THE DUTCH
SAFETY BOARD

Collision and capsizing of tug Fairplay 22 on the Nieuwe Waterweg near Hook of Holland

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11 November 2010

The Hague, March 2012 (project number M2010ZSV1111-01)

THE DUTCH SAFETY BOARD

The aim in the Netherlands is to reduce the risk of accidents and incidents as much as possible. If accidents or near-accidents nevertheless occur, a thorough investigation into the causes of the problem, irrespective of who is to blame for it, may help to prevent similar problems from occurring in the future. It is important to ensure that the investigation is carried out independently from the parties involved. This is why the Dutch Safety Board itself selects the issues it wishes to investigate, mindful of citizens' position of dependence with respect to public authorities and businesses. In some cases, the Dutch Safety Board is required by law to conduct an investigation.

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This report is published in Dutch and English. In the event of any discrepancy between these versions, the Dutch text shall prevail.

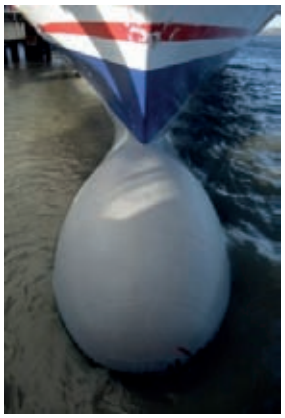
TABLE OF CONTENTS

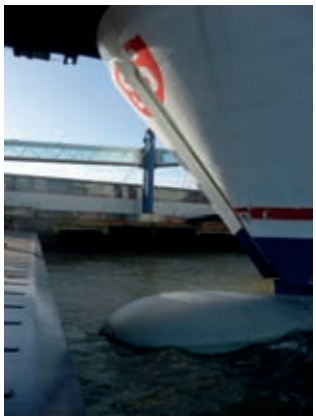
GLOSSARY OF TERMS AND ABBREVIATIONS

ABS	American Bureau of Shipping
AIS	Automatic Identification System
ASD	ASD stands for Azimuth Stern Drive; a type of tug with two thrusthers located at the stern that can be rotated 360 degrees, generating propulsive force in any horizontal direction.

An ASD-tug [source: Fairplay Towage B.V. (edited manually)].

Bareboat charter	An arrangement for the chartering of a ship whereby a vessel is crewed, operated and maintained by the chartering party (not by the owner).
Bow	The front part of the ship, from the front part of the hull to the broadest section of the vessel.
Bow-to-bow	A towage connection attached to the bow of the tug and the bow of the object that is to be towed.
Bow-to-stern	A towage connection attached to the bow of the tug and the stern of the object that is to be towed.
Bulbous bow	A bulbous bow is a protruding bulb at the bow of a ship, designed to reduce the amount of wave resistance the vessel encounters while it moves through the water.





The bulbous bow on Stena Britannica [source: Marine Accident Investigation Branch, United Kingdom].

Dead-slow speed	The speed at the lowest throttle setting at which the propeller rotates in order to maintain an extremely low speed.
Drift angle	In order to compensate for the effects of wind and currents, ships sail at an angle in order to stay on course. The angle between the ship's longitudinal axis and its course is referred to as drift angle.
Engine room power plant	The main engine, auxiliary engines and other systems in the engine room that are dependent on air supply.
ETA	European Tugowners Association

Free fluid moment	The free fluid moment occurs when fluids move to the low side of the ship if a vessel heels. This increases the ship's heeling angle.
GL	Germanischer Lloyd Group classification society
Gross Tonnage (GT)	A measure of the internal volume of a ship.
Ground speed	A ship's speed relative to the ground.
Heaving line	A relatively thin line, weighted at one end, which is thrown from the object to be towed to the tug to be connected to the towing line, in order to establish a towage connection.

The end of a Stena Britannica heaving line, with the weighting and towing line. [source: Marine Accident Investigation Branch, United Kingdom].

HSE-Q Manual	Health, Safety, Quality and Environmental Protection Manual (safety management Fairplay)
IACS	International Association of Classification Societies LTD
ILO	International Labour Organization
IMO	International Maritime Organization
ISO	International Organization for Standardization
Lee side	The side of the ship that is turned away from the wind.
MCA	Maritime and Coastguard Agency
Messenger	A messenger or messenger line is a light line used to connect the towing line to the heaving line.
MGN	Marine Guidance Note
Mooring bitt	Iron post on ship's deck used to connect ropes or chains.
Pilot Exemption Certificate (PEC)	A Pilot Exemption Certificate (PEC) is issued by the harbour master of Rotterdam, employed by the Port of Rotterdam Authority, and exempts a captain from compulsory pilotage for a specific ship and route.
Port	Left-hand side of the ship, for an observer facing forward.
PSC	Port State Control
SAR	Search and Rescue
Sidescuttle	Circular glass window in the ship's hull to admit light and air

A sidescuttle on Fairplay 22.

SMC	Safety Management Certificate

SMM	Safety Management Manual (safety management Stena)
Speed through the water	A ship's speed relative to the surrounding water mass. As a result of currents, there may be a considerable difference between a ship's speed through the water and its ground speed.
Starboard	Right-hand side of the ship, for an observer facing forward
Stern-to-bow	A towage connection attached to the stern of the tug and the bow of the object that is to be towed.
Stern-to-stern	A towage connection attached to the stern of the tug and the stern of the object that is to be towed.
TOS	Transport & Offshore Services
USCG	United States Coast Guard
VDR	Voyage Data Recorder
Waadi	Placement of Personnel by Intermediaries Act
Winch	Used to unwind and wind up the towing line.

CONSIDERATION

Introduction
On 11 November 2010, the captain of the Roll-on Roll-off (Ro/Ro) passenger ship Stena Britannica ordered two tugs from Fairplay shipping company to assist him in the mooring procedure at the Hook of Holland pier on account of the strong to gale-force southerly wind. Tugs Fairplay 22 and Fairplay III were deployed to assist the passenger ship. Using VHF, the captains of Fairplay 22 and Stena Britannica agreed to use two towage connections: one connecting the starboard stern of Stena Britannica to Fairplay III and one connecting the starboard bow of Stena Britannica to Fairplay 22. They also agreed to a speed through the water of seven knots while performing the manoeuvres to transfer the towing line. The foreward tug Fairplay 22 had to manoeuvre close to the bow of Stena Britannica in order to take in the heaving line,[1] which was to be thrown from the bow of Stena Britannica to the tug. In order to avoid having to cast the heaving line into the wind, the tug positioned itself on Stena Britannica's portside (lee side). This would also prevent the gale-force winds from driving the tug against Stena Britannica during the manoeuvre. When the tug manoeuvred close to the bow of Stena Britannica to take in the heaving line, Fairplay 22 collided with the bulbous bow of Stena Britannica, after which the tug found itself broadside in front of Stena Britannica's bow. The collision between Stena Britannica and Fairplay 22 caused the tug to heel to port and take on water, whereupon it capsized shortly after.[2] The accident resulted in the deaths of two people and one person was slightly injured.

During the course of the investigation, an incident similar to the incident involving Fairplay 22 occurred. This incident involved tug Smit Polen and occurred on 13 January 2011 while establishing a towage connection with the bow of a container ship. In this instance, too, the tug collided with the bulbous bow of the ship receiving towage assistance and the tug was pushed over. However, unlike Fairplay 22, the Smit Polen was able to right itself on its own shortly afterwards.

In consultation with the relevant authorities of the flag states of both ships, the Dutch Safety Board decided to launch an independent investigation into the accident of 11 November 2010 involving Fairplay 22 and Stena Britannica. The Safety Board also decided to include in its investigation the incident involving tug Smit Polen. The key research question for this accident investigation is as follows:

How did the accident occur and how did the parties involved control the risk of collision and capsizing while establishing towage connections?

Scope
The Safety Board's investigation focuses on the assistance provided by tugs to seagoing vessels in harbours. The Safety Board did not investigate towage assistance provided to other types of ships or at other locations. Nor did the Safety Board investigate the emergency response that was launched immediately after the accident. Almost instantly after Fairplay 22 had capsized, various ships arrived on the scene to offer assistance. Other emergency response services also responded quickly to the accident. The Safety Board therefore saw no reason to investigate the emergency response any further.

1 A heaving line is a relatively thin line which is weighted at one end and thrown from the vessel requiring towage to the tug where it is connected to the float line section of the towing line in order to establish a towing connection between the two vessels.
2 The term 'capsize' in this report refers to a situation where a ship rolls through a heeling angle so great that it is no longer able to right itself independently.

Relevant facts
In both incidents, the tugs had sailed close to the bulbous bow of a seagoing vessel and found themselves in the hydrodynamic sphere of influence centred around the bow of the seagoing vessel. This sphere of influence is characterised by strongly alternating hydrodynamic forces (attraction and repulsion). In both cases, the captains of the tugs were unable to maintain a safe distance and they collided with the seagoing vessel. Subsequently, both tugs ended up broadside in front of the seagoing vessel and were pushed over by the seagoing vessel's bulbous bow.

The investigation demonstrates that the speed through the water at which ships sail when performing such manoeuvres strongly influences the flow patterns that occur near the bow. It is likely that gale-force winds also played a role in the accident involving Fairplay 22 on 11 November 2010. The first manoeuvre to establish a towage connection failed, after which a second manoeuvre was attempted. During this second manoeuvre, Fairplay 22 collided with Stena Britannica, came broadside in front of its bow and subsequently heeled over. As the tug heeled over, an open door and open vents allowed water to flood in, which exacerbated and accelerated the capsizing of the tug.

Hydrodynamic effects around the bulbous bow and the bow
The investigation shows that, particularly in the immediate vicinity of the bow of a ship, hydrodynamic forces of attraction and repulsion both come into play. Moreover, the speed that ships maintain during assistance operations and the distances between the ships play a crucial role in this regard. The higher the speed and the smaller the distance between two ships, the stronger the forces at play. Other factors, such as wind, currents, the shallowness of the water and the drift angle of the seagoing vessel relative to the water can reinforce this effect even further. Tug captains must be mindful of these forces when approaching the bow of a ship and act accordingly. If a tug sails close to the bow of a seagoing vessel as it sails, it may become extremely difficult or impossible for the tug to maintain its position. In the worst case scenario, the tug can collide with (the bulbous bow of) the seagoing vessel and subsequently end up broadside in front of the bow. This is what happened in the incidents involving Fairplay 22 and Smit Polen.

Tug stability
Although the circumstances in which Fairplay 22 and Smit Polen ran into difficulties were virtually identical, the outcomes of the two incidents were different. Tug Fairplay 22 capsized as a result of the collision while the Smit Polen was able to right itself on its own. The different outcomes of these two incidents prompted the Dutch Safety Board to further examine and compare the stability of both tugs. The Safety Board's investigation revealed that, at the time of the accident involving Fairplay 22, the vents of the engine room and a door leading to the after deck were open. This enabled water to flood into the ship, at a heeling angle of just approximately 35 degrees, when the tug heeled over as a result of the collision with Stena Britannica. As a result, the vessel's stability deteriorated and capsizing was accelerated. The tug could no longer right itself.

After the accident the Dutch Safety Board investigated the stability of sistership Fairplay 23, because Fairplay 22 was no longer adequate. The investigation into the stability of the tugs uncovered that Fairplay 22 did not meet the additional criteria set by the major classification societies since 1998 with respect to the stability of new-build ships. These criteria are supplementary to the requirements of the International Maritime Organization. These additional criteria were not yet in force when Fairplay 22 was built in 1998.

However, Fairplay 22 was obliged to comply with the stability requirements specified by the See-Berufsgenossenschaft (SBG) in 1998. These requirements, which are less stringent than the additional criteria that have been in force since 1998, were also part of the certification of Fairplay 22 awarded by Germanischer Lloyd classification society.

The investigation conducted by the Dutch Safety Board shows that Fairplay 22 only complied with the SBG stability requirements when its vents were shut. When the ship was in operation, however,

the vents to the engine room could not be shut as doing so would largely block off the required air supply and the machine room would no longer be able to operate properly. Paradoxically, with its vents open, the ship did not meet the 1998 SBG stability requirements.

In practice, both ship designers and classification societies assume that, dependent on operational circumstances, the crew of a ship, as good seamen, will shut the vents in order to ensure the stability of the vessel. When providing tug assistance, the nature of which regularly places the tug in potentially dangerous situations and necessitates the flow of sufficient air to the engine room, tug operations should not have to depend on the crew shutting the vents.

This observation regarding the stability of Fairplay 22 prompted the Dutch Safety Board to submit an interim recommendation to the shipping company on 29 June 2011 in advance of the final report. Furthermore, the investigation into the vessel's stability revealed that Fairplay 22 was prone to steep heeling angles during operation. These heeling angles can exceed safe operational limits as well as influence the performance of the crew on deck and elsewhere on the vessel. However, currently virtually no requirements have been specified for the maximum heeling angles for tugs. Such requirements only exist in Norway with respect to 'anchor handling' operations; classification society Bureau Veritas has drawn up a proposal to address this issue.[3]

Unlike Fairplay 22, the Smit Polen was able to right itself on its own following the collision. This situation is attributable to a number of factors. Firstly, Smit Polen is a more stable vessel which complies with the stability criteria that currently apply to tugs. In addition, as the vents on the Smit Polen are located higher than on Fairplay 22 and the doors to the on-board accommodation areas were shut, no water flooded into the ship when it heeled over. Finally, the tug may have collided with the ship being assisted (Maersk Nijmegen) at a different location, allowing the tug to turn quickly from the front to alongside Maersk Nijmegen.

Design of seagoing ships
The Dutch Safety Board would like to point out that the design of seagoing ships, such as Stena Britannica, does not take sufficient account of the risks inherent in tug assistance operations. To facilitate the safe establishment of towage connections to the bow, it is important that seagoing vessels sail at low speed and that the hydrodynamic forces at the bow are minimised. It is also important that the risks associated with transferring the heaving line are controlled as much as possible. Currently, a tug is often forced to position itself in the dangerous area close to the bow of a seagoing vessel because it is not always possible to cast a heaving line from a location on board the seagoing vessel that is most suitable for the tug.

Safety management of the shipping companies involved
In 1998, the International Maritime Organization (IMO) drew up an international standard for safety management on board ships, known as the International Safety Management (ISM) Code. Some ships, including Fairplay 22, are not obligated to comply with this code owing to their size. Nevertheless, Fairplay shipping company decided for voluntary ISM certification of Fairplay 22. This was the case until 2009, when Fairplay decided to discontinue the voluntary ISM certification because of the administrative burden involved.

The Dutch Safety Board has established that the safety management system implemented by Fairplay fell short in a number of areas as follows:

- Fairplay did not conduct a hazard indentification and analysis (RI&E) for sailing at close quarters to the bow of a ship requiring assistance or for taking in a heaving line;
- Fairplay's procedure, which prescribes that the vents of the engine room must be closed during assistance operations, could not be implemented in practice - as already stated above. Fairplay did not monitor this procedure; and

3 This proposal is included on page 77 in Appendix 11. While this investigation was being conducted, it was not yet known whether the proposal had been submitted to the International Association of Classification Societies (IACS).

- The internal procedure regarding the speed through the water, which specifies a speed of six knots when a heaving line is taken up, was not monitored by Fairplay.

Fairplay was aware that Fairplay 22's sister ships, which had been chartered by another shipping company and which also provide assistance to seagoing vessels, were provided with permanent ballast to improve stability. In spite of this, Fairplay took no action to assess the stability of its own tugs or to determine whether Fairplay 22 complied with the stability requirements. Furthermore, Fairplay could have known that Fairplay 22 and her sister ships did not comply with the stability criteria that currently apply to tugs. After all, the shipping company put into operation a number of newly built tugs after the additional stability criteria had come into force. Fairplay nonetheless did not take any action to improve the stability of its older vessels.

With respect to Stena's safety management, the Dutch Safety Board has observed that Stena, too, failed to pay sufficient attention to the risks involved in establishing towage connections. For example, Stena's Safety Management Manual does not contain a procedure for establishing a towage connection or for tug assistance in general. Furthermore, Stena did not monitor the competence of its captains in working with tugs in the port of Rotterdam. Stena also failed to utilise the opportunity to assess beforehand (for instance in a written contract) the shipping company quality standard, the risks associated with establishing a towage connection and the risks involved in mooring and unmooring with tug assistance in the port of Rotterdam.

Issue and monitoring of a Pilot Exemption Certificate (PEC)[4]
As the authority responsible for the smooth, clean, safe and secure handling of shipping in the port of Rotterdam, the Port of Rotterdam Harbour Master issues Pilot Exemption Certificates and monitors their use. Since the monitoring of these certificates is managed by the Port of Rotterdam Harbour Master, he is responsible for both issuing the Pilot Exemption Certificate and monitoring its use.

In principle any captain of a seagoing vessel wishing to enter the Port of Rotterdam needs to have a pilot at his disposal. A captain of a seagoing vessel can obtain a Pilot Exemption Certificate after having successfully completed a training course. The captain of Stena Britannica participated in a simulator training course at Stena in 2003. The Port of Rotterdam Harbour Master issued the captain of Stena Britannica with a Pilot Exemption Certificate based on a certificate issued by Stena stating that the captain had completed this training course. The information obtained by the Dutch Safety Board from the Port of Rotterdam Harbour Master does not indicate that any kind of test of the subject matter took place regarding the training course completed by the captain.

In recent years, the Port of Rotterdam Harbour Master has stipulated that captains of similar vessels of various shipping companies complete additional training courses. The policy of the Port of Rotterdam Harbour Master in this regard is that training courses of this type are repeated every three years. However, the Port of Rotterdam Harbour Master did not stipulate that the captain of Stena Britannica should undergo further training. Furthermore, the captain of Stena Britannica was not required to repeat this training course every three years. The Dutch Safety Board is surprised that the Port of Rotterdam Harbour Master did not require the captain of Stena Britannica to undergo additional tug assistance training in the Port of Rotterdam, given that when tug assistance is requested exceptional and difficult circumstances, weather or otherwise, are usually at play.

Voyage Data Recorder (VDR)
Data stored on a ship's VDR is used to assist accident investigation. Fairplay 22 did not have a VDR on board as this was not required by law. The lack of a VDR has complicated the establishment and interpretation of the facts in this investigation.

4 A Pilot Exemption Certificate (PEC) is a certificate issued by the Port of Rotterdam Harbour Master, who is employed by the Port of Rotterdam Authority, exempting a captain from compulsory pilotage for a specific vessel and route.

Recommendations
To prevent tugs from colliding with seagoing vessels and capsizing during tug assistance operations, it is important to identify the risks involved in a tug sailing close to the bow of a seagoing vessel. The tug companies, shipping companies and pilots must identify and evaluate the risks and, if necessary, make agreements or specify mutual requirements. Important aspects in this regard are the speeds through the water to be maintained. It is also important that these companies set up a risk-awareness training programme for their employees, which also covers how they should control these risks.

Furthermore, given the substantial hydrodynamic forces at play around the bow of a seagoing vessel, it is important that the tug captain and the captain and/or pilot on board the seagoing vessel make clear agreements regarding the speeds to be maintained. The guiding principle in this respect is that the lowest speed possible must be maintained in all circumstances. In addition, the crew of the tug must ensure that all openings that can be shut and rendered watertight and weathertight are indeed closed during operations. These agreements could be incorporated in the training course and the Pilot Exemption Certificate.

Finally, it is important that the design of seagoing vessels takes account of the risks inherent in establishing towage connections. A point of attention in this context is the presence of suitable locations on a vessel from which to cast a heaving line to a tug, so as to allow a tug to avoid the dangerous areas near the seagoing vessel's bow.

In advance of this report, the Dutch Safety Board issued a recommendation on 29 June 2011. In its response to this recommendation, Fairplay stated that they: (1) are considering installing on the bridge an indicator light to show the status of the door to the aft deck; and (2) will inquire with the classification society whether a Certificate of Class was provided erroneously. In the response to the draft version of this report, Fairplay indicated that a number of measures have been taken, or are under consideration, regarding the stability of the shipping company's tugs. For the Safety Board, it is unclear whether these measures will result in Fairplay 23 satisfying the 1998 SBG stability requirements. No written response from Fairplay was received showing whether they intend to concur with the recommendation.

To Fairplay:

The Safety Board recommends that the shipping company determines the stability of Fairplay 23's sister ships. If the determined stability turns out to correspond with that of Fairplay 23, the shipping company is advised to take measures to improve the stability of all ships, in order to ensure that they at least comply with the 1998 SBG requirements.

In this report, the Dutch Safety Board has formulated the following recommendations:

To Fairplay:

1. Identify, preferably in consultation with the European Tugowners Association, the risks associated with sailing close to the bow of a seagoing vessel and take measures to minimise these risks. Pay particular attention to the speed through the water to be maintained, the stability and the position of tugs during the operation of establishing a towage connection. Implement this in your safety management system.
2. Monitor the operational procedures, including the speed maintained during tug assistance operations and the closing of watertight and weathertight openings.

To Stena:

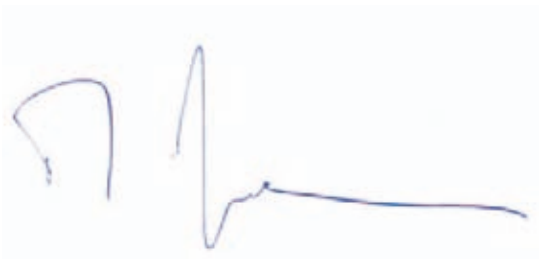
1. Compose an inventory of the risks involved in establishing a towage connection and take measures to control these risks as much as possible. Implement all this in your safety management system and ensure that captains are competent in using tug assistance in the port of Rotterdam.
2. Set out written agreements with tug companies regarding tug assistance and include herein safety criteria aimed at guaranteeing safety.

To the Port of Rotterdam Harbour Master:

1. Specify the maximum speed through the water at which a towage connection should be made between a tug and a ship requiring assistance in a procedure, and ensure compliance.
2. Specify requirements relating to the captain's knowledge, training and experience with respect to tug assistance for issuing a Pilot Exemption Certificate to a captain using tug assistance, and ensure compliance.

To the minister for Infrastructure and the Environment:

1. Investigate the possibilities of making tug captain training compulsory for all captains working on Dutch tugs and tugs in Dutch harbours, regardless of propulsion power.
2. Investigate, in consultation with other IMO member states if possible, the feasibility of requiring that all newly built tugs be equipped with a Voyage Data Recorder (VDR).



T.H.J. Joustra
Chairman of the Dutch Safety Board

M. Visser
General Secretary

1 INTRODUCTION

1.1 Background

On 11 November 2010, tug Fairplay 22 capsized on the Nieuwe Waterweg near Hook of Holland while establishing a towage connection to assist Roll-On Roll-Off (Ro/Ro) passenger vessel Stena Britannica. Two Fairplay 22 crew members died as a result of the accident.

The accident took place in Dutch territorial waters. According to the Casualty Investigation Code and EU directive 2009/18/EC, the accident is a very serious casualty and the Netherlands - as coastal and harbour state – is required to ensure that an investigation is conducted. An investigation of the accident is also required under the Dutch Safety Board Decree. According to an agreement with the ships' flag states, Antigua and Barbuda and the United Kingdom, the Netherlands is responsible for leading and conducting the investigation.[5] The Dutch Safety Board initiated the investigation immediately after the accident on 11 November 2010.

1.2 Objective of the investigation

This investigation aims to determine the direct and underlying causes of the accident in order to learn lessons that will help prevent similar accidents from occurring in the future and/or minimise their effects. The key question in this investigation is:

How did the accident occur and how did the parties involved control the risk of collision and capsizing while establishing towage connections?

The Safety Board also investigated whether any other accidents had occurred in which a forward tug had unintentionally collided with the ship it was assisting in addition to the Fairplay 22 accident. The Safety Board identified three such accidents. One of these, an accident involving tug Smit Polen on 13 January 2011, showed many similarities with the Fairplay 22 accident and was therefore investigated in further detail.

1.3 Scope of the investigation

This investigation is limited to (seagoing) harbour tugs establishing a towage connection with seagoing vessels. The scope of the investigation does not include other forms of tug assistance to sailing vessels.

Immediately after the accident, various vessels, an aircraft and a helicopter were deployed as a part of the Search and Rescue (SAR) operation. The Safety Board conducted a preliminary investigation into the SAR operation but found no reason to investigate this aspect in further detail.

5 EU Directive 2009/18/EC Article 7:
1. Accidents or incidents at sea are generally investigated once by a single member state or a responsible member state working in collaboration with other member states that have a significant stake in such an investigation. In the event of a safety investigation involving two or more member states, it is important that the member states involved quickly reach a consensus as to which member state will be responsible for the investigation.

1.4 Reading guide

Chapter 2 contains general information on tug assistance and describes the relevant facts of the accident involving tug Fairplay 22. This chapter also describes the relevant facts of a similar accident, which took place in January 2011. This is followed by the analysis in chapter 3. This chapter contains the reconstruction of the accident and the direct and underlying causes. Chapter 4 contains the conclusions of the investigation. In chapter 5 the Safety Board's recommendations are formulated.

2 RELEVANT FACTS AND BACKGROUND INFORMATION

This chapter features technical terminology. These terms are further explained in the glossary of terms and abbreviations.

2.1 Tug assistance and towage connections

Tugs are traditionally used to assist seagoing vessels. They may be used to assist a ship encountering technical problems or help the vessel carry out difficult manoeuvres such as mooring. Depending on the specific requirements and circumstances, such assistance may be provided by one or more tugs. The assistance may consist of towing, pushing and/or stopping the seagoing vessel. Towage connections using a towing line offer the most options as they allow the tug to exert force on the seagoing vessel from several directions.

Tug crews working to help a seagoing vessel moor in the harbour will generally establish the towage connection while the ship is sailing. This procedure may be carried out at sea, at the harbour entrance or inside the harbour area. In order to establish a towage connection, the tug must be manoeuvred within throwing distance of the seagoing vessel so that a heaving line (a weighted rope) can be thrown on board. Depending on the circumstances, the distance between both vessels can vary from less than ten metres to several dozen metres. The towing line, which is attached to the tug's winch and transferred by means of the heaving line, is attached to mooring bitts on the seagoing vessel's deck. The tug winch is usually remotely controlled (from or next to the bridge). The winch is used to wind out – and subsequently fasten - the towing line at the appropriate length. If necessary, the towing line can be rapidly lengthened in a short space of time. A towage connection can be established on various parts of the seagoing vessel. In practice, however, in most European harbours the bow or stern sections of the seagoing vessel are used.

Over the past few decades, there have been various developments in tug design, especially in terms of propulsion. As seagoing vessel sizes have increased, the demand for tugs with a greater traction force has risen. As a result, new tugs are increasingly fitted with higher powered engines. This higher engine power capacity is used to enhance the bollard pull forces, but has not resulted in increased tug speeds. Due to the fact that today's larger seagoing vessels have a higher dead-slow speed,[6] and towage connections are generally made at higher speeds, tugs have less reserve power to move away in the event of an emergency.

In the past, towage connections would be established near the mid-section of the tug, by means of a stern-to-bow towage connection, for example. This method is still commonly used on conventional tugs with one or two fixed pitch propellers and rudders.

Modern tugs are often equipped with one or more azimuth thrusters instead of fixed pitch propellers and rudders. Azimuth thrusters are capable of 360 degree rotation, and can generate propulsive force in any direction. This helps improve a tug's manoeuvrability. Due to the growing popularity of tugs with azimuth thrusters at the stern (Azimuth Stern Drive (ASD)), towage connections are increasingly made on the tug's bow section, by means of a bow-to-bow or bow-to-stern towage connection.

6 The speed at the lowest throttle setting at which the propeller rotates in order to maintain an extremely low speed.

2.2 Relevant facts

On the evening of 10 November 2010, Fairplay 22 moored at Tennesseehaven in Rotterdam. The crew did not provide any further assistance until the afternoon of 11 November. The permanent crew of Fairplay 22 consisted of a captain, a chief engineer and an able seaman. The permanent crew had been supplemented with a trainee captain and a trainee maritime officer.[7] On the morning of 11 November, the captains of Fairplay 22 and Fairplay III agreed that if they were called upon to assist a Ro/Ro passenger vessel, such as Stena Britannica, Fairplay III would assist at the stern, while Fairplay 22 would assist at the bow. This would offer the trainee captain on board Fairplay 22 the opportunity to experience this conventional form of towing (stern-to-bow). In Rotterdam, bow-to-bow connections are generally used when towing with this type of tug.

In the early afternoon, Fairplay III was instructed to assist Stena Hollandica – a sister ship of Stena Britannica – upon departure from the Hook of Holland terminal. The trainee captain transferred to Fairplay III in order to witness the procedure. Figure 1 shows Fairplay 22 and Fairplay III tugs.

Figure 1: Fairplay 22 (left) and Fairplay III (right) tugs [source: www.tugspotters.com].

In the meantime Stena Britannica was on its way from Harwich to Hook of Holland. The ship's ETA in Hook of Holland was 16.00.[8] Figure 2 shows an aerial view of the Nieuwe Waterweg off Hook of Holland.

Figure 2: Aerial view of the Nieuwe Waterweg showing the location of the Stena pier (green) and the Lage licht (red). [Source: Image Science and Analysis Laboratory, NASA-Johnson Space Center. 'The Gateway to Astronaut Photography of Earth.' (edited manually)].

7 At the time of the accident the trainee maritime officer had the rank of bosun and the position of trainee.
8 All times in this report are local times (UTC+1), unless stated otherwise. Times are represented in the following format [hh.mm:ss].

In view of the weather conditions on the North Sea (strong - gale force winds) the captain of Stena Britannica contacted the captain of Stena Hollandica, who had just departed from Hook of Holland, to enquire about the weather conditions at Hook of Holland and determine whether it would be safe to moor. The captain of Stena Hollandica confirmed that this was possible. The wind was southerly with force 7 to 8 on the Beaufort Scale, and was expected to become stronger later in the day. In view of the strong southerly wind, the captain of Stena Britannica decided to request tug assistance during mooring at the Hook of Holland terminal. He ordered two tugs from Fairplay Towage B.V.,[9] a towage company with which Stena Line Ltd[10] has an agreement regarding tug assistance. It was agreed that the two tugs would assist Stena Britannica during mooring by means of a towage connection at the front and aft starboard sides of Stena Britannica.

The captain of Fairplay 22 received an instruction from the planning department at Smit Harbour Towage B.V.[11] (responsible for scheduling ships for Fairplay). According to the instruction, Fairplay 22 and Fairplay III were to assist Stena Britannica during mooring at the Hook of Holland terminal. At that time Fairplay III was already on the Nieuwe Waterweg, having provided assistance to Stena Hollandica. At 15.12, Fairplay 22 departed from Tennesseehaven and sailed towards Fairplay III in order to take the trainee captain back on board. During an interview with Dutch Safety Board investigators, the captain of Fairplay III stated that he had asked the captain of Fairplay 22 whether it would be better if Fairplay III attached her connection to the bow, but the captain of Fairplay 22 decided to stick to the original agreement. The two tugs then sailed to their starting positions on the Nieuwe Waterweg west of Hook of Holland, where they would await the arrival of Stena Britannica. Fairplay III waited at buoy 3 (NW 3) on the Nieuwe Waterweg, while Fairplay 22 was positioned at the Maas 4 buoy. Figure 3 shows the positions of both tugs.

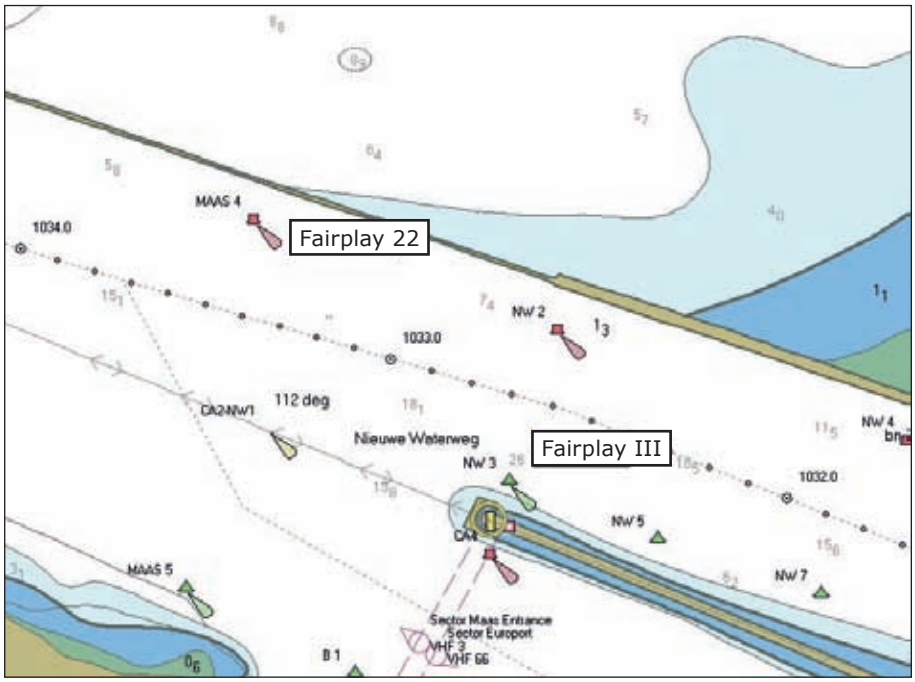


Figure 3: The positions of both tugs during the approach of Stena Britannica. The position of Stena Britannica is not featured on the illustration as she was located out of view, on the left.

9 All further references to Fairplay Towage B.V. shipping company have been abbreviated to Fairplay. Use of the term Fairplay 22 refers to the tug herself, not to the shipping company.

10 All further references to Stena Line Ltd shipping company have been abbreviated to Stena. Use of the term Stena Britannica refers to the Ro/Ro passenger vessel herself, not to the shipping company.

11 All further references to Smit Harbour Towage B.V. shipping company have been abbreviated to Smit. Use of the term Smit Polen refers to the tug herself, not to the shipping company.

Once Stena Britannica's captain had reported to Vessel Traffic Services[12] (VTS) at the port entrance (Maasmond sector), the tug captains contacted Stena Britannica's captain and agreed upon a dedicated VHF channel for further communications. Stena Britannica's chief officer, responsible for communicating with the tugs, asked the captain of Fairplay 22 at which speed through the water he preferred to establish the towage connection.[13] The captain of Fairplay 22 responded he preferred a speed between 6 and 8 knots. The chief officer then suggested to the captain of Fairplay 22 that the ship would maintain a speed of 7 knots, which the captain agreed to. In the meantime, both tugs had sailed in the direction of Stena Britannica in order to start establishing the towage connection. In view of the strong southerly wind, the captain of Fairplay 22 decided it would be better to take in the heaving line on the lee side[14] of Stena Britannica (the ship's port side). Stena Britannica would then offer some protection against the strong winds, so that the heaving line would not have to be cast out into the wind. Once the towing line was connected to the starboard side of Stena Britannica, the tug would manoeuvre to the starboard side of Stena Britannica in order to assist in the mooring procedure.

As Stena Britannica drew near, Fairplay 22 left its position near Maas 4 buoy at 15.41 in order to conduct its approach. During an interview with Dutch Safety Board investigators, the captain of Fairplay III stated that he had considered contacting Fairplay 22 as he felt the agreed speed was too high. However, Fairplay 22 had already started its approach, and he decided it would be better not to distract the crew by contacting them.

There were three people on board Fairplay 22's bridge, namely the captain, the chief engineer and the trainee captain. Initially, the tug was steered by the trainee captain, but he handed over the controls to the captain before starting the initial approach to Stena Britannica. The trainee captain then observed the captain's manoeuvres. The chief engineer was stationed on the bridge in order to operate the winch.

The able seaman was in position on the rear deck, waiting to catch Stena Britannica's heaving line and connect the messenger line.[15] The trainee maritime officer was located in the shower area in the on-board accommodation.

Stena Britannica's bridge was manned by the captain, the chief officer and a helmsman. The captain focused on general navigation while the chief officer communicated with the tugs. The helmsman followed orders from the captain in order to keep the ship on its intended course. Three able seamen and a bosun waited on the foredeck to cast the heaving line. The forward tug was not fully visible from the bridge.

At 15.47, the crew made its first attempt of transferring Stena Britannica's heaving line near the ferry's bow. Both ships were travelling at a ground speed of approximately 7.4 knots. There was a 1 knot current (approximately) in the direction of the sea. This resulted in a speed through the water of approximately 8.4 knots. Fairplay 22 was sailing on Stena Britannica's port side. The attempt to transfer the heaving line failed. Fairplay 22 then passed in front of Stena Britannica's bow, making a movement to starboard followed by a movement to port. Then, a second attempt was made. Figure 4 shows the tracks of the two ships and indicates their positions during the first and second attempts to transfer the heaving line.

12 Vessel Traffic Services are intended to ensure the safe and efficient transit of vessel traffic.
13 There is a difference between speed through the water and ground speed. Ground speed is a ship's speed relative to the ground. Speed through the water is the ship's speed relative to the surrounding water. As a result of currents, there may be a considerable difference between these two speeds.
14 The lee side is the side of the ship that is sheltered from the wind.
15 The messenger line is a light line used to connect the towing line to the heaving line.

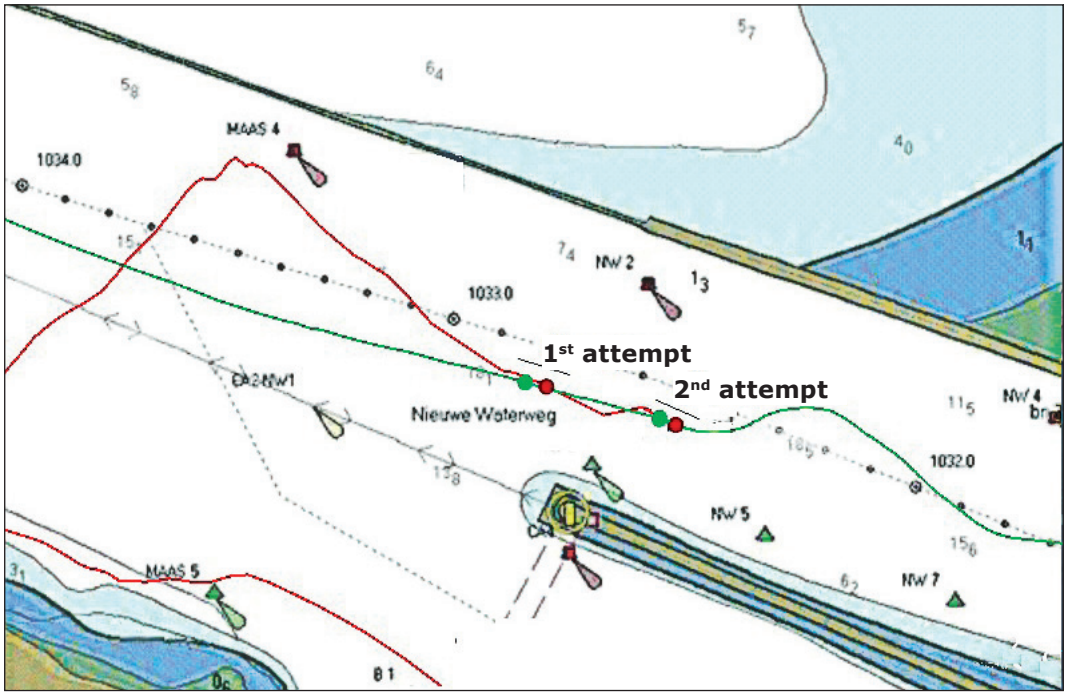


Figure 4: The trajectories of Fairplay 22 (red) and Stena Britannica (green) and the positions of both ships while attempting to pass the heaving line.

During the second attempt to take in the heaving line, Fairplay 22 repositioned itself to end up on Stena Britannica's port side. As in the first attempt, the captain manoeuvred the tug using the control panel at the rear of the bridge. This position offered him a better view of the rear deck than the control panel at the centre of the bridge. The captain was standing with his back facing the ship's sailing direction. Figure 5 shows the rear control panel (of sister ship Fairplay 23).

Figure 5: Rear control panel of Fairplay 23.

The second attempt of transferring the heaving line took place at approximately 15.49. The captain of Fairplay 22 manoeuvred the tug to Stena Britannica's port side. Both ships were now travelling at a ground speed of approximately 7 knots. The able seaman made an attempt to throw the heaving line from Stena Britannica. This attempt failed.

Over the course of the second attempt, Fairplay 22 collided with Stena Britannica. Fairplay 22 came broadside in front of Stena Britannica's bow with its starboard side, and heeled over to port. The captain of Fairplay III realised what was happening and communicated to the Stena Britannica captain by VHF: "Stena Britannica full speed astern". Stena Britannica complied immediately, and the ship reduced speed. The chief officer of Stena Britannica also saw that the tug started to heel. Shortly thereafter, the heeling of the tug was also reported to the bridge by the crew member on the fore deck of Stena Britannica. In the meantime, Fairplay 22's heeling angle had increased even further. A few moments later, Fairplay 22 capsized over its port side. Figure 6 shows Fairplay 22 after the vessel had capsized.

Figure 6: The capsized Fairplay 22 and tug RT Magic, which provided assistance after the accident [source: www.tugspotters.com].

As a result of Fairplay 22's heeling angle, the able seaman fell in the water and ended up under the rear deck of the tug that had meanwhile capsized.
His lifejacket activated automatically as he hit the water. The upward pressure of the lifejacket pushed him against the rear deck. He pierced the lifejacket with a knife and removed it. He then swam to the surface. Several vessels immediately sailed to the accident site in order to provide assistance. Figure 7 shows the accident site shortly after the ship had capsized. Fairplay III was first to arrive. The crew of Fairplay III noticed the able seaman and attempted to get him on board. Their attempts were hampered by the high bulwark of the tug. He was then picked up by a pilot vessel which had sped to the scene to join the rescue effort.

The trainee maritime officer was located in the shower area when the tug capsized. He managed to open a starboard sidescuttle, and escaped from Fairplay 22. He then swam to Fairplay III without further assistance. The captain, chief engineer and trainee captain found themselves trapped in the bridge of the capsized tug. They were able to breathe for a while thanks to an air bubble, but at a certain point there was no other option left but to abandon ship. The trainee captain managed to escape by opening one of the bridge doors and was subsequently rescued by the pilot vessel. The chief engineer and captain did not manage to escape from the tug.

Figure 7: The accident site shortly after the occurrence, with the capsized Fairplay 22 on the left and Stena Britannica in the background [source: www.tugspotters.com].

From Stena Britannica's starboard bridge wing a lifebuoy and a smoke signal were immediately launched, and a second lifebuoy was thrown into the water towards the tug. The captain also made preparations to launch the fast rescue boat. Because of the immediate assistance by Fairplay III and other ships it was decided not to launch the fast rescue boat. Due to the characteristics of the ship (such as its size and manoeuvrability), Stena Britannica could not provide any further assistance. The captain managed to maintain the ship's course until tugs arrived at the scene of the accident. Assisted by two other tugs, the ship finally moored at the Stena pier in Hook of Holland approximately half an hour after the accident. During the manoeuvres for establishing a towage connection with Fairplay 22 the bow thruster of Stena Britannica was not used. The bow thruster was used after the accident for coursekeeping and mooring of Stena Britannica.

A Search and Rescue (SAR) operation was initiated immediately after the accident. The Maasmond, the entrance to the port of Rotterdam, was blocked at 16.07 on 11 November 2010 and released at 17.41 on the same day, under temporary traffic regulation measures.

Several ships, an aircraft and a helicopter were used to search for the crew members on the day of the accident itself and the following days. Preparations were also made in order to deploy a team of divers to inspect the tug and initiate a salvage operation. Divers attempted to find survivors using tapping signals, but received no response. In view of the poor weather conditions, the tug was towed to a safer location within the port. Divers were unable to inspect the tug until a day after the accident. Neither of the crew members was found during the inspection.

The engineer's body was found washed up on the beach near 's Gravenzande on the morning of Friday, 12 November 2010. Search operations were carried out to find the captain but were unsuccessful. He was not found during several inspections carried out on board the tug either. The body of the captain of Fairplay 22 was finally discovered near the Noorderpier at Hook of Holland on Friday, 26 November 2010.

2.3 Personal injury

Fairplay 22
Two Fairplay 22 crew members died as a result of the accident. The other three crew members were taken to hospital by ambulance. The victims were suffering from hypothermia and were in a state of shock. One individual had also sustained ankle injuries.

Stena Britannica
The crew members and other persons on board Stena Britannica did not suffer any personal injury as a result of the accident.

2.4 Damage

Fairplay 22

Various parts of Fairplay 22 were damaged, including the hull and the starboard azimuth thruster. The propulsion system and ship's equipment also suffered water damage. The cause of the damage to the starboard azimuth thruster could not be determined with certainty; the damage was possibly sustained during the salvage operation. The tug was not put back into service after the accident, and was sold to a new owner in Greece. Figure 8 shows the damage to Fairplay 22's underwater hull.

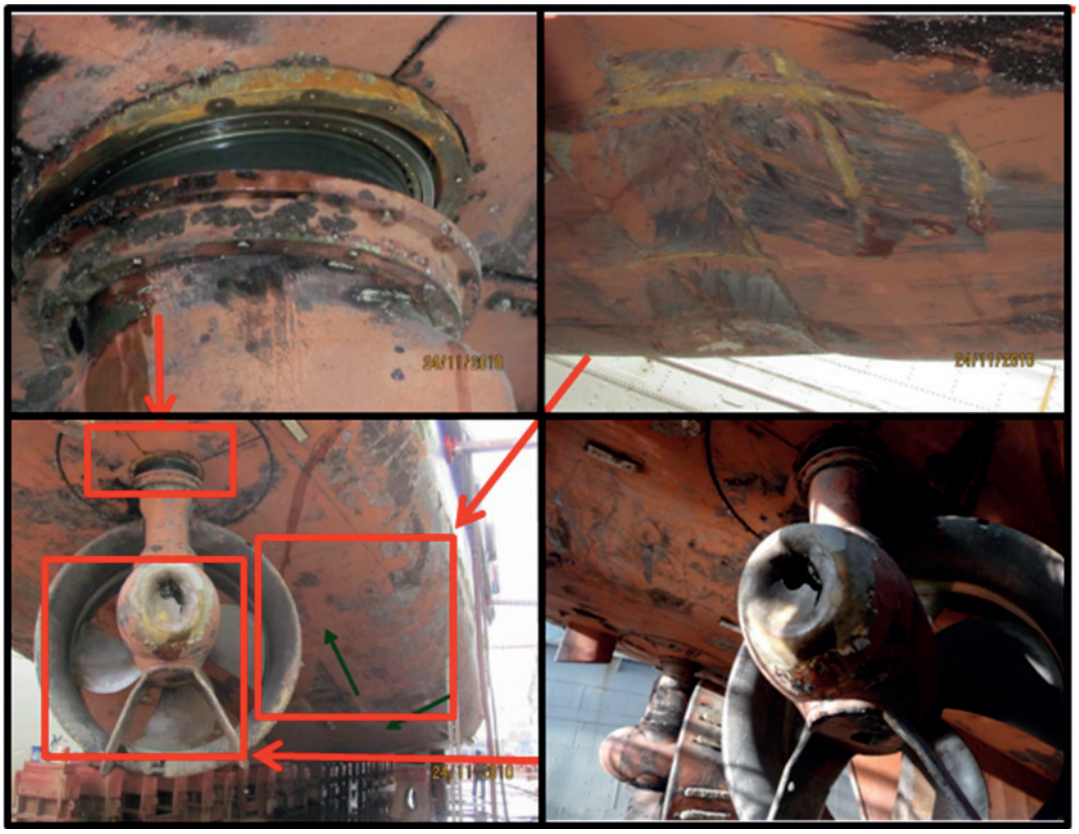


Figure 8: Damage to Fairplay 22 [source: Dutch National Police Services Agency (KLPD)].

Stena Britannica

An inspection was conducted on 23 November 2010 in order to determine the extent of damage to Stena Britannica. The inspection only found damage to the bulbous bow. This damage was limited to paint damage and light scuffing. The inspection found traces of red paint on Stena Britannica's bulbous bow. Figure 9 shows the damage to Stena Britannica.

Figure 9: Damage to the bulbous bow of Stena Britannica [source: Marine Accident Investigation Branch, United Kingdom].

2.5 Vessels involved

2.5.1 Fairplay 22

Figure 10 shows Fairplay 22; table 1 provides the most important vessel information.

Figure 10: Tug Fairplay 22 [source: Fairplay].

Name	Fairplay 22
Call sign	V2FG
IMO number	9148764
Flag state	Antigua and Barbuda
Home port	St. John's
Vessel type	ASD-tug
ISO certificate holder[16]	Fairplay Schleppdampfschiffs-Reederei Richard Borchard GmbH, Hamburg, Germany. Branch-office: Fairplay Towage BV, Rotterdam, the Netherlands.
Registered owner	BBB Schlepp- und Hafendienst GmbH, Rostock, Germany.
Classification society	Germanischer Lloyd, Germany
Year of built	1998
Length over all	35.55 metres
Width	10.8 metres
Maximum draught	4.6 metres
Gross Tonnage	496 GT
Engines	2 Deutz SBV 8M628 diesel engines
Propulsion	2 azimuth thrusters with fixed pitch propellers; bow thruster
Maximum propulsion power	3,292 kilowatts
Maximum speed	12.5 knots
Bollard pull	52 tons
Minimum number of crew members	2 persons
Number of crew members on board	5 persons, including 2 trainees
Vessel certificates	All certificates were valid.
Electronic (registration) equipment	In addition to standard navigation equipment: Automatic Identification System (AIS), Electronic Chart System (ECS), engine management system, no Voyage Data Recorder (VDR).

Table 1: Fairplay 22 vessel information

The preliminary design of Fairplay 22 and her identical sister ships Fairplay 21, 23 and 24 was created by Aarts Marine B.V. in Amsterdam. The preliminary design was based on the assumption that the vessel would be used for both towage activities at sea and port-based assistance. The preliminary design was worked out in detail by shipyard Construcciones Navales Santodomingo in Vigo, Spain, which has meanwhile been declared bankrupt. This yard also built the four ships. Fairplay 22 was put into service in 1998.

16 ISO 9001:2008 and ISO 14001:2004.

Documentation and technical state
Fairplay 22 carried all the required valid documentation. The tug had undergone the required annual inspections in both 2009 and 2010, at which time the validity of its certification was confirmed. In addition to these mandatory inspections, Fairplay 22 also underwent inspections in the period after the certificates were issued. These inspections were carried out by the vessel's flag state of Antigua and Barbuda (on 15 December 2008 and 10 May 2010) and Port State Control (PSC initial inspection on 10 July 2008). During the PSC initial inspection two shortcomings were identified, namely an earth fault in the main switchboard and a broken wire in a quick closing valve. Because of the limited severity of these shortcomings, a more detailed inspection was not carried out.

The most recent inspection of Fairplay 22 took place on 23 July 2010 on behalf of the flag state. The inspection established that the shortcomings identified during previous inspections had since been resolved. No new shortcomings were found.

2.5.2 Stena Britannica
Figure 11 shows Stena Britannica; table 2 lists the main information of the Ro/Ro passenger vessel.

Figure 11: Stena Britannica Ro/Ro passenger vessel [source: Stena].

Name	Stena Britannica
Call sign	2DMO6
IMO number	9419175
Flag state	United Kingdom
Home port	Harwich
Vessel type	Ro/Ro passenger vessel
ISM manager	Stena Line Limited, Holyhead, United Kingdom
Classification society	Lloyd's Register of Shipping, United Kingdom
Year of built	2010
Length over all	240 metres
Length between perpendiculars	224 metres
Width	32 metres
Height of bulwark on front deck, measured from waterline	Approx 11.50 metres
Maximum draught	6.40 metres
Arrival draught (bow/stern)	5.58/ 5.80 metres
Gross Tonnage	64,039 GT
Engines	2 MAN 6L48 diesel engines and 2 MAN 8L48 diesel engines
Propulsion	2 variable pitch propellers; bow thruster
Maximum propulsion power	33,600 kilowatts
Maximum speed	22 knots
Minimum number of crew members	20 persons
Number of crew members on board	91 persons (including hotel staff)
Maximum number of passengers	1,200
Number of passengers on board	72
Vessel certificates	All certificates were valid.
Electronic (registration) equipment	In addition to standard navigation equipment: Automatic Identification System (AIS), Electronic Chart Display and Information System (ECDIS), Voyage Data Recorder (VDR).

Table 2: Stena Britannica vessel information.

Stena Britannica, and her sister ship Stena Hollandica, were designed by Aker Finnyards (now: STX Europe) in Helsinki, Finland. The two vessels are currently the world's largest Ro/Ro passenger ships. The ships were built by Wadan shipping wharf (now Nordic Yards) in Wismar, Germany. Stena Britannica was put into service in October of 2010. The ship has since been used on the Harwich-Hook of Holland route together with Stena Hollandica.

Tug assistance
Since October 2010 Stena Britannica had called in the assistance of one or more tugs on seven separate occasions. In five of these cases, assistance was provided by Fairplay tugs. In three of these five cases, assistance was provided by multiple tugs of which one was used as a forward tug. On two occasions, Fairplay 22 together with Fairplay III was deployed for providing assistance to Stena Britannica.

Documents
The vessel held all the required documentation.

2.6 Electronic (registration) equipment

Fairplay 22 was equipped with an Electronic Chart System (ECS). All data stored on the ECS was lost as a result of water damage. Fairplay 22 was not equipped with a Voyage Data Recorder (VDR). Use of such equipment was not mandatory.

Registration of engine room alarms
Engine room alarms were recorded on board Fairplay 22. A printout of the system registrations shows that various alarms were generated on the day of the accident. The printout found by investigators is shown in figure 12.

Figure 12: Printout of Fairplay 22 engine room alarm registrations.

The first series of alarms on the day of the accident took place within a short timeframe ending at 09.58.[17] The subsequent alarms were registered at 14.55:54. These alarms are shown in figure 13.[18]

14.55:54	BOW THRUSTER *(bow thruster*	LUBOIL LEVEL LO *lubricating oil level low)*
14.55:59	AUX. ENGINE PORT *(port auxiliary engine*	LUBOIL PRESSURE LO *lubricating oil pressure low)*

Figure 13: The final two engine room alarms on Fairplay 22 printout.

No further alarms were recorded on the printout after this time.

2.7 Crew

2.7.1 Fairplay 22

Fairplay 22 had been issued two crew certificates specifying the minimum number of crew members. One of these certificates applied to voyages within 50 miles off the coast; the other applied to voyages of unlimited distance and duration. The first certificate mentioned above applied to the vessel's voyages within the port of Rotterdam, and specified a minimum crew of two persons.

The regular crew of Fairplay 22 consisted of a Belgian captain, a Polish chief engineer and a Polish able seaman. The captain and chief engineer both held a valid Certificate of Competency. The trainee captain also held a valid Certificate of Competency.

17 These are the times registered by the system. This is elaborated in further detail in the analysis.
18 The italic text in the figure was added to the original printout by way of an explanatory translation.

The crew had been sailing in this combination for months, using English as their working language. Most external communication with Port of Rotterdam pilots and officials was conducted in Dutch. Communication with Stena Britannica was conducted in English.
The crew did not engage in any activities in between having provided the final assistance on 10 November 2010 and assisting Stena Britannica on the afternoon of 11 November 2010.

Captain
The captain of Fairplay 22 had signed a contract of employment with Transport & Offshore Services (TOS) in Rotterdam on 1 January 2010, and worked at Fairplay. He was previously employed by the Unie van Redding- en Sleepdienst (URS), a Belgian towage and salvage company active in all Dutch and Belgian ports along the Schelde River. During his employment at URS in the period between 1980 and 1987, he worked as an able seaman, officer and captain and gained experience with various types of tugs, including Azimuth Stern Drive (ASD) tugs. In the period from 1987 to 2010 he worked for URS as a captain, mainly operating in the port of Antwerp. In the final year, he also operated ASD tugs in the port of Zeebrugge. He mainly provided stern-to-bow assistance during these years. Following a period of leave, the captain of Fairplay 22 resumed work on 4 November 2010.

Before the day of the accident, the captain had assisted Stena Britannica on one prior occasion. This assistance also involved the deployment of Fairplay III, which was piloted by the same captain steering the tug on the day of the accident. The captain of Fairplay 22 had also assisted Stena Hollandica on three previous occasions. Fairplay 22 had not previously provided stern-to-bow assistance to Stena Britannica (nor Stena Hollandica) as was attempted during the accident.

Stena Britannica

Manning requirements
According to Stena Britannica's Safe Manning Document issued on 16 September 2010 by the Maritime and Coastguard Agency (MCA), the ship's crew must consist of at least twenty persons working in various ranks.[19] These twenty persons were on board during the voyage from Harwich to Hook of Holland on 11 November. The crew included an extra chief officer, three able seamen, three engineers and an electrician (in addition to the hotel staff).

Captain
The captain of Stena Britannica had been authorised to serve as captain on all vessel types since 1991. He has been sailing the Harwich-Hook of Holland route for 17.5 years, serving as captain for 13.5 years. As a captain, he made a total of 1,710 voyages to Hook of Holland on the predecessor of the current Stena Britannica, also named Stena Britannica (now Stena Scandinavica IV). Over the course of this period, he was assisted by tugs on 167 occasions. On 22 of these occasions, he was assisted by a combination of two tugs. The captain made 28 voyages to Hook of Holland with the current Stena Britannica prior to the accident with Fairplay 22.

In the port of Rotterdam compulsory pilotage is applied. The captain of Stena Britannica had held a PEC[20] for various vessels since 1995. The document was issued by the harbour master of Rotterdam. In 2003, he was issued a PEC for the predecessor of the current Stena Britannica for the Stena piers in Hook of Holland. The captain had not participated in any training on tug-handling in the port of Rotterdam.

19 The Safe Manning Document calls for a crew consisting at minimum of the following crew members: 1 captain,1 chief officer, 2 second officers, 1 chief engineer, 1 second engineer, 4 third engineers, 1 electrician, 2 bosuns, 6 able seamen, 1 cook.
20 A Pilot Exemption Certificate (PEC) exempts a captain from compulsory pilotage for a specific ship and route.

2.8 Meteorological and current data

On the day of the accident, there was a deep area of low pressure west of Ireland. As a result, a cold front with a large amount of precipitation and a stormy southerly wind rapidly passed over Hook of Holland in an easterly direction at the start of the day. There had been warnings of a storm on the Southern North Sea: SOUTH 9 for the Thames district and the Hook of Holland coastal district. Wind gusts of up to 95 km/h were expected on the coast.

The environmental conditions measured by the Royal Netherlands Meteorological Institute (KNMI) at the time of the accident are listed in table 3.

Wind (direction/force)	180-200 degrees / 30-35 knots[21] with gusts of up to 50 knots[22]
Current (direction/speed)	No measurement
Water temperature	11.6 degrees Celsius
Wave height	3-4 metres at sea
Visibility	10 km, 1-3 km for short periods of time during rainstorms

Table 3: Weather conditions at Hook of Holland [source: KNMI].

2.9 Similar accidents

2.9.1 Thorngarth

On 13 April 2005, the Thorngarth operated as the forward tug attending the Stolt Aspiration chemical tanker. The assistance took place on the Mersey River near Liverpool (United Kingdom). As the ASD tug was manoeuvring to the bow of the tanker, the two vessels collided. A tug crew member was injured and the tug incurred serious damage as a result of the collision. The accident was investigated by the Marine Accident Investigation Branch (MAIB) in the United Kingdom.[23]

The tug company took various measures in response to the accident including the following:

- developing a simulator training programme for tug crew members;
- mandatory simulator training for tug captains;
- conducting an internal investigation and making the resulting report available to all interested parties;
- evaluating the training programme and training procedures; and
- organising a seminar to discuss the safety of bow-to-bow towage connections.

Among other recommendations, the MAIB has recommended port authorities, pilots and tug companies to hold periodic formal meetings in order to decide on the allocation of tugs to ships and the level of experience required of crew for carrying out towage operations.

21 This wind speed corresponds with wind force 7-8 on the Beaufort Scale. The KNMI classifies this wind force as 'near gale/gale'.
22 This wind speed corresponds with wind force 10 on the Beaufort Scale. The KNMI classifies this wind force as 'violent storm'.
23 *Report on the investigation of the collision between Thorngarth and Stolt Aspiration, River Mersey, Liverpool, 13 April 2005*, Marine Accident Investigation Branch, Southampton, November 2005.

2.9.2 Fairplay 21

On 19 November 2009 Fairplay 21 came broadside in front of the Lars Maersk container vessel during a towage voyage as a forward tug. Consequently, the two vessels collided. The accident occurred on the Nieuwe Waterweg near Hook of Holland. The accident was investigated by Smit, which had chartered[24] Fairplay 21 from Fairplay. Although the direct cause proved to be different from the Fairplay 22 accident, the conclusions and recommendations were sufficiently relevant to warrant inclusion in this investigation. Figure 14 shows Fairplay 21 and the container vessel during the accident.

According to the investigation report issued by Smit, which was distributed among Smit crew members, Fairplay 21 was towing at full speed at the request of the pilot and had insufficient reserve power to correct the Lars Maersk's course. The tug's speed through the water was approximately 5.5 knots. According to the report the 'failure to take into account the limitations of tugs as a result of the speed of the combination and the alternative towage/assistance methods' was one of the main causes of the accident. The following recommendation was issued: 'never use full power while providing assistance. Make sure there is always reserve power for unexpected situations.'

Figure 14: Fairplay 21 after having collided with Lars Maersk [source: Smit].

2.9.3 Smit Polen

On 13 January 2011 an accident occurred on the Nieuwe Maas involving tug Smit Polen, owned by Smit based in the Netherlands, and container vessel Maersk Nijmegen, owned by Maersk Benelux B.V. based in the Netherlands.

The Smit Polen was attempting to establish a port side towage connection with Maersk Nijmegen in order to provide stern-to-bow assistance. The crew took the heaving line and connected the messenger line to it. At the time of establishing the connection the tug was travelling at a ground speed of approximately 7.3 knots. Due to a 1.6 knot ebb current, the tug's speed through the water was approximately 8.9 knots. According to Smit's incident report, Smit Polen had a maximum available speed of 11 knots.

24 It concerns a bareboat charter. The tug was provided by Fairplay and crewed, operated and maintained by Smit.

During an interview with Dutch Safety Board investigators, the captain of Smit Polen stated that he moved from the control panel at the rear of the bridge to the control panel at the centre of the bridge. At that moment, the starboard stern of Smit Polen collided with the port side of Maersk Nijmegen's bulbous bow. Smit Polen's starboard side came broadside in front of Maersk Nijmegen. Smit Polen initially heeled over approximately 45 degrees to port and subsequently heeled over to an angle of approximately 80 degrees. As a result of Maersk Nijmegen's forward speed, Smit Polen pivoted on the container ship's bulbous bow. Smit Polen became free from Maersk Nijmegen's bulbous bow and righted itself. During the process, Smit Polen's bridge collided with the bow of Maersk Nijmegen, breaking several bridge windows. Figure 15 shows Smit Polen and the container vessel during the accident.

Figure 15: Tug Smit Polen after colliding with Maersk Nijmegen's bulbous bow [source: Smit].

Maersk Nijmegen had a pilot on board at the Nieuwe Maas. The captain of the Smit Polen indicated that he had not made any clear agreements with the pilot with regard to the appropriate speed for establishing the towage connection. The captain of Smit Polen was sailing full speed ahead while attempting to move away from the Maersk. He stated that he no longer recalled in which direction the rudder had been set. Smit Polen was the forward tug in a two-tug tow that was to provide assistance. No force was (yet) exerted on the towage connection during the manoeuvre. Table 4 shows Smit Polen's vessel data.

Name	Smit Polen
Call sign	PHOZ
IMO number	8521701
Flag state	The Netherlands
Home port	Rotterdam
Vessel type	Tug
ISO certificate holder[25]	Smit
Registered owner	Smit Harbour Towage Company
Classification society	Bureau Veritas
Year of built	1986
Length over all	28.60 metres
Width	8.70 metres
Maximum draught	3.45 metres
Gross Tonnage	236 GT
Engines	2 6FCHD240 SWD diesel engines
Propulsion	2 controllable pitch propellers
Maximum propulsion power	1,765 kilowatts
Maximum speed	11 knots
Bollard pull	35 tons
Minimum number of crew members	3 persons
Number of crew members on board	3 persons
Number of other persons on board	1 person
Vessel certificates	All certificates were valid.
Electronic (registration) equipment	In addition to standard navigation equipment: Automatic Identification System (AIS), engine management system, no Voyage Data Recorder (VDR).

Table 4: Smit Polen vessel information

2.10 Crew training

According to current Inland Waterways legislation, the minimum requirement stipulates that tug captains operating in Dutch ports and inland waterways must hold a commercial vessels master's certificate. No additional competences are required. According to the Manning Act and relative legislation, the captains of (seagoing) harbour tugs must – at minimum - hold an STCW-accredited Certificate of Competency or a Dutch captain's or engineer's licence for a limited operating range (30 miles from the Dutch coast, no more than 12 hours from the service harbour and less than 6 hours from a sheltered harbour or mooring place).

A distinction is made between captains/engineers that are allowed to sail on ships with a limitation in propulsion power and on ships with no restrictions in propulsion power. With the major revision of the Manning Act that entered into force in 2002, the specific tug training was terminated in order to reduce the diversity in Certificates of Competency amongst other things. For ships with a limitation in propulsion power the chief officer and captain are required to hold the certificate Skipper-Engineer Restricted Working Area. This certificate is valid for ships < 500 GT with propulsion power < 3,000 kilowatts and sailing near the coast.

25 ISO 9001:2008 and ISO 14001:2004, OHSAS 18001.

For chief officers and captains of tugs with propulsion power > 3,000 kilowatts, article 92b of the Manning Order Merchant Shipping and Sailing prescribes that an accredited course and accredited training are completed. The captain only requires a Master All Ships certificate if operating on the high seas.

No specific additional requirements apply in respect of the competences of a tug captain.[26] As regards basic training, tug captains are only required to complete general maritime training, which does not devote any particular attention to the specific nature and skills needed in order to provide tug assistance. Due to the lack of formal specific requirements for tug captains, further education and retraining programmes often consist mainly of on-the-job-training.

Fairplay and Smit captains involved learned how to assist seagoing vessels in day-to-day practice. For several years now, Smit has stipulated that both new captains and current captains transferring to a new type of tug follow a compulsory internal simulator training programme. A training manual was developed for this purpose. Other captains may practice on the simulator on a voluntary basis. Because of their complexity, the hydrodynamic effects cannot be accurately replicated on the simulator.

26 In 2010, the Transport, Public Works and Water Management Inspectorate, harbour towage sector and education sector joined forces to develop a short training course entitled 'skills for captains on vessels with unlimited propulsive force operating in restricted work areas'. After having completed the training course, experienced captains are deemed capable of safely navigating ships with an engine power greater than the limit specified in their previous licence (Certificate limited to vessels with a gross registered tonnage of less than 500 and a propulsive force of less than 3000 kW). The training course provides the knowledge needed in order to assist seagoing vessels in a port. Captains on tugs with a propulsive force of less than 3000 kW are not required to complete the training course.

3 ANALYSIS

3.1 Introduction

This chapter provides an analysis of how the collision between Fairplay 22 and Stena Britannica occurred and Fairplay 22 subsequently capsized. Section 3.2 contains the reconstruction of the accident. The analysis makes a distinction between the direct and underlying causes of the accident. The analysis of the direct causes in section 3.3 involved finding out which factors led to the collision between the two ships and which factors led to the capsizing of Fairplay 22. Section 3.4 then describes the underlying causes of the accident. The following aspects are discussed:

- to what extent the design of the ships involved and supervision thereof played a role in the accident;
- to what extent the parties involved controlled the risk of collision and capsizing while establishing towage connections; and
- to what extent the crew's behaviour and education/training formed an underlying cause.

Next, this chapter provides an analysis of the accident involving tug Smit Polen in order to answer the question why the Smit Polen did not capsize whereas Fairplay 22 did, despite the similarities between the two accidents. The analysis concludes by looking at the importance of Voyage Data Recorders (VDRs) and describes the safety actions taken by the parties involved as a result of the accident.

3.2 Reconstruction of the collision and capsizing of the tug

Stena Britannica and Fairplay 22 both carried a transponder that transmitted Automatic Identification System (AIS) data. The information was received by various aerials located near the accident site and was used to reconstruct the collision and capsizing of the tug.[27]

The distance between Fairplay 22 and Stena Britannica was calculated on the basis of the positions of the GPS aerials on both ships. The calculation method is shown in Figure 16. The calculated distance is absolute and is shown by the straight line between the two antennae. The angles at which the two ships were positioned relative to each other have not been taken into account. The actual distance could have been smaller as a result of the girth of the ships' hulls.

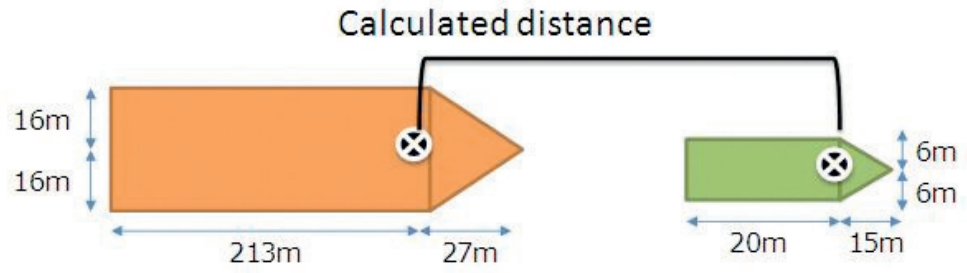


Figure 16: The distance between Fairplay 22 and Stena Britannica was calculated on the basis of the position of the GPS aerials on both ships.

27 The available data relating to the speed at which Stena Britannica was sailing differ. The Port of Rotterdam Authority uses a flow model to calculate the ships' speed. The measured values of the longitudinal and lateral water speeds were recorded on the Stena Britannica VDR. The data are not entirely consistent. The reconstruction is based on the data recorded on the Stena Britannica VDR because the values are measured values.

3.2.1 First attempt at passing the heaving line

Analysis of the AIS data shows that Fairplay 22 was located at a distance of approximately 400*[28] metres from Stena Britannica at 15.45. At 15.46:29 Stena Britannica called Fairplay 22 on VHF and asked Stena: "At what ideal speed through the water would you like to manoeuvre?" Fairplay 22 answered at 15.46:40 stating: "between 6 and 8 knots". Stena Britannica then stated it would reduce its speed to 7 knots: "We drop down to 7 knots", which Fairplay then confirmed, replying: "Okay". The distance between the two ships was approximately 125* metres at that time.

The first attempt to pass Stena Britannica's heaving line to Fairplay 22 began at around 15.47:20. Stena Britannica's ground speed was approximately 7.4 knots; its longitudinal water speed[29] was 8.4 knots and decreasing, its lateral water speed[30] was 0.7 knots to port side. Fairplay 22's ground speed was lower, approximately 7* knots, which meant that the distance between the two ships was decreasing. AIS data shows Fairplay 22 regularly changing course. This was interpreted as Fairplay 22 manoeuvring. Stena Britannica was making headway along a 114 degree course (see Appendix 5). The two ships were closest to each other at 15.47:36, at which time the distance between the two ships was 35* metres. Figure 17 shows the positions of both ships at that time.

Figure 17: Reconstruction of the position of Fairplay 22 and Stena Britannica during the first attempt.

After the attempt to pass the heaving line had failed, Fairplay 22 increased its speed and sailed alongside Stena Britannica. Fairplay 22 first made a turn to starboard, during which Fairplay 22's stern turned away from Stena Britannica, and then later turned to port. Fairplay 22 then repositioned itself to get into position on Stena Britannica's port side to make a second attempt.

3.2.2 Second attempt at passing the heaving line

During the second attempt that took place at around 15.49:00 Stena Britannica was making headway at a steady course. At 15.49:07 Fairplay 22's ground speed was 4.9 knots. At the same time, Stena Britannica's ground speed was 7.0 knots. The longitudinal water speed was 7.9 knots, which meant that the distance between the two ships was decreasing.

Due to current and wind Stena Britannica experienced a transverse movement to port. A lateral water speed of 1.2 knots was recorded on the VDR. Fairplay 22's speed increased to match Stena Britannica's speed. Fairplay 22 manoeuvred to Stena Britannica's port side. Figure 18 shows the positions of both ships during the second attempt.

28 The reconstruction makes a distinction between registered or measured values and calculated values. An asterisk* refers to calculated values.

29 Longitudinal water speed is the ship's speed through the water in the longitudinal direction of the ship, in other words in the direction in which the ship is sailing.

30 Lateral water speed is the ship's speed through the water in the lateral direction of the ship, in other words athwart to that of the ship.

Figure 18: Reconstruction of the position of Fairplay 22 and Stena Britannica during the second attempt.

At 15.49:08 the distance between the two ships was 35* metres. The distance was therefore the same as during the first attempt. Then, within two seconds, the distance decreased to 32* metres. The attempt to pass the heaving line to Fairplay 22 again failed.

3.2.3 Fairplay 22 collides and capsizes

At 15.49:14 the captain of Fairplay III announced "Stena Britannica full speed astern" over the VHF, whereupon the Stena Britannica captain acted immediately and gave full speed astern. The ship moved slightly to port. The analysis of the AIS data[31] obtained from Fairplay 22 show that the tug's rate of turn (ROT)[32] was 300 degrees per minute to starboard. The above ROT most probably indicates that Fairplay 22 was rolling and turning. The 300 degrees per minute ROT was again recorded twice at 15.49:17 and 15.49:21, which leads to the conclusion that this must have been when Fairplay continued to roll and the time at which the tug ultimately capsized. Figure 19 illustrates the damage location and damage direction on the tug.

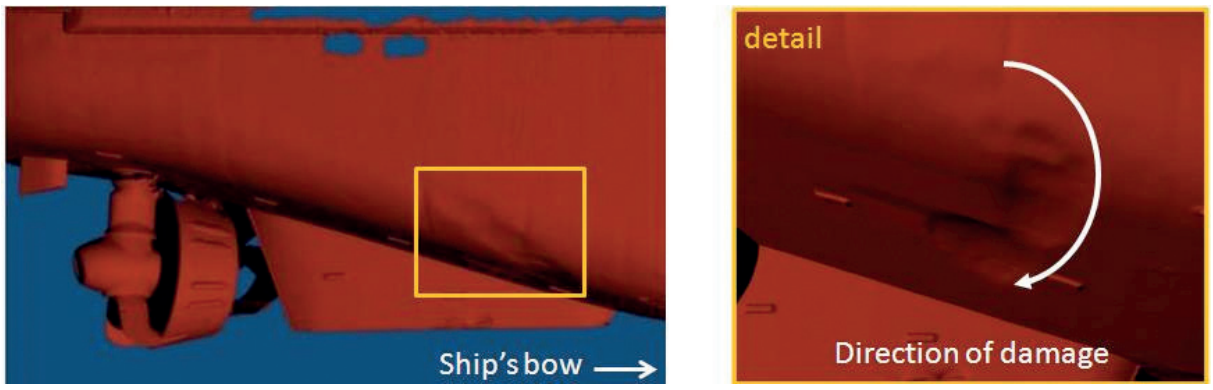


Figure 19: The damage location and direction of damage on Fairplay 22.

The damage found on the starboard side shows that Fairplay 22 rolled and ultimately capsized. The depth of the impact damage, which has set in, starts from aft and extends forward. The damage also turns or curves towards the bottom of the ship. After that a second impact that has set in on the bottom of Fairplay 22 can be seen, the shape of which is round.

31 Transmitted by Fairplay 22 and received by ground stations.
32 Rate of Turn (ROT) is the speed at which a ship turns to port or starboard expressed in degrees per minute.

With the aid of 3D software it was found that the shape and dimensions of the second impact imprint match the shape and dimensions of the bulbous bow of Stena Britannica. Figure 20 shows the impact of Stena Britannica's bulbous bow on Fairplay 22.

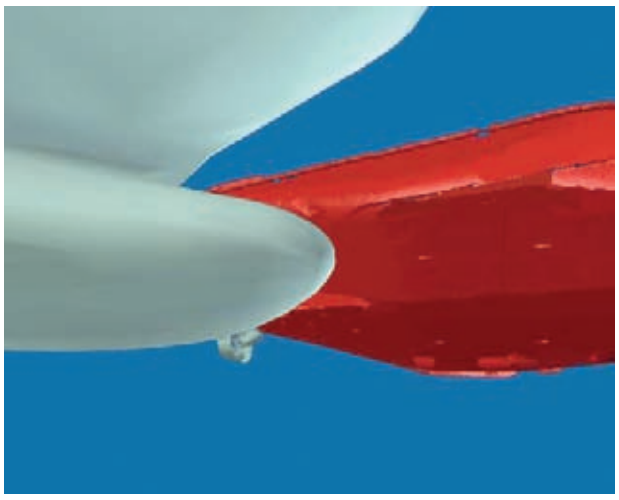


Figure 20: The impact of Stena Britannica on Fairplay 22.

The calculation of the distance during the last ten seconds (between 15.49:11 and 15.49:21), based on the available AIS information, shows that the distance between Stena Britannica and Fairplay 22 is increasing. This is inconsistent with the evidence from witness testimonies and the reconstruction, according to which the two ships remained in contact. The change in distance can be explained by Fairplay 22 rolling after the tug had contacted Stena Britannica's bulbous bow. The position of the GPS aerials changed because Fairplay 22 rolled. In reality the bulbous bow and Fairplay's hull remained in contact. This explanation corresponds to the rolling of Fairplay 22 as was seen by witnesses, the established pattern of the damage and the high ROT obtained from AIS data. Figure 21 shows the difference in GPS position and the actual position when Fairplay 22 rolled.

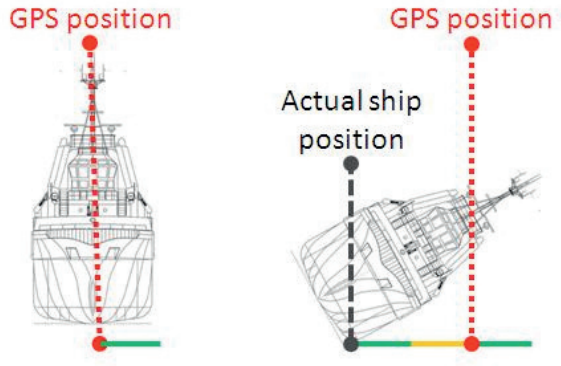


Figure 21: Difference between the GPS position and the actual position of the tug at the time Fairplay 22 was rolling.

3.3 Direct causes of the collision

This section provides an analysis of the possible causes of the collision between Stena Britannica and Fairplay 22. An analysis is then provided on whether, and if so to what extent, hydrodynamic interaction, the relative position of both ships, the speed of both ships, the wind and the crew's view played a role in the accident.

3.3.1 The influence of hydrodynamic aspects

The Maritime Research Institute Netherlands (MARIN) investigated the hydrodynamic interaction between Stena Britannica and Fairplay 22 on behalf of the Dutch Safety Board. It is important to point out that the calculations are based on conventional propulsion because it is difficult to calculate the effect of ASD propulsion, which featured on Fairplay 22. This means that the MARIN report (see Appendix 12) must be used and interpreted prudently as it is based solely on theoretical calculations.

The MARIN investigation revealed that the hydrodynamic interaction between two ships depends on the speed and the position of the two ships relative to each other. The hydrodynamic interaction consists of two components: a sideways force[33] and a turning moment[34]. The extent and the direction of the sideways force and the turning moment change as Fairplay 22 moves closer to Stena Britannica's bow lengthwise. The hydrodynamic interaction also grows substantially when the ships sail at higher speeds and when there is a shorter distance between the two ships.

The investigation furthermore shows that the strength of the forces and turning moments are so great that, in a number of positions, they attract and turn Fairplay 22 such that the tug can no longer move away from Stena Britannica. At the speed at which the two ships were sailing at the time of the accident, Fairplay 22 could have manoeuvred safely if the ship had been located in the Safety zone, as Figure 22 illustrates. If the distance between Fairplay 22 and Stena Britannica decreases, the likelihood of the tug no longer being able to move away from Stena Britannica increases, thus resulting in a collision. For that reason tugs should preferably manoeuvre in the Safety zone. In practice it sometimes proves difficult to manoeuvre in the Safety zone because the distance between the tug and the seagoing vessel in that case becomes too large to be able to take hold of the heaving line. However, by reducing speed the Safety zone can be enlarged so that the heaving line can be passed within a short distance from a seagoing vessel.

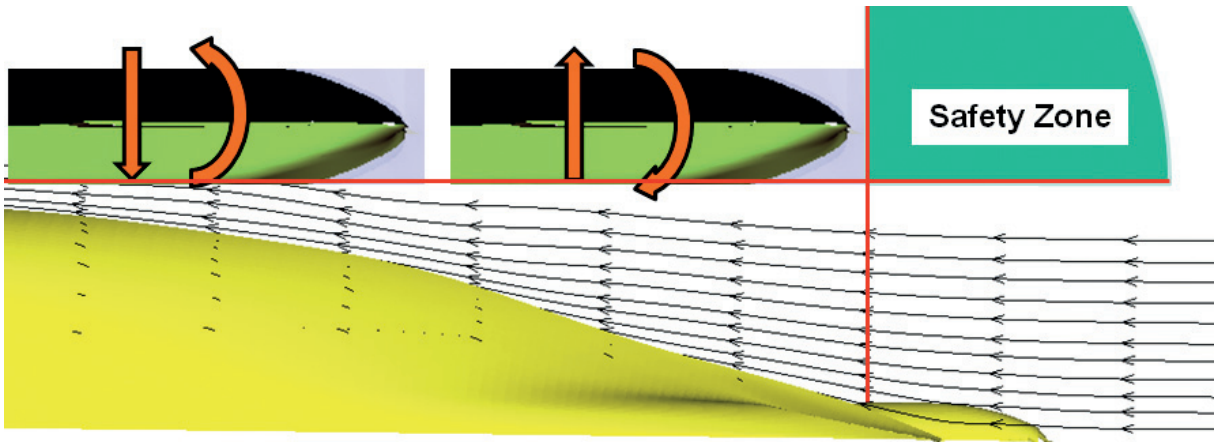


Figure 22: Safety zone, taking into account the streamlines surrounding the bow of Stena Britannica as well as the hydrodynamic force and the turning moment with a straight flow [source: MARIN].

MARIN was also given an assignment to include the drift angle[35] of Stena Britannica in the flow calculations with a straight flow. This situation, which takes account of lateral water speed, is consistent with the conditions that prevailed when Stena Britannica and Fairplay 22 collided. MARIN was however unable to obtain reliable results for the calculation including Stena Britannica's drift angle. According to MARIN, the fact that no reliable results could be obtained indicates that small changes in the situation produce highly variable forces and moments.

33 The force can be either attractive or repulsive.
34 The turning moment is the turning moment relative to the lengthwise direction of the ship.
35 In order to compensate for the force of the wind and currents, ships sail at an angle in order to stay on course. The angle between the ship's longitudinal axis and her course is referred to as drift angle.

For a speed of 7.2 knots and a drift angle it can be assumed that the situation for the tug deteriorates if compared to the calculations with a straight flow (without drift angle), as a result of both the augmented forces as well as their greater instability. From the above, it follows that due to Stena Britannica's drift angle there was an increased risk that the tug could not move away from Stena Britannica.

Conclusion
Speed substantially increases the hydrodynamic interaction between two ships.

The Safety zone should be taken into account when manoeuvring at Stena Britannica's bow. The hydrodynamic force and the turning moment in the area between the Safety zone and Stena Britannica increase to such an extent that the tug may no longer be able to move away to avoid a collision. Higher speed amplifies the hydrodynamic force and the turning moment. The drift angle of Stena Britannica also deteriorated the tug's situation.

A tug needs to manoeuvre close to a seagoing vessel when establishing a towage connection. By reducing speed, the Safety zone can be enlarged so that the tug can stay inside the Safety zone.

3.3.2 Fairplay 22's position

Fairplay 22 was located at close quarters to Stena Britannica when the first and second attempts were made in passing the heaving line. Figure 23 shows the AIS positions of Fairplay 22 in relation to Stena Britannica during both attempts. Based on the reconstruction of the first attempt it was found that Fairplay 22 was located within the Safety zone when starting the first attempt. In addition Fairplay 22's bow was directed away from the direction in which Stena Britannica was sailing.

Fairplay 22 left the Safety zone during the second attempt. The reconstructed position of Fairplay 22 now falls within Stena Britannica's breadth. The direction of the bow also pointed inward during the second attempt. The hydrodynamic interaction near the bulbous bow will amplify the turn towards the bulbous bow.

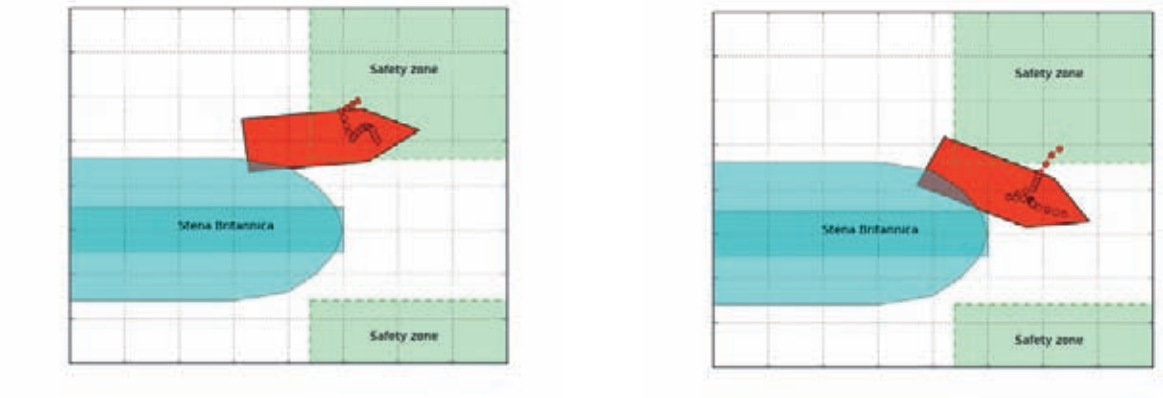


Figure 23 Reconstruction of Fairplay 22's positions (red) in relation to Stena Britannica (cyan) during the first attempt at 15.47:37 (left) and during the second attempt at 15.49:10 (right).

Conclusion
Unlike the first attempt, Fairplay 22 did not stay within the Safety zone during the second attempt. There was a heightened risk of collision due to the increased hydrodynamic interaction.

3.3.3 Speed

Generally speaking, reducing a vessel's speed decreases the pressure on the rudder, which deteriorates a vessel's manoeuvrability. Also due to the prevailing wind Stena Britannica required to keep a minimum speed during the attempts to pass the heaving line.

The minimum required speed depends on various factors, such as the ship's windage area, the wind force, the ship's operating condition and the current.

Prior to the manoeuvre Stena Britannica's chief officer asked the captain of Fairplay 22 at what speed through the water he wanted the manoeuvre to take place. The captain of Fairplay 22 replied that he wanted to establish the towage connection at a speed between 6-8 knots. Stena Britannica's chief officer then stated that the ship would reduce speed to 7 knots, which the captain of Fairplay 22 confirmed in his reply.

The reconstruction has shown that Stena Britannica was sailing at a ground speed of 7.4 knots during the first attempt. With the 1.0 knot current in the opposite direction and the influence of the wind, this resulted in a longitudinal water speed of 8.4 knots. During the second attempt Stena Britannica was sailing at a ground speed of 6.9 knots and a longitudinal water speed of 7.9 knots. During the second attempt the ship's speed therefore was lower than during the first attempt. In both cases the vessel's speed through the water exceeded the 7 knots as agreed on beforehand by Stena Britannica's chief officer and the captain of Fairplay 22. The speed was, however, less than the upper limit of 8 knots that had initially been requested by the captain of Fairplay 22.

The ground speed was readable on the bridge of the two ships while speed through the water was only readable on Stena Britannica's bridge. On Fairplay 22, it was common practice to estimate the speed through the water based on experience in combination with the readable ground speed and tide data.

Conclusion

During both attempts the speed through the water exceeded the 7 knots that had been agreed. During the second attempt Stena Britannica's speed was lower than during the first attempt.

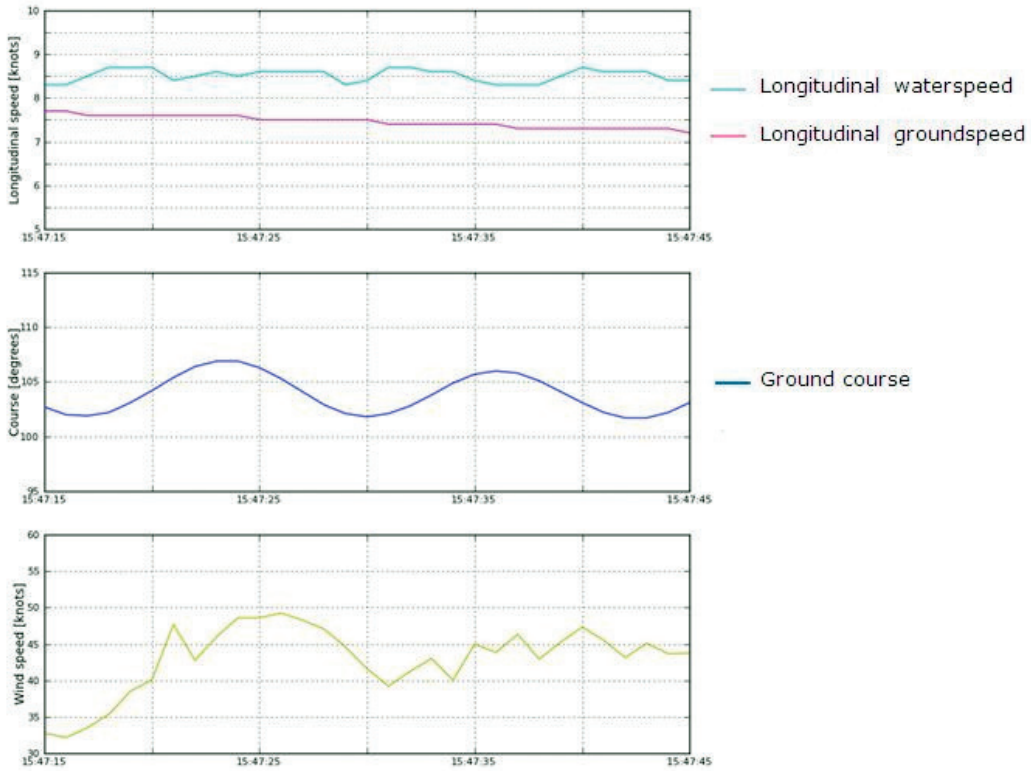
Speed through the water was only readable on Stena Britannica's bridge. On Fairplay 22 the speed through the water was estimated based on experience.

3.3.4 The effects of winds and currents

A force 7-8 southerly wind on the Beaufort scale (30 knots with gusts up to 50 knots) prevailed at the time of the accident. Stena Britannica was sailing an easterly course on the Nieuwe Waterweg. Sailing at a ground speed of 7 knots Stena Britannica had to steer approximately 7 to 10 degrees to starboard in order to maintain a steady ground course. By angling into the wind Stena Britannica was able to maintain a relatively steady ground course, despite the wind.

Gusts of wind of up to 50 knots were measured during manoeuvring. Since gusts of wind have a short duration and occur suddenly, it is difficult to maintain a steady ground course when they occur. Figure 24 shows Stena Britannica's ground course together with the gusts of wind measured.

First attempt to pass the heaving line



Second attempt to pass the heaving line

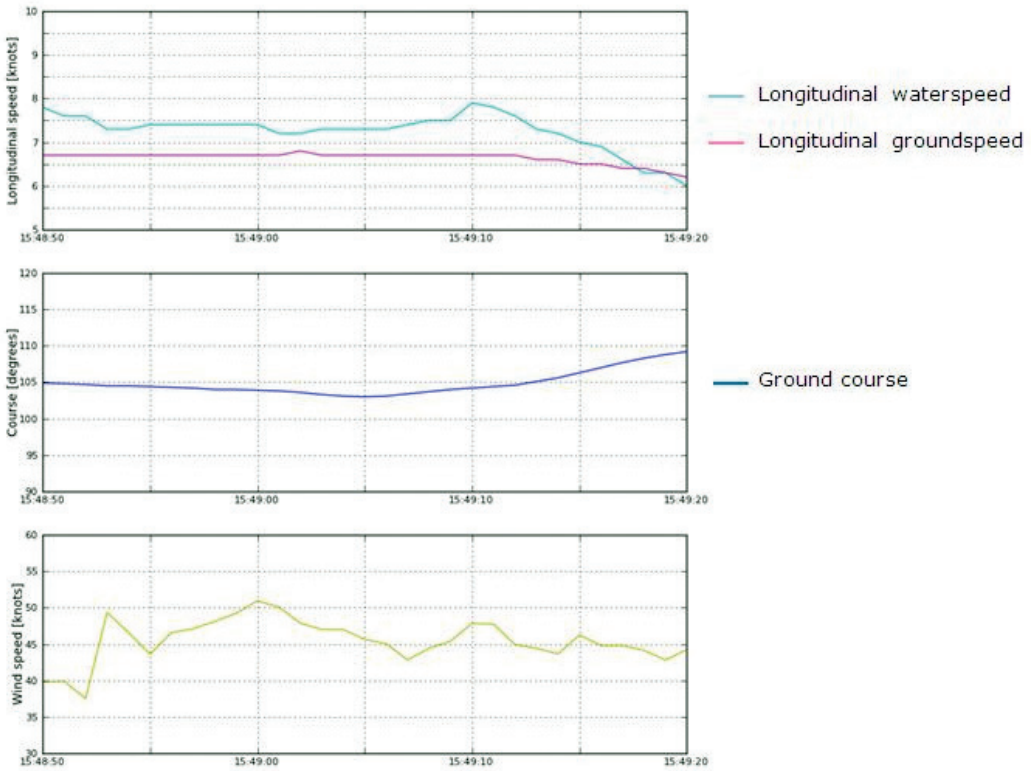


Figure 24 Overview of Stena Britannica's water speed, ground speed and ground course, and the wind force during the first and second attempts at passing the heaving line (the horizontal axis represents time and the vertical axis represents speeds and course).

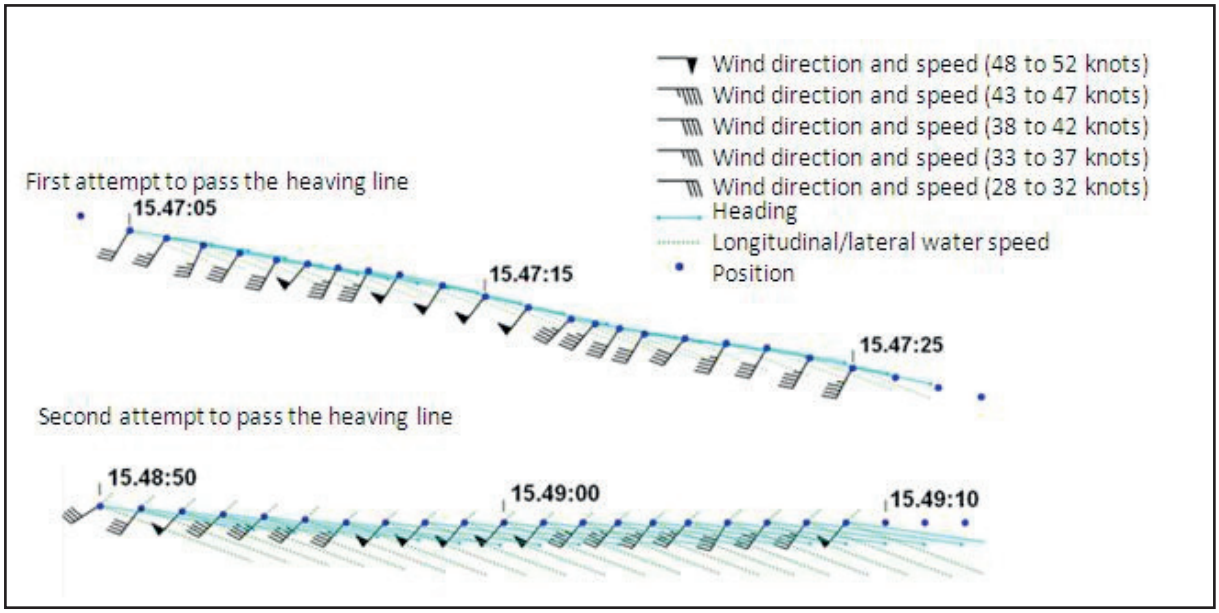


Figure 25: Overview of Stena Britannica's ground course and the speed and direction of the wind during the first and second attempts to pass the heaving line.

Figure 24 above shows that during the first attempt at 15.47:20 Stena Britannica's speed was not yet steady; the speed was still slowly reducing. The ground course fluctuated slightly, in part because of the effects of the wind and the lateral current.[36] During the second attempt between 15.49:00 and 15.49:07, Stena Britannica's speed was steady as was its ground course. Compared with the first attempt, however, the ship's lateral water speed was higher on average.

Figure 25 specifies the gusts of wind per second, and shows that the direction of the gusts of wind was fairly constant during both attempts. During the second attempt the force of the wind peaked on a number of occasions. It also shows that Stena Britannica's ground course only fluctuated slightly during the first attempt, despite the gusts of wind, and was steady during the second attempt.

The tide was rising with High Tide expected at 18.06. The wind prevailing for a prolonged period of time in part determines the behaviour of the current when the tide rises. For instance, a stormy, southerly wind will cause the water level to fall. A stormy westerly wind will cause the water level to rise or cause the water to fall slightly less. The behaviour of the current also depends on the depth of the water. The current and direction may differ at different water depths. Tidal calculations and the current diagram of the Port of Rotterdam Authority (calculated at a depth of 0 to 6 metres) and data recorded by Stena Britannica's VDR show that an ebb current was present on the Nieuwe Waterweg that may possibly have been caused by the stormy wind. The current diagram is illustrated in Figure 26.

36 Lateral current refers to the sideways current affecting the course in which the ship is being steered.

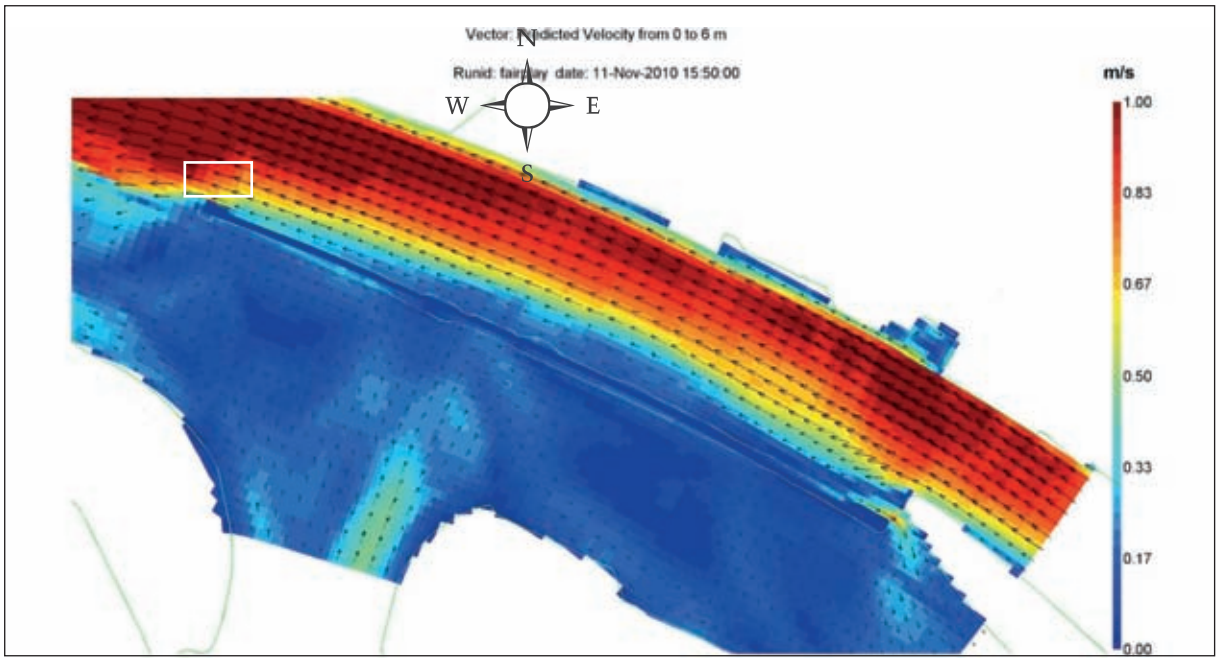


Figure 26: The current diagram at the accident location at the time the attempts to pass the heaving line (the white rectangle indicated the accident location) [source: Port of Rotterdam Authority (edited manually)]

Fairplay 22 did not have a VDR on board. As a result, no information was available on the force and direction of the wind affecting Fairplay 22 at the time both attempts were made. Partly because Fairplay 22 was located on Stena Britannica's lee side during the first attempt, the tug is unlikely to have been strongly affected by the wind. During the second attempt, Fairplay 22's position was more forward and less on Stena Britannica's lee side, as a result of which the tug possibly experienced more influence from the wind/gusts of wind, which were also stronger at that time than during the first attempt. However, there is no means of verifying whether the wind/gusts of wind affected Fairplay 22's course.

Conclusion
Stena Britannica's ground course fluctuated slightly during the first attempt but was steady during the second attempt. The ship's ground course was hardly affected by the wind/gusts of wind.

It is unclear whether and to what extent the wind/gusts of wind affected Fairplay 22's course.

3.3.5 View

Stena Britannica
From the bridge of Stena Britannica, Fairplay 22's stern was not fully visible during the tug's attempts to take in the heaving line. Because part of the tug was not visible from the bridge of Stena Britannica, the captain and chief officer were not fully aware of the risk of collision. Even though a radio equipped crew member was positioned on the foredeck, the crew were unable to intervene immediately to avoid a collision. Shortly after the collision had occurred, the captain of Fairplay III instructed Stena Britannica to go full speed astern. If the tug had been clearly visible from Stena Britannica, the vessel's crew could possibly have taken earlier action to avoid a collision.

Conclusion
Stena Britannica's captain and chief officer could not see Fairplay 22's stern during the attempts to take in the heaving line and were unable to take immediate action to avoid a collision.

Fairplay 22
During the attempts to take in the heaving line, the captain of Fairplay 22 was standing at the control panel located on the aft of the bridge. The captain was standing with his back facing the tug's sailing direction. The stern of Fairplay 22 and the bow of Stena Britannica were visible to the captain from this position. The tug's funnels and window mullions restricted the view from the rear control panel. Figure 27 shows the restricted view. The degree to which the captain of Fairplay 22's view was restricted depended on the angle of Fairplay 22 relative to Stena Britannica and the movements of the two ships as a result of the wind, current, waves and stability.

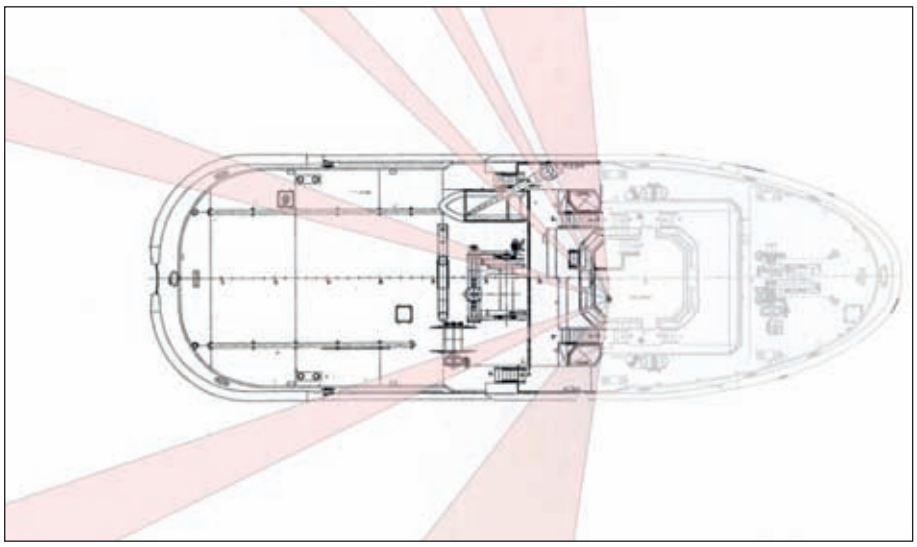


Figure 27: The view, shown in white, from the rear control panel on the bridge of Fairplay 22.

Considering Fairplay 22's changing position relative to Stena Britannica, the captain is unlikely to have had a continuous view of the bow of the ferry during the manoeuvre. He is likely to have expanded his view by moving. It is unclear, however, whether the captain of Fairplay 22 saw the bulbous bow because of the waves, and because the bulbous bow was only partially protruding above the water's surface and moreover was coloured grey.

Conclusion
It is unclear to what extent the view of Fairplay 22's captain of Stena Britannica contributed to the collision. It is also unclear whether Stena Britannica's bulbous bow was visible to the captain of Fairplay 22.

3.4 Direct causes of the tug not being able to move away and capsizing

This section examines why Fairplay 22 was not able to move away from Stena Britannica and subsequently capsized. To that end, an investigation was conducted of the performance of Fairplay 22's engines and the tug's reserve power. In addition, the water flooding into the tug was investigated to determine its contribution to the capsizing of Fairplay 22.

3.4.1 Performance of Fairplay 22's engines
Fairplay 22's engine room alarms are automatically recorded. Investigators were able to secure a print out of the registrations after the tug had been salvaged. The first series of alarms occurred within a short space of time until 09.58. Given the time of departure, these alarms relate to starting and operating the engines/auxiliary engines. The next alarms were recorded at 14.55:54. This is the on-board time and thus corresponds with 15.55:54 local time. It emerged from the reconstruction that the tug capsized between 15.49:11-15.49:21. The recorded time, so after the vessel had capsized, at which the alarms sounded differs from the time at which the tug capsized by a few of minutes.

The recorded alarms relate to the level of lubricating oil required for the bow thruster. In view of the nature of the failures and the time at which they were recorded, both can be explained by the large heeling angle as a result of the capsizing of the tug.

No failures had been reported shortly before the moment at which the tug capsized. During the interviews too, it was stated that no alarms had been noticed on the bridge before the time of the collision. Therefore, it can be concluded that the engines and the propulsion system performed normally until the moment the tug capsized. The performance of Fairplay 22's engines and propulsion system most likely did not contribute to the cause of the accident.

Conclusion
No engine room alarms were recorded until the moment the tug capsized and there was no power failure on board Fairplay 22. For that reason the accident is unlikely to have been caused by problems with the performance of Fairplay 22's engines and propulsion system.

3.4.2 Fairplay 22's reserve power

Fairplay 22 features 3,292 kilowatts of propulsion power. The maximum speed through the water that the tug can achieve is 12.5 knots. This speed can only be reached under ideal circumstances. In adverse weather conditions, for instance with wind and high waves, it will not be possible to reach that speed. Also, the maximum speed can only be reached with both azimuth thrusters in the fully forward position. If the thrusters are positioned in any other direction, for example during manoeuvring, Fairplay 22's maximum speed will be lower. This is inter alia due to the enlarged hull resistance forces and the reduced water flow to the thrusters.

It emerged from the reconstruction that Fairplay 22 was sailing at a speed through the water of approximately 7.9 knots when it first came into contact with Stena Britannica. A large part of the tug's power was needed to reach that speed, partly due to the weather conditions. As a result, Fairplay 22 probably did not have enough reserve power to move away from Stena Britannica's sphere of influence. Had the tug been sailing at a lower speed while manoeuvring, Fairplay 22 would have had more reserve power to move away from Stena Britannica.

Once a tug ends up in a ship's sphere of influence, apart from the tug's reserve power human factors also play an important role, in a negative sense.[37] A person – in this case the captain – is not always able to adequately anticipate the future situation of his ship. The hydrodynamic interaction between the two ships, the steering operations, the changes observed as well as the knowledge available on the behaviour of tugs in such situations are complex and have a detrimental effect on this process. It becomes even more difficult to accurately anticipate situations if steering/propulsive operations need to be performed in unexpected, non-routine circumstances.

For that reason, it is key that sufficient safety margins and options are available to the captain. A relatively low speed while manoeuvring increases safety margins and consequently reduces risks.

Conclusion
If a lower speed had been maintained during the manoeuvre, Fairplay 22 would have had more reserve power to enable the tug to move away from the ferry's sphere of influence and given the captain more time and opportunity to anticipate the situation.

37 Van Breda, L (1999). *Anticipating behaviour in supervisory vehicle control*. PhD thesis. Delft, The Netherlands: Delft University Press.

3.4.3 Influence of Stena Britannica

As a result of the impact when Stena Britannica and Fairplay 22 collided, the tug started to heel to port. Due to the force on Fairplay 22 resulting from Stena Britannica's forward speed, the heeling angle increased further. The force exerted by Stena Britannica on the tug and the heeling angle resulting from this force have not been determined. The investigation did reveal that due to this force, Fairplay 22's heeling angle increased to such an extent that water entered the tug.

Conclusion

Due to the force on Fairplay 22 resulting from the collision and Stena Britannica's forward speed, the heeling angle of the tug increased to such an extent that water entered the tug.

Fairplay 22's watertight and weathertight openings

A watertight opening is an opening capable of preventing the passage of water through the structure in either direction, with a proper margin of resistance under the pressure due to the maximum head of water which it might have to sustain. A weathertight opening is an opening capable of preventing water from penetrating into the ship in any sea conditions. Fairplay 22 has a number of weathertight openings, including the engine room vents and a door leading to the aft deck. It was found during the investigation that vents and the door leading to the aft deck were open at the time of the accident involving Fairplay 22. Figure 28 shows the door leading to the aft deck and the open vent (on sister ship Fairplay 23).

Figure 28: The door leading to the aft deck on Fairplay 23 (left), which was open on board Fairplay 22 at the time of capsizing, and the open vent on starboard side.

When Fairplay 22 heeled, water entered through these openings. Because the engine room vent on port side[38] was open, water could flood in at a heeling angle of approximately 35 degrees; water entered through the door leading to the aft deck at a heeling angle of approximately 73 degrees. This negatively affected Fairplay 22's stability in two ways.

The water flooding into the tug caused it to lie deeper in the water. The amount of water flooding into the tug continued to increase as a result.

38 This vent was not fully open, but contained foam to repel unwanted matter.

The tug's stability was also negatively affected by the free fluid moment[39] of the water that had flooded in. When the tug heeled, the tug's port side was lower than her starboard side. The water that had flooded in therefore flowed to the tug's port side. This further increased the tug's heeling angle to port.

Conclusion
Water flooded into Fairplay 22 because weathertight openings had not been closed at the time the tug capsized. This caused the tug to lie deeper in the water and increased the tug's heeling angle. These two factors negatively affected its stability, which accelerated Fairplay 22's capsizing.

3.5 Underlying causes

3.5.1 Fairplay 22's stability

Design stability
Stability requirements offer ships a certain level of safety against the risk of capsizing. If these requirements are not met, a ship has a greater risk of capsizing.
Stability calculations were made by the Dutch Naval Architectural Software and Engineering Centre (*Scheepsbouwkundig Advies en Reken Centrum BV*, SARC) and ASD Ship Design BV (ASD Ship Design) on behalf of the Dutch Safety Board. Amongst other things, they performed an inclination test with sister ship Fairplay 23 to determine Fairplay 22's stability at the time the tug capsized, using the reported weights and tank contents that were on board Fairplay 22. The investigation reports drawn up by SARC and ASD Ship Design are included in Appendices 10 and 11.

The stability calculations show that Fairplay 22 did not meet the stability requirements that were in force when the tug was built in 1998 because in day-to-day practice it was not possible to close the engine room vents when the tug was operating. Closing the vents blocks off the air supply required to operate the engine room machinery. Because the tug did not meet the stability requirements Fairplay 22 faced an increased risk of capsizing.

Conclusion
Fairplay 22 did not meet the stability requirements that were in force when the tug was built in 1998 because in day-to-day practice it was not possible to close the machine room vents while the tug was operating. This means that Fairplay 22 faced an increased risk of capsizing.

After 1998 the International Association of Classification Societies Ltd (IACS), an organisation representing the most important international classification societies, drew up additional stability criteria.[40] It should be noted that Germanischer Lloyd had previously already formulated such criteria. On behalf of the Dutch Safety Board, ASD Ship Design investigated whether Fairplay 22 complies with the current stability criteria as formulated by a number of the most important classification societies.[41] The investigation revealed that, under all calculated operating conditions (even with closed vents), Fairplay 22 does not meet the current criteria. This means that Fairplay 22 faces an increased risk of capsizing compared with modern tugs that do comply with these additional criteria.

39 The free fluid moment occurs when fluids move to the low side of the ship when the vessel heels. This increases the ship's heeling angle.
40 IACS stability criteria are recommended criteria; it is not mandatory for tugs to comply with the additional stability criteria. Classification societies which are members of IACS have incorporated these criteria in their requirements at their discretion. But there is a difference between the most and least stringent criteria formulated by the classification societies and flag states. The IACS criteria are considered minimum requirements. Most tugs that have since been built satisfy the additional criteria. Due to the fact that the additional criteria were not mandatory for tugs existing at that time, modern tugs offer a higher level of safety than the latter tugs.
41 These stability criteria can be found in Appendix 11, chapter 5.

Conclusion
Fairplay 22 does not comply with the additional stability criteria applicable to new built tugs today, even with closed vents.

Certification
A ship must satisfy, amongst others, stability requirements in order to obtain certification. In the design phase of a ship it should already be ensured that the ship will be able to satisfy the stability criteria and should take the operating conditions into account. The stability calculation and the results of the inclination test are documented in the ship's Stability Information Book. The flag state or classification society which grants the ship certification on behalf of the flag state, checks the Stability Information Book and assesses whether the ship satisfies the stability criteria.

The shipyard made the final design of Fairplay 22. The tug was designed and built to satisfy the stability requirements stipulated by See-Berufsgenossenschaft (SBG). Classification society Germanischer Lloyd checked, endorsed and signed off on the design and construction of the tug.

The shipyard and the classification society could have known that the engine room vents were required while the tug was operating and would therefore be open to supply air to the engine room. Because relevant legislation contains various terms regarding openings and allows for exceptions, sailing with open vents was possible in principle. In practice, both ship designers and classification societies use the full stability range in their calculations if vent openings on board of ships can be closed weathertight in accordance with SOLAS. It is assumed that, depending on operational circumstances, the crew of a ship, as good seamen, will shut the vents in order to ensure the stability of the vessel.

When the ship was in operation, however, the vents to the engine room could not be shut as doing so would largely block off the required air supply and the engine room power plant would no longer be able to operate properly. But with its vents open, the ship did not meet the 1998 SBG stability requirements. Fairplay 22 consequently did not possess the required level of safety with regard to stability.

Considering the fact that the vents would be open while the vessel was sailing, it is odd that the tug was designed, built and approved as is. For a tug, which is often put in potentially dangerous situations due to the nature of its activity when providing tug assistance, and requires sufficient air flow to the engine room for the engine room power plant to operate properly, it should not be possible to depend on weathertight openings.

Conclusion
Because relevant legislation contains various terms regarding openings and allows for exceptions, Fairplay 22 could obtain certification without actually satisfying the required level of safety in terms of stability.

Supervision
After a vessel has been put into service, regular inspections are performed by classification societies on behalf of the flag state and by Port State Control (PSC) authorities when visiting a foreign port. When a tug registered under a foreign flag operates more or less permanently in a Dutch port, apart from the flag state inspections it is also inspected by the Dutch Transport, Public Works and Water Management Inspectorate (PSC inspections).

There are different types of PCS inspections. Inter alia, the comprehensiveness of an inspection depends on:

- the flag state of a ship;
- the type of ship; and
- the classification society that certified the ship.

During a PSC initial inspection, which is carried out on board a ship, the following is inspected:

- whether all required documents are carried on board;
- whether all certificates are valid;
- whether ship, crew and equipment comply with international rules and standards; and
- whether any deficiencies found at previous inspections have been rectified.

During PSC inspections it is not inspected whether the watertight openings are constructed in accordance with the stability requirements of a ship. Because there are no rules or regulations on the speed to be used during tug assistance, this also forms no part of inspections. Since Fairplay 22's Stability Information Book had been endorsed, the inspections on board could not detect that Fairplay 22 was unable to meet the stability requirements in practice.

Conclusion
During regular inspections it could not be detected that Fairplay 22 did not comply with the stability requirements.

Fairplay
Fairplay was aware that another shipping company which regularly chartered Fairplay 22's sister ships added permanent ballast to the tugs to improve their stability. The shipping company filled the ballast tanks with liquid barium hydroxide, which has a high density. The heavier weight causes the vertical position of the centre of gravity to decline, which improves its stability. Nevertheless, Fairplay did not take any action to investigate and/or improve the stability of its vessels.

In its response to the draft version of this report, Fairplay indicated that, after the Dutch Safety Board issued its interim recommendation, Fairplay 23 was equipped with permanent ballast. Although the Safety Board concurs with this measure, the Board is surprised that Fairplay took this measure *after* the accident occurred even though Fairplay was aware that such a measure had already been taken by another shipping company.

Conclusion
Although Fairplay was aware that another shipping company improved the stability of the vessels chartered from Fairplay, Fairplay did not have the stability of its tugs examined to assess whether stability improvements are needed.

Since the construction of Fairplay 22 in 1998, a number of the most important classification societies drew up additional stability criteria applicable specifically to tugs. The shipping company itself has put several tugs into service after these additional stability criteria came into force. The shipping company is therefore could have been aware of the additional stability criteria which are currently applied to tugs.

The modern stability criteria are substantially 'more stringent' than the 1998 requirements. This means that the tugs that were built in accordance with the modern stability criteria have a higher stability level than Fairplay 22 and its sister ships. Fairplay nonetheless did not take any action to improve the stability of its older vessels.

Conclusion
Although Fairplay could have been aware that Fairplay 22 and her sister ships failed to meet the stability criteria for modern tugs, the shipping company did not take any action to improve the stability of these tugs.

3.5.2 Facilities for establishing a towage connection on board Stena Britannica

The heaving line on board Stena Britannica can only be passed from two positions on the portside of the foredeck. The two positions are shown in Figure 29.

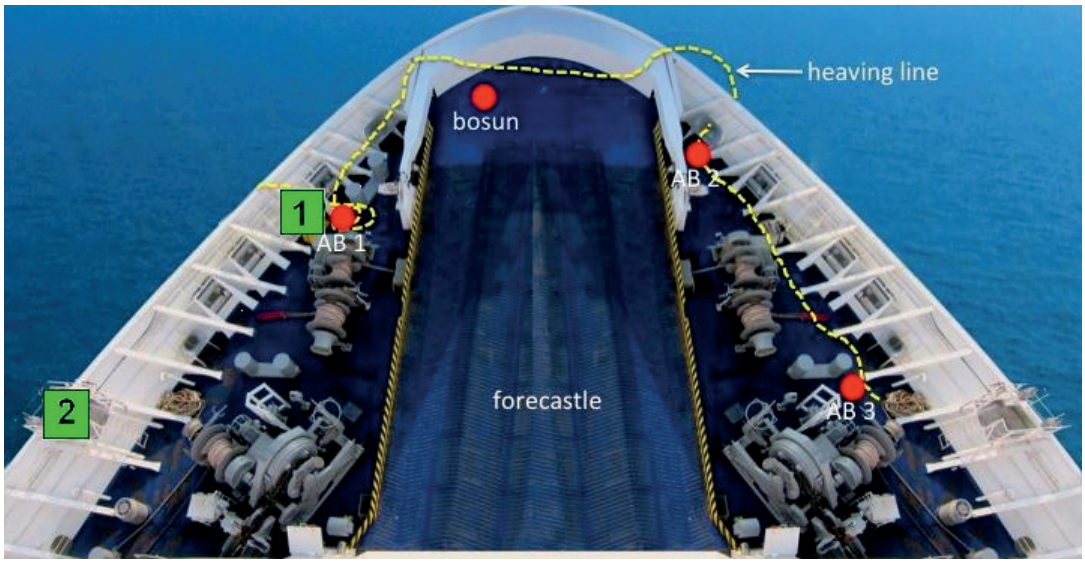


Figure 29: The two positions on the foredeck of Stena Britannica where the heaving line can be passed (the heaving line was passed from position 1 during the accident).

The heaving line can be passed from the front section of the foredeck (position 1) and standing on a fixed ladder located a few metres behind it (position 2). In order to take in the heaving line, a tug must position itself next to Stena Britannica, a short distance away from the position where the heaving line is passed. Due the fact that the heaving line can only be passed from Stena Britannica's foredeck, the tug needs to sail close to the bow.

One heaving line had been prepared to pass to the tug. If a second heaving line had been prepared, two heaving lines would have been available during both manoeuvres for establishing a towage connection. Then, if the attempt with the first heaving line failed, a second heaving line could immediately be passed to the tug when it manoeuvred close to the bow.

Conclusion

The options on board Stena Britannica to pass the heaving line are limited to the two positions on the portside of the foredeck. This means that when a tug takes a heaving line it must position itself at close quarters to the ship's bow where there is a greater risk of collision due to the greater hydrodynamic interaction.

No preparations had been made on board Stena Britannica to have a second heaving line ready for immediate use if the first attempt were to fail.

The investigation performed by MARIN focused on the hydrodynamic sphere of influence between Stena Britannica and Fairplay 22. The investigation results are likely to apply equally to ships with a similar underwater hull shape since the hydrodynamic sphere of influence is largely depending on the shape of the hull. The hydrodynamic sphere of influence ships with a different hull shape will probably show a different picture.

MARIN's investigation found that it cannot be asserted that the hydrodynamic sphere of influence near the ship's bow is always characterised by a positive force of attraction and a turning moment. The intensity and size of the hydrodynamic sphere of influence will show a different picture for each type of ship depending on aspects such as speed, draught, trim and water depth. In general for each type of ship, it can be asserted that a higher speed and a shorter distance between ships amplifies the hydrodynamic sphere of influence.

Conclusion
The hydrodynamic sphere of influence differs per type of ship. However, for each type of ship a higher speed and a shorter distance between two ships amplifies the hydrodynamic sphere of influence.

The scope of this investigation did not extend to checking whether it is accounted for in the design phase to assess whether the location for establishing a towage connection is favourable given the hydrodynamic forces exerted by the ship on a tug. If the hydrodynamic sphere of influence is extremely unfavourable at a certain location, for safety reasons it would be unacceptable to pass the heaving line from there.

In ship design today the hydrodynamic characteristics are mapped out for the purpose of optimising speed, performance and fuel consumption under various operating conditions. However, for ships requiring tug assistance (under certain conditions) it would be advised to take account of the hydrodynamic characteristics when determining the optimal location where a towage connection is to be established. This will help avoid establishing towage connections at a location where the hydrodynamic forces and moments are unfavourable.

Conclusion
When designing a ship, for safety reasons it would be advisable to take account of the hydrodynamic characteristics in order to optimise the location where a towage connection is to be established.

3.5.3 Safety management - Fairplay

Certification and policy
Fairplay had voluntarily obtained ISM certification for Fairplay 22 until 2009. Safety audits based on the ISM Code and ISO 9001:2008 standard were thus performed for both the shipping company and the tug. As such, the shipping company invested voluntarily in the safety of the tug and its crew. The shipping company thereby fulfilled its own responsibility for safety.

Mainly due to the administrative burden involved in obtaining certification the shipping company decided to discontinue ISM certification for Fairplay 22 in 2009. The safety management system continued to remain in force after 2009 but was no longer reviewed on the basis of the ISM Code. ISO certification was maintained, which meant that the audits performed on the basis of ISO certification remained in force.

Figure 30 lists the health and safety objectives defined in Fairplay's safety management system.

Health & Safety Objectives

- Each ship shall be operated in accordance with safe operational practices and healthy conditions documented in respective procedures.
- The working environment and conditions for the crew shall be governed by strict observance of safety at work regulations and other applicable requirements, e.g. port state regulations.
- Identified risks are taken account of by adequate documented precautions. Where a particular risk is identified on a vessel the Master shall establish safeguards appropriate to the situation and inform the Designated Person thereof.
- Safety awareness and skills of management and line personnel ashore and on company vessels shall be continuously improved for routine activities as well as emergency situations.

Figure 30: The health and safety objectives defined in Fairplay's safety management system [source: Fairplay].

Amongst other things, the HSE-Q Manual states the following:

- Control measures shall be taken and their effect shall be verified;
- A risk assessment shall be performed for each activity involving a specific risk;
- A periodic Master's review of the HSE-Q system shall take place;
- An annual management review of the HSE-Q system shall take place; and
- An annual internal audit shall take place.

The HSE-Q Manual contains procedures for identifying risks, performing work and how to act in the event of various types of incidents. A procedure for performing tug assistance is also available. However, there is no hazard identification and analysis for sailing at close quarters to the bow of a ship requiring assistance or for passing/taking in a heaving line. Inter alia, the tug assistance procedure incorporates the following:

- while performing tug assistance all watertight openings must be closed;
- when taking the heaving line, a speed through the water of 6 knots is advisable;
- the forward tug in particular is vulnerable when establishing a towage connection.

The internal audit reports, management reviews and Master's reviews performed do not contain any reports of procedural shortcomings related to securely fastening all watertight openings during towage operations. In addition, no procedural shortcomings have been reported in respect of the speed at which the vessels should sail.

Figure 31 contains a few extracts from the German and English versions of the procedure. A more detailed extract can be found in Appendix 8.

Verschlußzustand Während des Schleppens sind alle wasserdichten Türen/Luken sicher geschlossen zu halten.	*Watertight Integrity* When the tug is engaged in towage operations all watertight openings shall be securely fastened.
Sichere *Geschwindigkeit*: Geringe Fahrt in bestimmten Situationen Für Schlepper sind bei Übernahme der Leine etwa 6 kn durch das Wasser eine günstige Geschwindigkeit.	*Safe* Speed: Some speed is required at times When taking up the tow line, the tugs like to have about 6 knots through the water.

Figure 31: An extract from Fairplay's tug assistance procedure describing watertight integrity and safe speed [source: Fairplay].

Conclusion
Fairplay has not identified any shortcomings in the procedure for securely fastening watertight openings and the tug's speed when providing tug assistance.

Safety management - stability
Fairplay 22 was designed on the basis of the stability requirements in force when the vessel was built in 1998. The stability calculations made by SARC and ASD Ship Design show that Fairplay 22 failed to comply with the stability requirements if the machine room vents were not closed.

Safety management – closing watertight openings
Fairplay's HSE-Q Manual states that the engine room vents must be closed when engaged in towage operations. During interviews with a number of the company's employees, it emerged that if the engine room power plant is to function properly air supply is required. Closing the vents blocks off the air supply to the engine room, which causes failure of the engine room power plant. The procedure described in the HSE-Q Manual cannot not be carried out in practice because this would result in the breakdown of the engine room power plant.

If the engine room power plant breaks down, the ship will no longer be able to sail. This involves countless safety risks. The watertight openings on board Fairplay 22 could therefore not be closed when the tug was sailing.

Conclusion
Fairplay's procedure for closing watertight openings was unfeasible in practice.

Fairplay 22's crew were unable to work according to procedures because these were contradictory. The idea behind working in accordance with the safety management principles is to reduce risk and avoid such errors. If the latter is difficult, identifying and tackling the relevant areas should be the next step. The contradictory aspects could have been identified and action taken on the following occasions:

- during the hazard identification and analysis process;
- while sailing, had all procedures been followed; and
- if the shipping company had monitored whether all procedures had been carried out.

In Fairplay 22's case, the hazard identification and analysis (RI&E) contained shortcomings, the procedures were inadequately complied with and there was insufficient compliance monitoring. The system therefore failed to function as set out in the safety objectives. There was no pro-active operating procedure whereas this is exactly what the use of the safety management system seeks to achieve. Furthermore by awaiting the outcome of the Dutch Safety Board's investigation, Fairplay has failed to be pro-active in learning from the accident.

Conclusion
There are shortcomings in Fairplay's safety management system in respect of the hazard identification and analysis (RI&E), working according to procedures and monitoring compliance with procedures.

Safety management - speed
The importance of maintaining an appropriate speed when providing tug assistance is common knowledge within the sector. The Antwerp Port Authority guideline stipulates that when establishing a towage connection between a tug and a ship requiring assistance, speed through the water should not exceed 6 knots. The guideline was established in part because forward tugs were establishing towage connections at increasingly higher speeds, thereby having insufficient reserve power to manoeuvre away in an emergency situation. A towage company, which also has operations in the ports of Antwerp, Ghent, Zeebrugge, Terneuzen and Flushing, drew up a separate safety procedure and distributed it among its crew and customers, following an audit. The procedure also states that in order to ensure a safe speed, the maximum permitted speed through the water is 6 knots. It stresses that if the vessel's speed is higher, the tug captain may decide not to establish the towage connection.

At the end of 2009, in association with parties such as captains of seagoing vessels, shipping agents, tug captains, pilots, harbour masters, terminal operators and hydrographic services, the European Harbour Masters' Committee (EHMC) jointly released a DVD. The DVD shows that a towage connection should be made at a speed not exceeding 6 knots as best practice. Marine Guidance Note (MGN) 199 dating from 2002 issued by the Maritime and Coastguard Agency in the United Kingdom similarly emphasises the danger of high speed. A maximum speed is not mentioned but it does state that a manoeuvre of a tug at close quarters to a ship requiring assistance 'should always be carried out at very low speed'. Figure 32 contains a quote from MGN 199.

A further effect of interaction arises from the flow around the larger vessel acting on the underbody of the smaller vessel causing a consequent decrease in effective stability, and thus increasing the likelihood of capsize if the vessels come into contact with each other. Since it has been found that the strength of hydrodynamic interaction varies approximately as the square of the speed, this type of manoeuvre should always be carried out at very slow speed.

Figure 32: Quote[42] from MGN 199 [source: Maritime and Coastguard Agency, United Kingdom].

Fairplay's procedure also states that when carrying out harbour assistance a speed through the water of 6 knots is advisable when taking in a heaving line. The German and English versions of the text clearly state that this should be interpreted as a recommendation. Figure 33 contains a quote from Fairplay's harbour tug assistance procedure on maintaining safe speed.

Sichere Geschwindigkeit: Geringe Fahrt in bestimmten Situationen Für Schlepper sind bei Übernahme der Leine etwa 6 kn durch das Wasser eine günstige Geschwindigkeit.	*Safe Speed: Some speed is required at times* When taking up the tow line, the tugs like to have about 6 knots through the water.

Figure 33: Quote[43] on safe speed from Fairplay's harbour tug assistance procedure [source: Fairplay].

The above shows that the importance of sailing at an appropriate speed is a known fact within the sector. Fairplay's procedure confirms that the shipping company was also aware of the risks involved in maintaining a high speed when sailing at close quarters and establishing a towage connection. Nonetheless, the tug's speed through the water was considerably higher at the time of the accident than the recommended 6 knots. The captain of Fairplay 22 had proposed a speed between 6-8 knots. The investigation also revealed that Stena Britannica had sailed at a speed through the water exceeding 6 knots on a number of previous occasions while tug assistance was provided by Fairplay.

The safety management objective states that Fairplay seeks to guarantee that employees work in accordance with the procedures and that this is adequately supervised. Also according to the principles of safety management the shipping company is required to ensure supervision of compliance with the procedures. Had the shipping company maintained adequate supervision, it would have been aware that the crew did not adhere to the procedures when providing tug assistance. In that case, the shipping company could have taken action, such as emphasising the importance of maintaining a low speed or by tightening supervision of the procedure.

Conclusion
The shipping company has not monitored the harbour tug assistance procedure on maintaining a safe speed.

Safety Management – risk assessment
Fairplay's HSE-Q Manual states that it is required to perform a risk assessment for every activity involving a specific risk. No risk assessment was carried out for manoeuvring close to the bow of a ship requiring assistance, for passing/taking in a heaving line or for providing tug assistance even though the shipping company states in the harbour tug assistance procedure that the forward tug in particular is vulnerable while establishing a towage connection.

The sector has been aware of the fact that a forward tug is vulnerable while establishing a towage connection for years, as evidenced by the Marine Guidance Note (MGN) 199 issued by the Maritime and Coastguard Agency (MCA) in the United Kingdom in 2002. Figure 34 quotes from the MGN.

42 The extract containing the quote is included in Appendix 5.
43 The extract containing the quote is included in Appendix 6.

When vessels are manoeuvring at close quarters for operational reasons, the greatest potential danger exists when there is a large difference in size between the two vessels and is most commonly experienced when a vessel is being attended by a tug. A dangerous situation is most likely when the tug, having been manoeuvring alongside the vessel, moves ahead to the bow to pass or take a tow-line.

Figure 34: An extract from MGN 199 [source: Maritime and Coastguard Agency, United Kingdom].

In line with the safety management principles a shipping company should learn lessons from indicators, near misses and accidents, developments and renewed insights within and outside the sector. The MCA guideline was announced to the sector almost ten years ago. In spite of this the shipping company failed to apply the guideline to learn from it. The guideline also failed to prompt the shipping company to perform a risk assessment. The shipping company made inadequate use of the knowledge available within the sector about the risks involved in establishing a towage connection.

Regarding the safety management of Fairplay, several shortcomings have been identified. These concern the identification and analysis of hazards, the supervision of the safety management implementation on board and the use of the available knowledge within the sector to enhance safety. Because the safety management system of the shipping company did not work as intended, Fairplay failed to avail itself of the opportunity to improve its safety performance.

Conclusion
Fairplay failed to carry out a risk assessment for manoeuvring close to the bow of a ship requiring assistance or for passing/taking in a heaving line.

Fairplay made inadequate use of the knowledge available within the sector about the risks involved while establishing a towage connection. This means that the shipping company failed to avail itself of the opportunity to improve its safety performance.

3.5.4 Safety management - Stena

Stena's safety management objectives are described in its Safety Management Manual (SMM). These objectives are listed in Figure 35.

1.2.1 The objectives of the Code and the Company Safety Management System are to ensure safety at sea, prevention of human injury or loss of life, and avoidance of damage to the environment, in particular, to the marine environment and to property.

1.2.2 The safety management objectives of the Company are to, inter alia:
i. Provide for safe practices in ships operation and a safe working environment,
ii. Establish safeguards against all identified risks; and
iii. Continuously improve safety management skills of personnel ashore and aboard ships, including preparing for emergencies related both to safety and environmental protection.

Figure 35: The objectives defined in Stena's safety management system [source: Stena].

The SMM does not include a procedure for establishing a towage connection or for general tug assistance. Stena carried out a hazard identification and analysis for the crew on deck of Stena Britannica relating to the use of tugs. The hazard identification and analysis was limited to mooring on the quayside and does not provide any information on establishing a towage connection with a tug. In the Dutch Safety Board's view this is a shortcoming in Stena's safety management.

Stena has a procedure in place for sailing with a pilot on board. Among other aspects, the procedure states that it is common practice for captains to hold a Pilot Exemption Certificate (PEC) for the areas where they sail regularly. If a captain does not hold a PEC, the captain is required to obtain a PEC within a reasonable time-frame. Figure 36 describes part of this procedure.

PEC holders must be given the opportunity to maintain and further develop their skills. PEC holders are therefore recommended to make an inbound and outbound journey to the area at least once a month.

Pilotage Exemption Certificates (PECs)
7.3.13.13 It is normal Company practise for all Masters to hold PEC's for the pilotage districts that they regularly trade to. If a Master is appointed to a ship on a route for which he / she does not hold PEC's the Master shall work towards gaining such PEC's as soon as is reasonably practicable.

Figure 36: A quote from Stena's procedure for sailing with a pilot [source: Stena].

The SMM stipulates education and training requirements for captains. The SMM clarifies which certificates a captain should hold and what training programmes he should have followed. A distinction is made between compulsory, recommended and advisable education and training programmes. None of these compulsory, recommended and advisable training programmes concern tug handling in the port of Rotterdam.

Tug assistance regularly needs to be called in at both Harwich and Hook of Holland, particularly in adverse weather conditions. The sector considers establishing a towage connection as a high-risk operation. Nevertheless, the SMM does not contain a procedure for establishing a towage connection or for general tug assistance. No hazard identification and analysis has been carried out for establishing a towage connection with a tug. Stena's SMM also does not impose any requirements on the education or training of captains concerning tug handling.

Stena Britannica's captain has not participated in the three-yearly refresher training regarding the PEC. Stena consequently has not monitored whether the captain possessed the required competences regarding the PEC.

It is not always possible to plan the deployment of tugs for seagoing vessels in the port of destination because it is not always clear on beforehand whether tug assistance will be required and which tugs are available. It is not uncommon to deploy tugs at short notice and without signing a contract in advance. Stena, however, sails two identical Ro/Ro passenger vessels on a fixed route and arrives in the port of Rotterdam twice a day. In the Dutch Safety Board's view in this particular case Stena could have made concrete agreements beforehand with Fairplay about the deployment of tugs and the quality of the service provided, including emphasising safety and the possibility of performing an audit. Stena could have made agreements on making an inventory of the risks associated with establishing a towage connection and mooring and unmooring vessels. The Dutch Safety Board views the fact that this was not carried out as a shortcoming in the safety management systems of both Fairplay and Stena. Taking measures to improve safety necessitates both parties to coordinate.

Conclusion
Despite the fact that the Stena Ro/Ro passenger vessels regularly sail with tug assistance, Stena does not have a procedure for establishing a towage connection or for general tug assistance. No hazard identification and analysis had been carried out for establishing a towage connection with a tug either.

Stena has incorporated in its procedure that captains are required to hold a Pilot Exemption Certificate (PEC), but has not monitored whether the captains posses the required competences regarding the PEC.

Stena failed to utilise the opportunity to assess beforehand (for instance in a written contract) the quality, the risks associated with establishing a towage connection and the risks involved in mooring and unmooring with tug assistance in the port of Rotterdam.

3.5.5 Crew and education/training

Stena Britannica captain
The captain of Stena Britannica held a PEC. The Port of Rotterdam Harbour Master did not require the Stena Britannica captain to participate in additional training on tug handling in the port of Rotterdam. The Stena Britannica captain has therefore not participated in any training on tug handling in the port of Rotterdam. He has participated in Stena simulator training with the previous Stena Britannica in 2003. He has not participated in any refresher training, even when the new Stena Britannica was put into service.

The captain of Stena Britannica had called at the Hook of Holland harbour on over 1,700 occasions. He had also made use of tug assistance on 167 occasions. The captain had therefore gained a good knowledge of the local waters and had also gained experience in tug assistance.

It emerged from the reconstruction that Stena Britannica had sailed at a higher speed during both attempts than had been agreed between the two captains. It also emerged that Stena Britannica was reducing speed between the first and second attempts. The captain of Stena Britannica had disposal of equipment to detect this.

Fairplay 22 captain
The captain of Fairplay 22 did not work for Fairplay but had been hired in from Transport & Offshore Services (TOS), a temporary employment agency. He had acquired over ten months' experience on Fairplay 22. Prior to that he had gained 20 years' experience, including 13 years as a captain on various types of tugs, including ASD tugs. As such, the captain had extensive practical experience as a tug captain.

In part because the captain lost his life during the accident, the Dutch Safety Board was unable to ascertain to what extent human factors contributed to the accident. However, it emerged from the reconstruction that Stena Britannica (and consequently Fairplay 22) had sailed at a higher speed during both attempts than had been agreed between the two captains. Moreover, speed was considerably higher than the recommended maximum speed stated in Fairplay's HSE-Q Manual.

The captain had not undergone any theoretical tug captain training. As a result, he may possibly have had no or little theoretical knowledge of the risks involved in establishing a towage connection and in sailing at a higher speed.

Tug captain education/training
Tug captains often work as captains in different sectors and on different types of vessels before working as such. For that reason their backgrounds may be very different. In the Netherlands no dedicated theoretical training programme for tug captains exists. How shipping companies go about this is left to their discretion. Some shipping companies offer their own training programme, which all tug captains are required to follow before being permitted to work as such. Smit uses simulator training for this purpose. Other shipping companies, including Fairplay, only provide captains with on-the-job training.

Trainee captains sail under the supervision of a qualified tug captain. By performing an increasing number of tasks themselves, they acquire the necessary knowledge and skills in a stepwise manner to enable them to work as a tug captain.

To ensure safety in the towage sector, prospective captains are required to satisfy predefined competencies. Working as a tug captain involves specific risks. Although many shipping companies, pilots and other sector parties have extensive knowledge and experience of the risks involved, these are not systematically shared. The risks involved and relevant competencies could be incorporated in a joint training programme, which could help ensure that all tug captains acquire a basic knowledge of safety. This will also offer the sector the opportunity to learn from day-to-day situations, incidents and accidents, hazard identifications and analyses and suchlike, and to share such knowledge.

Conclusion
Due to the lack of a theoretical tug captain training programme covering tug assistance to seagoing vessels, knowledge and skills are transferred on the basis of experience. As a result not all tug captains possess standard basic knowledge regarding safety.

Temporary employment agency - Transport & Offshore Services (TOS)
Fairplay requested TOS to provide a captain and TOS began recruiting candidates for the position. TOS first assesses candidates on the basis of the following criteria: Education/training, Certificate of Competency, accumulated hours of sailing and experience, and references from previous employers. TOS then recommends a candidate to the client, in this case Fairplay. This is followed by a content-based interview covering experience of various tugs, propulsion, sailing areas, knowledge of the port of Rotterdam, etc. Fairplay then decides whether the relevant person is suitable.

According to the Working Conditions Act and the Placement of Personnel by Intermediaries Act (*Wet op allocatie arbeidskrachten door intermediairs*, Waadi), TOS is obliged to inform its temporary employees about the work-related risks based on the hazard identification and analysis provided by the hiring company (in this case Fairplay). The temporary employment agency failed to fulfil its responsibilities in the capacity of the captain's employer. TOS failed to monitor whether the shipping company had provided the captain with a hazard identification and analysis. The temporary employment agency furthermore failed to take action to identify the work-related risks. The temporary employment agency thus failed to ensure that the workplace and the relevant activities were sufficiently safe for the captain.

Conclusion
TOS failed to monitor that Fairplay provided the captain with a hazard identification and analysis.

3.5.6 Port of Rotterdam Harbour Master
As the person responsible for the quick, clean, safe and secure shipping in the port of Rotterdam, the Port of Rotterdam Harbour Master is responsible for issuing PECs and for supervision thereof.[44] The Port of Rotterdam Harbour Master's own staff provide supervision. This means that the Port of Rotterdam Harbour Master both issues PECs and performs supervision thereof.

The basic rule is that a captain of a seagoing vessel that wants to call at the port of Rotterdam is required to have a pilot on board. A captain of a seagoing vessel can obtain a PEC after successful completion of a Rotterdam-based training. Training programmes and examinations are conducted by pilots, in consultation with the Port of Rotterdam Authority. Pilots generally know the local waters on which they sail extremely well and are well placed to provide captains with navigation advice. Tug handling is included in pilot training programmes. Moreover, pilots have more experience of using various tug types than captains. These aspects help ensure the safety of ships in ports, particularly in adverse weather conditions.

The Stena Britannica captain has not participated in the training in the Netherlands for obtaining the PEC. He did participate in a Stena simulator training in 2003. The Port of Rotterdam Harbour Master issued a PEC to the Stena Britannica captain on the basis of a statement by Stena that the captain had participated in this training. The information obtained by the Dutch Safety Board did not reveal that any substantial evaluation on the subject matter took place regarding the training in which the captain had participated.

44 By the Regulation competent and regional authorities Compulsory Pilotage Decree (*Regeling bevoegde en regionale autoriteiten Loodsplichtbesluit 1995*) and the Decree Declaration Holders Maritime Traffic Act (*Besluit verklaringhouders Scheepvaartverkeerswet)*.

In recent years, the Port of Rotterdam Harbour Master has required captains of several shipping companies to complete additional training. After completing such training, the captains were allowed to make use of tug assistance without a pilot on board. The Port of Rotterdam Harbour Master's policy is that this training is repeated every three years. The Stena Britannica captain was also allowed to make use of tug assistance without having a pilot on board. However, the Port of Rotterdam Harbour Master has not required the Stena Britannica captain to participate in any additional training. Contradictory to his policy, the Port of Rotterdam Harbour Master also has not required the three-yearly refresher training, even after the new Stena Britannica was put into service in 2010.

The Safety Board is amazed by the fact that the Port of Rotterdam Harbour Master did not require the Stena Britannica captain to participate in any additional training for tug assistance, since tug assistance is generally requested during adverse and difficult weather conditions. Moreover, the Port of Rotterdam Harbour Master has requested captains of other similar seagoing vessels larger than 130 meters to take additional training.

Conclusion
The Port of Rotterdam Harbour Master allowed the Stena Britannica captain to make use of tug assistance without having a pilot on board, without requiring additional training, while he has required other captains of similar ships to participate in such training. In addition, contradictory to his policy, the Port of Rotterdam Harbour Master has not required the Stena Britannica captain to participate in the three-yearly refresher training. The Pilot Exemption Certificate was issued on the basis of a statement by Stena that the captain had participated in a Stena simulator training.

Currently the compulsory pilotage in the Dutch ports is being restructured. The work group Compulsory Pilotage New Style 2010-2011 (*Loodsplicht Nieuwe Stijl 2010-2011)* is set up to develop an unambiguous system regarding the PEC. It is expected that the Compulsory Pilotage New Style will come into force in 2014. The final content has not yet been established, as a result of which it is currently unclear what changes will take place.

3.6 Smit Polen

The accident involving tug Smit Polen shows a number of similarities with the accident involving Fairplay 22. Smit Polen wanted to take a heaving line from the bow of Maersk Nijmegen while sailing at a speed through the water of approximately 8.6 knots, with a west to south-westerly force 5 wind blowing and an ebb current of approximately 1.6 knots. The captain was standing with his back facing the tug's sailing direction and operated the tug from the rear control panel.

Just as Fairplay 22, Smit Polen collided with the bulbous bow of the container ship and ended up broadside in front of the bulb. Smit Polen also incurred a large heeling angle, but contrary to Fairplay 22, Smit Polen righted herself after she had become free from the bulb.

The Dutch Safety Board investigated why Smit Polen did not capsize despite the similarities between the two accidents. The Smit Polen investigation focused on design stability and the watertight openings.

3.6.1 Design stability
ASD Ship Design has carried out calculations for the purpose of assessing Smit Polen's stability. The tug's equipment and tank contents were equal to those on board Smit Polen at the time of the accident. Appendix 11 contains the investigation report drawn up by ASD Ship Design.

The results show that Smit Polen complies with the stability requirements in force when the tug was built.
Smit Polen furthermore complies with the additional stability criteria specified for modern tugs. The investigation did not cover to what extent the collision angle and the damage pattern contributed to the incident.

Conclusion
Smit Polen complied with both the stability requirements at the time of built and the additional stability criteria for modern tugs.

3.6.2 Watertight openings

Smit's safety management system specifies that watertight openings must be closed during tug assistance operations. The captain of Smit Polen stated that the watertight openings were closed during the accident. The negative effects of water flooding in, i.e. reduced freeboard and the free fluid moment that amplifies heeling, therefore did not occur.

The vents in front of the engine room were open during the accident. As the openings were located high up on Smit Polen's funnel, only a limited amount of water was able to pour in when the vessel heeled.

Conclusion
Due to the fact that the watertight openings were closed when Smit Polen heeled, no water flooded in. As the vent openings were located high up on Smit Polen's funnel, only a limited amount of water was able to pour in when the vessel heeled. Consequently, this only had a minor negative effect on the tug's stability.

3.7 Voyage Data Recorder (VDR)

This section looks at the use of Voyage Data Recorders (VDRs) on board ships. Although there is no direct relationship with the accident, the Dutch Safety Board believes it is important to emphasise this topic because it did influence the investigation of the accident.

A VDR continuously records data related to the navigation of a ship. The data are stored for a certain amount of time (at least 12 hours), and then overwritten. A VDR carriage requirement has been imposed for seagoing vessels, comprising a number of mandatory parameters to be recorded. Inter alia, the VDR must record speed, position, course, bridge communication, radar, AIS, alarms, and wind speed and direction. The primary purpose of recording the above data is that it can aid the accident investigation. The data can be used to obtain the relevant factual information of an accident and to support the analysis.

No VDR had been installed on Fairplay 22. Since a considerable part of the data recorded by a VDR could not be obtained in any other way, key accident data were not available for the investigation into the cause(s) of the accident. The missing information includes the following:

- the course over ground and the heading;
- the steering demand and response of both thrusters;
- the engine power demand and response;
- the communication on the bridge and other communication;
- the heeling angle;[45]
- the status of the alarms; and
- the wind speed and wind direction.

Moreover, VDR recorded data would also have provided a more accurate record with more frequent intervals of the position data for the purpose of the investigation. In addition, data recorded by other recording equipment could have been verified on the basis of VDR data. The lack of the above information made it more difficult to reconstruct the accident and increased the uncertainty of the reconstruction.

45 The heeling angle is not among the mandatory parameters that are required to be recorded by a VDR. However, on an international level developments are taking place which may result in adding heeling angle to the mandatory parameters in the future.

Various Dutch Safety Board's sister organisations abroad too have been impeded by the absence of VDR recorded data in accident investigations. Several studies have shown that the costs of installing a VDR on a newly built ship are very low in proportion to the total costs of a new ship. For existing ships, however, the costs could be considerable. In addition to accident investigation, VDR recorded data can also be used for other purposes, such as crew training.

Conclusion
Due to the absence of a Voyage Data Recorder (VDR) on board Fairplay 22 a number of aspects could not be established with certainty in the reconstruction. This impeded the accident investigation and increased its uncertainty.

3.8 Action taken after the accident

After the accident Fairplay and Stena proposed to hold a meeting together to evaluate the events. The statements of Fairplay and Stena regarding this meeting are contradictory. It is however clear that a further evaluation was not held for reasons of legal liability that may possibly come into play.

Fairplay
Fairplay itself has not carried out an investigation into the accident involving Fairplay 22 but has decided to await the results of the Safety Board's investigation. Fairplay has stated during the investigation that it took the following measures as a result of the accident:

- The Smit Safety Flash was issued to all of its ships' crews;
- An instruction was issued that each person on board during tug assistance that is not a member of the crew needs to be reported to the office (as the number of crew members on board during the accident was unclear for a rather long period);
- An instruction was issued that all seamen on deck are required to hold a knife (to be able to cut an inflatable life-jacket if needed); and
- The policy regarding watertight doors is revised: from the moment the engine is started for providing tug assistance until the moment the tug has returned to its berth, the doors to the accommodation and other openings are to be closed and monitored.

In response to the Safety Board interim recommendation Fairplay stated that it was considering installing. Fairplay will also contact the classification society to verify whether it is correct that a Certificate of Class was wrongly issued due to its inadequate stability.

In response to the draft version of this report, Fairplay indicated that the following measures have been taken:

- an indicator light on the bridge to verify whether the door to the aft deck is closed was installed on the tugs that did not yet possess such a light;
- a towing line and the subsequently required ballast water were removed from sister ship Fairplay 23 (to lower the vertical centre of gravity of the tug);
- few vent openings on tugs have been made more watertight; and
- permanent ballast was added to sister ship Fairplay 23.

Fairplay has stated that it considers modifying the vent openings to the engine room.

According to the safety management principles it is important to learn from incidents and accidents in order to prevent similar incidents from occurring in the future. By awaiting the results of the Dutch Safety Board's investigation, which extends over a period of around one year, Fairplay could only take limited preventive measures to improve safety shortly after the accident. By not conducting an investigation into the accident, Fairplay has failed to fulfil its own responsibility and has therefore failed to avail itself of the opportunity to increase safety in the short term.

In addition, the Safety Board notes that one of the shipping company's safety measures, i.e. closing the accommodation doors and vent openings to the engine room during tug assistance, is not practically feasible. Closing the vent openings blocks off the air supply to the engine room, which is required for the engine room power plant to operate properly. The Board therefore questions whether this procedure is followed on board and whether Fairplay monitors this procedure.

Stena
The captain of Stena Britannica drew up an Operational Incident Report, which contains a brief description of the accident. Stena registered the document into its incident reporting system. The system links up more than 70 ferry operators and aims to enable ferry operators to learn from each other in order to prevent similar incidents from occurring in the future.

Smit
Following the Smit Polen accident Smit sent a Safety Flash to all of the shipping company's operational managers. The Safety Flash briefly describes the accident and provides a number of recommendations to improve safety. One of the recommendations concerns closing watertight doors and hatches during tug assistance. A warning is also given on the 'Venturi effect'[46] of sailing at close quarters. The Safety Flash does not mention the importance of maintaining an appropriate speed. Appendix 6 contains the Safety Flash.

Smit also conducted an internal investigation into the accident. The accident report was completed on 7 February 2011 and includes five recommendations. One of the recommendations involves incorporating the incident scenario in the simulator training programme, where possible including the hydrodynamic effects. Another recommendation involves performing risk analyses to ensure that adequate procedures are developed and implemented. In terms of safety management it was furthermore concluded that too few internal audits and management visits on board take place, that a number of procedures are not carried out in day-to-day practice and that the shipping company should improve its monitoring.

Port of Rotterdam Harbour Master
Following the accident the Port of Rotterdam Harbour Master drew up an internal report on the SAR operation. The report was completed on 26 November 2010 and made available to the Dutch Safety Board. The report does not contain any conclusions or recommendations about improving safety but primarily sums up the facts. The Port of Rotterdam Harbour Master has not evaluated its own role in the report. The report also does not elaborate on the Port of Rotterdam Harbour Master's policy regarding PEC's.

46 The Venturi effect is the phenomenon that occurs when a fluid that is flowing through a pipe is forced through a narrow section, resulting in a decrease in pressure and an increase in velocity.

4 CONCLUSIONS

Direct causes

The direct cause of the collision
From the investigation it can be concluded that the high speed through the water was a crucial factor in the accident. The higher the speed through the water, the larger the hydrodynamic sphere of influence and hydrodynamic interaction between the ships. Sailing at high speed substantially increased the risk of the tug becoming uncontrollable and the risk of collision. The current and most probably also the drift angle contributed to this.

The investigation could not determine to what extent the captain of Fairplay 22's restricted view, his time to react and the influence of the wind contributed to the collision.

The direct cause of capsizing
Fairplay 22 was unable to move away from Stena Britannica's bow after the collision. The hydrodynamic forces and the tug's reserve power contributed to this. In addition, the limited human ability to anticipate may also have contributed given the circumstances.

Fairplay 22 was pushed over and subsequently capsized. The tug's capsizing was accelerated by the water flooding in. The limited design stability of the tug and the weathertight openings that had not been closed were contributing factors to the capsizing and increased the speed at which the tug capsized.

Underlying causes

Fairplay 22 did not have the required level of safety in accordance with the stability requirements and the stability criteria for modern tugs.

Fairplay failed to investigate whether the stability of its vessels needed to be improved despite the fact that the shipping company was aware that the stability of Fairplay 22's sister ships was enhanced when chartered by third parties and that the company could have known that the tug's stability failed to comply with the current stability criteria.

Fairplay's safety management system showed multiple shortcomings. The hazard identification and analysis (RI&E) was incomplete, the procedure regarding the watertight openings was practically infeasible and the procedure regarding speed was not followed. This went unnoticed due to insufficient monitoring. The safety management system therefore failed to meet the company's own safety objectives, such as continuous improvement ensuing from the identified risks, adequately documenting control measures and verifying the effect of the control measures implemented.

Stena's safety management system also showed shortcomings. There are no procedures for the operational processes relating to tug assistance and taking heaving and towing lines. These processes have also not been incorporated in the hazard identification and analysis and consequently no preventive measures were taken to reduce the risks. Stena has incorporated in its procedure that captains are required to hold a Pilot Exemption Certificate (PEC), but has not monitored whether the captains posses the required competences regarding the PEC.

Stena has not incorporated any safety related aspects in order to ensure safety in the price agreements with Fairplay regarding tug assistance.

The Port of Rotterdam Harbour Master issued a PEC to the Stena Britannica captain without any substantial evaluation on the subject matter regarding the training the captain had participated in. The Port of Rotterdam Harbour Master thereby allowed the Stena Britannica captain to make use of tug assistance without taking a pilot on board, without requiring additional training, while he has required other captains of similar ships to participate in such training. In addition, in contradiction to his policy, the Port of Rotterdam Harbour Master has not required the Stena Britannica captain to participate in the three-yearly refresher training.

During the flag state inspections by Antigua&Barbuda and Port State Control (PSC) inspections by the Dutch Transport, Public Works and Water Management Inspectorate it could not be detected that Fairplay 22 did not comply with the stability requirements.

The supervision of the Netherlands concerning vessels registered under a foreign flag that operate more or less permanently in a Dutch port is limited to the PSC inspections as carried out by the Dutch Transport, Public Works and Water Management Inspectorate.

Transport & Offshore Services (TOS), the temporary employment agency and employer of Fairplay 22's captain, failed to monitor that Fairplay provided the captain with a hazard identification and analysis.

Other findings

The Netherlands has no specific training programme for tug captains. Consequently, knowledge and experience of the sector-specific risks is not shared on a structured basis, i.e. in a training programme.

Due to the absence of a Voyage Data Recorder (VDR) on board Fairplay 22 a number of aspects could not be established with certainty in the accident reconstruction. This impeded the accident investigation and increased its uncertainty.

5 RECOMMENDATIONS

5.1 Interim recommendation

By issuing interim recommendations, the Safety Board urges parties to implement precautionary measures as soon as possible. Such recommendations are therefore only issued in specific cases, particularly where unsafe situations occur.

In view of the outcomes in determining the stability of Fairplay 23 the Safety Board decided to submit an interim recommendation to Fairplay shipping company ahead of the final report. The interim recommendation was submitted on 29 June 2011 as follows:

Determine the stability of Fairplay 23's sister vessels. If the determined stability is found to correspond with that of Fairplay 23, it is recommended that measures be taken to improve the stability of all vessels to at least ensure compliance with the requirements stipulated by SBG in 1998.

In its response to this recommendation, Fairplay stated that they: (1) are considering installing on the bridge an indicator light to show the status of the door to the aft deck; and (2) will inquire with the classification society whether a Certificate of Class was provided erroneously. In the response to the draft version of this report, Fairplay indicated that a number of measures have been taken, or are under consideration, regarding the stability of the shipping company's tugs. For the Safety Board, it is unclear whether these measures will result in Fairplay 23 satisfying the 1998 SBG stability requirements. No written response from Fairplay was received showing whether they intend to concur with the recommendation. The Safety Board therefore urges Fairplay to send a written response regarding the recommendation and to indicate the effect of the measures on stability.

5.2 Recommendations

To Fairplay:

1. Identify, preferably in consultation with the European Tugowners Association, the risks associated with sailing close to the bow of a seagoing vessel and take measures to minimise these risks. Pay particular attention to the speed through the water to be maintained, the stability and the position of tugs during the operation of establishing a towage connection. Implement this in your safety management system.
2. Monitor the operational procedures, including the speed maintained during tug assistance operations and the closing of watertight and weathertight openings.

To Stena:

1. Compose an inventory of the risks involved in establishing a towage connection and take measures to control these risks as much as possible. Implement all this in your safety management system and ensure that captains are competent in using tug assistance in the port of Rotterdam.
2. Set out written agreements with tug companies regarding tug assistance and include herein safety criteria aimed at guaranteeing safety.

To the Port of Rotterdam Harbour Master:

1. Specify the maximum speed through the water at which a towage connection should be made between a tug and a ship requiring assistance in a procedure, and ensure compliance.
2. Specify requirements relating to the captain's knowledge, training and experience with respect to tug assistance for issuing a Pilot Exemption Certificate to a captain using tug assistance, and ensure compliance.

To the minister for Infrastructure and the Environment:

1. Investigate the possibilities of making tug captain training compulsory for all captains working on Dutch tugs and tugs in Dutch harbours, regardless of propulsion power.
2. Investigate, in consultation with other IMO member states if possible, the feasibility of requiring that all newly built tugs be equipped with a Voyage Data Recorder (VDR).

Administrative bodies to which a recommendation is addressed should state their position in respect of compliance with this recommendation to the relevant minister within six months of the date of publication of this report. Non-administrative bodies or persons to whom a recommendation has been addressed should state their position in respect of compliance with this recommendation to the relevant minister within one year of the date of publication of this report. A copy of the response should at the same time be sent to the Chairman of the Dutch Safety Board and the Minister for Security and Justice.

APPENDIX 1: INVESTIGATION DETAILS

Reason for the investigation
On 1 January 2010 the Dutch Safety Board was mandated to investigate accidents involving seagoing vessels. In principle the Safety Board itself decides which accidents to investigate.

By virtue of international conventions it is mandatory for the Netherlands to investigate serious and very serious casualties involving a Dutch seagoing vessel. Pursuant to the same conventions the coastal state in whose territorial waters a serious or very serious casualty has occurred may institute an investigation. Given the impact of the accident in which two people lost their lives on 11 November 2010, the Dutch Safety Board took the decision to institute an investigation after consulting with the member states involved (Antigua and Barbuda and the United Kingdom).

During the course of the investigation, a similar accident occurred on 13 January 2011. There were no casualties and there was no legal obligation to conduct an investigation into the accident. Since the circumstances were similar, the Safety Board felt it would be useful to include the main aspects of the January 2011 accident in the investigation.

Objective
The primary objective of the investigation is to determine the direct cause of the accident. Various sources of information were used for this purpose, both on board the two ships and on shore. Information was also obtained from interviews and a literature study was performed. The second investigation objective was to find out what preventive measures the parties involved had taken to prevent such an accident from occurring. On the basis of the two objectives the Safety Board formulated the following key investigative question:

How did the accident occur and how did the parties involved control the risk of collision and capsizing while establishing towage connections?

Strategy
Dutch Safety Board investigators launched to the accident site immediately after the accident occurred. In order to determine the direct cause of the 11 November 2010 accident the following data sources were used amongst other things:

- Voyage Data Recorder (VDR) recorded data on board Ro/Ro passenger ship Stena Britannica;
- Automatic Identification System (AIS) data on board both ships;
- Vessel Traffic Services (VTS) data from the Port of Rotterdam Authority;
- Current diagram of the port of Rotterdam from the Port of Rotterdam Authority; and
- Electronic chart data obtained from tug Fairplay 22.

The radar images that were recorded on the Stena Britannica VDR and the VTS radar images of the Port of Rotterdam Authority were used in the investigation. Also, AIS data of both ships were analysed. AIS data are not transmitted at consistent intervals. This depends on variables, such as a ship's speed and turning speed. The available AIS data (ground speed, position and course over ground) were used for the analysis and reconstruction, and were then interpolated to create a per second reconstruction. The interpolation of the data was verifiable for Stena Britannica since the VDR had recorded the same data. In the verification of VDR recorded data some irregularities were found. The output data of bow thruster 2 were inconsistent with the input. The input and output of bow thrusters 1 did match. In the analysis of the VDR recorded data this was taken into account.

No additional sources were available to verify the Fairplay 22 AIS data. The reconstruction of Fairplay 22's position and movements is based on calculations made at certain points in time. Not all data were included in the report. Only the data that were used to draw conclusions were included in the report as appendix or figures in the text.

For the purpose of reconstructing the 11 November 2010 accident, the National Traffic Assistance Team (*Landelijk Verkeers Bijstands Team*, LVBT), a division of the Dutch National Police Services Agency (KLPD), determined the damage pattern on the ship's hull on behalf of the Dutch Safety Board. Using 360-degree photography and with the aid of a 3D laser scanner tug Fairplay 22's hull was scanned in the dry dock. A 3D image of Stena Britannica's bow was then inserted on the scanned damage pattern of tug Fairplay 22's hull in 3D CAD software.

The following was used for the investigation of the accident on 13 January 2011:

- Voyage Data Recorder (VDR) on board container vessel Maersk Nijmegen; and
- Vessel Traffic Services (VTS) data from the Port of Rotterdam Authority.

Expertise deployed
In order to answer the key investigative question, in addition to the investigation into the facts relevant to the accident, a number of sub-investigations were conducted by external experts to gain an understanding of the following:

- the hydrodynamic effects around the bow of the Ro/Ro passenger ship and the interaction with the tug (carried out by Maritime Research Institute Netherlands, MARIN);
- the stability of tug Fairplay 22 (carried out by the Dutch Naval Architectural Software and Engineering Centre [Scheepsbouwkundig Advies en Reken Centrum, SARC] and verified by ASD Ship Design);
- the stability of tug Smit Polen and an inventory of worldwide stability criteria (carried out by ASD Ship Design);
- relevant legislation and education/training relating to the operational deployment of tug assistance (Serendipity UnLtd).

In view of the outcomes in determining the stability of Fairplay 23, Fairplay 22's sister ship, the Safety Board decided to submit an interim recommendation to Fairplay shipping company. It is recommended that the shipping company determines the stability of Fairplay 23's sister vessels. If the determined stability is found to correspond with that of Fairplay 23, it is recommended that measures be taken to improve the stability of all vessels to at least ensure compliance with the requirements specified by See-Berufsgenossenschaft (SBG) in 1998.

The Dutch Safety Board's own investigators conducted the interviews, analysed the information collected and drew up the reports in a project team.

Review
In accordance with the Dutch Safety Board Act a draft version of this report was submitted to all parties involved for review. They were asked to check the report for any errors, omissions, factual inaccuracies and to provide comments. The Dutch Safety Board is obliged to include the views of parties that differ from those of the Dutch Safety Board in its report. These are contained in Appendix 2.

Guidance committee
When conducting its investigations the Dutch Safety Board enlists the assistance of a committee of external experts who contribute to the investigation process in a personal capacity. The committee members not only contribute their specific expertise but also function as a sounding board for the investigation team. The committee members are listed on page 2 of the report.

Investigation Manager
J.W. Selles

Project team

P.H. Verheijen	Project Leader/Investigator
R.P. Besnard	Investigator
M.J. Schuurman	Investigator
M. Vlag	Investigator
E. Willeboordse	Analist
A.A.J. van der Zee	Investigator
H.J.A. Zieverink	Investigator

The following people also made a significant contribution to the project:

J. Demir	Project secretariat
J. Zwaan	Project secretariat
M. Jager	Investigator

APPENDIX 2: RESPONSES RECEIVED FOLLOWING REVIEW OF THE REPORT

In accordance with the Dutch Safety Board Act a draft version of the report was submitted to the parties involved for review. The parties were requested to check the report for any factual inaccuracies and to provide additional information, where applicable. The report was submitted in full or in part to the following people and organisations:

- Fairplay superintendent;
- Temporary employment agency Transport & Offshore Services B.V.;
- Dutch Pilotage Service (Nederlands Loodswezen B.V.);
- Antigua & Barbuda (The Antigua and Barbuda Department of Marine Services and Merchant Shipping, ADOMS);
- Marine Accident Investigation Branch (MAIB);
- Stena Line BV;
- Captain of Stena Britannica;
- Fairplay Towage B.V.;
- Captain of Fairplay III;
- Classification society Germanischer Lloyd Group;
- Port of Rotterdam Harbour Master;
- Ministry of Infrastructure and the Environment; and
- Fairplay 22 captain's son.

All of the above parties availed themselves of the opportunity to respond.

In some cases the report was amended as a result of their comments and in other cases no changes were made. The responses that did not lead to amendment of the report are shown in the table below, including the reason for not doing so.

Section	Comments and the Dutch Safety Board's response
2.4	*Fairplay superintendent* Figure 20: Turn the azimuth 180 degrees. The POD drive was damaged during the collision with the bulb. *Dutch Safety's Board response* Since the investigation was unable to establish with certainty that the damage to the POD drive was caused by the collision (it may also be consequential loss or damage), the damage was not included in figure 20.
Appendix	*Transport and Offshore Services B.V.* Under the Working Conditions Act, the employer is deemed to be the employee's manager and supervisor. From a formal point of view TOS is indeed the official employer but is therefore not responsible for safety on board the ships where it places personnel. After all, TOS also has no influence on safety. In accordance with its legal obligation TOS also specifies in its contracts that the hiring party is responsible for safety on board the ship. Under the Placement of Personnel by Intermediaries Act (*Wet op allocatie arbeidskrachten door intermediairs*, Waadi) TOS has a duty to provide general information to its employees. In this case, however, the captain was highly experienced, having gained extensive experience operating similar tugs. Issuing an RI&E would certainly not have contributed to preventing the accident because an experienced captain can be assumed to be aware of the risks in making a towage connection. In effect, issuing an RI&E would not have given the captain any 'new' information.

Section	Comments and the Dutch Safety Board's response
	In practical terms, it is impossible for TOS to determine the level of safety of the workplace and the associated risks and TOS therefore transferred the responsibility to the hiring company, which in this case was Fairplay shipping company. The reason being that TOS temporarily places/deploys some 600-700 personnel on board various ships all over the world. In 2011, however, TOS introduced a Health & Safety Booklet to its fleet personnel in which the general workplace risks (on board ships) are highlighted in an overview. *Dutch Safety's Board response* The Dutch Safety Board maintains its view that TOS failed to comply with its obligation to provide information as specified in Section 5 (5) of the Working Conditions Act and further elaborated in Section 11 of the Placement of Personnel by Intermediaries Act (Waadi). This obligation serves several purposes, according to the Safety Board. First, the personnel supplier is aware of how the hiring party deals with safety risks for hired-in staff for whom the personnel supplier shares responsibility. Second, prior to placement hired-in personnel are aware of both the workplace-related risks and the manner in which the hiring party deals with these. Even if the captain has extensive experience, safety information is vital for both the personnel supplier and the hired-in staff. On the basis of his statutory duties the captain also has his own responsibilities in respect of safety on board the ship under his command, including going over documentation concerning a safe voyage and working safely on board. The Ministry of Social Affairs and Employment has published the following information on its website: 'The employer is required to inform the employment agency in good time about the specific risks involved in the work for the employee by means of the compulsory RI&E. This includes information such as the physical and mental stress, the use of hazardous substances and the necessary personal protective equipment for a temporary staff member. The employment agency must ensure that the information provided by the employer is in fact given to the relevant temporary staff member.'
3.5	*Transport and Offshore Services B.V.* See the above. TOS is not in a position to ensure that the working conditions on board are safe. TOS has been supplying crew members to Fairplay Towage BV for many years. Regular work meetings are held which are attended by a delegation of tug personnel. During these meetings no complaints relating to safety on board ships were made. In addition TOS has regularly visited Fairplay vessels in the past years. Irregularities were never found during such visits. *Dutch Safety's Board response* The Dutch Safety Board requested TOS to provide reports of the work meetings. TOS responded stating that safety aspects were not discussed during work meetings.

Section	Comments and the Dutch Safety Board's response
Misc.	*Dutch Pilotage Service* In various sections of the documents questions are raised about the crews' level of knowledge. However, the situation is such that the level and the knowledge of crews have come under further pressure on account of opening up the market to competition, and highly competitive pricing. A great deal of international pressure is still being exerted in order to maximise market forces but this usually does not include the fact that cost-saving measures must be taken which comprise safety. Safety has its price and this is seriously affecting safety support service providers in particular. This begs the question whether the overall desired level of safety is in fact affordable. Normally speaking a pilot can compensate by providing very clear instructions about the location where a tug should be made fast and this forms part of a follow-up course for PEC holders. Safety rather than efficiency forms the starting point in this context. *Dutch Safety's Board response* On the basis of his statutory duties and powers the captain also has his own responsibilities for safety on board the ship under his command, including going over documentation concerning a safe voyage and working safely on board.
2.2 / 3	*Dutch Pilotage Service* Everyone at Loodswezen knows that the position where the accident occurred is an area where strange seas can occur. Tenders never pilot alongside a ship in poor weather. As soon as the river water is given room at low light, this creates a kind of waterfall and rapids that can seriously disturb the ship's motion. *Dutch Pilotage Service* Flow: Again, this concerns the advancing river water. At the time of the accident, the river was flowing out and coming in at Europoort. The means that the water coming from the river wants to flow into Europoort creating faster flowing rapids at low light. The local current indeed has extreme gyre. *Dutch Safety's Board response* Based on this response the current diagram relating to the time of the incident was included in the report.
2.2	*Dutch Pilotage Service* How could the captain of Fairplay III have seen this? The impact and lowering of the ship's speed must have also been felt on board Stena Britannica. *Dutch Safety's Board response* Immediately after the collision Fairplay 22's bow coming out of the water could be seen from Fairplay III. It also emerged from the interviews that the Stena Britannica crew felt the impact of the collision.
2.7	*Dutch Pilotage Service* On how many occasions has Fairplay 22 used this captain to provide <u>forward</u> tug assistance in making fast to Stena Britannica? *Dutch Safety's Board response* The captain of Fairplay 22 had only provided assistance to Stena Britannica on one previous occasion prior to the incident, and that was on 9 October 2010. There is no record of whether Fairplay 22 was used as the forward tug on that date. However, we do know that the captain of Fairplay 22 had never before made fast stern-to-bow on Stena Britannica.

Section	Comments and the Dutch Safety Board's response
2.7	*Dutch Pilotage Service* Why is the qualification of the LL captain (trainee captain) not stated? He is bound to have all kinds of qualifications and gained experience in various areas which should provide a better picture of his level. This has affected the captain's desire to demonstrate his skills. Could the Safety Board be more specific about the intensity of the manoeuvre? The manoeuvre is not something that you would do automatically and is extremely taxing if a second person is involved as well. Without the captain having the desire to demonstrate his skills, the parties involved would probably have agreed that Fairplay III would make fast as the forward tug and Fairplay 22 would make fast as the tug operating aft, or Fairplay 22's captain would have decided to make fast from bow-to-bow. *Dutch Safety's Board response* The trainee captain was additional and had been added to the crew to gain experience. He had no official role in the tug's assistance operations. The investigation was unable to establish whether his presence on board affected the captain's actions. The decision taken on the roles assigned to the tugs, however, was subject to the trainee captain's duties.
2.9 / 3	*Dutch Pilotage Service* The MAIB is a consultative body. The pilots and tug captains of all shipping companies have held consultation meetings (GOALS) for many years at which they discuss the current situation and share their experiences. Sadly, by coincidence the captain of Fairplay 22 even participated in a full day's session the week before the incident occurred and his experiences were discussed at length. *Dutch Pilotage Service* Once again, I would like to highlight the fact that GOAL sessions are held around four times a year and the meetings between tug captains and pilots that are organised twice a year. The Dutch abbreviation GOALS stands for 'Joint Consultation between all pilots and tug services (*Gemeenschappelijk Overleg Alle Loodsen en Sleepdiensten*). *Dutch Safety's Board response* The Marine Accident Investigation Branch (MAIB) conducts worldwide investigations into all types of incidents involving ships or on board ships from the United Kingdom, and all incidents involving other ships that have occurred in the territorial waters of the United Kingdom. The MAIB is not a consultative body. The Safety Board is familiar with the GOALS sessions but was unable to include these in the investigation because no reports are made of these sessions. It further emerged from the statements made by various captains that they are indeed aware of the GOALS sessions but are unaware of the subject matter discussed. The Safety Board therefore views the GOALS sessions as a good initiative but holds the opinion that all the knowledge is not shared with the industry.

Section	Comments and the Dutch Safety Board's response
2.9	*Dutch Pilotage Service* Fairplay 21 report. What happened exactly, according to the Safety Board? The big difference is that this incident did not involve assistance but a towing voyage. The Maersk ship involved in the incident had no propulsion and was jointly towed by Fairplay 21. At Breeddiep passageway the tug operating aft was advised to turn the ship to port. Instead of simply pulling the ship straight ahead the captain of Fairplay 21 then felt that he had to assist in making the turn to port, however, and therefore began sailing at full speed off the port bow. Fairplay 21 was caught up in the ebb current and was no longer able to right itself under its own steam. Fairplay 21 then keeled over and ended up alongside the Lars Maersk the wrong way around. *Dutch Safety's Board response* In the text the term 'assistance' was changed to 'towing voyage'. The text in this section is based on the investigation report prepared by Smit Shipping Company.
3	*Dutch Pilotage Service* What is missing in the whole document is the reference to the VTS radar images. The data are indeed mentioned in the reference but surprisingly the AIS information from Stena Britannica and Fairplay 22 is considered to more accurate than the VTS information. Previous investigations have already proven that VTS data are much more accurate that the information obtained via AIS (from the ship's GPS). A prime example of this is the conclusion attached to the graph showing Stena Britannica's course during the first attempt. This shows that Stena Britannica reflected yaw behaviour between 102 and 108 degrees over 10 to 15 second periods. Please allow me to point out that the ship in question with its length of 240 metres has strong directional stability. If the ship had experienced these fluctuations in reality, the captain should in any case be asked whether this was the case. In any event I believe this would be highly unlikely, and perhaps has more to do with an instrument error or the incorrect extrapolation of the recording. *Dutch Safety's Board response* This is examined in further detail in the Explanation of the Investigation in Appendix 1. Shipping-related positioning and information systems were used for the investigation. This is because they are more accurate than external sensors. While VTS and other information sources were indeed included in the investigation, they have not been incorporated in the final report. The data shown in the graphs on page 48 are as recorded by the ship's sensors. Therefore there is no question of an extrapolation error. The Safety Board also has no reason to assume that an instrument error occurred. The fact is that no deviations were found on the positioning systems or ship's sensors during the relevant voyage or during previous voyages. The Safety Board was unable to find an explanation for the extended yaw of the ship around the basic course of 104.

Section	Comments and the Dutch Safety Board's response
3	*Dutch Pilotage Service* Drift: the difference in drift between Stena Britannica (1.2 km lateral) and Fairplay 22 has not been examined. The ferry is blown over the tug as it were. We are very familiar with this phenomenon in the Swath pilot tender which has great difficulty in moving away from a car carrier ship, for instance. Dutch Pilotage Service Silo effect: a small ship like Fairplay 22 experiences a considerable opposing wind force on the lee side of a ship like Stena Britannica. The wind on the side of Stena Britannica always creates a falling and recurring fall wind on lee side. At sea the pilot vessel will therefore always take up a position near a container ship or car carrier ship with its bow turned away from the ship. The recurrent wind force in the direction of the piloted ship can then always be counterbalanced by sailing away. *Dutch Safety's Board response* The Safety Board is aware of the opposing broadside wind force on lee side. However, extremely turbulent vortices occur near the bow as a result of which the force, by definition, is not opposing. For that reason, it cannot be said that Fairplay 22 was unable to move away from Stena Britannica as a result of the opposing force of the wind.
3.3	*Dutch Pilotage Service* This conclusion is a finding at the most: A conclusion should state what the captain could in fact have done. *Dutch Safety's Board response* The Safety Board included this conclusion in the report because it is important for the investigation to find out to what extent view contributed to the occurrence of the incident.
3	*Dutch Pilotage Service* Such a manoeuvre can only be performed safely if one can focus on a fixed point. More visibility in fact is not acceptable at all and is similar to sticking to a white line on the road surface in order carefully drive a car along a curve. I am asking the tug captain members of the Safety Board whether they concur with this. *Dutch Safety's Board response* Good situational awareness requires that the captain's position provides a good view. With an unrestricted view the captain of Fairplay 22 could have maintained his fixed reference point at all times. An important reference point, namely the bulb, may possibly not have been visible to the captain.
3	*Dutch Pilotage Service* Was Fairplay's lack of stability intentionally not communicated to the crew or were the crew aware of the fact and were they correct in attributing the policy on and responsibility for this to the captain. *Dutch Safety Board's response* The Dutch Safety Board only established after the incident that sister ship Fairplay 23 failed to comply with the stability criteria applicable when the tug was built. The Dutch Safety Board therefore submitted an interim recommendation to Fairplay shipping company to establish the stability of the sister ships and to take measures to improve their stability just as for Fairplay 23. After having reviewed the report, the shipping company responded stating that the stability of Fairplay 23 does indeed comply with the criteria applicable when the tug was built.

Section	Comments and the Dutch Safety Board's response
Appendix	*Dutch Pilotage Service* Has all of this information been obtained from the Voice Data Recorder (VDR) or does the equipment go by another name? *Dutch Safety Board's response* The information contained in Appendix 5 of the report is based on data from the Voyage Data Recorder (VDR) on board Stena Britannica and the Automatic Identification System (AIS) on board Stena Britannica and Fairplay 22.
4	*MAIB* In our early analysis of the case we considered that one of the direct causes of the accident was the difficulty encountered in passing a heaving line from a high-sided ship to a low freeboard tug in strong winds (our inspectors noted that the heaving line was quite lightly weighted). We concluded that this was the reason why Fairplay 22 manoeuvred so close to Stena Britannica. We suggest that the report could consider if there were more effective ways that Stena Britannica's crew could have used to pass the heaving line, such as using a more heavily weighted line or, perhaps the use of propellants (i.e. rocket lines). *Dutch Safety Board's response* Analysing the different possibilities of passing a heaving line falls outside the scope of the investigation. The Safety Board's investigations focus specifically on identifying structural safety shortcomings and the Safety Board formulates recommendations to enable the parties involved to learn lessons. It is up to the parties themselves to implement these recommendations and take improvement measures. The Safety Board leaves this up to the parties involved because they have the most expertise in-house in order to take appropriate measures.
2.2	*Stena* In his witness statement the boatswain states that the captain had taken over the wheel between the first and second attempts. This should at least be included. *Dutch Safety Board's response* On the basis of various sources the Safety Board has established that the captain of Fairplay 22 had already taken the con before the first manoeuvre at the request of the trainee captain.
Appendix	*Stena* 4.1 STENA: add: LINE Remove the entire paragraph and replace it with: Stena Line is part of Stena AB in Gothenburg. *Dutch Safety Board's response* A similar brief description was also given of the other parties involved.

Section	Comments and the Dutch Safety Board's response
3.3	*Stena* It is unclear where the statement 'the 1.0 knot current in the opposite direction' comes from. The only information in the report has been taken from Britannica's VDR. It is important to point out that the water speed measurements in the ship's log are inexact measured values because they are Doppler measurements, which only react to layers of water. The sensor is located under the ship's bulb. The water beneath the ship is subject to vortices due to the physical conditions of the river but the largest vortices and disruptive flows are created mainly by the water around the propeller, in this case that of the tug. It should also be pointed out that in any case the speed bandwidth was 6-8 knots as stated by the captain of Fairplay 22. *Stena* In view of the above the Britannica's water speed cannot therefore be taken as the exact value and the conclusion stating that the Britannica was sailing at too high a speed is a premature conclusion. Moreover, as also stated the ship's speed was within the speed bandwidth. *Dutch Safety Board's response* The flow is not based on Stena Britannica's VDR but on the flow chart provided by the Port of Rotterdam Authority. The flow chart has been included in the report for clarification purposes and to substantiate the conclusion drawn. The bandwidth of 6-8 knots is irrelevant in this context because it was explicitly agreed that a speed of 7 knots would be maintained when making fast.
3.5	*Stena* Although the report states a first and second attempt, the heaving line was only thrown once. And this was during the second attempt. The heaving line was not thrown during the first attempt because no one was standing on the after-deck. The tug then sailed away and a second attempt was made to pass the heaving line. This failed because the heaving line was blown away. *Dutch Safety Board's response* During the investigation it emerged that contradictory statements were made about the number of times the heaving line was thrown. The investigation was unable to establish whether the heaving line was thrown once or twice. Where the report refers to an attempt, the attempt made to pass the heaving line has been expressed in general terms, including the tug manoeuvres, and not the actual attempt to throw the heaving line.
3.5	*Stena* Preparations were not made for a second heaving line because a second heaving line is never used if the first attempt fails. Throwing a second line while the first line is still floating in the water, which usually is close to the tug's propellers, can be fatal. For that reason the first line is reeled in as soon as possible and can then be re-used straight away. A second heaving line is indeed available (several in fact for mooring) but it will only be used if the first line breaks or falls over board. *Dutch Safety Board's response* If an attempt to throw a heaving line fails, it usually takes a relatively long time before it can be re-thrown. Due to the fact that an attempt to throw a heaving line is not always successful, the availability of a second heaving line will increase the likelihood of the tug being able to make fast within a short period of time. During the investigation it was found that another tug shipping company does so in practice by informing its clients that a second heaving line should be made available on ships requiring tug assistance.

Section	Comments and the Dutch Safety Board's response
3.5	*Stena* Figure 31. In the German to English translation of Fairplay's procedure, a crucial error has been made with the translation of the German term 'Geringe Fahrt' (slow speed) into English. This has been translated as 'some speed' in English indicating that in some situations a ship should sail at a reasonable speed (the same applies to figure 33 and Appendix 8). *Dutch Safety Board's response* The English and German texts in the report both cite literally from Fairplay's procedure. The Dutch Safety Board agrees with Stena and acknowledges that the use of different terms in one and the same procedure can create uncertainty about how these terms should be interpreted and what action should be taken as a result.
3.5	*Stena* What is not stated in this section is what the actual immediate cause is. Little information has been given on this. This is because the information has shown that Britannica was sailing straight ahead and the tug therefore manoeuvred too close to the ship. Speed subsequently could possibly have played a role. Why did the tug sail too close? Was it the tug captain's experience? Was the situation misjudged? Was a steering error made? The stern-to-bow training manoeuvre, which ordinarily is unusual but even more so in these circumstances, was carried out despite the circumstances. Would it not have perhaps been better not to proceed with the manoeuvre? *Dutch Safety Board's response* The very intent of an attending tug is that it manoeuvres at close quarters to the ship and that a ship requiring towage maintains a stable course and speed. The risk involved in manoeuvring at close quarters to a seagoing vessel/ship is that the tug and the ship could collide. As concluded during the investigation, speed in particular was a key factor that contributed to the occurrence of the incident. This magnified the hydrodynamic effects and restricted the possibility of the tug ability to move away. Incidentally, the Safety Board would like to point out that the trainee captain was not carrying out a training manoeuvre.
3.5	*SMIT* … another shipping company (I assume this refers to SMIT) 'added weight to the tugs to improve their stability'. On account of the fact that this is driven entirely by the level of stability (see previous comments) we wonder whether this will create an adequate level of stability. Anyway the question is whether the accident could have been prevented by adding weight to the tug. It is not worded as such but we assume that you do indeed want to make clear that there is a connection. Should this not be the case, the conclusion is irrelevant. *Dutch Safety Board's response* In its report the Dutch Safety Board has not claimed that the tug's stability would have increased sufficiently by adding weight or that this could have prevented the accident. The conclusion is relevant because it cannot be ruled out that Fairplay 22 would not have capsized if all of the watertight openings had been closed. Apart from that, the water entering the tug is likely to have accelerated the tug's capsizing, reducing the chances of the crew timely evacuating the tug.

Section	Comments and the Dutch Safety Board's response
3.5	*SMIT* Appendix 10 states that stability is tested on the basis of two sets of criteria. However, the reference for both sets is the same: 'SBG sailing freely (24-10-84) Section 3, P3.1.2 and 3.2.2) see for example pages 17 and 23 of the Appendix. This is not clear. *Dutch Safety Board's response* Two sets of stability criteria are indeed used in the SARC investigation report, namely the criteria applicable to the tug when performing towage operations and the criteria that apply when the tug is sailing freely. A sensitive analysis was also performed by increasing the vertical centre of gravity (VGC) by 0.10 metres. Page 17 states a VCG of 4,989 metres when the tug is sailing freely (empty aft peak); page 23 states a VCG of 4,989+1.10 = 5,089 metres when the tug is sailing freely (empty aft peak);
3.5	*Germanischer Lloyd* Response to paragraph: 5.5.1 Stability of Fairplay 22 Classification requirements GL Rules of Classification 1998 I -Part I, Chapter 1, Section 25 Tugs, A General: 4. Supplementary to the provisions of Section 1, E for tugs assisting in ports intact stability shall be provided, which shows at least the following values: GM = 0.60 m h 30° = 0.30 m Range = 60° Comment: These criteria have been set up to ensure a certain hull form of the tug. Thus unprotected openings are not to be considered when checking the range of positive stability. Statutory relevant criteria - International Convention on Load Lines 1966/88 - See*BG, Bekanntmachung über die Anwendung der Stabilitätsvorschriften für Frachtschiffe, Fahrgastschiffe und Sonderfahrzeuge* dated 24 October 1984. Remarks: during the design phase, the class and statutory relevant stability criteria were checked and complied with the said standards. The statutory requirements have been examined by GL as consultancy service for German flag state administration. The four (4) engine room ventilation openings (see initial survey on load lines) V9 and V10 are fitted with a permanently attached weather-tight steel cover with 2 hinges and 4/6 toggles each. For the stability calculations and the righting lever curve weather-tight openings need not to be considered. Only unprotected openings limit the righting lever curve. Furthermore another seven (7) ventilation openings serving the engine room were fitted in addition to V9 and V10. Due to their heights, these are located at positions which do not have an influence on the stability requirements. Therefore, the stability criteria were complied with during the design phase (1998). No retroactive statutory requirements were set up for tugs.

Section	Comments and the Dutch Safety Board's response
	Dutch Safety Board's response The Dutch Safety Board disagrees with this response because all of the generally accepted definitions for the level of stability use water entering non-weather-tight (unprotected) openings as the limit. Moreover the SBG criteria applied to the stability of Fairplay 22, and not the GL criteria, which did indeed use the 60-degree level in the standard interpretation of 'no water entering any non-weathertight openings in this range'. According to the Load line Convention non-weathertight (unprotected) openings should at least be 2.30 metres above deck. This was not the case with Fairplay 22. The openings must therefore be closed during towage operations. However, the vessel can then no longer provide the certified bollard pull. Openings V9 and V10 are only weathertight when the openings are closed. If this is not the case, these openings will limit the stability of the tug. This already happens when the tug heels at an angle of 35 degrees, which means that the A40 and A40-A30 SBG criteria cannot be met if the openings are open. The SBG criteria in fact specify the non-weathertight (unprotected) openings as the break-off stability criteria.
3.4	*Fairplay* 'clients also regularly asked': not correct; clients never asked, supposedly because it is not compulsory for vessels <500GT; that contributed to our decision to stop the voluntary certification. *Dutch Safety Board's response* During the investigation Fairplay stated in writing that the shipping company's offshore clients always asked for ISM certificates, even though the tugs were not required to comply with ISM requirements.
3.5	*Fairplay* The bareboat charterer did not modify the engine room vents. *Dutch Safety Board's response* The Dutch Safety Board has included the charterer's remark about adjusting the stability of the sister ship of Fairplay 22 to show that not everyone considers Fairplay 22's initial level of stability as adequate. This should have prompted Fairplay to investigate the stability of Fairplay 22 and its sister tugs.
3.8	*Fairplay* About the meeting 'to analyse the events': this meeting was not suggested by Stena, but by Fairplay. Contrary to the draft report, a meeting indeed took place. A subsequent meeting was cancelled by Stena. *Dutch Safety Board's response* The statements made by Stena and Fairplay regarding the meeting are contradictory. The Safety Board has included this in the report as follows: 'After the incident Fairplay and Stena proposed holding a meeting to evaluate the events. The statements made by Stena and Fairplay regarding the meeting are contradictory. It is clear, however, that a further evaluation did not take place for reasons of legal liability that may possibly come into play.'

Section	Comments and the Dutch Safety Board's response
3.5	*Fairplay* About 'chartered': the charter was (and still is) a bareboat charter, this means that FP21 is crewed, operated and maintained by Smit. *Dutch Safety Board's response* The Dutch Safety Board has included the charterer's remark about adjusting the stability of Fairplay 21 to show that not everyone considers Fairplay 22's initial level of stability as adequate. In terms of ensuring proper safety management, this should have prompted Fairplay to investigate the stability of Fairplay 22 and its sister tugs.
3.8	*Port of Rotterdam Harbour Master* Lines 10 and 11 of page 69, state that in the internal report of the SAR operation the Port of Rotterdam did not further examine PEC holder policy. This is correct and was also not the intent of the internal report. The sole purpose of the internal report was to evaluate the SAR operation. I would like to stress that I will take the conclusions in the draft and final versions of your report seriously. As part of the 'New Style of Compulsory Pilotage', Pilot Exemption Certificates (PECs) and the attached conditions will too be scrutinised. Lastly, I would like to inform you that in anticipation of publication of the final report I have already spoken to Stena about taking measures to ensure that tugs are deployed safely. Perhaps superfluously, I would like to point out that I consulted with the Dutch Safety Board in advance about whether there would be any objection to our contacting Stena. *Dutch Safety Board's response* The response did not result in any changes to the report. The Dutch Safety Board acknowledges and approves of the fact that the Port of Rotterdam Harbour Master will take the measures described to improve safety.

APPENDIX 3: REFERENCE FRAMEWORK

Introduction

This chapter describes the reference framework according to which the Dutch Safety Board assesses its findings. Dutch Safety Board investigations are based on current legislation as well as other relevant standards and guidelines. The Safety Board also uses a reference framework to determine how the parties involved fulfil their safety management responsibilities.

The reference framework consists of four parts. The first part describes the laws and regulations relevant to this investigation. The second part describes the prevailing guidelines and best practices. The third part describes the safety management of the shipping companies relevant to this investigation, namely Fairplay and Stena. The final part describes the Dutch Safety Board's expectations regarding the approach adopted by the parties in fulfilling their safety management responsibilities.

Laws and regulations

International

International Convention on Load Lines (LL)
The LL Convention was drawn up in England in 1930, was later amended and subsequently adopted by the International Maritime Organization (IMO) in 1966. The Convention specifies requirements for freeboard, based on the reserve buoyancy of a ship and its watertight integrity.

International Convention for the Safety of Life at Sea (SOLAS)
The SOLAS Convention is an international treaty addressing maritime safety. The first version was adopted in 1914, in response to the Titanic disaster. The International Maritime Organization (IMO) adopted SOLAS in 1960. The Convention has since been revised and supplemented on many occasions, and specifies requirements for seagoing vessels relating to construction, crew, and safety, communication and other equipment. The Convention also incorporates ship stability criteria.

International Safety Management (ISM) Code
The ISM Code is an international standard for safety management on board ships. Shipping companies and ships are both required to employ a safety management system containing amongst others procedures for on-board operations, training, maintenance, evacuation, incident reporting and audits. The system should also include the responsibilities and tasks of the shipping company and the crew. A number of ships have been exempted from the requirements of the ISM Code.

The SOLAS Convention stipulates that both a shipping company and its ships are required to comply with the obligations set out in the Code. Periodic audits are required to verify whether this is the case. A shipping company must hold a Document of Compliance (DoC), which is valid for five years and states that the shipping company complies with the obligations stipulated in the ISM Code. Each ship that is required to comply with the obligations stipulated in the Code must carry a Safety Management Certificate (SMC) on board. The Certificate is valid for five years and is issued if the safety management system on board the ship complies with the Code's standards. An initial audit and subsequent periodic audits are performed to verify whether the shipping company and the ship comply with the ISM Code. Interim audits may be called for, if necessary. The audits are performed by the flag state or by a recognised classification society. In the latter case, the flag state is responsible for verification.

The ISM Code entered into force in 1998 for passenger vessels and tankers. Since 2002, the ISM Code became mandatory for all ships > 500 GT. Fishing and cargo vessels including tugs under 500 GT do not need to comply with the requirements of the ISM Code.

International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)
The STCW Convention was adopted by the International Maritime Organization (IMO) in 1978 and entered into force in 1984. The Convention specifies basic standards for training, certification and watchkeeping for ships' crews. The Convention was amended in 1995 and in 2010. The latest amended version will enter into force in 2012.

The LL, SOLAS and STCW Conventions were ratified by Antigua and Barbuda, and the United Kingdom – the flag states of both vessels. This means that the ships sailing under the flag of these nations are required to comply with the obligations set out in the above Conventions.

National

Shipping Traffic Act (Scheepvaartverkeerswet, SVW)
The SVW contains general rules for the safe and smooth passage of shipping traffic.
The SVW regulates aspects, such as the following:

- the safety and flow of shipping traffic;
- the upkeep and maintenance of waterways;
- preventing or limiting damage to riverbanks/shores, dykes, bridges and suchlike caused by shipping traffic; and
- preventing or reducing pollution caused by shipping traffic.

Inland Waterways Police Regulation (BPR)
The Inland Waterways Police Regulation (*Binnenvaartpolitiereglement*, BPR) elaborates on the Shipping Traffic Act (SVW). The BPR contains the traffic rules governing the Dutch inland waterways, including the Nieuwe Waterweg. The areas covered include traffic signs, the use of radar or VHF and nautical right-of-way and give-way rules. The BPR stipulates that the captain is responsible for compliance with the BPR provisions unless the provisions state that other parties are charged with compliance. The BPR also stipulates - even in the absence of specific regulations in the BPR - that the captain is required to take all necessary precautionary measures to prevent the following:

a. endangering people's lives;
b. damage being caused to other ships, floating objects, banks/shores, etc;
c. endangering the safety or smooth passage of shipping traffic.

Compulsory Pilotage Decree (Loodsplichtbesluit)
In the Netherlands compulsory pilotage applies to certain categories of seagoing vessels and ships carrying hazardous materials. A number of amendments entered into force in 1995, including relaxing the rules for certain categories of smaller seagoing vessels. Furthermore, more options for obtaining a Pilot Exemption Certificate (PEC) became available to captains and officers in 1995.

In the port of Rotterdam compulsory pilotage is in force. This means that it is mandatory for certain seagoing vessels to have a pilot on board when entering and leaving the port and when mooring. Captains may obtain a Pilot Exemption Certificate (PEC) from the Port of Rotterdam Harbour Master. The requirements for obtaining a PEC are described in the Decree Declaration Holders Maritime Traffic Act (*Besluit verklaringhouders Scheepvaartverkeerswet)*.

The Port of Rotterdam Harbour Master may require additional education or training on the issue of a PEC or impose restrictions. Training is provided by the Regional Pilot Corporation (*Regionale Loodsencoöperatie*).[47]

47 Information guide published by the Port of Rotterdam Authority and the Ministry of Infrastructure and the Environment: Loodsplicht Rotterdam Rijnmond, Pilot Exemption Certificate (PEC)

Working Conditions Act
The Working Conditions Act (*Arbeidsomstandighedenwet*) applies to all organisations that employ staff and regulates the improvement of working conditions, the aim of which is to promote employee health, safety and welfare. The Act focuses on both the employer and the employee.

Employers are required to ensure work-related health and safety of their employees and are therefore obliged to implement a policy aimed at achieving the best possible working conditions. Work may not have any negative effect on employee health and safety, the dangers and risks facing employees are required to be prevented or limited as far as possible and effective measures must be taken in the event of accidents, fire and evacuation. Employers are required to set out the risks in a written hazard identification and analysis (Dutch: Risico-Inventarisatie en –Evaluatie, RI&E), including the dangers and risk-mitigation measures. Employers must ensure that the work to be carried out and the related risks are effectively communicated to employees. Employees also have a right to effective training tailored to their distinct tasks.

Employees are obliged to take due care in relation to the work and to do their best, in line with their education/training and the instructions given by the employer, to ensure their own health and safety and that of other persons.

Placement of Personnel by Intermediaries Act (Waadi)
The Waadi requires the organisation supplying the employees to provide information on the required professional qualifications. Furthermore, before the start of the activities, the appointed employees must be provided with the description from the hazard identification and analysis of the dangers en mitigating measures and of the employee risks at the work location.

Guidelines and best practices

European Harbour Masters' Committee (EHMC)
On 4 November 2009, in collaboration with parties such as captains of seagoing vessels and tugs, shipping agents, pilots, harbour masters, terminal operators and hydrographic services, the EHMC produced a DVD,[48] containing a film featuring the activities performed by the various harbour parties. The aim of the film is to improve collaboration in the harbour chain by providing the parties involved with a better understanding of operations by sharing best practices and expanding knowledge. As best practice, the DVD recommends that a towage connection is made at a speed not exceeding 6 knots. Although it is common practice to refer to speed through the water, this is not explicitly stated on the DVD.

Maximum speed Antwerp
The Antwerp Port Authority guideline stipulates that when establishing a towage connection between a tug and a ship requiring tug assistance, the speed through the water should not exceed 6 knots. Investigations had revealed that forward tugs were making fast at increasingly higher speeds (speeds of up to 10 knots), as a result of which they did not have enough reserve power to allow them to manoeuvre out of an emergency situation.

Marine Guidance Note (MGN) 199
In 2002 the Maritime and Coastguard Agency in the United Kingdom circulated MGN 199 to shipping companies, captains, pilots and tug captains. The MGN highlights the impact of interaction effects, including the hydrodynamic effects, on ship manoeuvrability and describes several incidents and hazards. Figure 37 quotes some passages from the MGN describing the danger of manoeuvring at close quarters. The full text can be found in Appendix 7.

48 European Harbour Masters' Committee, The Chain. Awareness and best practices in the nautical chain.

MANOEUVRING AT CLOSE QUARTERS When vessels are manoeuvring at close quarters for operational reasons, the greatest potential danger exists when there is a large difference in size between the two vessels and is most commonly experienced when a vessel is being attended by a tug. A dangerous situation is most likely when the tug, having been manoeuvring alongside the vessel, moves ahead to the bow to pass or take a tow-line.
…
A further effect of interaction arises from the flow around the larger vessel acting on the underbody of the smaller vessel causing a consequent decrease in effective stability, and thus increasing the likelihood of capsize if the vessels come into contact with each other. Since it has been found that the strength of hydrodynamic interaction varies approximately as the square of the speed, this type of manoeuvre should always be carried out at very slow speed.

Figure 37: Quote from the MGN 199 [source: Maritime and Coastguard Agency, United Kingdom].

Safety management - parties involved

Fairplay
Fairplay[49] holds ISM certification as well as a Document of Compliance (DoC). A number of Fairplay's ships, including Fairplay 22, are under 500 GT and therefore do not need to comply with the obligations of the ISM Code. For that reason, these ships do not need to carry a Safety Management Certificate (SMC).

Although Fairplay 22 is not required to comply with the obligations stipulated in the ISM Code, the tug did hold an SMC until 2009. Fairplay 22's sister ships voluntarily carried ISM certification up to that year. The shipping company felt this was important because these tugs often performed activities at sea. Clients also regularly asked Fairplay whether its tugs carried an SMC. Since the autumn of 2009, Fairplay 22 was only deployed in the port of Rotterdam. The shipping company then decided to end the voluntary ISM certification of Fairplay 22, in part because of the administrative burden for its crew resulting from certification.

Fairplay sets out its safety objectives in the Health, Safety, Quality and Environmental Protection Manual (HSE-Q Manual). The document describes aspects such as the responsibilities of the shipping company's management, those of the captain and crew, the HSE-Q objective and the procedures for monitoring, analysing and improving the safety management system.

Stena
Stena has an ISM-certified safety management system and holds a DoC. Stena Britannica carried a valid (Interim) SMC.

The Safety Management Manual (SMM) contains a description of the shipping company's safety management system. The SMM also contains the shipping company's safety management objectives, the shipping company's policy, the responsibilities of management, quayside staff, captain and crew, the operating procedures, and the maintenance, incident-reporting and on-board documentation procedures.

49 The certificate holder is Fairplay Schleppdampfschiffs-Reederei Richard Borchard GmbH.

Safety management – Safety Board

In the past, the structure and implementation of safety management systems have proven to play a crucial role in the management and continuous improvement of safety. This applies to all organisations, both private and public, which are either actively or more remotely involved in activities which may expose Dutch citizens to risks.

In principle, the way an organisation complies with its responsibility to ensure safety is reviewed and evaluated from different perspectives. This means that no universal handbook for all situations exists. The Safety Board has selected the following five areas of focus, which require concrete measures in all situations and which can therefore be used for assessment purposes The safety areas selected by the Safety Board are based on national and international laws and regulations and a large number of widely accepted and implemented standards.

The five distinct safety priorities are set out below:

1. Identification of risks as the basis of the safety regime;
2. Concrete and realistic safety regime;
3. Implementation and enforcement of the safety regime;
4. Further upgrading of the safety regime; and
5. Management control, involvement and communication.

Appendix 9 provides further information on the above safety priorities.

The Safety Board acknowledges that the assessment of the way in which organisations actually comply with their responsibility with regard to safety is very much dependent on the organisations themselves. Aspects such as the nature of the organisation and its size can be important considerations and should therefore be included in the assessment. Although the final assessment may be different from case to case, the logical processes are identical.

APPENDIX 4: PARTIES INVOLVED AND THEIR RESPONSIBILITIES

Stena

Stena Sphere in Gothenburg, Sweden, consists of three companies, Stena AB[50], Stena Sessan AB and Stena Metal AB, wholly-owned by the Swedish Sten A. Olsson family. Stena Sphere's activities are organised in seven business areas: Ferry Lines, Offshore Drilling, Shipping, Property, Finance, Adactum (investments) and Recycling, Environmental Services and Trading. Stena Line, one of the world's largest ferry companies, forms part of Stena AB.

Stena Line operates in three geographical business areas: Scandinavia, North Sea and Irish Sea. The route network consists of 18 strategically located ferry routes in Scandinavia and around the UK operated by a fleet of 35 vessels that sail under the flag of various states. Stena Line operates Harwich-Hook of Holland route with Stena Britannica and Stena Hollandica, which were both put into service in 2010.

Stena made verbal agreements with Fairplay to assist Stena Ro/Ro passenger vessels at the Hook of Holland terminal, based on the Dutch Towage Conditions 1951. The price agreements are described in a written contract. No written agreement was set up regarding safety.

Captain
Pursuant to the Inland Waterways Police Regulations (*Binnenvaartpolitiereglement,* BPR), in force on the Nieuwe Waterweg, the captain is responsible for the safety of passengers and crew and is required to take all necessary precautions to prevent a collision.

The captains are allowed to decide themselves whether or not they make use of tug assistance. If Stena captains want to use tug assistance, they can address their request directly to Fairplay.

Fairplay

Fairplay Schleppdampfschiffs-Reederei Richard Borchard GmbH[51] in Hamburg, Germany, owns 12 companies that are mainly engaged in towage, including deep-sea towage and salvage work. The company also owns a shipyard and a real estate company.

The towage companies are based in Germany, Poland and the Netherlands. In addition, the company owns 50% of a towage company in Belgium. Its fleet consists of various types of tugs that sail under the flags of various states.

Fairplay Towage BV Rotterdam (Fairplay) operates a range of tug types in and from the port of Rotterdam. Fairplay 22, as well as its sister ships Fairplay 23 and Fairplay XII, sail under the flag of Antigua and Barbuda. Fairplay III sails under the Dutch flag. The tug crews have different nationalities. The crews are supplied by Project Żegluga in Szczecin, a Polish towage company owned by Fairplay – and by Transport & Offshore Services (TOS), a temporary employment agency based in Rotterdam.

Pursuant to the Working Conditions Act (*Arbeidsomstandighedenwet*), when hiring temporary staff Fairplay is obliged to inform the temporary employment agency and the temporary employee about the work, the risks involved and safety measures.

Fairplay has made verbal agreements with Stena about the deployment of tugs, including the finances, the availability and power of the tugs to be supplied.

50 AB = Aktiebolaget. Swedish name for a private limited company (*besloten vennootschap* or BV in Dutch).
51 GmbH stands for *Gesellschaft mit beschränkter Haftung*. This is the German name for a private limited company (*besloten vennootschap* or BV in Dutch).

Fairplay is a member of the European Tugowners Association (ETA), an organisation that represents the of European tugowners and –operators. Most of the larger tugowners, including Smit, are members of ETA.

Captain
Pursuant to the Inland Waterways Police Regulations (*Binnenvaartpolitiereglement,* BPR*)*, the captain is responsible for the safe carriage of passengers and crew and is required to take all necessary precautions to prevent a collision.

Routine on board Fairplay 22
When assisting ships, the routine performed by the permanent crew on board Fairplay 22 is usually as follows: the captain on the bridge manoeuvres the ship, the chief engineer operates the winch with the towing line (either forward or aft), and the able seaman on deck takes the heaving line and connects the messenger line to it. The able seaman always wears a life jacket and a helmet when performing these activities. After connecting the heaving line, the messenger line and the towing line are taken on board the ship requiring assistance, whose crew connects the towing line. Thereafter, towage assistance can be provided to the ship. The able seaman is responsible for closing the door leading to the aft deck.

Temporary employment agency - Transport & Offshore Services

Transport & Offshore Services (TOS) is an international supplier of nautical and technical personnel and holds certification, including ISO certification (9001:2008). Personnel can be supplied on a range of bases. TOS supplies ad hoc personnel or personnel on a project basis. Long term personnel is supplied on a secondment basis. TOS's head office is based in Rotterdam.

The captain of Fairplay 22 had been seconded on a long-term basis by TOS to Fairplay. TOS was responsible for paying his salary, including making the payroll deductions (social security contributions). TOS continued to act in the capacity of the employer and all TOS employees were subject to Dutch legislation.

Pursuant to the Working Conditions Act, TOS is responsible for providing information on workplace-related risks to its temporary staff based on the hazard identification and analysis[52] provided by the company hiring the staff, in this case Fairplay.

TOS is associated member of the European Tugowners Association (ETA).

Port of Rotterdam Authority

The Port of Rotterdam Authority manages, operates and develops the port of Rotterdam and industrial area. The Port Authority is a public limited company under Dutch law (*naamloze vennootschap*, NV) with two shareholders: the municipality of Rotterdam and the State of the Netherlands. The Port Authority's activities involve the following:

- the development, construction, management and operation of the port and industrial area in Rotterdam; and
- promoting the effective, safe and efficient handling of shipping in the port of Rotterdam and the offshore approaches to the port.

52 The website of the Ministry of Social Affairs and Employment states the following: "The employer must inform the temporary employment agency timely of the special risks inherent to the employee's activities through the mandatory hazard identification and analysis. This information includes physical or mental strain, the use of hazardous substances, and obligatory personal protective equipment for a temporary employee. The temporary employment agency must ensure that the temporary employee receives the information provided by the employer."

Port of Rotterdam Harbour Master
The Port of Rotterdam Harbour Master, employed by the Port of Rotterdam Authority, is responsible for the quick, clean, safe and secure shipping in the port of Rotterdam. He carries out a large number of nautical government tasks on behalf of the Dutch government and the municipality of Rotterdam. The Port of Rotterdam Harbour Authority Covenant, which was concluded between the Dutch government, the municipality of Rotterdam, the Port of Rotterdam Authority and the Port of Rotterdam Harbour Master, states that although the Port of Rotterdam Harbour Master is employed by the Port of Rotterdam Authority, the execution of his government tasks is not subject to supervision by the board of the Port of Rotterdam Authority. The supervision of the execution of government tasks is carried out by the managing body which delegated these tasks to the Port of Rotterdam Harbour Master. With regard to the Pilot Exemption Certificates, the Port of Rotterdam Harbour Master is supervised by the Minister for Infrastructure and the Environment.

Pilot Exemption Certificate (PEC)
The Port of Rotterdam Authority – in this case the State harbour master for Rotterdam – issues a PEC in consultation with the Regional Pilots' Corporation. The Port Authority is also responsible for the supervision of the PEC's. The crew working on board ships exceeding 130 metres in length may need to undergo additional training in the following areas:

- releasing/connecting tugs in general, including those on the Nieuwe Waterweg (as well as for
- Europoort);
- specific communication with tug captains or manoeuvring with tug assistance;
- specific communication with VTS operators, pilots and patrol vessels; and
- berthing and unberthing procedures in the dock/in the harbour basin/on the river.

In its response to the draft version of this report, the Dutch Pilotage Service indicated that the additional training also covers how to handle the various types of tugs in the port of Rotterdam.

Antigua and Barbuda

Following its independence from the United Kingdom in 1981, Antigua and Barbuda became a member of the International Maritime Organization (IMO) in 1986.

The Antigua and Barbuda Merchant Shipping Act 2006, which was amended in 2007, offers ships operated by international companies the opportunity to register with the flag of Antigua and Barbuda under certain conditions.[53] The Act includes the tax advantages[54] that apply to registration in Antigua and Barbuda. Fairplay has registered several ships in its fleet under the flag of Antigua and Barbuda, including Fairplay 22.

The Antigua and Barbuda Department of Marine Services and Merchant Shipping (ADOMS), which is responsible for merchant shipping matters and ship registration on behalf of the minister, registers, certifies and inspects ships.
This is set out in the Antigua and Barbuda Merchant Shipping Act referred to above. ADOMS also carries out accident investigation. This is performed by its Inspection and Investigation Division. ADOMS has two offices in Germany.

53 The Antigua and Barbuda Shipping Act 2006, Part III, Chapter 1, Section 11 (1-4).
54 The Antigua and Barbuda Shipping Act 2006, Part III, Chapter 1, Section 11 (5).

United Kingdom

The United Kingdom has been a member of the International Maritime Organization (IMO) since 1949. The Department of Transport in England has a separate department, the Marine Accident Investigation Branch (MAIB), which performs worldwide investigations into all types of casualties involving ships or on board ships from the United Kingdom, and all casualties involving other ships that have occurred in the United Kingdom territorial waters.

The MAIB performs its work on the basis of the Merchant Shipping Act 1995 and the Merchant Shipping (Accident Reporting and Investigation) Regulations 2005.

Germanischer Lloyd Group classification society (GL)

Sailing permission is granted by the flag state. In order to obtain permission, a ship is required to hold certification from a recognised classification society in respect of its construction, design and equipment. Fairplay 22 held certificates from Germanischer Lloyd Group classification society (GL). Classification societies set out requirements and rules for ship design, construction and surveys. The major classification societies (around 94% of the world fleet) are members of the International Association of Classification Societies (IACS). IACS' members are obliged to comply with the IACS Quality System Certification Scheme. GL holds IACS membership and has three business lines: the Classification Society, Oil and Gas Industry Services and Sustainable Wind Energy Services.

See-Berufsgenossenschaft (SBG)

Germany has largely transferred the implementation of international Conventions relating to maritime safety and the environment to the Ship Safety Division of the former See-Berufsgenossenschaft (SBG). Since SBG's merger with other Berufsgenossenschaften, this is now carried out by Dienststelle Schiffssicherheit, the Ship Safety Division of Berufsgenossenschaft Verkehr (BG Verkehr), which has the status of a German federal authority under the Ministry of Transport.

The Dienststelle Schiffssicherheit's responsibilities include the following:

- approving the design of life-saving equipment and the actual equipment itself, fire safety, engine room installations and environmental protection systems;
- inspecting the design of a ship in respect of stability and freeboard;
- carrying out initial and renewal ship surveys;
- assessing safety management systems (on the basis of the ISM Code); and
- examining lifeboat and fire-fighting crew.

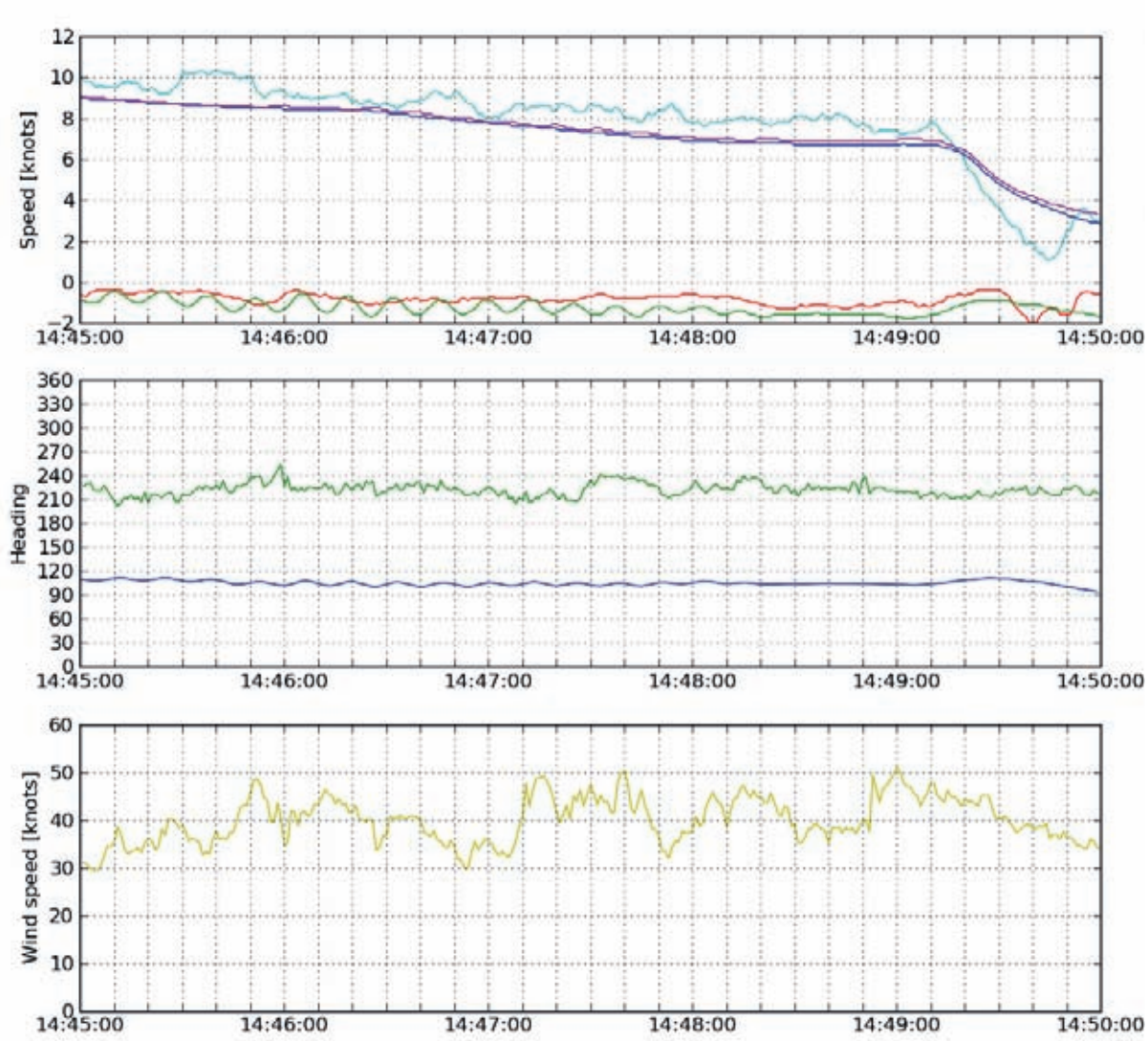
Dienststelle Schiffssicherheit at BG Verkehr is similar to the Transport, Public Works and Water Management Inspectorate in the Netherlands (*Inspectie Verkeer en Waterstaat*, IVW).

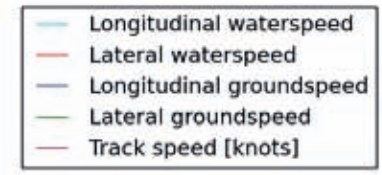
Transport, Public Works and Water Management Inspectorate

Internationally operating seagoing vessels are required to comply with international laws and regulations. The supervision is primarily the task of the ship's flag state. The port state is also allowed to supervise the compliance with these laws and regulations, this is known as Port State Control (PSC). In the Netherlands, PSC falls under the Transport, Public Works and Water Management Inspectorate, department of Shipping. PSC inspections are performed pursuant to the Port State Control Act (*Wet Havenstaatcontrole*), which is based on European Council Directive 95/21.

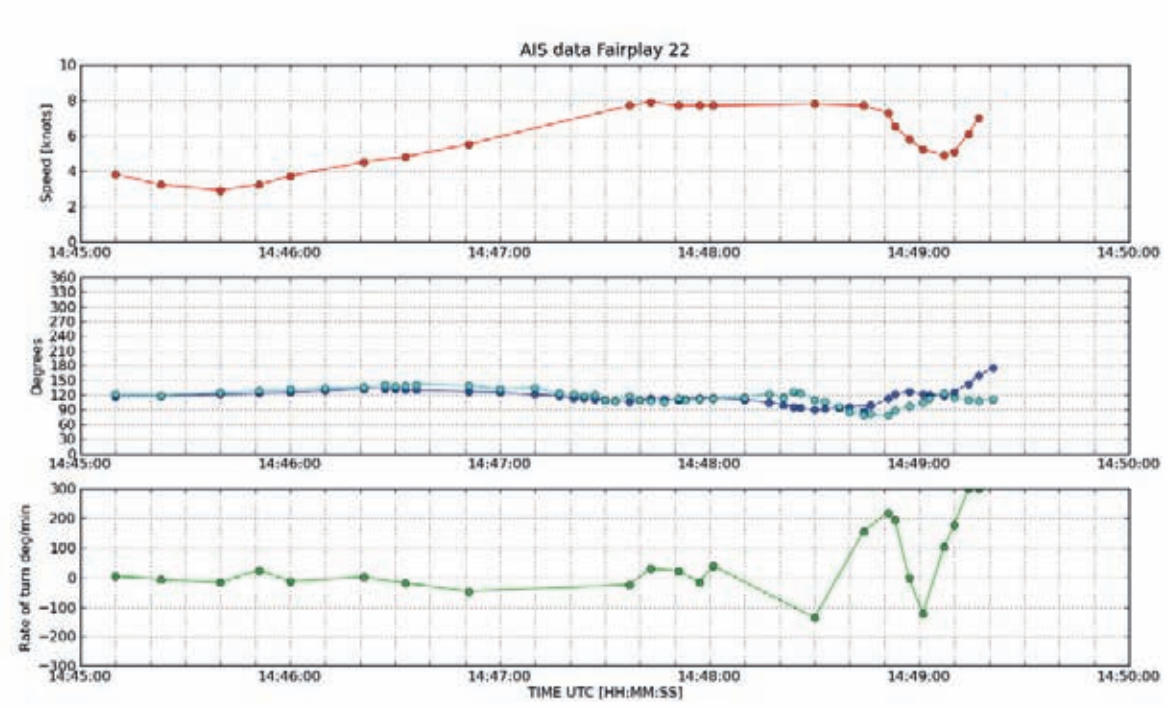
APPENDIX 5: DIGITAL DATA RELATING TO STENA BRITANNICA AND FAIRPLAY 22

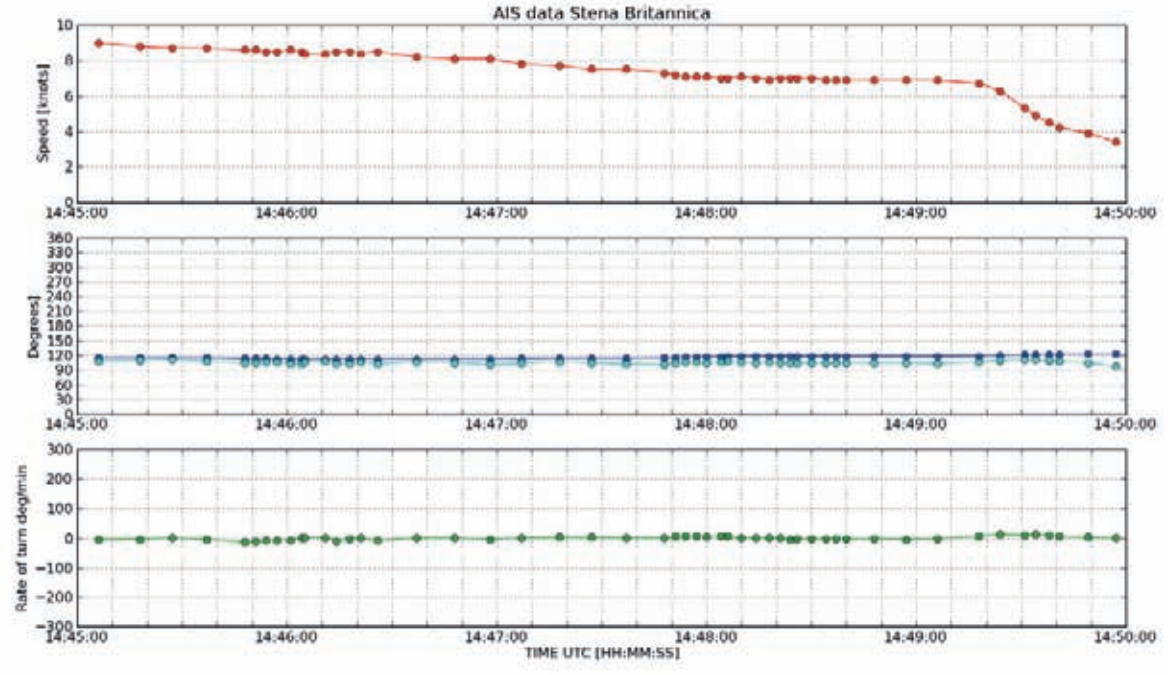
Data obtained from the Voyage Data Recorder (VDR) on board Stena Britannica. The times are Universal Coordinated Time (UTC); local time is UTC+1.





Automatic Identification System (AIS) data transmitted by Stena Britannica and Fairplay 22. The times are Universal Coordinated Time (UTC); local time is UTC+1.





Ground speed
Course over ground
Heading
Rate of turn

APPENDIX 6: SMIT SAFETY FLASH ISSUED FOLLOWING THE SMIT POLEN ACCIDENT

SHE-Q SAFETY FLASH

No. 35 (Januari, 2011)

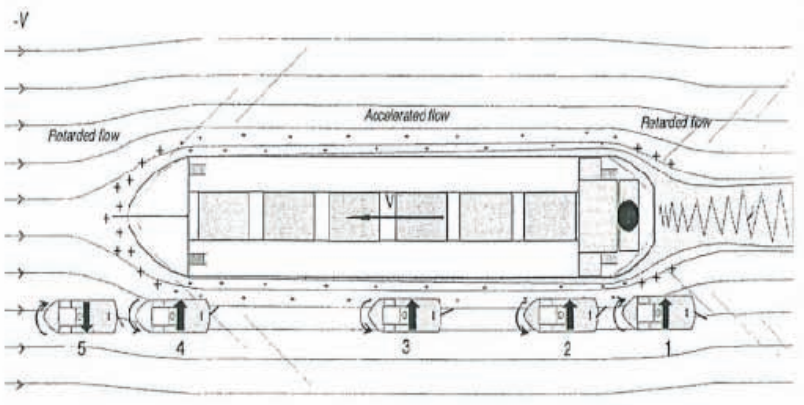
AANVARING MET SLAGZIJ TOT GEVOLG

Op 13 januari krijgt de SMIT Polen een werkopdracht om een container schip als voorboot op de rivier te assisteren. Tijdens het vast maken als voorboot is de bulb steven van het containerschip in aanvaring gekomen met het stuurboord achterschip van de SMIT Polen. SMIT Polen valt dwars in de vaarrichting van het container schip. Hierdoor maakt de SMIT Polen een sterke slagzij 80-90 graden over bakboord. Doordat alle waterdichte deuren en luiken gesloten zijn komt de SMIT Polen direct terug op gelijke kiel. Persoonlijke ongevallen zijn uitgebleven.

Note: Dit betreft het derde extreem ernstige incident waarbij voorboten zijn betrokken op de rivier de Maas binnen 6 maanden.

Aanbevelingen

- Alle waterdichte deuren en luiken tijdens assistentie gesloten.
- Buiten de PBM ook werkzwemvesten dragen aan dek tijdens assistentie.
- Houd rekening tijdens vastmaken met venturi werking (zie afbeelding 1).
- Onderhoud goede communicatie met loods tijdens de assistentie
- **Operations Managers,** bespreek deze situatie en het bijgevoegde SVMS Lessons learnt No.10 (juni, 2010) met kapiteins en bemanning.



Afbeelding 1.

Er is een intern een onderzoek gaande. Nadere aanbevelingen worden t.z.t. verspreid over de vloot.

Safety, Health Environment & Quality

APPENDIX 7: EXTRACT FROM MARINE GUIDANCE NOTE (MGN) 199

The text below is an extract from MGN 199 issued by the Maritime and Coastguard Agency in the United Kingdom. The MGN was sent to shipping companies, captains, pilots and tug captains in 2002.

MANOEUVRING AT CLOSE QUARTERS When vessels are manoeuvring at close quarters for operational reasons, the greatest potential danger exists when there is a large difference in size between the two vessels and is most commonly experienced when a vessel is being attended by a tug. A dangerous situation is most likely when the tug, having been manoeuvring alongside the vessel, moves ahead to the bow to pass or take a tow-line. Due to changes in drag effect, especially in shallow water, the tug has first to exert appreciably more ahead power than she would use in open water to maintain the same speed and this effect is strongest when she is off the shoulder. At that point hydrodynamic forces also tend to deflect the tug's bow away from the vessel and attract her stern; but as she draws ahead the reverse occurs, the stern being strongly repulsed, and the increased drag largely disappears. There is thus a strong tendency to develop a sheer towards the vessel, and unless the helm (which will have been put towards the vessel to counter the previous effect) is immediately reversed and engine revolutions rapidly reduced, the tug may well drive herself under the vessel's bow. A further effect of interaction arises from the flow around the larger vessel acting on the underbody of the smaller vessel causing a consequent decrease in effective stability, and thus increasing the likelihood of capsize if the vessels come into contact with each other. Since it has been found that the strength of hydrodynamic interaction varies approximately as the square of the speed, this type of manoeuvre should always be carried out at very slow speed. If vessels of dissimilar size are to work in close company at any higher speeds then it is essential that the smaller one keeps clear of the hazardous area off the other's bow.

APPENDIX 8: EXTRACT FROM FAIRPLAY'S TUG ASSISTANCE PROCEDURE

The text below is an extract from Fairplay shipping company's harbour assistance procedure.

Verschlußzustand Der uneingeschränkte Verschlußzustand auf dem Schlepper ist ständig einzuhalten. Während des Schleppens sind alle wasser`dichten Türen/Luken sicher geschlossen zu halten. An jeder dieser Öffnungen ist ein Hinweis anzubringen: "Während des Schleppens unbedingt geschlossen halten!"	*Watertight Integrity* The watertight integrity of the tug shall be maintained at all times. When the tug is engaged in towage operations all watertight openings shall be securely fastened. All watertight openings shall be marked with a sign stating that they have to remain closed during towage operations
Sichere Geschwindigkeit: Geringe Fahrt in bestimmten Situationen Für Schlepper sind bei Übernahme der Leine etwa 6 kn durch das Wasser eine günstige Geschwindigkeit. Dies ermöglicht ihnen, nahe an das Schiff zu manövrieren und noch genügend Rückwärtsleistung für gefährliche Situationen zu haben. Während die Schlepper sich in Position zur Übernahme der Leine manövrieren, soll die Schiffsgeschwindigkeit konstant sein. Falls der Lotse zur Aufrechterhaltung der Steuerfähigkeit die Geschwindigkeit ändern will, muss er die Schlepper vorher darüber informieren	*Safe Speed: Some speed is required at times* When taking up the tow line, the tugs like to have about 6 knots through the water. This gives them the necessary way to assist them to manoeuvre close to the ship while it gives them plenty of power in reverse should they have to break away. As the tugs try to balance themselves in a position to pass the towline they are looking for a steady speed. If the pilot requires to change the speed, e.g. to maintain steerage way, he must tell the tugs of his intentions before ordering a change to the engine speed.
Der vordere Schlepper ist bei der Übergabe der Leine besonders gefährdet. Er muss sich sehr dicht unter den Bug manövrieren, manchmal mit weniger als 1m Abstand. Der Schlepperkapitän hat auf einen Wulstbug, andere hervorstehende Unterwasserteile, Bugüberhang (Containerschiffe!) etc. des Schiffes besonders zu achten. Gleichzeitig muss er den Druck der Bugwelle beachten. Kursänderungen sind während der Leinenübergabe zu vermeiden.	The forward tug is especially vulnerable when passing up the tow line. This tug has to position itself very close under the bow, sometimes under 1 metre from the ships waterplane. The Tugmaster will be concerned about any bulbous bow or other underwater protrusion, the proximity of the flare of the bow and other odd bits sticking out (especially that some container ships seem to have up forward). At the same time he is fighting down the hydraulic pressure wave that exists around the bow. Alterations of course shall also be avoided whilst connecting the tow.

APPENDIX 9: EXPLANATORY NOTES ON SAFETY MANAGEMENT FROM THE DUTCH SAFETY BOARD

The safety management system's structure and content play a crucial role in being able to demonstrate the proper control and continuous improvement of safety. This applies to all organisations that are actively or more remotely involved in activities which may expose Dutch citizens to risk. These are organisations of varying types and sizes, which have different roles and responsibilities, such as Ministries, provincial authorities, municipalities, and private companies. The requirements that apply to setting up and adding content to a safety management system in a specific area of investigation are directly dependent on the context. This context is determined by factors such as the nature, size, and responsibilities of the parties involved. The phase in the life cycle (focus on design, execution, and management, etc.) also determines the context.
Based on international and national legislation and regulations, and a large number of broadly accepted and implemented norms, the Safety Board has defined a number of focal issues in the area of safety, which the safety management system of the organisations concerned must address. These are the following issues:

1. **Identification of risks as the basis of the safety regime:** The starting point for achieving the required level of safety is:

i. an analysis of the system, followed by
ii. an assessment of the associated risks. Based on these elements, it is decided which risks need to be managed, and which preventive and curative measures are required.

2. **Concrete and realistic safety regime:** In order to prevent and control undesirable events, a realistic and practically applicable approach to safety or safety policy, including the associated basic principles, must be documented. This approach to safety, or safety regime, must be decided upon and controlled at management level. This safety regime is based on:

i. relevant valid legislation and regulations,
ii. existing norms, guidelines, and 'best practices' in the sector and the organisation's in-house expertise and experience, and specific safety objectives that have been drawn up for the organisation.

3. **Implementation and enforcement of the safety regime:** Execution and enforcement of the safety regime, and control of the identified risks are achieved through:

i. a description of the way in which the chosen safety regime is to be implemented, with a strong focus on concrete objectives and plans, including the resulting preventive and curative measures.
ii. transparent and clear assignment of responsibilities on the work floor with regard to implementation and enforcement of safety plans and measures. This information must be accessible to everybody.
iii. clear documentation with regard to the required deployment of personnel and expertise for the different tasks.
iv. clear and active centralised coordination of the safety activities.

4. **Further upgrading of the safety regime:** The safety regime should be continually upgraded based on:

i. periodical and, in the event of changes to the basic principles, incidental performance of (risk) analyses, observations, inspections, and audits (proactive approach).
ii. a system for monitoring and investigating incidents, near-accidents and accidents, as well as expert analysis (reactive approach). Based on the above, evaluation takes place and the safety regime is adapted by management if required. Improvement actions are also revealed by the above, allowing focused management action.

5. Management control, involvement, and communication: The management of the involved parties/organisation should:

i. internally set clear and realistic targets in terms of the safety strategy, create a climate of continuous improvement to safety on the work floor by setting a good example at all times and, finally, make adequate manpower and resources available for this.

ii. externally clearly communicate the general working practices, assessment method, procedures when errors occur, etc. based on clear and documented agreements with the involved parties.

APPENDIX 10: SARC REPORT

For this appendix, see www.safetyboard.nl

APPENDIX 11: ASD SHIP DESIGN REPORT

For this appendix, see www.safetyboard.nl

APPENDIX 12: MARIN REPORT

For this appendix, see www.safetyboard.nl

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