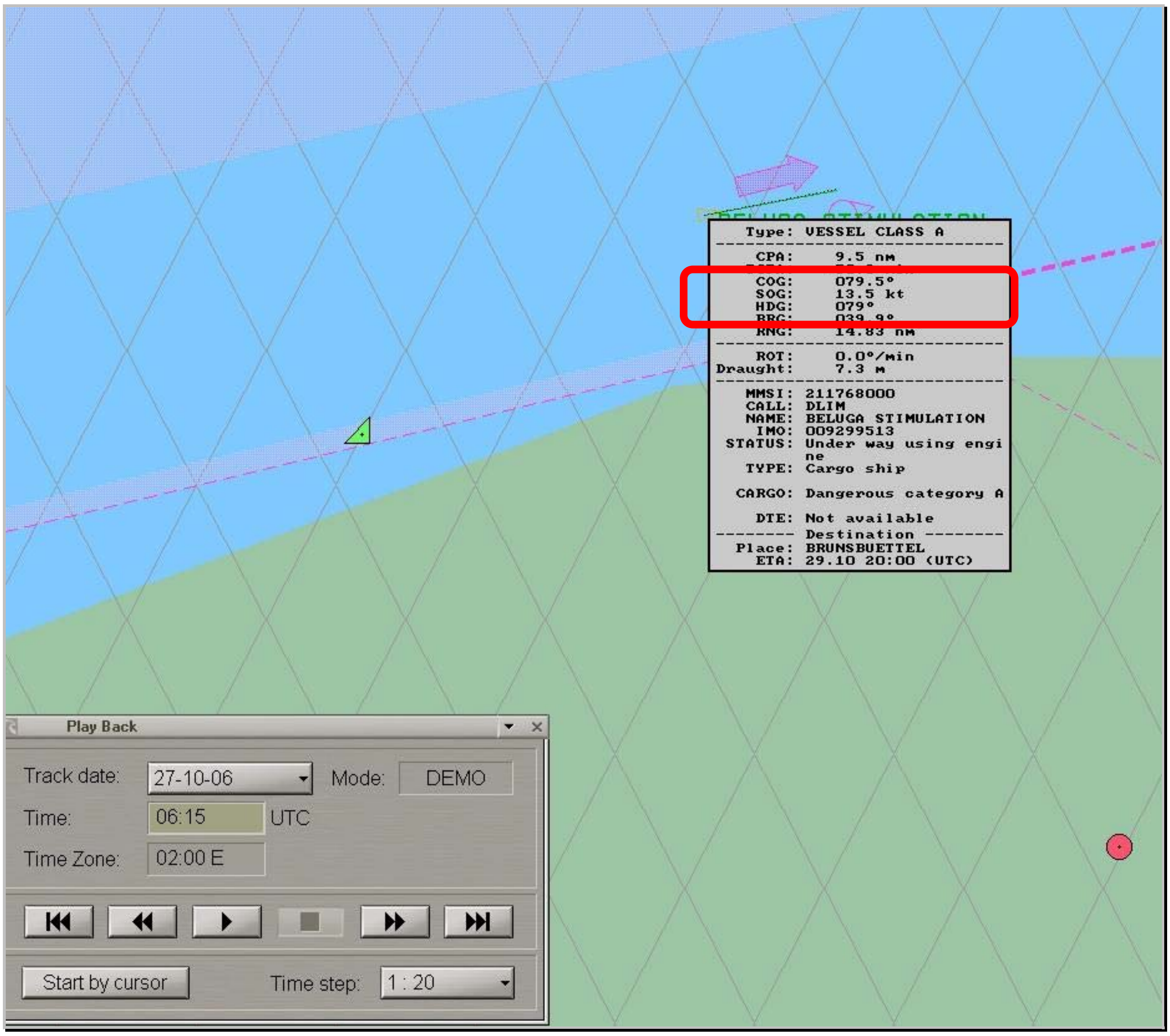

Figure 13: AIS data from 08:15 LT

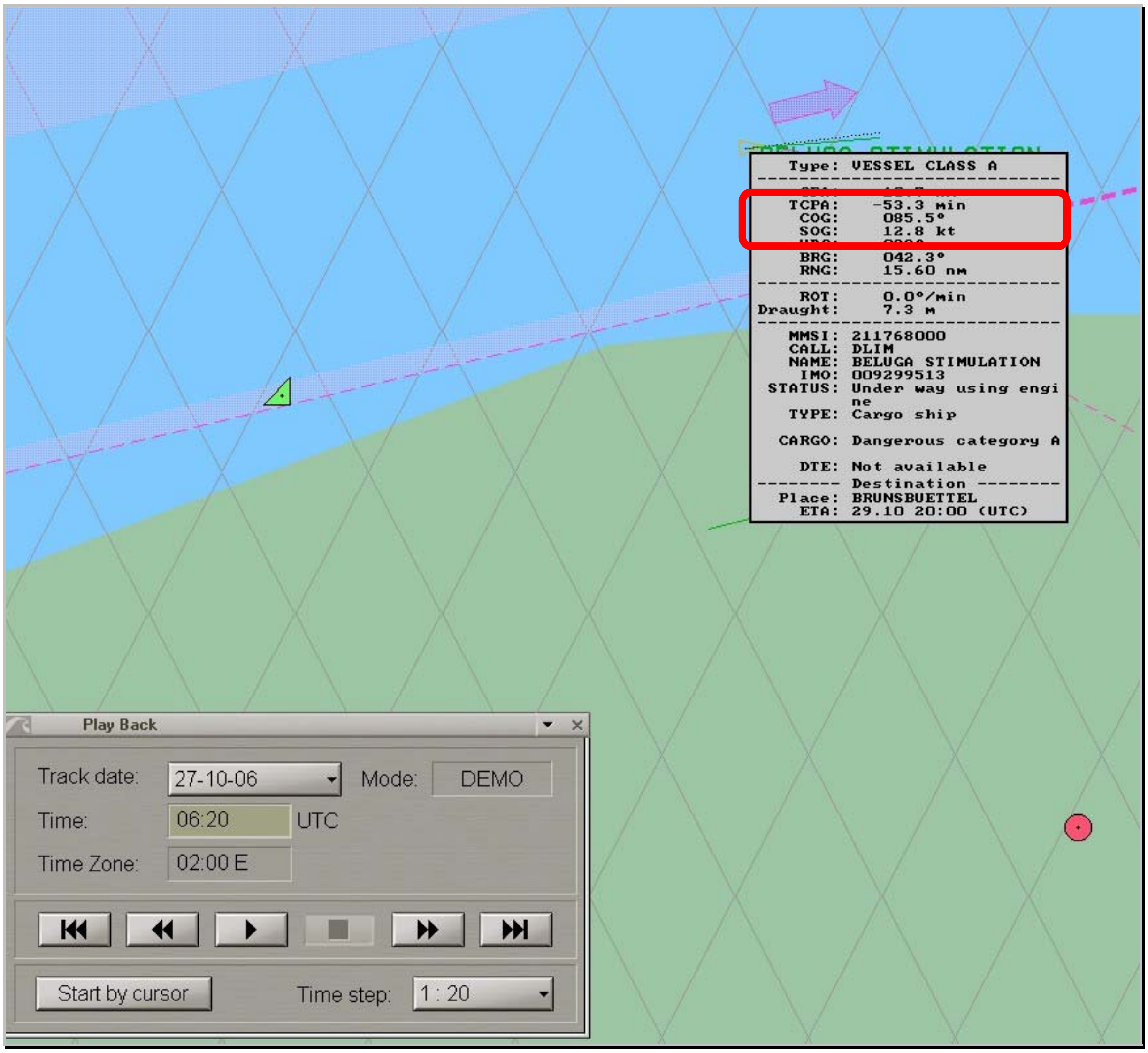

Figure 14: AIS data from 08:20 LT

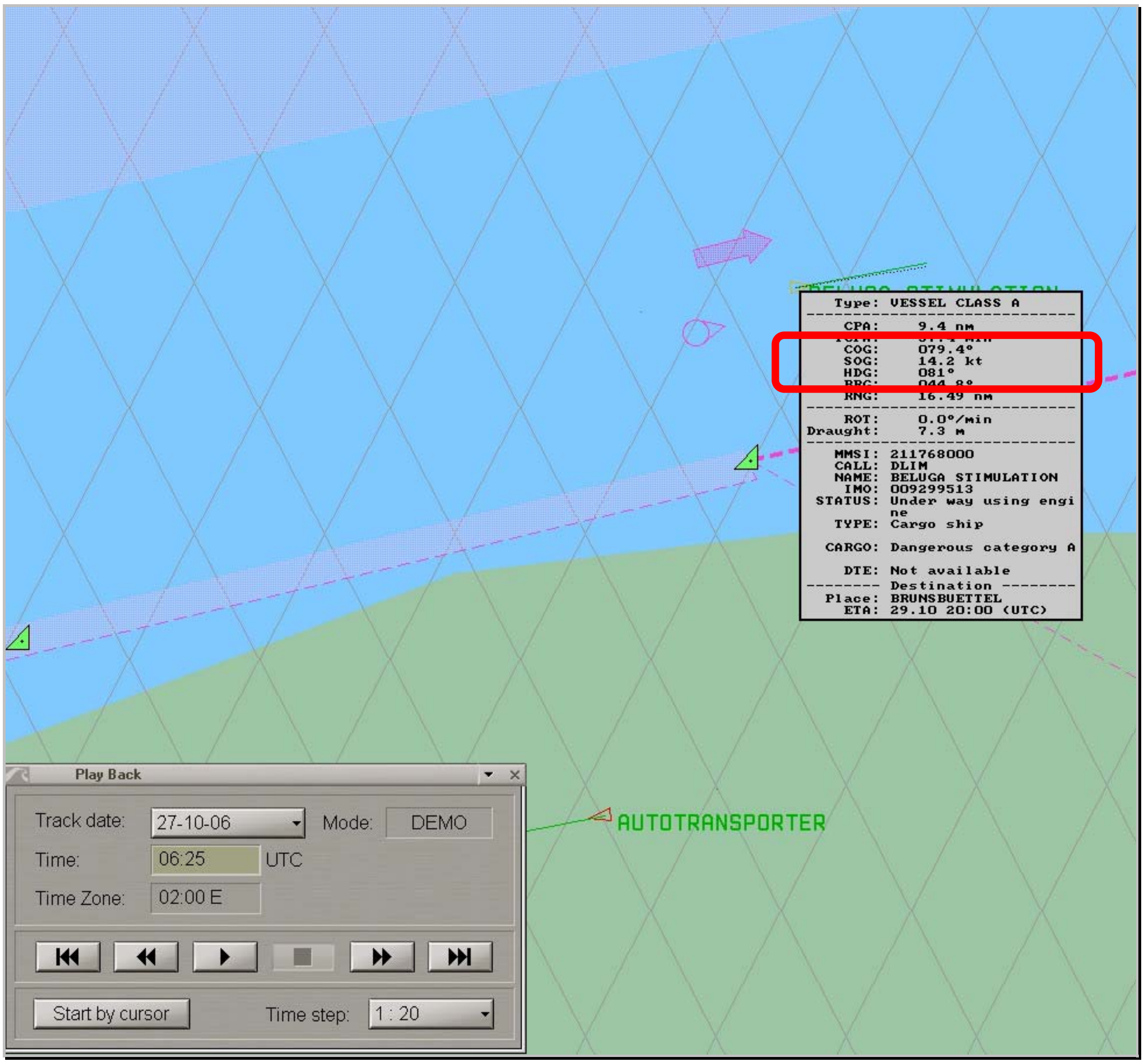

Figure 15: AIS data from 08:25 LT

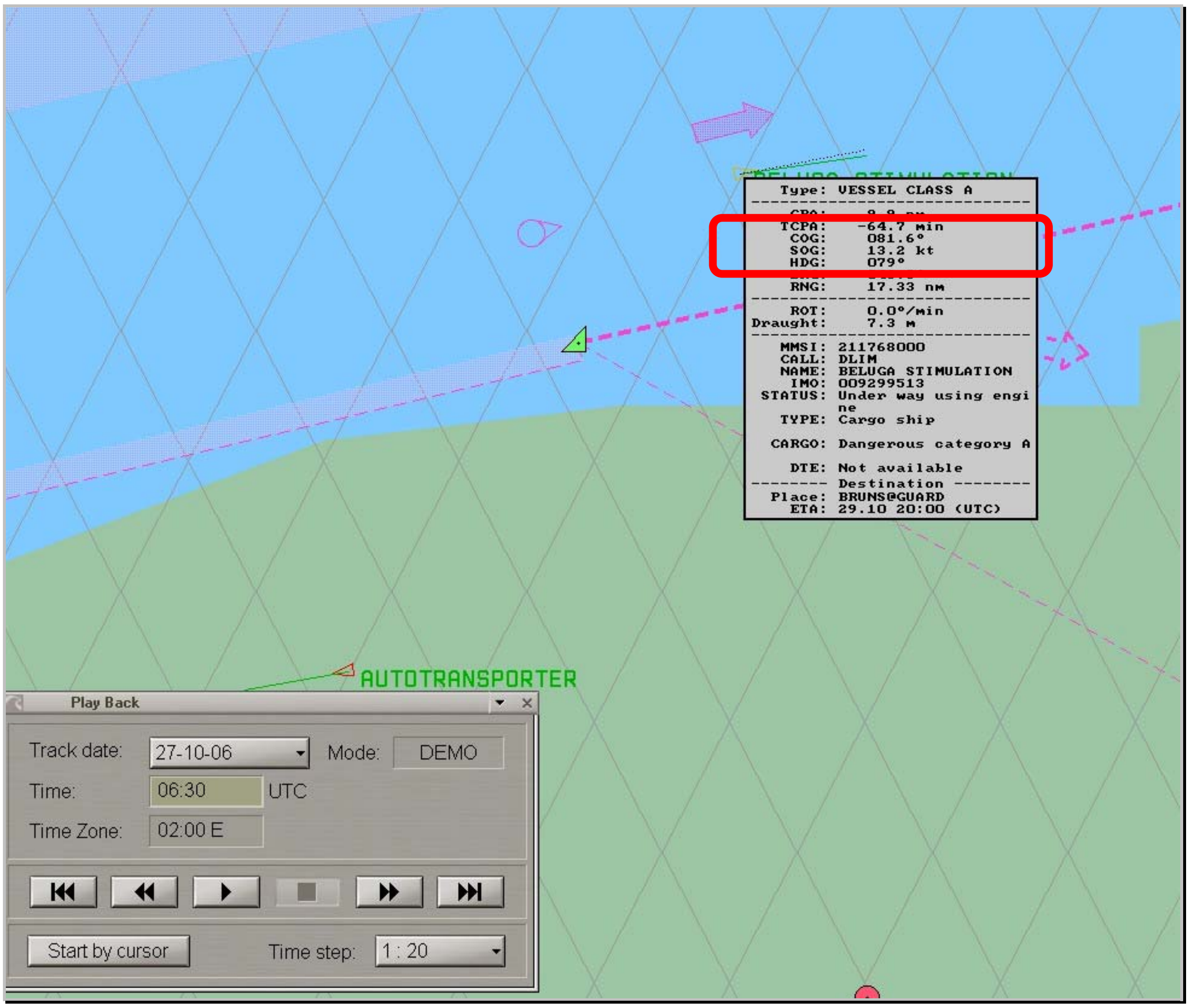

Figure 16: AIS data from 08:30 LT

6.4 Rescue by MRCC Bremen / DGzRS

In the Federal Republic of Germany the Federal Government assigned the following obligations and responsibilities for maritime rescue (Maritime Rescue Co-ordinating Center = MRCC) to the German Maritime Search and Rescue Service (DGzRS):

- Co-ordination and conduct of search and rescue at sea and along the German coastline
- Monitoring of VHF channels that are used for emergencies and safety purposes
- Medical care on board vessels at sea or evacuation of people with critical illness or serious injuries by the DGzRS

The DGzRS is a private, independent and voluntary institution which is financed by donations and does not receive financial support from the government. Its headquarters are located in Bremen as is the MRCC.

The DGzRS has over 54 stations and thus covers the entire German coastline. The DGzRS fleet includes 21 rescue cruisers between 23 m and 46 m in length that are operated day and night by 184 full-time crew members and 40 rescue boats between 7 m and 12 m length that are operated by over 800 volunteers. The type of vessel deployed at a particular station is contingent upon the area of operation.

The rescue cruisers and rescue boats were all specifically designed for the DGzRS. They are self-righting and are equipped for purposes of fire fighting and towing as well as being able to offer medical aid. The rescue cruisers have independent daughter boats.

The vessels of the DGzRS can be alerted by the MRCC or an SAR lookout station which is then obliged to transmit information directly to the MRCC. After an alert the rescue cruisers are ready for action within an average of 5 minutes. The small rescue boats respond within 15 minutes.

The DGzRS has a network of relay stations along the German coast for monitoring VHF channels and for communicating during operations. In addition, the DGzRS is supported by “SAR lookout stations”, the VTS Centres along the German coast.

The DGzRS co-operates with the SAR air units of the German navy in search and rescue operations at sea.

At 08:28 on 27 October 2006 Bremen Maritime Rescue Co-ordination Centre (MRCC) received information from the VTS Centre Wilhelmshaven concerning a person overboard accident on the BELUGA STIMULATION. Apart from the presumed scene of accident, they were also informed that a male person was involved who was wearing a orange-coloured immersion suit.
The weather at the scene of the accident was recorded as follows: westerly 8 Bft, hurricane gusts, 4-5 sm visibility over 5m, water temperature 13 ºC.
MRCC Bremen assumed the time of the accident to be around 08:25. As the first search unit a helicopter arrived at 09:03 at the scene of the accident.

Overall, five airborne search units and nine search units in the water had been co-ordinated by the time rescue had taken place.
At 10:08 the person was rescued by one of the rescue cruisers.
The person who was rescued was brought to shore land at 11:41 and then transported to hospital.

7 Analysis

7.1 Load condition

The vessel was a 750 TEU container vessel, built in 2003, with the following main dimensions and propulsion data:

Overall length:	134.64 m
Length between perpendiculars:	125.66 m
Breadth moulded:	21.50 m
Moulded depth:	9.30 m
Draught:	7.10 m
Freeboard:	2.20 m
Deadweight :	9180 t
Driving power:	7200 KW
Speed:	18.3 kn

With a mean draught of 6.94 m the vessel had a displacement of 13.127,5 t at the time of the accident.
At the time of the accident the vessel had a displacement of 13,127.5 t at an mean draught of 6.94 m. The service speed was 14 kn. According to the log book , the vessel travelled a course made good of 076º. The vessel had three big hatches, a long forecastle deck and also a forecastle and a poopdeck. The classification does not display any special features. The vessel had valid papers and left Rotterdam completely sea-worthy condition heading to St. Petersburg via the Kiel Canal.

The following stability data from October 27th 2006 at 17:28 are used as a basis:

Metacentric height:	$\overline{GM_0} = 1.03m$
Righting level arm at a tilted angle of 30°:	$GZ(30°) = 0.42m$
Maximum righting lever arm circumference:	$\Phi_{\max} = 46.5°$

All the values are more favourable than required by IMO Res. A167. There is no explicit requirement to use a minimal right arm circumference. However, vessels with a righting lever arm circumference smaller than 45º are generally not accepted.
The vessel has a breadth to draught ratio of about B/T = 3.0 and a breadth to freeboard ratio of about B/Fb = 9.8.
Relatively large values of $\overline{GM_0}$ are typical for vessels with these dimensions, with relatively large breadths, even under loaded conditions. The GZ curve has a max. righting lever arm circumference of 46.5º due to large breadth to draught or breadth to freeboard ratios. Indeed, minimal righting lever arm circumferences are not set out in accordance with the regulations but experts consider a circumference of 46.5º to be very low. The GZ curves are based on the assumption of the water being smooth and do not take any dynamic effects into account. They are based on the assumption of quasi-static equilibrium.

For this reason, the usual stability data is not sufficient in a relatively rough swell for the vessel when evaluating the present case.

A better indication of sufficient stability is supplied by quasi-static calculations during a regular swell whereas these should also take the into account the imbalance of the trim The distribution of the reserve buoyancy is characterised by concentration at the vessel ends. For this reason the relevant vessel has extremely small righting lever arms if it is on the crest of a wave.

Even though these calculations may help indicate whether such vessels are at risk during following seas, they do not include dynamic effects and, therefore, do not reproduce the actual characteristics during an irregular swell. With the aid of numerical simulation, endangerment during an irregular swell can be assessed and displayed in polar co-ordinate diagrams.

Presently no international regulations exist which refer to the state of the art of science in the field of predicting capsizing behaviour during irregular swell of seagoing vessels such as the relevant vessel .

The following calculation has been made to give a rough estimation of the dynamic behaviour of the vessel:

The encounter period can be approximately used to calculate the pitching period:

$$T\psi = \frac{T_m^2 \cdot g}{T_m \cdot g - 2\pi \cdot v_S \cdot \cos\mu}$$

For an average period Tm = 7.7 s

With an angle of encounter $\mu = 25°$ one receives [3] $T_\psi = 16.8$.

The rolling period can be estimated by $T_\varphi = (0.73 \div 0.91)\dfrac{B}{\sqrt{\overline{GM_0}}}$.

One receives B = 21.50 m and the metacentric height of $\overline{GM_0}$ = 1.03 m

$T_\varphi = 15.5 \div 19.0$ s [4]

Recent literature informs us that vessels with a ratio of

$$T\varphi / T_\psi \cong 1.0$$

[3] Meier-Peter, H.; Bernhard, F.: Handbuch der Schiffsbetriebstechnik, Seehafen Verlag, Hamburg 2006.
[4] The symbol “ ÷ ” stands for “in the range of – to”.

incline towards coupled pitching and rolling oscillations and thus, particularly during following seas, towards extremely large rolling angles. Vessels with malfunctioning bow flares particularly appear to incline towards these parametric oscillations.

All these indicators: following seas, lower righting lever arm curves when crossing over the crest of a wave, unfavourable ratio between the pitching and rolling period as well as a wavelength which roughly corresponds to the length of the vessel, were all present at the time of the accident.

Seagoing vessels of this size must be able to manoeuvre unrestricted during bad weather as prevailed at the time of the accident even though the weather conditions could not be described as extreme and should therefore be able to carry out rescue manoeuvres. On the other hand, endangerment due to a stability accident or the loss of containers during the aforementioned situation cannot be ruled out.

Establishing sea-worthiness of this vessel requires that the ship command comply with the IMO regulations. However, at the same time, these regulations cannot provide reliable evidence as to whether this vessel was capable of manoeuvring safely under the weather conditions that prevailed at the time of the accident.

The loading of containers usual today makes it difficult for the vessel's command to assess the loading of their vessel. Besides comprehensive shipping documents for possibly hundreds of containers in every port no guarantee can be given for the weights stated for the loaded containers. The BELUGA STIMULATION is said to have had no cargo plan[6].
International marine casualty investigations more and more focus on the problem of the unknown container weights. It should be internationally implemented a feasible solution as quickly as possible[7]

7.2 Assessment of endangerment as a result of a swell relating to resonance

At the time of the accident the vessel was in the resonance region for synchronous resonance. Under such circumstances initially small rolling amplitudes can increase the rolling oscillations due to the inclined following seas.

This is presumably the reason for the strong rolling oscillations of the vessel at the time of the accident which led the ship command to believe that the vessel was in an unsafe position. In addition, the vessel was in a state in which, for this course and speed, it lingered for a very long time on the crests of waves when under successive high wave attack and thus only has very low stability with low righting lever arms.
Indeed, these threats might have been diminished by a change (reduction) in the speed or a change in course. However, decision support in the form of a comprehensive survey of potential danger areas, e.g. in the form of a polar co-ordinate diagram, may have been required for the Captain to promptly receive the relevant information.

[6] see also report 187/05 – page 40
[7] see also http://www.maib.dft.gov.uk/cms_resources/MSC%20Napoli.pdf

7.3 Free surfaces

The impact of water on deck[5] on the rolling period in the resonance of a vessel can be shown as followed:

The rolling period is evaluated using $T = (0.73 \div 0.91)\frac{B}{\sqrt{\overline{GM}_o}}$

Whereas B = beam 21.5 m and $\overline{GM}_0$ = metacentric height 1.03 m.

Thus one obtains a rolling period of $T = 15.5 \div 19.0s$.

Vertical displacement of the centre of gravity G to G' occurred as a result of water on deck and the bunker room filling up. This displacement can be defined by means of a mass moment assessment:

$$\overline{KG} \cdot \Delta + h' \cdot \Delta' + h'' \cdot \Delta'' = \left(\overline{KG} + \overline{GG'}\right) \cdot \left(\Delta + \Delta' + \Delta''\right)$$

Whereas $\overline{KG}$ = 8.976 m is the height's centre of gravity via Kiel of the vessel without water on deck

h' = 9.55 m the height's centre of gravity over keel of the vessel without water on deck

h'' = 3.10 m the height's centre of gravity over keel of the water in the bunker room,

Δ = 13127.5 t the displacement of the vessel without water on deck,

Δ' = 26 t the weight of the water on deck,

Δ'' = 21 t the weight of the water in the bunker room.

The above equation broken down according to $\overline{GG'}$ produces vertical displacement of the centre of gravity with:

$$\overline{GG'} = \frac{\overline{KG} \cdot \Delta + h' \cdot \Delta' + h'' \cdot \Delta''}{\Delta + \Delta' + \Delta''} - \overline{KG}$$

[5] The water in the bunker room can be disregarded when calculating the rolling period as the free surface was very small.

$$\overline{GG'} = \frac{8.976 \cdot 13127.5 + 9.55 \cdot 21 + 3.10 \cdot 26}{13127.5 + 21 + 26} - 8.976$$

$$\overline{GG'} = -0.01$$

As a result of the so-called free surfaces, the height's centre of gravity is also displaced with

$$\overline{GG''} = \frac{i_W \cdot c}{(\Delta + \Delta')} \cdot \gamma_w ,$$

whereas

$i_W = \frac{b^3 \cdot l}{12}$, the geometrical moment of inertia of the free water surface is a b beam and l length.

γ_W = specific weight of the water 1.030 t/m^3

c = correction factor for installations between the hatches c=0.8.

Sometimes 0.5 m of water was on the deck between the hatches.

$b = 18.70m$,
$l = 6m = 2 \cdot 3m$

$$i_W = \frac{18.7^3 \cdot 6}{12} = 3270m^4$$

$\Delta' =$ 26 t

With this data one obtains a displacement of the centre of gravity of

$$\overline{GG''} = \frac{3270 \cdot 0{,}8}{13127.7 + 26} \cdot 1{,}030 = 0.2m$$

The percentage change in the rolling period of the vessel with water on deck T' compared to the rolling period of the vessel without water on deck T is then:

$$\frac{T - T'}{T} \cdot 100 = \left(1 - \sqrt{\frac{\overline{GM_0}}{\overline{GM_0} - \left(\overline{GG'} + \overline{GG''}\right)}} \right) \cdot 100$$

Thus with $\overline{GM_0}$ = 1.03 m one obtains a percentage increase in the rolling period with

$$\frac{T - T'}{T} \cdot 100 = \left(1 - \sqrt{\frac{1.03}{1.03 - (-0.01 + 0.20)}}\right) \cdot 100$$

$$= 10.7\%$$

This means that the rolling period with water on deck changes to such an extent that the minimum from 15.5 seconds was extended to 17 seconds and the maximum from 18 to 21 seconds. In order to ascertain such changes, accurate timing is required. Accordingly, the impact on the stability of the entire vessel must be assessed as low. Notwithstanding, the collection of water in the cross passageway and the lack of watertight integrity despite bad weather being forecast, is open to criticism.

7.4 Engine rating

The vessel has a main engine type Caterpillar Diesel 8M43 with 7200 kW and 500 rpm and thus can attain a max. speed of 18.3 kn. The rpm was reduced to 140 rpm by means of an axle gear. The vessel has a variable pitch propeller. At the time in question the cruising speed was 14 kn. Assuming that the increase in drag due to the swell was somewhat offset by the waves and the following winds, the rating amounts to

$$7200kW \cdot \left(\frac{14.0}{18.3}\right)^3 \approx 2500kW$$

3700 KW remain as reserves for a rescue manoeuvre in heavy seas – more than the 14 kn power required for the voyage - after 1000 KW is accounted for the shaft generator. Thus the ship command should have had sufficient driving power for a return manoeuvre.

7.5 Bunker room

The investigation conducted by the BSU showed that an oil leak occurred in the bunker room months prior to the accident. While the room was cleaned as a whole, the opening to the bilge was so polluted that it was not functional. Thus the ingress of water could not be removed by remote control using the bilge pumps.
In order to be able to comprehend whether the ship command saw a need to send crew members to this bunker room during bad weather, a recalculation was conducted to determine whether the main engine's necessary fuel supply was the reason for this.

The following key data were taken into consideration:

Ratings:
Efficiency of the main engine (HM = 100%): 7.200 KW
Journey through bad weather: assumed to be no more than 5.000 KW
2 auxiliary diesel (HD), each 371 KW
Average on-board supply system load at sea: about 300 KW
1 shaft generator: 1.500 KVA

Tank capacity:
2 settling tanks: combined useable volume : 41.5 41.5 m^3 - about 37.5 mt HFO
1 daily fuel tank: useable volume: 21.4 m^3 - about 19.2 mt HFO

2 MDO daily fuel tanks: combined useable volume: 12.6 m^3 - about 11.2 mt MDO

Specific consumption (propulsion and auxiliary diesel) – averaged very conservatively: 180 gr/kWh

This results in a possible period of consumption of about 39 hours, HM + HV operation with HFO without the heavy oil having to be transferred inside the vessel, i.e. without there being a need to go to the bunker room during bad weather.

Conversely, one can deduce from the shipping company particulars – at a service speed of 15.5 kn about 17 hours passage from Rotterdam to Brunsbüttel – that even the contents of the HFO settling tank 1 were sufficient to cover fuel consumption for this route.

It can be conclusively ascertained that during the passage in question from Rotterdam to the Kiel Canal there was no necessity to enter the bunker room particularly under the prevailing bad weather conditions. This applies provided that, the engine crew had filled up the HFO settling tank in Rotterdam. It has been calculated that the capacity of the heavy oil daily fuel tank should have sufficed for this voyage.

In principle, entry to the bunker room is only required in a case where the bunker tank extraction valves that cannot be controlled from the ECR have to be adjusted (2 x port and starboard deep tanks). As soon as a tank pair has been selected, the HFO transfer pump 2 automatically refills it once it falls short of the minimum alarm in the settling tank.
Whether a daily inspection of the bunker room is necessary appears to be doubtful.

7.6 Work on deck during heavy seas

When the first alarm from the bunker room reached the bridge and the ECR around 01:00, the Chief Officer on watch sent the Bosun forward of the vessel. Irrespectively, the Chief Engineer sent the Second Engineer to the bunker room. The Bosun and the Second Engineer were supposed to have met up on deck. However, each one went alone and without protection – neither personal protective equipment (PPE) nor safety personnel were employed. The Second Engineer consciously went between the containers in order to avoid falling overboard.
When the second alarm sounded from the bunker room shortly after 07:00 in the morning, the Chief Engineer also went forward. . However, he was allegedly already wearing an immersion suit. In addition, the Captain had also secured him with a long line. The afore-mentioned difficulties with such a long safety line can be comprehended.
Shortly after 08:00 the Chief Engineer and the Second Engineer both proceeded to the bunker room. Now it was bright. They wore immersion suits and mutual safety line could have been used but wasn't. The lack of a safety line between both engineers contributed significantly to the Second Engineer falling overboard.
The passageways on the starboard and portside were regularly flooded by green water . Notwithstanding, the Captain saw a greater danger from loose lashing material. Hence he gave instructions not to go forward between the containers but via the lee passageway. However, this assessment of the risk did not take into account whether there was a need to enter the main deck.

If it is inevitable to send persons on deck during bad weather, these persons should be aware of the risk of falling over board. In addition to wearing the personal protective equipment (working shoes, gloves and helmet), additional safety elements adequate to the weather conditions, e.g. life jacket, immersion suit and safety lines must be ordered depending on the situation as protection against falling overboard or to increase the probability of survival in the case of falling overboard, respectively.
Moreover, necessary activities on deck are to be supported by safety personnel protected in the same way. Furthermore, measures of good seamanship are to be applied in heavy seas. (Reduction of speed, bringing about a ship, communication between all concerned and similar.)

7.7 Pilot shipside door

The account of the accident apportioned considerable significance to the pilot shipside door located on the starboard side of the main deck.

Both engineers firstly closed the cover of the hatch cover controller. This is located at Bay 25 in immediate proximity to the pilot shipside door. They then gripped the railing when the next big wave washed over deck. The pilot shipside door is only differs slightly from the actual railing. A rope fender is always located directly beside the pilot shipside door underneath the pilot ladder to hold a pilot boot. The casualty had such a rope fender (see fig. 7) on his person when he was rescued by the lifeboat. Admittedly, it is very difficult to throw a rescue object to somebody who has fallen overboard so that it gets to him. Thus, in this specific case the Second Engineer was not able to use the life buoy that had been thrown to him. For this reason it can be assumed that he grabbed the fender when he was suspended from the outside railing – or even most probably from the pilot shipside door. The BSU assumes that the Second Engineer wanted to cling to the railing but, in fact, gripped the pilot shipside door unintentionally. His body resisted the onslaught of the body of water with the result that the pilot shipside door pressed his body inwards. The pilot shipside door lock enables this as it opens towards the inside (see fig. 17). At this moment the vessel lay on its portside. Then the BELUGA STIMULATION rolled starboard and the pilot shipside door struck the railing's limit stop with increased force. This jerking movement made the Second Engineer fall over the pilot shipside door and thus overboard. He was able to hold on for a brief moment and attempted to hoist himself up by grabbing the fender. This did not help secure him and he fell into the water with the fender.

Figure 17: Pilot shipside door - lock

7.8 Rescue measures

At the time of the accident the BELUGA STIMULATION was in the German Bight between the tons Weser 1 and 2.
The vessel was fully laden and was navigating a course of 080° to 085° with a speed of 13 to 14 kn in a virtually trailing, heavy sea. **The GM was 1.03 m. This corresponded with good stability for a vessel of this size and loading.**
Accordingly, upon putting to sea, the Captain deemed the vessel to be "seaworthy in every department".
At 08:25 a man-over-board-accident occurred at a position of 53° 55.0`N 007° 37.6`E (according to the deck logbook), 007° 37.8`E (according to the report form and information at the VTS Centre Wilhelmshaven).
However, this difference did not have an impact on the subsequent search for the casualty.

The particular regarding the meteorological situation are contradictory.
According to the expert opinion of the German Meteorological Service's Maritime Department, the wave heights were between 3.5 and 5 m.

While all vessels on site gave particulars concerning the weather of a maximum 8 Bft with a swell from a Westerly direction and wave heights of 5 to 6 m, sometimes even less the ship command described "North-westerly winds 9-10 and in gusts 11 Bft …with wave heights of 7-8 metres".

Reacting to this and due to the presumed threat for the vessel, cargo and crew the Master refrained from initiating a return manoeuvre and
continued the voyage unabatedly.

This gives rises to the question pertaining to endangerment of the vessel at the time of the accident.
The accurateness of this risk assessment is partly refuted by the behaviour of the ship command. If the vessel was at risk to the extent assessed it is incomprehensible why work was carried out on deck and the Master did not personally assume the vessel's command..

The ship command obviously presumed a threat, particularly as a result of a larger change in course with a greater rudder angle. However, the vessel had sufficient stability so that such a danger did not exist.
In practice, due to such considerations of stability, a return manoeuvre or greater changes in course are often undertaken **with the lower rudder angle** which would have been a possible solution in this case.
The MSCW of the FB Seefahrt Warnemünde[6] already provide simulation drills for such return manoeuvres. While, for example, a period of 6-7 minutes is required for a single turn with a hard rudder, at a 20º rudder angle the time is extended to a mere 7-8 minutes (larger turning circle but increased speed as a result of a lower rudder angle). This applies to the return manoeuvres "single turn" and "Scharnow turn".

[6] Maritime Simulation Centre Warnemünde (MSCW) at the Department of Maritime Navigation Seefahrt Warnemünde

However, in the case of the “Williamson turn“ mentioned by the ship command, the timing and accuracy of the reverse turn in a lower rudder position are considerably less favourable.

It is difficult to understand why the “Williamson turn” was considered in the given case. **In general, a single turn should be carried out in the case of an immediately noticed “PoB[7] accident ” and a Scharnow turn in the case of a time delay (such as for the given case) since the reversal times for both manoeuvres are much shorter.[8]**
A “Williamson turn” involves a more complex manoeuvre (two hard rudder positions within a short time), only reaches the opposite lane if one has relevant experience in practical manoeuvres and generally leads to intervisibility being lost with the castaway in the case of larger vessels. In this case it would not have been recommendable.

Immediate measures in the case of accidents involving a person falling overboard are clearly formulated and internationally unanimous with slight differences, particularly in the sequence of measures and are communicated, determined and practised both during training as well as part of board management in accordance with the ISM code.

Measures to be taken by witness(es) to the accident::
Throw life buoy, inform the bridge, and conduct a look out.

Measures to be taken by the bridge watch:
Throw a person overboard buoy (POB-Boje), sound the alarm, start return manoeuvres, keep your position, organise a look-out, external communication, documentation etc.

The duty of the Captain:
Decision about the return manoeuvre, external communication, decision about the rescue strategy, the request for external assistance, decision about the discontinuation of a rescue mission etc.

All the afore-mentioned measures could have been carried out by the crew except for the return manoeuvre which was the responsibility of the bridge watch.

Throwing a life buoy both by the witness and the officer of the watch not only serves to safeguard the casualty but also to recognise him during the subsequent search. In the given case this might have been facilitated and shortened by the PoB buoy from the bridge.

Refraining from taking many immediate measures by the crew shows that safety management on board was not effectively implemented in accordance with the ISM code. The measures that were subsequently introduced by the vessel’s command confirm that the immediate measures were not sufficiently determined or were not sufficiently binding.

[7] PoB = “Person over Board”
[8] See Handbuch Schiffsicherheit

Apart from the vessels nearby , the first recipient to be notified of an accident (here "MAYDAY"[9]) must have been the MRCC Bremen. In addition, important and necessary information on the course of the accident, the condition of the person, the marking of the person in the water and particularly the intention of the vessel not to provide or not to be in a position to provide any further support in the rescue of the castaway was not transmitted.

This leads to unnecessary inquires and considerable uncertainty in the entire rescue operation shortly before the rescue.
Even at 10:03 CET the VTS Centre Cuxhaven request a response from the BELUGA STIMULATION due to the lack of information about the detailed circumstances of the accident, the condition of the casualty and the markers used.

The vessel's command gave the impression that it has fulfilled its duty to provide information by sending a message to the VTS Centre.

The omission to give comprehensive information to the rescue team lead to a delayed arrival of the rescuers at the casualty and to an increased search effort. This and the continuation of the passage are

psychological factors for the casualty which have a significant adverse effect on his probability of survival.

The possible assumption that the immersion suit provided the castaway with sufficient protection is essentially erroneous. Without a life jacket the castaway's probability of survival due to injury or temporary unconsciousness would have been minimal. Hence there was further need on the part of the vessel's crew to promptly offer further safety measures as well as quick and safe rescue by rescuers, where possible. The vessel would have possibly have had to be steered back to the scene of the accident.

Given the alleged physically good condition of the casualty during subsequent rescue, the vessel may have even conceivably been in a position to carry out the rescue operation itself.

Positive emphasis must be placed on the measures carried out by the DGzRS. Despite the relatively bad weather, numerous sea and air craft of various sizes assisted in the search.

[9] See the manual „Search and Rescue" p. 83 – issued by BSH 2007

7.9 Summary

Water ingress into the bunker room was possible due to a lack of watertight integrity The water entered could not be pumped out of the bunker room as the bilge opening had not been cleaned after the a pollution. The quantity of water did not pose a risk to the stability of the vessel.
Following the first alarm the entry area to the bunker room was inspected. This was carried out without any significant safety measures for the personnel carrying out the inspection and without advance information from the Captain.
At the time of the accident the vessel was in the resonance regions for synchronous resonance. In addition, given its course and speed, it was in a condition which made it linger for a very long time on the crests of waves when under attack from a group of waves and thus only had very marginal stability with slight righting lever arms. However, these dangers could have been avoided by changing speed or course. Accordingly, a reverse manoeuvre to rescue the Second Engineer would have even had a positive impact.
The quantity of fuel that was directly available was sufficient for reaching the Kiel Canal. It was not necessary to take the risk of sending people out on deck.
The pilot shipside doors on both sides of the BELUGA STIMULATION are barely any different than the railing. The bolts of the pilot shipside doors can be opened from the inside which enables unintentional releasing. This contributed to the accident.
The calculations that were completed concerning the intact stability of the vessel at the time of the accident as well as the calculations of the Free Surfaces due to additional water on deck show that the stability of the BELUGA STIMULATION complied to a great extent with minimal requirements. The assertion that there was no desire to endanger the crew and the vessel due to the bad weather and the “delicate vessel” cannot be supported.
Of course, in the event of such a return manoeuvre, basic endangerment to the crew and cargo existed. In addition, hauling a person who is floating on water in rough seas is not without its dangers.
Nevertheless, it can be expected from the ship command that it at least attempts, by means of careful manoeuvring, to objectively ascertain the risk posed to the vessel and/or cargo. Such a risk would become apparent upon manoeuvring, e.g. by extreme rolling movements. However, the ship navigated hours in heavy following seas which couldn't have been more unfavourable. In addition, the BSU calculated the available rating of the main engine and ascertained that there were still significant reserves for manoeuvring in rough seas.
It was also possible to remain near the casualty by careful manoeuvring so as to effectively support the rescue by more appropriate vessels in this situation than the BELUGA STIMULATION or the DGzRS at the time of the accident.
Apart from the vessels nearby the MRCC Bremen must have been informed first, . Moreover, important and necessary information about the course of the accident and the condition of the person were not transmitted.
Thus the measures that were carried out by the ship command were unsatisfactory.

8 Measures already undertaken

8.1 Constructive measures on board

After the accident the shipping operator prompted the crew of the BELUGA STIMULATION to extend the gooseneck belonging to the ventilator so that water on deck could no longer penetrate the bunker room (also see fig. 8).

8.2 BSU preliminary safety recommendation

During the ongoing investigation into the accident on 15 February 2007 in accordance with § 9 Para. 2 Nr. 2; § 15 Para. 1 and 10 of the Maritime Safety Investigation Act (SUG) in connection with § 19 Law Relating to the Investigation into Accidents and Incidents Associated with the Operation of Civil Aircraft (FIUUG), the BSU issued a safety recommendation with the following wording as a result of the threat of imminent danger acknowledged in the context of the casualty investigation for the prevention of future casualties arising from the same or similar reasons:

"The Federal Bureau is investigating three accidents of 2006 and an accident dating from 2007 involving seamen who fell overboard from merchant ships during somewhat bad weather (seagoing vessels and fishing vessels) and in three cases resulted in death.

The investigation proceedings are still in the process of being concluded and are expected to take up more time due to the complexity of the cases. However, at the present point in time, the BSU assumes that the fact that the seamen were not wearing or had insufficient protection could have partly contributed to the person falling overboard.
As a result of the increase in such accidents on board merchant ships and the brief survival periods of the castaways that was contingent upon the weather conditions, the Federal Bureau thus addresses the proprietors and operators of all merchant ships and orders in accordance with § 15 para. 1 SUG in connection with § 19 FIUUG the following to be implemented on board their vessels:

If it is inevitable to send persons on deck, these persons should be aware of the risk of falling over board. In addition to wearing the personal protective equipment (working shoes, gloves and hard hats), additional safety elements adequate to the weather conditions, e.g. life jacket, immersion suit and safety lines must be ordered depending on the situation as protection against falling overboard or to increase the probability of survival in the case of falling overboard, respectively.
Moreover, necessary activities on deck are to be supported by safety personnel protected in the same way. Furthermore, measures of good seamanship are to be applied in heavy seas. (Reduction of speed, bringing about of the ship, communication between all concerned and similar.)

Finally, it must be emphasised that the afore-mentioned safety recommendation is directly related to the investigation of the marine casualties that were initially described but must not be misunderstood as an anticipation of the results of the investigation.
In this respect the BSU refers to the investigations which are currently in progress and particularly to the reports concluding the investigation that will be published upon completion.

9 Safety Recommendation(s)

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

1) **The Federal Bureau of Maritime Casualty Investigation recommends the operators of seagoing vessels and vessel command** (in accordance with Accident Prevention Regulation for Shipping Enterprises § 79):
Bilge-pumping and capacity-gauging devices must be kept clean and ready for use. Each watertight compartment must be sounded on a regular basis. Bilge pumps and wells must be kept pumped out. In particular, strainers and pumps must be protected from being blocked in an appropriate way.

2) **The Federal Bureau of Maritime Casualty Investigation recommends the operators of seagoing vessels and vessel command** (in accordance with Accident Prevention Regulation for Shipping Enterprises § 80):
Ventilators and air pipes must be closed in sufficient time when the danger arises that water can thereby penetrate the vessel in large quantities.

3) **The Federal Bureau of Maritime Casualty Investigation recommends the operators of seagoing vessels and vessel command** ensure that the bolts of the pilot shipside doors do not open in the same direction in which the door opens itself. This should be changed if necessary. **Shipyards and classification societies** are advised to pay due attention when constructing a new vessel.

4) **The Federal Bureau of Maritime Casualty Investigation recommends operators of seagoing vessels** to carry out advanced training for the crew, particularly for safety measures on deck, the reverse manoeuvre of the vessel in case of a person overboard accident, initial measures to be carried out by the crew, search and rescue of a person in the water, as well as risk assessment and avoidance of risks by swell, in particular by resonances and other effects.

10 Sources

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- Statements
  - Vessel's Command
  - Shipping Company/Owner
  - Classification Society

- Witnesses' accounts

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- Radar plots by Vessel Traffic Services (VTS) / Vessel Traffic Center Wilhelmshaven

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