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

Investigation Report 450/07

Very Serious Marine Casualty

Collision between M/V HANJIN GOTHENBURG and M/V CHANG TONG on 15 September 2007 in the Bohai Strait/PR of China

15 September 2008

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 2002.

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

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

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

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1 Summary of the Marine Casualty

On 15 September 2007, the large container vessel HANJIN GOTHENBURG, which was flying the German flag, was travelling from Xingang/People's Republic of China to Kwangyang/Republic of Korea. The voyage lead through the Bohai Strait in the Yellow Sea under good weather conditions.

At 1600[1] the Chief Officer took over the watch from the Philippine Second Officer. Sunset was at 1803. The HANJIN GOTHENBURG was travelling at a speed of 25 kn. The Chief Officer was the only person on the bridge from 1830 onwards. The seaman on watch was "on standby" in his cabin. The traffic volume was moderate. The Chief Officer spotted numerous radar echoes of fishing vessels on starboard. When a few of these vessels crossed the course of the HANJIN GOTHENBURG, he altered course from 121° to 117° since he had only detected few vessel echoes on portside.

At this point in time the bulk carrier CHANG TONG, flying the Panamanian flag, was on reciprocal course (305°) on her voyage in ballast from Taiwan to Qinhuangdao in North China. The vessel's speed was approximately 12 kn. The bridge of the CHANG TONG was manned by the Chief Officer, a look-out and two trainees, one of whom was acting as the helmsman. The entire crew was of Chinese nationality. The HANJIN GOTHENBURG was first spotted on the radar around 1917. However, the bridge crew were mainly focused on fishing vessels which were proceeding in front of CHANG TONG's bow.

On board the HANJIN GOTHENBURG, the course was altered at 1927 to 090° to port. The CHANG TONG was not spotted.

At approximately 1930, the CHANG TONG altered her course to starboard by approx. 15° and finally a "hard starboard" manoeuvre was carried out but failed to prevent the collision. At 1935 the HANJIN GOTHENBURG collided midships at an angle of 40° with the port side of the CHANG TONG. For the time being, both vessels remained wedged into each other. Later in the evening, rescue vessels and a helicopter of the Chinese coastguard arrived at the scene.

On 17 September 2007, the wedged vehicles were towed to calmer waters where they were torn apart during the passage of a typhoon three days later. Hence the CHANG TONG broke apart in the middle and sank.

One person was slightly injured as an indirect result of the accident. The wreck of the CHANG TONG discharged small quantities of oil.

1 All times in the report refer to the time on board = universal time (UTC) + 8 hours.

2 Scene of the Accident

Type of event:	Very serious marine casualty
Date/Time:	15 September 2007, 1935
Location:	Bohai Strait, People's Republic of China
Latitude/Longitude:	φ 38°18,7'N λ 121°29,3'E

Section from the nautical chart British Admiralty (BA) 1255

Figure 1: Nautical chart (used on the HANJIN GOTHENBURG)

3 Vessel Particulars

3.1 HANJIN GOTHENBURG

3.1.1 Photo

Figure 2: Vessel photo HANJIN GOTHENBURG, taken on 25 September 2007

3.1.2 Vessel particulars

Name of the vessel:	HANJIN GOTHENBURG
Type of vessel:	Container vessel
Nationality/flag:	Federal Republic of Germany
Port of registry:	Hamburg
IMO number:	9235103
Call sign:	DAXJ
Owner:	NSB Niederelbe Schiffahrts GmbH & Co. KG
Year built:	2002
Shipyard/yard number:	Hyundai Heavy Ind. Co., Ltd./H 1408
Classification society:	Germanischer Lloyd AG
Length overall:	274.67 m
Breadth overall:	40.00 m
Gross tonnage:	65,131
Deadweight:	68,063 t
Draught at time of accident:	fore and aft: 11.90 m
Engine rating:	57,100 kW
Main engine:	MAN B&W 10 K 98 MC-C
Speed:	25 kn
Hull material:	Steel
Number of crew:	22

3.1.3 Vessel's propulsion and manoeuvring parameters

The HANJIN GOTHENBURG is powered by a 10 cylinder 2-stroke diesel engine with nominal engine power of 57,100 kW. The nominal rated speed is 104 rpm. The main engine is reversible and has a direct impact on the right-handed fixed pitch propeller.

The machinery also includes four auxiliary diesel engines, each with 2,100 kW nominal power at 720 rpm.

The steering gear is a semi-spade rudder with profile, which is operated by hydraulic means. The maximum rudder angle is 35°. The time needed to change the rudder position from hard-over to hard-over port and starboard and vice-versa is 28 seconds with one power unit and 16 seconds with two power units. The turning cycle radius is indicated with 0.6 nm for “Full ahead Sea” under normal loading conditions. The time required for this is given with approximately 10 minutes.

The HANJIN GOTHENBURG has a bow thruster with an output of 2,000 kW.

According to the figures, the vessel can be fully stopped by means of an immediate “full astern” manoeuvre under normal loading conditions after about seven minutes and after covering a distance of approx. 1.17 nm.

3.2 CHANG TONG

3.2.1 Photo

Figure 3: Vessel photo CHANG TONG

3.2.2 Vessel particulars

Name of the vessel:	CHANG TONG
Type of vessel:	Bulk carrier
Nationality/flag:	Republic of Panama
Port of registry:	Panama
IMO number:	7709320
Call sign:	H9KD
Owner:	Da Tong Shipping SA
Year built:	1978
Shipyard/yard number:	Imabari Zosen K.K. -Magurame, 1052
Classification society:	Isthmus Bureau of Shipping (IBS)
Length overall:	182.33 m
Breadth overall:	26.04 m
Gross tonnage:	20,700 (1969)
Deadweight:	35,343 t
Draught at time of accident:	fore: 3.5 m; aft: 6.5 m
Engine rating:	8,613 kW
Main engine:	Mitsubishi Heavy Ind. 7RND68
Speed:	14,25 kn
Hull material:	Steel
Number of crew:	26

3.2.3 Vessel’s propulsion and manoeuvring parameters

The CHANG TONG was powered by a 7 cylinder diesel engine with a nominal engine output of 8,613 kW. The nominal rated speed was 150 rpm. The direction of rotation could be switched.

The BSU does not have any information pertaining to the manoeuvring parameters of the CHANG TONG.

4 Course of the Accident

4.1 External conditions at the time of the accident

4.1.1 Sea area

The Bohai Strait, in which the collision occurred, is a very busy passageway for the Chinese provinces in the north and is as well serving as an access to the sea for Beijing (cf. figure 4).

Figure 4: Geographical position of the sea area

The Bohai Sea is a semi-enclosed sea with an average water depth of 18m.

Apart from cargo ships, the Bohai Strait is navigated by fishing vessels both day and night due to its plentiful fishing grounds. The following figures convey an impression of the vehicle traffic during the day (figure 5) and night (figure 6).

Figure 5: Fishing vessel traffic in the Bohai Strait,
taken on 25 September 2007 at 1340

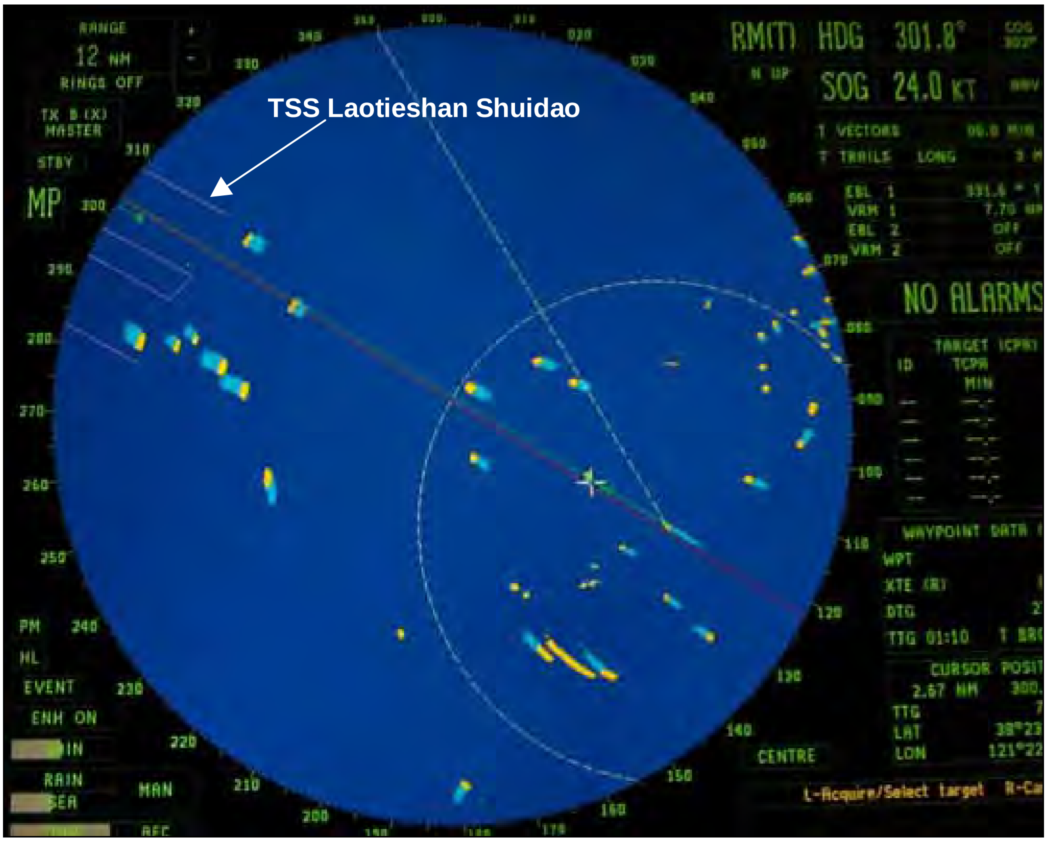

Figure 6: Radar image of the traffic volume in the Bohai Strait,
taken on 5 January 2008 at 1800

From figure 6 one can see that a large proportion of the traffic is almost aligned towards the Laotieshan Shuidao traffic separation scheme (TSS) and in the opposite direction respectively. Radar echoes of small vehicles are displayed on the right-hand edge of the image; they are either moving in different directions or stationary. These echoes are most probably of fishing vessels.

4.1.2 Weather at sea

Visibility was limited to approximately 0.5 nm due to fog on the morning of the day of the accident. Visibility improved to approximately 0.5 nm in the afternoon and later on to 9 nm. A slight breeze (2 - 3 Bft) was blowing from a westerly direction.

4.2 Course of the HANJIN GOTHENBURG

The HANJIN GOTHENBURG left the port of Xingang/People's Republic of China at 1042 on 15 September 2007. The next port of call was Kwangyang/Republic of Korea. The beginning of the sea voyage was noted for 1300. The official paper sea chart BA 1255 updated to the correct issue and revision status was used for navigation. The electronic chart system (ECS) was not operated with official data and for this reason was not to be used as a primary navigational system.

Both radar systems were in operation. The X-band-radar was set at a distance of 6 nm and the S-band-radar at 12 nm, both employing gain time control and anti-clutter sea. The HANJIN GOTHENBURG was on autopilot at a "Full Ahead Sea" rate of speed, travelling at a speed of approximately 25 kn over ground at a concurrent streaming of 0.5 - 1 kn. VHF radio communications were monitored via channels 10 and 16.

The bridge was manned by the Master, the Second Officer on watch and a look-out. At 16:00 hours, the Chief Officer took over watch from the Second Officer who then left the bridge together with the look-out.

According to Germany's National Meteorological Service (DWD), in the area of the accident the sun set at 1803.

At 1820, the HANJIN GOTHENBURG altered her course from 102° to 121° over ground before entering the TSS Laotieshan Shuidao (cf. figure 7).

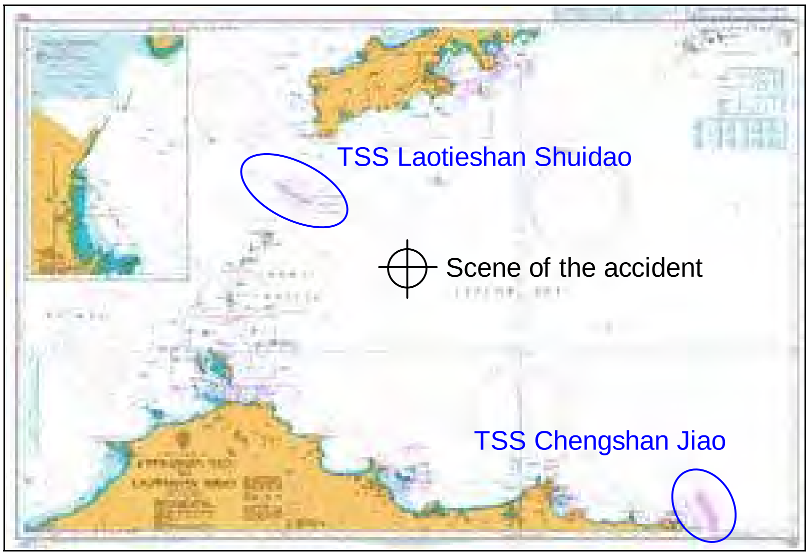

Figure 7: Positions of traffic separation schemes within the sea area, displayed on nautical chart BA 1255

Due to the volume of traffic, several evasion manoeuvres were performed after passing the TSS. The Chief Officer was the only person on the bridge at this point in time. The Master was in the officers' mess room and the seaman on watch was in his cabin "on standby".

Several smaller vehicles were plotted on the X-band-radar on starboard side. After sight these were fishing vessels. Four of these targets were acquired in the forward area using the ARPA[2] function. The radar system's range marker was set at 4 nm.

The Master reappeared on the bridge at approximately 1900 but left again a few minutes later and returned to the officers' mess room.

On the bridge the Chief Officer checked using the paper sea chart whether it was possible to evade to portside the vehicles spotted on starboard or to create a greater distance from them respectively. No sidelights were seen at this point in time, only the yellow and white lights of other vehicles.

Since the sea chart did not display any obstacles and shallowness in the area of the vessel position, the vessel's course was altered to 090° portside at 1927. The passing distance to the vehicles on starboard was thereby increased to more than 0.6 nm. Neither crossing traffic nor red or green sidelights had been sighted yet.

The CHANG TONG was spotted after sight as recently as immediately prior to the collision by her superstructure lighting. The collision itself occurred approximately 20 seconds later at 1935. The Master who hurried to the scene finally stopped the engine by emergency stop.

[2] Automatic Radar Plotting Aid

4.3 Course of the CHANG TONG

The bulk carrier CHANG TONG began her marine voyage during the evening hours of 12 September 2007 after leaving the port of Taichung on the island of Taiwan. Qinhuangdao in North China was the next port of call for the CHANG TONG which was proceeding in ballast.

Two radar systems were in operation on the bridge, one of which was set to a range of 6 nm, the other to 3 nm. The AIS[3] display which was installed on the bridge for processing the AIS data in graphic form was not used for navigation since it no longer functioned reliably. The vessel was steered by hand because the auto-pilot system did not function. The service speed of the CHANG TONG at "Full Sea Ahead" was approximately 12 kn above ground. VHF radio communications were intercepted via channels 8 and 16.

The Chief Officer approached the Second Officer in charge of the navigational watch and the look-out at around 1535 on the bridge.

When the CHANG TONG was still approximately 80 nm apart from the TSS Laotieshan Shuidao, her course was altered to 305° after the change of watch. The Second Officer had left the bridge after the watch had been handed over. Evasion manoeuvres with a rudder angle of max. 5° to port and starboard were performed the moment the Chief Officer assumed watch. Only few fishing vessels, which were fishing with trawls, could be seen ahead of the CHANG TONG.

Two trainees attended the bridge at approximately 1640. The trainees took over the helm alternating during periods of low traffic. The Third Officer relieved the Chief Officer for dinner at 1730. The position was determined. The Chief Officer left the bridge for dinner and returned at approximately 1750.

Nothing particular happened during the voyage until a target was sighted on the radar screen approximately 15-20° on portside at around 1917 which presumably was not on a course parallel with the CHANG TONG and was travelling at an estimated speed of about 20 kn. The look-out reported a red sidelight. The fore and aft masthead lights were no longer in line. The Chief Officer sighted the other vehicle through binoculars at a distance of 6 nm, by determining the distance from the radar screen. The Chief Officer also noticed that a fishing vessel with an extended net coming from starboard was heading at a distance of about 1.5 nm in front of the CHANG TONG. It was reported that the trainee at the helm was instructed to alter the course to starboard from 305° to 310°. According to the course records, the course of the CHANG TONG was altered above ground shortly marginal to port and afterwards by just one degree to starboard to 298°.

The proximity to the fishing vessel increased. At the same time, the other approaching vehicle - the HANJIN GOTHENBURG - was showing both sidelights, and other fisherman boats with trawls were seen. According to her radar, the

[4] Automatic Vessel Identification System

distance to the CHANG TONG was 2.6 nm. On board the CHANG TONG it was assumed that the course alteration of the thitherto unidentifiable HANJIN GOTHENBURG was only a temporary evasion manoeuvre. Between 1927 and 1932, course was slowly altered to starboard by approx. 15°, to provide the other vehicle with more sea-room.

When two minutes before the collision only the green sidelight of the HANJIN GOTHENBURG could be seen, the helm was ordered “Hard starboard”.

Reportedly, the inscription “HANJIN” could be seen on the hull of the other vehicle. Thereupon, the HANJIN GOTHENBURG was said to have been requested via VHF channel 16 to turn hard to port, but to no avail. In addition, the typhoon has reportedly been continuously sounded.

The vibration due to the ordered full rudder position was said to have been quite strong, resulting in a speed reduction carried out by the assistant engineer on his own accord. The engine had reportedly been stopped immediately prior to the collision. The Master of the CHANG TONG rushed to the bridge. Shortly afterwards both vessels collided at an angle of 40° (cf. figure 8), when the HANJIN GOTHENBURG’s bow hit the portside of the CHANG TONG.

Figure 8: Wedged vehicles following the collision

4.4 Course of events after the collision

Both vehicles were firmly wedged into each other after the collision. The crews first concentrated on identifying the damage. Each vessel notified the Vessel Traffic Services in Dalian and Yantai of the accident. The CHANG TONG let go her port anchor.

Not long after the collision, the CHANG TONG began to list by 5° to port. At 1953 her crew stepped over to the HANJIN GOTHENBURG but returned to the bulk carrier during the night. A rescue boat of the Chinese coastguard arrived at the scene of the accident at 2248. Rescue measures were not initiated on account of the calm weather conditions and the fact that nobody had been injured up to that point in time.

Pump works were continuously carried out on the CHANG TONG in order to counter the water ingress. A rescue boat was on standby at the scene from 1424 the next day. A coastguard helicopter monitored the scene of the accident for the discharge of pollutants.

On the 17 and 18 September 2007 the wedged vehicles were towed to an anchorage in calmer waters (cf. figure 9).

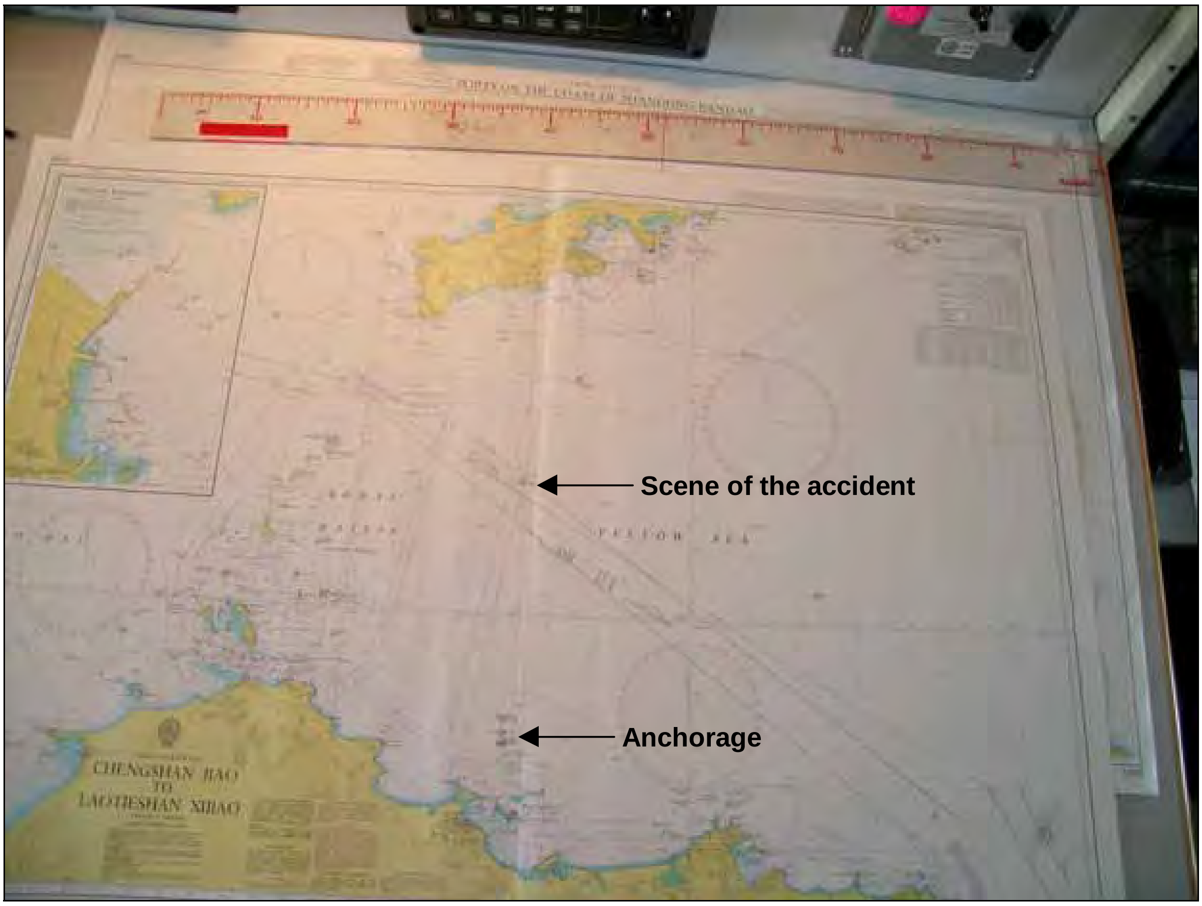

Figure 9: The anchor position of the HANJIN GOTHENBURG from 18 September 2007 on, excerpt from nautical chart BA 1255

On 19 September 2007 at approximately 2100 work began on setting up an oil barrier. One day later an attempt was made to separate the vessels involved in the accident by towing assistance and using the HANJIN GOTHENBURG's engine power. However, the attempt was abandoned due to the weather deterioration involving an intensifying typhoon.

At midday on 20 September 2007 the typhoon "Wipha" with strong gale forces of 9 Bft separated both vehicles. The CHANG TONG was torn apart upon separation (cf. figure 10).

Figure 10: Breaking of the CHANG TONG shortly after the typhoon had passed through

The forecastle bent in direction of the aft ship, tore and came to rest at an angle of about 90° to the aft ship below the surface of the water. The aft ship stuck in the seabed at a water depth of 18 m whereas the superstructure and the engine room remained above the waterline (cf. figure 11).

Figure 11: Wreck of the CHANG TONG on 21 September 2007

After the weather had improved, it was possible to pump out heavy fuel oil from the wreck of the CHANG TONG in not quantified quantities. During the winter, the forecastle sank down to the seabed. The aft ship also sank further with an increased list to port (cf. figure 12).

Figure 12: Wreck of the CHANG TONG on 8 January 2008

The HANJIN GOTHENBURG anchored off Yantai until the Chinese authorities had concluded their investigation and then proceeded to Singapore from the 4 October 2007 on for repairs.

4.5 Consequences of the accident

The marine casualty caused considerable damage to both vehicles. In the aftermath, the CHANG TONG broke in two and sank. One person was slightly injured as a result of the damage caused during the separation of both vehicles.

Limited quantities of oil were discharged which were not quantified in detail.

4.5.1 HANJIN GOTHENBURG

The bow of the HANJIN GOTHENBURG was deformed by the collision (cf. figure 13) and the ground tackle of the starboard anchor was damaged.

Figure 13: Forecastle of the HANJIN GOTHENBURG on 17 September 2007

The bulbous bow was severely notched when it slid under the hull of the CHANG TONG due to the impact of the HANJIN GOTHENBURG.

Ballast water tank no. 1 was penetrated by water due to a tear, about 20 cm wide, in the hull (cf. figure 14 with designated position of the deep tank and figure 15).

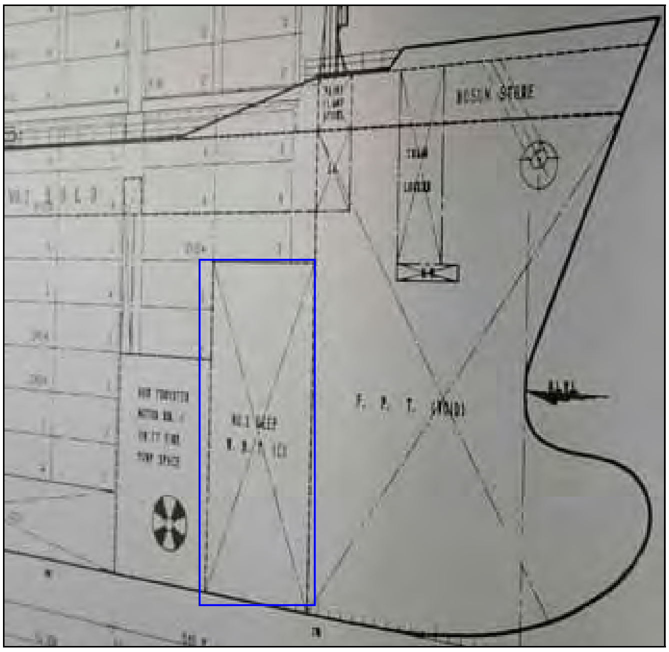

Figure 14: General Arrangement Plan Details

Figure 15: Tear in deep tank no. 1

The frames in the forecastle area suffered considerable deformation (cf. figure 16).

Figure 16: Bosun store of the HANJIN GOTHENBURG

A tear measuring approximately 5 m in length and 0.5 m in height above the water line occurred on the starboard side of the bosun store (cf. figure 17).

Figure 17: Tear in the hull of the HANJIN GOTHENBURG on 21 September 2007

When both vehicles were separated by the typhoon, the jib of the third deck crane of the CHANG TONG broke off and remained stuck athwart the forecastle of the HANJIN GOTHENBURG (cf. figure 18).

Figure 18: Forecastle of the HANJIN GOTHENBURG on 25 September 2007

The CHANG TONG's fourth deck crane was completely torn off during separation of the wedged vehicles and clung to the starboard side of the forecastle area of the HANJIN GOTHENBURG (see figure 19). Thereby the containers which were stowed in the first bay on deck were torn up, which led to chemicals being discharged which fall under the classification of the German Ordinance on the Transport of Dangerous Goods by Marine Vessels (Gefahrgutverordnung See) and the International Maritime Dangerous Goods (IMDG) Code (cf. figure 20).

The bosun of the HANJIN GOTHENBURG, who came into contact with these chemicals during the clear-up and safeguarding measures on the forecastle, suffered temporary irritation of the eyes.

Figure 19: Bow of the HANJIN GOTHENBURG on 25 September 2007

Figure 20: Damaged containers on the HANJIN GOTHENBURG on 20 September 2007

According to the vessel's owner, the jib of the crane which clung outboard came loose on the passage to Busan. The crane's cab and the second crane jib, which had gotten stuck on the forecastle, were being removed from the vessel in Busan.

4.5.2 CHANG TONG

During the collision the forecastle of the HANJIN GOTHENBURG penetrated CHANG TONG's hull on port side beyond the central plane (see figures 8 and 21).

The bow tore apart the bulkhead between cargo holds 3 and 4 which caused substantial deformation and breaking of the bulkhead and the frames. The upper and lower side tanks in these areas were destroyed. Water penetrated cargo holds 2 to 5.

Deck cranes 3 and 4 were damaged.

Figure 21: Close-up of the vehicles wedged into each other

After the typhoon had passed and separated both vehicles, the CHANG TONG broke amidships (cf. figure 10) and sank (cf. figures 11 and 12).

5 Investigation

5.1 Co-operation with China MSA

During the entire investigation, the Federal Bureau of Maritime Casualty Investigation (BSU) co-operated closely with the Marine Safety Administration of the People's Republic of China (China MSA) in Yantai und Qingdao. Investigators of China MSA were already present at the scene of the accident on 16 September 2007, where they began investigating and documenting details of the scene of the accident.

The information and documents which were exchanged in the course of co-operation created a comprehensive database for the investigation into the collision and its consequences.

The investigators of China MSA questioned the Chinese crew and contacted the CHANG TONG's owner, established at Qingdao. They then provided the BSU with all records and relevant vessel documents as well as extensive photo documentation and AIS records from the Vessel Traffic Services (VTS).

5.1.1 AIS records without an electronic sea chart overlay

The AIS records supplied by the VTS convey an overview of the spacious traffic situation within what was later to become the area of the accident. The following figures show the AIS targets within the relevant sea area without a sea chart overlay (cf. figures 22 to 24). The HANJIN GOTHENBURG is circled in red in figure 22, the CHANG TONG in yellow.

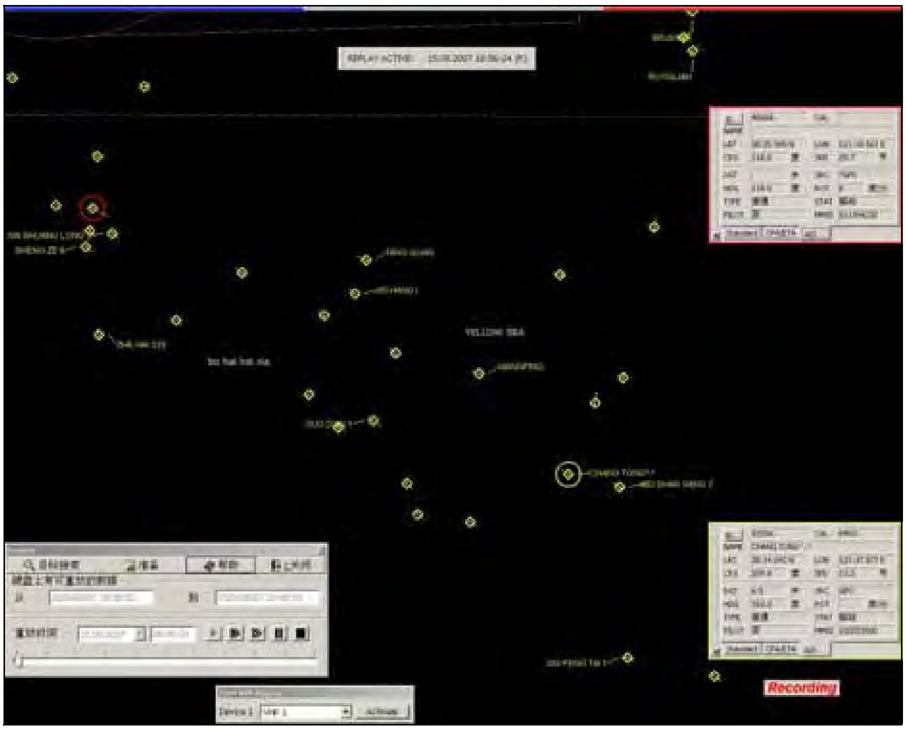

Figure 22: AIS record from 18:56:24

The BSU evaluated records for the time period between 18:56:00 and 20:00:48. The vessel positions and data (course, speed) displayed in the recordings without sea chart overlay sometimes deviate significantly from the actual positions and data. Temporarily data has been recorded for only one or in some cases even none of the vessels involved in the accident. In these cases either the vessel position shown did not change or the vehicle symbol disappeared completely from the screen (cf. figure 23).

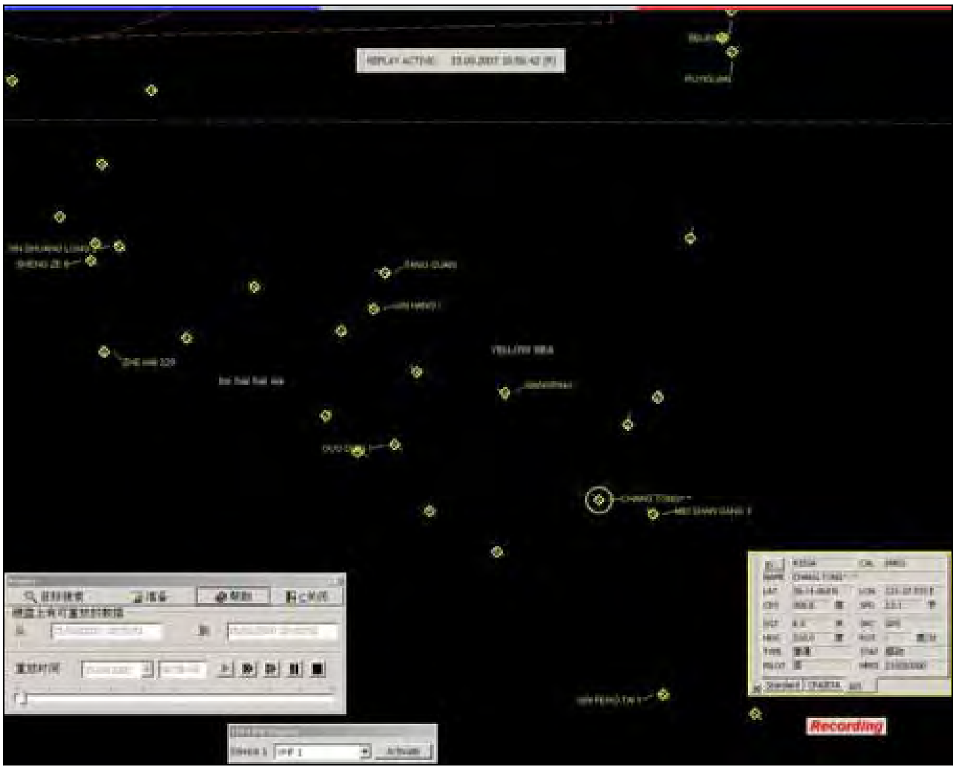

Figure 23: AIS record from 18:56:42,
without a vessel position display for the HANJIN GOTHENBURG

At any rate, the aforementioned records are a reliable source for the number of seagoing vessels equipped with AIS within the traffic area. The record was completed in intervals of an average of six seconds and therefore made it easier to reconstruct the courses steered (cf. para. 5.1.3), as far as it contains information which can be evaluated.

Overall, there was no overabundance of vehicles with AIS navigating the sea area in question (cf. figure 24; HANJIN GOTHENBURG is marked in yellow, CHANG TONG in red). The vehicles without an AIS transponder such as e.g. fishing vessels are not included in the VTS records.

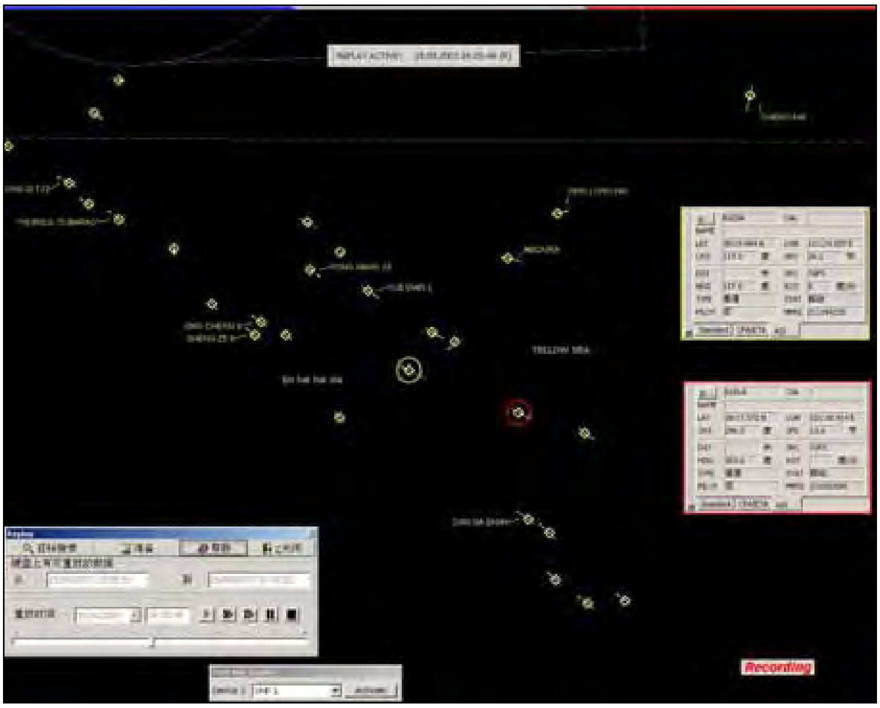

Figure 24: AIS record from 19:25:48

5.1.2 AIS records with an electronic sea chart overlay

In addition to the above records, AIS tracks were also stored with an electronic sea chart overlay from which the tracks of both vehicles involved in the accident can be traced in detail[4] (cf. figures 25 to 32). According to this, both vehicles were navigating on reciprocal courses before the collision (cf. figure 25).

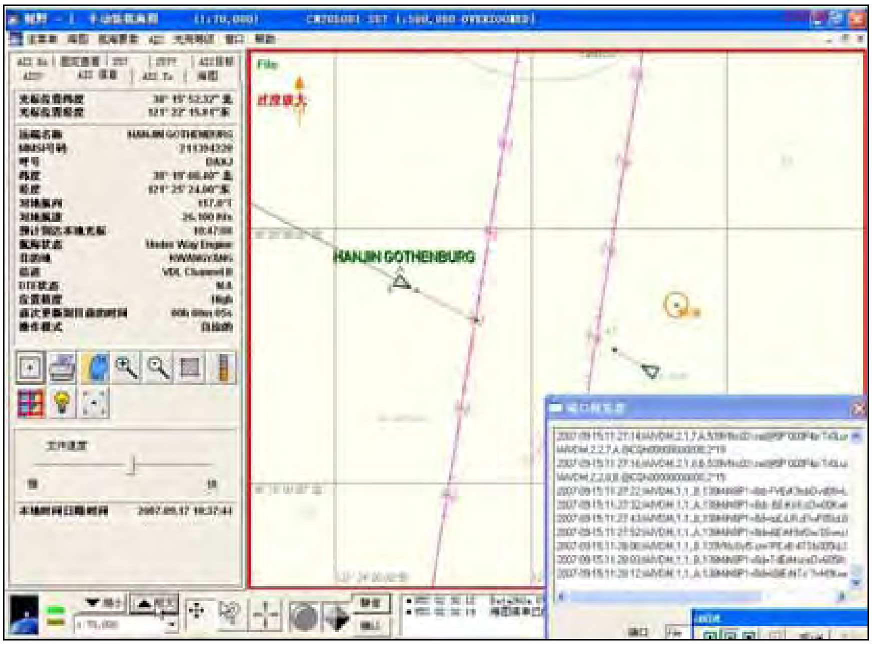

Figure 25: Reciprocal courses of the vessels involved in the accident

4 The time on the records is not that from the day of the accident.

The HANJIN GOTHENBURG altered her course to port (cf. figures 26 to 28). Her speed was reduced from 26 kn to 25 kn. The manoeuvre to port resulted in crossing courses.

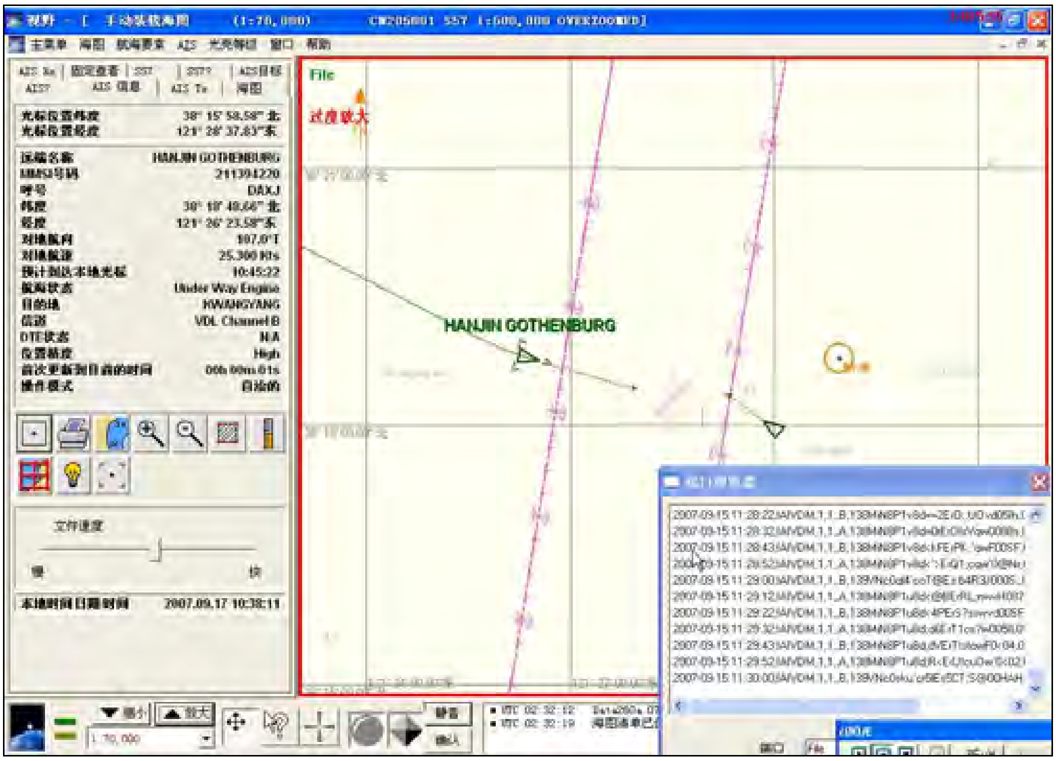

Figure 26: HANJIN GOTHENBURG's manoeuvre to port (course 107°)

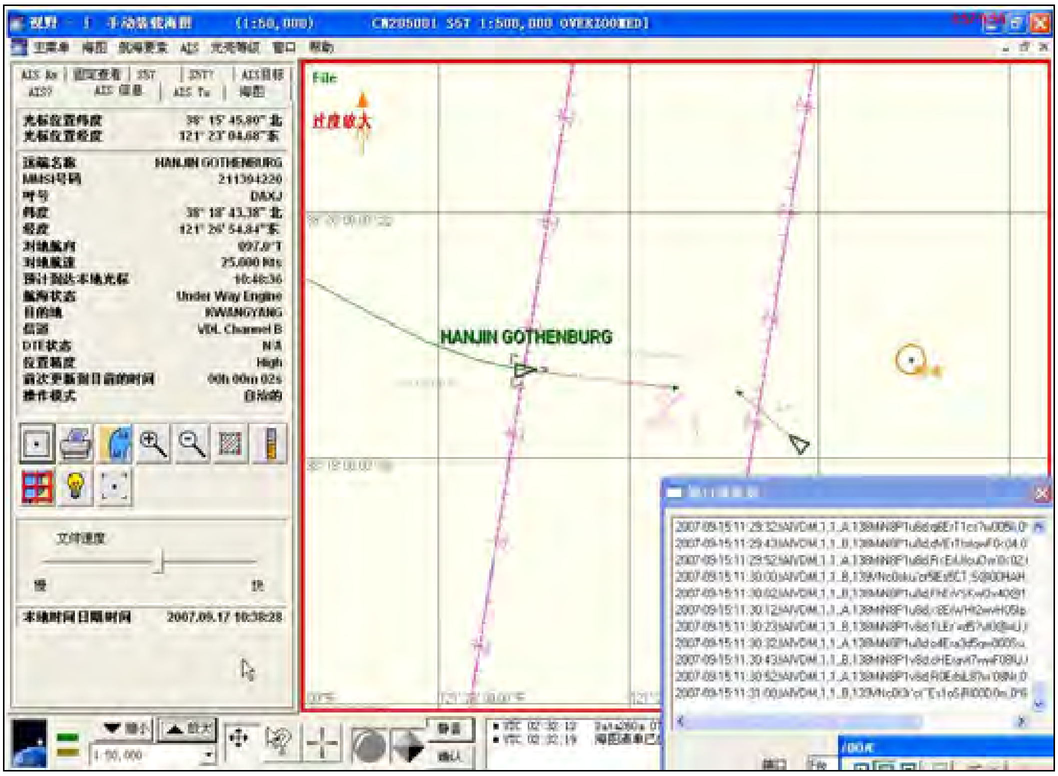

Figure 27: HANJIN GOTHENBURG's manoeuvre to port (course 097°)

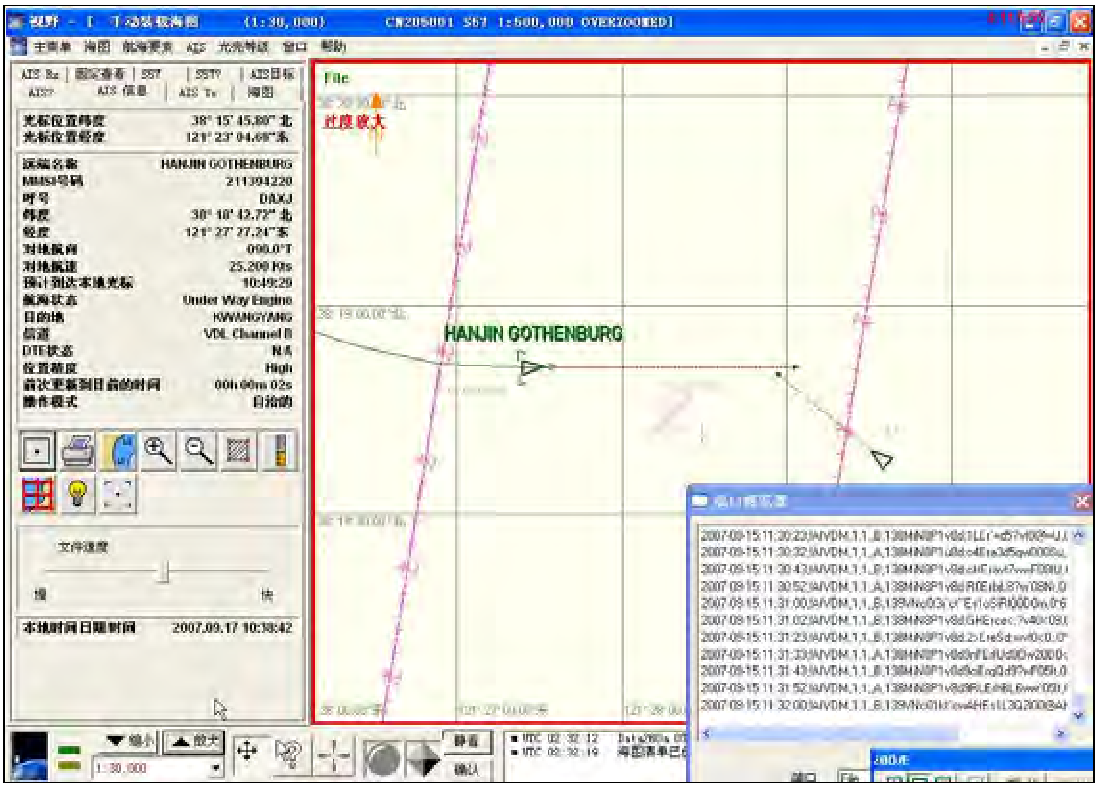

Figure 28: HANJIN GOTHENBURG's manoeuvre to port (course 090°)

When the HANJIN GOTHENBURG was on course 090°, the CHANG TONG started an evasion manoeuvre to starboard (see figures 29 to 31).

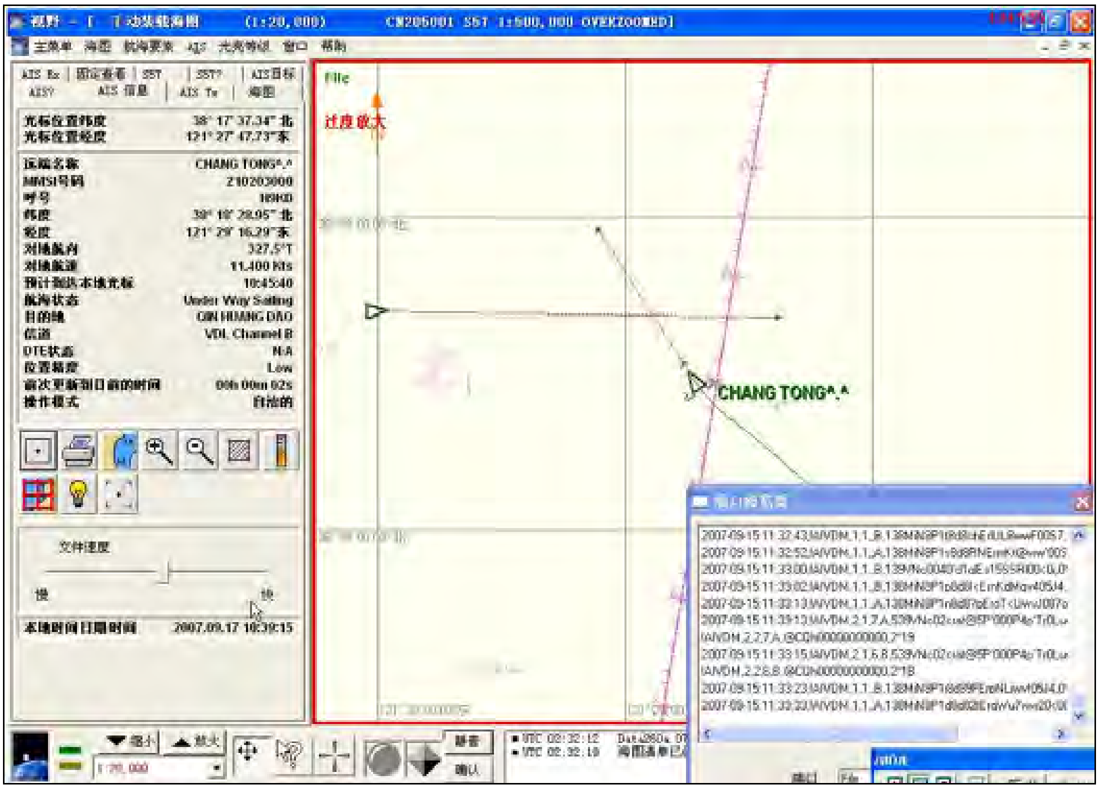

Figure 29: Evasion manoeuvre of the CHANG TONG (course 327,5°)

The speed displayed for the CHANG TONG reduced during the evasion manoeuvre from 11.4 kn to 8.8 kn.

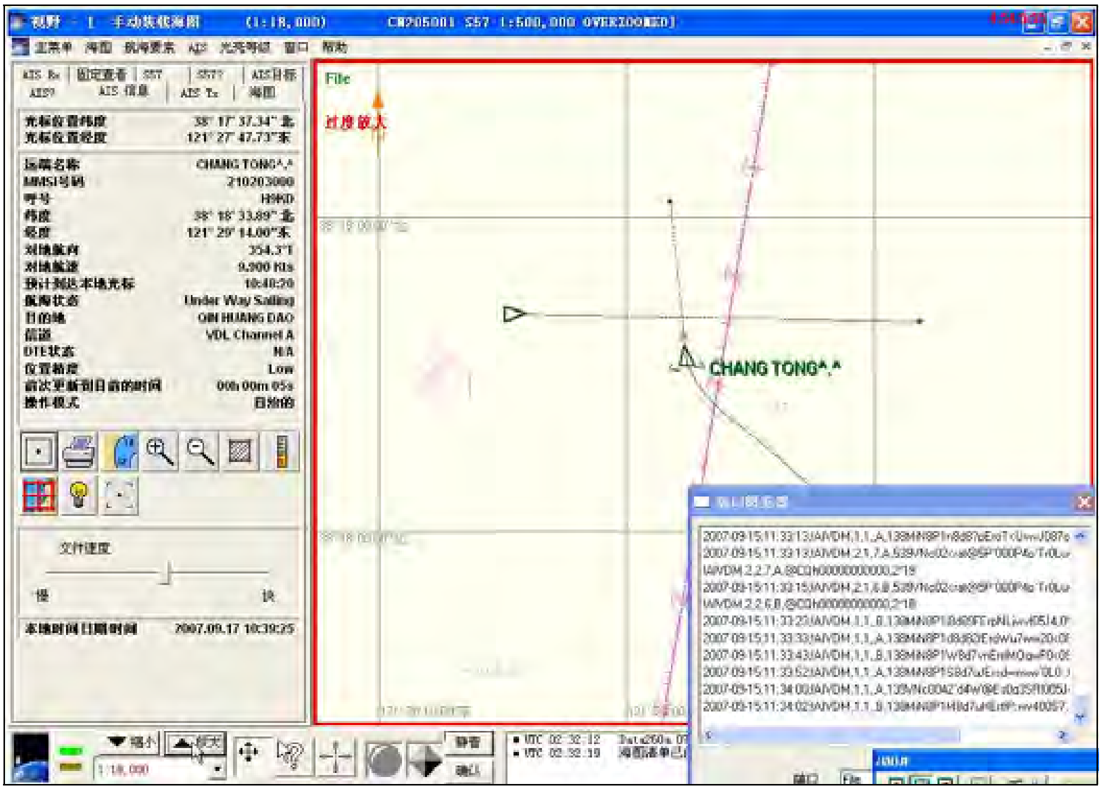

Figure 30: Evasion manoeuvre of the CHANG TONG (course 354.3°)

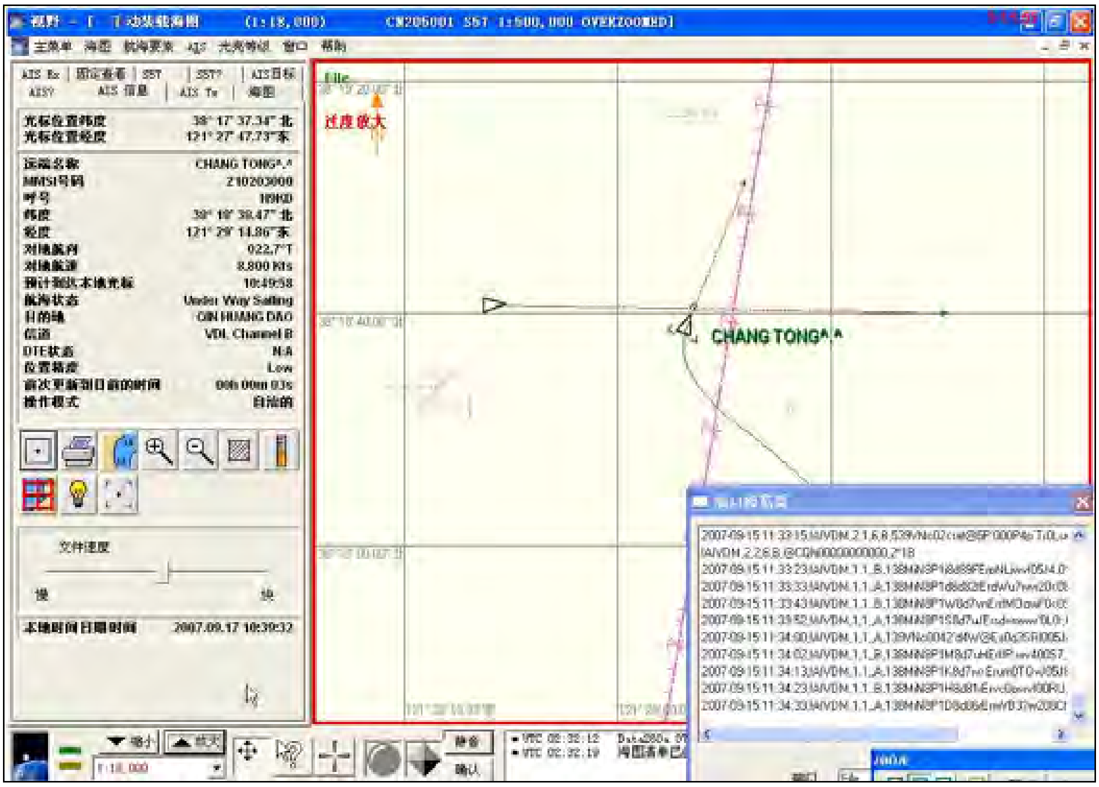

Figure 31: Evasion manoeuvre of the CHANG TONG (course 022.7°)

In the following figure 32, CHANG TONG's speed suddenly increases to 21.6 kn. It can therefore be assumed that the collision had already taken place at this point in time, although the vessel positions shown still imply distance. The discrepancy between the illustrated and actual vessel position is due to inaccurate data relating to the statistical data sent by the vehicles (including the location of the GPS antenna, the length of each vehicle) and/or dynamic data (including the vessel position according to the GPS).

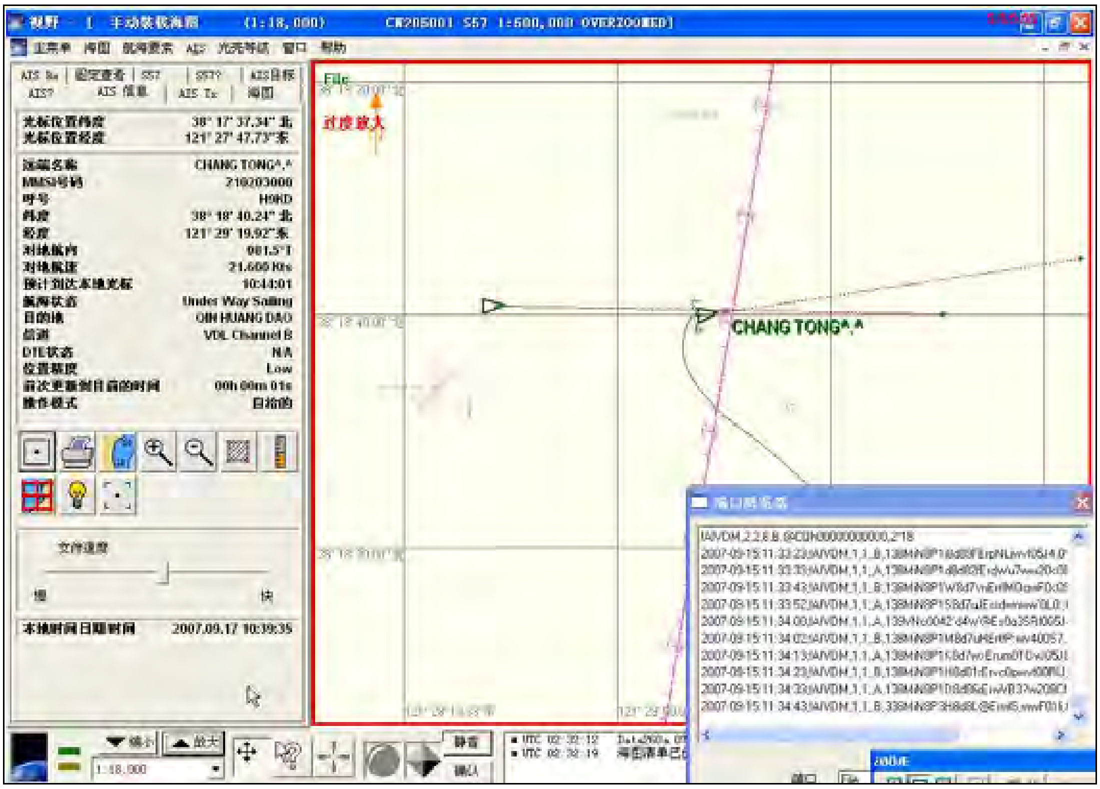

Figure 32: Probable time of collision

The tracks of the HANJIN GOTHENBURG and the CHANG TONG as well as the respective distance between both vehicles can be gleaned from the following figures with an electronic sea chart overlay (cf. figures 33 to 37). In comparison with figures 25 to 32, both tracks can be seen in these figures.

In figure 33 both vehicles were navigating reciprocal courses. At this point in time, the combined approaching speed amounted to approx. 38 kn (approx. 26 kn speed of the HANJIN GOTHENBURG, approx. 12 kn speed of the CHANG TONG).

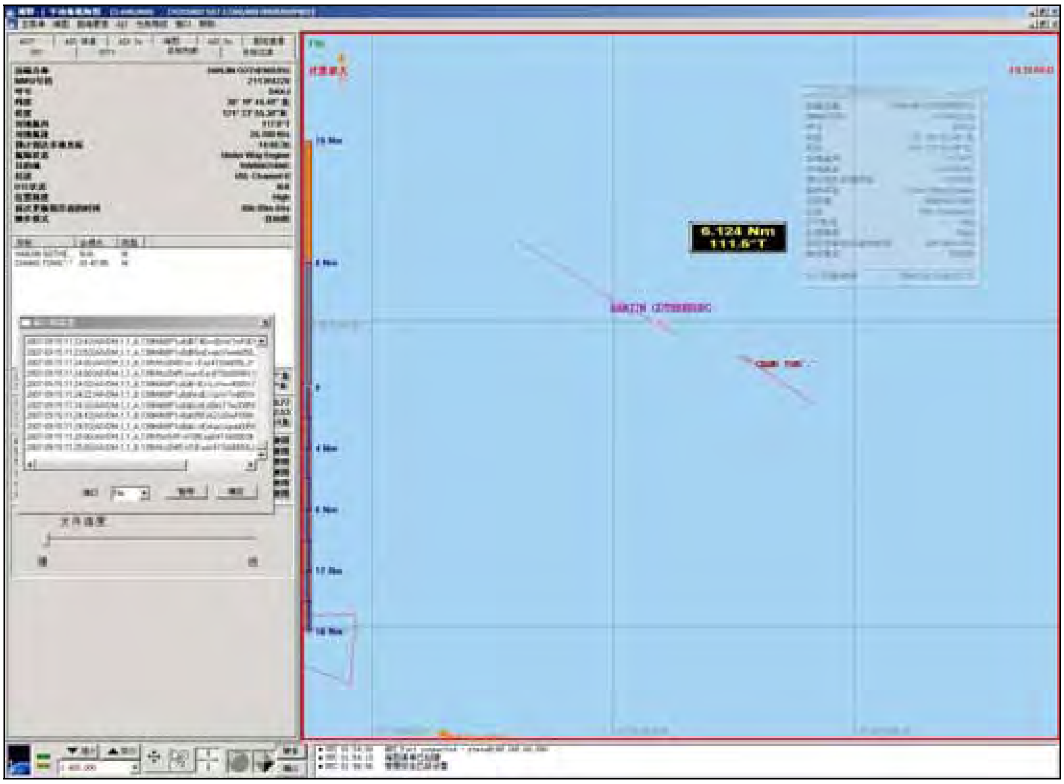

Figure 33: Reciprocal courses at a distance of approx. 4.5 nm

After both vehicles had altered course, the distance upon crossing courses was reduced to approx. 2.5 nm (cf. figure 34).

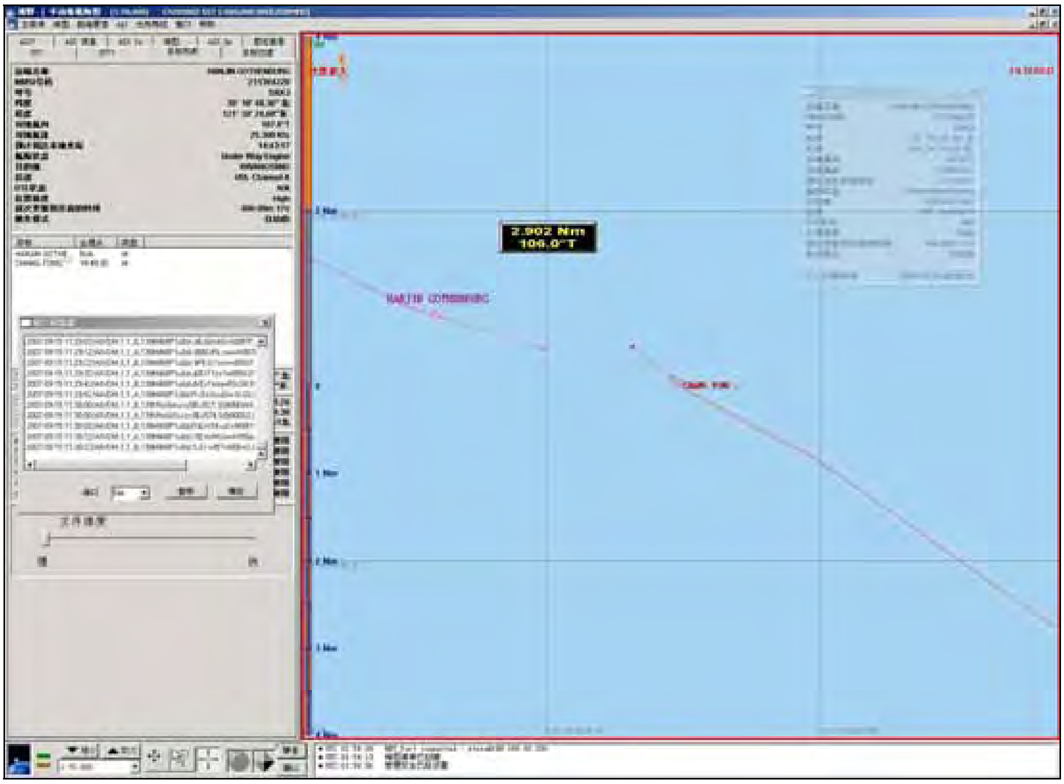

Figure 34: Distance approx. 2.5 nm after both vehicles altered course

Figures 35 and 36 show the course of the evasion manoeuvre of the CHANG TONG to starboard.

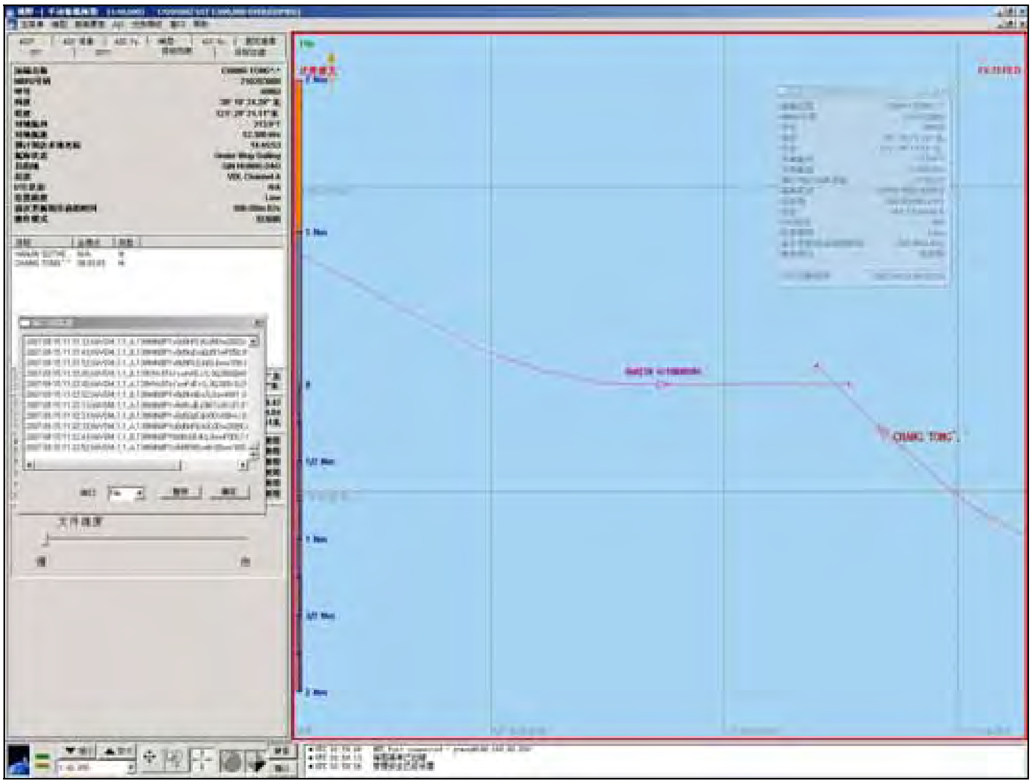

Figure 35: Evasion manoeuvre of the CHANG TONG at a distance of approx. 1 nm

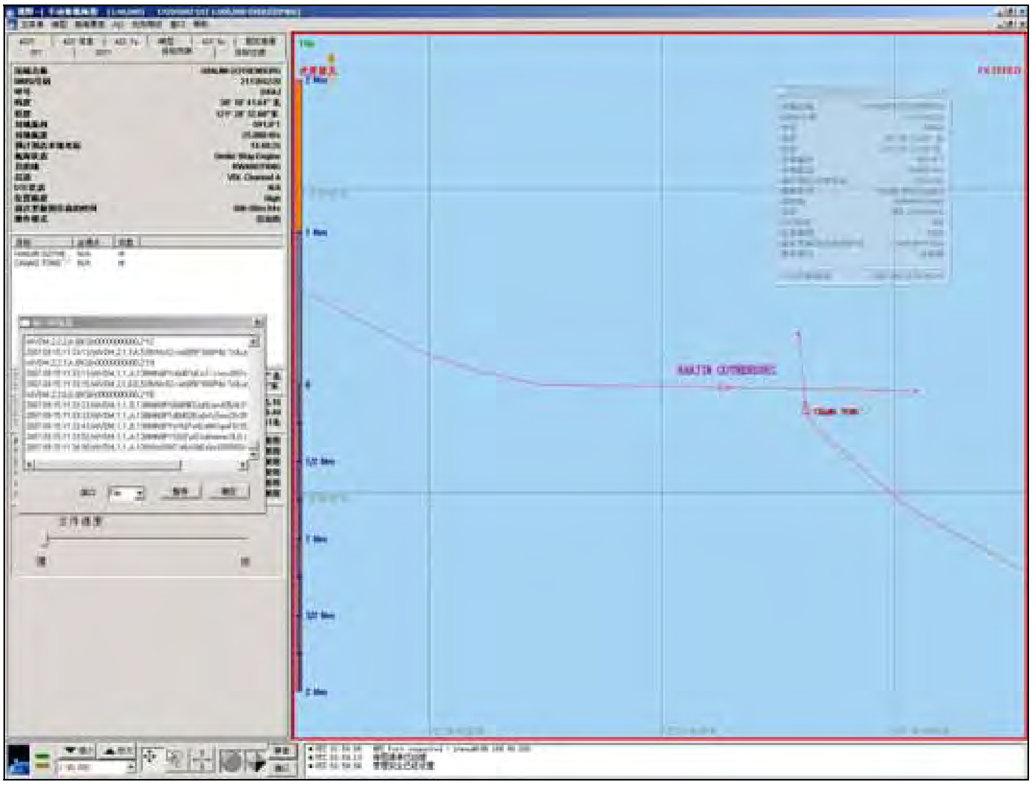

Figure 36: Both vehicles immediately prior to the collision

In the following figure 37 the suddenly increased speed displayed for the CHANG TONG (19.9 kn) is again attributed to the collision.

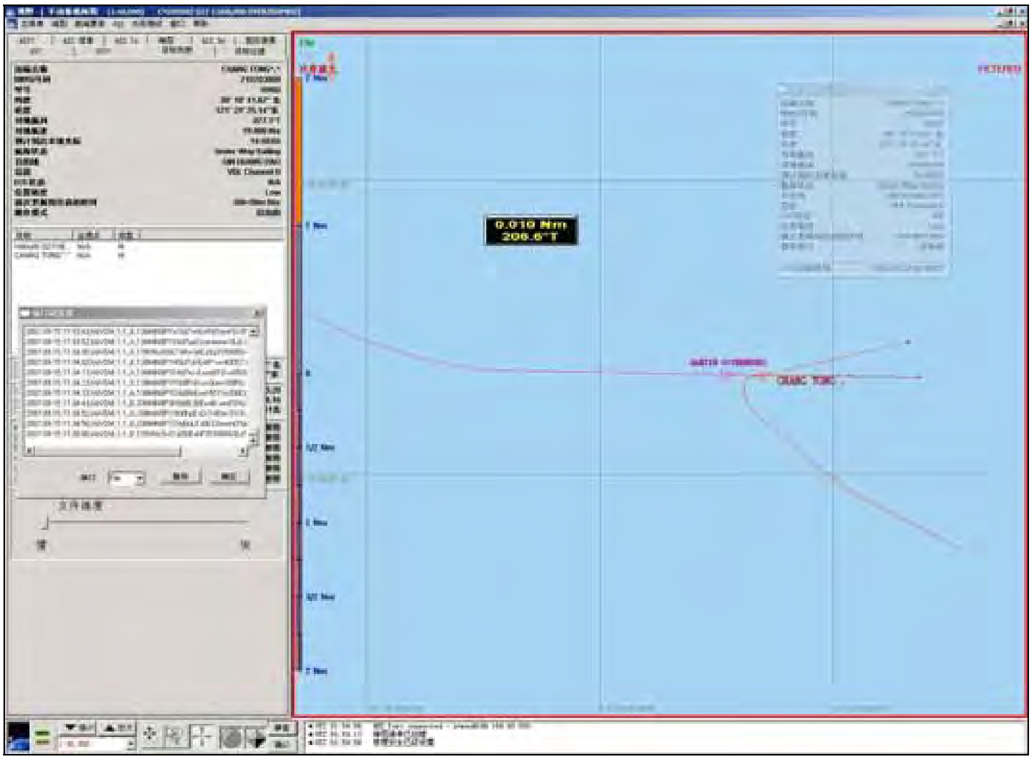

Figure 37: Both vehicles after the collision

5.1.3 Courses steered

In order to obtain a better overview, the recorded courses and speeds of the HANJIN GOTHENBURG and the CHANG TONG are compared in the following table[5]:

Time	HANJIN GOTHENBURG			CHANG TONG		
	Course	Heading	Speed (kn)	Course	Heading	Speed (kn)
19:10:06	122,0°	122,0°	26,1	305,4°	310,0°	12,9
[6]	122,0°	122,0°	26,1	305,4°	310,0°	12,9
19:10:24	122,0°	122,0°	26,1	304,9°	310,0°	12,9
19:10:36	121,0°	122,0°	26,1	304,9°	310,0°	12,9
	121,0°	121,9°	26,2	304,9°	310,0°	12,9
19:11:18	121,0°	122,0°	26,1	-[7]	-	-
	121,0°	122,0°	26,1	-	-	-

5 The table includes the data from the VTS AIS records. For the periods in which the AIS records did not contain any data for the HANJIN GOTHENBURG, reference was made to the existing ECS records of the HANJIN GOTHENBURG (cf. para. 5.2.5 below).

6 Constant information each 4 to 8 seconds up to the next updating.

7 No data available.

Time	HANJIN GOTHENBURG			CHANG TONG		
	Course	Heading	Speed (kn)	Course	Heading	Speed (kn)
19:13:18	121,0°	122,0°	26,1	304,8°	305,8°	12,9
19:13:48	-	-	-	306,2°	305,8°	12,9
19:14:18	-	-	-	304,8°	305,8°	12,9
19:14:48	121,0°	122,0°	26,2	304,6°	305,8°	12,9
19:14:54	121,0°	122,0°	26,2	304,6°	305,8°	12,9
19:15:00	121,0°	122,0°	26,2	305,0°	305,8°	12,8
19:15:06	121,0°	122,0°	26,2	305,4°	305,8°	12,9
	121,0°	122,0°	26,2	305,4°	305,8°	12,9
19:15:48	121,0°	122,0°	26,2	306,0°	305,8°	12,9
19:15:54	121,0°	122,0°	26,2	305,5°	305,8°	12,8
	121,0°	122,0°	26,2	305,5°	305,8°	12,8
19:16:18	-	-	-	305,5°	305,8°	12,8
19:16:24	-	-	-	305,5°	305,8°	12,8
19:17:24	-	-	-	-	-	-
19:17:30	121,0°	122,0°	26,2	306,7°	306,7°	12,7
	-	-	-	306,7°	306,7°	12,7
19:18:00	-	-	-	306,7°	306,7°	12,7
19:18:30	-	-	-	303,0°	306,7°	12,7
19:19:00	-	-	-	303,9°	306,7°	12,7
19:19:30	-	-	-	303,9°	306,7°	12,7
19:20:35	-	117,1°	26,1	-	-	-
19:21:50	-	117,0°	26,2	-	-	-
19:22:30	116,0°	117,1°	26,1	-	-	-
19:22:36	-	117,1°	26,1	297,0°	303,6°	12,4
19:22:48	-	117,1°	26,1	297,0°	303,6°	12,4
19:22:54	-	117,1°	26,1	297,0°	303,6°	12,5
19:23:35	-	117,1°	26,2	297,0°	303,6°	12,5
19:23:48	-	-	-	296,9°	303,6°	12,5
19:24:18	-	-	-	297,1°	303,6°	12,5
19:24:48	-	-	-	297,2°	303,6°	12,5
19:24:54	117,0°	117,0°	26,1	297,2°	303,6°	12,5
19:25:00	117,0°	117,0°	26,1	296,6°	303,6°	12,5
	117,0°	117,0°	26,1	296,6°	303,6°	12,5
19:25:18	117,0°	117,0°	26,1	296,3°	303,6°	12,6
	117,0°	117,0°	26,1	296,3°	303,6°	12,6
19:25:36	117,0°	117,0°	26,2	296,3°	303,6°	12,6
	117,0°	117,0°	26,2	296,3°	303,6°	12,6
19:26:18	117,0°	117,0°	26,2	-	-	-
	117,0°	117,0°	26,2	-	-	-
19:26:54	117,0°	117,0°	26,1	297,2°	297,7°	12,6
	117,0°	117,0°	26,1	297,2°	297,7°	12,6
19:27:24	117,0°	116,9°	26,2	298,5°	297,7°	12,6
	117,0°	116,9°	26,2	298,5°	297,7°	12,6
19:27:48	117,0°	117,0°	26,1	299,2°	297,7°	12,6
	117,0°	117,0°	26,1	299,2°	297,7°	12,6
19:28:18	-	113,2°	26,1	299,2°	297,7°	12,6
19:28:30	-	113,2°	26,1	-	-	-
19:28:48	-	104,8°	26,0	297,0°	297,7°	12,6
19:28:55	-	104,8°	26,0	-	-	-
19:29:18	-	105,8°	25,4	303,5°	297,7°	12,6
19:29:30	-	105,8°	25,4	-	-	-
19:29:48	-	105,8°	25,4	305,8°	297,7°	12,5
19:30:00	-	099,5°	25,4	-	-	-

Time	HANJIN GOTHENBURG			CHANG TONG		
	Course	Heading	Speed (kn)	Course	Heading	Speed (kn)
19:30:18	-	099,5°	25,4	308,3°	297,7°	12,5
19:30:30	-	092,4°	25,3	308,3°	297,7°	12,5
19:31:00	-	088,5°	25,2	308,3°	297,7°	12,5
19:31:30	-	089,2°	25,1	308,3°	297,7°	12,5
19:31:54	090,0°	090,0°	25,2	310,9°	311,5°	12,6
	090,0°	090,0°	25,2	310,9°	311,5°	12,6
19:32:30	090,0°	090,0°	25,4	307,3°	311,5°	12,6
19:32:36	091,0°	090,0°	25,6	307,3°	311,5°	12,6
19:32:42	091,0°	090,0°	25,6	307,3°	311,5°	12,6
19:32:48	091,0°	090,0°	25,6	310,7°	311,5°	12,4
	091,0°	090,0°	25,6	310,7°	311,5°	12,4
19:33:18	091,0°	090,0°	25,6	322,3°	311,5°	11,8
	091,0°	089,9°	25,6	322,3°	311,5°	11,8
19:33:48	091,0°	090,0°	25,6	345,4°	311,5°	10,3
	091,0°	090,0°	25,6	345,4°	311,5°	10,3
19:34:06	091,0°	090,0°	25,6	004,3°	311,5°	9,3
	091,0°	089,9°	25,6	004,3°	311,5°	9,3
19:34:18	-	089,9°	25,6	014,5°	014,5°	9,1
	-	089,9°	25,6	014,5°	014,5°	9,1
19:35:00	-	082,7°	25,4	-	-	-
19:35:18	-	082,7°	25,4	074,9°	074,9°	18,0
19:35:30	-	080,4°	21,8	074,9°	074,9°	18,0
19:35:48	074,0°	082,0°	17,8	074,9°	074,9°	18,0
19:36:00	-	083,5°	18,4	074,9°	074,9°	18,0
19:36:30	-	086,7°	16,4	-	-	-
19:36:48	078,0°	086,7°	15,2	081,4°	081,4°	14,5
19:37:00	078,0°	089,4°	15,2	081,4°	081,4°	14,5
19:37:18	078,0°	091,0°	15,2	083,3°	083,3°	14,2

Table 1: Courses steered

Due to inaccuracies during transmission and possible malfunctions of the CHANG TONG's AIS, it must be considered when interpreting the afore-mentioned course data that these must not necessarily accord with the actual headings and courses steered. In particular, the heading data of the CHANG TONG raises doubt about the reliability of the data since the courses remain exactly constant over longer periods of time despite hand-steering.

The recorded course leaps of up to 63° within eight seconds (c.f. entry from 19:34:18, jump from 311.5° to 014.5°) are unrealistic. In order to reconstruct the courses steered, the course over ground was therefore considered in the case of the CHANG TONG. Irrespective of the accuracy of the data, one can basically deduce from the records whether and when the course was altered to starboard or to port.

5.2 Survey of the HANJIN GOTHENBURG

Two investigators from the BSU visited the HANJIN GOTHENBURG on the 25 and 26 September 2007 at her anchorage off Yantai. The attempt to board on the 23 September 2007 had to be called off on account of the weather. The investigators went on board a second time on the 6 December 2007 when the HANJIN GOTHENBURG visited Hamburg. Finally, the BSU inspected the vessel accompanied by an expert on the 28 March 2008 (cf. para. 5.4).

During the surveys both the owner of the HANJIN GOTHENBURG as well as the crew were highly co-operative.

5.2.1 Wheelhouse and navigational equipment

The wheelhouse is equipped inter alia with ECS, AIS, two radar systems (X-band and S-band) with ARPA function and a voyage data recorder (S-VDR[8]).

The following figures 38 and 39 provide an overview of the wheelhouse of the HANJIN GOTHENBURG.

Figure 38: Wheelhouse of the HANJIN GOTHENBURG

8 Simplified Voyage Data Recorder

Figure 39: Conning position onboard the HANJIN GOTHENBURG

The positioning of the navigational equipment including the chart table can be inferred from figure 40. The AIS display and operating device (Minimum Keyboard Display - MKD) is positioned above the right ECS screen (cf. figure 41).

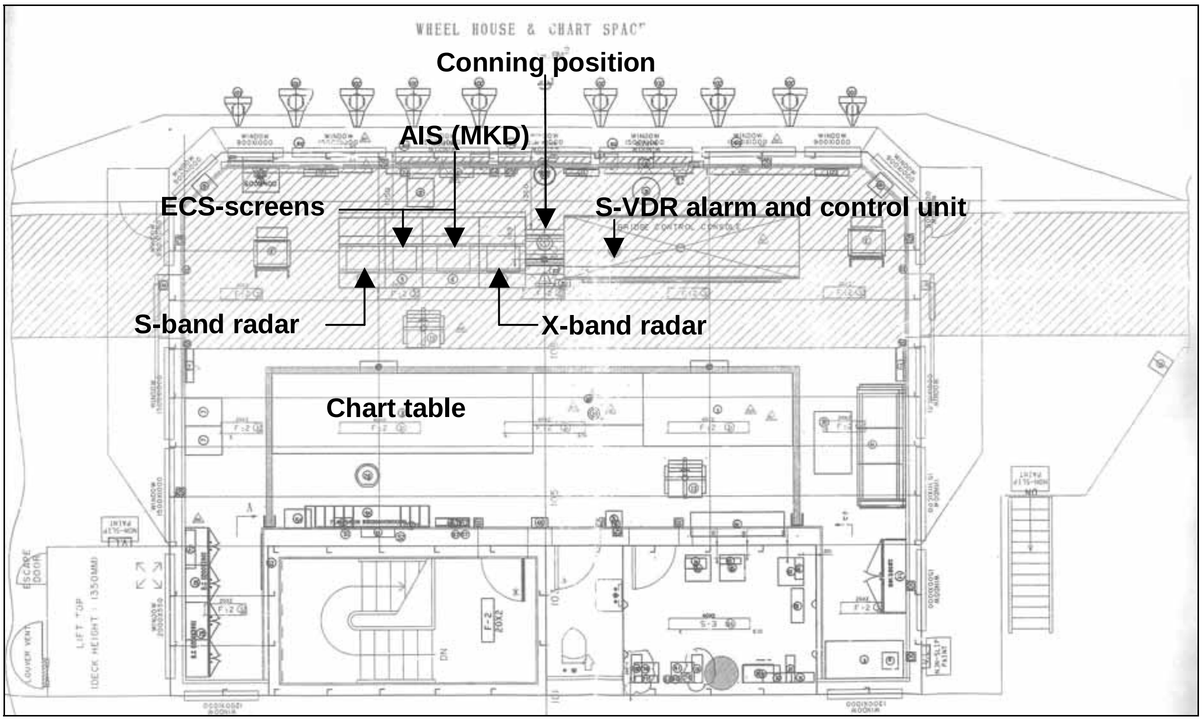

Figure 40: Wheelhouseplan of the HANJIN GOTHENBURG

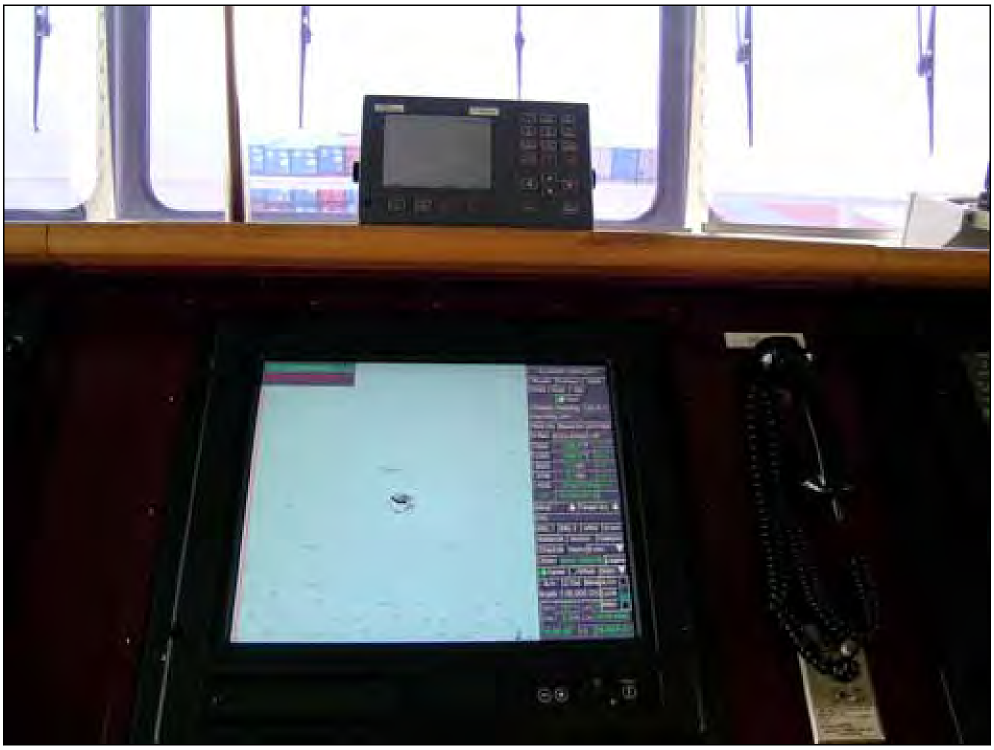

Figure 41: AIS Minimum Keyboard Display above the right ECS screen

5.2.2 Voyage Data Recorder (S-VDR)

The operating console of the S-VDR displayed an error message when the BSU first performed a survey (cf. figures 42 and 43).

Figure 42: Positioning of the S-VDR operating console

Figure 43: S-VDR display

Nevertheless, data relating to the day of the accident could not be secured for the marine casualty investigation despite the correct recording attempt carried out in time by the Master of the HANJIN GOTHENBURG.

When the investigators of the BSU surveyed the HANJIN GOTHENBURG on the 6 December 2007 for a second time, they discovered a total blackout of the S-VDR operating console.

In the course of the investigation, the BSU co-operated closely with the product-licence holder of the S-VDR in order to identify the cause of the malfunctions which appeared several times. In this regard the company was extremely co-operative and provided the BSU with work reports as well as internal error reports for analysis.

The S-VDR has originally been installed in March 2007 onboard the HANJIN GOTHENBURG by a subsidiary of the licence holder in Korea. At that time a problem occurred with the S-VDR's operating unit which displayed an error message. This problem was reputed to have been rectified by means of new configuration on the 1 May 2007. Until the collision occurred on the 15 September 2007, no further VDR data had been recorded so that the repeat malfunction was only noticed after the recording attempt was to no avail. The S-VDR operating unit was then exchanged on the 1 October 2007 and the error was identified in the service report as having been "settled". During the HANJIN GOTHENBURG's subsequent stay in Busan/South Korea, a back-up attempt on the 7 October 2007 proved unsuccessful again. All attempts made by the licence holder's service technicians to rectify the problem were to no avail. The S-VDR ignored commands. When the HANJIN GOTHENBURG reached the shipyard in Singapore on the 22 October 2007, the S-VDR was re-configured again. This solved the problem which had existed since March 2007. The reason for the repeat malfunctions was a configuration problem which had appeared immediately after installing the system in March 2007. An out-dated configuration tool was then used for the installation of the S-VDR. This resulted in the back-up function not operating securely in all operating modes, irrespective of operating actions being performed or not. A back-up was recorded or not, depending on at which position within the programme cycle the internal programme actually was. The reaction (back-up performed or not) could not be foreseen by the vessel's crew, regardless of whether the back-up was initiated on the control unit or on the S-VDR main unit. Apart from this malfunction, which was rectified on the 22 October 2007, a fuse had burned through leading to the operating device's display not functioning properly. The system's functionality was restored after the fuse had been exchanged.

The licence holder of the VDR maintains a global service network. In order to avoid misconfigurations such as those which occurred on the HANJIN GOTHENBURG, he provided downloads for all actual software versions in the service intranet prior to the accident. New versions are reported in a circular letter for which receive and acknowledgement has to be confirmed by each service employee. Despite this reassurance, an out-dated configuration software had been used on board the HANJIN GOTHENBURG. This circumstance was not immediately recognisable because the error files did not contain any reference to the software version having been used.

5.2.3 Navigation bridge visibility

Visibility on the evening of the accident was approx. 9 nm. The following figure 44 illustrates the visibility from the navigation bridge during daytime.

Figure 44: Visibility from the wheelhouse during daytime

According to Chapter V Regulation 22 of the SOLAS Convention[9], view of the sea surface from the conning position shall not be obscured by more than two ship lengths, or 500 m, whichever is the less, forward of the bow to 10° on either side (cf. figure 45).

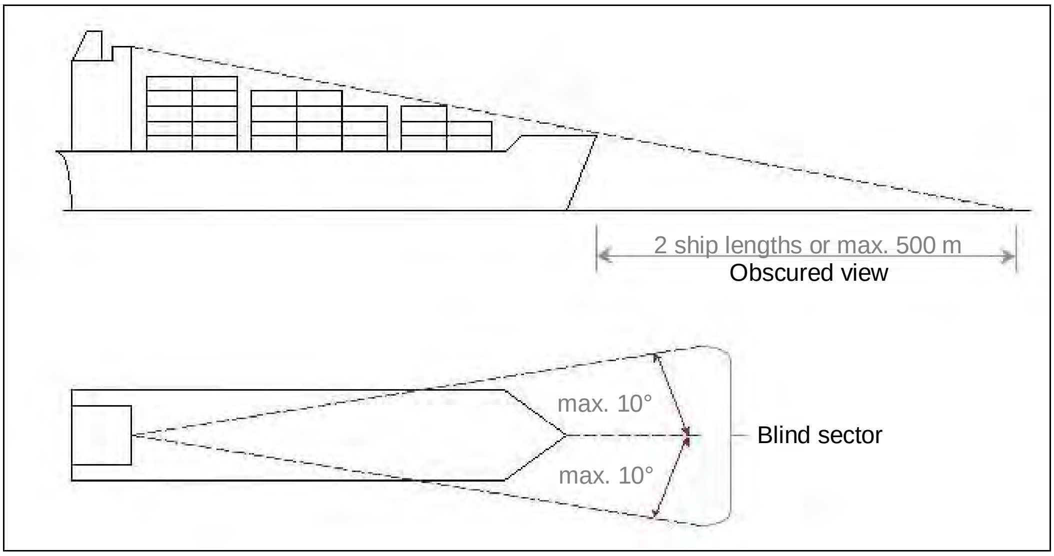

Figure 45: SOLAS navigation bridge visibility requirements

With the draught of the vessel and the height of the containers stowed on deck, the obscured view from the navigation bridge of the HANJIN GOTHENBURG to the sea surface on the day of the accident was approximately 268 m. The visibility requirements stipulated by SOLAS were therefore complied with.

Several masthead lights were sighted on the evening of the accident according to the reports of individual crew members on board the HANJIN GOTHENBURG. According to the DWD the sun set at 1803. Nautical dusk was until 1901, astronomical dusk until 1933. The moon did not contribute much to the visibility because it was in the first quarter, and it was also slightly cloudy. According to the DWD, it can be assumed that it was already dark after 1900 despite the continuous astronomical dusk.

As a result, other vehicles could only be spotted by means of their position lights when navigating after sight.

5.2.4 Nautical charts and determination of position

The paper nautical chart BA 1255 used on board the HANJIN GOTHENBURG was of the correct issue and revision status. The electronic chart system was not operated with official vector data. The marine casualty investigation revealed discrepancies regarding the approval for the ECS on board. While the German Federal Maritime and Hydrographic Agency (BSH) questioned the EC type approval and prompted the ship's owner to dismantle the system, the See-Berufsgenossenschaft listed the ECS as an ECDIS in the Cargo Ship Safety Equipment Certificate. However it can be

9 International Convention for the Safety of Life at Sea

ruled out, that this unsettled the bridge team of the HANJIN GOTHENBURG in using the ECS, as a warning note has been shown in the upper left corner of the screen, stating :"Chart is not ECDIS compliant data". By now, the discrepancies have been rectified. It was extraneous to the marine casualty.

Positioning was carried out on the HANJIN GOTHENBURG by means of GPS. The standing orders for the bridge watch prescribed that the position of the vessel had to be taken in coastal waters at least every 20 minutes and at least every hour whilst at sea, and entered in the bridge log. After the Chief Officer took over the watch at 1600, only two further positions had been entered in the bridge log by the time the accident occurred: one at 1800 and one after the course had been altered off the TSS Laotieshan Shuidao at 1820. In addition to these positions, two others had been marked in the paper chart before the accident occurred (for 1900 and 1930).

When the BSU surveyed the HANJIN GOTHENBURG, the paper chart entries had already been erased for further use. However, investigators of China MSA had already photocopied the original entries (voyage planning and positions) on the day after the accident, so that the BSU could reconstruct them on site (cf. figure 46).

Figure 46: Paper chart excerpt with voyage planning and entered vessel positions

5.2.5 ECS records

The ECS records were reproduced on board the HANJIN GOTHENBURG in playback mode. On the one hand, courses and speeds of the HANJIN GOTHENBURG could be seen for those periods not contained in the VTS AIS records. On the other hand, acquired viz. manually selected and thereby radar traced ARPA targets were viewed on the ECS after data transfer via interface from the radar. Since the CHANG TONG had not been acquired, she is not included in the records.

At 1900 the Chief Officer had acquired several vehicles on the radar using the ARPA function, which encountered the HANJIN GOTHENBURG on reciprocal course. As officer in charge of the navigational watch the Chief Officer had to obey the Master's standing orders, whereby a passing distance of more than one nautical mile from other vehicles during the voyage had to be maintained.

Three vehicles were initially acquired at 1910 (cf. figure 47) which apparently turned out to be fishing vessels.

Figure 47: ECS record from 19:10:45

Another vehicle was acquired five minutes later (cf. figure 48).

Figure 48: Detail from the ECS record from 19:15:40

The vehicles were overtaken at approximately 1923 on starboard (cf. figure 49). The overtaking distance was estimated at approximately 0.5-0.6 cable.

Figure 49: ECS record from 19:23:35

After the vehicles were overtaken, target plotting was not terminated (cf. figure 50).

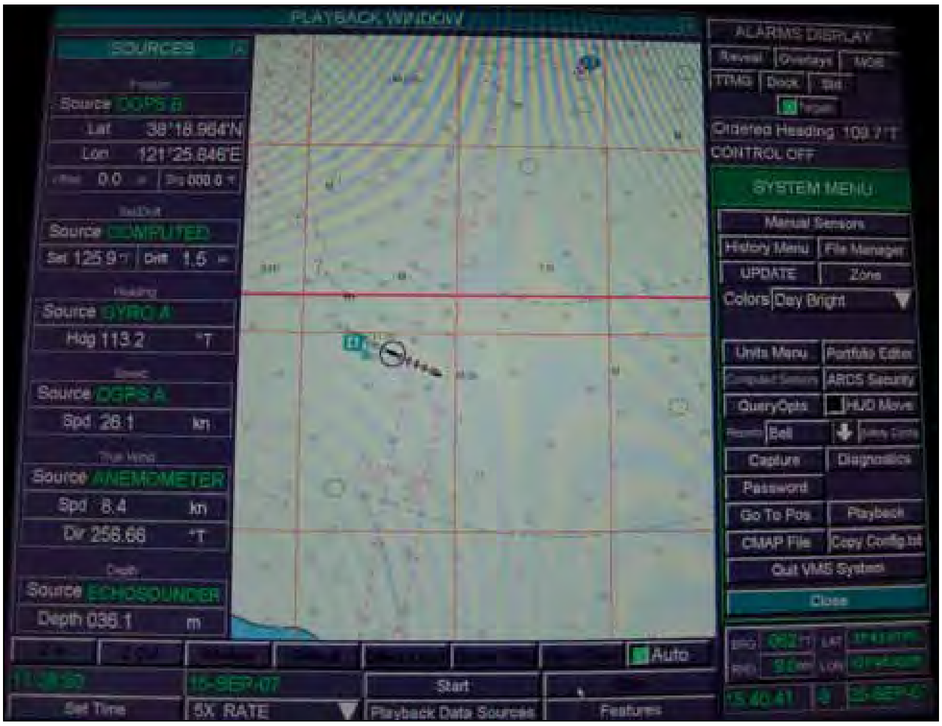

Figure 50: ECS record from 19:28:30

The port manoeuvre was continued without new targets being plotted using the ARPA function (cf. figure 51).

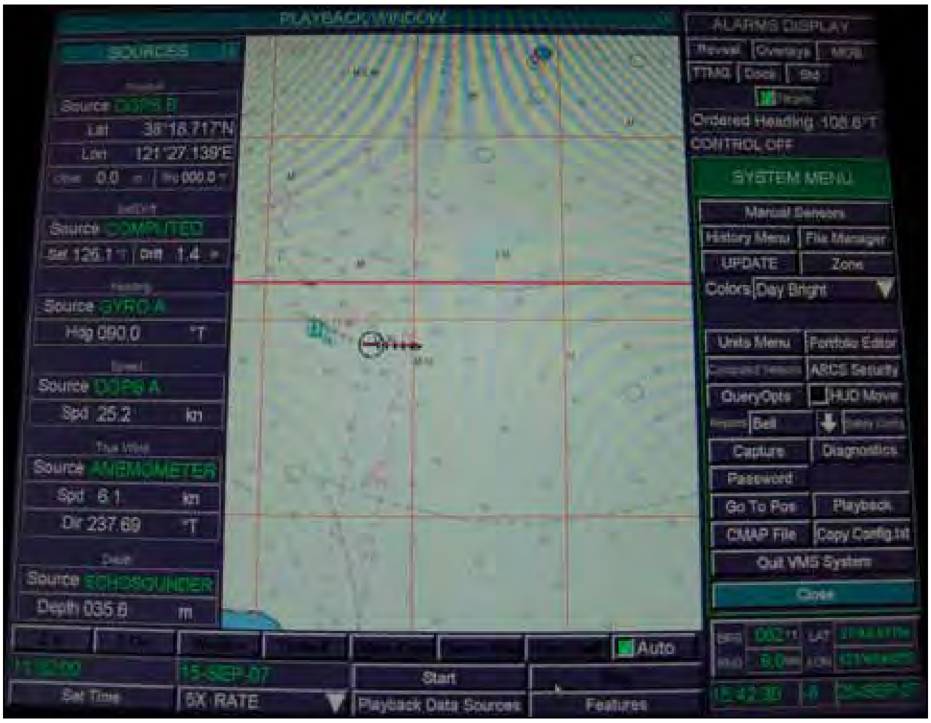

Figure 51: ECS record from 19:32:00

The collision occurred at 1935, when the HANJIN GOTHENBURG's speed rapidly declined (cf. figure 52).

Figure 52: ECS record from 19:35:30

5.2.6 Working hours

In collaboration with the specialist from the Occupational Safety and Health Administration in Hamburg, Master Ulrich, the BSU assessed the time sheets of those crew members of the HANJIN GOTHENBURG who were appointed to bridge watch duties from July to September 2007.

As the HANJIN GOTHENBURG was manned with 22 crew members on the day of the accident, four more were provided than necessary for safe operation of the vessel according to the Minimum Safe Manning Certificate. Sea watch duties were scheduled according to a watch plan rotating three times a day. The watch schedule for the 4-8 bridge watch arranged for the Chief Officer, the Fourth Officer and an Able-bodied Seaman (A/B) to keep watch for the month of September 2007. At the start of September, the Fourth Officer acted as look-out and the seaman scheduled for the 4-8 watch was regularly deployed for work on deck during the day. When the Fourth Officer disembarked on the 8 September 2007, the seaman scheduled as 4-8 bridge watch look-out could scarcely perform as such, as he was still deployed for work on deck. On the day of the accident and according to his time sheet, the seaman on watch properly performed as look-out on the bridge from 0400 to 0800. He then worked for two hours before lunchtime and another four hours from 1300 to 1700. From 1700 on he was "on standby" in his cabin. The Chief Officer did not have a look-out on the bridge since the beginning of his watch.

At the time of the accident the Chief Officer has been skilled as an officer for nearly five years, and he was familiar with the vessel. As stated in his time sheet for

September 2007, he used to work mostly on a regular basis and within the permitted limits. However, a week before the accident and particularly on the 13 and 14 September 2007 as well as on the day of the accident, there had been an increased workload, which led to working hour limits being exceeded (cf. table 2, the time of the accident is marked in blue). It was evident from this, that the accident occurred when the earlier workload had reached its peak. Master Ulrich stated in his evaluation of the time sheet for the days immediately prior to the accident[10]:

> *“Both the timing and the duration of the rest periods are insufficient, particularly since the rest period was interrupted by half an hour of work (0230-0300) during the night (15.09). The last “sensible” rest period concluded at 0400 on 13.09; from then onwards the rest periods were either (much) too short or were at an inconvenient time during the day. This situation lasted over 3 ½ days till 2000 on the 16.09. when an 8-hour rest period followed.”*

Tag	Zeit	0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18	18–19	19–20	20–21	21–22	22–23	23–24	Maxima 16,5	71 Arbeitszeit	8 Ruhezeit	x	
Sa	1					x x	x x	x x	x x	x	x x	x						x x	x x	x x	x x					10				Schiff: Hanjin Gothenburg
Su	2					x x	x x	x x	x x	x	x x	x						x x	x x	x x	x x					10				Reeder: HSB
Mo	3					x x	x x	x x	x x	x	x x	x						x x	x x	x x	x x					10				Monat: September 2007
Di	4					x x	x x	x x	x x	x	x x	x						x x	x x	x x	x x					10				
Mi	5					x x	x x	x x	x x	x	x x	x						x x	x x	x x	x x					10				
Do	6					x x	x x	x x	x x	x	x x	x						x x	x x	x x	x x					10				
Fr	7					x x	x x	x x	x x	x	x x	x						x x	x x	x x	x x	x x	x x	x x	x x	14	74	94		
Sa	8	x x	x							x x	x x	x x	x x	x x				x x	x x	x x	x x					10,5	74,5	93,5	99	Unterschreitung Ruhezeiten
Su	9					x x	x x	x x	x x	x	x x	x					x x	x x	x x	x x	x x					11	75,5	92,5		
Mo	10					x x	x x	x x	x x	x	x x	x						x x	x x	x x	x x					10	75,5	92,5		
Di	11					x x	x x	x x	x x	x x						x x	x x	x x	x x	x x	x x					11	76,5	91,5		
Mi	12					x x	x x	x x	x x									x x	x x	x x	x x					8	74,5	93,5	82	Überschreitung Arbeitszeiten
Do	13					x x	x x	x x	x x	x	x x	x x	x x					x x	x x	x x	x x			x x	x x	13,5	78	90		
Fr	14	x x	x x	x x							x x	x x	x x	x x	x x	x x	x x	x x					x x	x x	x x	14	78	90		
Sa	15	x x		x				x x	x x	x x	x x	x	x x	x x	x			x x	x x	x x	x x	x x	x x	x x	x x	16,5	84	84		

Table 2: Extract from the working hours evaluation for the Chief Officer

Food intake is another factor taken into account during the evaluation of the Chief Officer’s capability on the day of the accident. He took his last meal prior to the accident at lunchtime. However, he was used to not being released from watch for dinner from 1600 to 2000 but waited for the watch hand-over.

When the BSU surveyed the HANJIN GOTHENBURG, no specific indications were provided during discussions with crew members regarding obvious fatigue on the part of the Chief Officer prior to the accident.

5.2.7 Safety management

The shipping company which operates the HANJIN GOTHENBURG maintains a safety management system (SMS) in accordance with the requirements of the International Safety Management (ISM) Code[11].

The ISM Code aims to create an internationally valid standard for measures to ensure safe operation of vessels and for the prevention of marine pollution. The code was prepared by the International Maritime Organization (IMO) and incorporated in Chapter IX of the SOLAS Convention in May 1994. All SOLAS states are bound to

[10] The statement has originally been issued in German language.
[11] International Code for Measures to Organise Safe Vessel Operation and the Prevention of Sea Pollution (IMO resolution A.741(18))

apply the ISM Code. Since 1 July 2002, the ISM Code is also binding for companies that operate cargo vessels of 500 gt and above in international trade. At European level, the Regulation (EC) No 336/2006[12] ensures uniform implementation of the ISM Code. The Code was incorporated as a vessel-related safety standard into the annex to the Vessel Safety Act (Schiffssicherheitsgesetz).

The shipping company which operates the HANJIN GOTHENBURG fulfilled the obligations arising from the ISM Code and introduced instructions and procedures for the safe operation of ships as well as safety measures to counter all assessed risks.

The Bridge Operational Management (BOM) inter alia includes the following procedural instructions for the sea watch:

- Consideration of the working hour requirements in accordance with the Seaman's Law (Seemannsgesetz), the Accident Prevention Regulations for Shipping Enterprises (UVV See) of the See-Berufsgenossenschaft and the STCW Code[13];
- Observance of the COLREGs[14], particularly regarding proper look-out;
- Close observation of the movements, bearing and distances of approaching vehicles;
- Observation of radar.

Furthermore, explicit reference is made to the fact that for the officer in charge of the navigational watch the engine is at his disposal for manoeuvring.

5.3 Investigation regarding the CHANG TONG

The CHANG TONG could not be surveyed by BSU investigators due to the severity of the damage caused by the accident. Therefore, the investigation concerning the vessel and her crew was limited to the evaluation of documents. China MSA interrogated the crew in Chinese and this was then translated into German.

The classification society, IBS, provided the technical documentation required for the investigation. The bridge of the CHANG TONG was inter alia equipped with two radar systems, one of which provided ARPA functionality. According to IBS, the equipment

[12] Regulation (EC) No 336/2006 of the European Parliament and of the Council of 15 February 2006 on the implementation of the International Safety Management Code within the Community and repealing Council Regulation (EC) No 3051/95

[13] International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, as amended; cf. the Annex to the third Ordinance of 18 June 1978 about the enactment of the amendments of the Annex to the STCW Code in Germany (STCW-Gesetz).

[14] Convention on the International Regulations for Preventing Collisions at Sea

also included an Electronic Chart Display and Information System (ECDIS), AIS and a S-VDR system.

5.3.1 Seaworthiness

After evaluating the documents, the BSU was not able to verify beyond doubt whether the CHANG TONG was seaworthy on the day of the accident. A valid Certificate of Class was not presented despite being requested on several occasions. The only certificate that was submitted was an Interim Certificate of Class which had been issued on the 24 January 2006 and was valid until the 23 June 2006. It had been issued because the CHANG TONG had failed to carry out a dry-dock inspection due date.

A total of 16 Port State Controls have been carried out since 1998. No deficiencies were raised during the last inspection prior to the accident (cf. table 3; source: Equasis database).

Based on	inspecting State	Port	Date of report	Detention	Deficien-cies
Tokyo MoU[15]	PR China	Qinhuangdao	27.01.2007	none	
Tokyo MoU	PR China	Huanghua	05.07.2006	none	7[16]
Tokyo MoU	PR China	Qinhuangdao	30.03.2006	none	
Tokyo MoU	PR China	Qinhuangdao	29.09.2005	none	4
Tokyo MoU	PR China	Qinhuangdao	01.09.2004	none	
Tokyo MoU	PR China	Qinhuangdao	06.03.2004	none	
Tokyo MoU	PR China	Qinhuangdao	09.09.2003	none	
Tokyo MoU	PR China	Qinhuangdao	11.08.2003	none	
Tokyo MoU	PR China	Qinhuangdao	28.02.2003	none	
Tokyo MoU	PR China	Qinhuangdao	03.03.2002	none	
Tokyo MoU	PR China	Tianjin	23.08.2001	none	6
Paris MoU	Spain	Gijón	20.10.2000	none	3
Paris MoU	Russia	St. Petersburg	31.05.2000	none	1
Paris MoU	Russia	St. Petersburg	15.07.1999	none	
Paris MoU	Russia	St Petersburg	17.11.1998	none	
Paris MoU	Spain	Gijón	02.03.1998	none	6

Table 3: Summary of the Port State Controls of the CHANG TONG

As proved by the summary of the Port State Controls, after the Interim Certificate of Class had expired no deficiencies were reported during both inspections with regard to this circumstance.

When the course of the accident was reconstructed, it emerged that the autopilot no longer worked since the gyro compass had been replaced on board the CHANG TONG. The BSU was not able to specify the time of the malfunction.

[15] MoU = Abbrevation for the legal basis for Port State Control (Memorandum of Understanding)
[16] 2 x lifesaving appliances, 3 x fire safety measures, 2 x violations of International Convention for the Prevention of Pollution From Ships (MARPOL) - Annex 1

The AIS display had not been used for navigation since it was considered old and no longer reliably functioning. Thus, at the least, the crew on the bridge of the CHANG TONG could not use an important technical tool for navigation on the day of the accident.

5.3.2 Navigation lights

The investigation carried out by the BSU did not reliably conclude whether the CHANG TONG properly turned on her navigation lights after darkness fell. Accordingly, the CHANG TONG could only be recognised by the HANJIN GOTHENBURG due to her superstructure lighting. Sidelights were reportedly not sighted. The CHANG TONG' s navigation and deck lights were said to have only been switched on after the collision.

Thus, in case of navigating after sight, the CHANG TONG was reputed to have been recognisable not until immediately before the collision.

The doubt concerning proper navigation light usage still remained after the crew of the CHANG TONG had been questioned. The following was recorded in extracts:

"Question: *What about the navigation lights of your vessel?*
Answer: *The Third Officer had to switch it on at approximately 1730 local time. (...) I took a quick look to see whether the navigation lights had been turned on properly. In seafaring it is customary to give a signal if an accident has happened ."*

Previously, the measures that were carried out after the collision were described as follows:

"After the collision we switched on the deck signal light for accidents, (...)."

It could not be verified, whether "signal" or "deck signal light" respectively indicated e.g. the use of an ALDIS lamp.

In the regard of the "Deck signal lights for accidents" described, the question remains unanswered if the navigation lights had in fact been switched on. At least it could not be ruled out that the description corresponds with the facts from the viewpoint of the HANJIN GOTHENBURG. However, one must also account for the translation from Chinese into German and then English, which might have led to linguistic nuances being lost despite all the care that has been taken.

5.3.3 Working hours

Information regarding the working hours of the bridge crew on the day of the accident has not been made available to the BSU. It was therefore impossible to evaluate whether the Chief Officer in charge of the navigational watch at the time of the accident was sufficiently rested.

By the time the accident occurred, the Chief Officer has been skilled as an officer since April 1998 and had signed on the CHANG TONG four months prior to the accident. The owner of the CHANG TONG stipulate that trainees should only take over the helm after having completed a three-month training. The trainees that were deployed on the bridge as alternate helmsmen and as support for the look-out were just about to complete the obligatory three-month training.

5.3.4 Nautical charts

It could not be verified in the course of the investigation whether the electronic sea chart on board the CHANG was operated with ENC[17] data and thus had been operated as an ECDIS. It is evident that at least the official Chinese paper sea chart 11900 "Dalian Gang to Yantai Gang" had been used for navigation.

5.3.5 Voyage Data Recorder

Any data storage of the S-VDR installed on board the CHANG TONG could not be used for the investigation of the marine casualty. The BSU is not aware whether the data had been stored. Upon reaching the vessel position on the 25 September 2007, the BSU investigators could not secure or readout the data since the CHANG TONG had already been destructed. The S-VDR's Final Recording Medium (FRM) was not salvaged. Since the CHANG TONG sank not until five days after the collision and the FRM only saves data from the last 12 hours, the data from the day of the accident was reputed to be no longer available to the BSU investigators upon their arrival at the wreck of the CHANG TONG.

5.4 Expert opinion on the course of the voyage

The area of the accident demanded a lot of attention from the bridge crews due to the traffic volume which was often high, comprising mainly fishing vessels. When carrying out the investigation, the BSU used the expertise of a graduate engineer master mariner who has been employed since 1996 on various large container ships and as of 2004 had previously performed as Master with a German shipping company in the seafaring area of East Asia. He works as a pilot since the end of 2006.

The findings and evaluations of the expert primarily refer to

- Watch keeping,
- Use of bridge equipment, especially radar systems,
- Voyage planning,
- Bridge team, as well as to
- Possible accident scenarios.

The results of the expertise were incorporated into the following analysis of the marine casualty and are indicated by reference to the expert's opinion.

[17] Electronic navigational chart = official vector data

6 Analysis

6.1 Sea watch

The legal requirements which the watchkeepers, particularly the sea watch, were subject to were not complied with to the required extent on both vessels involved in the accident. The obligation to place a look-out was not fulfilled by the HANJIN GOTHENBURG and the lack of smooth co-operation between members of the bridge team compromised safe seafaring.

6.1.1 HANJIN GOTHENBURG

In the absence of a look-out, the bridge team of the HANJIN GOTHENBURG did not meet the mandatory requirements and the principles for watchkeeping.

The so-called proper look-out was incorporated in the COLREGs as a separate regulation in 1972. Previously, this aspect was a component of the rule of good seamanship. Rule 5 (look-out) of the HVR states in extract:

> *Every vessel shall at all times maintain a proper look-out by sight as well as by hearing as well as by all available means (...) so as to make a full appraisal of the situation and of the risk of collision.*

This rule did not necessarily require for a second person on the bridge of the HANJIN GOTHENBURG. It was the sole responsibility of the Chief Officer to recognise the possibility of a risk of collision by sight and by hearing as well as by using the available navigation equipment effectively. In addition, the supervision and operability of the bridge equipment had to be continuously supervised by the watchstander.

The amount of attention necessary for the proper look-out was lacking on the evening of the accident. Even if is taken into account that the CHANG TONG possibly could not be made out after sight due to poor navigational light usage, then it should have been detected early on through effective radar use. The First Officer was supported by the MKD as the minimal variant when performing numerous tasks. The transfer in respect of the AIS information displayed on the MKD inevitably cost the officer in charge of the navigational watch more time than if the AIS targets had been immediately displayed on the radar screen. Indeed, the MKD satisfies the requirements for marine equipment; however, only an additional data link would have been necessary to provide the bridge watch with additional relief (cf. para. 6.2). The radar system which had been installed on board the HANJIN GOTHENBURG includes the serial port necessary for the data connection as standard.

The requirements which the bridge watch, particularly a proper look-out, are supposed to follow are specified by the international STCW Code.

In principle, the Master is obliged to take ample measures to ensure a safe bridge watch[18]. In addition to the requirements pursuant to Rule 5 of the KVR, the STCW Code contains the following regulation concerning the look-out[19].

14 The look-out must be able to give full attention to the keeping of a proper look-out and no other duties shall be undertaken or assigned which could interfere with that[20] task.

15 The duties of the look-out and helmsperson are separate and the helmsperson shall not be considered to be the look-out while steering (...) The officer in charge of the navigational watch may be the sole look-out in daylight (...).

(...)

32 It is of special importance that at all times the officer in charge of the navigational watch ensures that a proper look-out is maintained. (...)

(...)

In hours of darkness

46 The master and the officer in charge of the navigational watch when arranging look-out duty shall have due regard to the bridge equipment and navigational aids available for use, their limitations; procedures and safeguards implemented.

According to this, another person should have been employed as a look-out on the bridge at the latest when night was beginning to fall (sunset, 1803).

Given the fact that it is a container vessel under German flag, the UVV See is also employed on the HANJIN GOTHENBURG In addition to the regulations of the COLREGs and the STCW Code. The provision of § 50 (sea watch) of the UVV See prescribes:

Bridge, helm, lookout and machinery shall be properly manned.

According to the corresponding performance directive, the look-out shall be manned by a qualified person from sunset to sunrise. According to the UVV See, it was therefore imperative that another person be assigned as a lookout on the bridge from sunset.

The fact that the Master of the HANJIN GOTHENBURG let the Chief Officer decide to summon the scheduled lookout from his cabin onto the bridge, did not satisfy the requirements of safe bridge watch. Since the look-out had worked on deck during the day, it seems most likely that he would not have had enough rest to meet the requirements of a proper or properly manned look-out. The “option” which the officer in charge of the navigational watch had at his disposal, can therefore hardly be

[18] Cf. Chapter VIII, Section A-VIII/2, Part 3 para. 9 and Part 3-1 para. 16 of the STCW-Code.
[19] Cf. Chapter VIII, Section A-VIII/2, Part 3-1 of the STCW-Code.
[20] Inter alia the obligations according to Rule 5 of the COLREGs.

categorised as such. In fact, another crew member who had already rested should have been employed. According to the STCW Code, both the Master and the officer in charge of the navigational watch bore responsibility for this.

As the bridge was solely manned with the officer in charge of the navigational watch even though darkness fell, this one person was not only responsible for safe navigation but also for the duties of the officer on watch, helmsman and look-out. The situation was made much more difficult by the fact that navigation could only be carried out using primary the paper sea chart. As a result, the Chief Officer was forced to leave the conning position and go to the chart table. His view of essential navigational equipment such as the radar and AIS was therefore hampered. The lack of overlay of radar and AIS information did not help when attempting to obtain a quick overview of the traffic situation. For this fact it did not matter whether the paper sea chart or the ECS were used for navigation.

The regular technical committee of the German Nautical Association (DNV) analysed "Operating experiences using AIS on board" in a practical report which was compiled after about two years period of use. The report was published in 2005 as a position paper. Page 11 states with regard to the issue of MKD operating devices with graphic display:

> *„(...) These practical experiences show that these variant is not suited to developing the potential of AIS technology in a user-friendly way. The displays are too small for comprehensive illustration already when it comes to two-digit number of AIS targets observed; the display lacks contrast and visual differentiation.*
>
> *Recommendation 5:*
> *In order to use AIS in the intended modality, the minimal variants of a „Minimum Keyboard Display" (MKD) are unsuitable as operating and display devices. (...)"*

Page 14 states in relation to practical experiences and conclusions:

> *"The radar system is in many ways the ideal candidate for displaying AIS information: AIS information on the radar enables master mariners to obtain a quick, comprehensive overview of the situation - waiting for the ARPA tracker to stabilise is not necessary. (…) The (…) extra reconciliation of data from the MKD or ECDIS using the radar image is no longer necessary.*
> *(...)*
> *If AIS information and ARPA tracking are combined in a visibility device, the advantages that both tools offer can be used to the full.. (...)"*

The BSU agrees with the comments made by the DNV. However, it is of the opinion, congruent with the DNV in its position paper, that at least the positioning of the MKD on top of the radar screen near the conning position is to be considered best.

The HANJIN GOTHENBURG's equipment with the MKD undoubtedly meets the equipment requirements and is therefore not objectionable. All the same, these minimal variants make the requisite AIS information available to the vessel's command.

However, if one takes into account all the events that took place on the day of the accident, such as

- A large container vessel travelling at approx. 25 kn,
- At least a moderately busy traffic area,
- A possibly fatigued officer in charge of the navigational watch, who simultaneously acts as both a look-out and a helmsman,
- Plenty of radar information, including numerous fishing vessels,
- The legal requirement to navigate with a paper sea chart and
- Darkness,

then it must be held that providing the means for overlaying radar and AIS information could have made it easier to spot the CHANG TONG. However, this required constant monitoring of the radar screen. Whether and to what extent this was performed on the evening of the accident cannot be unreservedly clarified in hindsight. In technical terms, however, the job of the officers in charge of the navigational watch on board the HANJIN GOTHENBURG to ensure safe navigation was not made easier by installing the MKD.

It was therefore imperative that a look-out join the bridge team of 4-8 watches on the evening of the accident. Abandoning this necessity neither conformed to the legal requirements nor the instructions issued by the HANJIN GOTHENBURG's owner.

6.1.2 CHANG TONG

The manning of the bridge with an officer in charge of the navigational watch and a look-out conformed to the specifications of the COLREGs and the STCW Code. However, members of the bridge team did not co-operate smoothly with each other.

During interviewing the bridge crew discrepancies became evident, both in relation to the times at which certain steering was supposed to have been ordered as well as in relation to the order per se. If the specifications of the STCW Code had been complied with, then there wouldn't have been any vagueness concerning the courses to be steered. According to Chapter VIII, Section A-VIII/2, Part 3-1 para. 34.1 of the STCW Code, the nautical officer in charge of the navigational watch should have made regular checks to ensure that the helmsman was steering the correct course. This could have led to discrepancies between the courses which had supposedly been ordered and the actual course that was steered being recognised and cleared up on time. The course recordings which have been evaluated only illustrate a tentative evasion manoeuvre to starboard.

According to the instructions of the shipping company, both trainees should not have been appointed as helmsmen. Although employing the trainees as helmsmen did not contribute to the collision with the HANJIN GOTHENBURG, it cannot be ruled out that their training placed extra demands on the attention of the officer in charge of the navigational watch.

6.2 Radar use

Particularly when proceeding through sea areas with high traffic volume, it is essential that the radar, as a technical tool for supporting safe navigation, is used consistent and with the appropriate settings. The officers in charge of the navigational watch of both vessels involved in the collision mainly plotted the sea traffic with radar systems set at a range of a maximum of 6 nm. Indeed, the HANJIN GOTHENBURG's S-band radar was set at 12 nm; however, the S-band system could not be seen from the conning position (cf. figures 39 and 40). The speed of the vessels measuring approx. 25 kn (HANJIN GOTHENBURG) and approx. 12 kn (CHANG TONG) led to a combined approaching speed of up to 38 kn. At this approaching speed, the 6 nm range selected led to a narrow timeframe for navigational decisions to be made by the ship's commands.

According to the STCW Code, officers in charge of the navigational watch shall select an appropriate range scale and observe the display carefully[21]. In addition, it must be ensured that the range scales employed are changed at sufficiently frequent intervals[22]. A change of the range scale was not carried out on both vehicles involved in the accident.

Apart from other measures, Rule 7 (b) of the COLREGs deems the use of long-range scanning essential for proper use of a radar system. According to the COLREGs, plotting in a 6 nm range without observing the situation using long-range scanning was not to be considered proper radar use.

Even when selecting the "off-center" function, 20 minutes remained for the officers in charge of the navigational watch to identify the other vehicle in a 6 nm range, to assess the situation with regard to obtain early warning of risk of collision and perform evasion manoeuvres where appropriate. As the commands of both vessels mainly concentrated on avoiding collisions with fishing vessels, this timeframe did not suffice.

It is the nature of hindsight to criticize in the context of investigation into the specific circumstances of the accident the decisions taken by the ship's commands, which have been appropriate under other circumstances. According to the BSU, regular or alternate plotting in a range scale of at least 12 nm (so-called long-range scanning) would have been more appropriate for the traffic situation on the evening of the accident.

When the course was last altered from 117° to 090°, the Chief Officer on the HANJIN GOTHENBURG must have stood at least for a short in front of the X-band radar since the autopilot could only be operated from the conning position next to this radar. According to the ECS recordings, the change in course was performed approximately seven minutes before the collision. At this point in time, the distance

[21] Cf. Chapter VIII, Section A-VIII/2, Part 3-1 para. 39 of the STCW Code.
[22] Cf. Chapter VIII, Section A-VIII/2, Part 3-1 para. 38 of the STCW Code.

was approx. 2.5 nm. Due to the lack of overlay of radar with AIS information, it must be assumed that the CHANG TONG did not stand out from the countless radar echoes reflected by fishing vessels. The BSU considers it evident that countless fishing vessels were actually navigating between the HANJIN GOTHENBURG and the CHANG TONG. Witness reports of those involved in the accident concur in this regard. In addition, the evasion manoeuvres carried out by both vessels else would not have made much sense.

After the course had been altered, careful attention was no obviously no longer paid to the radar on board the HANJIN GOTHENBURG. Else, ARPA targets which had already been acquired would have been terminated. New targets could have been selected. Continuing with the new course, without taking the CHANG TONG into account, which must have been visible at this point in time even if the radar was operated centrally, must be considered non-compliant with the STWC code.

Apart from choosing a larger range scale, alternating with the 6 nm range if necessary, guard zones could have been set on the radar when needed in order to warn the officers in charge of the navigational watch of possible risks of collision with other vehicles by setting off alarms in case specific distances were undercut. From the point of view of the BSU, the setting of guard zones would only have been useful if the guard zones could have been restricted to AIS vehicles. In theory, this would have been technically possible by means of overlaying radar with AIS information on board the HANJIN GOTHENBURG. Since the area of the accident was busy with fishing vessels which often significantly undercut the general passing distances, a guard zone set for all radar targets would have set off a permanent alarm, however. This would not have helped obtain a better overview of the traffic situation.

The BSU expert considered the passing distances of 0.5-0.6 cables from fishing vessels to the HANJIN GOTHENBURG to be normal for Chinese waters. He confirmed that greater distances were often not feasible when there is moderate to heavy trawler traffic. In this respect, the BSU considers the undercutting of the requirements laid out in the standing orders of the HANJIN GOTHENBURG justifiable.

6.3 Steering rules and collision avoiding action according to the COLREGs

Both vehicles involved in the accident did not conform to the legal requirements of the COLREGs to the extent described below. The HANJIN GOTHENBURG did not fully comply with these requirements since the colliding vehicle was only spotted a few seconds before the collision took place. The CHANG TONG did not meet the requirements to the extent required.

6.3.1 Head-on situation

Both vehicles originally encountered each other as they were steering nearly reciprocal courses. Rule 14 of the COLREGs prescribes course alterations to starboard if two vehicles approach each other in such a manner and a risk of collision cannot be definitely ruled out. The look-out of the CHANG TONG sighted the red sidelight of the HANJIN GOTHENBURG when making initial visibility contact. As proven by figures 25 and 33, a CPA[23] of much less than a nautical mile was to be expected when there was less than 6 nm distance between the vehicles. It was only approx. 8 minutes by the time the collision happened and the combined approaching speed was approx. 38 kn.

6.3.2 Determining the risk of collision

Rule 7 of the COLREGs contains provisions with regard to the risk of collision. Whether such a risk exists, must be confirmed by all available means according to 7 (a) of the COLREGs. Consistent use of the radar was indispensable in this regard but the officer in charge of the navigational watch on board the HANJIN GOTHENBURG did not see to this to the extent required. No proof exists for the radar not having worked properly and thereby leading to the CHANG TONG not being displayed properly on the radar.

The HANJIN GOTHENBURG did not recognise the traffic situation as it related to the CHANG TONG as a vehicle approaching on reciprocal course. She altered her course at approx. 1927 to 090° to port in order to evade the congestion of fishing vessels at her starboard side. The CHANG TONG steered slightly to port for a short while before she slowly altered her course at 1927 to starboard. Observation on the HANJIN GOTHENBURG had already been intensified at this point in time since the look-out had confirmed that both masthead lights of the other vehicle were no longer seen in line and therefore an alteration in course had taken place. By means of her own course alteration to port, it was tried to provide the HANJIN GOTHENBURG with more sea-room for her evasion manoeuvre.

6.3.3 Assumptions

The risk of collision was underestimated on board the CHANG TONG due to assumptions made on the basis of scanty information. The assumption was made that the HANJIN GOTHENBURG would return to her original course within due time, and therefore focused most on the fishing vessels in the immediate vicinity. Without verification of the assumption of an only temporary evasion manoeuvre, the CHANG TONG was obliged according to Rule 7 (c) of the COLREGs to at first observe the steering rules as set out by the COLREGs and finally to avert the then existing risk of a collision by all means possible.

The attempt to establish VHF contact with the HANJIN GOTHENBURG was the correct approach taken to clarify what was an unsafe situation. Whether the VHF call was indeed made and why it had not been heard respectively, could not be clarified in hindsight due to the absence of any record from VHF radio communications.

On board the HANJIN GOTHENBURG the fishing vessels at starboard were as well considered the greatest danger. In the absence of a record of S-VDR radar images dating from the evening of the accident on board of the HANJIN GOTHENBURG, it was not possible to reconstruct how many radar targets had actually been displayed on the screens. It is conceivable, that even the radar echoes of large vehicles could only be spotted with great difficulty within the numerous echoes of fishing vessels.

[23] Closest point of approach

This view is shared by the expert who was commissioned by BSU. The CHANG TONG did not stand out in any way on the bridge of the HANJIN GOTHENBURG due to the lack of overlay of radar echoes with AIS information. Nevertheless, the radar echo must have displayed particularly the CHANG TONG as a vehicle approaching the HANJIN GOTHENBURG on reciprocal course. The course alteration to 090° steered by the HANJIN GOTHENBURG without recognising the risk of collision thus becoming imminent can be attributed to assumptions made on the basis of scanty information, which should not have been made according to Rule 7 (c) of the COLREGs.

6.3.4 Action to avoid collision

None of the vehicles involved in the collision met the requirements of Rule 8 of the COLREGs with regard to actions to avoid collision. Those on board the HANJIN GOTHENBURG did not determine the risk of collision. At least the CHANG TONG performed an evasion manoeuvre to starboard. However, this was not carried out positive in ample time as Rule 8 of the COLREGs prescribes.

According to Rule 8 (a) of the COLREGs, action to avoid collisions collision shall, if the circumstances of the case admit, be positive, made in ample time and with due regard to the observance of good seamanship. On the bridge of the CHANG TONG the favoured evasion manoeuvre to port could not be carried out since there was a congestion of fishing vessels at this location being evaded by the HANJIN GOTHENBURG. There was obviously no alternative plan such as to how to counter the increasing risk of collision. In fact, the vessel continued to alter course by a total of 15° to starboard which lasted a total of five minutes. This manoeuvre was neither performed positive nor in ample time with the result that the collision could not be avoided. As proven by the records of courses over ground, the hard rudder angle was ordered too late, that is at a distance of approx. one nautical mile. It failed as a last-minute manoeuvre.

The sea area was restricted by several fishing vessels on both sides of the CHANG TONG with the result that only timely stopping or reversing by means of propulsion could have prevented the collision, according to Rule 8 (e) of the COLREGs.

Both vehicles virtually maintained the same speed by the time the collision happened. Speed was reduced to approx. 9 kn on board the CHANG TONG after she had altered course to starboard shortly before the collision and the assistant engineer had independently reduced speed. In this regard, it must be taken into account that although the CHANG TONG was proceeding at full speed it was only 12 kn. Consequently, it was only slightly possible to gradually slacken her speed without endangering manoeuvrability. However, according to Rule 8 (e) of the KVR, decisive stopping of the vessel would have been advisable in view of the situation growing acute as the distance to the HANJIN GOTHENBURG had been reduced to approx. 4 nm. The machine was stopped far too late immediately before the accident.

Had they navigated properly, the vehicles would have spotted each other much earlier and from a greater distance, by this ensuring sufficient sea-room for the evasion manoeuvres and action to avoid collision as stipulated by the COLREGs.

6.3.5 Safe speed

According to Rule 6 of the KVR, each vehicle shall at all times proceed at a safe speed so that she can take proper and effective action to avoid collision. Determining safe speed is a complex process since an array of circumstances such as visibility conditions, traffic congestion and manoeuvring characteristics have to be taken into account.

Numerous marine casualties are the result of inappropriate vessel speed. When looking back at the circumstances which should have been taken into greater consideration when choosing the rate of speed, general seafaring practice must always be considered.

The HANJIN GOTHENBURG was travelling at approx. 25 kn, the CHANG TONG at approx. 12 kn. Both chose the „Full ahead sea“ rate of speed, although the prevailing traffic restricted the available offing and partly required momentary evasion manoeuvres. The expert appointed by the BSU considers the chosen voyage speed, particularly of the HANJIN GOTHENBURG, as normal. Such rates of speed are said to be maintained even if moderate traffic with fishing vessels prevails. After inspecting all the available documents, the expert states that there was no reason to slacken speed.

It must be assumed that traffic on the evening of the accident was more moderate than heavy. Otherwise, more course alterations for evasion manoeuvres performed by the vehicles involved in the accident would have been recorded. The expert concluded from course recordings that apparently clusters of fishing vessels came across which could be bypassed without having to deviate far from the planned route. The fishing vessels sailing between these clusters were supposedly so scattered that they did not necessitate evasion manoeuvres. The radar system settings which were selected at a 6 nm range are said to also support this conclusion.

According to this, there was no need for the ship’s commands of the HANJIN GOTHENBURG and the CHANG TONG to slacken the speed with sole respect to the traffic. In the opinion of the BSU, the chosen vessel speeds for the voyages did not contribute to the accident. However, they significantly narrowed the timeframe available for decisions and manoeuvring as discussed above. As a consequence, the choice of vessel speed should under any circumstances have had an impact on the composition and co-operation between members of the bridge team as well as on the use of bridge equipment. Only in this way could the general risks associated with high vessel speeds have been reduced effectively when encountering other vessels.

6.3.6 Warning signals

When the bridge crew of the CHANG TONG noticed the acute risk of a collision, it gave an uninterrupted whistle signal as a warning. According to Rule 34 (d) of the COLREGs, such a warning should have been given immediately by means of at least five short and rapid blasts on the whistle. A light signal of at least five short and rapid flashes would have supplemented the warning signal and thus increased the chances of being spotted by the HANJIN GOTHENBURG at last. Whether the collision could have been prevented or the damage reduced remains open to doubt due to the marginal distance between the vessels and the vessel speeds.

6.4 Sea-worthiness and use of navigational lights of CHANG TONG

The marine casualty investigation was not able to conclusively clarify whether the CHANG TONG was sea-worthy on the day of the accident. The technical deficiencies of the bridge navigation equipment have been verified sufficiently. However, the BSU is not aware of any further problems with the operation of the vessel or the structural integrity of the hull.

Likewise, it could not be verified whether the CHANG TONG made proper use of her navigational lights. The BSU expert concluded from the details of interviews that it was customary on the CHANG TONG to switch off the navigational lights during the day. A binding statement as to whether the lights were on before the collision is not forthcoming. Indeed, an inspection took place according to the statements provided. However, nothing is known about the results it produced.

6.5 Working and rest periods on the HANJIN GOTHENBURG

Only the time sheets of the HANJIN GOTHENBURG could be assessed as part of the marine casualty investigation. Therefore, no statement can be made about the bridge crew of the CHANG TONG as to whether and to what extent fatigue was partly to blame for the collision.

Assessment of time sheets belonging to those appointed as bridge watch on board the HANJIN GOTHENBURG resulted in significant violations of the stipulated maximum work and minimum rest periods.

6.5.1 Officer in charge of the navigational watch

From the 1 July 2007 to the evening of the accident, the Chief Officer in charge of the navigational watch on the evening of the accident exceeded the maximum work times permissible of 72 hours in each 7-day period as stipulated in § 84a para. 1 of the German Seamen's Law (Seemannsgesetz). Minimum rest periods[24] were undercut. On the day of the accident, the Chief Officer did not have more than three hours continuous rest. The Chief Officer's workload not only violated the provisions of the Seamen's Law but also the identical requirements of the German seamen's industry-wide employment agreement (MTV See) and the shipping company's procedural instructions.

According to the STCW Code, the general minimum period of ten hours rest within 24 hours can be reduced to not less than six consecutive hours in exceptional circumstances provided that any such reduction shall not extend beyond two days and at least 70 hours rest are guaranteed in each period of seven days[25]. On the day of the accident, the Chief Officer only had a maximum of three consecutive hours of rest. Even if the accident had not occurred, the required six hours could not have been achieved as he had been scheduled for the 4-8 bridge watch. According to this, the rest periods stipulated by the STWC Code with regard to fitness for duty of the officers in charge of a watch or ratings forming part of a watch were significantly undercut.

Even if, given his time sheets, the Chief Officer should have been accustomed to a workload contrary to regulations, it is worth noting that the accident occurred on the days involving the peak workload. The last six consecutive hours rest had by the Chief Officer took place one day before the accident on the 14 September 2007, in the period from 0300 to 0900. Thereafter, he virtually worked on a continuous basis except for a few hours. Of the few remaining rest periods, the non-specific times required for eating must also be deducted.

The BSU assumes that the Chief Officer's fatigue was one of the factors which ultimately contributed to the collision with the CHANG TONG.

6.5.2 Appointed look-out

In contrast to the Chief Officer, the appointed look-out for the 4-8 bridge watch in September 2007 seldom exceeded the maximum working hours in the period under review from July 2007 to the day of the accident. July 2007 saw work times being exceeded by 4.5 and 2.5 hours and by a half an hour and 1.5 hours in August 2007. In September 2007 the maximum working hours permitted had been complied with by the day of the accident. However, working hours became increasingly irregular from the 8 September 2007 when the Fourth Officer disembarked. Of the 16 bridge watches from the 8 September 2007 which he was allocated, he did ten not at all or not for the full four hours respectively. If rest periods had not been „inserted“ instead of bridge watch times, the maximum work hours could not have been complied with in September 2007.

According to the STCW Code, the minimum rest periods were guaranteed in the

[24] Ten hours in each period of 24 hours and 77 hours in each period of seven days; cf. § 84a para. 2 of the Seamen's Law.
[25] See Chapter VIII, Section A-VIII/1, para. 4 of the STCW Code.

entire period under review. This would not have been possible after the Fourth Officer had left without abandoning the workload involved in the bridge watch duty.

6.5.3 Monitoring of working hours by the ship's owner

The owner of the HANJIN GOTHENBURG carries out regular sample checks of time sheets sent by the vessel crew in co-operation with the competent Occupational Safety and Health Administration. With regard to the HANJIN GOTHENBURG, the Chief Officer's workload which had exceeded the permitted maximum limits for months on end, was not noticed before the accident.

In the opinion of the BSU and its appointed expert, this is not a problem specific to the ship or the ship's owner but, in fact, one which affects the entire shipping sector. The German Association of Occupational and Environmental Medicine (DGAUM) confirmed during its annual meeting from the 12 to the 15 March 2008 in Hamburg that many officers on German vessels work for longer periods of time on a regular basis, than was otherwise permitted. Some 60 % of seamen were confirmed as having frequently exceeded the maximum working times[26]. The reasons for this are complex. Regarding the marine casualty investigation, an evaluation took place especially of those onshore control mechanisms relating to this collision which should take over if monitoring of working hours on board fails.

The HANJIN GOTHENBURG's owner makes explicit reference to the legal work and rest requirements in its Bridge Operational Management which is available on board and also refers to the necessity of a look-out from sunset to sunrise. If, as happened on board the HANJIN GOTHENBURG, these requirements are neither implemented by the Master as representative of the shipping company nor the officers on watch and ratings forming part of a watch on board, then the shipping company's safety management laid out in the procedural instructions borders on what it can possibly achieve. According to the ISM Code, safety management does not aim to prevent the Masters and crews on board from acting independently by stipulating meticulous requirements. As part of a well-functioning ISM system, the designated person should have been made aware of the violations against internal regulations in the opinion of the BSU and its expert. The designated person is the link between the shipping company and those on board, mainly bearing responsibility for monitoring aspects relating to the safety of the vessel[27].

It is therefore necessary that conclusions be drawn from the occurred accident and safety management improved. Initial measures were already taken by the shipping company shortly after the accident[28].

[26] Quoted from the newspaper article "Offiziere arbeiten zu lange - Übermüdung ist oft ein Grund für Schiffsunfälle" (Officers work too long – fatigue is often a reason for marine casualties), published in the THB Deutsche Schiffahrts-Zeitung from the 13 March 2008, p. 3.

[27] Cf. Rule 4 of the ISM Code.

[28] Cf. para. 7.1.

6.6 Functionality of the Voyage Data Recorder

The reconstruction of the course of an accident is rendered significantly more difficult if the VDR is either not at all or only partially functional.

The VDR is a salvageable data storage device for use on seagoing vessels. The gradual implementation of VDR carriage requirements for ships in international traffic according to Chapter V / Rule 20 of SOLAS began on 1 July 2002. Since 2006 existing cargo vessels must gradually be retrofitted with VDR or S-VDR. This carriage requirement also results from European Community Law (cf. Directive 2002/59/EC[29]). Both the HANJIN GOTHENBURG and the CHANG TONG are equipped with S-VDR systems.

Fast access to VDR stored data is essential for accident investigations. After an accident, the data can be used not only to determine causes, but also for prevention, as they provide the necessary information concerning such events. This particular accident illustrates just how important it is to store (S-)VDR data for reconstruction of the course of the accident. The collision angle of both vessels could not be reconciled with the original voyage plans and the courses entered in the paper charts. Only evaluation of the AIS recordings of the Chinese VTS helped reconstruct the course of the accident.

Data from the day of the accident could not be retrieved due to the use of configuration software which was not suited to the hardware on board the HANJIN GOTHENBURG when the system was installed. The detection and thus the remedying of the causal error lasted more than eight months. Indeed, the S-VDR did not completely malfunction during this period. However, the storing of manoeuvre data did occur entirely by coincidence and was not foreseeable for the crew.

The BSU has already published reports with safety recommendations as part of other investigations which address the problems associated with malfunctioning (S-)VDR systems[30].

[29] Directive 2002/59/EC of the European Parliament and Council of 27 June 2002 establishing a Community vessel traffic monitoring and information system, repealing Council Directive 93/75/EEC (Official journal L 208/10 of 5/8/2002 p. 10)

[30] Cf. the reports regarding the collision between m/v RITHI BHUM and m/v EASTERN CHALLANGER (Ref. 343/04), the collision between m/v LASS URANUS and m/v XIN FU ZHOU (Ref. 305/06) as well as the capsizing of the pilot tender ELBE 3 while casting off from m/v DELTA ST. PETERSBURG (Ref. 415/06), which are available on BSU's website at www.bsu-bund.de.

6.7 Summary

The collision between the HANJIN GOTHENBURG and the CHANG TONG was primarily caused by the HANJIN GOTHENBURG altering course to port from 117° to 090° while disregarding the approaching CHANG TONG which steered on reciprocal course. After this change in course the CHANG TONG did not take positive action to avoid collision in ample time.

It could not be clarified why the CHANG TONG was not spotted. Indeed, it is certain that the traffic situation was not observed closely enough on the radar on the bridge of the HANJIN GOTHENBURG and the obligatory look-out was not present. It remains open to question whether the reasons for the oversight are to be found in the officer in charge of the navigational watch being fatigued due to his continual workload or whether the CHANG TONG could not be made out by sight due to lack of navigational light usage in darkness.

Ultimately, it is due to coincidence that no persons were injured during this very serious collision.

7 Actions taken

7.1 Actions taken by the HANJIN GOTHENBURG's owner

The HANJIN GOTHENBURG's owner already issued a circular letter on the 27 September 2007 concerning the safe navigation of its fleet in which the Masters and ship crews were once again reminded of the importance of proper watchkeeping and the use of navigational equipment.

The following measures are expressly referred to in the circular letter:

- look-out in accordance with Regulation 5 of the COLREGs,
- proper use of radar equipment including long-range scanning and guard rings with activated acoustic alarm, in order to obtain an early warning of risk of collision,
- observance of safe speed in order to be able to take proper and effective action to avoid collision.

In addition, the circular provides for frequent review of the COLREGs under supervision of the Master.

According to the owner, the course of the accident has been integrated in simulator operations. It has become integral part of all simulator training courses and is free spoken about in-house.

7.2 Actions taken by the licence holder of the Voyage Data Recorder

The licence holder of the S-VDR which was installed on board the HANJIN GOTHENBURG informed the BSU in February 2008 that henceforth he would more intensively advise the staff during VDR service training courses to use the correct combination of software version and all S-VDR/VDR components including the configuration tool.

In addition, a note was included in the Technical Manual which clearly refers to the necessity of using a configuration tool which is compatible with the VDR software version.

As a further measure, the error logs now display the VDR configuration version used during installation.

8 Safety Recommendation(s)

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

8.1 Owners and operators of seagoing vessels

The Federal Bureau of Maritime Casualty Investigation recommends the owners and operators of seagoing vessels remind the shipboard management vigorously of the importance of keeping a proper look-out. In particular, the look-out must be manned between sunset and sunrise in order to be able to obtain and maintain a complete overview of the risk of collision.

8.2 Vessel commands

The Federal Bureau of Maritime Casualty Investigation recommends the commands of seagoing vessels monitor the radar display in accordance with the requirements of the STWC Code during the navigational watch and select appropriate range scales to assure an overview of the traffic situation.

8.3 Operators of seagoing vessels under German flag, vessel commands

The Federal Bureau of Maritime Casualty Investigation recommends all operators of seagoing vessels under German flag and the vessel commands observe the given statutory working and rest periods for vessel crews and monitor its compliance on board.

8.4 Companies which install and maintain Voyage Data Recorders

The Federal Bureau of Maritime Casualty Investigation recommends that companies which install and maintain Voyage Data Recorders ensure by taking the appropriate measures that only software which is compatible with (S-)VDR hardware is used when installing and maintaining the system. Furthermore, it is recommended to optimize the procedure for analysing and eliminating errors.

9 Sources

- HANJIN GOTHENBURG
  - Witness' Statements of the Master and the Chief Officer
  - Statement of Facts by the Master
  - Protocols of the interviews carried out by the China MSA with the Master and the Chief Officer
  - Crew list
  - Excerpts from the deck log book and the bridge bell book
  - Time sheets (July to September 2007) for the Chief Officer, the Fourth Officer and the look-outs
  - Familiarization document for the Chief Officer
  - List of navigational equipment
  - Cargo documentation
  - Recordings of the course recorder
  - Voyage plan details
  - Minimum Safe Manning Certificate
  - Pilot card
  - Watch schedule
  - Matrix of responsibility
  - Visibility board
  - Master's standing order for watchkeeping on the bridge
  - Survey reports of the GL
  - Excerpts from the Bridge Operational Manual
  - Circular letter of the vessel's owner, dated 27 September 2007
  - Work reports and error details for the S-VDR
  - Paper nautical chart BA 1255
- CHANG TONG
  - Statement of the Master
  - Protocols of the interviews carried out by the China MSA with the Chief Officer
  - Crew list
  - Excerpts from the deck log book and the bridge bell book
  - Experts from the engine log book
  - Interim Certificate of Class
  - List of navigational equipment
  - Entries regarding port state controls, contained in the Equasis database
- Photographic documentation
- Evaluation of the time sheets for part of the HANJIN GOTHENBURG's crew, carried out by the Occupational Safety and Health Administration (port control / shipping), Hamburg
- Expert opinion regarding the course of the accident, ordered by BSU
- Information given by Germany's National Meteorological Service
- Information given by the manufacturer of the radar systems equipped on board the HANJIN GOTHENBURG
- Investigation Report of China MSA
- Diagram 4 shows the Bohaiseamap2.png chart taken from the free encyclopaedia, Wikipedia, which is licensed by *Creative Commons Attribution ShareAlike 2.5*[31]. Karl Musser is the originator of the chart.

[31] Cf. http://creativecommons.org/licenses/by-sa/2.5/deed.de