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

Lithuanian Maritime Safety Administration
Maritime Safety Division

Joint investigation report in accordance with
the IMO Casualty Investigation Code
(Resolution MSC.255(84))
by the flag State Republic of Lithuania
and the coastal State Federal Republic of Germany

Investigation Report 445/10

Very Serious Marine Casualty

Fire on the ro-ro passenger vessel LISCO GLORIA on 8 October 2010 north-west of Fehmarn

1 February 2012

The following is a **joint report by** the German Federal Bureau of Maritime Casualty Investigation as lead investigating authority and the Lithuanian Maritime Safety Administration. The two bodies have conducted this investigation jointly and in accordance with the IMO's Casualty Investigation Code (Resolution MSC.255(84)). The working language used for this joint investigation was English. The German text shall prevail in the interpretation of this report.

Moreover, 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 said act, the sole objective of this investigation is to prevent future accidents and malfunctions. This investigation does not serve to ascertain fault, liability or claims. This report should not be used in court proceedings or proceedings of the Maritime Board. Reference is made to art. 19 para. 4 SUG.

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Abbreviations

AIS	Automatic Identification System
BSH	German Federal Maritime and Hydrographic Agency
BSU	German Federal Bureau of Maritime Casualty Investigation
CCME	German Central Command for Maritime Emergencies
CCT	Casualty Care Team
DGzRS	German Maritime Search and Rescue Service
FFU	Fire-fighting Unit
GLZ-See	Joint Situation Centre-Sea
JRCC	Joint Rescue Coordination Centre
MLZ	Maritime Situation Centre of the CCME
MSA	Maritime Safety Administration
MSZ	Maritime Security Centre
MRCC	Maritime Rescue Co-ordination Centre
RCC	Rescue Coordination Centre
SAR	Search and Rescue
SOK	Søværnet Operative Kommando / Operational Command of the Royal Danish Navy
VDR	Voyage Data Recorder
WSA	German Waterway and Shipping Board

1 Summary

On the evening of 8 October 2010, the ro-ro passenger vessel LISCO GLORIA, which was flying the flag of Lithuania, began her voyage from Kiel in Germany to Klaipėda in Lithuania. 32 Lithuanian crew members and 203 passengers of various nationalities were on board.

Trucks, trailers and cars were parked on the largely open upper deck of the LISCO GLORIA. Refrigerated goods were transported in some of the trailers. The refrigeration units at the front of each trailer were regularly inspected by crew members of the LISCO GLORIA to monitor the temperature of the cargo. One hour after the start of the voyage, the duty crew member went to start a round and inspect the upper deck. He started in the forward, garage area below the superstructure on the far right parking lanes and then worked his way aft to the open area of the weather deck. A few minutes before midnight, while making his way back to the superstructure he noticed the smell of burning. At about the same time a fire alarm for the garage area of the upper deck sounded on the bridge, where the chief officer was on duty. Just as the chief officer was identifying the source of the fire on one of the CCTV monitors, he received a radio call from the duty crew member, who had discovered the fire on one of the trucks inspected first. At that point, the LISCO GLORIA was located in the German Exclusive Economic Zone north-west of Fehmarn.

Shortly afterwards, the master who had been called to the bridge started the drencher system in the garage area of the upper deck, but the system did not deliver water. The fire spread rapidly. The fire fighting team was also unable to make any inroads due to the thick smoke. Therefore, the master opted to evacuate the ferry.

All available vessels were called to the scene of the accident via Bremen Rescue Radio to assist by taking the persons to be evacuated on board and if necessary to fight the fire. Passengers and crew members disembarked the ferry to lifeboats and life rafts as fire spread through the full length of the upper deck. They were picked up by vessels that had rushed to the scene and ultimately taken back to Kiel on board the ferry DEUTSCHLAND, which had also proceeded to the distressed vessel. Some of them had suffered injuries and were treated in hospital. However, no one was seriously injured.

In the meantime, the ferry had drifted into Danish waters. In the ensuing period, it was not possible to extinguish the fire. Therefore, the LISCO GLORIA was towed to the port of Munkebo in Denmark for the remainder of the fire-fighting operation, where she made fast on 22 October 2010, two weeks after the accident. The ferry was later declared a constructive total loss.

The marine environment was marginally impaired in consequence of the fire.

2 SHIP PARTICULARS

2.1 Photo

Figure 1: Photo

2.2 Particulars

Name of vessel:	LISCO GLORIA
Type of vessel:	Ro-ro passenger vessel
Nationality/flag:	Lithuania
Port of registry:	Klaipėda
IMO number:	9212151
Call sign:	LYQT
Owner:	DFDS Lisco[1]
Year built:	2002
Shipyard/yard number:	Szczecin Shipyard (Stocznia Szczecińska) / B591-I/1
Classification society:	American Bureau of Shipping (ABS)
Length overall:	199.00 m
Breadth overall:	25.00 m
Gross tonnage:	20,140
Deadweight:	7,620 t
Draught (max.):	6.32 m
Engine rating:	18,900 kW
Main engine:	2 x Wärtsilä 9L46C
(Service) Speed:	22 kts
Hull material:	Steel
Hull design:	Double bottom
Minimum safe manning:	14

[1] Now renamed to DFDS Seaways.

2.3 Voyage particulars

Port of departure:	Kiel, Germany
Port of call:	Klaipėda, Lithuania
Type of voyage:	Merchant shipping International
Cargo information:	trucks, trailers, cars
Manning:	32
Draught at time of accident:	5.90 m (fore), 6.00 meters (aft)
Pilot on board:	No
Canal helmsman:	No
Number of passengers:	203

2.4 Marine casualty or incident information

Type of marine casualty:	Very serious marine casualty, fire
Date/time:	8 October 2010/2358[2]
Location:	Baltic Sea, German EEZ, about 7 nm north-west of Fehmarn
Latitude/Longitude:	φ 54°34.345'N λ 010°47.391'E
Ship operation and voyage segment:	High sea
Place on board:	Upper deck
Human factors:	No, technical fault
Consequences (for people, vessel, cargo, the environment and other):	28 injured, constructive total loss of the vessel, partial total loss of the cargo, minor pollution to the marine environment

Excerpt from Chart 54, Federal Shipping and Hydrographic Agency (BSH)

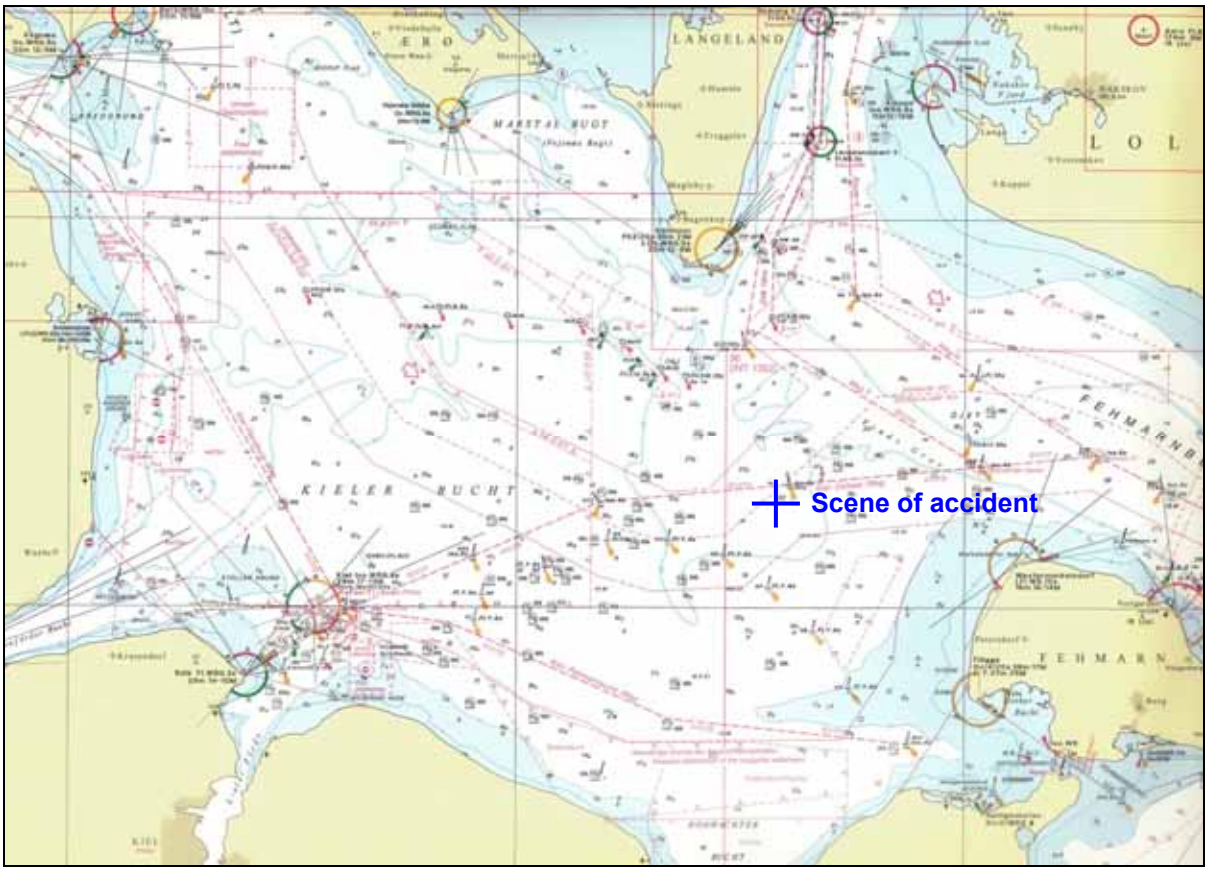


Figure 2: Nautical chart

[2] All times shown in this report are local = Central European Summer Time (CEST) = (UTC + 2 hrs.).

2.5 Shore authority involvement and emergency response

Organizations involved:	– DGzRS[3] – Central Command for Maritime Emergencies (CCME) – Navy – Federal Police – Fire brigade units from Kiel, Brunsbüttel, Lübeck, Flensburg, Cuxhaven, Hamburg and Rostock – WSÄ[4] Lübeck, Stralsund – Waterway Police Kiel and Heiligenhafen – State Office of Criminal Investigation Kiel – SOK[5] – German Red Cross – St. John Accident Assistance – Worker Samaritan Association – Malteser Hilfsdienst (Emergency Service)
Resources used:	– FFUs[6] – CCTs[7] – Boarding team – Crisis intervention team – Various vessels (see Tab. 1 on the following pages) – Helicopter: ▪ Germany: PIROL 848, SAR 8957, SAR 8961, Wiking SB ▪ Denmark: MERLIN 507 ▪ Sweden: one SAR helicopter
Actions taken:	– Rescue of passengers and crew – Fire-fighting – Search for missing persons – Anchoring the vessel – Personal information centre – Psychosocial care
Results achieved:	– Casualty care and transportation – Evacuees transported to Kiel – Fire control measures – Tow to Munkebo

[3] Deutsche Gesellschaft zur Rettung Schiffbrüchiger (German Maritime Search and Rescue Service)
[4] Waterways and Shipping Boards
[5] Operational Command of the Royal Danish Navy (Søværnet Operational Command)
[6] Fire-fighting units
[7] Casualty care teams

Vessels deployed[8]

Vessels of the Coast Guard, Navy, and WSV[9]

ARKONA (DBBU)

- 2 fire-fighting cannons
- 1 water/foam cannon 400 m³/h, 70 m
- 1 portable water/foam cannon, 50 m
- 1 foam nozzle 300 m³/h
- 4 handheld foam nozzles 400 l/min
- Equipment for environmental protection

BAD BEVENSEN (DREV)

Emergency tug BALTIC (GGWJ2)

- 2 fire-fighting cannons 1,200 m³/h

BREDSTEDT (DLGZ)

FEHMARN (DRLF)

GUNNAR SEIDEN-FADEN (OUDV)

- Equipment for environmental protection

GUNNAR THORSON (OUDU)

- Equipment for environmental protection

HARALD B (OX2322)

- Fire-fighting equipment

MARIE MILJØ (OUEA)

- Equipment for environmental protection

[8] In each case, the call sign is shown in brackets behind the vessel's name (categorised, listed alphabetically). Where known, the extinguishing capacity is shown under the image of each vessel.

[9] Federal Waterways and Shipping Administration (WSV)

(Cont.) Vessels of the Coast Guard, Navy, and WSV

MHV 901 ENØ (OVLA)

- Fire and environmental protection pumps 2 x 22 kW (about 9 t of water per min.)
- Water cannons

MHV 92 HOLGER DANSKE (OVGD)

NEUSTRELITZ (DBIF)

ROTA (OVFF)

- Fire-fighting equipment

SCHARHÖRN (DGOQ)

- Equipment for environmental protection
- Extinguishing capacity 2 x 600 m³/h and 3 x 250 m³/h
- Range between 50 and 130 m
- Surge height between 25 and 70 m
- Gas protection system
- Surgery for emergency doctor

Merchant shipping

AMNY DOLLARD (ZDIK5)

(no picture available)

CREOLA (V2BP3)

DEUTSCHLAND (DMLQ)

<table>
<tr><th colspan="3">(Cont.) Merchant shipping</th></tr>
<tr>
<td>GOTLAND (DFWT)
(no picture available)</td>
<td>FRI SKIEN (ZDGD3)
  </td>
<td>SCHLESWIG-HOLSTEIN (DMLM)
  </td>
</tr>
<tr>
<td>SPARTO (P3VW9)
  </td>
<td>VIDI (SLBI)
(no picture available)</td>
<td>VISSERSBANK (PIHB)
  </td>
</tr>
<tr><th colspan="3">Rescue vessels</th></tr>
<tr>
<td>ARKONA (DBAD)
 
▪ Capacity (castaways) 145
▪ Extinguishing capacity 2000 m³/h
▪ Range 130 m
▪ Foam reserve 500 l
▪ Emergency packs for advanced medical initial treatment</td>
<td>BERLIN (DBAH)
 
▪ Capacity (castaways) 145
▪ Extinguishing capacity 2000 m³/h
▪ Range 130 m
▪ Foam reserve 500 l
▪ Emergency packs for advanced medical initial treatment</td>
<td>BREMEN (DBAS)
 
▪ Capacity (castaways) 145
▪ Extinguishing capacity 2000 m³/h
▪ Range 130 m
▪ Foam reserve 500 l
▪ Emergency packs for advanced medical initial treatment</td>
</tr>
</table>

(Cont.) Rescue vessels		
JOHN T. ESSBERGER (DBAI)  ▪ Extinguishing capacity 580 m³/h ▪ Range 70 m ▪ Foam reserve 2000 l ▪ Portable bilge pumps ▪ Hospital ward ▪ 2 t crane ▪ Helicopter working deck	VORMANN JANTZEN (DBAG)  ▪ Extinguishing capacity 200-380 m³/h ▪ Range 90 m ▪ Foam reserve 200 l ▪ Medical equipment ▪ Emergency packs for advanced medical initial treatment	
Fire brigade vessels		
KIEL (DLQO)  ▪ Foam reserve ca. 15 t ▪ 2 Fire and salvage pumps, 540 m³/h ▪ 2 Foam pumps, je 27 m³/h ▪ 2 Hydraulic pumps, each 200 l/min at 216 bar ▪ 2 fire-fighting cannons, each 540 m³/h, ▪ Range ca. 100 m ▪ Equipment for oil barriers ▪ 1 Separation plant, max. 320 m³/h	40-3 FLORIAN (DBEP)  ▪ Main fire pump 2 x 6.600 l/m ▪ 1 x 6.600 l/m ▪ Aux. fire pump: 800 l/m ▪ High pressure fire pump 250 l/m ▪ Foam pump: 2 x 400 l/m, 1 x 160 l/m ▪ Foam reserve: 16,100 l ▪ Fire-fighting cannons: 3 x 3.600 l/m ▪ Range 80 m	

<table>
<tr><th colspan="3">Tugs and other vessels</th></tr>
<tr>
<td>ASTERIX (OXLL2)
 
▪ Fire-fighting system 2700 m³/h
▪ 2 Fire pumps, each 350 m³/h
▪ 2 Fire pumps, each 1,200 m³/h
▪ 2 Fire-fighting cannons
▪ Life saving appliances</td>
<td>BÜLK (DJVM)
  </td>
<td>DANPILOT VEGA (OU9508)
(no picture available)</td>
</tr>
<tr>
<td>FAIRPLAY-26 (V2FF3)
 
▪ 2 Fire-fighting cannons, each 1.350 m³/h
▪ Range 140 m, 40 m high</td>
<td>SKAGERAK (OVXQ2)
(no picture available)</td>
<td>VILM (DFGH)
 
▪ Pollution control vessel</td>
</tr>
</table>

Table 1: Overview of the deployed vessels

3 COURSE OF THE ACCIDENT AND INVESTIGATION

3.1 Course of the accident

3.1.1 Night of 8/9 October 2010

The LISCO GLORIA made fast in the Ostuferhafen in Kiel at 1800 on 8 October 2010. The boarding of new passengers and loading of the decks for the return voyage to Klaipėda started at around 1930. The ferry was fully loaded. The cargo transport units were secured by lashing teams for the forthcoming passage predominantly with chains. Units on the upper deck, for which the temperature had to be monitored (mostly refrigerated trailers with meat products), were either connected to the shipboard electrical system in the forward, semi-enclosed area below the superstructure (‘garage area’) or diesel-electrically operated on the open weather deck area. In addition to the other cargo, five cargo transport units were carrying dangerous goods; these were all loaded in the open deck area. All in all, the loading operation passed uneventfully.

Figure 3: Part of the upper deck of the LISCO GLORIA during the loading operation on the night of the accident

The passengers were taken on board in shuttles at the same time as the decks were being loaded. According to the lists of people on board, the LISCO GLORIA had 32 crew members, 115 passengers and 89 truck drivers on board that evening, i.e. a total of 236 people. However, a female passenger checked in ashore, but did not commence the voyage; accordingly, there were only 235 people on board. With one exception, all the entrances to the cargo decks were locked after completion of the loading operation. One access point, from the superstructure to the upper deck via the stairwell on the port side, was left open. The passengers, including drivers, were generally prohibited from entering the vehicle decks for the duration of the passage to Klaipėda.

When the LISCO GLORIA cast off from the Ostuferhafen at 2200, the master, the third officer, and a helmsman were on the bridge. Weather conditions were reasonable: a 5 to 6 Bft wind from east-north-east prevailed and visibility was about 8 nm. The water temperature was 12 °C.

At 2300, the watch was taken over by the chief officer and an AB (able-bodied seaman). The helmsman left the bridge, but the master remained for a short period, as did the third officer who was carrying out administrative tasks. The duty seaman was ordered by the master to commence his inspection on the upper deck (deck 6). The actual temperatures of the refrigeration units loaded there were to be compared to a list of required values. The AB began the inspection on the upper deck at 2307. The chief engineer, the electrician and a motorman, who were on their way from the engine control room, had passed deck 6 shortly before and found no irregularities. At about this time, the ferry passed Kiel Lighthouse. On the advice of the master, the speed was reduced from 18/19 kts to 17 kts. The master and third officer then left the bridge. The AB began his round in the forward, garage area on the far right parking lanes. The refrigeration unit of the truck parked in the front of lane 8 (see shaded area in Fig. 4) was one of the first to be inspected.

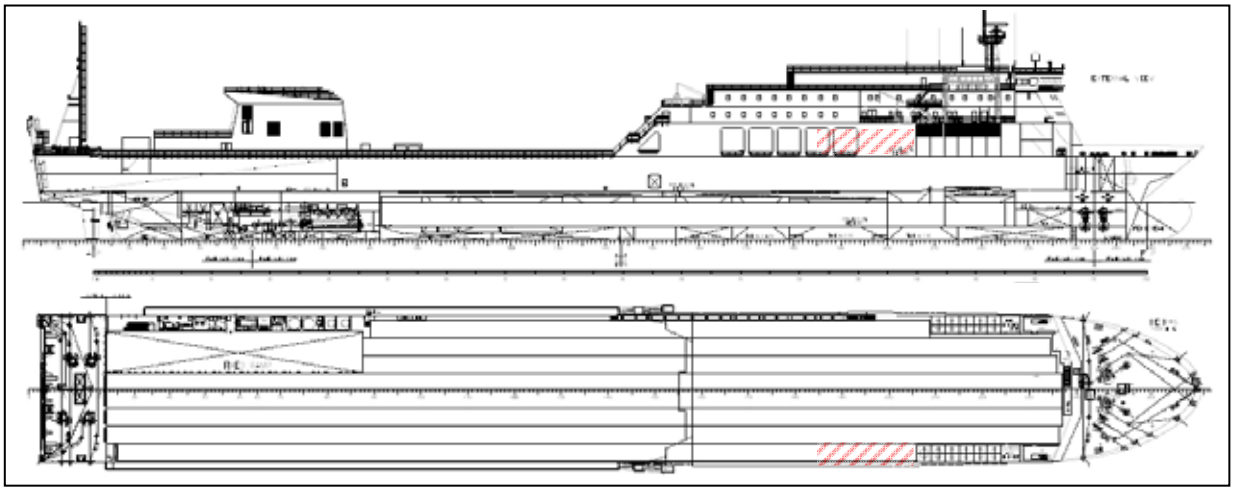


Figure 4: First parking position on lane 8 of the upper deck

The refrigeration unit was connected to the shipboard electrical system. According to the list entry, a temperature of -20 °C was to be maintained; however, -28 °C was displayed. The AB made a note of this inconsistency, but in accordance with general procedures on board did not inform the officer on watch or the driver because the specified temperature was not exceeded. The inspection was continued towards aft.

At 2335, the AB called the chief officer on the bridge via ship radio and requested that lights for the open weather deck be turned on. Following that, the floodlights were turned on in the aft section. The seaman inspected lanes 1 to 4 on the way back to the superstructure. The floodlights were turned off as he approached the garage area following a brief message. Shortly before midnight, the AB noticed the smell of burning, but at first he was unable to locate the source. He moved on in search of the source of fire from lane 2 to lane 4 on the starboard side. At 2358, a smoke detector alarm sounded on the bridge, which indicated a fire in the garage area of the upper deck. The officer on watch went to the CCTV[10] monitors, which showed, amongst other things, camera images of the forward area of the upper deck. Smoke was seen on these. A few seconds later, the officer on watch was informed by the AB of a fire at the first parking position on lane 8 via ship radio. The seaman identified the refrigeration unit mounted between the cab and trailer, from which flames covering an area of about 40 x 40 cm were leaping, as the source of the smell of the fire. He left the upper deck one minute after the message via the stairwell on the starboard side and went to the fire-fighting team's equipment room on deck 8, because he was a member of the emergency response unit. At that point, the LISCO GLORIA was located in the German Exclusive Economic Zone north-west of Fehmarn (see Fig. 2).

The officer on watch notified the master, who arrived on the bridge within a few seconds; his immediate action was to order that the power supply on the upper deck be switched off. At midnight, the master ordered the deckcrew to go to the upper deck via a loudspeaker announcement in the crew area. He then ordered the officer on watch to obtain an overview of the situation at the scene. Furthermore, shortly after midnight the master issued an order to the duty engineer in the engine control room to shut off the power supply to the cargo transport units on the upper deck. After speaking with the electrician briefly on the phone, the engineer switched off the power to the upper deck, which triggered an alarm in the quarters of the chief engineer. Following that, the chief engineer went to the bridge, as did the third officer, who heard the announcement.

At 0002 on 9 October 2010, just four minutes after the first fire alarm, the master activated the drencher system in the garage area of the upper deck. At that time, an audible alarm was heard, which was determined to be a 'network time-out' on the shipboard monitoring system. One outlet of the drencher was located above the observed source of the fire, however the drencher system did not activate. After the master noticed the malfunction, the duty engineer was instructed to start the drencher system from the engine control room. This was unsuccessful. At 0007, the

[10] Closed-circuit television.

master communicated information about the fire on VHF Channel 16 to Bremen Rescue Radio. At the same time, the first passengers noticed smoke in their cabins and went to the assembly point in the bar on deck 7. Some of the passengers began to knock on doors of others to draw attention to the fire.

At 0009, eleven minutes after the fire broke out, the master ordered the evacuation of the LISCO GLORIA. The purser, who was responsible for coordination, briefed the evacuation teams and went to the assembly point himself, from where he made initial preparations for evacuation by the starboard lifeboat.

The automatic sprinkler system also triggered at 0009, presumably in the area of the port side stairwell in the garage area of the upper deck. At the same time, the connection of one of the sprinkler system's pressure pipes parted near the engine control room, causing water to flow uncontrolled into the engine room. One of the members of the engine crew was situated there. The duty engineer in the engine control room noticed that the pressure pipe had parted and hurried across deck 4 to the sprinkler room in the fore section on deck 5, where he turned off the sprinkler system.

The fire on the upper deck had already spread across the whole of the garage area. Due to thick smoke, the fire-fighting team was unable to push forward on the upper deck in spite of wearing breathing apparatus. All emergency teams were then ordered to proceed to the lifeboats at 0013. At the starboard lifeboat, measures to cool the deck using a number of fire hoses began under the guidance of the second officer to make it possible for passengers to board the lifeboat from deck 7.

At the same time, Bremen Rescue Radio sent a mayday relay message on VHF Channel 16 to all vessels and ordered them to proceed to and assist the LISCO GLORIA. As a result, numerous vessels changed course and headed for the distressed vessel. The SAR helicopter located in Kiel was alarmed at 0019.

As cooling continued on deck 7 on the LISCO GLORIA’s starboard side, the passengers were taken out of the bar in small groups, where they were first provided with life-jackets and then placed in the starboard lifeboat. The port lifeboat was also made ready. At 0035, the starboard lifeboat was lowered into the water with approx. 50 passengers and five crew members on board. At that point, the first four vessels had arrived at the scene: two cargo vessels (GOTLAND and CREOLA), one tanker (SPARTO) and the patrol boat of the Federal Police BP-22 NEUSTRELITZ, which in consultation with Bremen Rescue Radio assumed the role of on-scene co-ordinator (OSC). The NEUSTRELITZ took the people evacuated by the starboard lifeboat on board.

At 0044, passengers on the LISCO GLORIA started to board the port lifeboat. In addition, the three life rafts were prepared on the starboard side. The entire length of the ferry’s upper deck was now on fire. Fifteen minutes later, the port lifeboat was lowered into the water and also proceeded to the NEUSTRELITZ.

Meanwhile, in addition to other vessels, the ferry DEUTSCHLAND, which had sufficient capacity to accommodate all the people from the LISCO GLORIA, had arrived at the scene. The JRCC (Joint Rescue Coordination Centre) Aarhus in Denmark as well as the RCC Gothenburg in Sweden offered their assistance in terms of further helicopters. These were put on hold by the RCC Glücksburg, as at this point in time no or only a small number of injured were assumed. Both helicopters started nevertheless. The Danish flew to the distressed vessel, and the Swedish landed in Kiel where it was kept in standby.

The master of the LISCO GLORIA instructed the duty engineer to stop the main engine, take the engine log book and abandon the vessel. He then made an announcement on VHF Channel 16 that two crew members were at the ship's stern and required assistance. As the engineer and the watchkeeper attempted to fight the flames with a fire hose and reach the superstructure after leaving the engine room and arriving on the upper deck, they realised the futility of this endeavour. Instead, using torches they made the Danish Coast Guard boat ROTA aware of their presence. When the ROTA was close enough, the watchkeeper lowered the duty engineer to about 2 m above the waterline in a lifebuoy, from where the engineer jumped. The watchkeeper followed him, but jumped from a greater height. The two crew members did not suffer any injuries and were picked up immediately by the ROTA.

At 0115, the master reported on VHF Channel 16 that all passengers were reportedly evacuated and 13 crew members were still on board. At this point, however, a 16-year-old adolescent was still on board, who looked for a way out alone. He was finally able to smash a window, climb out of this and was rescued by the naval helicopter 8957.

The German Central Command for Maritime Emergencies took over coordination of the rescue and fire-fighting operation at 0120.

At 0130, the last members of the crew of the LISCO GLORIA, including the chief engineer, the first officer, and finally the master climbed into one of the life rafts via a rope ladder, which had been fastened to the starboard side on deck 7 in the meantime. With that, all 235 people had been successfully evacuated from the ferry.

3.1.2 Subsequent events on 9 October 2010

3.1.2.1 Sea-based measures

Before the last crew members left the LISCO GLORIA, they were instructed to drop an anchor by the NEUSTRELITZ. However, that was not possible owing to the smoke on the fore section. This led to the vessel drifting in a north-westerly direction (see Fig. 5).

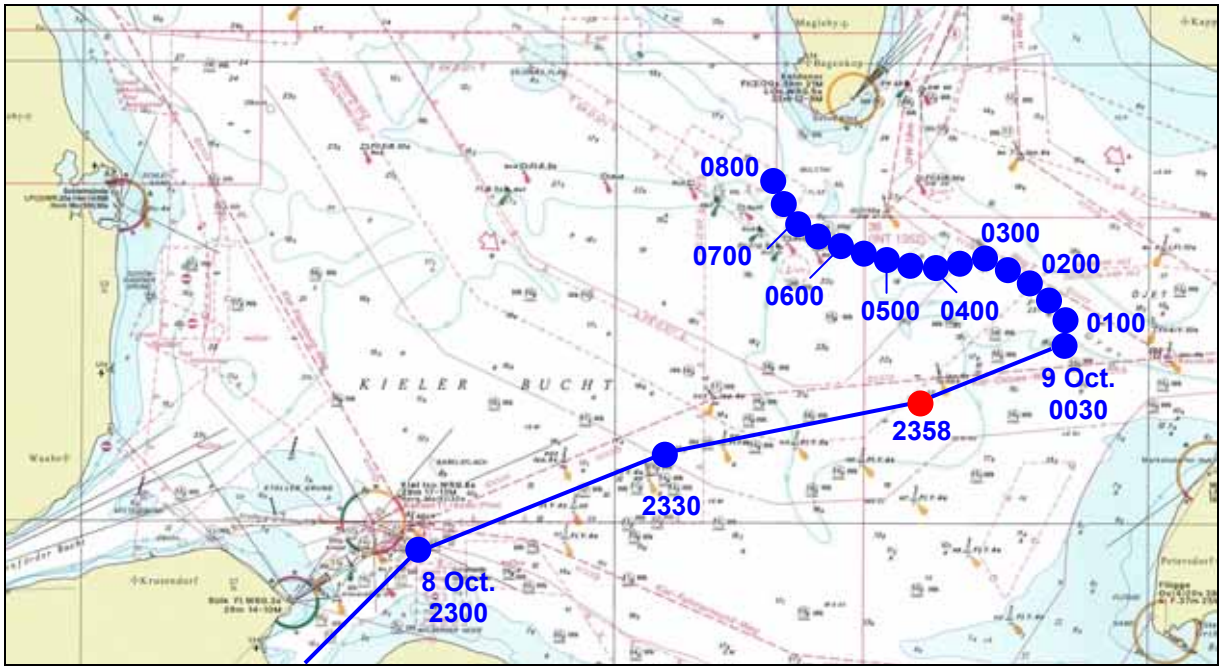


Figure 5: AIS track of the LISCO GLORIA

The smaller vessels HARALD B, SKAGERAK, NEUSTRELITZ, ROTA and DANPILOT VEGA were directly involved in rescuing the crew and passengers of the LISCO GLORIA. They provided assistance to the boats and rafts, took people from them on board and transferred them to the DEUTSCHLAND. Bremen Rescue Radio started to release the larger vessels at 0137. Two people who had suffered the effects of smoke inhalation were picked up by the German naval helicopter and flown to Kiel.

At 0200, the LISCO GLORIA drifted into Danish waters. In spite of that, in consultation with the Danish Navy the CCME remained responsible for overall coordination of the operation.

At 0219, the environmental protection vessel[11] SCHARHÖRN had reached the LISCO GLORIA and begun the fire-fighting operation in gas protection mode. The role of OSC for the fire-fighting operation[12] was transferred to the SCHARHÖRN's master by the CCME. In addition to the ROTA, the fire-fighting operation was also joined by the rescue vessels JOHN T. ESSBERGER, VORMANN JANTZEN, ARKONA, BERLIN and BREMEN.

At 0222, the Head of the CCME designated the naval base in Kiel as the port of distress, at which all the people from the LISCO GLORIA were to be taken ashore. Casualty care teams (CCTs[13]) were assembled there. Furthermore, an accurate recording of the crew and passengers was to be made there.

[11] As per VV-WSV 1103. These ships are referred to as multi-purpose vessels in the Baltic Sea as well.
[12] In the language use of the DGzRS called as On-Scene Incident Response Manager. In differentiation to the OSC, who is responsible for search and rescue.
[13] One CCT consists of one emergency doctor and two paramedics.

At about 0230, based on information from the shipping company and master, the rescuers understood that there were supposedly 236 people on board the LISCO GLORIA. However, the situation was unclear as no one had an overview of the number of persons who had been picked up. Although in a radio conversation with the NEUSTRELITZ, Bremen Rescue Radio gave instructions at 0048 in German to report back with the actual number of persons picked up by each vessel, which the NEUSTRELITZ relayed to the GOTLAND and the SPARTO in English shortly afterwards, this was not consistently complied with. In the ensuing period, the DEUTSCHLAND continuously reported to Bremen Rescue Radio the numbers of people transferred to her in groups by various vessels; however, these exceeded the actual number of people on board considerably.

A request for an emergency doctor was made by the DEUTSCHLAND and at 0250 the Danish rescue helicopter 507 flew the doctor to the vessel. The helicopter later took a person suffering from smoke inhalation and the emergency doctor on board and transported the injured person to the University Hospital in Kiel.

At 0258, the SCHLESWIG-HOLSTEIN as the last of the large vessels that had rushed to assist was being released.

At 0307, a helicopter of the Federal Police arrived at the scene with the first fire-fighting unit (FFU) from Lübeck on board. This unit was assigned by the CCME to be set down on board the SCHARHÖRN in order to provide the ship's command and OSC for the fire-fighting operation with technical support. However, they were ultimately set down on the ARKONA, as otherwise the SCHARHÖRN would have been forced to interrupt her fire-fighting operation. At that point, the ARKONA was about 30 minutes away from the distressed vessel and also took part in the fire-fighting operation when she reached the scene.

At 0318, the DEUTSCHLAND began her voyage to Kiel after all the people, except the master and two crew members, from the LISCO GLORIA had been taken on board. The group with the master initially stayed on board the NEUSTRELITZ in order to assist in the activities surrounding the LISCO GLORIA with their knowledge.

The German naval helicopter set an emergency doctor taken on board in Kiel down on the DEUTSCHLAND and flew back to Kiel to transport two CCTs from there to the DEUTSCHLAND. At that point, it was assumed that 243 people had been taken on board the DEUTSCHLAND.

At 0348, the rescue vessel BREMEN carrying out fire-fighting operations at the bow reported to the OSC on board the SCHARHÖRN that the LISCO GLORIA was listing 5° to port. The list had increased to 10° by 0415. At 0447, the BALTIC, another vessel with fire-fighting capacity, arrived at the burning vessel. At that point, the fire was no longer being actively extinguished, as by then the LISCO GLORIA’s list had increased to 15°; only the shell plating was being cooled down (see Fig. 6).

Figure 6: Cooling the shell plating of the LISCO GLORIA on the morning of 9 October 2010

At the same time, discussions were being held in relation to a towing connection to the LISCO GLORIA. The fire service vessel KIEL, the fire service vessel 40-3 FLORIAN from Rostock, and the tug BÜLK from Kiel were also on their way to the scene. The KIEL arrived at about 0530. At this point in time, the ARKONA had detected and reported highly toxic gases in the atmosphere surrounding the LISCO GLORIA's bow and portside area, after having carried out a measuring procedure. The ARKONA therefore retreated from the polluted area.

At 0548, a helicopter from the company WIKING reported in by radio with four members of a boarding team on board. Since the entire length of the LISCO GLORIA was on fire, the co-ordinator from the Lübeck Fire Brigade on the ARKONA was of the view that operations directly on board were no longer possible. Following that, the boarding team, which was to be taken on board the LISCO GLORIA, in particular, to establish a towing connection, was set down on the BALTIC. The helicopter then left the area to refuel and was replaced shortly afterwards by another naval helicopter.

At about 0600, the DEUTSCHLAND arrived at her berth at the naval base in Kiel, where the evacuees disembarked and were provided with further care.

At about 0640, two members of the boarding team were taken on board the naval helicopter in order to assess the situation with respect to boarding from the air with the aid of the helicopter's thermal imaging camera. This aerial assessment was completed at about 0700 and the next steps were discussed between the helicopter and the BALTIC. The OSC on the SCHARHÖRN considered boarding via a winch to be too hazardous. Before the boarding team commenced its task, the atmosphere around the LISCO GLORIA needed to be checked again for explosive and toxic atmospheres using the measuring equipment on the ARKONA. Highly toxic gases were detected again during this test. The task was aborted by the CCME at about 0730 for this reason and because of the heat on the forecastle. Also at about 0700, the shipping company, DFDS, informed the CCME that a salvage tug it had chartered was on the way to the LISCO GLORIA. At 0730, the CCME was informed about the engagement of a salvage company by DFDS. In the meantime, the fire service vessel 40-3 FLORIAN had also reached the scene.

From 0800 onwards, the Danish MARIE MILJØ, an environmental protection vessel, was at the scene. Shortly before 0900, the LISCO GLORIA drifted towards Langeland (course 340°) at 1.6 kts. Therefore, another attempt was ordered by CCME to set the boarding team down on the LISCO GLORIA. For that purpose, the SCHARHÖRN pushed the vessel in a direction to the wind that would clear the forecastle of toxic gases. Two members of the team were taken on board the WIKING helicopter, which was back in operation, and set down on the LISCO GLORIA equipped with breathing apparatus. These quickly succeeded in dropping both anchors. The entire task, including the return journey, was completed at 0937.

Due to a misunderstanding, the OSC ordered the cooling of the LISCO GLORIA's hull to be stopped at 1030. Instead, the CCME had only ordered to suspend the fire-extinguishing measures. Shortly after that, only the ARKONA and the salvage tug FAIRPLAY 26, which had arrived in the meantime, continued the cooling operation.

At about 1100, the fire service vessel 40-3 FLORIAN, the NEUSTRELITZ, the BAD BEVENSEN, and, with the exception of the ARKONA, all the rescue vessels were released from the operation. Instead , the oil spill recovery vessel VILM was put on stand-by. The fire service vessel KIEL was released by the CCME at 1300.

The master and the two other crew members of the LISCO GLORIA left the NEUSTRELITZ in Puttgarden at 1310 and were taken to Kiel. At the same time, the WIKING helicopter took off in order to take the four-member salvage team commissioned by the shipping company to the SCHARHÖRN. The salvage team was brought to the LISCO GLORIA's aft deck at 1342 in order to check the situation. Two further members of the salvage team commissioned by the shipping company transferred from MARIE MILJØ to SCHARHÖRN at 1506, as did the officer in charge of the Lübeck fire brigade as well as a further fire brigade member from the ARKONA. On board the SCHARHÖRN, the condition of the distressed vessel was discussed between all team leaders. Temperature measurements were carried out by means of an infrared camera.

In the course of the operation, additional fire-fighters were stationed on the vessels still situated in the sea area. These remained on the vessels or were replaced by new fire-fighting units.

The Federal Police helicopter PIROL 848 took numerous aerial photographs of the burning ferry (see Fig. 7). The fire had now spread to the main deck. The fire-fighting operation was halted temporarily to prevent the heeling ferry from capsizing.

Figure 7: The LISCO GLORIA burning, taken at midday on 9 October 2010

In addition to German vessels and FAIRPLAY 26, the tug commissioned by the shipping company, the Danish vessels HOLGER DANKSE, MARIE MILJØ, ENØ, GUNNAR SEIDENFADEN and ROTA were kept at the scene in the afternoon, in particular, to prevent water pollution caused by leaking fuels if necessary. The ferry's shell plating was cooled down by FAIRPLAY 26 at the direction of the salvage team; this was continued until the next day.

On the SCHARHÖRN, the OSC and the co-ordinator from the GUNNAR SEIDENFADEN shared information at 2000. The GUNNAR THORSON, a water pollution control vessel, was approaching the scene.

3.1.2.2 Shore-based measures

After the evacuees arrived at the naval base in Kiel, about 150 support personnel assisted during the course of the morning. These included the Deutsche Rote Kreuz (German Red Cross), the Johanniter (St. John Accident Ambulance), the Arbeiter-Samariter-Bund (Worker Samaritan Federation), the Malteser Hilfsdienst (Emergency Service), a crisis intervention team, units of the Fire Brigade, emergency doctors and paramedics.

After the DEUTSCHLAND arrived at the naval base in Kiel, the police counted the evacuees and compared the particulars with the crew and passenger lists provided. Including the three remaining crew members on the NEUSTRELITZ and the three casualties in hospital, a total of 235 survivors were counted.

From 0800 onwards, the evacuees were supported by 15 emergency psychosocial care counsellors at the naval base. Interpreters were also engaged. The personal information centre was operational from 0930 onwards.

At 1330, most of the evacuees had been taken to a hotel in Kiel on the initiative of the shipping company, from where the onward journey was coordinated.

3.1.3 Week from 10 to 17 October 2010

On 10 October 2010 at midnight, the Danish Navy assumed overall responsibility for the emergency command from the CCME. The LISCO GLORIA was lying at anchor about 2 nm off the southern tip of Langeland. The ARKONA and the SCHARHÖRN were to remain at the scene. The last fire-fighting units and casualty care teams on the ARKONA were withdrawn after boarding the BÜLK. Henceforth, the GUNNAR SEIDENFADEN acted as SOSC (State On-Scene Co-ordinator) and the SCHARHÖRN as NOSC (National On-Scene Co-ordinator) for the German units on scene.

Fire was seen on the bridge of LISCO GLORIA at around 0100. FAIRPLAY 26 carried out fire-extinguishing operations until approx. 0230. At 0230 also the tug ASTERIX that had been chartered by the salvage team commissioned by the shipping company was on scene with five salvage experts on board.

The tug ASTERIX assumed responsibility for cooling the shell plating of the LISCO GLORIA from FAIRPLAY 26 at 0315. At 0415, the water pollution control vessel GUNNAR THORSON also arrived at the scene. Still at the scene, the BALTIC as well as the tug BÜLK were released from the operation in the morning. At early midday, a meeting was held between the shipping company, the insurance company, the salvage team and the Danish supervisory authorities on board the GUNNAR SEIDENFADEN. It appeared that the fire was dying down, only a few flames were still visible. More information regarding a possible salvage was expected in the afternoon. In the meantime, FAIRPLAY 26 had started to cool down the ferry's shell plating again. The German vessels ARKONA and SCHARHÖRN were released from the operation at 1330.

Contrary to expectations, fires continued to break out on the LISCO GLORIA. In the ensuing period, the LISCO GLORIA was monitored at the scene around the clock. On 11 October 2010, a fire-fighting team from the salvage company managed to push forward from the aft section of the upper deck to amidships on the port side. Furthermore, the engine room, which had not been directly affected by the fire, was entered to close the valves for the oil and ballast tanks.

The temperature on the ferry was measured periodically and the cooling measures were continued. On the night of 11/12 October 2010, a temperature of 80 °C was measured on deck 4; the temperatures on the remainder of the vessel were between 10 and 25 °C.

It was not possible to bring the fire on deck 4 under control, not even on the following day. The amount of fire-fighting water on the main deck was estimated at 150 t. Extensive equipment (pumps, emergency lighting, etc.) had to be delivered before work could continue on the vessel.

In the ensuing period, attempts were continued to extinguish the remaining fires on board and to calculate the stability of the LISCO GLORIA. On 15 October 2010, the oil spill recovery vessel VILM took on approximately 250 m^3 of fire-fighting water residue from the LISCO GLORIA. On the following day, the salvage team began to

restore a power supply on board the vessel. The cooling measures were continued until 18 October 2010.

3.1.4 Tow to Munkebo from 18 to 22 October 2010

On 18 October 2010, the salvage company presented a revised salvage plan. The LISCO GLORIA was still lying at anchor only two nm south of Langeland. Although the fire on board was under control, it was not possible to extinguish it permanently. Due to the fire-fighting water on board the ferry, she was still heeling at a constant 6 to 7° to port. A stability calculation was performed in consultation with the classification society as it was planned to tow the ferry to Munkebo.

Following approval of the salvage plan by the Danish supervisory authorities, preparations were made for the towing operation during the next two days. Cooling of the hull's temperature was continued to prevent the occurrence of extreme temperatures which may have fractured the hull. On 19 October 2010, the VILM discharged the water pumped from the ferry in Aarhus, Denmark, and then returned to the distressed vessel to take on more. Fire fighting water was to be pumped from the vessel to prevent instability during towing operations due to free surface effects. At the same time, the salvage team re-established functionality of the bow winch using mobile generators.

The towing operation involving the tugs FAIRPLAY 26 and ASTERIX, which were supported by the GUNNAR SEIDENFADEN and VILM, began at 1400 on 21 October 2010. A 4 Bft wind from west-north-west prevailed, visibility was good and swell stood at 0.5 m. At around midnight, the wind freshened to 6 Bft from north-north-west and it started to rain. On the morning of 22 October 2010, the tug-and-tow combination reached the approach to Odense without incident, where it waited for the arrival of Danish officials and pilots. The entry into Odense began at about 1300. At 1700, the LISCO GLORIA made fast on the pier in Munkebo.

3.1.5 Stay in Munkebo from 23 October 2010 to 17 February 2011

Having managed to extinguish the remaining fires on the LISCO GLORIA in Munkebo, the official investigation began on 25 October 2010. In consultation with the Danish investigating authority (Opklaringsenheden - Danish Maritime Accident Investigation Branch, DMAIB), a team from the BSU went on board together with an investigator from the marine casualty investigating authority of the flag State Lithuania (Lietuvos saugios laivybos administracija − Lithuanian Maritime Safety Administration / Maritime Safety Division) and several experts. In the ensuing period, the investigators carried out four more surveys in the presence of the experts. The wreck of the LISCO GLORIA was officially released by the BSU on 16 November 2010 in consultation with the Lithuanian investigating authority. From 23 to 26 November 2010, the LISCO GLORIA was put into dry dock before being towed to Klaipėda in mid-February 2011.

3.1.6 Transfer to Klaipėda from 18 to 22 February 2011

The transfer of the wreck of the LISCO GLORIA to Klaipėda began on 18 February 2011 with the assistance of the Lübeck-based tug CLAUS. The LISCO GLORIA made fast in Klaipėda on 22 February 2011.

3.2 Damage

3.2.1 Personal injuries

There were a total of 28 injured people, of whom 23 were treated in hospital. Most of the people who were injured had suffered the effects of smoke inhalation. In isolated cases, bruises, light burns and lacerations were also treated. All the casualties were either discharged after outpatient treatment or on the next day. There were no serious injuries.

3.2.2 Damage to the ferry

The LISCO GLORIA was damaged so heavily by the accident (see Fig. 8) that she was declared a constructive total loss. The superstructure as well as cargo decks 4 and 6 were completely gutted by the fire. Beyond that, amongst others, the engine room was damaged by water used for fighting the fire and by smoke.

Figure 8: LISCO GLORIA after the fire

3.2.3 Damage to the cargo

Most of the cargo was completely destroyed by the fire. This concerned both the upper deck (see Fig. 9) and deck 4 (see Fig. 10) below it. The cargo loaded on deck 2, however, was not affected by fire but partly by smoke and water used for cooling the deckhead and preventing fire spread.

In addition, most of the passengers and crew members lost the belongings they took on the voyage as a result of the fire.

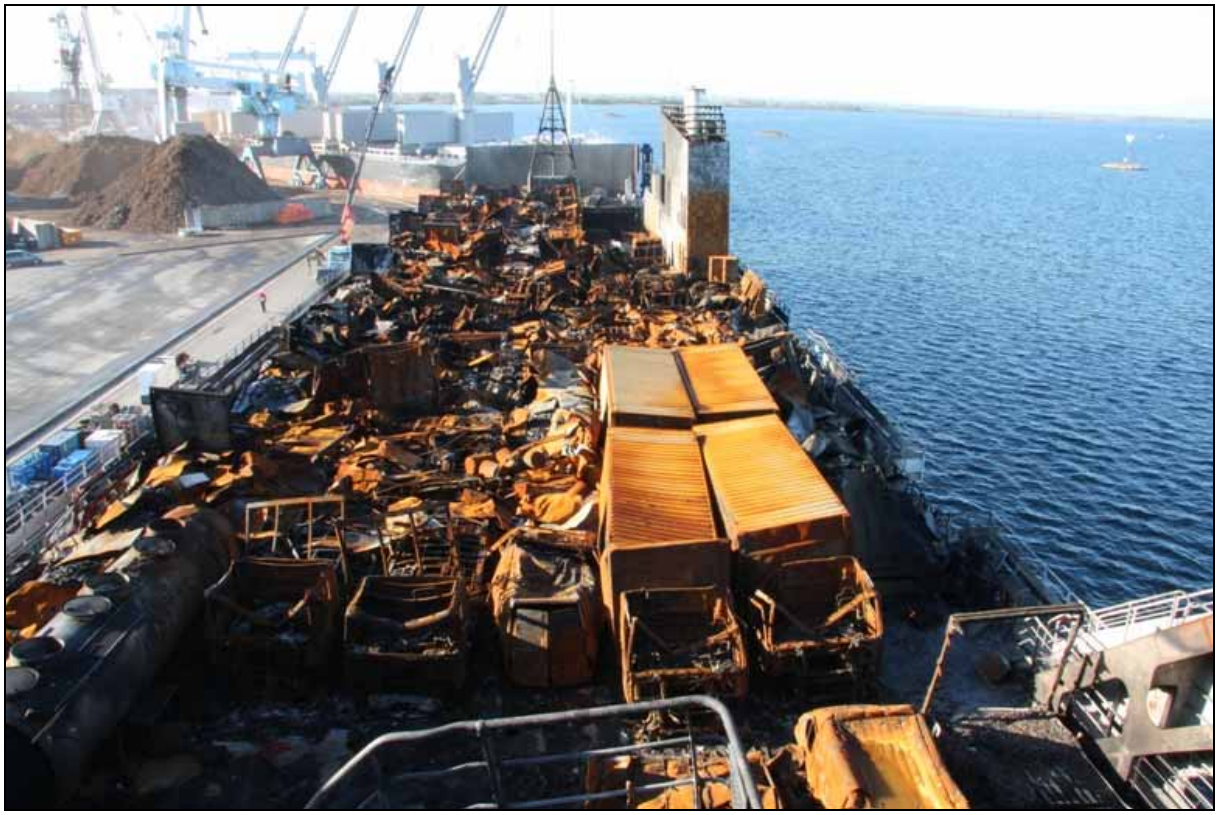


Figure 9: Upper deck after the fire, looking aft

Figure 10: Deck 4 after the fire, looking forward from the stern ramp

3.2.4 Damage to the marine environment

In the days following the fire aboard the LISCO GLORIA, there were isolated cases of sooty lumps of fat (see Fig. 11) being washed ashore on both the German and the Danish Baltic Sea coast.

Figure 11: Contamination on the beach at Lindhöft

The first incidents of contamination were reported on 12 October 2010 in the German area Hasselberg to Falshöft. Further contamination was washed ashore on 14 October 2010 on the Danish island of Als and on 17 October 2010 back in Germany in the areas Surendorf to Lindhöft and Damp to Schuby. In Denmark, the estimated amount of the contamination was 1 to 2 tons.

The Operational Command of the Royal Danish Navy (SOK) monitored the area around the LISCO GLORIA and off Als from the sea with the environmental protection vessel MARIE MILJØ, the patrol vessel NYMFEN and from the air with helicopters. The initial suspicion that the brown lumps washed ashore might be oil could not be confirmed. Four samples from different localities were examined by the German Federal Maritime and Hydrographic Agency (BSH) and found to be of vegetable or animal origin, where animal origin was regarded to be more likely. One sample contained traces of a very light petroleum product, like that used in a solvent or cleaning agent. The BSH also conducted a drift calculation, according to which it was very likely that the lumps of fat had drifted from the scene of the accident involving the LISCO GLORIA. In Denmark, one sample was analysed by the National Environmental Research Institute of Aarhus University. The results of the gas chromatography–mass spectrometry were the same, leading to the conclusion that the sample consisted mostly of fat which included fuel residues (see Fig. 12).

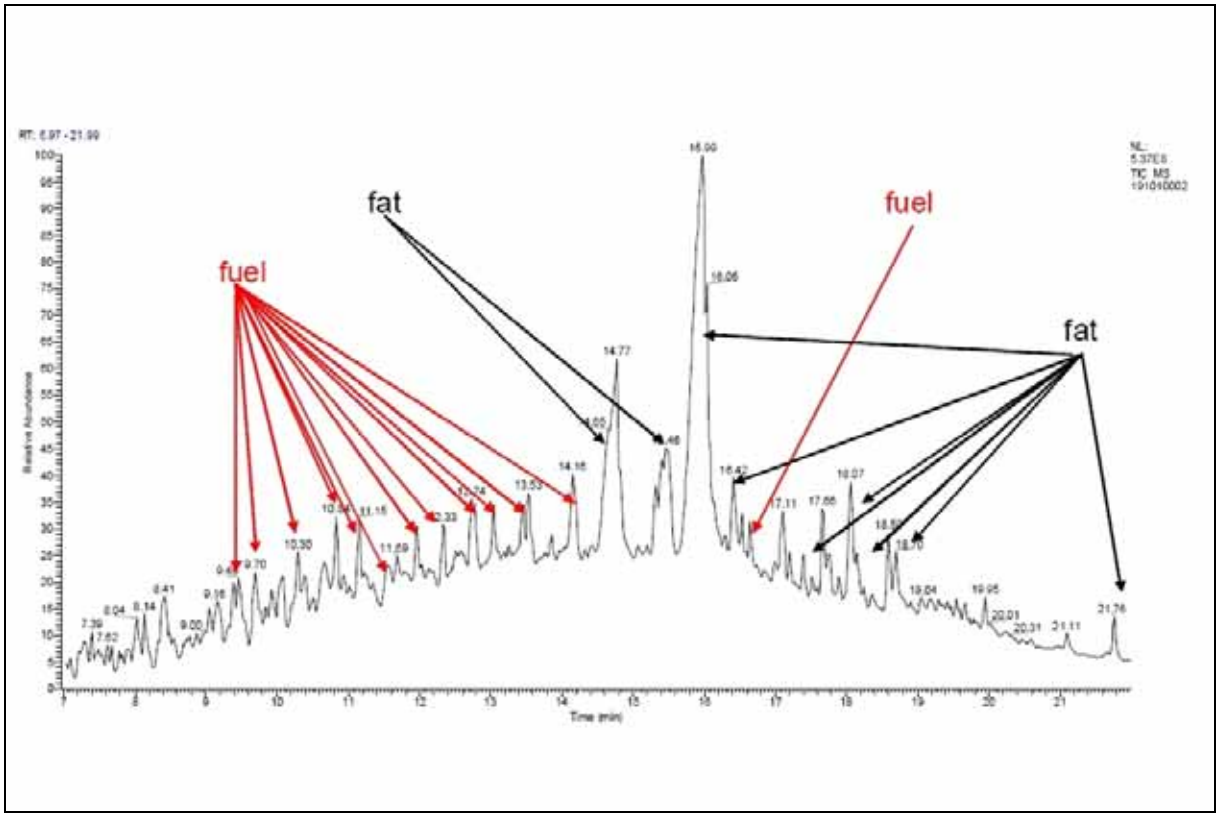


Figure 12: Analysis results of the fat lumps

On the night of the accident, the LISCO GLORIA was loaded with seven transport units with frozen pork fat, 47 units with fresh and frozen meat, one unit with palm oil and one with margarine as well as one with livestock, totalling more than 1,100 t of meat.

3.3 Investigation

3.3.1 Preliminary note

The safety investigation was jointly conducted with the marine casualty investigating authority of the flag state Lithuania. After consultation, the BSU assumed the role of the lead investigating state in accordance with the Casualty Investigation Code of the International Maritime Organisation (IMO)[14] and the German Maritime Safety Investigation Law (SUG)[15].

The BSU investigation team boarded the LISCO GLORIA in Munkebo on 25 October 2010 together with a representative of the Lithuanian investigating authority. The investigators were accompanied by two experts for fire damage and electro-technology from the State Office of Criminal Investigation (LKA) Schleswig-Holstein and two cargo experts from Waterway Police (WSP) Kiel. Four more surveys followed on 1, 3, 15 and 19 November 2010 as well as one survey of the sister vessel, the DANA SIRENA, on 25 January 2011 in Esbjerg, Denmark.

The safety investigation was based on the knowledge gained from these surveys and numerous meetings with the parties involved. Additional sources of information included the secured recordings of the voyage data recorder (VDR), a report by the experts from LKA Schleswig-Holstein and the findings of WSP Kiel.

From the beginning of the investigation, close cooperation prevailed in the spirit of trust with the shipping company and the expert engaged by the insurance company. The witnesses also contributed important knowledge.

3.3.2 The LISCO GLORIA

The LISCO GLORIA was originally designed for use in the Mediterranean by an Italian shipping company. DFDS acquired the ferry in 2002 and initially operated her under Danish flag as the DANA GLORIA on the Harwich/Esbjerg route. Since June 2003, the LISCO GLORIA operated on the Klaipėda/Kiel route under the flag of Lithuania for DFDS Lisco (now DFDS Seaways).

3.3.2.1 Survey of the vessel

During the survey, the LISCO GLORIA was moored with her starboard side to the pier. The sheer magnitude of the fire damage was clearly evident from the shore.

[14] See Part II, Chapter 7 of the 'Code of the International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident' (Casualty Investigation Code) of 16 May 2008, Annex to Resolution MSC.255(84).

[15] See art. 16 of the law to improve safety of shipping by investigating marine casualties and other incidents (German Maritime Safety Investigation Law) of 16 June 2002.

Large areas of shell plate coating were burned on the side (see Fig. 13).

Figure 13: LISCO GLORIA alongside the pier in Munkebo after the fire

In contrast, the bow's coating as well as the forecastle were hardly affected by the fire (see Fig. 14).

Figure 14: Hardly damaged forecastle of the LISCO GLORIA

For the most part, the superstructure had collapsed on the starboard side (see Fig. 15). The accommodation decks 7 and 8 were completely destroyed (see Fig. 16).

Figure 15: Structural damage in the superstructure, view from observation deck to the stern

Figure 16: Destroyed accommodation decks, view from deck 7 to the bow

The steel ceiling between the upper deck and overlying accommodation decks showed signs of a very large fire funnel (see Fig. 17).

Figure 17: Fire funnel opening between deck 6 and the accommodation decks above

The starboard side had sustained far more severe structural damage than the port side. In relation to the longitudinal axis, the fire funnel (origin: frames 210 to 220) was offset slightly to starboard. On the other hand, the outside area on the port side on deck 9 showed only limited damage, was still passable and partially equipped with intact wooden table sets (see Fig. 18).

Figure 18: Outside area on deck 9, view to the bow

The investigation team had access to the bridge via deck 9 (port side). Unlike the rest of the bridge, there was no fire damage to the port wing (see Fig. 19).

Figure 19: Port and starboard bridge wings

The affect of the fire in the wheelhouse increased from port to starboard (see Fig. 20). All navigation systems and other equipment were destroyed.

Figure 20: Wheelhouse, view from port and from starboard

On deck 7, parts of the completely gutted bar area were still passable (see Fig. 21).

Figure 21: Burned-out bar area

The severity of fire damage suffered by the lifeboat station on deck 7 was considerably less to port than to starboard (see Figs. 22 and 23).

Figure 22: Lifeboat station to port and to starboard, view to the bow

Figure 23: Lifeboat station to port and to starboard, view to the stern

The gravity davits were swung out on both sides (see Fig. 24) but, at the time of the survey in Munkebo, the hoisting hooks were no longer in their original position because the ferry was moored at the pier.

Figure 24: Davit system, port side lifeboat station

However, the original position of the hoisting hooks was documented by photos taken when the LISCO GLORIA was still at sea. One can see in the images that the two hoisting hooks were lowered parallel to just above the waterline both on the port and on the starboard side; however, the starboard hoisting hooks are hanging significantly higher due to the considerable heel of the LISCO GLORIA at the time the images were taken (see Figs. 25 and 26).

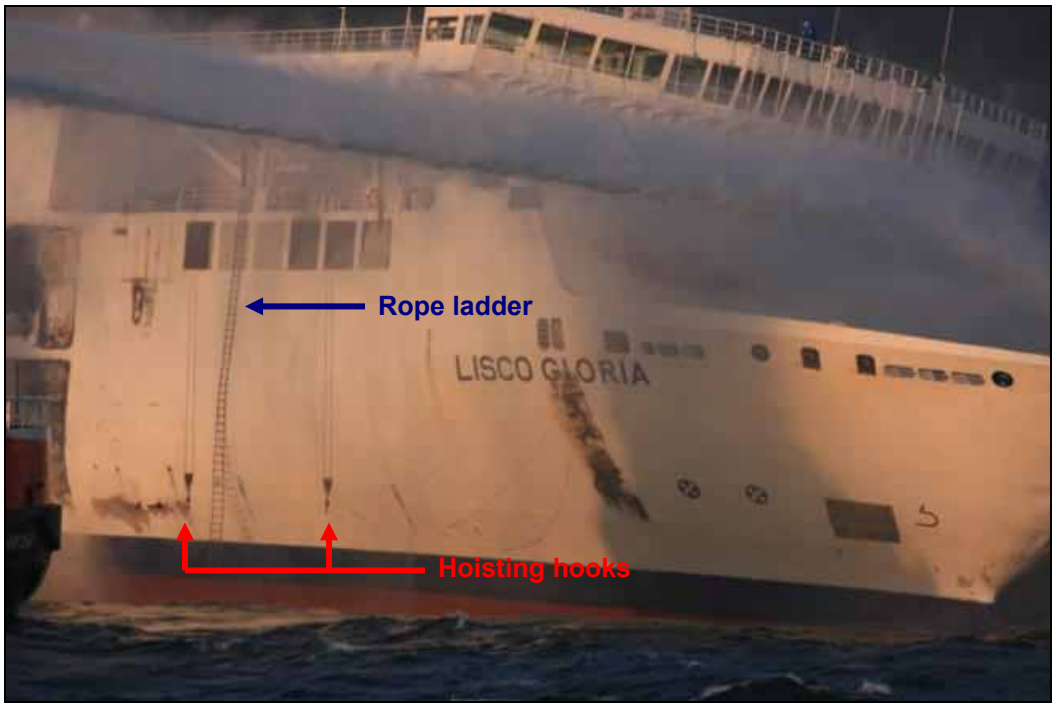


Figure 25: Lowered hoisting hooks on the starboard side, taken on 9 October 2010

Figure 26: Lowered hoisting hooks on the port side, taken on 10 October 2010

The davit system on board the LISCO GLORIA consisted of so-called roller track davits. Here, lowering from the stowage position (deck 9) to the embarkation position (deck 7) as well as the ultimate launching of lifeboats is essentially gravity-based. The speed at which lowering takes place is controlled via a brake integrated in the hoisting winch; in an emergency, this can be operated directly from the boat. In principle, it would also be possible to lower or heave by means of an electric motor. On the night of the accident, both lifeboats were lowered manually. Fall preventer devices (FPD) were not made use of.

Each lifeboat was able to accommodate 150 people. Both boats on the LISCO GLORIA were taken to Klaipėda after the accident and examined there by the Lithuanian investigating authority (see Fig. 27). Here, damage was found on the stern of Boat 1 on the port side (see Fig. 28). A video, which was recorded on board the NEUSTRELITZ, indicates that the damage resulted from the lowering of the boot at LISCO GLORIA. Other damage or deficiencies were not found.

Figure 27: Salvaged lifeboats of the LISCO GLORIA

Figure 28: Damage to the stern of Lifeboat 1, view from outside and from inside

In addition to the two lifeboats, there were also six life rafts, each with a capacity of 25 people, a fast rescue boat (capacity: six people) and a rescue boat (capacity: six

people) on board. The two rescue boats and four of the life rafts were not needed for the evacuation.

The davit system, lifeboats and equipment as well as the hoisting hooks were inspected most recently on 15 April 2010 and did not give rise to objection. The last inspection of the life rafts took place on 30 December 2009. All inspections and maintenance work were performed by a service company certified by the manufacturers of the davit system and the life rafts as well as various classification societies, but not by the manufacturer of the lifeboats.

A scene of destruction (see Figs. 9 and 29) prevailed throughout the upper deck (deck 6). The remains of the trucks, trailers and cars parked there formed a confusing mixture of debris. Only an extremely limited inspection was possible during the first survey.

Figure 29: The remains of cargo in the garage area of the upper deck

Initially it was not possible to determine any clear pattern of fire damage.

A small area amidships on the weather deck had been cleared with the consent of the BSU prior to the arrival of the investigation team to create an access opening to the main deck (deck 4) for the last part of the fire-fighting operation (see Fig. 30).

The necessary clearance work was carefully documented by video and still images.

Figure 30: Area on the upper deck cleared for fire-fighting – before and after

After the survey on 25 October 2010, the upper deck was cleared in stages in consultation with the BSU. Although the severity of the fire damage made it impossible to narrowly define the area of origin of the fire, the overall damage pattern suggested a tendency to the starboard side. Therefore, according to the assessment of the expert from the LKA, the overall pattern of fire damage was consistent with the descriptions of the duty crew member who discovered the fire. Consequently, a decision was taken to clear most of the remains of the cargo from the open part of the upper deck and lanes 1 to 5 in order to then be in a position to gradually move forward to the observed source of the fire. In the process, two vast deformations where the deck had sagged over a large area became apparent under the vehicle debris (see Figs. 31 and 32). In relation to the longitudinal axis, these two deformations were slightly offset to starboard.

Figure 31: Partly cleared deck 6, view of lanes 5 to 8 in the forward area

Figure 32: Cleared upper deck (amidships), view to the stern

After the partial clearance, the investigation team worked its way forward through the remaining debris to lane 8 with the support of excavators and shipyard workers. Debris which could be moved by hand was assessed and if necessary documented photographically before being removed. Larger items of debris, especially chassis parts, could only be removed using an excavator after the chain retainers had been removed. This time-consuming procedure took several days before the front part of the upper deck was, with the exception of the observed source of the fire, finally cleared on 3 November 2010 (see Fig. 33).

Figure 33: Partly cleared deck 6 with debris at the observed source of the fire

The heavily damaged remains of a truck with a refrigerated trailer were found in the first parking position on lane 8 (see Fig. 34).

Figure 34: Remains of the truck and refrigerated trailer on lane 8

The cargo consisted of offal (chicken necks). The registration number of the trailer was still legible and corresponded with the truck/trailer identified by the Kiel Criminal Investigation Department on 9 October 2010 on which the outbreak of fire was observed. As opposed to other towing vehicles, the cab of the truck had completely collapsed (see Fig. 35). Metal parts of the body had transformed into a condition which appeared brittle owing to the tremendous heat effect. They could be 'crumbled' simply by touch.

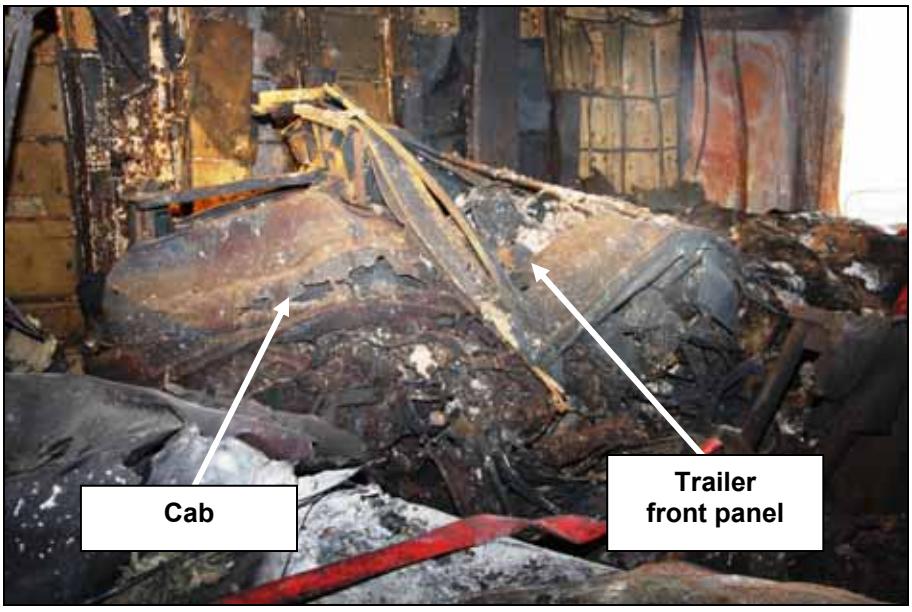


Figure 35: Collapsed truck on lane 8

The front was folded forward due to the structural collapse of the refrigerated trailer.

The front panel of the trailer on which the remains of the refrigeration unit were still present was held upright using an excavator (see Fig. 36).

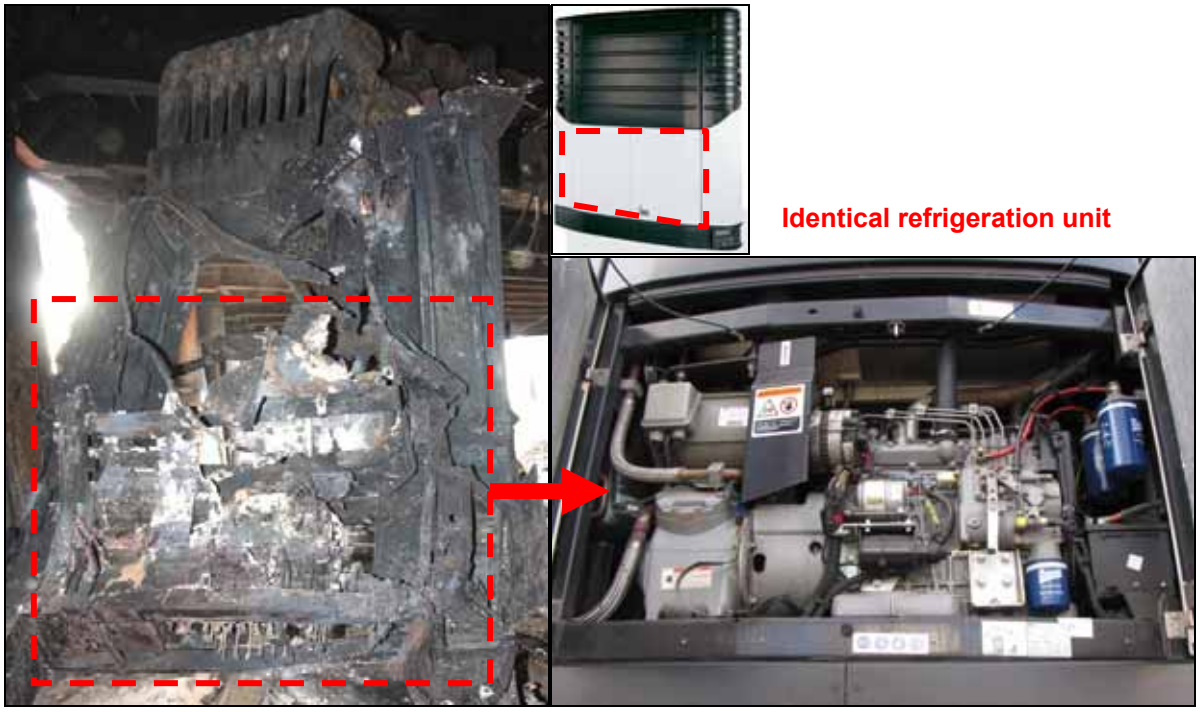


Figure 36: Remains of the refrigeration unit on the first refrigerated trailer on lane 8

Heavily thermally stressed parts of the fan (see Fig. 37) and other components were found.

Figure 37: Remains of the refrigeration unit fan

However, the condition of the parts was so bad that a more detailed investigation of these items was not possible. The remains of the electrical system of the towing vehicle in question, the electronic control of the refrigeration unit, and the internal wiring of the refrigeration unit had been so badly damaged that a conclusive investigation was no longer possible with respect to an electro-technically induced fire.

Three fragments of the electrical contacts of a connector socket and plug could be found below the refrigeration unit in the fire debris (see Fig. 38). Since, factory-made, the appliance inlet of the refrigeration unit is installed in this area, the remains were kept as evidence for a comparative investigation.

Figure 38: Fragments of the electrical contacts of a connector socket and plug

To provide the trailers parked on the upper and the main deck with shipboard electrical power, switchable three-phase current power outlets with a rated current of 32A were mounted next to the frames. Using appropriate extension cables, a connection could be made between consumers and the vessel's electrical systems. On deck 6, several preserved switchable three-phase current power outlets were found in the area of frames 176 to 188 (starboard), which had only been slightly thermally stressed (see Fig. 39).

Figure 39: Slightly thermally stressed socket with an inserted plug (deck 6, lane 8)

The plugs inserted there with extension cables were traced during the clearing work. In the process, it was found that after some distance only fragments of the cables remained; it was therefore no longer possible to identify which cable was connected to any particular refrigeration unit mounted on a refrigerated trailer.

According to the vessel's electrical plans, there were a total of eight three-phase current power outlets installed up to the end of lane 8 on the starboard side of deck 6 (frames 159 to 201). The two sockets that should be mounted at frame 201 were not present; therefore, these were searched for in the fire debris. It was possible to find fragmentary parts of two switchable three-phase current power outlets (see Fig. 40) in the area of frame 200.

Figure 40: Remains of three-phase current power outlets at frame 200 (starboard)

In addition, the electrical contact materials of two plugs and sockets were also found in this area (see Fig. 41).

Figure 41: Remains of the male plugs and female contacts from the electrical socket at frame 200 (starboard)[16]

[16] They were found remaining coupled together showing that a plug was inserted into the socket before the fire.

Furthermore, amongst other things, the remains of cables found under the towing vehicle on lane 8 were kept as evidence. However, it was considered that a more extensive investigation would not be worthwhile due to the high degree of damage.

The electrical supply for the switchable three-phase current power outlets was provided via the engine control room (see Fig. 42). The switch cabinets located there which served these circuits were visually inspected.

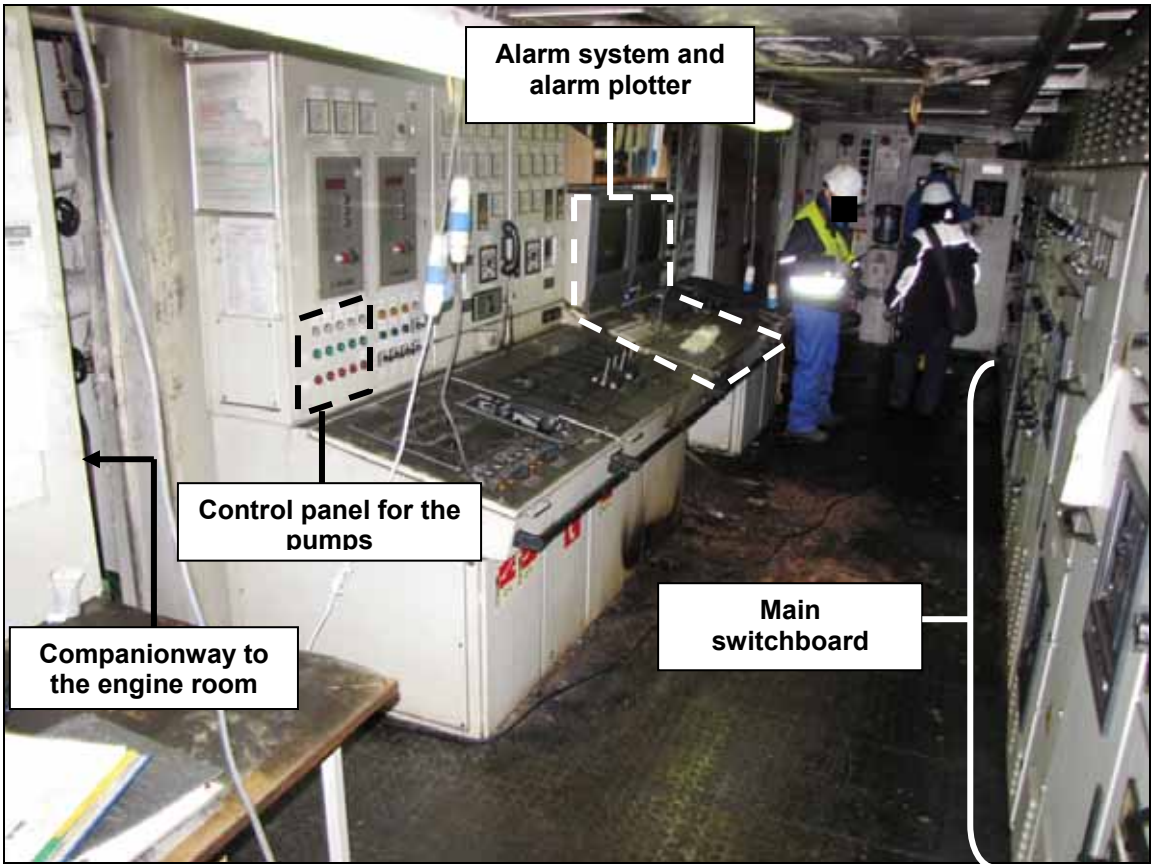


Figure 42: The engine control room of the LISCO GLORIA

It was found later that, meanwhile, the switch settings on the main switchboard had been changed. On 11 October 2010, when the fire was under control, the salvage company was able to take a member of the crew into the engine room to assist them. During this inspection the crew member took photographs of the main switchboard. All the switches are in the 'Off' position on these photos; however, during the first inspection by the German and Lithuanian investigation team on 25 October 2010, the switches were, almost without exception, set to 'On' (see the right of the main switchboard on Fig. 43, for example).

Figure 43: Part of the main switchboard on 11 October 2010 (left) and on 25 October 2010 (right)

The switch settings found on the main switchboard were therefore no longer conclusive for the investigation. It was not possible to clarify who changed the positions or when this happened. Since it was neither possible to restore the shipboard power supply at sea nor at the pier in Munkebo, the investigators could not see any need to operate any switches on the main switchboard.

In the engine control room behind the main switchboard is a second corridor in which several mostly locked switch cabinets are situated. Two of these contain circuit breakers serving the switchable three-phase current power outlets (see Fig. 44). The key for these cabinets was not readily available; therefore, the investigation team used its own tools. Due to the limited accessibility, it could be assumed that the switching or tripping condition corresponded to the original incident-related situation.

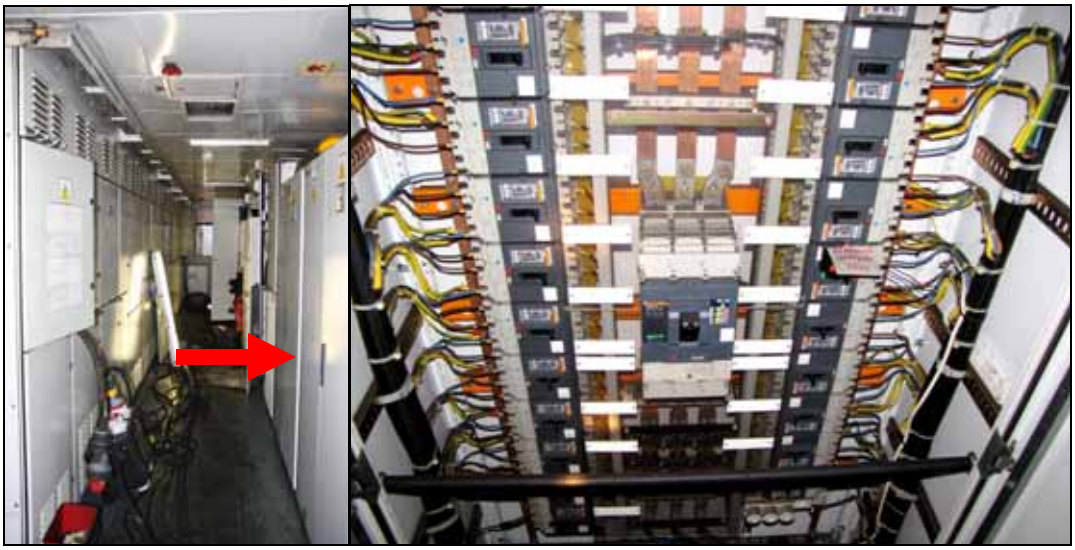


Figure 44: Switch cabinet with circuit breakers

Based on the circuit diagrams, these circuit breakers were upstream of the three-phase current power outlets on deck 4 and deck 6. The switch settings found were documented in detail and evaluated by the expert for electrical engineering (see sub-para. 3.3.2.7).

It was not possible for the investigation team to enter the main deck (deck 4) during the first survey because of thick smoke. The deck was cleared after the last pockets of fire had been extinguished. Documentation proved to be difficult because the air was extremely dusty and in the forward part of the deck, in particular, only dim lighting conditions prevailed. Almost all the clearing work was completed on 9 November 2010 and temporary lighting was installed (see Fig. 45). It was found that the area on deck 4, beneath the parking position of the truck/trailer on which the fire outbreak was observed on deck 6, was empty (frames 196 to 206). The first truck with refrigerated trailer on the far right parking lane on deck 4 extended to frame 196.

Figure 45: Partially cleared deck 4, view to the bow

The scuppers on decks 4 and 6 were partly clogged (see Fig. 46) with debris from the fire (cargo, metal parts, etc.).

Figure 46: Scupper on deck 4

3.3.2.2 Manning

32 Lithuanian crew members were on board on the day of the accident. A crew with at least 14 members was obligatory according to the minimum safe manning certificate. The specified working language was Lithuanian. Communication between the bridge and engine control room, for example, was also conducted in Russian to some extent.

A three-watch system was operated on board. The last change of watch on the bridge and in the engine control room took place at 2300. A fire patrol was carried out every four hours. In addition, inspections were made to check the temperatures of refrigerated cargo.

The LISCO GLORIA was managed by an experienced master, who at the time of the accident had been in the service of the shipping company DFDS for 24 years, including 14 years as a master.

3.3.2.3 Passengers

The Lithuanian Maritime Safety Administration issued a passenger ship safety certificate for the LISCO GLORIA most recently on 15 July 2010, according to which the ferry was licensed to transport 302 passengers.

To embark, passengers are required to present their identification documents and, where applicable, vehicle papers when checking in at Kiel Ostuferhafen in order to obtain a boarding pass. The boarding pass has a section marked with a bar code; this is retained by the ship security officer if the passengers embark by shuttle or with their vehicle. Generation of the final passenger and driver list is based on the scanned bar codes. Here, there was a discrepancy on the evening of the accident as the list of people on board generated by the passenger office of the seaport agency contained one passenger less than the reservation list from the terminal. Two passengers had actually checked in together ashore; however, one of them spontaneously decided not to commence the voyage while still in the waiting area for the shuttle. This discrepancy in the number of passengers led to communication between the passenger terminal and vessel. Nevertheless, after unsuccessfully paging the passenger, this person was left on the passenger list as she and her companion were known due to frequent trips with the LISCO GLORIA on the Kiel/Klaipėda route and it was recalled that they had checked in together at the terminal. Hence, instead of the 115 people recorded on the passenger list (not including truck drivers), there were in fact only 114 on board. This discrepancy was not noticed until the final count of the evacuees at the naval base in Kiel. Following that, a missing person's case was initiated as a precaution by the police. However, this was discontinued a short time later after the missing person was found.

Passengers who had reserved cabins on the LISCO GLORIA received their cabin cards at the reception on deck 7, where the restaurant and bar area was also located (see Fig. 47). The bar was also the designated assembly point for emergencies. Rather than cabins, some of the passengers had reserved so-called Pullman seats in the public area on deck 7.

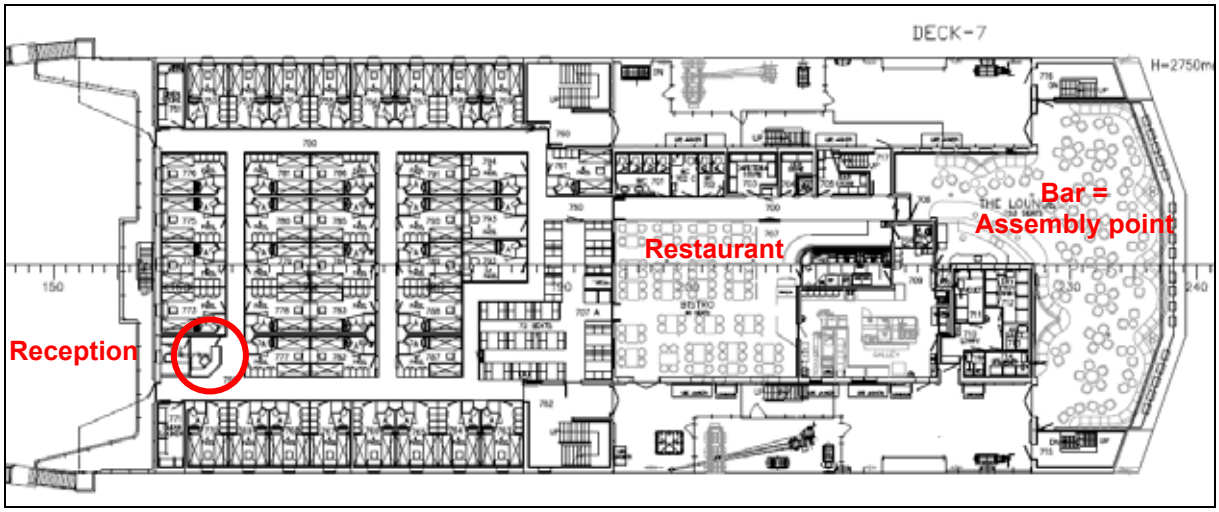


Figure 47: Accommodation and public areas on deck 7

Three TVs were mounted on the walls in the bar. A mimed safety video approved by the Danish Maritime Safety Administration was shown repeatedly on one of these TVs (see Fig. 48). Additional safety information was published on posters (see Fig. 49). A separate safety briefing did not take place.

Figure 48: Screenshots of the safety video shown on board

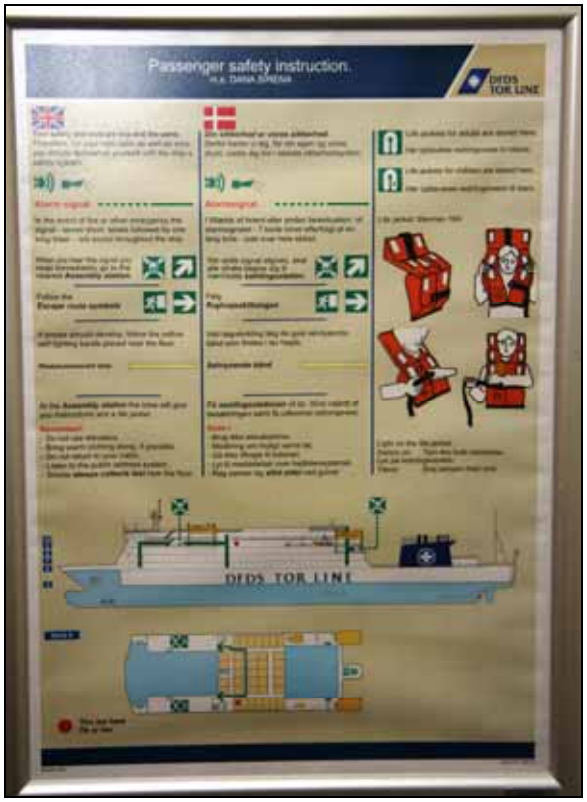


Figure 49: Safety poster placed next to the reception on the sister vessel, DANA SIRENA

The escape routes to the assembly area were marked on each passenger deck (decks 7 and 8) by pictograms (see Figs. 50 and 51).

Figure 50: Escape route pictogram in the cabin area on the DANA SIRENA

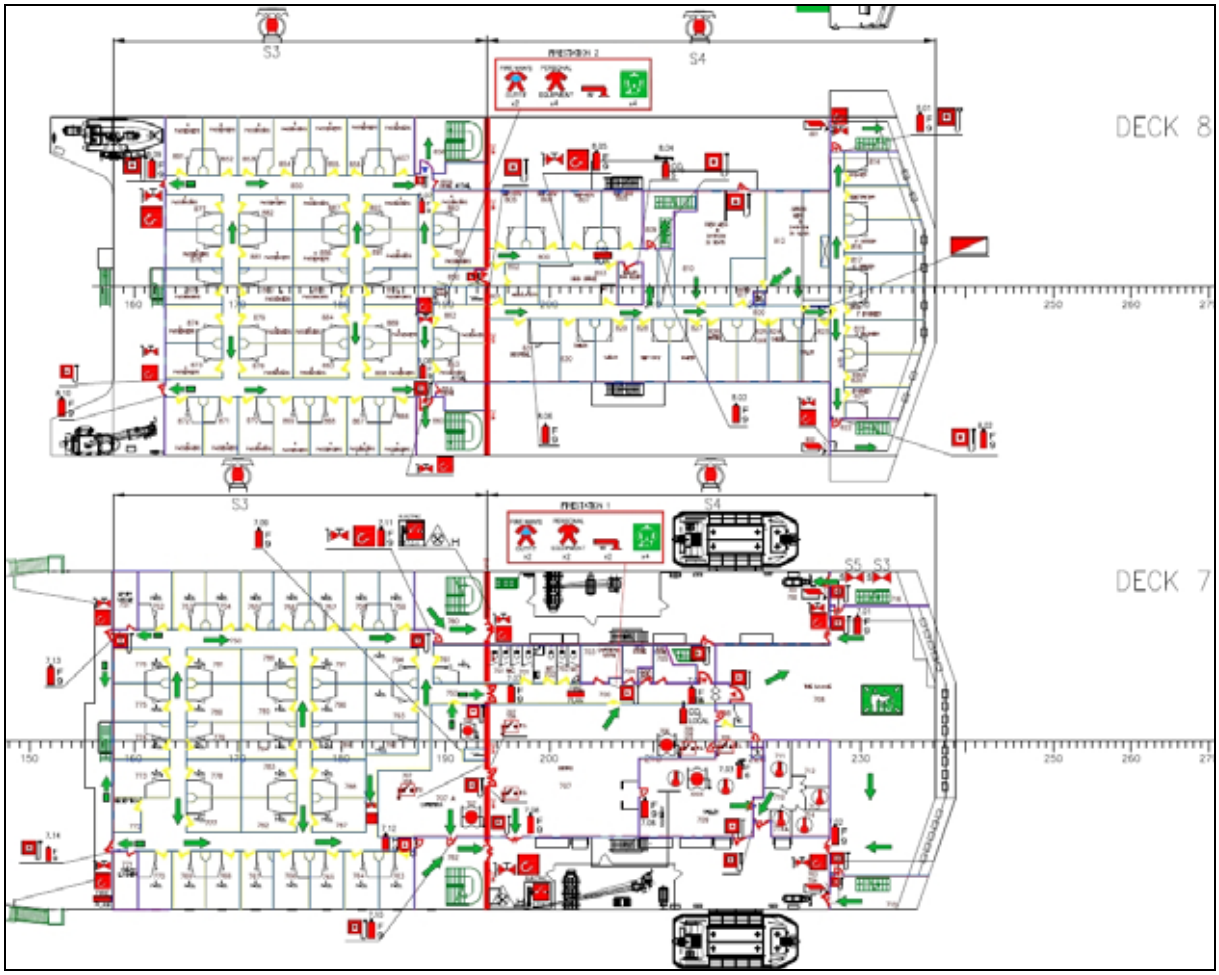


Figure 51: Escape routes and life-saving equipment in the accommodation area of the LISCO GLORIA

On the evening of the accident, the bar of the LISCO GLORIA was busy owing to a football match being broadcast on TV. Quite a few passengers remained in the bar area after the match finished at about 2300 until the evacuation was initiated.

The ferry DEUTSCHLAND took the evacuees to the naval base in Kiel, where they received, amongst others, emergency medical treatment and psychosocial care. The police conducted witness interviews locally with the support of interpreters. Following that, most of the passengers were taken to a hotel rented by the shipping company, from where they continued their journey later by plane or another ferry.

3.3.2.4 Cargo

Cargo and dangerous goods experts from WSP Kiel investigated on behalf of the BSU and prepared a report on the transportation of cargo on board the LISCO GLORIA.

The LISCO GLORIA was loaded and unloaded via a moving stern ramp (see Fig. 52).

Figure 52: Stern ramp in closed and open state

The LISCO GLORIA was fully loaded on the voyage to Klaipėda. Vehicles were stowed on decks 2, 4 and 6. Decks 2 and 4 are enclosed cargo holds. Deck 6, the upper deck, is an open deck (weather deck). Viewed from the stern of the ferry, about 100 m of the weather deck is not covered; the superstructure with lounges and bridge was located above the remaining forward part (‘garage area’, frame 155 to 237, approx. 60 m).

In the garage area of deck 6, it was possible to supply vehicles, trailers and tanks that had to be cooled or heated during transportation via the shipboard electrical system. The power units of cargo transport units that were not supplied via the shipboard electrical system were diesel-electrically operated during the passage.

During the loading of the ferry, vehicles waiting to be loaded were called on the basis of issued numbers and stowed on board the LISCO GLORIA according to the instructions of the respective cargo officer. In line with usual practice, stowage plans were prepared on board the ferry, but not passed on to the stevedoring company or relevant seaport agency. However, as specified in the dangerous goods regulations, the stowage spaces for dangerous goods units were submitted to the competent authorities. The vehicles on board the vessel were secured predominantly with chains for the voyage by lashing teams. In the case of vehicles that required an electrical connection, the connection to the shipboard electrical system was made by crew members using the vessel's own cables. A list containing specified temperatures was kept on board for shipments for which temperatures had to be monitored (mainly refrigerated trailers with meat products). These temperatures were regularly checked by reading the values displayed on the refrigeration units. The outbreak of fire was observed on one of these units (see identical unit in Fig. 53) in the course of the last check on 8 October 2010.

Figure 53: Refrigeration unit mounted between the cab and trailer

According to the cargo capacity plan, the individual decks had the following capacities:

	Deck 2	Deck 4	Ramp from Deck 4 to Deck 6	Deck 6
Number of parking lanes	6	7	2	8
Max. trailer capacity	19	62	6	74
Max. lane metres	350 m	920 m	85 m	1,015 m

Table 2: Cargo capacity on decks 2, 4 and 6

Accordingly, the LISCO GLORIA was capable of loading a maximum of 161 trailers (2,370 lane metres).

Five different dangerous goods shipments were stowed on the upper deck; these contained materials of the following IMDG[17] dangerous goods classes:

- Class 2.1 – Flammable gases: 1,905 kg (gross) aerosol dispensers/spray cans in limited quantities
- Class 3 – Flammable liquids: 3,506 kg (gross), mostly paint
- Class 5.2 – Organic peroxides: 14 kg (gross) in limited quantities
- Class 8 – Corrosive substances: 52.5 kg (gross)
- Class 9 – Miscellaneous dangerous substances and articles: 20,825 kg (gross) environmentally hazardous substances, mainly chemical auxiliary agents for curing

In particular, the dangerous goods of the classes 2.1, 3 and 5.2 are to be regarded as oxidizing even though they were packed in limited quantities.

[17] International Maritime Dangerous Goods (IMDG) Code

The stowage positions of the dangerous goods being transported were listed properly in the dangerous goods manifest. Based on the remains of the cargo (see Fig. 54), during the survey of the LISCO GLORIA it was possible to confirm that the actual stowage position complied with that specified in the manifest for four of the five dangerous goods shipments. The fifth cargo transport unit was too badly damaged to permit identification. Altogether, it became clear during the survey that to a large extent the dangerous goods had thermally reacted due to the fire.

Figure 54: Cargo remains (spray cans) from a dangerous goods shipment

In line with usual practise, the stowage positions of the other cargo transport units on the upper deck were not noted; however, for the most part it was possible to reconstruct this with the help of the crew and shipping company as well as image material (see Fig. 55; **blue** marking = truck/trailer, **light blue** marking = diesel operated refrigerated transport, **turquoise** marking = refrigerated transport connected to the shipboard electrical system, **red** marking = dangerous goods shipment, **orange** marking = tank container, **green** marking = cars).

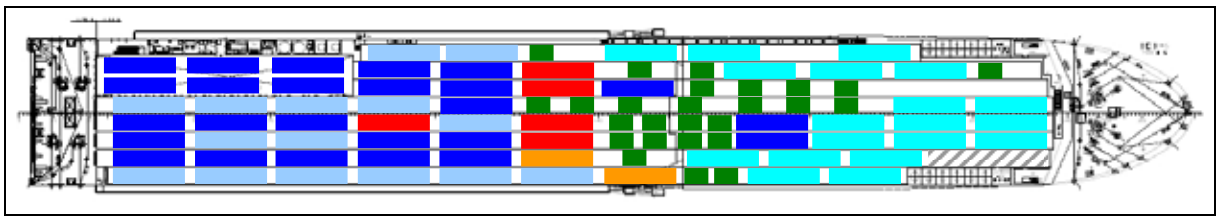


Figure 55: Reconstructed stowage plan for the upper deck

According to the manifest, there were a total of 47 shipments containing fresh and frozen meat products on the LISCO GLORIA with a total weight of about 1,120 t and 10 refrigerated shipments with other goods. 37 of the 57 refrigerated trailers were registered for operation via the shipboard electrical system. Those cargo transport units that were operated independently by diesel were stowed on the open upper

deck. The first trailer in lane 8 of the upper deck on which the fire outbreak was observed was loaded with frozen chicken necks.

The cargo decks of the LISCO GLORIA provided six parking lanes on deck 2, seven lanes on deck 4 and eight lanes on deck 6 (see Fig. 56).

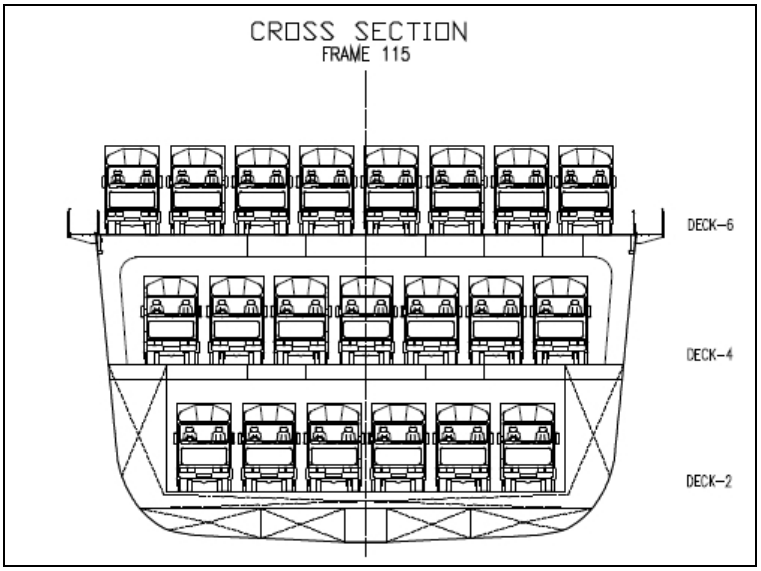


Figure 56: Arrangement of the parking lanes on decks 2, 4 and 6

Depending on the vehicle widths, the distances between individual cargo transport units were between almost 30 cm (at the maximum admissible width of 2.60 m for refrigerated transporters) and almost 38 cm (average width of a cargo transport unit of 2.50 m). Accordingly, the accessibility of individual cargo transport units was – as is usual on ro-pax ferries – restricted (see Fig. 3).

3.3.2.5 Fire safety

3.3.2.5.1 Fire insulation - A-60

Vertical main fire zones and horizontal fire zones were included in the LISCO GLORIA's design. For the most part – in particular, also in the area in which the fire started – the individual decks had class A-60 partitions (see red lines in Fig. 57). The vessel's structure was subject to the following SOLAS requirements[18], in particular:

- Divisions constructed of steel or other equivalent material;
- suitably stiffened;
- insulated with approved non combustible materials such that the average temperature of the unexposed side will not rise more than 140 ºC above the original temperature, nor will the temperature, at any one point, including any joint, rise more than 180 ºC above the original temperature, within 60 minutes;
- capable of preventing the passage of smoke and flame to the end of the one-hour standard fire test.

[18] See SOLAS Chapter II-2, Part A, Regulation 3.2.

Aluminium alloy components were used on the superstructure of the LISCO GLORIA. These met the special requirements for integrity under SOLAS[19] and were thus to be regarded as equivalent material in terms of the aforementioned fire safety criteria.

Figure 57: Fire partitioning on the LISCO GLORIA

The A-60 insulation ran between decks 2 and 4 over almost the entire length of the vessel (frames 60 to 239), between the main deck 4 and the garage area of the upper deck (frames 158 to 239), in the garage area of the upper deck to the cabins and lounges on deck 7, and between the accommodation decks 7 and 8.

During the survey on the LISCO GLORIA, the investigation team obtained an impression of the actual implementation of the fire insulation and its condition after the fire. There was no fire damage on deck 2 and the insulation was intact (see Fig. 58).

Figure 58: A-60 insulation on deck 2

[19] See SOLAS Chapter II-2, Part C, Regulation 11.3.

The insulation was largely destroyed on decks 4 and 6, where fires had been raging for weeks (see Figs. 59 and 60). The investigation team therefore went on board the LISCO GLORIA's sister vessel, the DANA SIRENA, to gain an impression of the comparable insulation (see Fig. 61) that existed there. The properties of the insulation found there were investigated in more detail during the expert analysis by LKA Kiel (see sub-para. 3.3.2.8 of the report).

Figure 59: Remains of the A-60 insulation on deck 4

Figure 60: Remains of the A-60 insulation in the garage area on deck 6

Figure 61: A-60 insulation on deck 6 of the sister vessel, DANA SIRENA

During the inspection of deck 4 of the LISCO GLORIA, it was found that the additionally reinforced insulation in the areas below the lifeboat launching appliances

was still intact (see Fig. 62). Consequently, the external paint on the side of the LISCO GLORIA is still preserved in these areas.

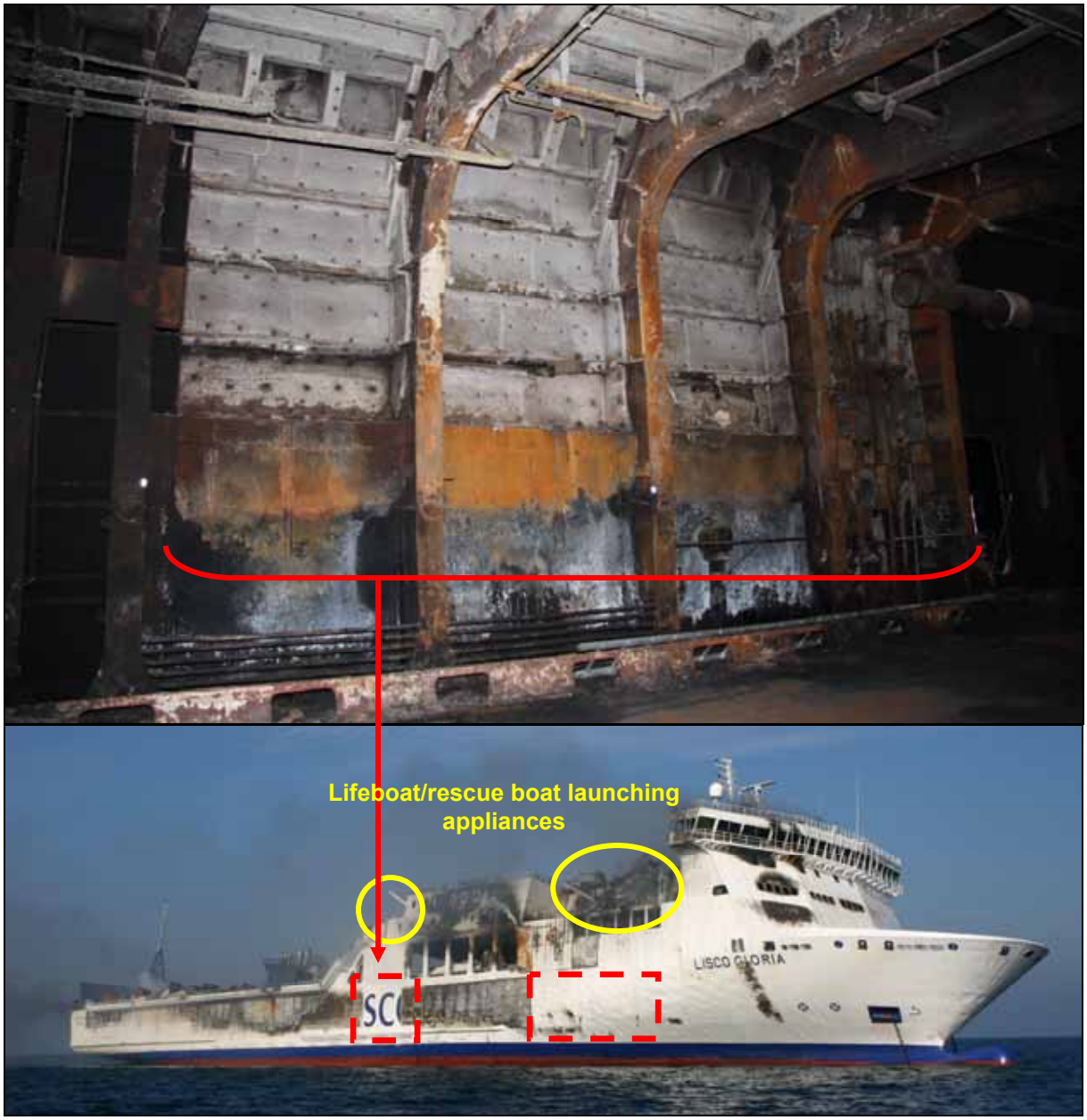


Figure 62: Reinforced insulation in the area of the life-saving equipment

In the garage area of the upper deck, where the fire broke out, openings in the ceiling were examined separately during the surveys by the investigation team with respect to the A-60 standard. These concerned a drop tube for shipboard waste and a hatch opening.

The area intended in the design for waste collection on the upper deck is on lane 7 (starboard side) at frames 218 to 230 (see Fig. 63).

Figure 63: Waste containers and chute on deck 6 after the clearing work

The upper part of the waste chute level with frame 222 lead to a housing outside of the galley on deck 7, which was found completely intact and largely unaffected by fire (see Fig. 64).

Figure 64: Area outside of the galley, starboard side of deck 7

The waste opening was said to be properly closed and locked on the evening of the accident. In the course of the investigation, there was no evidence to suggest that the A-60 insulation was impaired in this area. The type and design of the waste containers on the upper deck complied with SOLAS.

A hatch is located directly above the first parking position on lane 8 of the upper deck, where the outbreak of fire was observed (see Figs. 65, 66 and 67).

Figure 65: Hatch opening on deck 7 – before the accident

Figure 66: Hatch opening on deck 7 – after the accident

Figure 67: Hatch opening above the first parking position on lane 8 (upper deck)

No remains of A-60 insulation were found on the hatch during the surveys. The hatch was closed tightly.

Deck 7 was significantly discoloured and deformed, in particular in the area of the hatch. According to witness statements given, this area was cooled by means of fire hoses on the night of the accident to permit entry to the deck.

3.3.2.5.2 Fire alarm system

The LISCO GLORIA was equipped with a fire alarm and fire indication system, which could be operated from the bridge and the engine control room. The garage area of the upper deck, where the fire broke out, was equipped with smoke detectors. In the event of a smoke alarm being triggered, the affected section was displayed on the bridge and in the engine control room on the corresponding control panel (see identical control panel of the sister vessel, Fig. 68).

Figure 68: Control panel of the identical fire alarm and detection system on the sister vessel, DANA SIRENA

Alarms were not only displayed on the control panel and issued with an audible signal, but could also be identified via the bridge computer (see Figs. 69 and 70). The mode of operation was simulated on board the sister vessel, DANA SIRENA, by the investigation team. According to that, if one single smoke alarm was triggered, the entire area would be marked. Therefore, when the smoke alarm was triggered on the LISCO GLORIA it would be evident to the officer on watch on the bridge that the garage area of the upper deck was affected, not a particular detector head. For each particular case, further localisation was possible via the CCTV system, which was also installed on board. The deck area for which the alarm had sounded could thus be called up via an operator screen. The recordings of the CCTV system were not available for the investigation due to destruction by the fire.

Figure 69: Smoke detector status indicator on the bridge PC of the DANA SIRENA

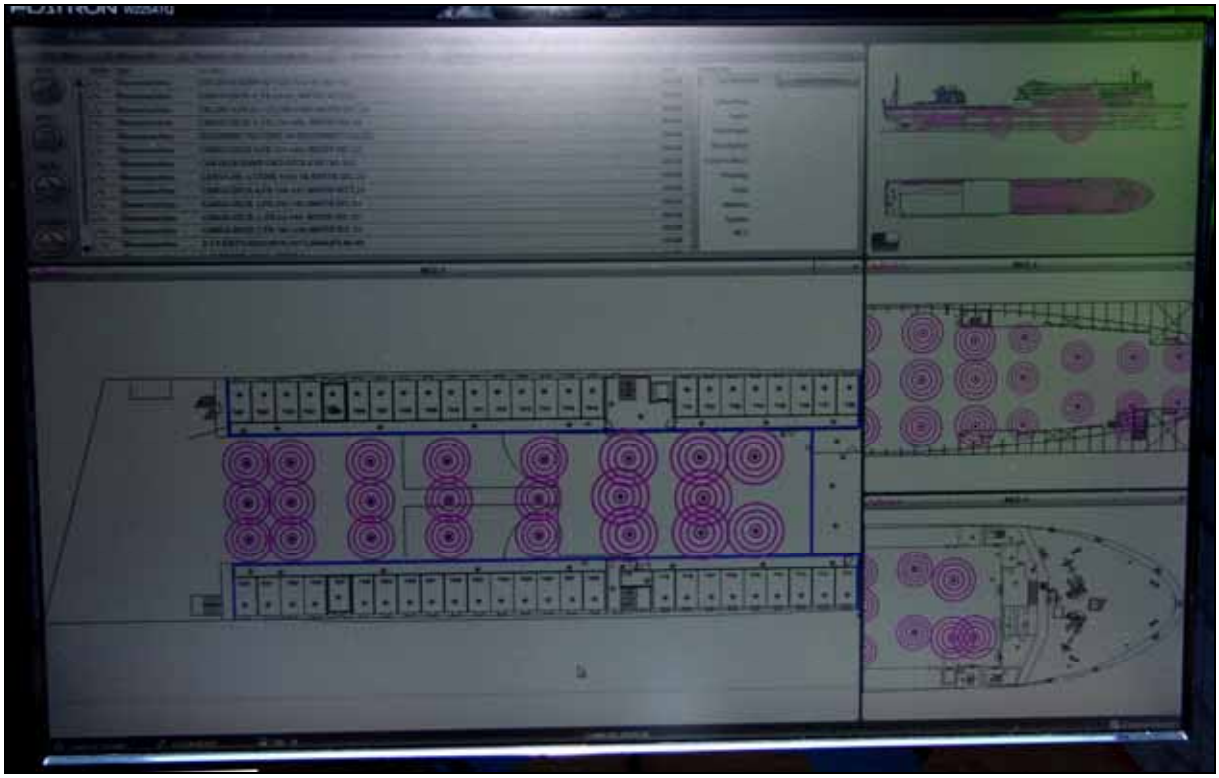


Figure 70: Smoke detector status indicator for triggered alarm on the DANA SIRENA

3.3.2.5.3 Ventilation system

The ventilation system could be controlled from the bridge of the LISCO GLORIA. Several control panels were available for this purpose. Fire dampers and fans could be opened and closed area by area (see Fig. 71).

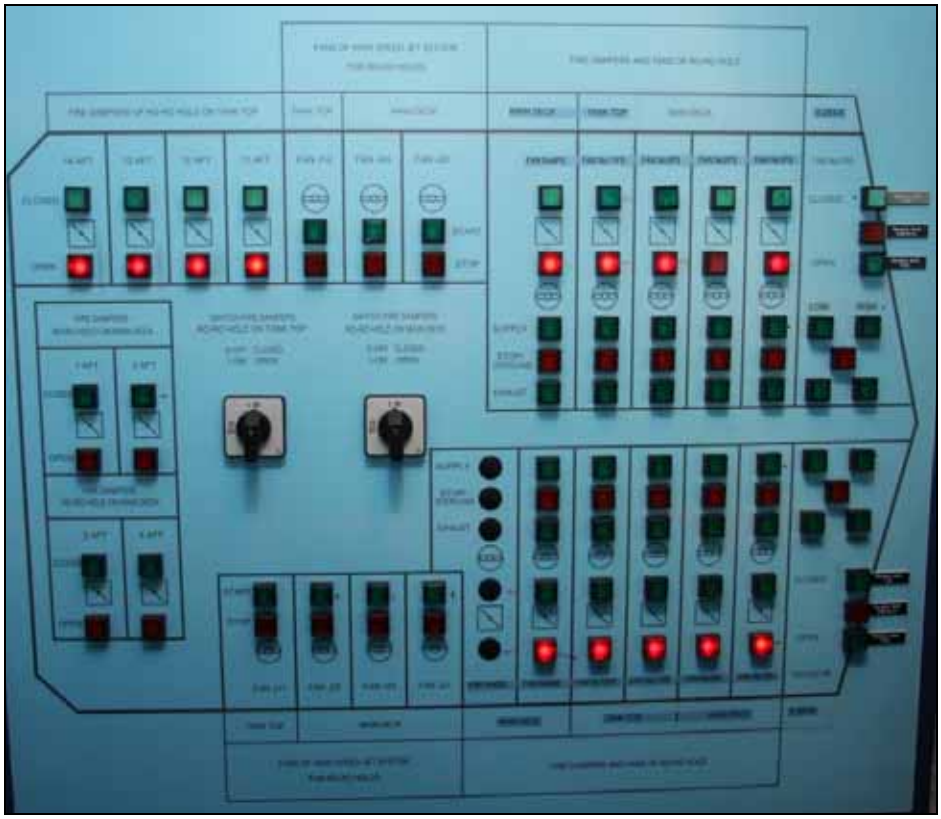


Figure 71: Comparable control panel for fire dampers and fans on the DANA SIRENA

In addition, a separate emergency shut-down for the ventilation system was situated above the fire alarm control panel (see Fig. 72).

Figure 72: Comparable emergency shut-down for the ventilation system on the DANA SIRENA

From the upper deck, five ventilation ducts ran to deck 2 on the port side and six on the starboard side (see Figs. 73 and 74).

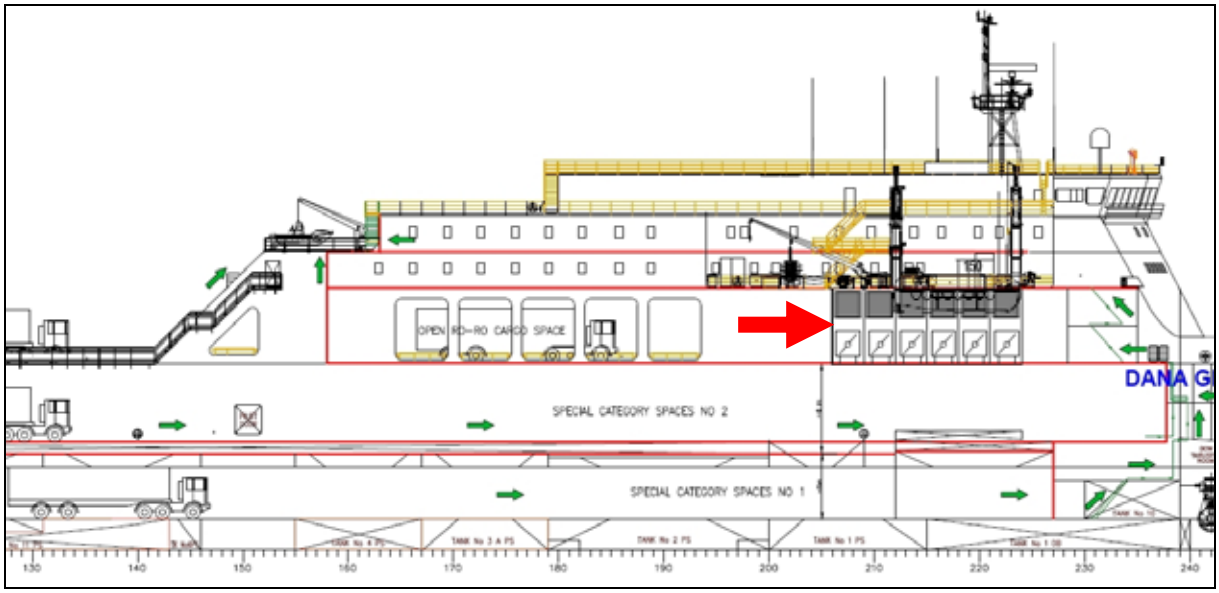


Figure 73: Arrangement of the ventilation ducts on the starboard side

Figure 74: Entrances to the ventilation ducts on deck 6 – port side

Two of the six entrances to the ventilation ducts on the starboard side of the upper deck were deformed due to heat, causing openings to be formed (see Figure 75). Some of the bolts for the closing of the manholes were fastened only by a few nuts, to make it easier for the crew to open the access covers and carry out their routine inspections.

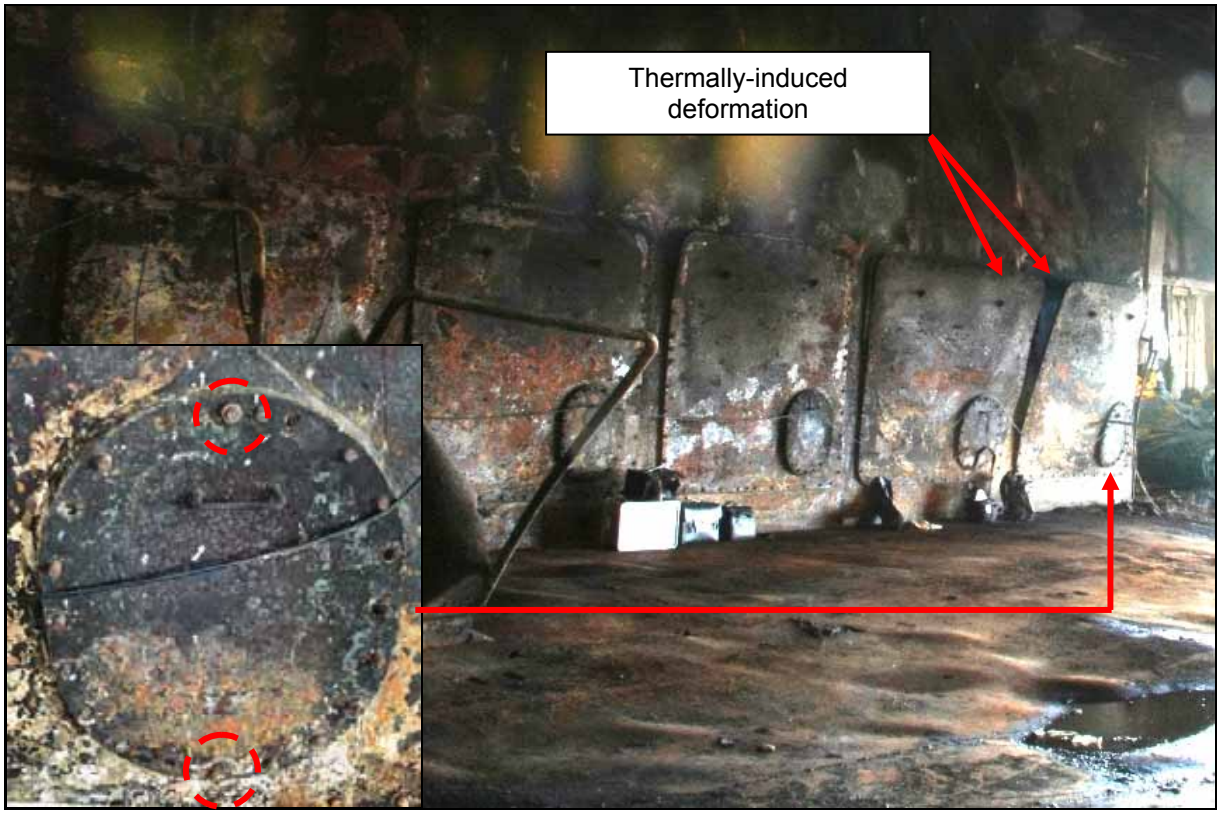


Figure 75: Manholes to the ventilation ducts on deck 6 – starboard side

The ventilation ducts were covered by perforated mesh on deck 4 (see Fig. 76). An access for maintenance and inspection purposes was not provided for from this deck. The investigation team removed a perforated mesh to gain access to the ducts. It was found that the ventilation flaps were tightly closed, meaning no light penetrated from above (deck 6).

Figure 76: Ventilation ducts on deck 4 – starboard side

3.3.2.5.4 Fire doors

All entrances from the garage area of the upper deck to the three stairwells on the port and starboard sides as well as amidships were secured by self-closing fire doors (see Fig. 77). The same applied to the two entrances to the store rooms to port and starboard.

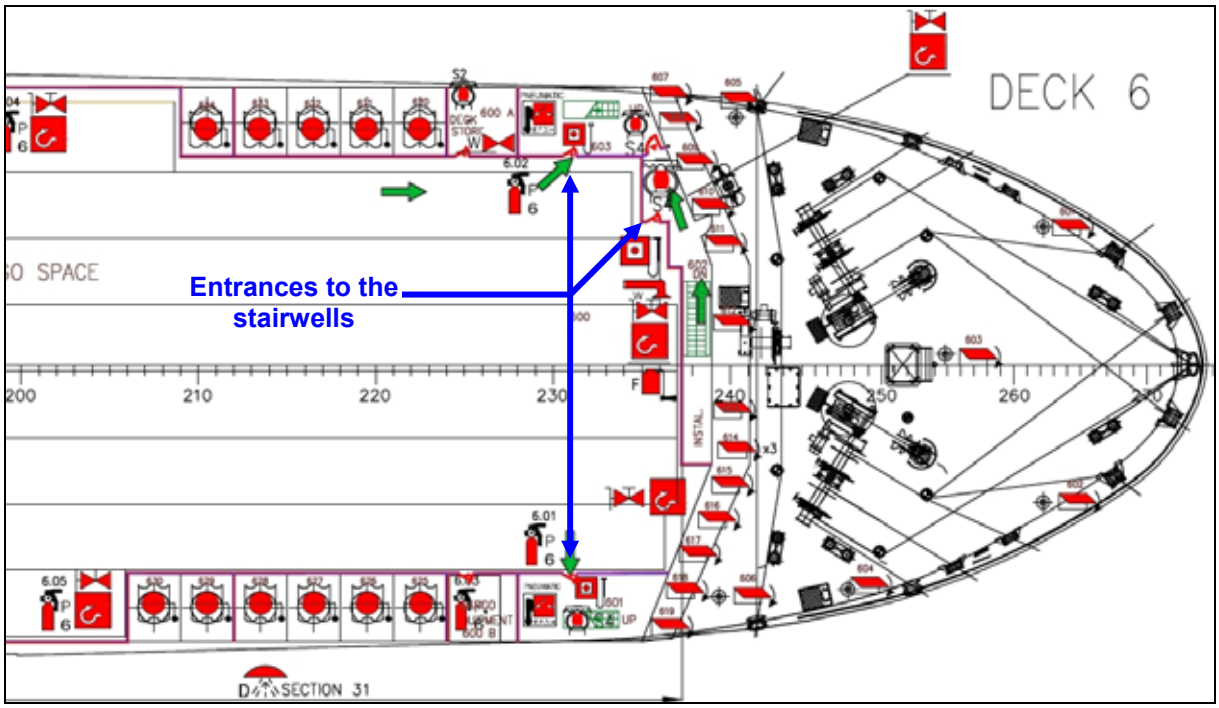


Figure 77: Fire control plan for the forward area of the upper deck

The recordings of the voyage data recorder (VDR; see sub-para. 3.3.2.10) show that the fire door on the port side was permanently open before and during the voyage. However, according to a crew member's statement it was closed when he tried to access the upper deck after the fire started. It was no longer possible to establish if the self-closing mechanism was defective. In addition, it is evident from the VDR recordings that to carry out his inspection the duty crew member entered the upper deck via the fire door to the stairwell on the starboard side, which was secured by a combination lock. He also left the upper deck via that door after the fire alarm.

3.3.2.6 Fire-fighting

3.3.2.6.1 Drencher system

A drencher system was permanently installed in the garage area of the upper deck of the LISCO GLORIA and in cargo decks 2 and 4. Similar to a sprinkler system, fire-fighting water is transported to the ceiling via piping in such systems and released through outlets (extinguishing nozzles, see Fig. 78) when required. Upon being released, the fire-fighting water is deployed through the nozzles as a coarse spray in high volume. It differs to a sprinkler system in that to begin with the pipes are open without being under pressure and the fire-fighting water stops at a valve, which has to be physically opened. It cannot be triggered automatically. In normal use the pump must be started to operate the system.

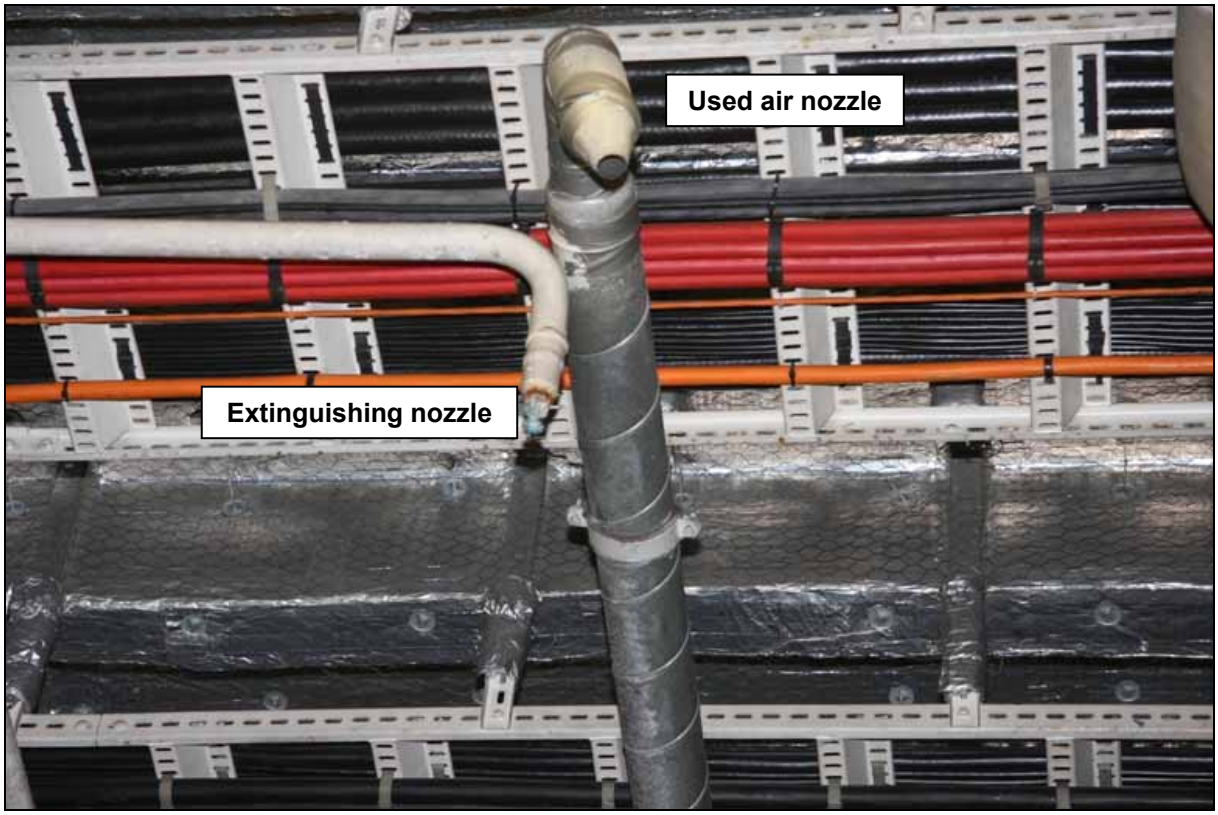


Figure 78: Extinguishing nozzle of the comparable drencher system on the DANA SIRENA

The drencher system was divided into two sections on the upper deck (sections 31 and 32; see Fig. 79), into five sections on deck 4 (sections 21 to 25), and into two sections on deck 2 (sections 11 and 12). One extinguishing nozzle in Section 31 was almost directly above the observed source of the fire (see Fig. 79 and 80).

Figure 79: Drencher sections on the upper deck of the LISCO GLORIA

Figure 80: Extinguishing nozzles on the upper deck after the fire

Both sections of the drencher system on the upper deck were triggered by the master at 0002 on 9 October 2010, just four minutes after the first fire alarm. However, the system did not deliver water; therefore, an order was issued to the duty engineer in the engine control room to start the drencher system from there.

In the engine control room, it was possible to check the functional capability of the pumps for the water supply, amongst other things to the drencher system, by means of indicating lights (see Fig. 81). The first attempt to start the pump for the drencher system was said to have failed. Following that, the pump control was reportedly switched to 'Automatic' on the main switchboard, which reportedly caused the indicating light for the pump to illuminate, after which the pump apparently started. No changes were reportedly made to the settings of the pump itself in the engine room.

Figure 81: Control panel for the fire and drencher pumps
in the engine control room of the LISCO GLORIA

When the investigation team surveyed the engine room of the LISCO GLORIA, it was found that the valve for the water supply was set to manual mode on the switchboard for the drencher pump (see Fig. 82).

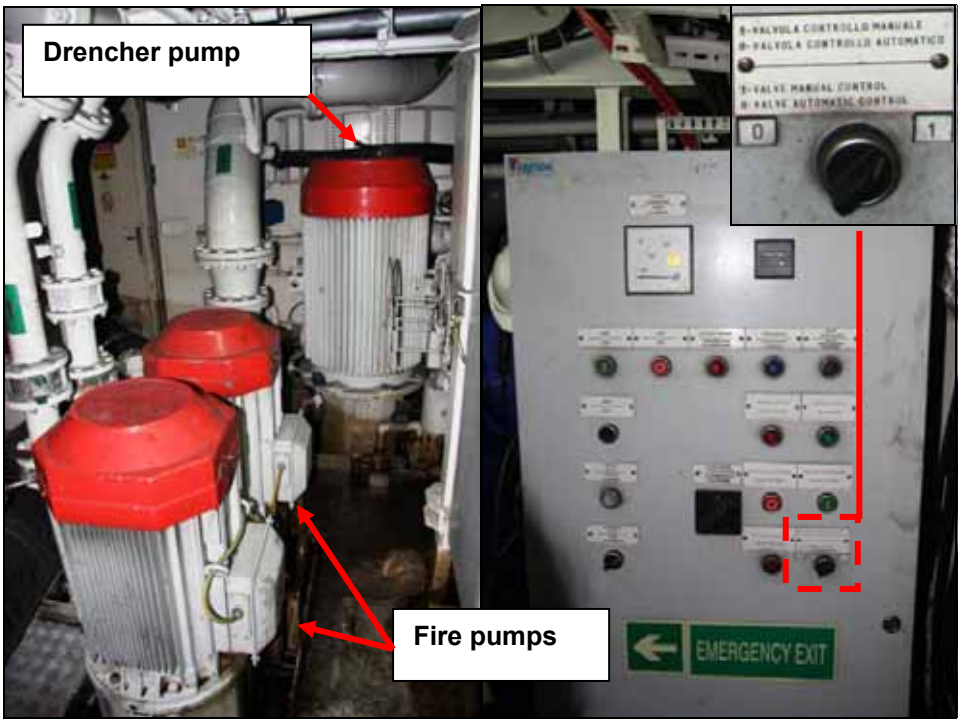


Figure 82: Drencher pump and switchboard in the engine room of the LISCO GLORIA

Since it was only possible to restore the power supply on board the LISCO GLORIA to a limited degree after the fire, the investigation team went on board the sister vessel, DANA SIRENA, in order to examine the effects of different settings on the switchboard for the drencher pump.

If the pump and the water supply valve are in automatic mode on the switchboard for the drencher pump in the engine room, then the yellow indicating light for 'Remote control' illuminates in the engine control room. If the drencher pump is activated by pressing the green 'Start' button, then this illuminates green as the pump starts to operate (see Fig. 83).

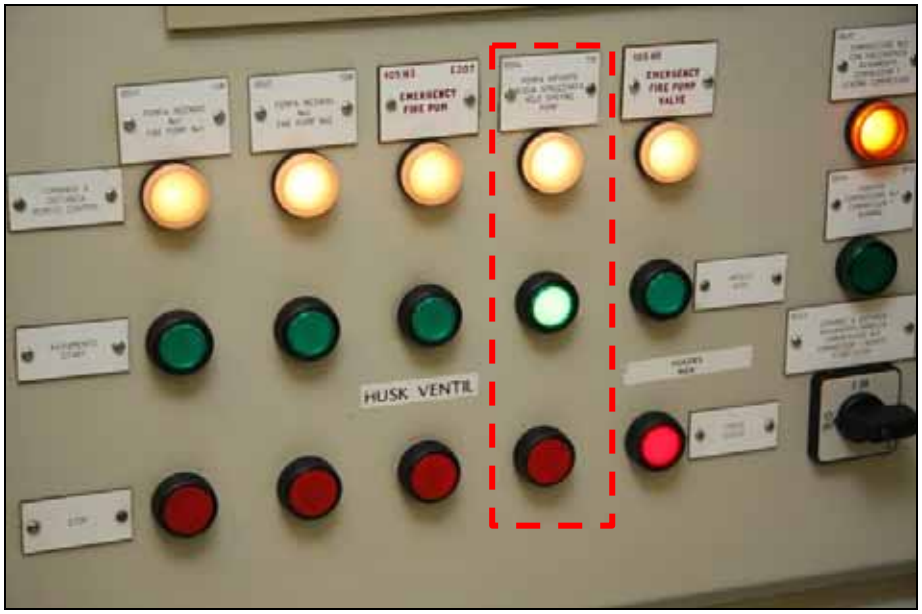


Figure 83: Control panel for the fire and drencher pumps in the engine control room of the DANA SIRENA when the drencher pump has started

However, if the switch for the valve is set to 'Manual' on the switchboard for the pump in the engine room, then the yellow standby indicator extinguishes in the engine control room and it is not possible to start the pump, i.e. although the green button can be pressed, it does not illuminate (see Fig. 84).

Figure 84: Control panel for the fire and drencher pumps in the engine control room of the DANA SIRENA when the valve setting on the switchboard for the drencher pump has been changed

Therefore, after the tests on the DANA SIRENA the possibility of the drencher pump being activated successfully via the switchboard in the engine control room on the LISCO GLORIA on the night of the accident could be excluded, if the valve control on the switchboard for the pump in the engine room was not set to 'Automatic', but to 'Manual'. Regardless of that, the investigation on board the LISCO GLORIA could not exclude the possibility of the valve setting in the engine room being changed in the days following the accident, as was also proven in the case of the main switchboard in the engine control room.

The drencher pump was tested on board the LISCO GLORIA on 22 November 2010 for further clarification of possible malfunctions. The expert engaged by the P&I insurer conducted the test after consultation with the BSU and in the presence of personnel from the Lithuanian public prosecutor's office; the test report was then submitted to the BSU. For the test, a temporary power supply, capable of providing 140 Amp required by the drencher pump, was provided to the main switchboard in the engine control room. This supply was connected upstream of the main circuit breaker protecting the drencher pump so that the circuit breaker would be in use during the test. The control panel for the drencher pump was also provided with power. The test itself was carried out in the Sprinkler Room 505 in the fore section of the vessel, where it was possible to connect the fire main with the drencher system. The feeders for the drencher, sprinkler and fire system converged in this room. The corresponding sections were handwritten on the section valve automatic actuators, which were each also equipped with hand wheels (see Fig. 85), amongst others, also for Section 31 (drencher section in the area of the observed source of the fire, see Fig. 79). Furthermore, a 'D' for 'drencher' and the red pump icon had been affixed to the pipe to the left of the unit for Section 31.

Figure 85: Sprinkler room on board the LISCO GLORIA

When setting up the test, it was necessary to find a solution for drawing off the fire-fighting water, which would otherwise flow through the drencher system during the test. A purpose made connection had been installed in the fire main connection to the drencher system. The valve between the manifold of the fire main and the drencher system had been removed and the individual section valves closed for this purpose. Two 3" diameter hoses were connected to the branch fitted (see Fig. 86) and led through the chain locker store to the forecastle where they discharged to the forecastle.

Figure 86: Setup for testing the drencher pump in the sprinkler room

A nautical officer of the LISCO GLORIA remained in the Sprinkler Room during the test, while the remainder of the party proceeded to the engine room. The first time an attempt was made to start the pump the motor started however the system did not produce any pressure or deliver water to the drencher system. A crew member present remembered that the main inlet to the seawater chest had recently been closed whilst operations were going on alongside with the ballast pump and other systems. The pump was stopped then using the control panel and this seawater chest valve was opened. Water was heard by the attendees rushing into the system. The drencher pump was started again. On this occasion the pump worked perfectly, and water was discharged through the hoses connected in the Sprinkler Room onto the forecastle. The pressure developed and maintained throughout the test was recorded as 11 bar. Further tests were carried out later on against a static head system. Those were carried out with the system closed at the Sprinkler Room and locally at the discharge from the pump. The drencher pump operated satisfactorily in both situations. Under these conditions the pump was started and left to run for a period of over five minutes during which time there was no increase in power consumption or any other observed effects.

3.3.2.6.2 Sprinkler system

A sprinkler system was permanently installed both in the area of the engine rooms and in the superstructure (cabins, corridors, lounge and utility rooms, stairwells) on the LISCO GLORIA. With this type of system, the fire-fighting water is transported through pipes mounted on the ceiling and discharged at the respective seat of a fire through nozzles, which are referred to as sprinkler heads. Sprinkler systems trigger automatically when needed: the sprinkler heads (see Fig. 87) are equipped with small glass bulbs; these contain a liquid, which causes the bulbs to burst when a certain temperature is reached.

Figure 87: A smoke detector and sprinkler head in a comparable cabin on the DANA SIRENA

Since only those sprinkler heads located above a fire source trigger, the fire-fighting operation is controlled. The system installed aboard the LISCO GLORIA was operated at a pressure of 25 bar in the piping and triggered when a temperature of 100 °C was reached. The high-pressure backup system, which could produce water mist at a pressure of up to 140 bar, was activated automatically if the pressure dropped to 10 bar for more than ten seconds.

At 0009 on 9 October 2010, eleven minutes after the fire broke out, the sprinkler system in the superstructure triggered. Indeed, the corresponding audible alarm was recorded by the VDR; however, not the section in which the system triggered. Since the fire door in the garage area of the upper deck that led to the stairwell on the port side was not closed, it can be regarded as probable that the fire spread to that stairwell.

At the same time as the sprinkler system was triggered, the connection of one of the sprinkler system's pressure pipes (see Fig. 88) parted near the engine control room on deck 4, causing an uncontrolled flooding of this area with fire-fighting water.

Figure 88: Parted sprinkler system pressure pipe near the engine control room

The duty engineer in the engine control room noticed the problem and then hurried to the sprinkler room in the forward part of the vessel via deck 4 to shut down the system. Amongst other things, the nitrogen cylinders (in the background on the left of Fig. 86) that activate automatically if a sustained drop in pressure in the sprinkler system occurs are also connected there. According to the VDR recordings, it took the duty engineer 15 minutes back and forth to shut down the system in room 505 (see Fig. 89). The bridge was not informed about the problem with the sprinkler system.

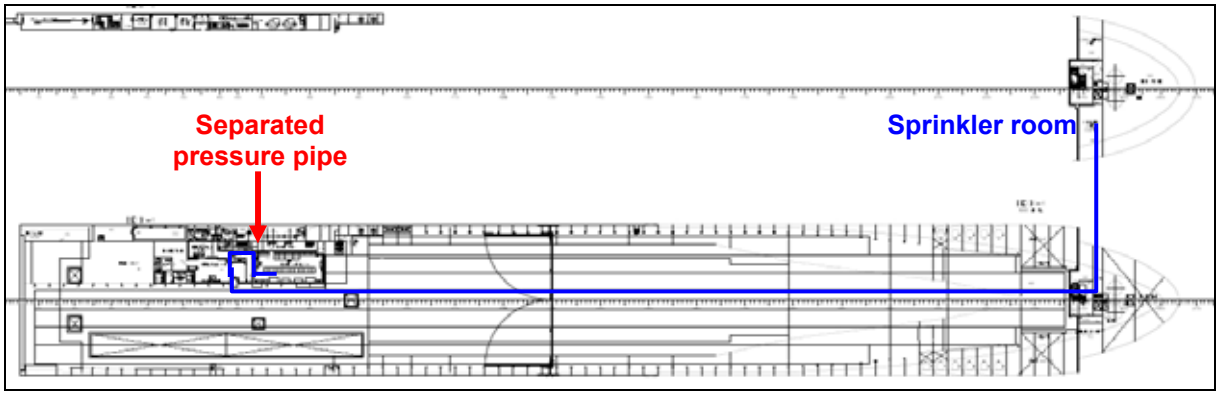


Figure 89: Route from the engine control room to the sprinkler room via deck 4

3.3.2.6.3 Other fire-fighting equipment

The functional capability of the two fire pumps installed in the engine room next to the drencher pump (see Fig. 82) was also checked when the drencher pump was tested. Some crew members stated that there was reportedly a temporary drop in water pressure when deck 7 was being cooled in order to make the lifeboat ready. When tested on 22 November 2010, both pumps were put into operation independently of one another without the occurrence of any problems. Both pumps maintained a constant water pressure of 10 bar. However, an external power supply was used for this and the drencher pump test.

In addition to the two fire pumps in the engine room, there was an emergency fire pump in the forward section of the vessel on deck 4 (see Fig. 90).

Figure 90: Emergency fire pump in the forward section of the LISCO GLORIA

Additional fire-fighting equipment included numerous dry powder extinguishers at regular distances on each deck; these contained 6 kg or 9 kg of powder.

3.3.2.7 Electro-technical report

The two experts from LKA Schleswig-Holstein appointed by the BSU prepared a report, which dealt with the electro-technical investigations and findings, and based on that the rate and pattern of fire development. For clearer presentation in the context of this investigation report, the two aspects are looked at separately.

The explanations of the experts regarding electro-technical matters are set out below, supplemented by remarks in *italics* for integration into the investigation context.

The circuit breakers found in the two locked switch cabinets in the engine control room were extensively documented with photographs by the experts and compared with the corresponding shipboard circuit diagrams.

The operating levers of the circuit breakers were each set to one of three possible positions 'On', 'Off' and 'Tripped' (see Fig. 91).

Figure 91: Circuit breaker, close up

It was possible to set the operating lever to the position 'On' or 'Off' manually. The position 'Tripped' could be activated only by the circuit breaker if the rated current was exceeded or by pressing the button 'Push to trip' on the circuit breakers. Since all three switching positions were found on the circuit breakers in the two switch cabinets, these were set in relation to the respective deck and associated frame number. The result could be depicted as follows, based on the sketches relating to the tripping situation on decks 4 and 6 (see Fig. 92 and 93).

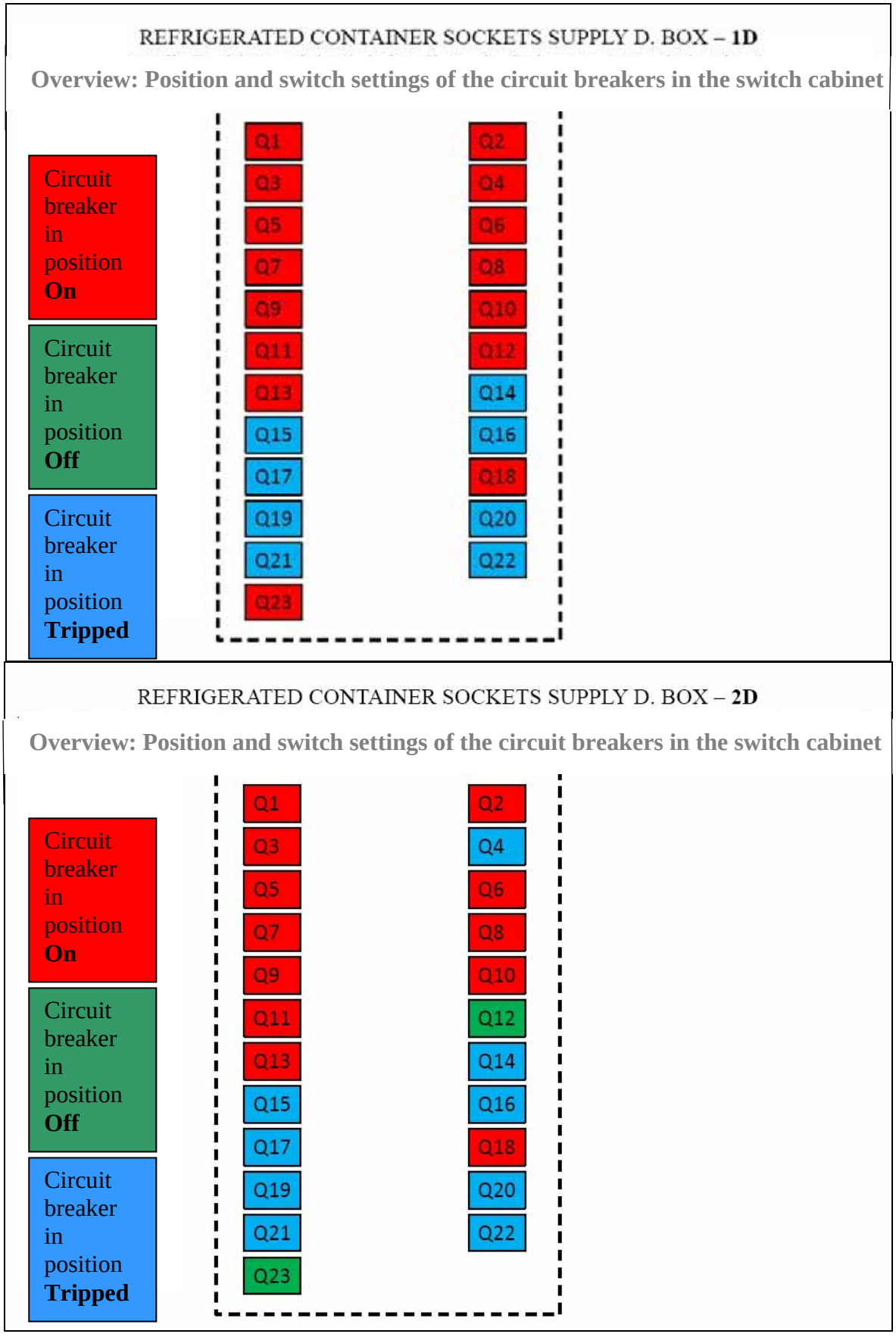


Figure 92: Overview of the position and switch setting of the circuit breakers

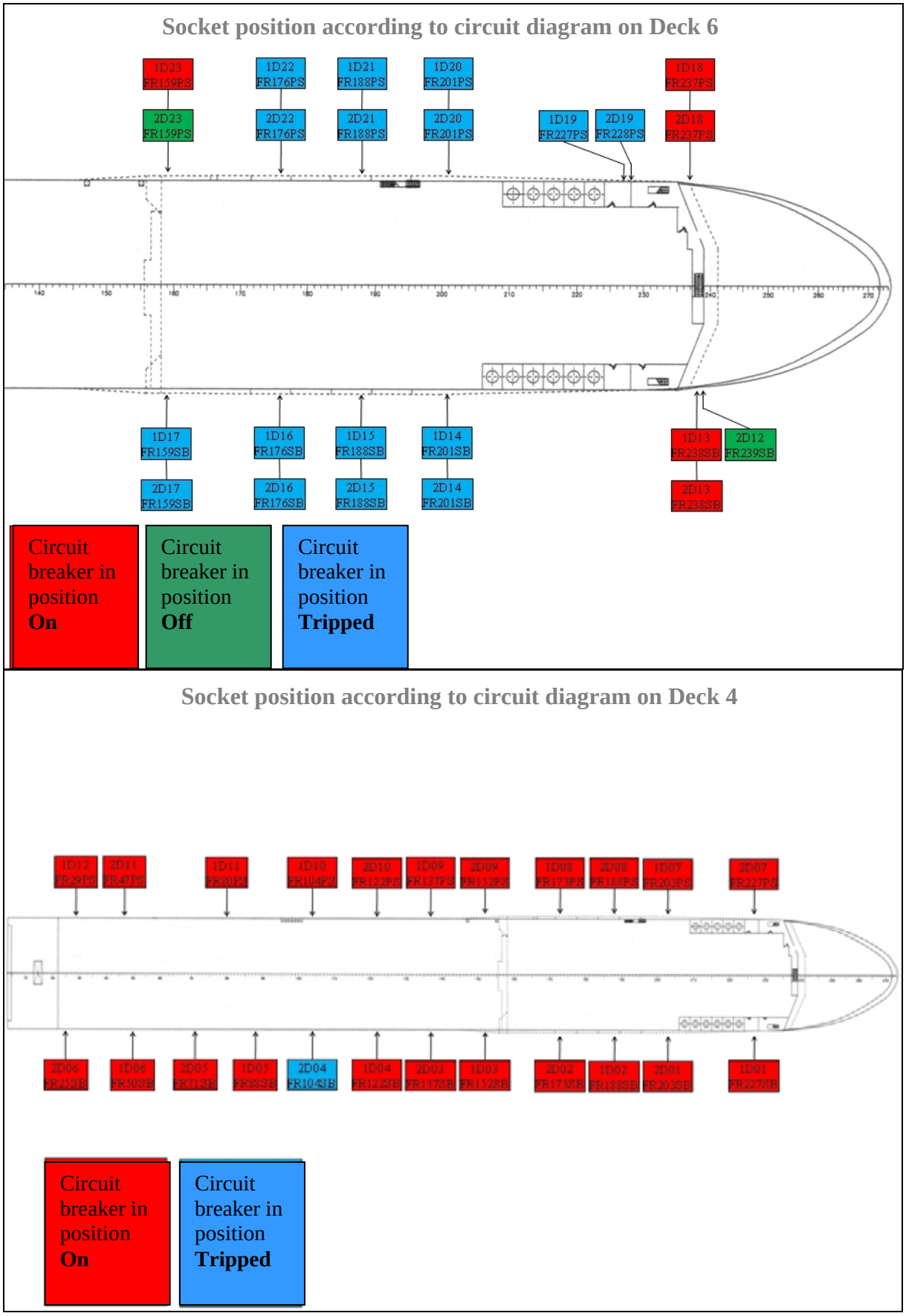


Figure 93: Socket positions on decks 6 and 4 according to circuit diagram

The tripping situation of the circuit breakers found was consistent with the witness' statement that the fire reportedly started on deck 6. At the time of the investigation, 16 of the 23 circuit breakers associated with deck 6 were in the position 'Tripped'.

In contrast, during the investigation of the tripping situation no evidence was found which indicated that the fire started on deck 4, as here only one circuit breaker, in the area of frame number 104 (starboard) in the aft section of the vessel, was in the switching position 'Tripped'.

This indicated that damage to the insulation of the supply cable to the switchable three-phase current power outlets did not take place in the course of the fire on deck 4 until after the electrical voltage had ceased to run through it.

The exhibits secured on board the LISCO GLORIA were subsequently examined in a laboratory.

The exhibits consisted of the remains of two switchable multiple sockets (see Fig. 94), the contact materials of the plug-in connectors (see Fig. 95), as well as the remains of the three contact pins of a connector socket and a plug found between the first truck and trailer on deck 6, lane 8 (see Fig. 96).

Figure 94: Remains of two switchable multiple sockets

Figure 95: Remains of the contact materials of the plug-in connectors

Figure 96: Remains of the contact pins found between truck and trailer

The fragments of the multiple sockets, and the discovered contact pins, gave rise to the conclusion that in this area a plug was inserted in both sockets. However, it was no longer possible to establish the switching position of the switch on the socket due to the high degree of destruction.

To make it possible to match the individual contact pins with a plug or connector socket, an identical mounted connector plug was acquired. The contact pins of the phase conductor and the protective conductor were cut out of the plastic housing of the plug and compared with the exhibit. Here, based on the shape and outer dimensions it was apparent that two of the three contact pins could be matched with those of the plug (see Fig. 97).

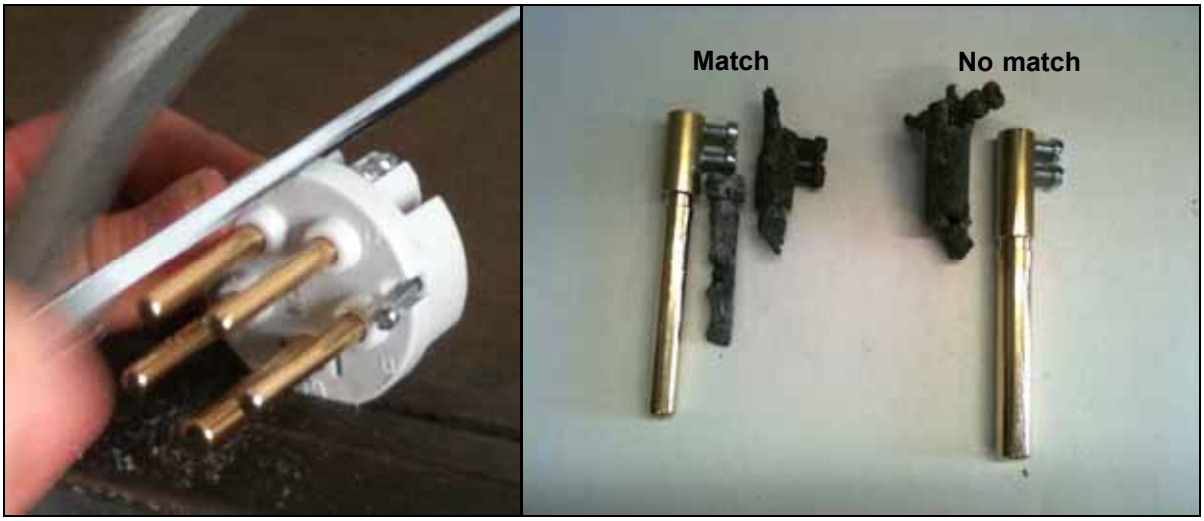


Figure 97: Classification of the contact pins kept as evidence in the laboratory test

However, one contact pin differed from those with which the comparison was made and therefore could not be attributed to the mounted connector plug of the refrigeration unit. Therefore, the remains of the contact pins of a connector socket and a plug were found in the area between the trailer and towing vehicle on deck 6, lane 8.

This finding was consistent with the witness statement, according to which the truck on which the fire was discovered was connected to the vessel's power supply.

Regarding the electro-technical findings, the experts have come to the following conclusions:

The tripping situation of the circuit breakers in the switch cabinet in the engine control room pointed against an origin of the fire on deck 4 of the vessel since here only one single circuit breaker, which was upstream of the switchable three-phase current power outlets, had tripped.

In contrast, 16 of the 23 circuit breakers installed there, which were upstream of the switchable three-phase current power outlets on deck 6 of the vessel, were in the switching position 'Tripped'.

Hence, the findings of the electro-technical investigations on board the ferry LISCO GLORIA were consistent with the witness statement, according to which the fire started between the first towing vehicle and refrigerated trailer parked on deck 6, lane 8.

When compared with a sample not affected by the fire, the external appearance of the contact pins found between the aforementioned towing vehicle and refrigerated trailer indicated that they belonged to the mounted connection plug of the refrigeration unit and a coupling socket.

Due to the extremely high degree of destruction, the condition of the electrical system of the vessel, the truck, and the refrigerated trailer in the area in which the witness

observed the fire starting was such that a conclusive investigation of the electro-technical fire inducing processes was impossible.

Accordingly, an electro-technically induced fire in this area (e.g. insulation failure of conducting materials, contact heat via transfer resistance, failure of electronic components) could not be ruled out as the cause.

The following report on the development of the fire concludes with further comments in this regard.

3.3.2.8 Development of the fire

The comments of the experts regarding the rate of fire growth and pattern of fire spread are given below, supplemented by remarks in *italics* from the BSU.

Digital photos made from board the environmental protection vessel SCHARHÖRN were the main source of information when depicting the rate of fire growth and pattern of fire spread. According to a BSU analysis of the radio traffic, the SCHARHÖRN reached the LISCO GLORIA at about 0219 on 9 October 2010 and then participated in the fire-fighting and emergency operations for several days. In addition, photos taken by a person in one of the lifeboats, which were only of poor quality and therefore had to be brightened, as well as photos which originate from the Danish vessel ROTA were analysed. The ROTA reached the distressed vessel before the SCHARHÖRN. Three aerial shots taken by the German Naval Air Wing (MFG) 5 were also added to the image folder[20].

A comparison with the time of arrival recorded in the radio log made it possible to ascertain that the time data of the photos of the SCHARHÖRN were one hour behind CEST and therefore had to be corrected by plus one hour. In the image folder, correspondingly amended times are noted. No analysable time data exists for the photos taken from the lifeboat and the ROTA, since the date is not included in the image information. However, due to the sequence of the rescue operation it is likely that these were taken before the arrival of the SCHARHÖRN, which is also consistent with the documented spread of the fire. The times of the images taken by the MFG 5 were adopted without being changed.

Interpretation of the photos – sub-series 'Lifeboat'
The images of the sub-series 'Lifeboat' show that after the vessel was abandoned the fire had already spread across the upper deck, and seized the garage area below the cabin superstructure as well as parts of the upper deck behind it (see Fig. 98). The starboard side was windward.

[20] *Note by BSU:* Dozens of pictures are appended to the original report. A meaningful selection was made for this investigation report.

Figure 98: Extent of the fire on deck 7,
taken on 9 October 2010 at about 0100

The photos were taken by a witness who was evacuated by the port lifeboat. The passengers began boarding the lifeboat at 0044 and transferred to the NEUSTRELITZ at 0105, meaning it is likely that the photograph was taken at about 0100.

The stage of the fire documented in the photographs can be described as an extensive, fully developed fire. Nevertheless, as can be seen in Fig. 99, for example, the destructive fire had not yet covered the entire length of the upper deck. Here, the silhouettes of four trucks and trailers can be seen aft of the dark looking enclosure of the external ladder to the accommodation superstructure, that is the section of the vessel immediately aft of the five large ventilation windows. Based on the ferry's stowage plan, more stowing positions as well as the stern with mooring winches must have been behind that, in an area not yet affected by the fire. Structures can be dimly seen along the ventilation windows, which presumably belong to the first truck and refrigerated trailer parked in lane 8 (source of the fire) and a second trailer behind it. Further insights into the spread of the fire towards the port side cannot be gained from the photographs.

Figure 99: Extent of the fire on the upper deck,
taken on 9 October 2010 at about 0100

Figures 98 and 99 give the impression that the destructive fire had also spread upwards into the outer area of the cabin superstructure. The red arrow marks a bright spot, which is situated approximately where an open part of deck 7 with crane jib and lifeboat was positioned. However, in this respect a definitive conclusion is not possible due to poor image quality.

Interpretation of the photos – sub-series 'Rota'

In Figure 100, the fire seems to have spread further towards the stern. There is, as silhouettes, an indication of six burning trucks and trailers on the open section of the upper deck. *The time the photograph was taken is unclear. However, since the ROTA was at the scene at 0105, the photograph could have been taken at about the same time as the witness photographs from the lifeboat.*

Figure 100: Fire continues to extend along the upper deck,
taken on 9 October 2010, exact time unknown

Interpretation of the photos – sub-series 'Scharhörn'

It was probably not possible to approach the burning ferry from the port side due to the smoke, which was blowing leeward. The entire length of the upper deck is now on fire. The stern and name of the ferry is easily visible in Figure 101.

Figure 101: Fire extends across the whole of the upper deck,
taken on 9 October 2010 at 0221

Figure 102 provides an overview of the entire length of the LISCO GLORIA. A bright spot can again be seen diagonally above the ventilation window, indicating a localised fire on deck 7.

Figure 102: Full shot of the burning LISCO GLORIA,
taken on 9 October 2010 at 0221

In Figure 103 it can be seen that deck 4 is also affected by the fire.

Figure 103: Onset of fire on deck 4,
taken on 9 October 2010 at 0254

Below the ventilation windows, burnt coating had formed in a black line. It appears that the fire spread from deck 6 in the forward section, since no such fire traces had

formed further back. This is logical in view of the presumed source of the fire being immediately above. The discussed discolouration is sharply limited, at its top by the recessed upper deck and forward by the ventilation ducts. Since the hot combustion gases accumulated under the ceiling after the fire spread, the traces of the fire initially do not cover the entire height of deck 4.

Figure 104 was taken at 0434:08. The fire damage on the shell plating has progressed further downward; its lower edge is limited by deck 4. There is no indication of the fire spreading to deck 2.

Figure 104: Development of fire damage to the side of the vessel,
taken on 9 October 2010 at 0434

The rear end of the refrigerated trailer on which the fire reportedly started is completely destroyed; only the rear tailboard has remained upright. The area in front of the trailer cannot be viewed. *However a fire marking at the position of the space between the cab and the trailer can be seen on the hull plating*. Figure 105 was taken at 0628:37. Another intensification of the traces of the fire is evident on deck 4. As illustrated by the glow from the last two windows on deck 7, it is now also burning in the rear section of the cabin superstructure.

Figure 105: Fire spreads to the superstructure,
taken on 9 October 2010 at 0628

A crack has formed between the cabin superstructure and the underlying structure (see Fig. 106).

Figure 106: Crack forms between decks 6 and 7,
taken on 9 October 2010 at 0629

However, the open part on the side of deck 7, where the starboard lifeboat was stowed, appears to be dark. It is not possible to confirm the aforementioned signs of the fire spreading into this area with Figure 107.

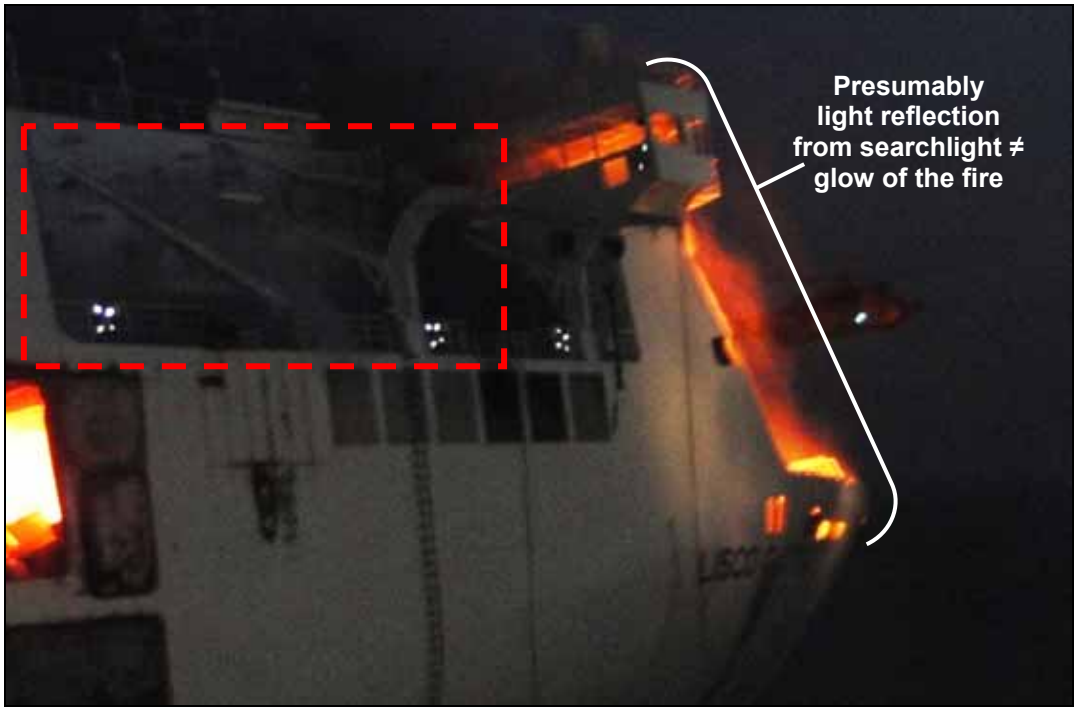


Figure 107: No fire at the lifeboat station on the starboard side,
taken on 9 October 2010 at 0656

Figure 108 shows the condition of the LISCO GLORIA on the morning of 9 October 2010 at 0753:28. The lateral fire trace on with deck 4 has progressed further towards the stern and stretches to the name of the ferry.

Figure 108: Evaporating fire-fighting water on the morning of 9 October 2010, taken at 0753

The light grey smoke above the vessel indicates a high proportion of evaporating fire-fighting water. It can be clearly seen that the speed with which the fire developed on deck 4 was relatively slow. This is due to the lack of oxygen, which probably occurred on deck 4 after the fire spread resulting in a ventilation-controlled development of the destructive fire – in contrast to the course of the fire on the open upper deck. Dark smoke can be seen rising mainly from the upper decks in Figure 109. Other shots confirm the impression that all decks of the cabin superstructure were burning at 0840. It is only in the area of the bridge that no smoke is visible.

Figure 109: Signs of fire in the superstructure, taken on 9 October 2010 at 0840

Dark smoke is also emanating from a side vent and deck 6 is in flames at the first ventilation window (see Fig. 110).

Figure 110: Fire on deck 6 on the morning of 9 October 2010,
taken at 0839

At 0939 on 9 October 2010, the LISCO GLORIA is lying at anchor. The wind is now blowing the fire smoke from the bow to the stern of the vessel. Figure 111 shows that at 0940:54 the mast on deck 10 *(wheelhouse top)* is still upright. At this point, it appears that the structural collapse of the superstructure is not yet complete.

Figure 111: Photograph before the structural collapse of the superstructure,
taken on 9 October 2010 at 0940

Since the ferry was lying at anchor in the wind, the view on the port side was free. In several images, fire can be seen on the port side at 0946. It can also be seen that the signs of fire damage on the shell plating of deck 4 are not as prevalent on the port side as on the starboard side (see Fig. 112). This can be interpreted as an indication that the fire started on the starboard side.

Figure 112: Fire on the port side in the garage area of the upper deck,
taken on 9 October 2010 at 0946

On further images, signs of the heat of the fire on deck 4 can be seen on the shell plating, up to behind the name on the side of the ferry. Figure 113 shows that above the first ventilation window on the starboard side a massive material loss has occurred on the lower edge of the aluminium cabin superstructure. This provides evidence of an effect that cannot be attributed to the early phase of the fire, but which occurred only during its subsequent development. Black smoke is emanating from the rear ventilation openings below the lifeboat station on starboard.

Figure 113: Material loss in the transition to deck 7,
taken on 9 October 2010 at 1038

Flames can also be seen on the upper deck again (see Fig. 114).

Figure 114: Another fire on the weather deck,
taken on 9 October 2010 at 1038

In Figure 115, the hole in the outer wall of the cabin superstructure above the first ventilation window on the starboard side is clearly visible. *This damage was most likely caused by flames venting out of the deck 6 windows*

Figure 115: Hole in the outer wall on deck 7,
taken on 9 October 2010 at 1456

In Figure 116, it can be seen that the main intensity of the fire is shifting back to the open area of the upper deck. In contrast, the destructive fire in the area of the cabin superstructure is abating. It is possible that for the most part the flammable material has been consumed. At least the rear section of the cabin superstructure has collapsed at this point owing to prolonged exposure to heat.

Figure 116: Fire on the weather deck and partially collapsed superstructure,
taken on 9 October 2010 at 1645

The fire continued to spread across the entire vessel during the ensuing night (see Fig. 117).

Figure 117: Fire on the evening of 9 October 2010,
taken at 1919

On 10 October 2010, the LISCO GLORIA's degree of external destruction essentially corresponds with her condition during the subsequent investigation (see Fig. 8). The mast on deck 10 has tilted to the rear and the side superstructures inwardly. According to that, the vast fire funnel in the superstructure on Figure 118, as photographed from the air on 15 October 2010, was probably fully developed by this time.

Figure 118: Fire funnel, taken on 15 October 2010 at 1139

A comprehensive analysis of the structural details of the LISCO GLORIA and evaluation of these with regard to fire protection requirements is not the subject of this report. However, the BSU requested some general statements about the spread of the fire on the ferry. This has been accomplished in the preceding section using photographs from the perspective of eyewitnesses and will now be supplemented by several considerations relating to the physical aspects of the fire.

Basically, four main mechanisms are of importance when considering the scenarios surrounding the way in which the fire spread: advancing open flames, convection of hot combustion gases, thermal radiation and thermal conduction. In the event of fire, the effectiveness of these factors can be influenced by fire protection measures. Here, it is important to distinguish between active measures, such as built-in fire extinguishing systems, and passive measures, such as the use of fire-retardant materials or inclusion of fire zones in the design.

The spread of fire via open flames depends, amongst other things, on the fire-related properties of the combustible materials involved, their geometric arrangement, and the presence of oxygen in the inflowing combustion air. An accumulation of highly combustible plastic materials, such as those present in various forms in the vehicles parked on the cargo decks of the ferry, provide particularly favourable conditions in terms of facilitating the rapid spread of fire. Added to this is the combustible operating materials and hazardous materials, the proportion in the fire load of which in these sections of the vessel was probably also significant. In the cabin superstructure above, the upholstery of mattresses and chairs and, if present, wall and ceiling coverings made of wood or plastic as well as combustible fittings, for instance, can be added to the list.

Therefore, in general it can be concluded that the density of the fire load was relatively high on the ferry. In places, the very small distance between the trucks, trailers and cars parked on decks 2, 4 and 6 also facilitated the rapid spread of fire. In areas where open flames could not move directly from one object to another, thermal radiation emitted from hot objects possibly ensured the progression of the flame front.

Potential for the fire to spread, such as open flames and thermal radiation, are phenomena that can (also) carry the fire forward in a horizontal direction if the distances between combustible objects are sufficiently low. With regard to the propagation of flames from one place to another, the wind effect must also be taken into account which, coupled with the spread of fire through combustion gases (convection), may also have played a role.

The vessel's structure consisted of metal (steel hull/aluminium accommodation superstructure). Since metal is a good conductor of heat, the vertical spread of fire was facilitated by thermal conduction. Structurally, this danger was met in many places on the LISCO GLORIA by the addition of mineral materials in order to achieve a thermal shielding of the respective surfaces.

Hot combustion gases of complex composition form during the combustion process. They rise due to their low relative density, accumulate below the ceiling in covered sections, where they can then distribute across a wider area. If, based on their volume, more combustion gases are formed than can escape from the area under

consideration through openings, a concentration occurs which progresses from top to bottom and results in lower lying areas being reached.

The report continues with information on the hypothetical course of the fire.

Regarding the specific fire event on the LISCO GLORIA, certainly all potential mechanisms outlined here played a part in the fire to spread through the vessel. Starting with the presumed development of the fire on the first truck in lane 8, deck 6 on the starboard side, one can conclude that, initially, combustible vehicle parts in the immediate vicinity of the fire's source were involved. In the course of the fire spreading, the flames are likely to have then propagated via the refrigerated trailer, which was insulated with synthetic foam, and the towing vehicle. A sufficient quantity of combustion air was able to flow in through the ventilation windows on the side of the garage area of the upper deck. A shortage of oxygen, which would have reduced the speed of the fire spread, did not occur.

The hot upward flowing combustion gases accumulated beneath the cabin superstructure and were initially 'trapped' there between the steel girders of the ceiling structure. Open flames and thermal radiation led to the fire spreading horizontally on deck 6. Here, the presence of an additional lateral component from starboard to port was ensured by the laterally acting wind.

The rapid spread of fire on the upper deck was caused primarily due to the high fire load density coupled with an unrestricted supply of combustion air. As is apparent from an analysis of the photos, about two hours passed before it was evident that deck 4, the cargo deck located below deck 6, had been reached by the flames. This process was externally apparent due to a discolouration of the coating on the starboard hull. It is possible that at this point the static stability of deck 6 had already been lost due to the heat of the fire. As was subsequently revealed, the steel structure near the source of the fire had collapsed over a large area. This may have led to an adverse change in the structure's fire protection properties, which would possibly have facilitated the spread of fire. However, further statements are not possible in this regard.

The destructive fire spread much more slowly on deck 4; although it can be assumed that the average fire load density (apart from any hazardous materials) was similar to that of deck 6. However, due to a significantly restricted supply of combustion air, the oxygen concentration decreased rapidly in this closed section of the vessel.

Accordingly, ventilation-controlled combustion conditions existed there, resulting in the fire tending to spread more slowly, as demonstrated during the days spent attempting to extinguish it.

The spread of fire upwards into the cabin superstructure also took several hours. Perusal of the witness photos does not reveal with any certainty whether open flames were already burning earlier in the area of deck 7 on starboard.

The spread of fire upwards is also likely to have been associated with a loss of structural integrity. Since aluminium melts at about 660 °C, it is understandable why

the large fire funnel was able to form in the cabin superstructure. However, based on the photos it can be shown that at least temporarily the progress of the fire was comparatively slow, which is an indication of ventilation-controlled combustion conditions.

During the local investigation, discussions were held as to whether the lateral ventilation ducts, which run from bottom to top, played a role in the vertical spread of the fire during its early phase. Here, it can be concluded that the photographically documented course of the fire for the starboard side does not offer any reliable evidence in this regard. Only on the morning of 9 October 2010 is it possible to see smoke emanating from the duct grating.

To obtain an impression of the original situation on board the LISCO GLORIA, her sister vessel, the DANA SIRENA, was visited in the port of Esbjerg on 25 January 2011. The structural parts of the cargo decks in the forward section of the vessel were clad with 4 centimetre thick aluminium laminated mineral wool (see Fig. 119).

Figure 119: Ceiling covering on the sister vessel, DANA SIRENA

The insulating material was held in place by small metal plates. The piping in these areas was partially covered with black synthetic foam. Tape was used in several places for fastening. Electrical conducting materials were mounted on cable trays. Cables fastened to the bottom of these were fixed at large intervals with metal cable ties. Plastic cable ties were used between the metal ones (see Fig. 120).

Figure 120: Metal and plastic cable ties used on board the DANA SIRENA

To roughly assess the fire performance of the aforementioned materials, samples were taken (see Fig. 121): one piece of a cut leather glove, one piece of grey-

coloured fabric tape, one piece of black synthetic foam material, one piece of greenish mineral wool material as well as one piece of a black and a transparent plastic cable tie.

Figure 121: Material samples from aboard the DANA SIRENA

The samples were bench tested under the fume hood using a Bunsen burner to establish combustibility. Materials that continued to burn unaided after the ancillary flame was removed were additionally characterised in terms of their physical composition using Fourier transform infra-red spectroscopy (FT-IR).

The findings are summarised in the following table:

Material	Fired sample	FT-IR
Glove	Does not continue to burn unaided; extinguishes with brief glow and smoke	---
Grey fabric tape	Continues to burn unaided with yellow flame and crackling; vapours smell slightly fruity	Front is similar to polyethylene. Back?
Black synthetic foam	Does not continue to burn unaided; extinguishes immediately with smoke	---
Greenish mineral wool	Does not continue to burn unaided	---
Black cable tie	Continues to burn unaided, drips when burning and then extinguishes	Polyamid
Transparent cable tie	Continues to burn unaided, drips when burning and then extinguishes	Polyamid

Table 3: Burning test results for the materials from aboard the DANA SIRENA

From the survey of the DANA SIRENA and the burning tests carried out, the experts draw the following conclusion.

Structural differences between the LISCO GLORIA and the DANA SIRENA existed. Nevertheless, a visual inspection of the sister vessel provided insights into the design and finish in the area of the cargo decks. Occasionally, flammable materials were found in certain places; however, their impact in terms of facilitating the vertical progress of the fire was difficult to assess. It was not possible to conduct an analysis in this regard.

The experts stated the following with regard to the possible cause of the fire on the LISCO GLORIA:

As has been shown, the generally high degree of destruction made it impossible to narrowly define the source of the fire. Rather, the global trace pattern of the fire was considered with a witness statement relating to the early phase of the fire in order to assess its validity. The corresponding findings did not give rise to fundamental doubt as regards the possibility of the fire starting on the first truck on lane 8 of deck 6; therefore, this was generally accepted as the basis for investigating the cause of the fire subsequently.

The observation that the destructive fire was reportedly first noticed between the towing vehicle and refrigerated trailer was regarded to be a credible possibility and consistent with the connecting facts. Establishment of the source of the fire set the basis for the fire cause elimination procedure. This method is based on a review of the various sources of ignition (which may have been in the vicinity of the presumed source of the fire) for their potential effectiveness in the light of existing connecting facts and physical principles relating to fire. Ideally, only one possible cause of fire remains at the end. If several possible causes of fire are identified, one can only attempt to put these in relation to one another and in so doing derive graduated priorities. It transpired that the latter option had to be applied in the present case.

The results of the investigation either confirmed or at least could not refute the following hypotheses:

1. The destructive fire broke out on a truck with a refrigerated trailer, which was the first vehicle in lane 8, deck 6. The source of the fire was between the towing vehicle and the trailer.

2. The trailer's refrigeration unit was connected to the shipboard power supply.

Therefore, it follows that a fire cause elimination procedure would focus on electro-technical and technical causes.

The Maxima 1300 refrigeration unit made by Carrier was mounted on the outside of the front of the refrigerated trailer behind the towing vehicle. This device contained electrical components (starter battery, electric motor, cable materials). Other electro-technical equipment was also present in the immediate vicinity of the presumed source of the fire, e.g. in the form of the truck's vehicle batteries and the electrical supply line between shipboard and vehicle connectors.

As discussed, direct evidence of a fault in one of the aforementioned electro-technical components, or at least a concrete indication in this regard, was not present due to the high degree of destruction. However, this does not rule out the occurrence of such an event but simply means that it cannot be confirmed with the corresponding findings.

Basically, under these circumstances heat or sparks produced by a damaged section of the connecting cable between the vessel and refrigerated trailer, the electrical system of the truck or the refrigeration unit are all possible sources of ignition that could cause a fire.

Potential technical causes of the fire

Firstly, it must be considered that the refrigeration unit was run with a diesel engine before being connected to the shipboard power supply. Naturally, that would involve hot surfaces on the engine block and exhaust path. Faults in the exhaust system can, without wishing to attest this as regards the fire on the LISCO GLORIA, result in hot exhaust gases escaping. In this context, combustible materials could, next to plastic components, also include, for example, leaking (highly) combustible operating materials, which escape due to faulty hose connections or defects in the respective line and thus come into contact with one of the listed sources of ignition. However, it was not possible to arrive at a conclusion in this regard as all the combustible components of the diesel engine, including its hose connections, had been completely destroyed by the intense thermal effects during the fire.

Secondly, it should also be noted that mechanical moving parts can also produce frictional heat or sparks, in particular, if their bearings are defective or when striking metal components. Whether an effective source of ignition can form in the process depends on numerous factors (e.g. properties of the material, rotational speed), the specifications of which are not known in detail. Here, it remains questionable whether the fan of the refrigeration unit could have played a role; although its fragments were found in the fire debris, it was no longer possible to examine them conclusively.

Weighting of potential electro-technical and technical causes of the fire

Referring to the potential causes of the fire discussed, which although conceivable in principle could neither be excluded nor confirmed by an investigation on the LISCO GLORIA, it is only possible to derive their potential 'likelihood of occurrence'[21] under the inclusion of certain marginal conditions.

Accordingly, the aforementioned possibility of fire ignition due to faulty operation of the diesel engine is pushed well into the background. In such a scenario, the fire ignition would have occurred before the refrigeration unit was switched to electric operation and the development of the fire would have had to then remain undetected until it was discovered by the deckhand on deck 6. This would only have been possible if a spatially limited smouldering or glowing fire formed in the interim. However, since the period between the parking of the truck in question on lane 8 and

[21] *Expert's note*: This term is not meant to express a mathematical probability. It is simply an attempt to assess the relative plausibility of the potential causes of the fire discussed.

the discovery of fire is likely to have been about 4 hours, this theory does not seem very plausible.

The following table summarises the assessments given here for the plausibility of the different causes of the fire that have been discussed:

Source of ignition	Plausibility	Reasoning
Diesel engine of the refrigeration unit	Low	Large amount of time between truck being parked and discovery of the fire (no recognition of signs of a smouldering or glowing fire).
Ventilation of the refrigeration unit	Possible	In principle, mechanical moving parts can produce very high temperatures due to faulty bearings.
Electrical parts of the refrigeration trailer, the truck or the ferry	Possible	The refrigeration unit was connected to the shipboard power supply. Electro-technical devices were present in the presumed centre of the fire.
Other sources of ignition	?	No indication

Table 4: Expert's assessments for the plausibility of the discussed different causes of the fire

In closing, only findings that relate to the core mandate of investigating the fire on the ferry LISCO GLORIA are summarised. This was to arrive at conclusions on the source and cause of the fire.

It was possible to arrive at the following (essential) findings:

1. The general pattern of fire spread and development is consistent with fire originating as reported in the first truck parked at the starboard side of deck 6 in lane 8. The overall pattern of fire damage tends towards the starboard side. The aforementioned vehicle's degree of destruction was remarkably high.

2. The fire did not reach the cabin superstructure, the bridge and the sections of the vessel below deck 6 until a certain amount of time had passed. This is demonstrated, inter alia, by images that were taken at the scene by eye witnesses during the fire-fighting and rescue operation. It took about two hours for the fire to spread from deck 6 to deck 4. Initially, the fire spread horizontally on the upper deck.

3. An indication that the fire started on deck 6 is also provided by the tripping situation of the fuses for this area. While almost all the fuses tripped for the vessel's sockets in the area of the presumed source of the fire, almost all the corresponding fuses for deck 4 are switched to 'on'. This switching position was 'frozen' during the power failure on the ferry and represents the incident-related tripping condition at that point in time.

4. The remains of conducting materials, two of the vessel's sockets and parts of an electrical plug-in connector were found in the vicinity of the source of the fire, which, in accordance with the discussed witness statement, makes it seem plausible that the refrigeration trailer was connected to the shipboard power supply at the time the fire started. According to that, the refrigeration unit was operated electrically and not by means of a diesel engine. However, it

was no longer possible to conclusively investigate the electro-technical components of the truck, the refrigeration trailer or the shipboard power supply with respect to a possibly existing electrical fault due to the high degree of destruction. That also applied to other technical components, such as the refrigeration unit's air circulation fan.

5. In the course of a fire cause elimination procedure it is neither possible to exclude an electro-technical nor any other technical cause based on present knowledge.

6. In particular, it is not possible to arrive at a decision on whether the fire started on the truck, the trailer or the shipboard power supply.

3.3.2.9 Emergency management by the shipping company

The shipping company has laid down, amongst other things, procedures for handling emergency situations in the safety manual for the fleet. The procedures described in the safety manual are designed to complement the emergency planning and standing orders for each vessel.

In the event of fire, the following actions are recommended in the safety manual:

- Investigate, whether alarm is false;
- Close fire doors and watertight doors and stop ventilation;
- Warn the captain;
- Start fire roll in crew accommodation;
- Warn engine room;
- Start fire pumps;
- Send fire task group to fire location;
- Note position and time;
- Stop ship, where relevant;
- Give information to passengers, nearest MRCC;
- Follow fire and evacuation emergency instructions.

The following instructions are in place to abandon a vessel:

- Send “DISTRESS ALERT” using all available equipment (DSC, VHF etc.);
- Activate “ABANDON SHIP” alarm; sound appropriate signal;
- Inform the passengers via public address system; summon them to the designated assembly. Pay attention to their clothing;
- Switch on lighting at Assembly stations, boats and rafts decks;
- Start preparing life saving equipment for lowering. Check the falls securing to the deck;
- Check assembled passengers according to passenger and crew lists. Organize searching of missing people;
- Divide the crew and passengers to the life saving appliances (life boats, life rafts);
- Start embarking the people to the life saving appliances;
- Start lowering the life saving appliances on the water;
- Start engines of life boats, disconnect hooks and move away from the ship;

- Organize lowered life saving appliances meeting in one place; try to follow abandoned ship;
- Activate the EPIRB[22], switch on SART[23], turn on VHF channel 16.

On board of LICSO GLORIA, the muster list[24] required under SOLAS was posted on the bridge, in the crew's accommodation area, and in the engine control room. The muster list defines the particulars of the general alarm system:

- general alarm: seven short blasts, one long blast;
- abandon ship alarm: continuous blast for at least 30 seconds.

In addition, the actions that need to be taken by the crew and the passengers in the event of an alarm signal sounding were defined in the muster list. The muster list in the engine control room was not destroyed by the fire. It assigned the following tasks, amongst others, to crew members, who were designated by name:

- equipping, making ready and lowering the life-saving equipment;
- muster of the passengers;
- composition of the fire fighting teams;
- responsibilities of officers for the respective teams; and
- notifying and gathering the passengers.

In addition to the muster list, emergency plans were posted on board, and each crew member held a card with personal instructions for an emergency (so-called Cabin Card).

The emergency procedures were implemented by weekly trainings and exercises on board.

3.3.2.10 Accident data backup

The LISCO GLORIA was equipped with a voyage data recorder (VDR). The main unit was located in the wheelhouse and was completely destroyed in the fire (see Fig. 122).

Figure 122: VDR main unit in its original condition (model for comparison) and after the fire

[22] Emergency Position Indicating Radio Beacon
[23] Search and Rescue Radar Transponder
[24] See SOLAS Chapter III, Part B, Section 5, Regulation 37.

It was no longer possible to read from the hard disks due to the degree of destruction. Therefore, the investigation was forced to rely on the data stored in the VDR's protectively encapsulated final recording medium (FRM). The FRM was mounted on the wheelhouse top and survived the fire almost undamaged (see Fig. 123).

Figure 123: Capsule of the VDR in its original condition (model for comparison) and from aboard the LISCO GLORIA

The capsule was recovered by a boarding team from the ferry while she was still burning in order to prevent the recorded data from being overwritten or, as far as possible, otherwise damaged. During the recovery, only the upper part of the capsule was taken; this was subsequently handed over to the Danish Maritime Authority. The lower part – the interface required for exporting the stored data – remained on board (see Fig. 124).

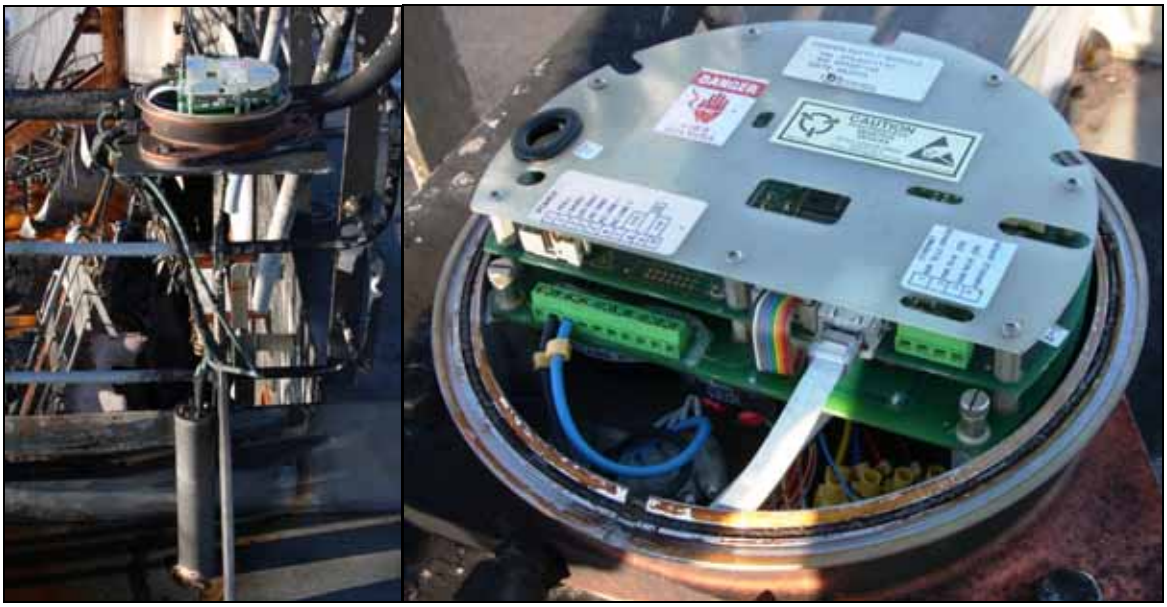


Figure 124: VDR interface on the observation deck of the LISCO GLORIA

The interface, which amongst other things is used to power the storage medium in the capsule, was exposed to the weather without protection until the investigation team's first survey on the LISCO GLORIA on 25 October 2010; therefore, the investigators decided against attempting to use this interface to export the data. Instead, the capsule was taken by BSU staff to the manufacturer of the VDR, Consilium, to minimise the risk of data loss by using the technical equipment with original components available there. The data stored in the capsule were exported in the presence of the BSU on 28 and 29 October 2010. This proved to be challenging as the capsule was a model from the second series, which differed fundamentally from the newer models available from the manufacturer in terms of the configuration of the data. It was finally possible to restore data for the period 8 October 2010 at 205346 to 9 October 2010 at 002345 with help from a software engineer. More data were not stored. The audio recording had already stopped at 002246. The stored data record contained, in particular:

- vessel positions and times;
- information on speed, course and rudder angles;
- recordings of the bridge microphones and VHF radio traffic;
- information on the wind and echo sounder;
- recordings of the closing status of each of the fire doors; and
- radar images.

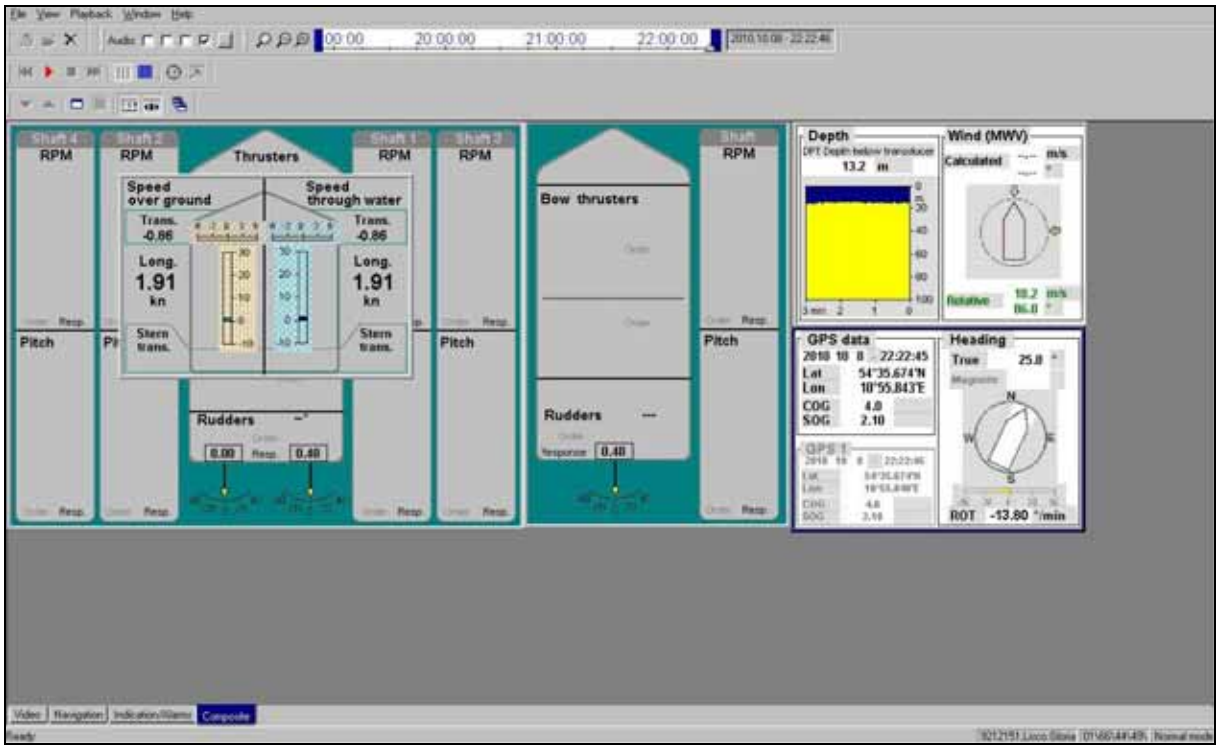


Figure 125: Playback program of the LISCO GLORIA's VDR

The recordings of the bridge microphones were of particular importance to investigating the marine casualty. These were analysed with the help of translators for Lithuanian and Russian. However, communication on the bridge becomes partially difficult to understand fifteen minutes after the fire broke out due to being superimposed by various audible alarms. From then it was no longer possible to

completely comprehend the communication, even with the help of technical audio filters.
The recordings of VHF channel 16 were provided to the BSU by the Vessel Traffic Service Centre Travemünde. These cover the period 8 October 2010 at 2200 to 9 October 2010 at 1000.

The analysis of the VDR recordings revealed the following important findings regarding the course of the accident:

Time	Event
8 October 2010 235810	Fire alarm on the bridge Course over ground (COG) 083°, speed over ground (SOG) 20.3 kts
235859	Duty crew member reports the discovery of a fire on lane 8 to the officer on watch on the bridge by ship radio
235920	Officer on watch notifies the master by telephone
235937	Master is on the bridge
235938	Master issues order to switch off the power supply
235956	Master starts fire roll in the crew accommodation area and issues order for the deck crew to proceed to the upper deck via speaker announcement
9 October 2010 000005	Officer on watch informs the master that ventilation has been turned off.
000055	Master instructs the duty engineer in the engine control room to switch off the power connection to the trailers on the upper deck
000145	Report to the master by ship radio: upper deck cannot be entered due to heavy smoke
000154	Master starts the drencher system on the upper deck
000200	Network time-out alarm sounds on the bridge
000327	Master notices that drencher system is not working
000337	Order to the duty engineer in the engine control room to start drencher system from there
000436	Continuous alarm sounds on the bridge
000541	Master notices persistent failure of drencher system in spite of open valves
000640	Vessel's speed is slowly reduced; 20 kts SOG
000716	Master informs Bremen Rescue Radio about the fire on VHF channel 16; 19 kts SOG
000853	Audible alarm (sprinkler system has triggered); 18.5 kts SOG
000909	Master issues order to evacuate
001323	Bremen Rescue Radio sends mayday relay message on VHF channel 16 and calls on all shipping in the vicinity to assist the distressed vessel; LISCO GLORIA 8 kts SOG
001500	Fire pumps in operation for cooling down/extinguishing on the starboard lifeboat station; 4.8 kts SOG
002030	Master informs Bremen Rescue Radio about the start of the evacuation
002150	Engine stopped; 2 kts SOG

Table 5: Results of the analysis of the VDR recording

During the first survey of the LISCO GLORIA on 25 October 2010, the investigation team removed, as another possible source of data, the two hard disks of the central control system in the engine control room (see Fig. 126).

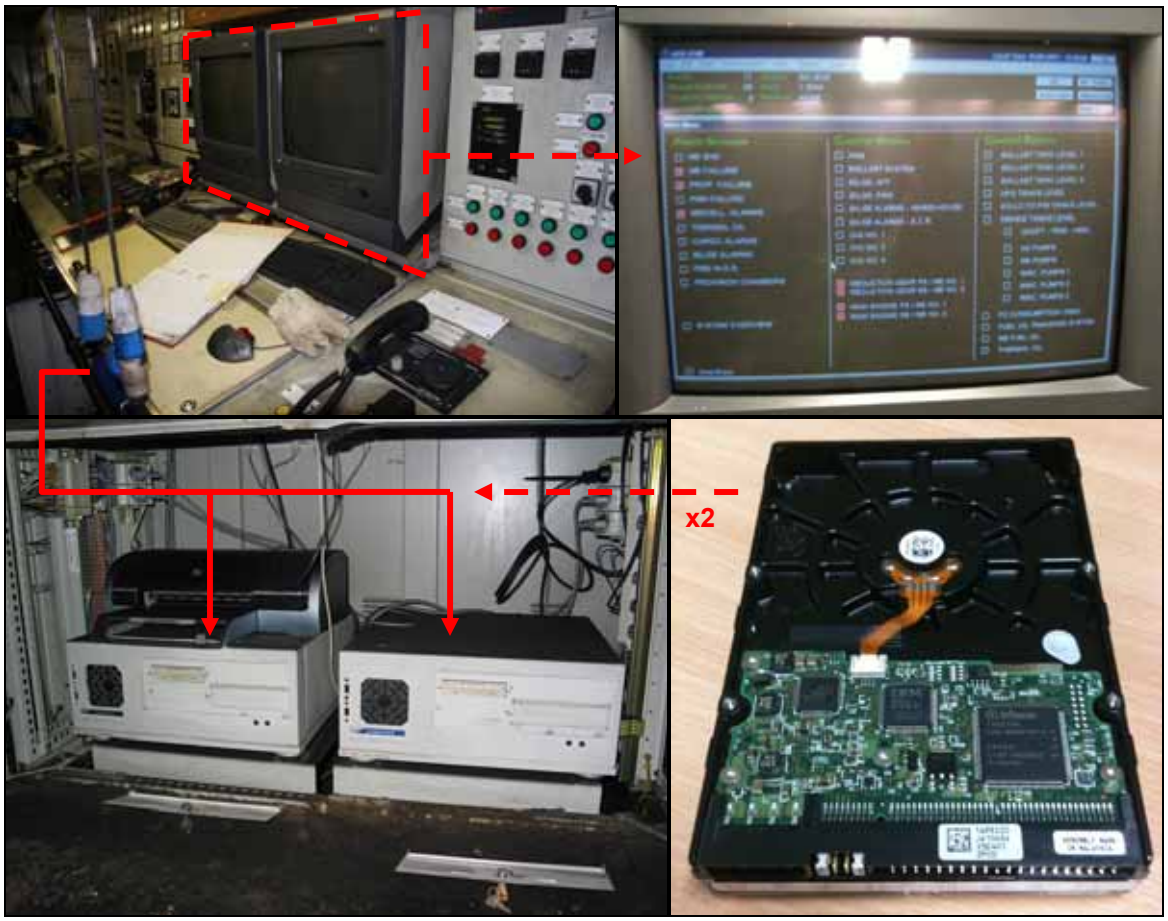


Figure 126: Control and monitoring system in the engine control room of the LISCO GLORIA

One component of this system was monitoring the vessel's operating systems. Incoming alarms were logged by the system and were, in normal operation, output on a screen or printer (see Fig. 127).

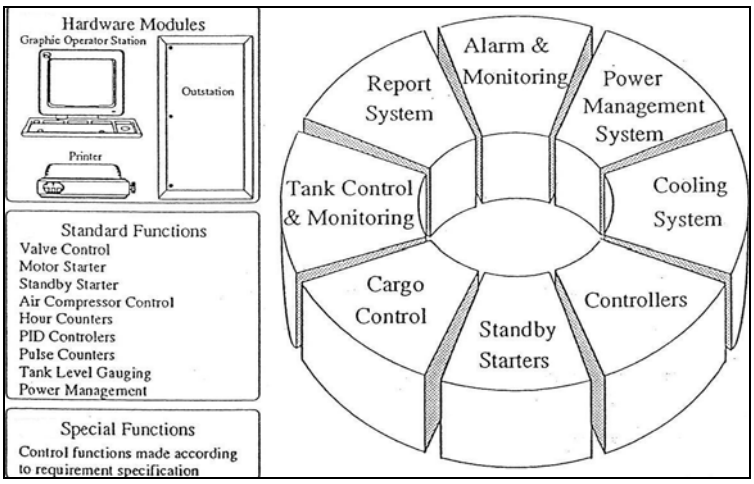


Figure 127: Overview of the components contained in the control system

There was no visible damage to the hard disks when they were secured. They were interrogated for the marine accident investigation by a distribution partner of the system manufacturer. This made it possible to restore an event list (see Fig. 128).

ID	Description	State	Message	Value	Unit		UTC	
AIR004	CONTROL AIR PRESSURE	ALM	LOW ALARM	+8.0	bar	M1	10-10-07 20:12:19	B
			(...)					
ME1087	ME1 SEA COOL.W.PRESSURE	ALM	LOW ALARM	+0.11	bar	M1	10-10-08 18:58:43	B
ME1083	ME1 START.AIR PRESSURE,INLET	ALM	LOW ALARM	+0.3	bar	M1	10-10-08 19:00:15	B
ME2083	ME2 START.AIR PRESSURE,INLET	ALM	LOW ALARM	-0.2	bar	M1	10-10-08 19:02:16	B
ME1061	ME1 LT COOL.WATER TEMP.IN	ALM	HIGH ALM	+39.0	°C	M1	10-10-08 19:58:27	B
ME2083	ME2 START.AIR PRESSURE,INLET	NORM	NORMAL	+24.4	bar	M-	10-10-08 22:09:30	E
ME1083	ME1 START.AIR PRESSURE,INLET	NORM	NORMAL	+24.5	bar	M-	10-10-08 22:09:55	E
ME1086	ME1 CPP HYDR. OIL PRESS.	NORM	NORMAL	+31.5	bar	M-	10-10-08 22:34:06	E
ME2086	ME2 CPP HYDR. OIL PRESS.	NORM	NORMAL	+26.3	bar	M-	10-10-08 22:34:06	E
ME1085	ME1 RED.GEAR CLUTCH OIL	NORM	NORMAL	+23.4	bar	M-	10-10-08 22:40:59	E
ME1084	ME1 RED.GEAR LO PRESSURE	NORM	NORMAL	+2.70	bar	M-	10-10-08 22:41:01	E
ME2085	ME2 RED.GEAR CLUTCH OIL	NORM	NORMAL	+23.6	bar	M-	10-10-08 22:41:03	E
ME2084	ME2 RED.GEARLO PRESSURE	NORM	NORMAL	+2.48	bar	M-	10-10-08 22:41:05	E
ME1087	ME1 SEA COOL.W.PRESSURE	NORM	NORMAL	+0.66	bar	M-	10-10-08 22:54:10	E
AIR002	STARTING AIR RECEIVER 1	ALM	LOW ALARM	+17.4	bar	M1	10-10-08 22:55:32	B
AIR002	STARTING AIR RECEIVER 1	NORM	NORMAL	+18.3	bar	M-	10-10-08 22:55:51	E
ME2061	ME2 LT COOL.WATER TEMP. IN	ALM	HIGH ALM	+39.1	°C	M1	10-10-08 22:55:53	B
ME1061	ME1 LT COOL.WATER TEMP.IN	NORM	NORMAL	+38.1	°C	M-	10-10-08 22:56:03	E
ME2061	ME2 LT COOL.WATER TEMP. IN	NORM	NORMAL	+38.6	°C	M-	10-10-08 22:57:40	E
ME2133	ME2 COOL.WATER EXP. TK HIGH	ALM	ALARM			M1	10-10-08 22:58:33	B
ME2133	ME2 COOL.WATER EXP. TK HIGH	NORM	NORMAL			M-	10-10-08 23:09:24	E
<END OF LIST>								

Figure 128: Excerpt from the event list of the control and monitoring system

According to the times in the list, it contained the events from 7 October 2010 at 2019 UTC to 8 October 2010 at 2309 UTC. However, it later transpired that the times, unlike indicated in the right column, concerned Lithuanian local time (UTC + 3) rather than UTC. Hence, the reconstructed list contained only the events leading up to 8 October 2010 at 220924 German time. Consequently, relatively few entries are present on the list and it finished with preparation of the main engines for the forthcoming voyage to Klaipėda.

The stored data were identical on both hard disks, meaning that reading the second hard disk did not reveal any additional findings.

Together with the hard disks, the manual for the control and monitoring system was also secured on board the LISCO GLORIA. This contained a reference to the network time-out alarm, which the VDR had recorded on 9 October 2010 at 0002:

> Panel communication error
>
> The alarm will occur in case of communication failure between the selected master Gamma and one or more of the alarm panels because of one of the following reasons:
>
> a) The 24Vdc power to the panel is switched off / fuse broken.
> b) The communication cable interconnecting the alarm panel(s) and the Gamma ACC[25] is disconnected.
> c) The SIO[26] module or the BASIC-Module controlling the panel communiation network in the Gamma ACC is faulty.

[25] Alarm Control Cabinet
[26] Serial Input / Output

The correction of a) and b) are self-explanatory. If a panel is operating and the communication to the Gamma ACC is lost, the panel will raise a local alarm, indicating the following in the LCD display:

----- NETWORK TIME-OUT -----
----- CONNECTION LOST. -----

Panel communication failure indication at an AAP[27].

The alarm will also occur at the moment when the power is connected to the alarm monitoring system.

In case of c) the SIO module which is located in the cabinet of the Gamma ACC must be replaced. Please follow the procedure for spare part exchange.

In the course of the investigation, it was not possible to establish precisely what triggered the network time-out alarm at 0002 on 9 October 2010. The same applies to the question as to whether and to what extent – possibly due to a brief drop in voltage – it was connected with the immediately preceding activation of the drencher system. At the time of the attempted start-up of the drencher pump (capacity: 440 V 60 Hz at 3,600 r/min), one of the generators was in operation. During the investigation, no evidence was found to suggest that a momentary overload could have occurred due to switching on the drencher pump in addition to the other consumers. On the sister vessel, the DANA SIRENA, the investigation team carried out a test involving the drencher pump being started and stopped repeatedly at short intervals, which led to an increased load. But even such extreme conditions did not cause a voltage drop.

During the period until the end of the VDR recording (002345 on 9 October 2010), there was definitely no general blackout on the LISCO GLORIA as the other systems continued to function regardless of the network time-out alarm. However, brief problems with the power supply were reported while the lifeboat on the starboard side was being made ready, meaning the lowering operation had to be conducted manually. At this point, almost half an hour after the fire broke out, the fire pumps were still operational; this made it possible to use the fire hoses to cool the deck.

3.3.2.11 Witness interviews

The interviewing of witnesses was a key element of the marine casualty investigation. 235 people from nine different countries were on board the LISCO GLORIA on the night of the accident. All the crew members were from Lithuania, as were 73% of the passengers, including the drivers. The remaining passengers came from Germany, Latvia, Estonia, Denmark, Armenia, Uzbekistan, Spain and the Netherlands. After the evacuees arrived in Kiel, the witness interviews were carried out by the police and the BSU, and subsequently amongst others also by the Lithuanian investigating authority. Crew members, passengers and truck drivers were

[27] Accommodation Alarm Panel

interviewed. In this manner, it was possible to trace the course of the accident and rescue operation from the perspective of 165 of a total of 235 people on board.

The witness accounts varied in detail. The information given indicates that 107 of the 141 passengers interviewed (70 passengers and 71 truck drivers) became aware of the fire independently. Most of them noticed a burning smell or smoke in their cabin and then proceeded to the assembly point in the bar. Explicitly, they did not hear an alarm. On the other hand, four passengers reported that they had heard a faint beeping noise. According to the crew, an abandon ship alarm was sounded. Seven passengers reported that they had been alerted by a knock on the door of their cabin. Two of them attributed the knocking to what they thought were drunken passengers rather than an alarm and became aware of the fire only when the power failed in their cabin. Alerting others by knocking had been done by both crew members as well as passengers. It was difficult for the passengers to distinguish who was a passenger and who was a crew member as most of the crew wore leisure clothes while off duty.

After being alerted, most of the crew members went to the stations to which they were assigned according to the allocation of duties on the muster list. Reportedly, one crew member initially made an unsuccessful attempt to get out into the fresh air on deck 7 and deck 6 before being let into the bar on deck 7 by another crew member and taken to the lifeboat station. Furthermore, contradictory statements also exist as regards the rescue of a female crew member from a cabin on deck 8 above the starboard lifeboat station. Ultimately, the crew succeeded in getting all the passengers and itself to safety except for the adolescent subsequently rescued by helicopter.

Seven passengers reported difficulties in launching the lifeboats. In particular, the starboard lifeboat was reportedly lowered unevenly and let go from the hooks too far above the water line. According to two passengers, not enough life-jackets were distributed. Two other passengers reported that they were sent back to their cabin by crew members.

The investigating authorities do not have witness statements on hand to the effect that the crew had been made aware of missing persons during the evacuation. The absence of the adolescent, who was the last passenger to be evacuated from the LISCO GLORIA by helicopter, was noticed only after his classmates had already been picked up by the DEUTSCHLAND.

3.3.3 Shore-based emergency management

The shore-based emergency management got started after the accident was reported on VHF channel 16. Bremen Rescue Radio, respectively, MRCC Bremen initiated the necessary measures during the first hour. After that, the Central Command for Maritime Emergencies (CCME) assumed overall responsibility for coordination of the operation at 0120. On 10 October 2010, the Royal Danish Navy assumed overall responsibility for coordination of the operation.

3.3.3.1 MRCC Bremen and Bremen Rescue Radio

MRCC Bremen is operated by the DGzRS and manned around the clock. In an emergency case it coordinates search and rescue operations. In case of an

emergency, MRCC uses the DGzRS's own coastal radio station Bremen Rescue Radio, which maintains a daily 24-hour listening watch on the internationally obligatory radio channels VHF 16 and DSC (digital selective calling) 70. Both, MRCC as well as Bremen Rescue radio are located in the headquarters of the DGzRS.

At the workstations of the watch teams, it is possible to access the WSV operated Automatic Identification System (AIS) “German coast”, which delivers a clear picture of the current traffic situation for vessels equipped with AIS in the North and Baltic Seas. Detailed vessel information for vessels flying the German flag can be accessed via the national database of the Federal Network Agency. For information about vessels flying a foreign flag, the DGzRS uses various publicly available databases on the internet. In addition, vessel operators have provided MRCC Bremen with numerous, and regularly updated, emergency plans, for their respective passenger vessels in accordance with SOLAS Chapter V, Regulation 7.3. These include, amongst others, ship plans and contact information. The SOLAS emergency plan for LISCO GLORIA was agreed upon with MRCC Klaipėda. MRCC Bremen did not hold this plan.

On the night of the accident, the watch supervisor, a radio operator and one other employee of the DGzRS began their shift at 2100. Night shifts usually ended at 0700 on the following day.

The first contact with Bremen Rescue Radio was made at 0007 on VHF channel 16 in English. The master of the LISCO GLORIA reported with a normal call the name of the vessel and vessel type (motor vessel) and notified about the fire on board. Due to language problems, a few minutes passed before Bremen Rescue Radio was able to properly classify the message. The core information, notably that the vessel was a ro-ro passenger ferry, was ultimately sent in German by the pilot station at Kiel (Kiel Pilot), which was monitoring the VHF channel. The further exchange of information about the vessel's position and location of the fire was then continued directly between the LISCO GLORIA and Bremen Rescue Radio. At the same time MRCC Bremen started with coordination of the rescue operation and information of the relevant authorities. At first, as provided for in the reporting structure, the Maritime Emergencies Reporting and Assessment Centre (MERAC) of the CCME was informed about the accident.

The number of people on board the LISCO GLORIA was requested by Bremen Rescue Radio at 0012. After sending the mayday relay message at 0013, Bremen Rescue Radio started to order the ships in the area to proceed to the distressed vessel. In a radio communication with the NEUSTRELITZ in German at 0048, Bremen Rescue Radio pointed explicitly to the need for a reliable head count of those taken on board. A number of vessels on scene did not comply with this consistently.

At 0115, MRCC Bremen and MRCC Klaipeda exchanged information about the on scene situation. Even after the CCME had assumed overall responsibility for coordination of the operation, the further communication with the vessels involved in the rescue operation was conducted on VHF channel 16 with the involvement of Bremen Rescue Radio. At 0325, a request from the Rescue Coordination Centre at

Kiel regarding the ETA of the DEUTSCHLAND in Kiel and number of evacuees was forwarded to Bremen Rescue Radio, which in return reported that 243 evacuees were headed for Kiel. The ETA at Kiel Lighthouse was 0430. The required communication regarding the berth and necessary tugs for the DEUTSCHLAND was also conducted via Bremen Rescue Radio.

Meanwhile, the German vessels at the scene communicated extensively in German on VHF channel 16; therefore, at 0447 Bremen Rescue Radio repeated the mayday message in English and requested that radio discipline be observed. Coordination of the fire-fighting operation and communication between the vessels and helicopters at the scene was subsequently conducted partly on the VHF operating channel 10, which was not recorded.

3.3.3.2 German Central Command for Maritime Emergencies

The German Central Command for Maritime Emergencies (CCME) is based in Cuxhaven, Germany and has been the maritime emergency response organisation of the German federal government and federal coastal states since 2003. In the event of serious marine casualties (so-called complex damage scenarios), it shall ensure unified management of the operation, including public information. For this purpose, it operates the Maritime Emergencies Reporting and Assessment Centre (MERAC) around the clock. The manning of MERAC is divided equally between its own nautical personnel and representatives from waterway polices from the coastal states. CCME is responsible for planning, preparing, exercising and implementing all precautionary measures for maritime emergencies, including

- life-saving;
- marine pollution response;
- fire-fighting;
- technical assistance;
- medical response;
- salvage operations to avert hazards, and
- press and public relations.

MERAC is located at the same premises as the German Joint Situation Centre Sea (GLZ-See) of the Maritime Security Centre in Cuxhaven. The operating units of the federal government and coastal states work together in the GLZ-See in the form of an 'optimised network'. Personnel from the Coordination Centres of the Federal Police, Customs, the Department of Fisheries Protection of the Federal Agency for Agriculture and Food, the Coordination Centre of the Waterway Polices of the Coastal States, the Waterways and Shipping Administration of Germany's federal government and a liaison officer of the German Navy work there alongside the staff of MERAC. The GLZ-See is also manned around the clock. Although the CCME, through its MERAC, is represented in the GLZ-See, the crisis management team is based in a separate building complex. Communication between the crisis management team, MERAC and the GLZ-See is conducted via conventional telephone lines.

For complex damage scenarios, such as the fire on the LISCO GLORIA, the head of the CCME assumes overall responsibility for coordination of the operation and is

supported and advised by the crisis management team. Here, the CCME utilises all authorities, organisations and other agencies with responsibilities at sea and the coastal area of the federal government and the states. The objective is a uniform and coordinated approach by all task forces of the federal government and coastal states. The legal bases for the work of the CCME are laid out in agreements between the federal government and all five coastal states[28]. The DGzRS, with its Maritime Rescue Coordination Centre, as well as adjacent Rescue Coordination Centres and the German Navy are also fully involved in the work of the CCME via cooperative agreements.

The CCME has supported the marine accident investigation since the night of the accident with trustful cooperation and information sharing. For the reconstruction of the emergency management, representatives of the BSU attended several meetings of the CCME with the task forces and authorities. The detailed documentation of the CCME made it possible to trace in depth the actions taken on the night of the accident and during the period that followed, thereby making a significant contribution to analysing the emergency management.

The accident notification of the LISCO GLORIA was relayed to the CCME by MRCC Bremen on 9 October 2010 at 0011. In return, the duty personnel of section 4 – Fire-Fighting, Rescue and Medical Response – as well as FFUs (one from each of the following fire brigades: Lübeck, Kiel, Rostock and Hamburg) and one CCT from Hamburg were alerted promptly. After these initial measures, detailed information was obtained (passenger list, location of the fire, dangerous goods plan, etc.) and transportation of the task forces to the distressed vessel coordinated. The CCME assumed responsibility for coordinating the operation officially at 0120. All authorities and agencies concerned were informed of this by fax. At this point, the crisis management team of the CCME consisted of five people.

At the same time, the Rescue Coordination Centre “Central” at Kiel informed the Rescue Coordination Centre of the Administrative District of Ostholstein about the marine casualty and the required measures to provide for some 220 evacuees. This message was forwarded from there to numerous agencies and more than a hundred people from the rescue and fire services were ordered to the DEUTSCHLAND's presumed port of call, Puttgarden. There was no prior coordination with the CCME in this regard. The CCME was not aware of the actions taken by the Rescue Coordination Centre. The flow of information between the CCME and the Rescue Coordination Centre was restricted, amongst other things, due to limited personnel resources on the part of the CCME. This led to a considerable delay in the forwarding of information, especially to the task forces of the Ostholstein Administrative District.

At 0222, the head of the CCME issued instructions for the DEUTSCHLAND to proceed to the naval base in Kiel with the evacuees. The situation centre and casualty collection point were also set up there. There were brief differences regarding the choice of Kiel or Puttgarden. However, these were settled by the CCME, which clearly defined Kiel.

[28] “Havariekommando-Vereinbarung”; literally translated: “Agreement on a Central Command for Maritime Emergencies”

Meanwhile, the executive director/head of the rescue services section of the DGzRS had arrived at the operational headquarters of the CCME in Cuxhaven, where he acted both as an adviser and liaison officer with MRCC Bremen. It was possible to alert more advisers and CCME personnel during the following hours in order to relieve the five-member team. The on-site team in Cuxhaven alerted further FFUs and CCTs as well as a boarding team and coordinated the transport of the task forces to the scene of the accident by helicopter. Essentially, mobile phone was used to communicate with each operational commander; occasionally, this led to problems contacting them due to a lack of network availability. Additionally there were also delays in sharing information with the GLZ-See.

At about 0400 the SAR helicopter 8957 had already been waiting with running engine at the naval flight squadron 5 in Kiel since 40 minutes. The CCT, announced by CCME, had a major delay during its journey. The CCME was informed of this. Overall, there was no central coordination of the air rescue services to and from the distressed vessel.

At 0550, the Danish Royal Navy and CCME agreed that overall responsibility for coordination of the operation would remain with the CCME, for the time being, even though the LISCO GLORIA had drifted into Danish waters in the meantime. In a further conversation with the Danish Navy at 0600, a possible capsizing of the LISCO GLORIA because of her list was discussed. It was agreed that the SCHARHÖRN would continue to act as OSC, the ROTA would remain at the scene and in addition the MARIE MILJØ and GUNNAR THORSON, both environmental protection vessels, would be deployed to the distressed vessel.

The medical response was ready at the naval base in Kiel from 0600 onwards and at 0618 the waterway police began to ascertain the particulars of all the evacuees on-site.

At 0640, the CCME was informed that due to the highly toxic gases measured, the environmental protection vessel ARKONA could not be deployed in the area of the smoke gases on the port side of the LISCO GLORIA for any longer. After consulting with the OSC on the SCHARHÖRN at 0735, the CCME aborted the hitherto planned transfer of the two-member boarding team to the LISCO GLORIA for reasons of safety.

The psychosocial emergency care organised by the CCME for the evacuees at the naval base in Kiel started at 0810 with 15 carers. At the same time, the telephonic personal information centre was organised. Before that, this was carried out by the CCME crisis management team.

At 0830, a first briefing with operational commanders of the shore-based rescue and fire-fighting services, naval officials, representatives of the waterway police Kiel as well as representatives of the vessel operator and the BSU was held at the naval base in Kiel. The scope of duties and powers of the CCME were not known to all the operational commanders in Kiel. The CCME was not represented at the naval base due to its limited personnel resources. Any inquiries were relayed to the employees of the crisis management team by mobile phone.

Furthermore, a navigational warning for seafarers was issued by the Vessel Traffic Service Centres on the initiative of the CCME. At 0938 the drifting of LISCO GLORIA could be stopped as the boarding team managed to drop both of the anchors.

At about 1300, most of the evacuees had been registered and interviewed by the police and had then been taken to the hotel rented by the vessel operator. At the same time, the crisis management team coordinated the release of individual vessels and task forces at sea as well as the relief and provision of units still required on scene, possible fire-fighting measures without continued risk to the stability of the vessel, possible towing manoeuvres, the exchange of information with ministries, authorities, the salvage company of the vessel operator and international agencies (SOK and MRCC Klaipėda) concerning the situation at the scene and in Kiel, preliminary water protection measures and liaising with the press.

3.3.3.3 Royal Danish Navy (SOK)

The Operational Command of the Royal Danish Navy (SOK) was informed about the accident of the LISCO GLORIA on the morning of 9 October 2010 at 0014 by Lyngby Radio and at 0138 by the CCME. JRCC Aarhus was informed by MRCC Bremen at 0018. The SOK promptly deployed the naval vessel ROTA, the coast guard vessels HOLGER DANKSE and ENØ as well as the naval helicopter MERLIN 507 to the distressed vessel. After the evacuation had been completed successfully, the ROTA participated in the fire-fighting operation.

The focus of the Danish Navy on 9 October 2010 and in the following days was the prevention of water pollution. To that end, the environmental protection vessels MARIE MILJØ and GUNNAR SEIDENFADEN were alerted at 0200 and the GUNNAR THORSON at 0835, deployed to the distressed vessel and kept on stand-by for the oil pollution response. Deploying oil booms was considered several times, but ultimately regarded as ineffective due to the prevailing sea conditions (1.5 to 2 m swell). In addition, deploying of oil booms would have hampered the ongoing fire-fighting operation. Given the extremely thin film of oil, which was observed only in close proximity to the LISCO GLORIA, a decision was made to abstain from the use of oil booms. There was no further oil spillage in the ensuing period.

The SOK assumed overall responsibility for coordination of the operation from the CCME on 10 October 2010. Focus continued to be put on the prevention of water pollution. Accordingly, on 12 October 2010, the SOK instructed the salvage company commissioned by the shipping company not to dispose the fire-fighting water overboard, but to arrange for a barge to pump it out. This was complied with.

The SOK's role in the operation ended with the successful tow of the LISCO GLORIA to the port of Munkebo.

4 ANALYSIS

After several weeks of fire, the high degree of destruction of vessel and cargo remains made it impossible to conclusively determine, through a thorough scientific investigation, the cause of the fire. Regardless of the question as to what ultimately caused the fire, the joint investigation of Lithuania and Germany offered many indications for further analysis with the aim of improving the safety of shipping and the protecting the marine environment.

4.1 Cargo

In national and international ferry transport the checks by the vessel operator and crew, to which the cargo on board is subject to, are inevitably only limited. Although a cargo plan can be prepared based on the submitted cargo data after the corresponding passage has been booked, the extent to which the booked cargo concurs with the actual cargo can, at best, be determined through random testing and general experience. Only the stowage of dangerous goods is regulated. On vessels that carry passengers, flammable gases (Class 2.1) and flammable liquids (Class 3) must be stowed at a safe distance from any decks or areas intended for use by passengers.[29] This requirement had been complied with by the vessel operator of the LISCO GLORIA. Accordingly, the investigation did not reveal any evidence that would suggest that the fire may have been caused by, e.g., dangerous goods stowed on the weather deck. Moreover, the thermal reaction of the dangerous cargo, in particular the spray cans, caused by the fire spreading across the open weather deck is not likely to have been crucial for the extent of the fire. The passengers and crew of the LISCO GLORIA as well as the crews of those vessels that approached for assistance reported several explosions. Judging by the damage pattern found and in accordance with the accounts given, numerous vehicle tyres and tanks had exploded along the entire length of the vessel.

The cargo in the trailer at which the duty crew member had observed the fire starting was refrigerated chicken necks. Self-ignition of this cargo can be excluded, but not a possible ignition of the refrigeration unit or other truck parts (e.g. the battery) due to a technical or electrical fault. Similarly, the ignition of objects in the cab cannot be excluded, even though this is less likely in view of the comprehensible observations of the duty crew member. Beyond that, the investigation did not reveal any evidence of arson.

4.2 Fire safety

The fire safety on board the LISCO GLORIA is rated above average, especially with respect to the effectiveness of the A-60 fire insulation. The SOLAS criteria, according to which the average temperature of the unexposed side of the insulation shall not, for a period of 60 minutes, rise more than 140°C above the original temperature, nor shall the total temperature rise more than 180°C above the original temperature, does apply for an average fire under laboratory conditions. Due to the unlimited supply of oxygen from three sides, the magnitude of the fire on board the LISCO GLORIA can by no means be compared with a fire under controlled conditions. According to the fire experts, temperatures must have risen to above 660 °C as the

[29] See IMDG Code, Regulations 7.1.8.2.2 and 7.1.9.8.

aluminium fitted in the superstructure melted. In spite of that, the A-60 insulation resisted the fire for an hour, even though the lifeboat station on the starboard side directly above the observed source of the fire had to be cooled down before it could be entered. However, the temperatures that occurred on the starboard side of deck 7 during the evacuation could still have easily been within the permissible approx. 200 °C (180 °C plus the estimated original temperature).

Due to the attentiveness of the crew member on duty, the fire and cargo round also proved to be effective and resulted in the bridge and fire-fighting teams being alerted promptly.

The fire safety objectives for sea-going vessels under SOLAS[30] are as follows:

- prevent the occurrence of fire and explosion;
- reduce risk to life caused by fire;
- reduce the risk of damage caused by fire to the ship, its cargo and the environment;
- contain, control and suppress fire and explosion in the compartment of origin; and
- provide adequate and readily accessible means of escape for passengers and crew.

Since despite an in-depth investigation it remains open whether the fire was caused by a fault on the ship or the truck, and precisely what that fault was, the investigating authorities are abstaining from speculating on possible fire prevention options. The danger to life for passengers and crew was effectively reduced by the A-60 insulation and closing of the fire dampers. The risk of damage caused by the fire could not be reduced under the prevailing conditions. Despite the insulation between both the upper deck and superstructure as well as between the main and upper deck, the spread of fire to the rest of the vessel and the majority of the cargo was only a matter of time given the devastating temperatures of the initial fire. Moreover, containment or control of the fire in the garage area of the upper deck was only possible to a very limited extent. Here, the only available means of fire protection were the fire doors that separated the cargo area from the superstructure. According to the VDR recordings, the fire door to the portside stairwell was open the whole time, whereas one crew member stated to have found it closed. The investigating authorities did not find any indication for a supposedly incorrect display for this single fire door. All other fire door VDR recordings were plausible and match the known movements of persons on board by indicating doors alternately as either open or closed. It is therefore assumed that the originally designed fire safety of the fire door to the portside stairwell was compromised, although that does not necessarily mean it stood wide open. The accessibility of the sprinkler room on deck 5, from where the drencher system failure could have been resolved, was impaired by smoke building up in the stairwell.

Based on the VDR recordings of the bridge microphones, it can more or less be ruled out that the bridge was aware that the fire door in question was open. A number of

[30] See SOLAS Chapter II-2, Part A, Regulation 2.

times, lack of understanding is expressed about the heavy and rapid development of smoke although the ventilation systems was being closed. At no time was the closing status of the fire doors on the upper deck discussed. The investigating authorities believe that information about the existing malfunction was available in a sub-menu of the fire detection and alarm system and basically should have been discovered.

Nearly all the passengers and all the crew members were able to cope with the sufficient and easily accessible escape routes (see also sub-para. 4.6).

4.3 Fire-fighting

The violent course of the fire on the LISCO GLORIA is largely due to problems encountered during the fire-fighting. Although the fire was quickly identified by the smoke detector and reported by the duty crew member with concrete information about its source, neither the bridge crew nor the fire-fighting team had a realistic chance of controlling or even extinguishing the fire because the drencher system did not work. The unanimous opinion of several fire experts interviewed is that it was very unlikely that the duty crew member could have contained the fire, e.g. with the aid of a powder extinguisher. Accordingly, the duty crew member behaved – also in terms of his personal safety – appropriately when he reported the fire to the bridge and then immediately went to the fire-fighting team's equipment room.

The investigating authorities are of the opinion that successful use of the drencher system would not necessarily have led to the fire being extinguished. Experience gained from other ferry fires (see sub-para. 4.8) has shown that in spite of using significant amounts of water, fires are not always completely extinguished by drencher systems. However, in all probability, a fully operational drencher system would have given the ship's command of the LISCO GLORIA more time to contain the fire and use the fire-fighting team for targeted measures. The rapid temperature increase in the garage area of the upper deck and the build-up of smoke could have been reduced. This may have made it possible for the LISCO GLORIA to return back to Kiel and fight the fire there with the support of the fire brigade. The investigating authorities believe that the drencher system was actually fully operational on the night of the accident. However, many indications suggest that the operation of the drencher system was compromised due to the valve control being set to “manual”. This may have been apparent from the engine control room because the operational readiness indicating light for the drencher pump is unlikely to have been illuminated in that condition. However, after the incident, it was not possible to determine this conclusively.

Beyond dispute is the fact that the lack of water supply was noticed quickly by the master on the bridge, who therefore ordered the duty engineer in the engine control room to start the system from there. From that point, a number of different circumstances converged, which collectively ultimately led to the failure of the attempt to extinguish the fire. Due to the fire door on the port side of the upper deck being open, the smoke was able to enter the stairwell there unhampered. According to SOLAS Chapter II-2, Regulation 10, passenger vessels carrying more than 36 passengers shall be equipped with an automatic sprinkler, fire detection and fire alarm system of an approved type complying with the requirements of the FSS

Code[31] in all control stations, accommodation and service spaces, including corridors and stairways. This requirement was met by installing a sprinkler system on board the LISCO GLORIA, which, as intended, triggered automatically when the temperature threshold of 100 °C was exceeded. The investigating authorities further believe that activation of the sprinkler system, or the temporary, associated increase in pressure in the sprinkler pipes caused to the connection near the engine control room to part (see Fig. 88), resulting in an uncontrolled flooding of this area as well as lower lying areas. This circumstance was highly threatening to the stability and safety of the LISCO GLORIA and, therefore, required immediate action by the duty engineer, as did the incorrect valve setting on the drencher pump. Since the ship's command was not informed about this simultaneously occurring problem, the master on the bridge was not in a position to relieve the duty engineer, if necessary, by other crew members (e.g. the chief engineer).

When the duty engineer headed for the sprinkler room on deck 5, the fire had already been raging on the upper deck for more than ten minutes. In addition to the option to disable the sprinkler system in the sprinkler room, it would also have been possible to connect the drencher to the fire main line by operating a hand wheel. This would have circumvented the problem with the valve setting on the drencher pump in the engine room and the drencher system could have delivered fire-fighting water on the upper deck. It remains unclear whether the duty engineer was aware of this option for connecting the drencher and fire main system, or whether he mistakenly assumed that the drencher pump had already been activated due to the settings made on the main switchboard in the engine control room. The only certainty is that the drencher system was not supplied with water from the fire main system and the duty engineer did not report back to the bridge even after correcting the problem with the sprinkler system and returning to the engine control room.

With regard to the lack of fire-fighting water, the bridge crew constantly assumed this was due to a problem with the power supply. Consequently, the master decided on an evacuation. The option of connecting the fire main system with the drencher system was not discussed. However, more than ten minutes after the fire broke out it was almost impossible to reach the sprinkler room from the superstructure because of the thick smoke. This would have required the use of breathing apparatus.

The fire-fighting team had no chance of launching its own attempt to extinguish the fire. For reasons of personal safety, fire-fighting suits and equipment had to be donned first. Here, several crew members who did not belong to the team provided assistance. During the first attack then the smoke and heat met by the team on the upper deck made fire-fighting impossible, even with breathing apparatus. Also visibility and the cargo stowage situation made it impossible to advance to the observed seat of fire. Since the master took the decision to evacuate shortly after the first feedback from the fire-fighting team, crew members were then required to carry out their duties according to the muster list.

Effective fire-fighting by the other vessels that had rushed to assist the distressed ship was no longer possible, either. Evacuating the passengers and crew was the

[31] International Code for Fire Safety Systems (Resolution MSC.98(73)).

sole priority of the first vessels at the scene and the first attempts at extinguishing the fire were only possible after that was completed. Since the entire length of the upper deck of the LISCO GLORIA was already in flames when the first vessels arrived, a promising attempt at extinguishing the fire was no longer possible. The unhampered supply of oxygen fanned the fire repeatedly; furthermore, with the cargo and later the furnishings in the superstructure (e.g. the upholstery of mattresses and chairs as well as combustible fittings and luggage), there was a considerable amount of combustible material available to feed it. In addition, the scuppers had become partly clogged with debris from the fire, resulting in fire-fighting water being trapped on the upper deck, which caused the ferry to heel to the port side. Henceforth, it was more and more a case of preventing the LISCO GLORIA from capsizing, if possible, and eventually ensuring that the ferry burned in a controlled manner (see sub-para. 4.7.3 with regard to shore-based coordination of the fire-fighting operation).

4.4 Development of the fire

Since the fire had raged on the LISCO GLORIA for two weeks, and even after brief successes in terms of fire-fighting had reignited several times, the level of destruction found on board during the first survey was too great to be able to make reliable statements with regard to the exact source of the fire. Generally, it was found that the damage, in particular, to the supporting structures, tended to be greater on the starboard side. The garage area on the upper deck was affected by the fire most of all, where on the starboard side, viewed from the longitudinal axis, the fire funnel towards the accommodation superstructure (see Figs. 17 and 18) and significant frame deformation towards the main deck (see Fig. 31) had formed. The truck on which the outbreak of fire was observed was also the one with the greatest fire damage. The investigating authorities and the fire experts rate the observed source of the fire as credible.

The small distance between the sides of the parked vehicles, which is normal on all ro-pax ferries, favoured the rapid spread of fire. The fire broke out between the cab and trailer and presumably leapt across to the adjacent trailer parked on the left within a shortest period of time. A further significant factor was the unlimited supply of combustion air. The fire was initially limited to the garage area and then, through open flames and thermal radiation, spread horizontally to the open weather deck. It took several hours before the fire spread vertically downwards to the main deck. On the photo taken at about 0100 (Fig. 98), there is no visible sign of a fire on deck 4 as the paint on the hull at the level of the main deck is still intact. The spread of fire through the ventilation ducts can be virtually ruled out since the air inlets were closed immediately after the first fire alarm. Moreover, on the lifeboat stations no smoke was seen coming out of the ventilation ducts during the evacuation. First signs of the fire spreading vertically downwards only became visible nearly 2.5 hours after the fire broke out (see Fig. 102 at 0221). Since there was not an unlimited supply of oxygen on deck 4, the fire developed more slowly there.

It took several more hours for the fire to spread from the upper deck to the superstructure. In the ensuing period, fires flared up continuously on deck 6 and in the accommodation area, therefore also affecting the wheelhouse.

4.5 Navigational watch and emergency management

The bridge was manned only by the officer on watch at the time the fire broke out. The required lookout was absent because the rating certified to form part of the watch, who was on duty with the officer on watch, was on a round. The requirements for the navigational watch and, in particular, a proper lookout are set out in Regulation 5 of the COLREGS and in the STCW Code[32]. Basically, the master is required to make adequate arrangements for keeping a safe navigational watch[33]. Another person had to be assigned to the bridge as lookout by dusk at the latest. A lookout could have assisted the officer on watch, or, after the alarm, the team consisting of the master and the officer, designated for emergency situations according to the muster list, in dealing with the emanating tasks.

DFDS maintains a safety management system (SMS) for the LISCO GLORIA in accordance with the requirements of the International Safety Management (ISM[34]) Code. The aim of the ISM Code is to establish an internationally valid standard for the safe operation of vessels and the prevention of marine pollution. The SMS of the LISCO GLORIA contained a checklist for emergency situations. This provided for the following actions in the event of an outbreak of fire:

- Investigate whether alarm is false.
- Close fire doors and watertight doors and stop ventilation.
- Warn the captain.
- Start fire roll in crew accommodation.
- Warn engine room.
- Start fire pumps.
- Send fire task group to fire location.
- Note position and time.
- Stop ship, where relevant.
- Give information to passengers, nearest MRCC.
- Follow fire and evacuation emergency instruction.

Almost all the items on this list were executed first by the officer on watch and then by the master on the bridge after he was alerted.
However, after the audible release of the fire roll in the crew accommodations, this was limited to a part of the crew, since the master only explicitly made an announcement to the deck crew calling them to the upper deck. Hence a part of the crew did not feel addressed by the alarm at this time. This seemed to be the usual procedure in cases the fire detector activated itself and the cause was not known.

Without this limitation the other part of the crew would have assembled at the muster station according to the muster roll and would have been ready.

However, the passengers were not informed and the vessel's speed was not reduced. The LISCO GLORIA was still proceeding at 18.5 kts 10 minutes after the

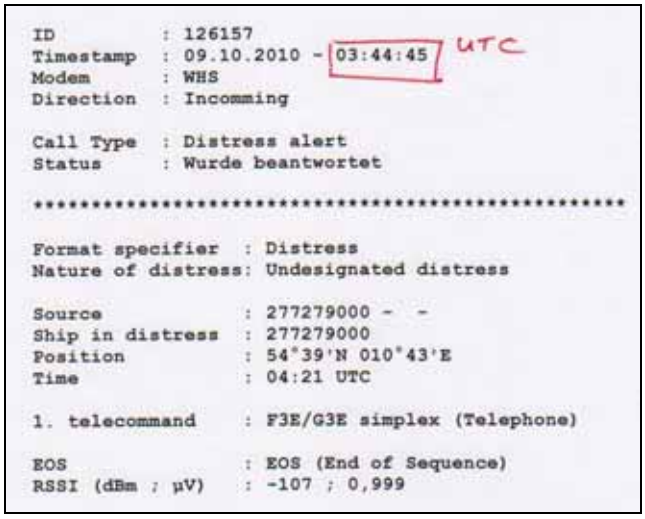
[32] See Chapter VIII, Section A-VIII/2, Part 3-1 International Code on Standards of Training, Certification and Watchkeeping (STCW Code).
[33] See Chapter VIII, Section A-VIII/2, Part 3 (9) and Part 3-1 (16) STCW Code.
[34] International Management Code for the Safe Operation of Ships and for Pollution Prevention.

fire broke out. The investigating authorities are of the view that an earliest speed reduction might have helped not to additionally fan the flames by the strong headwind. However, with the drencher system not working, a speed reduction alone would, in all probability, not have resulted in a different damage outcome.

The SMS contained the following additional instructions with respect to abandoning the vessel:

- Send DISTRESS ALERT using all available equipment (DSC, VHF and etc.).
- Activate ABANDON SHIP alarm.
- Inform the passengers via public address system; summon them to the designated assembly. Pay attention to their clothing.
- Switch on lighting at Assembly stations, boat and rafts deck.
- Start preparing life saving equipment for lowering. Check the falls securing to the deck.
- Check assembled passengers according passenger and crew lists. Organize searching of missing people.
- Divide the crew and passengers to the life saving appliances (life boats, life rafts).
- Start engines life boats, disconnect hooks and move away form the ship.
- Organize lowered life saving appliances meeting in one place, try to follow abandoned ship.
- Activate the EPIRB, switch on SART, turn on VHF Ch. 16.

The question as to whether the SAR coordination could have been accelerated in general if the LISCO GLORIA had sent a DSC message early on was raised in the course of the investigation. When assessing this question, it proved to be problematic that the ship's command of the LISCO GLORIA reported to have transmitted such a message, while neither MRCC Bremen nor another coastal or mobile station initially could confirm receipt of it. As the investigation progressed, it transpired that a DSC message from the LISCO GLORIA was, in fact, received by MRCC Bremen, but not until 0544 on 9 October 2010 (see Fig. 129).



```
ID          : 126157
Timestamp   : 09.10.2010 - 03:44:45 UTC
Modem       : WHS
Direction   : Incomming

Call Type   : Distress alert
Status      : Wurde beantwortet

************************************************

Format specifier  : Distress
Nature of distress: Undesignated distress

Source            : 277279000 -  -
Ship in distress  : 277279000
Position          : 54°39'N 010°43'E
Time              : 04:21 UTC

1. telecommand    : F3E/G3E simplex (Telephone)

EOS               : EOS (End of Sequence)
RSSI (dBm ; µV)   : -107 ; 0,999
```

Figure 129: DSC message from the LISCO GLORIA

From a technical aspect, this message is a mystery because it was supposedly transmitted by the bridge crew, who left the ferry at 0115. The message was not only delayed, but also contained the current position coordinates at 0544 (south of Langeland). However, there was no one on board at this point in time. Moreover, also the ships in the vicinity of the distressed vessel had not received the DSC message, but only the mayday relay message from MRCC Bremen. Ultimately, it was not possible to explain the technical circumstances under which the significantly delayed message could have been sent. MRCC Bremen was not in a position to provide any explanation in this regard, either. In conclusion, the investigating authorities presume that the DSC message had been triggered by the bridge crew before leaving the vessel, but was sent with the considerable time lag due to technical problems. Even though in this case the DSC message could not help to simplify communication for the LISCO GLORIA, the investigating authorities still regard it as an important tool in terms of summoning assistance in an emergency via a standardised text message.

No general alarm (seven short blasts, one long blast) was sounded on board the LISCO GLORIA. It remains unclear whether, and if applicable in what area, an abandon ship alarm was sounded. This is defined in the muster list as one long continuous blast. Such a sound can be heard on VDR recordings of the night of the accident at 000436. Since alarm log data could not be secured and an objective classification of the alarm was therefore not possible, the investigators triggered different alarms on the sister vessel, the DANA SIRENA, for testing purposes. In this test, purely in terms of auditory perception, the continuous sound recorded by the VDR corresponds with the alarm that occurs when recurring fire alarms are not acknowledged. However, it is possible to assign audible alarms individually from vessel to vessel. Therefore, the findings in relation to the alarms on the DANA SIRENA are not necessarily transferable to the LISCO GLORIA. Nevertheless, the investigating authorities believe that the alarm recorded by the VDR was such a fire alarm, which had not been acknowledged. This is supported on the one hand by the time at which the alarm occurred: six minutes after the fire broke out multiple audible alarms had accumulated on the bridge. For the most part, these were probably smoke detector alarms from the garage area of the upper deck. The bridge team had more important things to do than continuously acknowledge new fire alarms (several short blasts in each case). With that in mind, it seems quite plausible that six minutes after the fire broke out a continuous noise generated by the fire detection system as the alarms were not acknowledged. In addition, it seems premature to initiate an abandon ship alarm at that point. After all, the master took the decision to abandon the ferry at 000909, which was four and a half minutes after the continuous sound was recorded by the VDR. On the other hand, only four of the passengers interviewed reported that an audible alarm was heard. This reportedly sounded like a "faint beeping noise" quite some distance away, similar to a smoke detector alarm. The only witnesses who reported that they heard an abandon ship alarm were crew members. Therefore, it is quite possible that such an alarm was sounded only for the crew.

In conclusion, there is strong evidence to suggest that neither the general nor the abandon ship alarm had been sounded throughout the vessel. However, it cannot completely be ruled out that the abandon ship alarm was triggered somewhen later than 0004, but due to technical problems (speaker problems due to burnt cables,

etc.) was not heard by the passengers. From the perspective of the investigating authorities, it would have been highly desirable if in addition to sounding the general or abandon ship alarm after deciding to evacuate, the master had also made use of the public address system to inform the passengers. Since the passengers on board came from nine different countries, a brief recorded message in several languages would also have been helpful. Regarding the safety video that was shown on board, there are doubts as to whether the passengers recognised that this pertained to safety and whether the information was relevant. Some witnesses reported that they thought the video (see Fig. 48) was a children's programme and therefore ignored it. Furthermore, the video addressed only the general alarm, which was not used on the night of the accident. The safety posters addressed only the general alarm, too. Therefore, even if an abandon ship alarm was sounded, it cannot be taken for granted that those passengers who had familiarised themselves with the safety instructions would have been able to interpret the alarm signal correctly. However, it can be assumed that regardless of length and sequence of blasts, passengers would have paid attention if an alarm had sounded, and made inquiries with the crew if in doubt.

4.6 Evacuation

Passengers first noticed the presence of smoke within about 7 minutes of the fire breaking out. Thus, the evacuation ordered by the master shortly after was actually set in motion at the earliest possible moment by the passengers themselves who proceeded to the assembly point in the bar. The time disadvantage lasting until then and resulting from the limited release of the fire roll was compensated by the fact, that most passengers had already left their cabins when the crew started the actual evacuation. The fact that some passenger areas were not checked by the crew members to the full extent had ultimately no adverse effect.

On the whole, organisation at the lifeboat stations progressed smoothly. The crew members had difficulties loosening some of the boat lashings; therefore, and quite appropriately, they simply cut them off. It was quickly recognised that the outer area of deck 7 had to be cooled down before it could be entered. Passengers were admitted to the outer area in a controlled manner, so that although the bar was crowded and there was some pushing, there was no outbreak of panic. Even though some passengers reported there were shortages, a sufficient number of life-jackets was issued. On photos taken by witnesses on the port lifeboat, it can clearly be seen that all the evacuees are wearing a life-jacket.

The investigating authorities find it difficult to understand why the first lifeboat was lowered into the water with only about 55 people on board. After all, the boat was designed to accommodate 150 people. Moreover, when this lifeboat (starboard side) was winched down, it was still unclear whether it would also be possible to launch the lifeboat on the port side. Ultimately, the second lifeboat was almost fully occupied with 147 people. A more balanced distribution and utilisation of the full capacity of the first lifeboat would have been desirable to minimise the risks associated with rescuing the remaining people on board. However, the distribution of the people in the lifeboats and life-rafts had no negative impact on the success of evacuation.

As regards the instruction in the LISCO GLORIA's SMS to check everyone against the passenger and crew list, the investigating authorities take the view that there was no time under the prevailing conditions. Within 10 minutes, the fire had developed into such a threatening situation that the evacuation had to be carried out as quickly as possible. Moreover, the deck in the outer area on the starboard lifeboat station was so hot that it was almost impossible to remain there for more than a few seconds even after it had been cooled down. Accordingly, the crew member who controlled the influx of people waiting to be evacuated at the door from the bar suffered burns on his feet. Under such conditions, accepting an additional delay by checking off lists of names would have been extremely risky and very difficult to implement. After all, almost the whole of the upper deck was already on fire when the first lifeboat was lowered into the water. However, abstaining from verifying the lists meant it was impossible to determine whether everybody had been evacuated. If such a check had been made, a female passenger would have been identified who was not even on board the LISCO GLORIA. This may have resulted in the life of crew members being put at risk by searching for a missing person who had not been on board when the voyage started.

The EU-Directive 98/41/EC and SOLAS Chapter III Regulation 27 contain analogously the requirement, that

- all persons on board passenger ships must be counted before departure;
- additional personal information must be gathered for voyages over 20 nm[35];
- the information shall be kept ashore and made readily available to search and rescue services when needed.

The discrepancy regarding the female passenger, who had checked in at the terminal but ashore did not board the LISCO GLORIA, was noticed prior to departure. Calling for the passenger on board did not clarify the matter; therefore, strict application of the organisational provisions would have meant that she should have been removed from the passenger list. On the other hand, it was also possible that the female passenger was yet on board as she and her companion had booked the voyage with their own car; therefore, they did not need to board the vessel in the shuttle bus. Had she been deleted from the list even though she was on board, then this would have distorted verification of the list during the evacuation; as did the alternative scenario to leaving her on the list even though she was not on board. Since then, DFDS Seaways has informed the investigating authorities that it intends to make organisational changes regarding checking-in on board. Regardless of that, the investigating authorities also deem it necessary to call upon the responsibility of passengers in order to avoid such situations on other ferry lines. If circumstances that prevent embarkation arise between checking-in at the terminal ashore and boarding the vessel, then the ferry operator should be informed of this, without exception. Retention of the boarding pass may, as happened in the present case, lead to an incorrect passenger list being issued, which, in turn, may lead to considerable difficulties in the SAR operation in an emergency.

[35] Article 5 Directive 98/41/EC

Ultimately, during the evacuation of the LISCO GLORIA reliance was put on other passengers likely to report any missing person, which transpired not to be the case. Even the last passenger, who had to be rescued by helicopter, was not reported missing during the evacuation. He initially ignored the knocking on the cabin door, which was done to alert them, because he and the person he was sharing the cabin with thought it was a prank by drunken passengers. When they both became aware of the seriousness of the situation, the other passengers had already gone to the assembly point. At this point, the starboard lifeboat had probably already been lowered into the water. Hence, as the last two passengers left their cabin, the corridors were deserted and full of smoke. They split up in the panic that ensued; one of them bumped into crew members in time and was evacuated. The other one continued to wander through the superstructure. It is assumed that some of the escape routes could no longer be used at this point due to the smoke. Fortunately, the passenger finally succeeded in smashing a window and drawing the attention of the helicopter. Although he was travelling in a group, the crew of the LISCO GLORIA was not aware that one of the members of this group was still missing during the evacuation.

All in all, the evacuation was successful as despite some adversities, it was possible to save everyone from the vessel.

4.7 Coordination of assistance

4.7.1 International cooperation

International cooperation was carried out on several levels. The early exchange of information between the German Operational Command (CCME) and the Danish Operational Command (SOK) is rated very positively by the investigating bodies. Trustful cooperation in cross-border incidents has intensified between the two countries in recent years. The decision by the Danish Operational Command on the night of the accident to initially leave overall responsibility for coordination of the operation with the CCME after the LISCO GLORIA drifted into Danish waters was appropriate and practicable in consideration of the situation and the significant involvement of German vessels and task forces at the scene. Due to the continuing close involvement of the Danish side in basic considerations on how to proceed via joint meetings of the OSCs, a smooth transition of the overall operational command was facilitated on the following day, 10 October 2010.

The exchange of information between MRCC Bremen and MRCC Klaipėda also progressed positively. Both the Lithuanian Embassy in Berlin and the Lithuanian Maritime Safety Administration were included in the exchange of information from the morning of 9 October 2010 onwards.

It is rated that integration of the international vessels into the rescue and fire-fighting operation at the distressed vessel could have been better. Since communication between German vessels, helicopters and Bremen Rescue Radio was, for the most part, conducted in German, the ship's commands and helicopter crews from other countries, who communicated mostly in English, had only very limited access to essential information and arrangements. This concerned, inter alia, the requirement to count the people from the LISCO GLORIA taken on board and immediately report

back to Bremen Rescue Radio with these numbers. Since the evacuees were not reliably counted on any of the vessels at the scene, it was, for an extended period, not possible to clarify whether all the passengers had been rescued. Subsequently, counting errors also occurred, leading to incorrect passenger numbers being circulated for days, which caused unnecessary uncertainty on the part of the vessel operator and the public.

In addition, coordination of the fire-fighting operation was limited to German vessels in the hours immediately after the accident, although the Danish ROTA, a vessel with fire-fighting capacity was at the scene promptly. Even if her capabilities were not equivalent to those of the special purpose vessels that arrived later, overarching coordination would have been desirable. However, that would not have changed the overall extent of the damage as the entire upper deck of the LISCO GLORIA was on fire when the first vessels arrived at the scene, meaning a successful fire-fighting operation would not have been possible even if all available resources had been coordinated perfectly (see sub-para. 4.6.3).

4.7.2 Rescue coordination

With regard to the extent of the occurrence, the biggest challenge on the night of the accident was coordinating the rescue of people. The result, the successful rescue of 235 people from a ferry burning along her entire length at night on the high seas, and with virtually no injuries, is due to the outstanding commitment of everyone involved and fortunate prevailing circumstances, such as the favourable weather conditions, amongst other things. Crucial to success, after the swift evacuation by the crew, was the resolute action of the vessels and helicopters rushing to the distressed ship as well as of the shore-based rescue agencies.

The first phase of the rescue was coordinated by MRCC Bremen and its radio station Bremen Rescue Radio. After the accident report was received, any action necessary to ensure that the evacuees could be picked up from the lifeboats and life-rafts by other vessels or helicopters was initiated from there promptly. Manned initially by only three people, the Maritime Rescue Coordination Centre in Bremen not only ordered all available vessels to proceed to the distressed ship, but in parallel set the reporting chain for other agencies and authorities in motion at an early stage, meaning preparations for further coordination of the large-scale occurrence could also be initiated there. The essential information (affected vessel, location, type of accident, number of people) was obtained and forwarded promptly. When considering the full scale of the occurrence, the initial language problems encountered by Bremen Rescue Radio were negligible. Bremen Rescue Radio sent the mayday relay message just six minutes after the accident report; this was immediately answered by the vessels in the vicinity changing their courses correspondingly. The readiness and availability of the NEUSTRELITZ to act as OSC for the rescue of people at the scene proved to be particularly advantageous. Although the ship's command and crew of the NEUSTRELITZ were, at times, taken to their performance limits due to the parallel responsibilities of taking evacuees on board, coordinating the transfer of additional evacuees from other vessels, and the extensive communication with Bremen Rescue Radio along with the documentation, yet all the people in the lifeboats and life-rafts were taken on board, where they received initial care and were later transferred to the DEUTSCHLAND.

The arrival of the DEUTSCHLAND at the scene provided the ideal means of transporting the evacuees back to shore. The dedicated ship's command of the DEUTSCHLAND was quick to report the existing capacity to Bremen Rescue Radio in consultation with her shipping company, Scandlines, and expressed willingness to take all the evacuees on board and return them.

The last passenger and the two crew members trapped by flames at the stern could be rescued from the LISCO GLORIA by the German naval helicopter 8957 and the Danish ROTA respectively. Even those vessels (especially the GOTLAND, CREOLA, FRI SKIEN, VIDI, and SPARTO) that were ultimately unable to actively participate in rescuing people, but were involved in searching for further lifeboats, life-rafts and people possibly in the water, contributed to the success of the rescue operation.

The active rescue phase, conducted ashore via VHF channel 16 by Bremen Rescue Radio, coordinated by MRCC Bremen and simultaneously by the Navy's SAR Coordination Centre in Glücksburg, was completed at 0200. By this time, the CCME had already assumed overall operational command and for its part alerted shore-based rescue teams for the second phase of the rescue: caring for the evacuees and casualties at sea and ashore. The decision to disembark the evacuees in Kiel was made early in the incident. The naval base in Kiel proved to be the most appropriate landing location and port of refuge, in particular, because of the existing infrastructure and capacity to provide care. However, the decision regarding Kiel was not communicated to all the involved agencies on the foreseen reporting channels to the extent required. The set-up of a casualty care centre in Kiel with a team of more than 150 people was ultimately executed simultaneously, and with no coordination, to the activation of more than 100 rescue personnel of the Ostholstein Administrative District, who had been deployed to Puttgarden by their coordination centre. At 0120 a fax was sent by the CCME to, inter alia, the Ministry of the Interior of Schleswig-Holstein declaring that they had assumed overall operational command, but this information was not passed on to the rescue coordination centres. Therefore, the rescue coordination centres did not consult with the CCME before activating task forces. Due to this uncoordinated action and the limited technical availability, the most important information that at 0222 Kiel had been defined as the location to disembark evacuees was not received by the various operational commanders until about 0400. This led to resources being tied up unnecessarily and there was some annoyance, which could have been avoided had communication been better. However, it must be remembered that the crisis management team did not have sufficient manning to cope with the extensive communication with other rescue coordination centres in addition to the overriding task of alerting the task forces for Kiel. Although the CCME was supported by the designated representative of the waterway police and a representative of the federal police, ideally, they should have been able to request additional support from the watchkeepers in the German Joint Situation Centre Sea; however, this is not provided for from an organisational perspective. At that time, the Joint Situation Centre had been conducting marine surveillance, and arrangements were made between the different representatives and their particular forces deployed. The flow of information between the German Joint Situation Centre Sea and the CCME, however, was also time-delayed. This can be partially attributed to their accommodation in different buildings. Overall, the investigating authorities are of the view that it was not possible for the CCME to

communicate decisions promptly and transparently to the extent necessary to others on the night of the accident. Tasks had to be prioritised for lack of personnel resources in the crisis management team. Here, focus was consistently and logically put on organising the care for evacuees and casualties at the naval base in Kiel and the fire-fighting operation at the distressed vessel.

There was also a lack of coordination with respect to the air rescue services at the scene on the night of the accident. Until 0400, there were three helicopters (two German and one Danish) at the scene to assist in the search effort and take casualties to hospital if necessary. These were subsequently joined by a helicopter from the company Wiking. Use of the airspace in the area of the distressed vessel was coordinated by neither the CCME nor by any other shore-based agency; also, no precautionary safety zone was established. The investigating bodies believe that overarching coordination would have increased the safety of the air rescue services deployed at the scene. However, this task was beyond the personnel resources of the crisis management team. External consultants were not available for this task, either.

Some room for improvement was also noted during the personal care phase in Kiel. Although the casualty care, including onward transport to the University Hospital in Kiel, and the supply of blankets and meals to the other evacuees ran smoothly, there was some confusion in the operational commanders' briefings, which could have been avoided. Essentially, this concerned the question of the right time for onward transportation of the evacuees to the hotel and liaising with the press. The CCME decided at an early stage to permit the evacuees to go to the hotel or home only after the casualty care and the psychosocial emergency care as well as the recording of personal data was completed. Furthermore a certain protection of the casualties should be ensured. This decision, which the investigating authorities regard as being appropriate, was repeatedly questioned by operational commanders on-site. In turn, this led to an increased number of individual inquiries being made with the crisis management team, which was already operating at its performance limits in terms of both technical and personnel resources. The same applied to the press relations, which, after the CCME had assumed the overall responsibility for the operation, had to be conducted centrally by the CCME; not every operational commander involved was aware of this. Fortunately, both aspects only became evident when the evacuee care was more or less finished.

4.7.3 Fire-fighting coordination

When the first vessels with fire-fighting equipment arrived at the scene of the accident, the entire length of the LISCO GLORIA was already on fire. Explosions, largely caused by exploding tyres and fuel tanks, had already been observed during the evacuation. Under these conditions, the prospect of an effective fire-fighting operation was not very good at the time, especially in view of the unlimited supply of oxygen on the weather deck. Consequently, the first vessels that rushed to provide assistance initially focused all their efforts on the SAR operation. The fire-fighting operation did not begin until about 0220 when the evacuees had been transferred safely to the DEUTSCHLAND and, with the rescue cruiser JOHN T. ESSBERGER and the SCHARHÖRN, the first vessels with appropriate fire-fighting equipment had arrived at the scene. It was attempted to contain the fire on the upper deck from the

windward side. Foam had not been used. In the course of the accident investigation, extensive discussions were held with experts as to whether and to what extent the use of foam may have achieved different results. In this regard, the interviewed fire experts from different fire brigades unanimously concluded that given the wind conditions (5-6 Bft) and the distances that had to be kept from the LISCO GLORIA for safety reasons, that it would not have been possible to lay a foam blanket to suffocate the flames. This would have required large amounts of low-expansion foam, which inevitably would have reduced the throw distance. Moreover, even if a foam blanket had been laid successfully, while suffocating the flames temporarily, it would not have been able to remove the energy from the fire. Water would have been needed for this, which, consequently, was used by all the fire-fighting vessels from the beginning of the fire-fighting operation.

In this regard, the amount of water trapped on the upper deck during the attempts to fight the fire was a problem. The scuppers were not designed to accommodate the amount of water delivered externally and were partly clogged with debris from the fire in any case. Therefore, the fire-fighting water, which did not evaporate immediately, accumulated on the port side (leeward) and as the fire-fighting operation progressed caused an increasing list of more than 15°.

The vessels at the scene continuously monitored any externally visible changes in the fire on and stability of the LISCO GLORIA and reported their observations to the OSC on the SCHARHÖRN, who, in turn, relayed the incoming reports to the CCME. Fortunately, an external expert on stability was available in the crisis management team on the morning of 9 October 2010, who agreed to provide the team with technical support. Ultimately however, it was only possible to decide on appropriate fire-fighting measures at the scene based on the development of the fire. Here, the aim of all the parties involved was to prevent the LISCO GLORIA from foundering. Both the vessel operator and the Danish Navy contacted the CCME to discuss the possibility of a critical loss of stability due to the fire-fighting water. In consultation with the OSC, the CCME decided at an early stage that, reportedly, the efforts to fight the fire should be discontinued and instead the shell plating should be cooled down. This instruction was not followed consistently; firstly, because of misunderstandings between the CCME and the OSC, and secondly, because not all the fire-fighting vessels at the scene were coordinated. In this regard, the distance between the OSC (SCHARHÖRN) and the operational commander of the fire brigade (ARKONA) was disadvantageous. In the meantime, the salvage team commissioned by the vessel operator planned to cut holes in the hull (on the leeward side) to allow the fire-fighting water to drain off. Ultimately, this measure was no longer needed; although the LISCO GLORIA drifted off Langeland with a list of 15° after anchoring, stability was yet maintained and efforts were limited to cooling the shell plating now. In addition, an instruction of the CCME was that no contaminated water should escape into the Baltic Sea, if possible.

The fact that the environmental protection vessel ARKONA had to pull back from the contaminated atmosphere of the LISCO GLORIA on the night of the accident because of the highly toxic gases measured had no impact to coordination of the fire-fighting measures. An air protection system is installed on board the environmental protection vessels of the Waterways and Shipping Administration; therefore,

basically, they can also be deployed in contaminated atmospheres. However, routine controls had revealed that some pollutants cannot be detected properly by the system's sensors. To protect crews, the responsible Waterways and Shipping Directorates North and Northwest instructed ship's commands to discontinue work in contaminated areas if it involves a potential health hazard. This instruction was issued via the competent waterways and shipping agencies as responsible operator of the equipment, and remains valid until the system manufacturer has corrected the malfunction and ensured the technical reliability of the sensor as envisaged. The chemical substances measured at the LISCO GLORIA were unquestionably harmful; therefore, the decision of the ship's command of the ARKONA to withdraw from the leeward side was the consistent and responsible implementation of the instruction. The fire-fighting efforts were not adversely affected by that because they could be continued without any limitations on the windward side.

In addition to the vessels with fire-fighting capacities, there were numerous FFUs at the scene. Since the associated risk precluded a mission on board, the only thing that remained for the various operational commanders was to advise the different ship's commands. In this regard, the investigating authorities would have considered closer cooperation between the OSC on the SCHARHÖRN and the operational commander of the FFU on the ARKONA to be worthwhile. The original plan to put the FFU from Lübeck down on the SCHARHÖRN could also have been executed at a later stage when the first fire-fighting measures had been completed and only the shell plating was being cooled down. Having the OSC and the operational commander of the FFU in different places hampered a smooth collaboration, and complicated communication, also with the CCME.

Since the fire went on for days and weeks when the Danish side assumed overall operational command, the German FFUs did not play any further part. However, when the accident report was received and the FFUs were alerted, it was not possible to foresee the extent of the fire, meaning timely transportation of the FFUs to the scene was essential. Moreover, when following up the operation, it was possible to gain valuable insights for the investigation through cooperation with the task forces.

4.8 Experience gained from other ferry fires

Fortunately, fires on ro-pax ferries, in particular, with consequences as serious as in the case of the LISCO GLORIA, are an extremely rare occurrence around the world. For the most part, the few cases that have occurred in recent decades have differed significantly in terms of causes, contributing factors and consequences. Nevertheless, general conclusions and lessons can be drawn from them. In the past, these have already led to modifications to the international standards for ship safety, cargo safety and training, amongst other things.

The investigating authorities have incorporated the lessons and measures for improvement from the previous ro-ro and ro-pax ferry fires into the present investigation. Those accidents, in which the fire also broke out in the cargo area were analysed for the investigation. The following table provides an overview of the accidents that have been considered.

Vessel	Year of accident	Findings
FALSTER LINK Year built: 1969 Flag: Denmark	1994	▪ The fire broke out at sea on a truck that had just been parked on the car deck. The drencher system was activated within 10 minutes of the fire breaking out. It took 90 minutes to bring the fire under control. ▪ One truck driver lost his life because he was asleep in the cab.
SUPERFAST III Year built: 1998 Flag: Greece	1999	▪ The fire broke out at sea on a refrigerated trailer. It was possible to extinguish it by means of the drencher system and fire-fighting team. ▪ 307 passengers and 106 crew members were evacuated and taken on board vessels which had rushed to assist. 14 stowaways who were hiding in a trailer lost their lives in the fire.
SILVER RAY Year built: 1978 Flag: Panama	2002	▪ The fire broke out in port on a deck loaded with used cars. Fire-fighting was considered too hazardous due to the rapid spread of the fire. Therefore, after the 24-member crew was evacuated, it was decided to allow the fire to burn under control. ▪ The cargo of 2,900 cars was destroyed. The vessel was declared a constructive total loss.
KNOSSOS PALACE Year built: 2000 Flag: Greece	2003	▪ The fire broke out at sea in a cargo transport unit with chemicals; but could be extinguished by means of the drencher system. ▪ The ferry called at the nearest port, where there were problems removing the 1,040 passengers and 116 crew members from the vessel. ▪ Three passengers were treated for respiratory problems. 28 vehicles were damaged. The vessel sustained only minor material damage.
JOSEPH AND CLARA SMALLWOOD Year built: 1989 Flag: Canada	2005	▪ The fire broke out in a trailer, but could be extinguished. Passengers and crew were evacuated because the deck had become very hot.

(Cont.) Vessel	Year of accident	Findings
Al-SALAM BOCCACCIO 98 Year built: 1970 (rebuild in 1991) Flag: Panama	2006	▪ The fire broke out at sea, probably in a trailer laden with luggage in the forward cargo area on the port side. Despite activation of the drencher system and fire-fighting by three fire-fighting teams, it was not possible to bring the fire under control. ▪ The wind blew from the port side, causing the fire-fighting water to accumulate on the starboard side. This resulted in the ferry listing to 5-7°. Attempts to pump out the fire-fighting water failed. However, the efforts to fight the fire were still continued. This subsequently led to a heeling angle of 15° to starboard, which could not be reduced by ballasting. The scuppers were clogged and part of the cargo had shifted to starboard. The ferry was listing to 25° four and a half hours after the fire broke out, which led to her capsizing. ▪ Only 387 of the 1,418 people on board were saved.
UND ADRIYATIK Year built: 2001 Flag: Turkey	2008	▪ The fire broke out at sea on the main deck and could not be controlled. The ferry was almost fully loaded with 200 trucks and trailers allocated on all four loading decks. Within 10 to 15 minutes, the fire had spread across several decks. ▪ There were problems activating the drencher system. The 'open' position for the water supply valve was different from all the other valves of the drencher system. ▪ For the 22 crew members and 9 passengers, the escape route to the life-saving equipment in the area of the superstructure had been cut off by the fire. They reached the life-raft on the foredeck and were finally rescued from the water – where they had held out in the life-raft designed for only 6 people – by a vessel that had rushed to provide assistance. ▪ The ferry burned for several days before she could be towed to a port of refuge. ▪ Several people were injured during the evacuation. The vessel was declared a constructive total loss.
VINCENZO FLORIO Year built: 1999 Flag: Italy	2004 and 2009	▪ The fire in 2004 broke out at sea, presumably due to cargo shifting in heavy seas. There was a power failure on board, which caused a delay in activating the drencher system. ▪ The fire was brought under control after a few hours. ▪ During the fire in 2009, 526 passengers were evacuated nearly three hours after the fire broke out. Part of the 35-member crew continued to attempt to bring the fire under control, but they were also evacuated later. ▪ The fire raged for ten days.

(Cont.) Vessel	Year of accident	Findings
COMMODORE CLIPPER Year built: 1999 Flag: Bahamas	2010	▪ The fire broke out at sea on one of the refrigerated trailers connected to the shipboard electrical system in an enclosed loading deck. Overheating due to an electrical fault between the shipboard power supply and the refrigerating unit of the trailer was identified as the cause of the fire. This overheating caused the trailer's side tarpaulin to ignite. The fire was investigated by the British MAIB[36]. ▪ It was not possible to extinguish the fire by means of the drencher system. Therefore, the ferry called at a port of refuge, where the fire was finally extinguished 18 hours after it broke out with the support of shore-based fire-fighters. The trailers had to be pulled ashore to extinguish the fire. ▪ Several vehicles and the loading deck were damaged. ▪ The 62 passengers and 39 crew members were unhurt. They were taken to safe parts of the vessel during the fire-fighting operation. Later, the evacuation was complicated because the port of refuge was not appropriately equipped.
PEARL OF SCANDINAVIA Year built: 1989 Flag: Denmark	2010	▪ The fire broke out at sea in the aft section on the port side of an enclosed car deck. The battery of an electric car, which had been charged during the voyage, was identified as the cause of the fire. ▪ The drencher system was activated 17 minutes after the fire broke out. It was possible to extinguish the fire in just less than two hours. The crew was assisted by an external fire-fighting unit, which had been flown in. ▪ The 490 passengers were taken to safe parts of the vessel before and during the fire-fighting operation. ▪ There were no injuries due to the fire. Several vehicles and the car deck were damaged.
MECKLENBURG-VORPOMMERN Year built: 1996 Flag: Germany	2010	▪ The fire broke out on a truck in an enclosed loading deck while the ship was approaching port. The accident is currently being investigated by the BSU. ▪ It was possible to extinguish the fire after two hours with the support of shore-based fire-fighters. ▪ There were no injuries. Several vehicles and the car deck were damaged.
PETER PAN Year built: 2001 Flag: Sweden	2011	▪ The fire broke out just as the ferry was about to leave port. The fire started on a truck loaded with aluminium powder on loading deck 5. ▪ About 100 passengers were evacuated via the bow ramp. The truck was taken ashore and extinguished.
SCHLESWIG-HOLSTEIN Year built: 1997 Flag: Germany	2011	▪ The fire broke out at sea on the refrigerating unit of a trailer. The fire was discovered early on by a crew member on round and extinguished with a powder extinguisher. ▪ The refrigeration for the trailer had not been registered. It was operated diesel-electrically despite the prohibition to do so. The BSU is currently carrying out a preliminary investigation of the accident.

Table 6: Overview of other ferry fires

[36] Marine Accident Investigation Branch; www.maib.gov.uk; report no. 24/2011

As can be seen from the overview of other ferry fires, both the causes and the consequences of fires differ considerably. Often, it is not possible to determine the causes of the outbreak of fire with certainty after the event. To draw meaningful conclusions from the accidents, the detailed investigation with disclosure of the findings, which only happened for very few cases, is usually required.

11 of the 14 fires considered started in vehicles; in the case of two others, it was not possible to establish the causes. Drencher systems were used in nine cases, which in five cases extinguished the fires. Problems when using the drencher system were reported in two cases (UND ADRIYATIK and VINCENZO FLORIO in 2004). This statistic illustrates that the fires could be brought under control or extinguished, respectively, only in 56% of the cases even with an operable drencher system. Additional, mostly shore-based, fire-fighting equipment was needed for the other cases.

Looking at previous ferry fires universally shows that the outbreak of a fire on the loading deck of a ro-ro or ro-pax ferry may result in two general problems in terms of ship safety. Firstly, the design of the vessel makes it possible for a fire to spread quickly due to small parking distances, and at the same time over a large area due to a lack of subdivided sections. Secondly, also the fire-fighting water can accumulate on the entire deck; depending on the amount, this can lead to an impairment of the vessel's stability. Accordingly, in the case of the fire on the LISCO GLORIA, two typical risks materialized. Experience from other ferry fires shows that essentially both risks can be minimised only by rapid and effective use of the fire fighting systems as well as a high level of alertness by the crew during fire patrols.

In recent years, technical and fire experts from various countries and institutions have looked closely at ship fires and the effectiveness of fire fighting systems on board[37]. Here, particular attention has been given to ferry fires, which, although being a rare occurrence globally, can have particularly far-reaching consequences depending on the course of fire. The scientific debate focuses on the extent to which the fixed fire fighting systems provided for in IMO Resolution A.123(V)[38], published in 1967, are still sufficient for fighting the cargo fires of today. However, this question is not raised in the case of the LISCO GLORIA because her drencher system could not be started. It should also be noted that structural and technical improvements relating to fire protection do not affect those vessels that already existed at the relevant time.

In conclusion, provision of a drencher system does not guarantee being able to control a fire successfully. However, the fire-related damage in the accident scenarios analysed were usually significantly less with an operable drencher system due to the relevant physical effects listed, inter alia, by Hakkarainen et al. (2009)[39]:

[37] See Rasmus Frid and David Palm: An analysis of fixed water sprinkler systems on ro-ro decks, Department of Fire Safety Engineering and Systems Safety, University of Lund, Report 5326, Sweden 2010; Tuula Hakkarainen et al.: Survivability for ships in case of fire. Final report of the SURSHIP-FIRE project. VTT Research Notes 2497, Finland 2009; Magnus Arvidson: Large-scale ro-ro deck fire suppression tests, SP Technical Research Institute Report 2009:29, Sweden 2009; Det Norske Veritas (DNV): Fires on ro-ro decks. Technical Paper Series No. 2005-P018.

[38] IMO Recommendation on fixed fire extinguishing systems for special category spaces, 1967.

[39] Hakkarainen et al. (see footnote 30), p. 32 (relating to automated fire suppression systems).

- slowing down the fire progress
- reduction of the peak heat release rate
- cooling of the gases flowing in the fire plume and consequently reduction of the heat exposure from the hot smoke layer
- reduction of the direct heat exposure from the burning item to other items.

5 Actions taken

5.1 Vessel operator

As a result of its internal analysis of the accident, the vessel operator, DFDS Seaways, has taken, inter alia, the following actions, which it deems to be generally important for fire protection and fire-fighting on board.

- As a consequence of the fire onboard LISCO GLORIA and the car deck fire on the ferry PEARL OF SCANDINAVIA, a workgroup was established in cooperation with the Danish Maritime Authorities and DFDS A/S, resulting into a submission to the IMO sub-committee on Fire Protection[40].
- MRCC Bremen has received a comprehensive emergency information package for all DFDS ferries used on routes to and from German ports.

In addition, the following actions have been laid down for the entire fleet:

- Verification that remote releases and indication of fire doors and watertight doors on bridge panels are working properly, and that all fire doors and watertight doors are inspected to ensure they are intact and undamaged.
- Verification that all inspection hatches including maintenance access to ventilation systems are mounted properly and that all bolts are mounted and tightened properly.
- All section valves to be tested for proper operation both from all remote and main drencher control station. Verification that operation of drencher pump, including emergency supply to the drencher system e.g. by fire pumps and emergency fire pumps is working properly, and that all valves are fully functional. Verification that all valves essential for the normal operation are retained in correct position, and that marking is provided on these valves e.g. with a sign “normally open”. Verification that all deck and engine officers are fully familiar with the normal and emergency operation of the drencher system, and that this is included in the training of the new personnel, and that training is provided to all persons required in intervals not exceeding 3 months. Corresponding requirements have been issued regarding the sprinkler system as well as fixed local application fire-fighting systems.
- Verification that all deck officers and other crew assigned to public address system are fully familiar with the function of the different operational modes.
- Verification that all deck officers are fully familiar with the different functions of activating the different alarm types, and that the general alarm system is working properly for all different alarm types.
- Verification that all available auxiliary engines are connected in “stand-by” mode, enabling the power management system to request sufficient power.
- Verification that all fire fighting teams receive sufficient training in fire fighting patterns, search patterns and fire fighting strategy.
- Verification that all crew are fully familiar and trained in their evacuation tasks, and sufficient support systems are present, implemented and up to date, to support an effective evacuation and control of passengers.

[40] Submission FP-55-12-INF to the 55th meeting of the IMO sub-committee on Fire Protection

- Verification that fire rounds are conducted at least once each hour, between 2200 and 0600.

5.2 DGzRS

To assist the marine radio operators on watch of Bremen Rescue Radio, the DGzRS has prepared an extract from the IMO Standard Marine Communication Phrases (SMCP) in English and German, which is clearly structured and available at the workstation. This is designed to offer guidance, especially in stressful situations during large-scale incidents.

5.3 German Central Command for Maritime Emergencies

In the course of the internal follow-up of the accident involving the LISCO GLORIA, the German Central Command for Maritime Emergencies, amongst other things, held numerous meetings with the authorities and task forces involved and analysed requirements for optimisation. This resulted, in particular, in the actions listed below:

- Instructions for deployment by the CCME, which are initially issued verbally, should be repeated briefly in written form afterwards.
- For air traffic in complex damage scenarios, a central coordination and control of the deployed aircraft should be established in the future. The available helicopters (both public and private) will be registered with this position (Aircraft Co-ordinator) and deployed in terms of mission command as directed by the CCME.
- The ship's commands at the scene of the accident should be relieved by a separate, subsequently deployed Operational Commander Sea to preclude a double burden on the ship's command.
- For complex damage scenarios, a liaison officer of the CCME should ensure the flow of communication to and from the CCME in the respective situation centre on-site, if necessary.
- In consultation with WSDs North and Northwest, the ship's commands of the water pollution control vessels of the federal government should, in future, attend the CCME's 'Fire-Fighting Operational Commander Course'.
- The CCME is currently developing a concept for a four-day training module (On-Scene Co-ordinator Sea / OSC CCME' [working title]) for nautical personnel, which aims to facilitate a more transparent communication flow between the crisis management team and respective on-scene co-ordinator.
- Press liaison work on-site shall be coordinated by CCME personnel.
- The CCME has developed a plan for making improvements to the technical communications equipment in the short-term.

6 CONCLUSIONS

The fire on the LISCO GLORIA is one of the most severe marine casualties in the Baltic Sea of recent decades. A combination of, a decisively acting ship's command, alert passengers, favourable weather conditions, rapid shore-based organisation, and, not least, the selfless actions of the people rendering assistance at the scene ultimately brought about the main objective – that is the successful rescue of all persons on board. Since the LISCO GLORIA was in a relatively busy sea area near the coast and most of the passengers were still awake at around midnight, the location and timing of the accident also proved to be advantageous.

Fortunately, large-scale incidents of this nature are exceedingly rare due to continuously improving safety standards. However, when they do occur they provide all the more reason to send back to the drawing board existing emergency and safety systems, both on board and ashore, and to work constructively with all stakeholders on possible improvements during the follow-up stage. This investigation report, which is the result of extensive and transnational investigations, demonstrates the full commitment of all stakeholders to learn from the circumstances of the accident and derive consequences, which can enhance ship safety and shore-based emergency management in general.

6.1 Vessel's crew and operator

The vessel operator, DFDS Seaways, supported the German/Lithuanian investigation with great commitment from the beginning. Since it was not possible to identify the actual cause of the accident due to the high degree of destruction after weeks of fire on board the LISCO GLORIA, the investigation focused on the behaviour of the ship's command and crew after the fire broke out and the technical aspects, in particular, fire safety and fire-fighting equipment.

The outbreak of fire was discovered and reported to the officer on watch on the bridge very quickly by both the smoke detectors and the alert crew member on round. Quite logically, the master was called and took all necessary essential measures within four minutes of the fire breaking out (power switched off on the upper deck, deck crew alerted, drencher system activated).
Although the vessels command was already aware of the fact that a real fire broke out when the fire roll was released only the deck crew was called. Therewith the specifications of the muster roll were not adhered to. Even by alerting the complete crew one could have refrained from the notification of the passengers in the first place in order not to worry them unneeded. However, the crew would have been more ready in this case.
The time lag resulting from that and unfolding during the subsequent evacuation had actually no effect, since the passengers partly alerted themselves.

When the drencher system did not work, correction of the malfunction was delegated to the duty engineer in the engine control room, where necessity to activate the drencher system was overridden by a problem with the automatic sprinkler system, which occurred almost simultaneously. While the fire was spreading rapidly on the upper deck, there was an uncontrolled flooding of the engine room due to fire-fighting water escaping from the pressure pipe of the sprinkler system. The only remaining

means of putting the drencher system into operation was ultimately lost due to the simultaneous risk scenario. In any case, the period in which the fire could have been brought under control under certain circumstances by the drencher system in the garage area only amounted to a few minutes.

The fire insulation proved to be significantly more effective than one would have expected under the given circumstances and, supplemented by the cooling measures of the crew, facilitated safe evacuation of the passengers.

In view of the rapid development of the fire, the crew of the vessel were, just like the passengers, in a very exceptional situation. Consequently, the evacuation was not entirely consistent with the SOPs of the vessel operator. Eventually, also because of the rapid availability of external sea and airborne support, this did not have an adverse effect on the successful completion of the evacuation.

Prior to completion of this investigation, the vessel operator had already arranged numerous control measures and training sessions for the entire fleet and crews in order to further enhance ship safety and prevent similar accidents. This rendered a large number of possible safety recommendations of the investigating authorities unnecessary.

6.2 Shore-based emergency management

Due to their reliable and well-rehearsed management of the initial phase of the operation on the night of the accident, MRCC Bremen and Bremen Rescue Radio ensured that all the measures necessary for rescuing the evacuees were taken immediately and implemented successfully. Also after the overall responsibility for coordination of the operation was assumed by the CCME, Bremen Rescue Radio, in particular, proved to be a reliable point of contact for the vessels still at the scene as things progressed on 9 October 2010. The DGzRS's internal follow-up of the communication on the night of the accident has resulted in the implementation of improvements irrespective of the outcome of the marine casualty investigation, again rendering a potential safety recommendation unnecessary.

The German Central Command for Maritime Emergencies mastered the mammoth task of planning, coordinating and documenting all the emergency management activities ashore and at sea. The crisis management team was ready within an hour. With initial minimum manning of just five employees, it simultaneously organised, inter alia, the build-up of a casualty care centre and psychosocial care at the naval base in Kiel, a personal information centre for relatives, fire-fighting on-scene and transportation of fire-fighting units to the scene from four different states, press liaison work and the notification of foreign agencies as well as German authorities and ministries. Over several days, the team members were taken to their performance limits. In the process, they were supported by external consultants and employees of the CCME, all of whom were marked by enormous personal commitment and who also contributed their expertise outside of any duty rosters. The joint efforts made it possible to implement the emergency management almost as planned, even though the ensuing success of the operational management – optimum care for casualties and evacuees, distressed vessel did not founder, no

significant damage to the marine environmental – could neither be planned for nor was likely.

The German Central Command for Maritime Emergencies subsequently examined the event in depth and has already prompted a whole range of measures. The investigating authorities are, nonetheless, of the view that four aspects, all of which are beyond the control of the CCME, are essential for the optimisation of the emergency management by the German Central Command for Maritime Emergencies.

- The personnel and technical equipment may well be sufficient for 'average' damage scenarios; however, experience now shows that with respect to complex damage scenarios, like the LISCO GLORIA, the crisis management team is understaffed and not equipped with the necessary technical means to promptly communicate decisions to the task forces and third parties (rescue coordination centres, authorities, etc.). The resulting burden on the crisis management team affects both the quality and quantity of operational decisions. The crisis management team neither received necessary information within a reasonable time, nor did decisions always reach the task forces early enough.
- In addition, the close link between MERAC and the German Joint Situation Centre Sea did not support the crisis management team to the extent originally envisaged in the planning of the Maritime Security Centre. Essentially, the accommodation of the CCME and the German Joint Situation Centre Sea in different buildings as well as the legal and organisational frame of the Maritime Security Centre are regarded, by the investigating authorities, as impeding factors. This resulted in the same issues being dealt with in parallel and delays in sharing information.
- The powers of the German Central Command for Maritime Emergencies were not known to all the task forces to a sufficient extent; therefore, in some cases the implementation of orders of the CCME did not happen or was delayed. This not only hampered the planned course of the emergency management, but also led to an increased volume of communications in the crisis management team due to inquiries and discussions.
- In this case, it is also evident that the helicopter capacities were only sufficient because of the extremely low number of casualties and the availability of Danish and Swedish helicopters at short notice. For the future, predictable helicopter capacities should be considered for the maritime emergency response.

The investigating authorities believe it is essential to address the aforementioned issues within the framework of safety recommendations to the Kuratorium Maritime Notfallvorsorge (Board of Trustees Maritime Emergency Response [sic]), which is responsible for policy matters of the CCME, and the Ministry of the Interior of Schleswig-Holstein. That the people involved and the marine environment were relatively unscathed by this marine casualty must not hide the fact that the accident occurred in relatively good overall conditions, which may be different with future accidents.

7 SAFETY RECOMMENDATIONS

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

7.1 DFDS Seaways

It is recommended that the crews be sensitised to report any equipment malfunctions immediately, in order to allow for maintenance and repair work to be carried out. Reported and resolved malfunctions should be rechecked during the regular internal ISM audits.

With regard to emergency management, it is recommended that in the event of evacuation crew members are equipped with safety vests to make them recognisable as a point of contact for passengers. It is also recommended that passengers are informed via multilingual recorded messages on the public address system and via the general, respectively, abandon ship alarm in an emergency.

7.2 Kuratorium Maritime Notfallvorsorge

It is recommended that the Kuratorium Maritime Notfallvorsorge equip the German Central Command for Maritime Emergencies with the personnel and technical resources necessary to ensure planning, coordination and documentation of the measures during complex damage scenarios and, in particular, appropriate communication. When assessing the tasks of the German Central Command for Maritime Emergencies, the limited availability of predictable helicopter capacities should be considered realistically.

It is also recommended that the accommodation of the CCME and the German Joint Situation Centre Sea in different buildings be removed.

7.3 German Central Command for Maritime Emergencies

It is recommended that the German Central Command for Maritime Emergencies also make use of the marine radio service as a means of communication, possibly via delegation to MRCC Bremen and Bremen Rescue Radio, for messages of basic importance (assuming command of the operation, fundamental strategic decisions, etc.).

7.4 Ministry of the Interior of Schleswig-Holstein

It is recommended that the Ministry of the Interior of Schleswig-Holstein, through notification to subordinated agencies, ensure that the powers of the German Central Command for Maritime Emergencies are known, and thus ensuring that any task forces and resources necessary are put at the full disposal of the German Central Command for Maritime Emergencies after it assumes command of the operation.

8 SOURCES

- Witness interviews
- Ship plans, lists and certificates
- Recordings of the VDR
- Recordings of the central control system in the engine control room
- Recordings of VHF channel 16 by Vessel Traffic Service Centre Travemünde
- Salvage plan
- Fire and cargo expertises
- Mission reports of the shore-based fire-fighting and rescue services
- Mission reports of the vessels and aircraft deployed to the distressed vessel
- Reports and documents of the CCME, MRCC Bremen and SOK
- Reports of the BSH and the Danish National Environmental Research Institute of the University of Aarhus on the analysis of pollution samples and on drift calculations
- Information, testing and maintenance reports of the life-saving equipment manufacturer