TECHNICAL REPORT A-20/2012

Investigation of the capsizing of merchant vessel DENEB
at the Port of Algeciras on 11 June 2011

GOBIERNO
DE ESPAÑA

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SUBSECRETARÍA

COMISIÓN PERMANENTE DE
INVESTIGACIÓN DE ACCIDENTES
E INCIDENTES MARÍTIMOS

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Edited by: Centro de Publicaciones
Secretaría General Técnica
Ministerio de Fomento ©

NIPO Papel: 161-12-110-X
NIPO Línea: 161-12-112-0
Legal Depository: M-38472-2012
Print: Centro de Publicaciones

The electronic version of this report can be viewed at website www.ciaim.es

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NOTICE

This report has been drafted by the Standing Commission for Maritime Accident and Incident Investigations, CIAIM, regulated by the 26th Additional Provision to Law 27/1992, dated 24 November, by National Ports' (Puertos del Estado) and the Merchant Navy (Marina Mercante), and by Royal Decree 862/2008, dated 23 May, whose functions are:

1. To carry out the investigations and technical reports of all serious and very serious maritime accidents in order to determine the technical causes that originated them and make recommendations for the purpose of implementing the necessary measures to prevent them from occurring in the future.

2. To carry out the technical investigation of maritime accidents when lessons learned can be obtained for maritime safety, to prevent marine pollution from vessels, and to produce technical reports and recommendations on the same.

In no case will the purpose of the investigation be to determine any fault or responsibility, and the drafting of the technical reports will in no way pre-judge the decision that may fall upon courts of law, nor will it seek the evaluation of responsibilities or determination of culpabilities.

In accordance with the aforementioned, the direction of the investigation listed in this report has been carried out without necessarily resorting to test procedures and without any fundamental purpose other than to determine the technical causes that may have caused the maritime accidents and incidents, in order to prevent these from occurring in the future.

Therefore, the use of the investigation results with any purpose other than the one described is subject in all cases to the aforestated premises and must not, therefore, prejudge the results obtained from any other report that, in relationto the accident or incident, may be initiated in accordance with current legislation.

The use made of this report for any purpose other than for the prevention of future accidents may lead to erroneous conclusions or interpretations.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

GLOSSARY OF ABREVIATIONS, ACRONYMS, SYMBOLS AND TERMS

AB ....: *Able Seaman*. 1) Name designated for an on-board position, which has similar responsibilities as those of a "Sailor". 2) Sailor, who is a member of the navigation watch and a person that meets the requirements and has completed the training and tests required by rule 11/4 of international treaty STCW 1978, as amended.

Bay ....: Each one of the longitudinal divisions of the cargo area of a container ship, corresponding to the location for stowing the containers longitudinally, from forward to aft. These locations are identified using two digits, which refer to the following types of containers:

- 20 feet: Odd number, in sequence from forward to aft (01-03-05-07–etc.).
- 40 feet: Even number, increasing from forward to aft (02-06-10-14-etc.), corresponding to the position between two 20 foot containers.

Bayplan ....: Container ship stowage plan, which shows the position of the containers grouped by bays.

BAPLIE ....: Type of EDIFACT message, which provides a coded bayplan for a container ship. This message can be mutually sent between carriers, agents, forwarders, stowage personnel, Skippers and ship operators.

B/L ....: *Bill of Lading*. Bill of lading: Document issued by a shipper as requested by the loader, which serves as proof of the reception of merchandise by the carrier for shipment and grants its legitimate holder the right to receive the merchandise at the port or destination.

TM treaty ....: United Nations treaty regarding the International Multimodal Shipping of Merchandise of 1980.

COPRAR ....: Type of EDIFACT message, regarding the orders for loading and unloading containers. This message indicates to the container terminal that the specified containers must be unloaded or loaded onto a ship. This message is part of a series of messages relative to the container which are used to facilitate the intermodal handling of containers by making the exchange of information more efficient.

EDIFACT ....: *Electronic Data Interchange for Administration, Commerce and Transport*. United Nations Organization Standard for the exchange of data. Sub-standards exist for each business environment (distribution, automotive, transportation, customs, etc.) or for each country.

Feeder ....: In intermodal shipping language, a feeder ship is a vessel that is much smaller than an oceanic shipping vessel, and which is used for supplying small ports in the area and vice versa, from a larger port known as a hub.

MG ....: Transverse metracentric height. Distance between the centre of gravity (G) of a vessel and the transverse metacentre (M).

IMO ....: International Maritime Organization.

OS ....: *Ordinary Seaman*. Sailor who is not qualified for standing watches on board a merchant vessel providing at a support level, which are known in the Spanish merchant navy as "Mozo".

Packing List ....: List of contents. Document that accompanies a container, which lists the goods it contains, indicating its size and weight along with other data.

Paris-MOU ....: *Paris Memorandum of Understanding on Port State Control*. A harmonized vessel inspection system for the purpose of ensuring that vessels operating at European and North Atlantic ports, comply with international safety and standard environmental requirements, as well as ensuring that the crew lives and works under the proper conditions.

Elephant leg ....: Also known as *distance cone* or *height adapter*. Support or stowage item consisting of an anchorage extension, used for levelling the cargo hold, middle decks and decks, where containers are stowed.

Hub port ....: In intermodal transport, ocean port that groups a large number of containers; some to be distributed in its area of influence using feeder ships and others to be subsequently shipped to destinations far away using ocean going vessels. It is also knows by the name of transfer port of concentrator port.

Row ....: Each one of the transverse divisions of the cargo area of a container ship corresponding to the location for stowing the containers transversely, from port to starboard.

These locations are identified by two numeric digits using the vessel's centreline as a reference; its characteristics are the following:

- If the number of rows from port to starboard or vice versa is odd, the centreline will be identified using digit 00.
- If the number of row is even, the vessel's centreline or centre axis will be the limit between rows 01 and 02.
- The rows that occupy from the centre of the vessel (centreline) to the starboard side will be identified using odd numeric values (01-03-05-etc.). Therefore, those on the port side will be (02-04-06-etc.).

Skimmer ....: Equipment used for cleaning up oil spills in the water.

STCW ....: *International Convention on Standards of Training, Certification and Watchkeeping*.

TEU ....: *Twenty feet Equivalent Unit*. A standard unit of measurement that expresses the transport capacity of a container ship.

Tier ....: Each one of the vertical divisions of the cargo area of a container ship, corresponding to the location for vertically stowing the containers, from forward to aft. These locations are identified by two even numeric digits, beginning from the bottom with number 02 and continuing with 04, 06, etc. When loaded on the deck, the convention is to begin the count from 82 and continue with 84, 86, etc.

UNCTAD ....: *United Nations Conference on Trade & Development*.

UNCITRAL ....: *United Nations Commissions for the Unification of International Trade Law*.

Chapter 1. SUMMARY

The times indicated in this report correspond to Spanish official time, unless indicated otherwise in the text.

Figure 1. Location of the accident

On 11 June 2011, merchant container ship (M/V) DENEB, under Antigua and Barbuda Flag, was loading 20 and 40 foot containers while she was docked on the starboard side of pier Juan Carlos I-East, from the APM Terminals in the Port of Algeciras. The vessel was scheduled to take on a complete load of 163 containers and was bound for the Italian ports of Livorno and Genoa.

The ship's load was to be boarded from forward to aft, separating the containers with destination to one or the other port in bays. In order to correct the excessive trim to the ship's bow, the port and starboard number 1 double lined tanks were to be deballasted.

On the forward side of cargo hold 1 and the aft side of cargo hold 2, due to the narrowing of bays 07, 09 and 17 (see Figure 17), the bay plan was not uniform and stowage supports (the so called "elephant legs") had to be installed under the containers, located farther away from the centreline. These supports levelled the load plane, allowing containers to be stowed over them.

Early in the morning on the 11th, after an incident involving the installation of these extensions and the loading of some containers placed over them, stowage personnel responsible for this task refused to use these extensions because they considered them to be unsafe for use in the bays that had not been loaded yet (bays 09 and 17), and therefore, personnel from the terminal and the ship's crew were forced to modify the initial stowage plan.

According to the new plan ship positions requiring the installation of extensions were left uncovered. The affected containers, a total of 12, were assigned to other positions on board.

After resuming the loading and as it was being carried out it was evident that the ship had a tendency to heel towards her port side, which led the first officer to ballast the starboard side tank no. 1 with 65 tons.

According to statements, during the loading the ship had experienced heeling as much as 10° to each side and, therefore, the loading of containers on the sides was alternated. As the operation was close to being completed, at 13:38 hours, as container number 150 was being loaded on bay 18 (on the stern, on top of hatch number 2), row 03 (second to last row on the starboard side), tier 86 (third deck above the main deck), the DENEB began to heel towards the pier and instead of stopping at 10°, she continued heeling without stopping until she impacted and ended up resting on the pier, at a permanent 45° heel angle. At that time, 13 other containers still had to be loaded.

In barely 30 seconds, the vessel went from floating upright to lying on the pier, with an approximate heel angle of 45°.

Personnel from the port and crewmembers that were on the deck at the time abandoned the vessel by using the fenders to jump into the water or onto the pier. Those crewmembers that were in their berthing or in the engine room were not able to leave these spaces until minutes after the vessel had tilted over onto the pier.

Two crewmembers were injured but did not require hospitalization and several other crewmembers and stowage personnel suffered contusions.

After this first heeling of the vessel, she moved several metres forward and aft as the lines began to give way, causing her to heel even further to approximately 50°.

Personnel from the port immediately reported the accident and two tugs from the port arrived within 14 minutes and pushed the vessel against the pier, preventing her from completely tipping over. SASEMAR dispatched its resources in order to guarantee the safety of personnel and minimize any contamination that could have been generated as a consequence of the accident. Absorbent and rigid barriers were deployed to control the contamination.

Approximately two hours after the accident, the shipowner hired salvage company SVITZER to coordinate the fuel extraction task as well as the rest of the tasks required to re-float the vessel.

Small gasoil spots were detected in the water after the accident and the necessary measures were implemented to contain the contamination.

At 12:54 hours on the 12th the containers began to be moved to shore. The effort to recover the cargo and refloat the vessel continued until the 13th of July, when the vessel was righted and she was able to float by herself.

On the 18th of July, after the work required to tow the vessel to a different location and clear the pier was completed, the vessel was towed to the pier of Campamento in Algeciras. At this pier different disassembling work and recovery of machinery was carried out on the vessel, which was to be subsequently towed and scrapped in Santander.

1.1. Conclusions

This Commission has concluded that the accident involving container ship DENEB occurred because of errors made during the planning and loading of the cargo. As a consequence of these errors, a load condition was reached in which the vessel lost her stability and capsized. The following factors contributed to the vessel's inadequate load condition and subsequent capsizing:

- The weights declared for many containers were much lower than the actual weights.
- The containers were never weighed to verify that the declared weights were accurate.
- Errors were made during the preparation of the electronic information (BAPLIEs) that was transmitted to the vessel to check her stability under the different expected load conditions. The weights included in the BAPLIEs did not coincide with the declared weights.
- The final load plan transmitted to the vessel included a load condition in which the vessel would not comply with the regulatory stability criteria. In spite of this, the Skipper authorized the loading of the vessel.
- The team of deck officers improperly directed the loading of the vessel. During the loading process several indications suggested that the load planning may be erroneous; however, no steps were taken to check this.
- None of the deck officers had sufficient experience in the positions they held on board. This fact made it difficult to form a solid working team with established procedures, and was conducive to the crew neglecting their obligations.
- The deck officers were overloaded with work and were probably fatigued.

* * *

Chapter 2. OBJECTIVE DATA

2.1. Vessel data

M/V DENEB was a merchant container ship, whose main characteristics are included in Table 1.

She had a dual hull except for the area surrounding the engine room. She could load containers inside her, over the hatches and over the engine room.

Table 2 lists the status of the ship's certificates. Figure 17 shows a stowage plan with the nomenclature of the position of the containers.

Figure 2. M/V DENEB

Table 1. Main Characteristics

Vessel Name	DENEB
Type	Container ship
Flag	Antigua and Barbuda
Port of Registry	St. John
Call sign	V2CM6
IMO number	9061306
Place of the construction	Hamburg (Germany)
Hull material	Steel
Builder	J.J. Sietas KG Schiffswerft GMBH & Co.
Year built	1992
Owner	MS "ELBSAILOR" GmbH & Co. KG
Operator	USC Barnkrug GmbH & Co. KG
Total number of crewmembers	10
Number of cargo holds	2
Container capacity of 20 feet	509
Capacity to transport grain	7,275 m^3
Length overall	101.130 m
Length between perpendiculars	93.130 m
Total breadth	18.200 m
Maximum draught in the summer	6.547 m
Gross Tonnage (GT)	3,992
Net tonnage (NT)	2,233
deadweight	5,330 t
Ballast	1,896 m^3
Propulsion	Diesel engine, Deutz, 4T L9
Maximum power	3,825 kW (600 rpm)
Maximum speed	15.50 knots

Table 2. Status of the vessel's certificates

Certificate	*Status*	*Issued by*	*Date issued*	*Expiration date*
Document of Compliance	Valid	Germanischer Lloyd	28/03/2007	23/01/2012
International Ship Security	Valid	Germanischer Lloyd	11/10/2007	30/09/2012
Safety Management Certificate	Valid	Germanischer Lloyd	20/12/2007	30/09/2012
Cargo Ship Safety Construction	Valid	Germanischer Lloyd	29/04/2009	30/04/2014
Cargo Ship Safety Equipment	Valid	Germanischer Lloyd	29/04/2009	30/04/2014
Cargo Ship Safety Radio	Valid	Germanischer Lloyd	29/04/2009	30/04/2014
International Oil Pollution Prevention	Valid	Germanischer Lloyd	29/04/2009	30/04/2014
International Air Pollution Prevention	Valid	Germanischer Lloyd	29/04/2009	30/04/2014
International Sewage Pollution Prevention	Valid	Germanischer Lloyd	29/04/2009	30/04/2014
LoadLline	Valid	Germanischer Lloyd	29/04/2009	30/04/2014
Minimun Safe Manning Document	Valid	Antigua y Barbuda	04/04/2011	03/04/2013
Document of Compliance Dangerous Goods	Valid	Germanischer Lloyd	05/05/2009	30/04/2014

2.1.1. *Stability criteria*

All the references to stability criteria used in this report refer to the stability code without failures for all types of vessels, which is governed by IMO instruments, approved on 4 November 1993 by resolution of IMO assembly A.749(18), and is the reference framework by which M/V DENEB was designed and built.

The vessel was operating according to the stability criteria of the German See-BG organization, which are identical to the criteria included in IMO's stability code.

Although on the date of the accident, the international code on stability without a failure, 2008 (code IS 2008), adopted on 4 December 2008 by means of resolution MSC 267 (85) had already come into effect, the application of one or another stability regulation makes no difference because the regulations applicable to this vessel are the same in both codes.

2.1.2. *History of inspections of the vessel*

In the six months prior to the accident M/V DENEB underwent two inspections by the port state control (MOU inspections).

The first one occurred on 28 April 2011 in Seville, where 12 discrepancies were discovered on the vessel, which did not require it be detained. The deficiencies were related to:

- Crew fatigue, legal documentation relative to work, rest periods and records of rest periods for watch personnel.
- Inflatable life rafts.
- *International Oil Pollution Prevention Certificate* (IOPP).
- Installation of MH/HF.
- Nautical publications.
- Another propulsion and auxiliary engine.
- Personal fire fighting equipment.
- Radio salvage equipment.
- Safety signs.

Afterwards, and as a result of the previous inspection, a more detailed inspection was carried out in Genoa on 7 may, during which no discrepancies were discovered.

2.1.3. *Minimum Safe Manning Certificate*

According to the minimum safe manning certificate issued for the vessel on 4 April 2011 by the authorities of Antigua and Barbuda, the vessel's minimum crew was established at 10 personnel.

The vessel complied with the minimum number of crewmembers but not with their qualifications. According to the ship's certificate, she was to have three Junior Officers, who would be part of the navigation watch and one Junior Deck Officer (an OS), who would not necessarily be in possession of a certificate according to rule 11/4 of agreement STCW 78, as amended. The crew list included the following personnel: One Boatswain, one AB and two OSs.

The certificate included a section relative to requirements or special conditions. Its third point stated the following: *"The ranks and numbers of personnel listed above reflect the minimum number of persons necessary for safe navigation and operation. Additional personnel that may be considered necessary for cargo handling and control, maintenance or watch keeping, and as needed for required rest periods, are the responsibility of the owner and the master"*[1].

2.2. M/V DENEB chartering

The vessel was owned by the company MS ELBSAILOR GmbH & Co. KG (IMO 5340913), from Drochtersen, Germany. Since 2010, the vessel had been managed by company USC BARNKRUG GMBH & CO KG (IMO 5505060), based in the same city.

The vessel had been chartered for some time by SEA CONSORTIUM (SEACON), a company with headquarters in Singapore, which had, in turn, sub-chartered the vessel to XPRESS CONTAINER LINE (XCL), a company with headquarters in London and regional offices in Dubai, Barcelona, Genoa and Geneva.

According to available public information, between both companies, they operate around 60 ships dedicated to feeder type transport in Europe, the Mediterranean Sea, the Black Sea, the Persian Gulf, the Indian Subcontinent, Southeast Asia and the coast of China.

XCL used M/V DENEB as a container ship feeder in the MAERSK LINE. In other words, XCL leased the vessel space to MAERSK LINE (hereinafter referred to as "the line") to transport its containers.

Companies SEA CONSORTIUM and X-PRESS CONTAINER LINE maintain independent legal personality, but operate offering their services under the same commercial brand name X-PRESS FEEDERS (from now on referred to as X-PRESS).

2.3. Crew and organizing of the work on board

The crew was comprised of 10 persons: Skipper, first officer, Second Officer, Chief Engineer, Boatswain, an AB type Seaman, two OS type Seaman, a Cook and an Oiler.

In spite of having lost part of the documentation when the ship capsized, the information provided from the ship's flag country and from the countries that issued the competency certificates for the crew, allowed verifying that all the crewmembers were properly certified and that officers were in possession of the corresponding endorsements issued by the ship's flag country.

Table 3 lists information relative to the members of the ship's deck officer team.

The rest of nationalities were: The Chief Engineer was Ukranian, the Boatswain and Cook were Polish, and the AB, the two OSs and the Oiler were Filipino.

[1] The grades and number of persons included in this list reflect the minimum number of personnel required for safe navigation and operation. The Shipowner and Master are responsible for increasing the number of personnel as required for handling and controlling the cargo, maintenance or watches in order to comply with the prescribed rest periods.

Table 3. Information relative to the deck officer team

Position on board	*Nationality*	*Approximate time on board*	*Remarks*
Skipper	Ukraine	9 months	One month as a Skipper and the rest as the First Officer. Since 1998 with First Officer experience on board container ships.
First Officer	Lithuania	2 months	This was his first experience on board a container ship. He came from tankers.
Second Officer	Poland	On board since November 2012 as a Boatswain. Was promoted and had been serving as a Second Officer since February 2011, 4 months prior to the accident.	During the previous campaign, from April to August 2012, he served on board as an OS.

The organization of the work on board for the Deck Officers was different depending on whether the ship was underway or in port. While underway the Skipper was part of a traditional three-shift watch, and when in port, the skipper did not stand any watches. In the case of the First and Second Officers, they alternated, being on watch every six hours. The First Officer covered the watch from 6 to 12 and from 18 to 24 hours, while the Second Officer covered the watch from 12 to 6 and from 12 to 18 hours.

2.3.1. *Instructions to the Watch Officer*

The Second Officer was the Watch Officer at the time of the accident. At that moment he was on the pier next to the gangway. The Watch officer did not have any written procedures available relative to cargo issues. He did not have a copy of the stowage plan nor was he provided with instructions relative to ballast operations.

2.4. Details of the voyage

The ship had departed from Casablanca, Morocco, with a load of 232 empty containers, which were to be unloaded in Algeciras. The ship arrived at the Bay of Algeciras on 7 June at 20:20 hours, and headed to the anchorage area to wait for orders.

On the morning of 10 June the ship received the call from the Algeciras pilot station. At 11:40 hours the ship was anchored on the starboard side of the pier, at the APM TERMINAL, at Pier Juan Carlos I East in the Algeciras Bay Port.

The unloading operations began at 14:00 hours and were completed without incident.

The ship loading operations began at 02:00 hours on the 11th, using a crane. The loading began at bay 3, on the ship's bow.

M/V DENEB was supposed to load 163 20 and 40 feet containers from the line, bound for the ports of Livorno and Genoa in Italy. The loading was going to be carried out on the bays, starting at the bow and working back to the stern until all the cargo was loaded.

Among other goods, the containers contained cotton, wood, fertilizer, copper, frozen goods, cocoa, safety shoes, etc.

The origins of the containers were diverse, originating mainly from Africa, Central America and South America.

2.5. Consequences of the accident

2.5.1. *Consequences for the ship*

The ship was declared a Constructive Total Loss on 01 July and was released into the custody of HANSEATIC P&I Protection and Indemnity Club.

On the 18th of July, after the work required to tow the vessel to a different location and clear the pier was completed, the vessel was towed to the pier of Campamento in Algeciras. At this pier different disassembling and recovery of machinery work was carried out on the vessel, which was to be subsequently towed to Santander to be scrapped.

2.5.2. *Consequences for the personnel that were on board*

Two crewmembers were injured, receiving blows and contusions of varying severities. However, these injuries were not life threatening and first aid was administered by health care services without requiring any hospitalization.

2.6. Information relative to the load

M/V DENEB was chartered by company X-PRESS (XCL). This company, which operates ships around the world, provided instructions to M/V DENEB from its offices in Dubai, which is where the team responsible for checking and organizing the cargo plans for the ships they are operate is located. These offices received available information relative to the cargo that was to be transported from the line (MAERSK LINE). Once this information was organized, it was distributed by X-PRESS through its agent (MARÍTIMA DEL ESTRECHO), which served as a liaison between the terminal (APM Terminal), the company operating the ship (X-PRESS) and the line (MAERSK LINE).

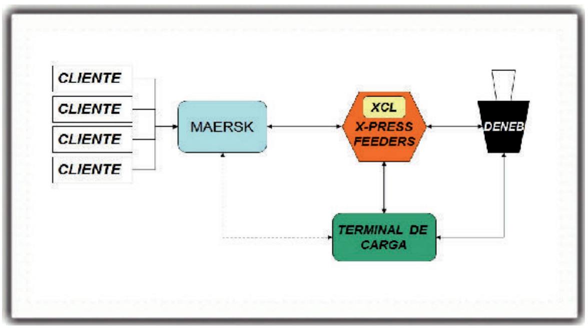


Figure 3. Information flow diagram between the parties

Last-minute modifications of the cargo plans were carried out by the terminal operator when requested by the ship; however, if these modifications were important, they had to be supervised by the ship's operator X-PRESS.

The loading and unloading information systems operated as per the EDIFACT (*Electronic Data Interchange for Administration, Commerce and Transport*) standard.

The ship's loading program was prepared for working with this standard, able to read BAPLIE type messages, which were transmitted between operators, terminal and stowage personnel. With this system, the proposed loads were quickly calculated in the ship's load program, which would automatically assess her stability.

During normal operation, all the information required by the terminal to prepare the loading of the vessel were to come from the ship's operator.

According to information received from the terminal, the operator was not sending the information in an EDIFACT message with the proper codes, which would cause the terminal to only properly process part of the information provided by the operator (the BAPLIE messages), while another part of the information was received from the line (MAERSK LINE) (i.e.: Load/unload lists or COPRAR messages). According to the Terminal, this could cause strange situations to occur in the sequence of the information received, such as the reception of a list of modifications of the load (from the line) prior to having received the first loading instructions from the ship's operator.

According to the ship's charterer, XCL, they did not have information on the proposed load modifications; this information was a matter between the terminal and the Skipper, who was to have all the information relative to the stowage plan and to approve it prior to proceeding with the loading.

In this regard, the Skipper always maintained that the first information relative to the cargo came from the XCL office in Dubai. This information was checked on board and was accepted.

The subsequent modifications were approved on board and were reported to the terminal for them to be implemented.

2.7. Suitability of the pier

After the accident personnel from SASEMAR verified the depths around the ship, ensuring they were in accordance with the specifications of the port. The nominal depth of this pier is 14 m. The maximum draught of the ship in the summer was 6.547 m.

The pier fenders as well as the arrangement of the dock were adequate and the height of the pier in relation to the ship's freeboard was also adequate.

2.8. Involvement of the authorities on shore and the emergency services response

When the ship first began to heel there were a large number of workers in the area because it coincided with a work shift change.

Port police limited access to the area and established a safety perimeter.

The accident did not produce any fatalities, in spite of its magnitude. When the ship began to tip over, several members of the crew were trapped in the spaces they were in at the time.

Personnel from the port immediately reported the accident and the different available port services arrived to the site of the accident. At 14:52 hours, when nearly 14 minutes had elapsed, among other resources, two tugs from the port arrived and began to push the ships bilge against the pier, preventing the ship from completely tipping over.

The port notified SASEMAR, which sent a tug and an auxiliary ship to the area.

Emergency health services administered first aid to crewmembers for contusions and bruises at the pier; no one was hospitalized.

The General Directorate for the Merchant Navy activated the logistic base of Seville and the National Contingency Plan for Accidental Marine Contamination.

That same evening, the Shipowner's P&I Club, HANSEATIC P&I, agreed to carry out the salvage with company SVITZER. This company sent its salvage tug called ROTTERDAM to Algeciras, which was nearby with part of the required human resources and equipment on board.

On 12 June, the company SVITZER began the refloating of M/V DENEB after the person in charge of carrying out this operation arrived on the scene.

2.8.1. *Response against contamination*

No significant fuel spills into the ocean occurred beyond the barrier protected area.

The accident occurred at about 13:38 hours. Slightly after this time, SASEMAR services were notified by the port operations technician. SASEMAR dispatched its resources in order to guarantee the safety of personnel and minimize any contamination that may be generated as a consequence of the accident. Between 16:00 and 16:30 hours, absorbent and rigid barriers were deployed to control the contamination.

At 22:05 hours, a third barrier was deployed after a leak of about 800 litres of oil was detected.

This oil or mixture of oil and water contamination was confined inside the barriers, where it was subsequently collected using skimmers.

Also, company SVITZER, following instructions from the Maritime Authority, immediately began sealing the fuel tank vents and extracted the fuel.

2.9. Details of the investigation

The following entities collaborated in the investigation:

- APM TERMINALS.
- MAERSK LINE.
- MARINSUR, Agents named by HANSEATIC P&I.

- USC BARNKRUG GMBH, company according to the international safety management code.
- Port Authority of Algeciras.
- Civil Guard Criminal Services Engineering Department.
- Civil Guard from the Algeciras Headquarters.
- MARAPIE (Port of Algeciras Cargo Loading and Unloading Society).
- Algeciras Maritime Authority.
- X-PRESS CONTAINER LINE (XCL).
- SEA CONSORTIUM.
- SASEMAR.
- GERMANISCHER LLOYDS.
- Maritime Consulting and Research GmbH (MARCARE), acting as representatives for the maritime authorities of Antigua and Barbuda.

MAERSK LINE did not provide CIAIM with a copy of the "packing list" used to devise the B/Ls. As a consequence, the veracity of the weights included in the B/Ls obtained by CIAIM investigators could not be corroborated.

Between the 14th and the 16th of June CIAIM investigators interviewed the crew, the shipowner representative and representatives from the APM TERMINALS.

On 5 June, CIAIM investigators held a meeting with stowage personnel that were on board the ship when the accident occurred.

On 15 July, two CIAIM investigators accessed the ship after receiving approval from SVITZER Salvage Company, being the first persons other than the personnel involved in the refloating to access the ship after the accident. The reason for accessing the ship was to recover the computer that had the load program installed as soon as possible, as well as to check the evidence present in the Wheelhouse. The computer hard drive was removed at the pier and turned over to the Civil Guard for analysis at their laboratory. The result of the information extraction operation was negative because the computer had been found in the area of the ship that was submerged and the salt water had damaged the magnetic substrate of the hard drive.

On 12 February 2012 a meeting was held in Algeciras, which was called by experts from the ship's P&I Club. All parties were invited to attend this meeting for the purpose of evaluating and determining the weights of the ship's containers, especially those that were flooded as a consequence of the accident. CIAIM investigators attended this meeting.

During the course of the investigation many conversations were held by telephone and in writing with the different departments of the ship's operator, the shipowner, the line, the terminal and the local P&I agent.

2.9.1. *Integrity of the hull, tanks and ballast and bilge pumping system*

The structural integrity of the ship was checked by the company that executed the rescue (SBITZER) to determine if she could be re-loated, as well as by the different experts named by the insurance companies and the interests of the ship, terminal, operators and cargo.

The deballasting, bilge pumping and removal of fuel operations for the purpose of preventing contamination and re-float the ship, were carried out using the tank vent tubes, without manipulating the valves.

Between the 15th and the 29th of June, after having refloated and towed the ship to the pier of Campamento in Algeciras, the ballast and bilge pumping system was inspected in its entirety by the experts named by the insurance companies and the ship's interests, terminal, operators and cargo (MAERSK LINE, XCL, part of the cargo and shipowner/P&I).

During the expert assessment it was verified that all the engine room valves were completely closed, with the exception of one of them, which was completely open. This valve was used for pumping out to the deck and to the high tanks.

Also, it was discovered that all the actuator controls of the pneumatic ballast control panel were in position "0", except the electrical power control, which was in position "1". The ballast selector control was in position "2" (port). This indicated that all the remotely controlled valves were closed at the time of the accident. Also, neither the manual operation valves nor the electrical controls had signs of having been manipulated.

Due to the difficulties encountered with checking all the valves located outside the engine room, the experts opted to subject the ballast system to a hydraulic test. For this, the circuit was pressurized at 2.2 bar for one hour, during which time no leaks were detected, which allowed them to conclude that the circuit did not have any leaks and that all the valves were closed.

* * *

Chapter 3. DETAILED DESCRIPTION

3.1. Background

On 7 June 2011 at 20:20 hours container ship M/V DENEB, which had departed from Casablanca, arrived at the anchorage area of the Port of Algeciras.

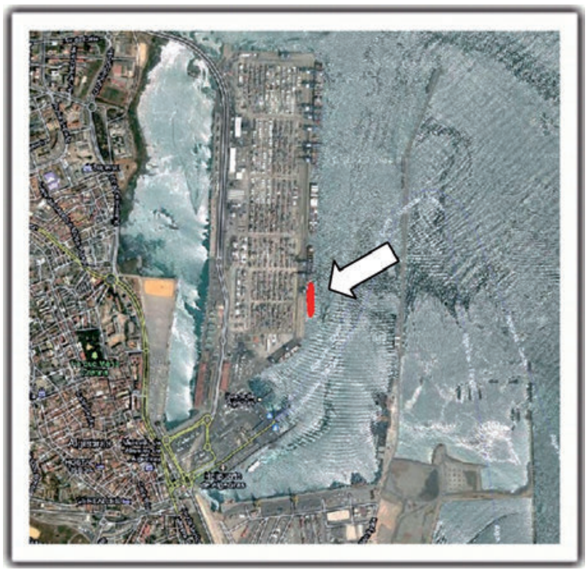


Figure 4. Position of container ship M/V DENEB at the Port of Algeciras

In Algeciras the ship was supposed to unload all the empty containers she was transporting from Casablanca and load all the containers that had arrived at Algeciras from the different countries. Her new destination was Genoa, after Livorno, and finally she was to return to Algeciras.

3.2. Planning the load

The ship's load planning process could not be recreated in its entirety because some documental evidence was found damaged.

According to information from APM TERMINALS ALGECIRAS (hereinafter referred to as "the terminal") on the 7th of June a local XCL agent provided them with a list of empty containers arriving to Algeciras on board M/V DENEB. Later that same day the XCL coordinator provided instructions to the terminal regarding the unloading of containers.

On that day the terminal began receiving lists of changes that were to be applied to the stowage plan from several sources (from MAERSK in Manila, among others). At that time the stowage plan had not yet been received at the terminal.

The next day, on the 8th, the XCL coordinator sent a first message with container stowage instructions; in other words, after the modifications that had been received the day prior.

On the 9th, the terminal received a message from MAERSK LINE in COPRAR format confirming the cargo list.

3.3. Unloading and starting of the loading operations

Around 10:45 hours on the 10th one of the pilots from the port of Algeciras went on board to oversee her entry into port.

At 11:40 hours, the ship arrived at the pier, where she was to begin the unloading/loading of containers (Figure 4). Around 14:00 hours, the ship began to be unloaded without interruption.

Once the unloading was completed, at 02:00 hours on the 11th of June, the ship began carrying out the loading operations. The plan was to begin at the bow and begin loading back towards the stern. A single crane was to be used.

3.4. Modifications to the loading plan

On the forward side of cargo hold 1 and the aft side of cargo hold 2, the bay plan was not uniform and stowage supports had to be installed under the containers located farther away from the centreline. These supports were portable extensions and were referred to by stowage personnel as "elephant legs," which levelled the load plane allowing for containers to be installed over them.

At 04:10 hours on the 11th of June the loading operations were halted because stowage personnel considered the working conditions unsafe. Early that morning, after an incident involving the installation of these extensions and the loading of some containers placed over them, stowage personnel responsible for this task refused to use these extensions because they considered them unsafe. As a result personnel from the terminal and the ship's crew were forced to modify the initial stowage plan.

When the loading operations were stopped the Second Officer, who was on watch, notified the Skipper and the First Officer. The Skipper ordered the First Officer to check the stability of the ship under the assumption of leaving the locations requiring the use of elephant legs unloaded and loading the containers that were supposed to be stowed at these locations on the deck.

In the initial stowage plan that the charterer had provided to the Skipper for approval and subsequently to the load terminal, the ship had an MG (transverse metracentric height) of 0.92 m. Once the new adjustment to the loading of containers was carried out, said MG decreased to 0.68 m, according to statements provided by the crew. This data, always according to statements, were obtained from the ship's loading program, where the calculations were carried out by the First Officer and approved by the Skipper (this data differs from the calculations conducted by the commission, see analysis and annexes).

One of the consequences of modifying the stowage plan was not loading containers that should have been placed in the rows farther away from the centreline, especially in bays 10 and 18, of the cargo hold. This resulted in loading the cargo holds without completely filling the rows that were located on the sides, leaving the central block of loaded containers without the protection of the containers that should have been loaded on the sides. Also, guides were not used for loading the containers onto the ship's cargo holds, which does not mean that they were not properly fastened using other stowage elements.

The Skipper made use of his authority by approving and ordering the changes to the cargo stowage plan be implemented.

3.5. Resuming the loading

At 06:20 hours on the 11th of June, once the shift change with terminal personnel had been carried out, the loading of containers was resumed according to the new stowage plan supplied by M/V DENEB, which contained the changes made by the First officer. The ship's loading operation resumed in the morning as normal.

The first Officer's watch ended at noon. He then went to get something to eat before meeting with the Second Officer, who was the incoming Watch Officer. He was with him until just a few minutes prior to the accident, when he went to his berthing to get some rest. The First Officer in his own words, "had barely stopped working" from the time they arrived to Algeciras on the morning of the 10th.

During the loading operations of the Second Officer's watch, when he noticed that the containers that were being loaded on the deck were very heavy, he gave the order to load the containers in an alternating fashion on each of the ship's sides. When the containers were loaded, the ship would heel nearly 10° to each side.

At 13:30 hours, the pier supervisor gave the final stowage plan to the First Officer (final stowage condition upon the ship's departure, including the modifications required by the Skipper) and the report of damage detected during the loading operation. Upon leaving the ship the pier supervisor was informed by the foreman that the ship's bow was overdraught and that two crewmembers were checking the draught.

3.6. The accident

At 13:38 hours, after loading a 40 foot container in bay 18, on the starboard side at a three story height and after three attempts, the ship began to heel to her starboard side, slowly at first and then progressively at a faster speed until the containers located on the deck touched the pier. Some mooring ropes were missing, which allowed the ship to move several metres forward. According to witnesses, the heel angle at that moment was approximately 45°.

Figure 5. Moments after the accident

When the accident occurred, several workers from the cargo terminal of Algeciras approached the ship to find out what had happened and assist as necessary (see Figure 5). Police officers arrived at the scene, who notified the Port's emergency services and established a safety perimeter.

3.6.1. *Consequences for personnel on board*

When the accident occurred, crewmembers were in the berthing area with the exception of the sailors on watch (they were on the deck), the Second Officer (was on the pier), and the Chief Engineer and the Oiler (were in the engine room carrying out some work separately). The crew that was on deck at the time as well as personnel from the cargo terminal that were carrying out and overseeing the loading operations, jumped into the water or quickly abandoned the ship by jumping over the pier fenders as they were sliding and falling as the ship was heeling.

The crew that was in the berthing area had a hard time exiting the ship because the exits became obstructed by moving furniture and fixtures due to the heeling.

The First Officer, whose berthing space had a door facing towards the heel side, took between 3 and 4 minutes to exit his berthing space due to the accumulation of fixtures over the door, which made it difficult to open it.

The person who had the hardest time exiting was the Oiler, who was in the lower floor plates area of the engine room when the accident occurred. He had to make way with difficulty by climbing up the ladders located inside the engine room, holding on to the handrails and suffering repeated falls and blows. He suffered multiple contusions to his body and extremities.

One of the last persons to get off the ship was the Skipper, who attempted to take all the documentation relative to the crew and the ship. Carrying all the documentation, he first climbed up to the wheelhouse, slipping and crawling on the deck due to the large heel angle. He received blows and contusions, which forced him to backtrack and climb down three decks to the bow.

All these crewmembers were able to exit and jump into the water.

Figure 6. Position at 14:00 on 11 June

3.7. Hours following the accident

At 13:52 hours, two port tugs pushed the ship's bilge against the pier, preventing the ship from completely capsizing.

As the ship heeled, part of the containers located on the deck and over bay 2 came loose and their locking mechanisms moved starboard (see Figure 7).

Figure 7. Containers over bay 2, whose locking mechanisms did not withstand the heeling

The ship's heel angle increased and initially, her bow began to flood until it touched the bottom, while her stern remained afloat while the heel angle continued to increase. As the day progressed and the engine room flooded, the stern of the M/V DENEB began losing floatability until finally resting on the bottom; she slightly separated from the pier with an approximate heel angle of 54°. At 20:00 hours, the starboard wheelhouse's wing contacted with the pier, and remained balanced in that position (Figure 8).

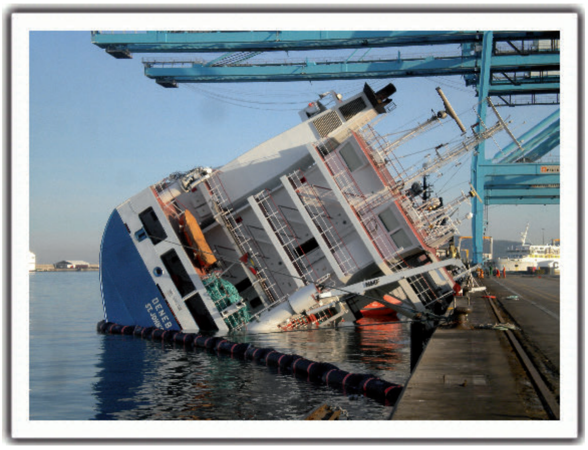


Figure 8. Position at 20:00 on 11 June

During the night the structure supporting the wheelhouse's starboard side wing weather deck gave in. The ship continued heeling until she reached about a 75° heel angle. The forward light post, which was one of the elements marking the limit between the heeling of the vessel and the wing's wheelhouse, also gave in, allowing the ship to reach this new balance position.

3.8. Removal of the cargo and re-floating

During the evening of the 11th the shipowner's P&I Club HANSEATIC P&I contacted the company SVITZER, which would carry out the salvage operations. That same night, personnel from the salvage company were already checking the condition of the ship.

The following day, on 12 June at 06:50 hours, an operations technician from SASEMAR reported that no air was exiting along the quay, which was interpreted as a sign that the ship must be lying on the bottom. Figure 9 shows the ship's condition moments later.

Around 9 AM, SVITZER began the preparations for removing the containers that had come loose as well as those on the deck and out of the water.

Figure 9. Position at 08:30 on 12 June

As shown in Figures 6 and 7, which correspond to the evening of the 11th of June, the ship continued heeling throughout the night until ending up in the position shown in Figure 10 on the morning of the 12th of June.

Figure 10. Position at 09:30 on 12 June

Figure 11. Container removal work carried out by the company in charge of the salvage operations on 12 June

During the evening of the 12 of June 2011 SVITZER began removing the containers that had become detached or were locked on deck but were dry.

During he 13th of June and the days following all the containers located on the deck were removed.

On the 13th SVITZER presented the Salvage Plan to the Maritime Authority of Algeciras.

On the 14th of June they began removing the submerged containers that were located outside the bays, which required using divers to carry out the underwater work.

On 1 July the ship was declared a Constructive Total Loss.

The ship was refloated on 13 July. The forward cargo hold hatch was then opened and they began unloading the containers located inside the cargo holds.

On 18 July, upon completion of the container recovery work and after the required preparation work had been carried out, M/V DENEB was towed to the pier of Campamento in Algeciras. At this pier different disassembling and recovery of machinery work was carried out on the vessel, which was to be subsequently towed and scrapped in Santander.

* * *

Chapter 4. ANALYSIS

4.1. Cargo loading operation of M/V DENEB

The loading and unloading operation of the container ship begins after a client hires the shipping company to transport cargo. The client supplies the shipping company directly or through intermediaries, the information relative to the cargo he wants to ship. In this way the company responsible for configuring the cargo on the ship will have the necessary data to decide what containers it can transport, how many containers, and the locations in the cargo holds or on the deck where the containers will be placed.

The documentation to be prepared by the client for the transport is:

- The invoice of the goods to be shipped in order to carry out the exporting dispatch and payment of duties and
- The packing list, which is a document describing the cargo to be transported and providing a list of the items transported inside the containers. The packing list, among other things, includes the weights of the transported goods.

The shipping company is to issue a document called a bill of laying[1] or B/L, the purpose of which is the following:

- It serves as a receipt of the goods on board and certification of its status.
- It provides proof of the existence of a shipping contract and the details of the shipping conditions.
- It certifies the property title of the transported cargo in favour of its legitimate holder and via which it has the exclusive right to receive the cargo at the port of destination.
- It is negotiable and admitted as credit by banks in the letters of credit.

The data and description of the cargo supplied by the shipper are included in the part of the B/L corresponding to the description of the goods and is usually in a block located under a header called *"Kind of packages; description of goods; Marks and numbers; Container No./Seal No."*. Also, inside this block and filled in by the shipping company, the following phrase is included *"X container(s) said to contain"* and under this is usually a description of the transported goods and the conditions of the transport along with the container number and seal supplied by the shipping company. This data includes the weight of the transported goods and its volume.

Other data included in a B/L are:

- Contracting parties: Shipper, consignee, shipping company or shipowner, ship consignee.
- Vessel Name.
- Trip number.
- Loading port.
- Unloading port.
- Numbering of the containers (if the goods are carried inside containers).
- Gross weight and volume of the cargo.
- If the freight is paid at the origin (prepaid) or at the destination (collect).
- Location and date the document was issued.
- Number of original B/Ls issued by the ship consignee.

Once the B/Ls are issued the company that is going to create the freight already has the data required to configure the ship's cargo.

The initial configuration of the cargo is prepared while taking into account several basic parameters: the ports where it will be unloaded, the weight of the containers (the heaviest must be located below), whether special containers are used (for example, frozen goods), and separating dangerous goods, etc.

This configuration is sent to the ship to be checked using the ship's cargo calculator pro-

[1] Marine goods shipping law of 22 December 1949 in bill of laying mode.

gram, where the different parameters are entered relative to the location of the loads:

- Filling of the ship's different tanks (fuel, water, oil, ballast, etc.).
- Provisions and storerooms.
- Crew and their personal luggage.
- Configuration of the hatches (open or closed).
- Container guides in the cargo holds.
- Loaded containers.
- Other data.

When entering the containers in the program the following data must be provided:

- Weight of the container.
- Size of the container: 20 or 40 feet.
- Height of the container: 8.5 or 9 feet.
- Location where each container will be stowed including the bay, row and tier.
- Other data relative to the type of container or conditions of the trip (for example: frozen goods).

After carrying out the naval architecture calculations, the program provides the following outputs:

- Summary of the cargo by bay: weights and centre of gravity.
- Bayplan: Distribution of containers by bays with the data relative to the containers.
- Summary of the resulting stability for the load condition defined, with its stability curves, and verifying compliance with regulatory stability criteria.
- A diagram of the distribution of forces (bending moments and shear forces) acting on the ship.

4.2. Weight of the containers

This report includes three lists of container weights (also see 0).

- **Weights in the B/L:** Declared by the owners of the cargo in the Bill of Ladings.
- **Weights included in the BAPLIE,** electronic documents transmitted between the different parties related to the cargo and used to carry out the stowage calculations for containers on board.
- **Calculated weights**, obtained by weighing the containers after the accident, considering the effect of the water on the weight of the submerged containers. It is estimated that the calculated weights are those that most accurately reflect the actual weights of the containers at the time the ship was loaded.

During the investigation, CIAIM obtained a copy of the B/Ls for the 150 containers that were on board.

Also available are the BAPLIEs sent between the different parties and which, to all effects, constitute the ship's stowage plan. It is worth mentioning that the weights listed in the BAPLIEs of all the containers that were loaded were kept unchanged from the first BAPLIE message to the last, including the modifications that were made to the original plan.

The containers recovered after the accident were removed and grouped in a separate area inside the same terminal. The terminal proceeded to weigh all the unloaded containers, as allowed by their normal workload. The contents of damaged containers were transferred to other containers that were empty and then weighed.

The 13 containers that were never loaded on board were not weighed and their corresponding B/Ls are not available. The only information relative to the weight of these 13 containers is the figure in the BAPLIEs.

All the containers located inside the cargo holds and part of the containers stowed on deck were submerged and therefore flooded. Only 13 % of the loaded containers were not flooded. The affected parties (P&I, representatives from the shippers, terminal) agreed to a procedure for considering the effect of the water on the weight of cargo inside the containers in order to compare their weight with the data declared in the documentation for each container. The commission considers the resulting estimate of the weights of flooded containers to be adequate and to accurately reflect the actual weights of the containers on board.

According to the aforementioned the weights of the containers considered in this report are summarized in the following table:

Table 4. Weight of the containers

	Weight (tons)	
	Scheduled Cargo - 163 cont.	*Cargo involved in the accident - 150 containers*
Weights in the B/Ls	4,087 (*)	3,775
Weights in the BAPLIEs	3,996	3,684
Calculated weights	4,327 (*)	4,016

(*) The weight listed in the BAPLIEs was considered accurate for the 13 containers that were not loaded on board.

It is verified that the weights of the containers listed in the BAPLIEs do not coincide with the weights listed in the B/Ls or with the actual weights of the containers.

Therefore, the information used for checking the load condition of the ship was inaccurate.

We are not entirely sure of what information was available to the Skipper and whether or not he used this information since we have not found any evidence or documents to confirm it. However, CIAIM is convinced that the Skipper had the same BAPLIEs available as those available at the terminal.

4.3. Analysis of the weights of the containers on board the M/V DENEB at the time of the accident

The three different lists of weights were compared:

- Weights in the B/Ls.
- Weights in the loading BAPLIE.
- Calculated weights.

Table 5 shows the differences in the total weights of the ship's cargo:

Table 5. Differences in the weights of the 150 loaded containers

Calculated weights minus the weight listed in the BAPLIE	332 t
Calculated weights minus the weight listed in the B/Ls	241 t
Weight listed in the B/Ls minus the weight listed in the BAPLIE	91 t

According to this table the weight of the cargo used for calculating the stability was 332 t lower than the calculated weight, without considering the effect of the 13 containers that were not loaded on board.

In summary, according to the BAPLIEs, the ship was carrying less weight than that reflected in the documentation supplied by the owners of the cargo (B/Ls) and less weight than that calculated once the containers were weighed.

4.3.1. *Differences in weights between the B/Ls and the BAPLIEs*

An analysis was carried out of the differences in weights between the B/Ls and the BAPLIEs for the 150 containers on board. The following results were obtained:

- In 86 containers (57 % of those on board) the difference between the weight manifested in the B/Ls and that listed in the BAPLIE was less than 10 %.
- In 25 containers (17 %) the difference in weight was between 10 and 20 %.
- In 18 containers (12 %) the difference in weight was between 20 and 30 %.
- In 3 containers (2 %) the difference in weight was between 30 and 40 %.
- In 2 containers (1 %) the difference in weight was between 40 and 200 %.
- In 7 containers (5 %) the difference in weight was between 200 and 300 %.
- In 5 containers (3 %) the difference in weight was between 300 and 400 %.
- One container had a difference between 400 and 500 %.
- In 3 containers (remaining 2 %) the difference in weight was between 500 and 600 %.

For weight differences greater than 40 %, the weights used in the BAPLIE were always less than those manifested in the cargo documentation (B/Ls).

In addition to the aforementioned, it was verified that the 16 containers with a difference greater than 200 % (in other words, those containers with a declared weight two times greater than the weight used for carrying out the ship stability calculations) were located high above on deck, which is not a favourable location in terms of the ship's stability. These containers were among the lightest in accordance with the weight listed in the BAPLIE, which explains why during the new load configuration, they were relocated to a higher position on deck.

The weights listed in the BAPLIEs should be identical to the weights listed in the B/L. No explanation has been provided regarding why there were differences in most of the weights of the loaded containers.

4.3.2. *Differences in weights between the calculated weights and the B/Ls*

An analysis was carried out of the differences in weights between those declared by the owners of the cargo and the shippers, which is the weight manifested in the B/Ls, and the calculated weights after the actual weighing of containers.

In 65 % of loaded containers (98 containers), the difference in weight between the weight declared and listed in the B/Ls and the weight resulting from the actual weighing, was less than 10 %.

Of the total 150 containers, 92 weighed more than that listed in the documentation (B/Ls), while 58 of them weighed less. If we compare the total weight of the containers according to the B/Ls with the total weight as per the calculated weights, the difference in weight was 241 t higher according to the calculated weights than according to the B/Ls.

4.3.3. *Calculated weights as compared to the BAPLIE*

The magnitude of error that is normally assumed during this type of transport is around 10 %, which was predominant in this case. The weights of 85 % of the containers had been properly transferred to the BAPLIE.

4.3.4. *Distribution of containers according to the percentage of weight difference*

When distributing the number of containers loaded on board according to the percentage of weight difference, the graph in Figure 12 is obtained, which reflects the percentage differences summarized in the previous paragraphs. If the difference in weights observed in the containers is random, the associated distribution of probability should follow a Gaussian bell curve. An anomaly is observed in a significant number of containers (located on the right hand side of the graph) where the error in weight of the BAPLIE is greater than 160 %.

4.3.5. *Inconsistencies found in the information on the cargo*

After having analyzed the data relative to the weights of containers, two inconsistencies were found:

1. Large differences exist between the weights declared in the B/Ls and the weights used for carrying out the calculations and which were included in the BAPLIEs. In practice, the latter were the ship's cargo stowage plans.
2. Differences exist between the weights declared in the documents (the B/Ls) with respect to the weights resulting from the actual weighing of the containers (hereinafter referred to as calculated weights).

4.3.5.1. *Differences between the weights declared in the B/Ls and those used in the calculations (BAPLIE)*

Under normal conditions, the weight of the goods declared by the owners of the cargo to the line should remain unaltered throughout the information flow chain relative to this cargo. In other words, the BAPLIEs should have the same weights as those declared in the packing list and in the B/Ls.

As mentioned above, the line contacted X-PRESS Iberia to request shipping of the containers from Algeciras to Italy (X-PRESS Iberia, located in Barcelona, belonged to company X_PRESS. X-PRESS Iberia used MARITIMA DEL ESTRECHO, S.A., located in Algeciras as agents or consignees). Following the internal procedures of X-PRESS, their planners from the offices of Dubai carried out

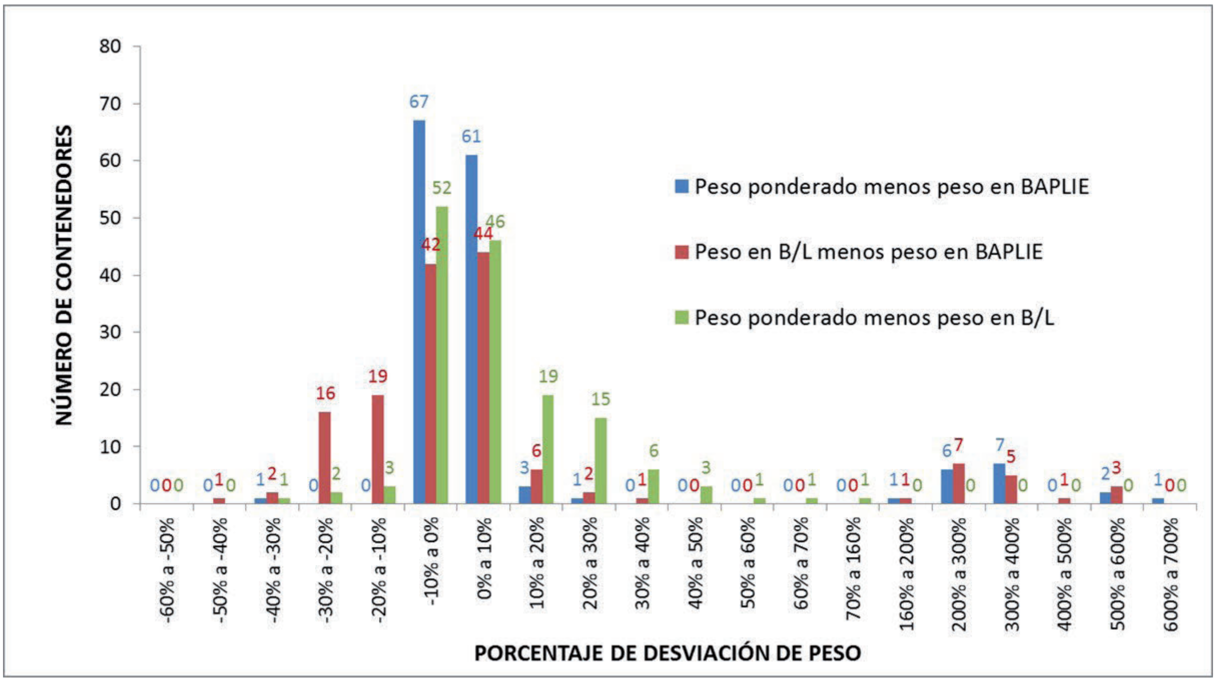


Figure 12. Distribution of the weight differences found in loaded containers

the initial planning of the cargo on board the M/V DENEB, taking into consideration the loading and unloading ports and the different weights transported in each container. Once this stowage plan was devised it was sent to the Skipper via satellite for his approval as well as to the terminal by means of a cargo BAPLIE.

At some time in the information flow chain between the different parts erroneous weights were added to the cargo BAPLIEs of M/V DENEB, which did not correspond to the weights declared by the shippers in the B/Ls of the containers.

The error affected a large percentage of containers.

The immediate consequences were that the Skipper carried out the stability calculations using erroneous data.

4.4. Stability analysis

A copy of the load program used on M/V DENEB, certified by *Germanischer Lloyd* at its origin, was used to analyse the load conditions on board.

To carry out the analysis of the ship's load status, data was compared relative to the expected load condition, its modification and the status at the time of the accident. For this the three different weights of the containers were used; in other words,

a. The weights transmitted to the parties in the stowage plans, which were listed in the BAPLIEs.
b. The weights declared in the B/Ls.
c. The calculated weights obtained by actually weighing the containers after the accident.

The different calculations were carried out while maintaining the rest of the ship's weights constant; that is, the ballasts, fuel, oils, etc. The load conditions analyzed were:

- "Scheduled stowage plan": Initial stowage plan with 163 loaded containers.
- "Modified stowage plan": Stowage plan resulting from applying the modifications approved by the Skipper after the load problem pointed out by stowage personnel, with 163 containers on board.

- "Stowage condition at the time of the accident": Status that summarizes the ship's load status at the moment she capsized, with 150 containers on board.

In the first two load statuses the weight of the 13 containers that were not loaded on board and which are listed in the BAPLIE have been considered valid since their corresponding B/Ls are not available and they have not been weighed after the accident.

4.4.1. *Scheduled stowage plan*

According to the calculations carried out by CIAIM, the scheduled stowage plan that was available to the Skipper when he began loading the ship according to the initial BAPLIE received on board was in compliance with applicable stability criteria.

However, the same load condition considering the weights declared according to the B/Ls or the calculated weights after the containers were weighed does not comply in any case with the stability criteria. Figure 13 shows the three stability curves obtained for the scheduled stowage plan:

- In black: Stability curve drafted by the ship using the BAPLIEs exchanged between the ship and the load terminal.
- In green: Stability curve for the same load condition devised with data from the B/Ls; in other words, with the information provided by the owners of the cargo to the line.
- In red: Stability curve for the same load condition but using the calculated weights of the containers obtained when these were weighed after the accident.

In all three cases the ship maintains a positive MG. If the ship had been loaded according to the scheduled stowage plan, in her final configuration, she would not have capsized in port. Also, she would have been overloaded had her ballast not been modified. In this respect, it is worth mentioning that the ship was carrying 65 t in starboard side tank no. 1 and that the forward double lined tanks had been filled.

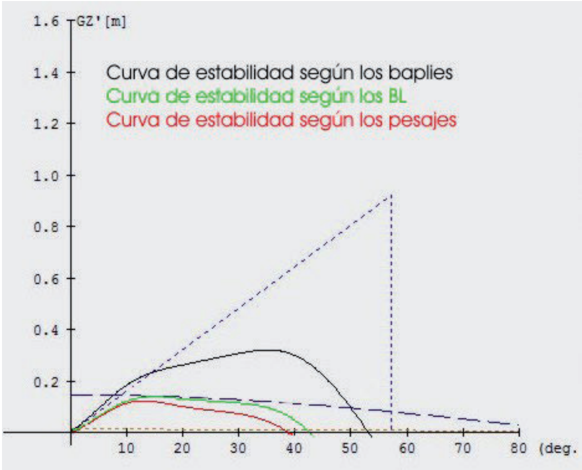


Figure 13. Scheduled stowage plan: comparison of the three stability curves corresponding to the three available weights

The ship had departed with her stability in a seriously compromised condition, even with a risk of capsizing. The Skipper would not be aware of this hazardous condition.

During the load planning, had the weights manifested in the B/Ls been used, the Skipper would have rejected the plan, as it was not in compliance with stability criteria. The same can be said, even more so, if the Skipper had known the calculated weights.

4.4.2. *Modified stowage plan*

Once the ship's scheduled stowage plan was modified, the new configuration for the load according to the modified BAPLIE created a new stability curve, as can be seen in Figure 14.

In the figure we can see how the ship's stability curve for the new condition, represented in red, was considerably reduced. In this load condition most of the regulatory stability criteria were no longer complied with.

Surprisingly, the Skipper agreed to load the ship according to these parameters.

Likewise, considering the calculated weights or the weights listed in the B/Ls, the ship did not comply with the stability criteria. Figure 15 shows the three corresponding stability curves.

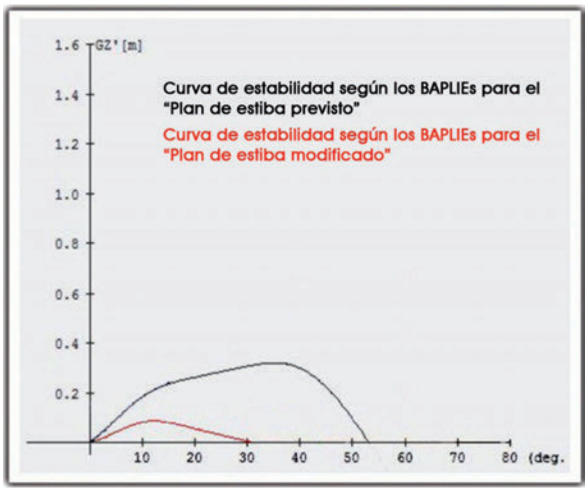


Figure 14. Comparison of the stability curves using the data in the BAPLIEs for the scheduled and modified stowage plan

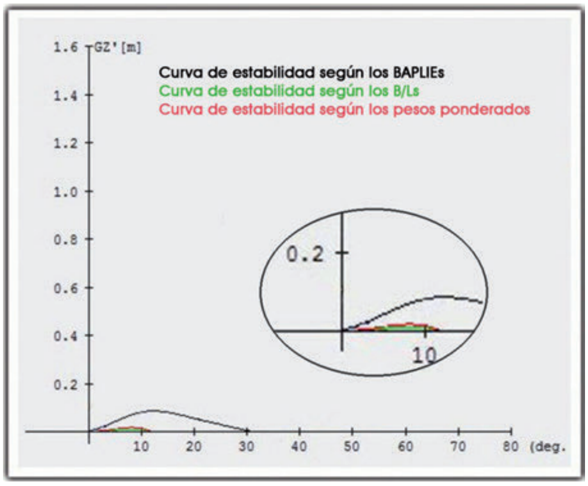


Figure 15. Modified stowage plan: Comparison of the stability curves drafted using the three analyzed weight lists

The area of interest has been written in an ellipse and has been enlarged due to its small size.

The colours in the graph of Figure 15 must be interpreted as follows:

- The curve corresponding to the weights in the BAPLIEs is represented in black.
- The curve corresponding to the weights in the B/Ls is represented in green.
- The curve corresponding to the calculated weights is represented in red.

The stability curves with the weights according to the B/Ls and according to the calculated weights are basically flat, there is no dynamic stability and the ship's MG is negative or null.

The result was that the ship was practically in an unstable balance condition. This load configuration would surely result in the ship capsizing at some time throughout the loading operations and definitely as soon as the ship cast off to set sail.

If the Skipper actually checked the new stowage plan shown to him by the First Officer for approval, the Skipper should have been aware that the ship did not comply with the stability criteria. Since the actual weights were greater than the weights used for the stability calculations on board, the ship had less stability than that shown in the calculations.

4.4.3. *Stowage condition at the time of the accident*

The moment in which the accident occurred corresponds to an intermediate point in the modified stowage plan. At that moment 150 containers had been loaded of the 163 that were scheduled according to the modified stowage plan, and the 13 remaining containers were still going to be loaded on the deck. The stability curves at the time of the accident are shown in Figure 16:

- The curve corresponding to the weights in the BAPLIEs at that moment is represented in black.
- The curve corresponding to the weights manifested in the B/Ls is represented in green.
- The curve corresponding to the calculated weights is represented in red.

None of the three cases were in compliance with the regulatory stability criteria.

The corrected metacentric height was 5, 11 or 47 cm, depending on what data is used for the stability calculations.

In any case, the actual stability of the ship was so compromised that a slight breeze or small swell would have sufficed to counteract the ship's residual righting torque.

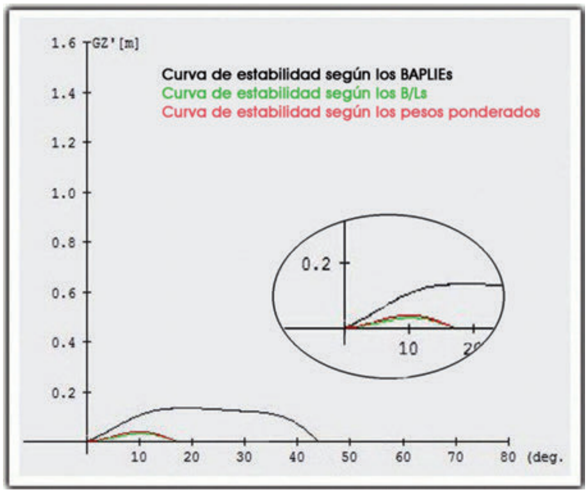


Figure 16. Comparison of the righting arm curves at the time of the accident

4.5. Loading operation

4.5.1. *Results of the calculation software*

Studying the evolution of the data provided by the calculation program, it is easy to notice that the loading of containers on deck negatively affects the stability, as its immediate effect is to decrease the metacentric height. Therefore, the data that must have been observed by the First Officer, who carried out the new stowage plan, and which the Skipper subsequently approved, should have been sufficient to raise concern that that load condition would seriously compromise the ship's stability.

This program visually and clearly shows if the ship is properly loaded or not as long as the entered data is accurate.

4.5.2. *Use of the ballasts*

This ship did not have any type of help in controlling the heeling since the ballast was carried out by ordering the Oiler to enter more or less ballast in the tanks.

During the First Officer's watch he had ordered to pump out "double lined tanks number 1 port and starboard" and subsequently fill 65 t in the "starboard side tank no. 1" to compensate for the heeling. In other words, the filling of the ballast tanks at that moment was asymmetrical.

The aforementioned 65 t, which have been used for the calculations carried out by the investigation to document the entire report, were obtained from crew statements. Reasons exist indicating that this information was not correct.

Calculations have been carried out that show that in the condition the ship was in, she would have been righted using 85 t in the starboard side tank no. 1 instead of the 65 t that were manifested. However, this data must be taken with certain reservations since the ship was near indifferent balance, if not negative.

It is worth noting that the modified stowage plan, in order for the ship to be righted, required introducing 163 t into Stbd. Side tank no. 1 instead of the 65 t that the crew stated they had entered at the time of the accident. It must be taken into account that only 13 containers remained to be loaded during the 2nd Officer's watch, and that neither he nor the Oiler had received any instruction to modify the ballast. This fact denotes that the ship's ballast was practically final with the exception of small, last minute corrections. This means that the crew neglected to implement a change of practically 100 t in the ballast of a side tank (at 7.95 metres from the centreline), without said change even being considered. A crew carrying out an adequate supervision of the loading process should have been aware of this change in the ballasts, which indicated that the configuration of the load and/or the ballasts was not correct.

4.5.3. *Planning*

It is surprising that the Skipper and the First Officer did not implement any changes in the load planning in order to minimize correction using the ballast tanks.

This was an unequivocal sign that the weights used for the calculations were tarnished by a serious lack of good judgement.

Load planning is always carried out to ensure the ship is able to remain upright by maintaining positive stability. It is normal for a ship's stability to be affected by inaccurate weights being indicated by the shippers.

4.5.4. *Lack of integration by part of the Deck Team Lack of instructions*

During the loading of the containers, and due to the heeling of the ship, it was decided to begin stowing alternatively on each side. The ship would sometimes reach 10° of healing to either side. These heeling movements did not get the crew's attention, despite their intensity and duration.

Movements of the ship to both sides may be observed by examining the available video recording; however, the ship seems to heel more frequently to her starboard side. The fact that the camera is far away and that the quality of the video is not ideal, have prevented us from carrying out measurements to obtain more information.

When the watch was relieved and the Second Officer came on, in spite of him alternating the loading of containers to each side because he noticed they were heavy and causing the heeling, it seems surprising that he did not have a loading sequence for the containers nor for the ballasts. Therefore, it seems that his job only consisted of monitoring the loading of the containers on the deck, even though he was standing in as Watch Officer.

Obviously, the behaviour of the ship was also noticed by the rest of the crew, Skipper and First Officer included, since they were on the same ship and experiencing the ship's movements. However, nobody reported being concerned about the ship's behaviour.

4.6. Control of the weight of containers

Even though the safety of a vessel was conditioned by the accuracy of the weights declared in the process that went from the weights declared by the cargo expediter to the loading of the ship, there were few controls to check that the weights of containers were reasonably close to what was indicated in the documentation.

The terminal of Algeciras weighs all the containers that access the terminal by ground for export, but the containers that are unloaded from one vessel to be loaded onto another (transfer of containers) are not weighed, even though most of the containers handled by the terminal fall into this category. All the containers that were scheduled to board M/V DENEB had been transferred from another ship and therefore, none of them were weighed by the terminal of Algeciras.

Several intermediate steps exist where it is possible to weigh the cargo in containers from the time they enter a cargo terminal.

- The moment in which the truck could have been weighed at the time the cargo enters the terminal via ground transportation.
- When containers are downloaded from the feeder ship and are stacked and stored until loaded onto another ship.
- When they are transported from that storage location to the crane that will subsequently load it onto the ship.
- Finally, when they are loaded onto the ship.

Once the container has been loaded onto the ship, it is impossible to weigh.

For ship safety reasons, the best time to weigh a container is when the crane is loading it on board, where significant weight differences can be detected when compared to the weight included in the BAPLIE transmitted to the ship. Currently, container loading cranes are available that are capable of weighing containers during the loading.

4.7. Capsizing towards the starboard side

The pressing against the fenders and the pier produced by the ship's mooring lines explains the ship's limited transverse movements. Surely, the mooring lines caused the ship to capsize towards the pier and not towards the ocean side, which would have had destructive consequences since the ship would not have encountered any obstacle preventing her from completely tipping over. If this had occurred, it is very possible that some crewmembers may not have been able to disembark the ship to safety.

The ship was moored using two long lines and one spring rope per head, fibre lines, which were not operated by constant tension machines. Even though the tide was going down when the accident occurred, the amplitude was 80 cm and the height of the pier with respect to the ship's deck was such that the lines arrived almost straight and therefore, were ideal for effectively mooring the ship.

After the accident, some mooring lines failed, which allowed the ship to move several metres forward, resulting in some containers coming loose and sliding off the deck and into the side of the pier, deforming and breaking as a result of the movement. 14 minutes later two tugs from the port arrived on the scene and began to push the ship against the pier by its port bilge in order to prevent the ship from separating from the pier and completely capsizing due to the fact that the mooring lines had broken off.

4.8. Human factor assessment

4.8.1. *Commercial pressures*

The vessel was not a pure container ship. It could operate as a multipurpose vessel or traditional cargo ship.

It could transport containers permanently, but for this purpose cranes would need to be installed to facilitate the task of stowing the containers. This installation is costly and affects the operation of a ship of this type, because if the ship is to be used for a different type of transport (for example general cargo or bulk) the cranes must be disassembled, which is expensive and time-consuming. Regardless of whether cranes are used or not used, the use of stowage accessories to stow containers in the cargo bays are required.

When stowage personnel refused to load over these stowage supports because they considered these to be dangerous to work near them, if the ship would have set sail without the 13 affected containers on board, it would have looked like the vessel was having problems or that she was not capable of transporting the containers manifested in the freight. The Skipper did not want to leave the 13 containers affected by the problem encountered with stowage personnel on the pier and the evidence shows that he agreed to load the cargo holds, leaving some rows located adjacent to the sides empty.

4.8.2. *Risk perception*

There were two persons on board, the Skipper and the First Officer, who were responsible for handling and stowing the cargo in accordance with the STCW 1978 agreement as amended. From the analysis of the events, it can be concluded that neither of them carried out this function properly.

Regardless of whether the Skipper was provided with inaccurate information, the facts indicate that the crew did not carry out stability calculations using the information they received, nor did they properly assess the obtained results, or they simply ignored the results.

The fact that it was not possible to recover the contents of the ship's loading computer hard drive prevented us from determining if the crew actually carried out the required calculations prior to authorizing the loading of the ship.

4.8.3. *Lack of experience*

The First Officer only had a few months of experience on these types of ships, the Second Officer had been promoted from his position as a Boatswain three months prior, and the Skipper had only been in this position for one month.

The Second Officer had recently been qualified as a Bridge Officer. His competency certificate for "officer in charge of navigating on board ships larger than 500 GT" was issued on 19 March 2010.

The lack of experience may explain why the anomalous behaviour of the ship was not detected, which became evident at some time due to the loss in stability she was experiencing. The ship was docked at the pier but at some point they must have noticed that the heeling movements were too pronounced and not consonant with the loading of each container. The movements were too slow and it took too much time for them to stop.

The lack of awareness of danger on the part of the Skipper, who did have experience as a first Officer on these types of ships, may be a result of fatigue on his part. This fatigue would be aggravated by the fact that he was the only officer with experience on the ship with regards to carrying this type of cargo.

4.8.4. *Lack of communication between members of the Deck Officers Group*

The Deck Officers did not form a cohesive working group. The lack of integration with each other may have contributed to the situation getting out of control.

All three persons comprising the group of Deck Officers were of a different nationality.

The evidence points to the fact that the Second Officer did not participate in the load planning or the ballasts, nor was he made aware of what was going on with these issues. On the day of the accident, according to his statement, he did not have a copy of the stowage plan that included the planning of the ballasts, even though he was standing duty as a Deck Watch Officer.

The ballasts were handled directly between the First officer and the Oiler, who operated the pumps and valves.

According to statements, permanent written orders from the Skipper were available at the wheelhouse and in the ship's navigation log. However, there is no evidence to suggest that these orders included instructions regarding excessive heeling movements of the ship or, more importantly, slow response behaviour by the ship during the loading of containers.

4.8.5. *Lack of planning*

An operational load planning of the containers had not been carried out so the Officers and Skipper could control the loading of the cargo with a pre-existing plan. Said control would be carried out by checking the expected draughts and heels (normally none permanent) as well as the status of the ballasting and de-ballasting operations.

Any deviation from the plan should lead to a reaction by the Watch Officer to find out the reason and be able to explain it (advance or delay in the ballast operations, advance or delay in the loading operations, improper load sequence, incorrect weights, etc.).

4.8.6. *Fatigue*

Fatigue may have played an important part in the management and development of the events. Of the interviews maintained with the crew, and especially with the two senior Deck Officers, a feeling of fatigue and stress was evident in both professionals after having been called in the early morning hours to modify the load plan.

The First officer completed his watch from 4 to 8 am on the 10th and shortly thereafter was called to heave in the anchor and head to the port. The unloading was then carried out, followed by the loading, and he also had to handle all the issues regarding the refusal of stowage personnel to load containers in addition to carrying out their duties as Watch Officers throughout their watches. In his own words, the moments after the accident were the only time he had had a breather since their arrival to Algeciras.

The Skipper must have experienced something similar, aggravated on one hand by the performance of the representative and management duties of his position, even though in port he was exempt from standing any watches. As has previously been mentioned in this regard, it is important to consider that the Skipper was the most competent Officer; in other words, he was the only officer with experience transporting containers on board the M/V DENEB.

* * *

Chapter 5. **CONCLUSIONS**

This Commission has concluded that the accident involving container ship DENEB occurred because of errors made during the planning and loading of the cargo. As a consequence of these errors, a load condition was reached in which the vessel lost her stability and capsized. The following causing factors contributed to the vessel's inadequate load condition and subsequent capsizing:

- The weights declared for many containers were much lower than the actual weights.
- The containers were never weighed to verify that the declared weights were accurate.
- Errors were made during the preparation of the electronic information (BAPLIEs) that was transmitted to the vessel to check her stability under the different expected load conditions. The weights included in the BAPLIEs did not coincide with the declared weights.
- The final load plan resulting from the modifications requested by the ship during operations reflected a load condition in which the vessel would not comply with the regulatory stability criteria. In spite of this, the Skipper authorized the loading of the vessel.
- The team of deck officers improperly oversaw the loading of the vessel. During the loading process several indications suggested that the load planning was erroneous, but no steps were taken to verify this.
- None of the deck officers had sufficient experience in the positions they held on board. This fact made it difficult to form a solid working team with established procedures and was conducive to the crew neglecting their obligations.
- The deck officers were overloaded with work and were probably fatigued.

* * *

Chapter 6. SAFETY RECOMMENDATIONS

In order to prevent similar accidents and as a result of the assessment of the accident involving M/V DENEB, the Standing Commission for Maritime Accidents and Incident Investigations Plenary makes the following safety recommendations:

- TO MAERKS LINE and X-PRESS:

  1. To conduct internal audits to detect the origin of the errors resulting in the weights included in the BAPLIE being different from the weights included in the Bill of ladings (B/L), and to inform CIAIM of the results of said audits.

- TO MAERKS LINE, X-PRESS and APM TERMINALS Algeciras:

  2. To implement quality control systems that will guarantee the proper transmittal of information on the weights of containers between all parties involved in the load planning of container ships, including the agents used for drafting or transmitting the information.

- To the container terminal APM TERMINALS Algeciras:

  3. To carry out an effective weighing of the containers prior to loading them on board to confirm that their actual weight coincides with the weight listed in the BAPLIE that is transmitted to the ship.

- To shipowning company USC BARNKRUG GMBH & Co KG:

  4. To implement a human resources policy that promotes the formation of efficient working teams on board their ships. As a minimum, this policy should include

     a. The establishing of specific work procedures for managing the loading and unloading of their container ships.
     b. Determine the minimum number of deck officers in order to guarantee an adequate supervision of the loading and unloading process by well-rested personnel.
     c. Training deck officers regarding the loading and unloading of container ships.
     d. Ensure that officers with sufficient experience are on board.
     e. Establish management principles for the company that gives priority to decisions made by their Skippers over any commercial decision.

* * *

Annex 1. CARGO ARRANGEMENT DIAGRAM

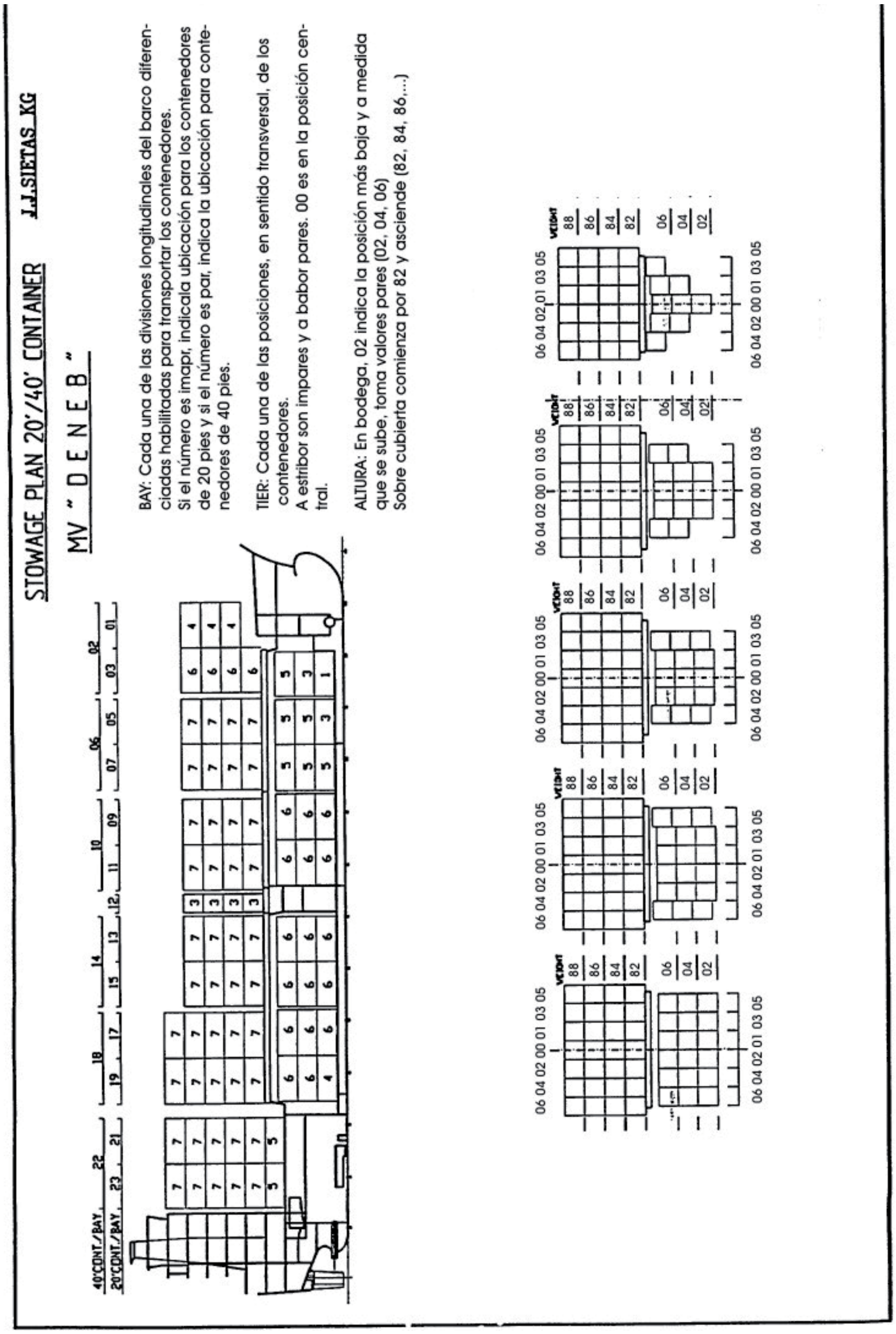


Figure 17. Diagram of ship divisions and nomenclature of the locations of containers

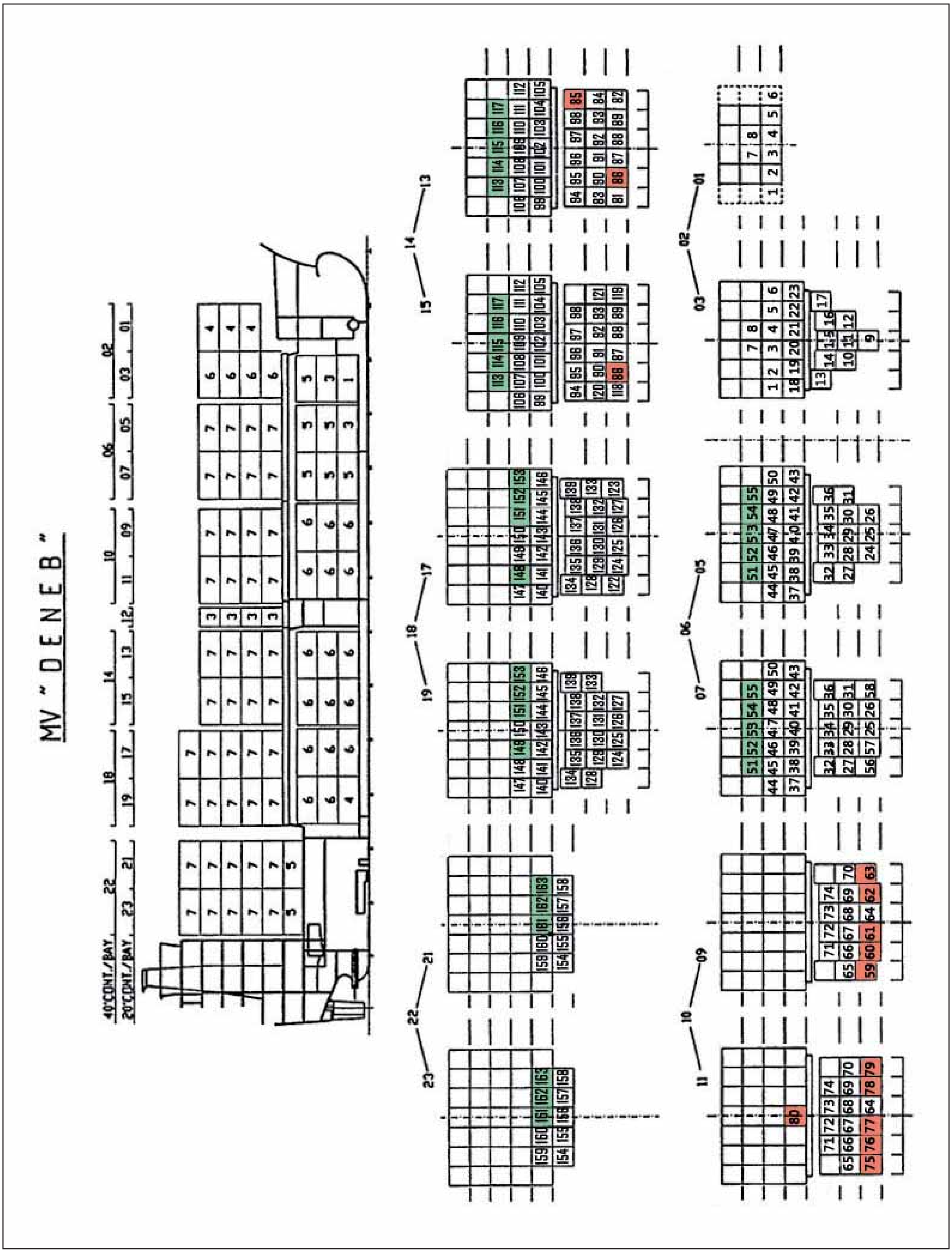


Figure 18. Initial cargo loading plan for container ship M/V DENEB

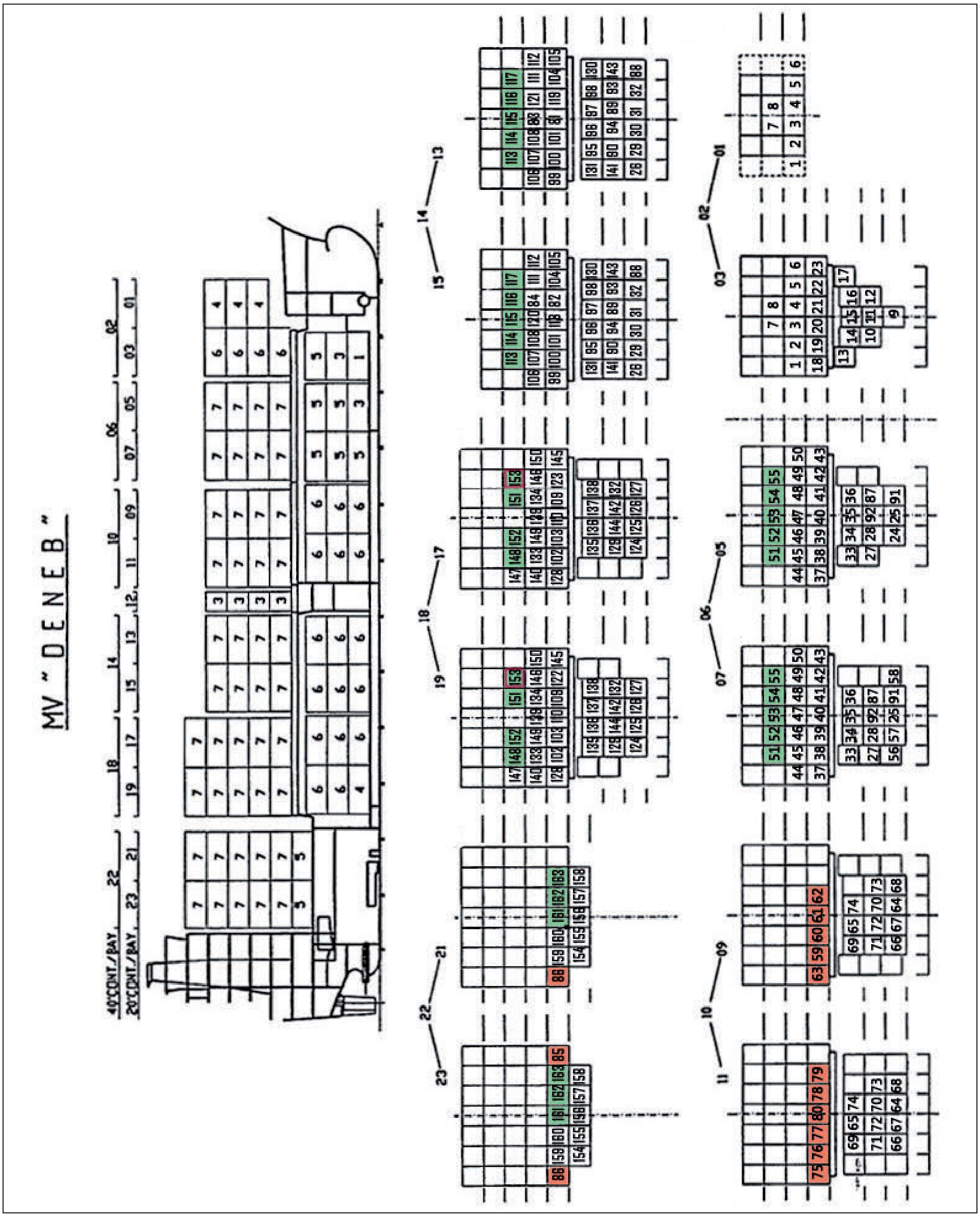


Figure 19. Final condition of the cargo of M/V DENEB Container 153 marked with a red square was the last container loaded on board. The containers marked with a green background are those whose actual weight exceeded the weight listed in the BAPLIE by more than 200%. Containers with a red background are those that at the time of the accident were not on board; however, their position on board was reflected in the modified stowage plan

Annex 2. STABILITY CALCULATION

All the references to stability criteria used in this annex refer to the stability code without failures for all types of vessels, which is governed by IMO instruments, approved on 4 November 1993 by resolution of IMO assembly A.749(18), and is the reference framework by which M/V DENEB was designed and built. Due to requirements of her flag, the code was mandatory for M/V DENEB.

The general stability criteria without failure for all ships under said code and applicable to M/V DENEB are the following:

3.1.2 *Criterios generales recomendados*

3.1.2.1 El área bajo la curva de brazos adrizantes (curva de brazos GZ) no será inferior a 0,055 m.rad hasta un ángulo de escora $\theta = 30°$ ni inferior a 0,09 m.rad hasta un ángulo de escora $\theta = 40°$, o hasta el ángulo de inundación θ_f* si es inferior a 40°. Además, el área bajo la curva de brazos adrizantes (curva de brazos GZ) entre los ángulos de escora de 30° y 40° o de 30° y θ_f, si este ángulo es inferior a 40°, no será inferior a 0,03 m.rad.

3.1.2.2 El brazo adrizante GZ será como mínimo de 0,20 m a un ángulo de escora igual o superior a 30°.

3.1.2.3 El brazo adrizante máximo corresponderá a un ángulo de escora preferiblemente superior a 30° pero no inferior a 25°.

3.1.2.4 La altura metacéntrica inicial GM_o no será inferior a 0,15 m.

Figure 20. General stability criteria that was to be complied with by M/V DENEB

Compliance with the stability criteria has been studied for the following three load conditions:

- "Scheduled cargo stowage plan" corresponding to the initial stowage plan with the 163 containers in the position that had been initially contemplated prior to stowage personnel stopping the loading operations.
- "Modified stowage plan". According to this new plan the 163 containers were going to be loaded on the ship, leaving empty spaces in the cargo holds and loading the affected containers on the deck as long as no other incidences had occurred.
- "Moment of the accident", corresponding to an intermediate condition of the "modified stowage plan", which includes the moment in which the accident occurred with 150 containers on board instead of the 163 that were scheduled to be loaded.

The three previous load conditions have been devised while considering the three different lists of weights that exist. These three lists weights correspond to:

- Weights declared by the owners of the cargo in the Bill of Ladings.
- Weights included in the BAPLIE, electronic documents transmitted between the different parties involved with the cargo and used to carry out the stowage calculations for containers on board.
- Calculated weights, obtained by weighing the containers after the accident, considering the effect of the water on the weight of the submerged containers. It is estimated that the calculated weights are those that most accurately reflect the actual weights of the containers at the time the ship was loaded.

The stability calculations were carried out using a copy of the load calculation program that M/V DENEB had installed on board, which was supplied by the shipowner.

The following sections include a summary of each one of the aforementioned stowage plans and for the different lists of handled weights. In the following table the values that are not compliant with the IMO criteria included in the first column are listed in red.

Scheduled stowage plan

Table 6. Scheduled stowage plan Compliance with stability criteria

	Scheduled cargo stowage plan			
	IMO criteria	*Weigths in the BAPLIEs*	*B/Ls weights*	*Calculated weights*
No. of containers		163	163	163
GM' (corrected)	≥0.15	0.92	0.58	0.59
A_{30}	≥0.055	0.105	0.054	0.046
A_{40}	≥0.09	0.159	0.07	0.054
A_{30-40}	≥0.03	0.054	0.016	0.057
GZ'_{30}	≥0.20	0.304	0.111	0.075
GZ'_{max}	25°	0.317 to 35.2°	0.136 to 14.8°	0.125 to 13°
Heeling (+starboard)		−0.61°	3.70°	1.48°
Notes relative to de status of the cargo				OVERLOADED

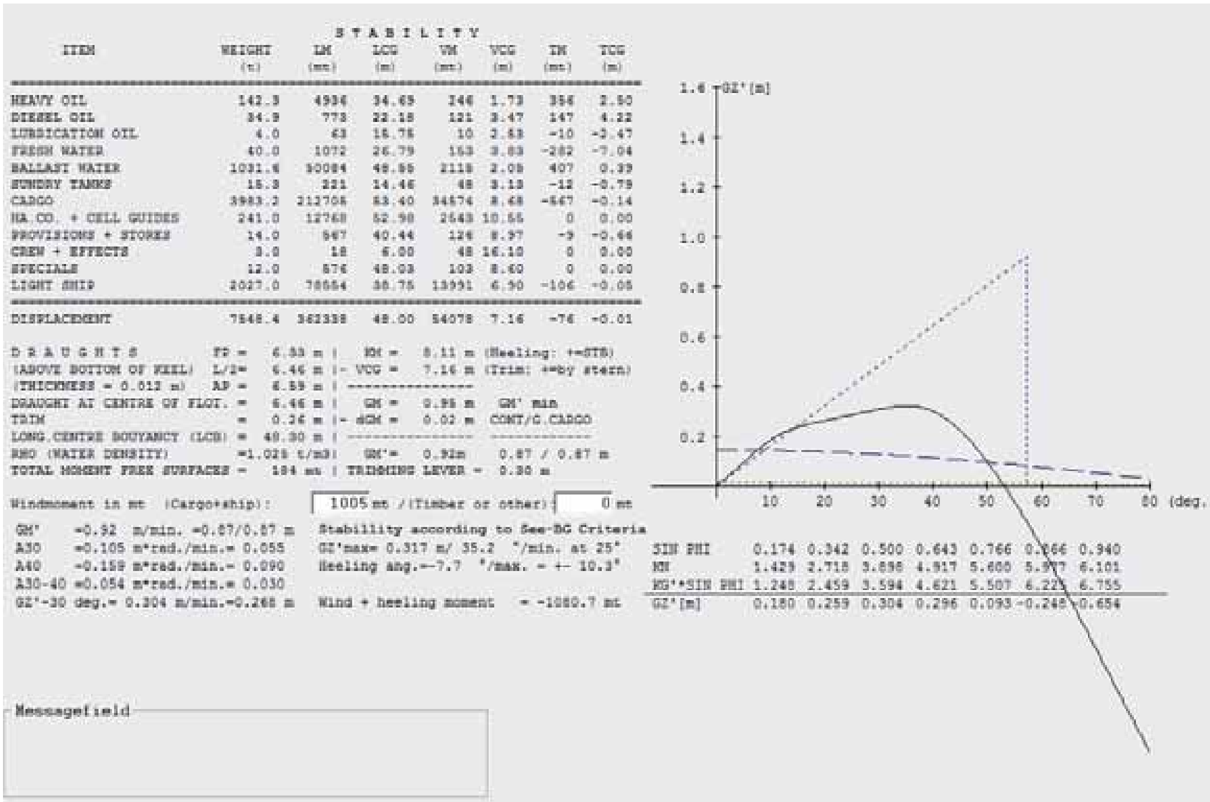
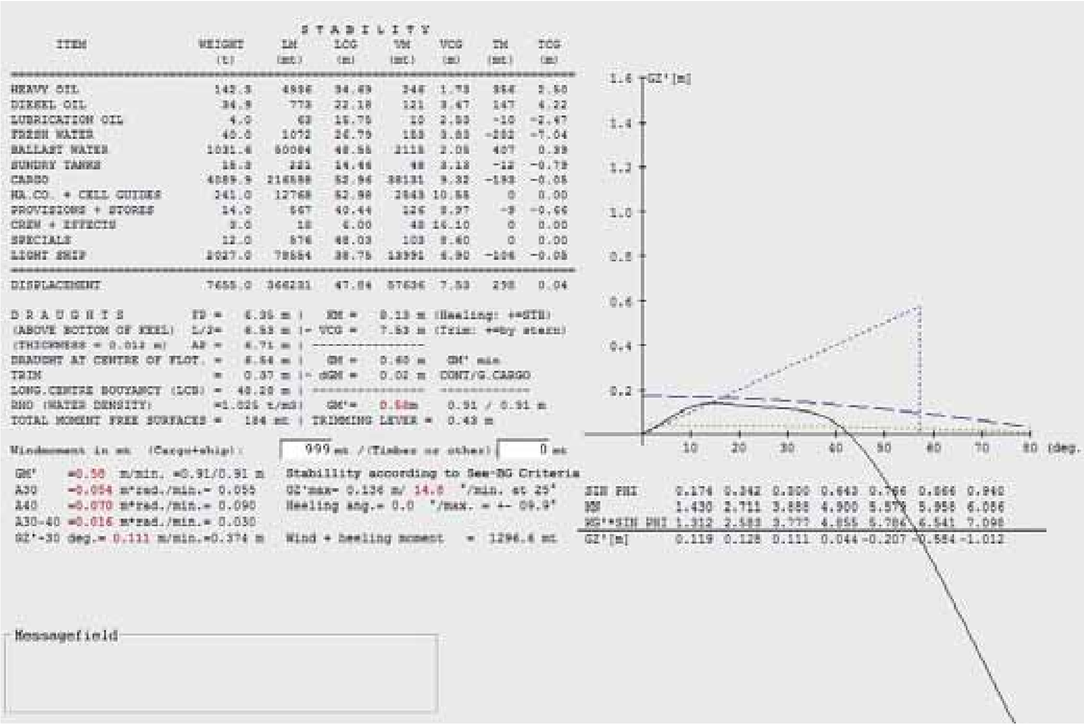


Figure 21. Scheduled stowage plan, weights according to the BAPLIE



S T A B I L I T Y

ITEM	WEIGHT (t)	LM (mt)	LCG (m)	VM (mt)	VCG (m)	TM (mt)	TCG (m)
HEAVY OIL	142.3	4986	34.69	246	1.73	356	2.50
DIESEL OIL	34.9	773	22.18	121	3.47	147	4.22
LUBRICATION OIL	4.0	63	15.75	10	2.53	-10	-2.47
FRESH WATER	40.0	1072	26.79	153	3.83	-282	-7.04
BALLAST WATER	1031.6	50084	48.55	2115	2.05	407	0.39
SUNDRY TANKS	15.3	221	14.46	48	3.13	-12	-0.79
CARGO	4089.9	216588	52.96	38131	9.32	-193	-0.05
HA.CO. + CELL GUIDES	241.0	12768	52.98	2543	10.55	0	0.00
PROVISIONS + STORES	14.0	567	40.44	126	8.97	-9	-0.66
CREW + EFFECTS	3.0	18	6.00	48	16.10	0	0.00
SPECIALS	12.0	576	48.03	103	8.60	0	0.00
LIGHT SHIP	2027.0	78584	38.75	13991	6.90	-106	-0.05
DISPLACEMENT	7655.0	366231	47.84	57636	7.53	298	0.04

D R A U G H T S FP = 6.35 m | KM = 8.13 m (Heeling: +=STB)
(ABOVE BOTTOM OF KEEL) L/2= 6.53 m |- VCG = 7.53 m (Trim: +=by stern)
(THICKNESS = 0.012 m) AP = 6.71 m | ----------------
DRAUGHT AT CENTRE OF FLOT. = 6.54 m | GM = 0.60 m GM' min
TRIM = 0.37 m |- dGM = 0.02 m CONT/G.CARGO
LONG.CENTRE BOUYANCY (LCB) = 48.20 m | --------------- -------------
RHO (WATER DENSITY) =1.025 t/m3| GM'= 0.58m 0.91 / 0.91 m
TOTAL MOMENT FREE SURFACES = 184 mt | TRIMMING LEVER = 0.43 m

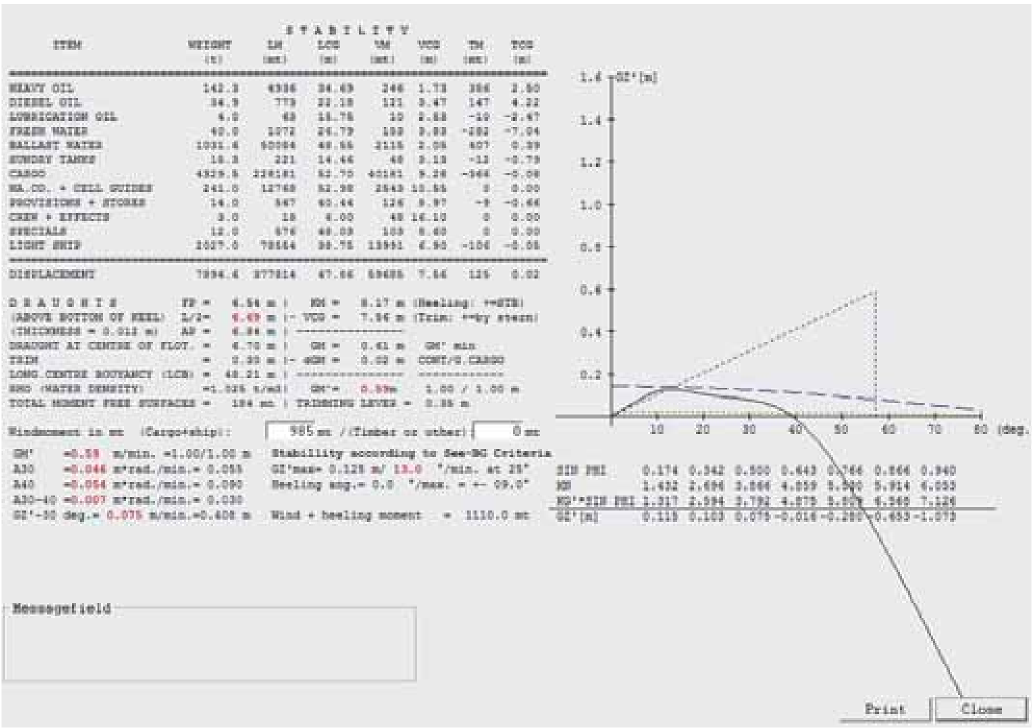
Windmoment in mt (Cargo+ship): 999 mt /(Timber or other) 0 mt

GM' =0.58 m/min. =0.91/0.91 m
A30 =0.054 m*rad./min.= 0.055
A40 =0.070 m*rad./min.= 0.090
A30-40 =0.016 m*rad./min.= 0.030
GZ'-30 deg.= 0.111 m/min.=0.374 m

Stabillity according to See-BG Criteria
GZ'max= 0.136 m/ 14.0 °/min. at 25°
Heeling ang.= 0.0 °/max. = +- 09.9°
Wind + heeling moment = 1296.4 mt

	10	20	30	40	50	60	70
SIN PHI	0.174	0.342	0.500	0.643	0.766	0.866	0.940
KN	1.430	2.711	3.888	4.900	5.57[illegible]	5.958	6.086
KG'*SIN PHI	1.312	2.583	3.777	4.855	5.784	6.541	7.098
GZ'[m]	0.119	0.128	0.111	0.044	-0.207	-0.584	-1.012

Figure 22. Scheduled stowage plan, weights manifested in the B/Ls



S T A B I L I T Y

ITEM	WEIGHT (t)	LM (mt)	LCG (m)	VM (mt)	VCG (m)	TM (mt)	TCG (m)
HEAVY OIL	142.3	4936	34.69	246	1.73	356	2.50
DIESEL OIL	34.9	773	22.18	121	3.47	147	4.22
LUBRICATION OIL	4.0	63	15.75	10	2.53	-10	-2.47
FRESH WATER	40.0	1072	26.79	153	3.83	-282	-7.04
BALLAST WATER	1031.6	50084	48.55	2115	2.05	407	0.39
SUNDRY TANKS	15.3	221	14.46	48	3.13	-12	-0.79
CARGO	4329.5	228181	52.70	40181	9.28	-366	-0.08
HA.CO. + CELL GUIDES	241.0	12768	52.98	2543	10.55	0	0.00
PROVISIONS + STORES	14.0	567	40.44	126	8.97	-9	-0.66
CREW + EFFECTS	3.0	18	6.00	48	16.10	0	0.00
SPECIALS	12.0	576	48.03	103	8.60	0	0.00
LIGHT SHIP	2027.0	78584	38.75	13991	6.90	-106	-0.05
DISPLACEMENT	7894.6	377814	47.86	59685	7.56	125	0.02

D R A U G H T S FP = 6.54 m | KM = 8.17 m (Heeling: +=STB)
(ABOVE BOTTOM OF KEEL) L/2= 6.69 m |- VCG = 7.56 m (Trim: +=by stern)
(THICKNESS = 0.012 m) AP = 6.84 m | ----------------
DRAUGHT AT CENTRE OF FLOT. = 6.70 m | GM = 0.61 m GM' min
TRIM = 0.30 m |- dGM = 0.02 m CONT/G.CARGO
LONG.CENTRE BOUYANCY (LCB) = 48.21 m | --------------- -------------
RHO (WATER DENSITY) =1.025 t/m3| GM'= 0.59m 1.00 / 1.00 m
TOTAL MOMENT FREE SURFACES = 184 mt | TRIMMING LEVER = 0.35 m

Windmoment in mt (Cargo+ship): 985 mt /(Timber or other) 0 mt

GM' =0.59 m/min. =1.00/1.00 m
A30 =0.046 m*rad./min.= 0.055
A40 =0.054 m*rad./min.= 0.090
A30-40 =0.007 m*rad./min.= 0.030
GZ'-30 deg.= 0.075 m/min.=0.408 m

Stabillity according to See-BG Criteria
GZ'max= 0.125 m/ 13.0 °/min. at 25°
Heeling ang.= 0.0 °/max. = +- 09.0°
Wind + heeling moment = 1110.0 mt

	10	20	30	40	50	60	70
SIN PHI	0.174	0.342	0.500	0.643	0.766	0.866	0.940
KN	1.432	2.696	3.866	4.859	5.[illegible]	5.914	6.053
KG'*SIN PHI	1.317	2.594	3.792	4.875	5.[illegible]	6.560	7.126
GZ'[m]	0.115	0.103	0.075	-0.016	-0.280	-0.653	-1.073

Figure 23. Scheduled stowage plan, calculated weights

Modified stowage plan

Table 7. Modified stowage plan Compliance with stability criteria

	Modified stowage plan			
	IMO criteria	*Weigths in the BAPLIEs*	*B/Ls weights*	*Calculated weights*
No. of containers		163	163	163
GM' (corrected)	≥0.15	0.34	−0.07	0.00
A_{30}	≥0.055	0.024	0.001	0.002
A_{40}	≥0.09	0.024	0.001	0.002
A_{30-40}	≥0.03	0	0	0
GZ'_{30}	≥0.20	0.002	−0.223	−0.231
GZ'_{max}	25°	0.083 to 12.2°	0.009 to 8.2°	0.015 to 8.2°
Heeling (+starboard)		<−5°	–	<−5°
Notes relative to de status of the cargo	OK		OVERLOADED	OVERLOADED

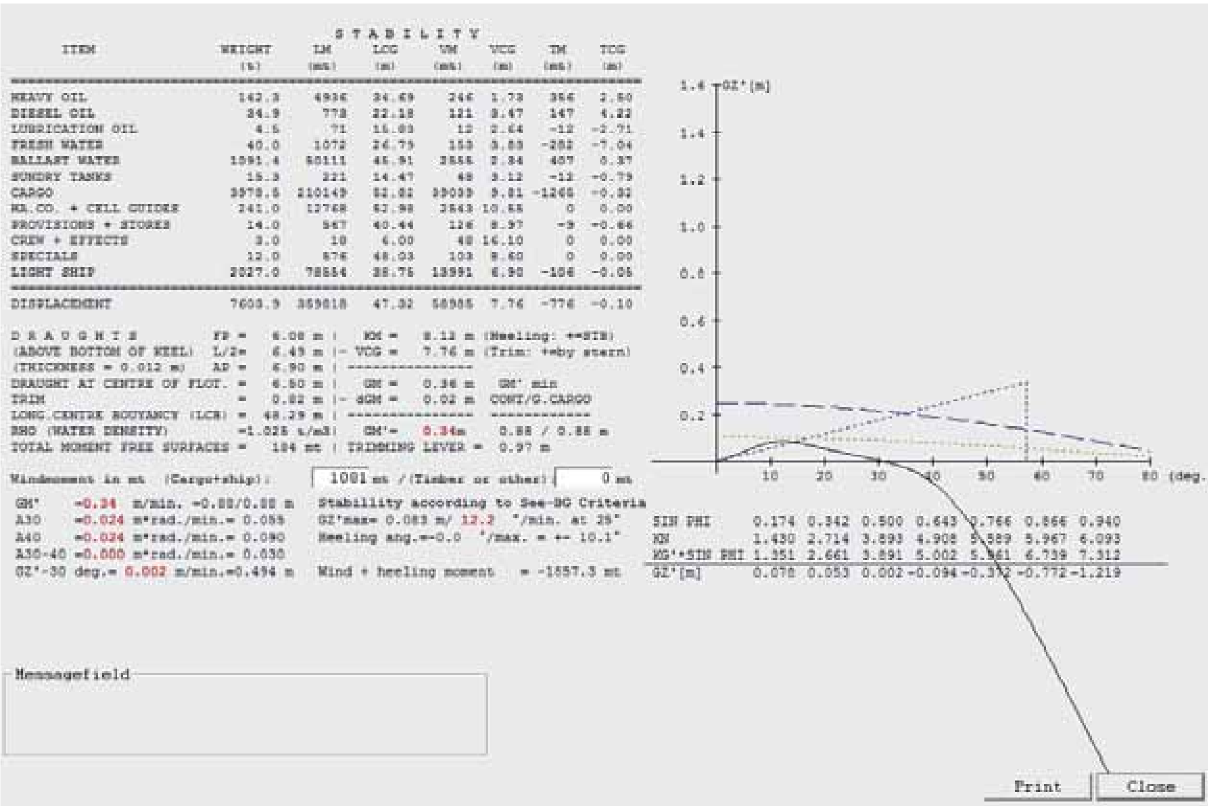


Figure 24. Modified stowage plan, weights according to the BAPLIE

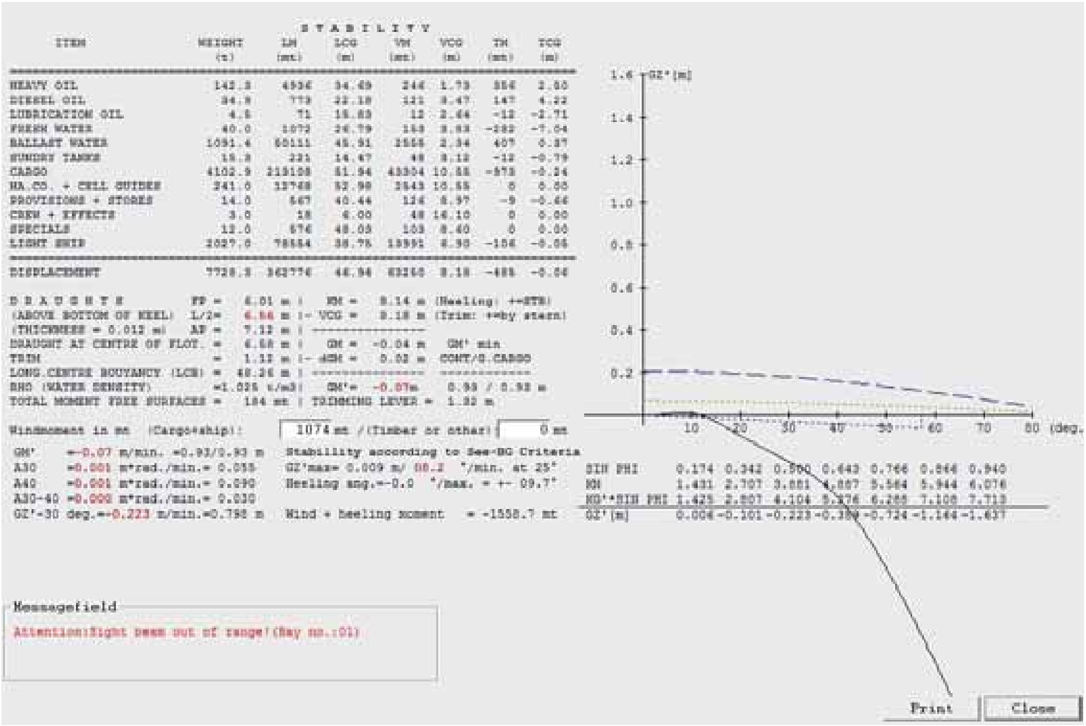


Figure 25. Modified stowage plan, weights according to the B/Ls

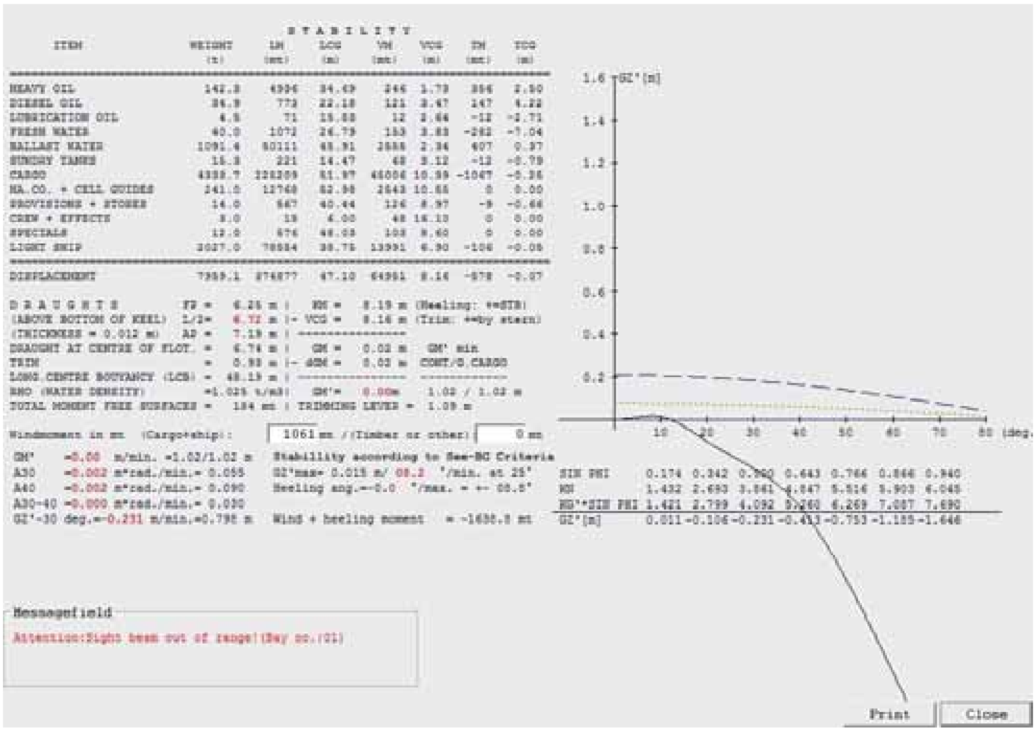


Figure 26. Modified cargo stowage plan, calculated weights

Stability at the time of the accident

Table 8. Time of the accident Compliance with stability criteria

	Stowage plan at the time of the accident			
	IMO criteria	*Weigths in the BAPLIEs*	*B/Ls weights*	*Calculated weights*
No. of containers		150	150	150
GM' (corrected)	≥0.15	0.47	0.05	0.11
A_{30}	≥0.055	0.052	0.005	0.006
A_{40}	≥0.09	0.071	0.005	0.006
$A_{30\text{-}40}$	≥0.03	0.018	0	0
GZ'_{30}	≥0.20	0.119	−0.110	−0.121
GZ'_{max}	25°	0.132 to 18.4°	0.030 to 10.4°	0.038 to 10°
Heeling (+starboard)		−2.59°	<−5°	<−5°
Notes relative to de status of the cargo	OK			

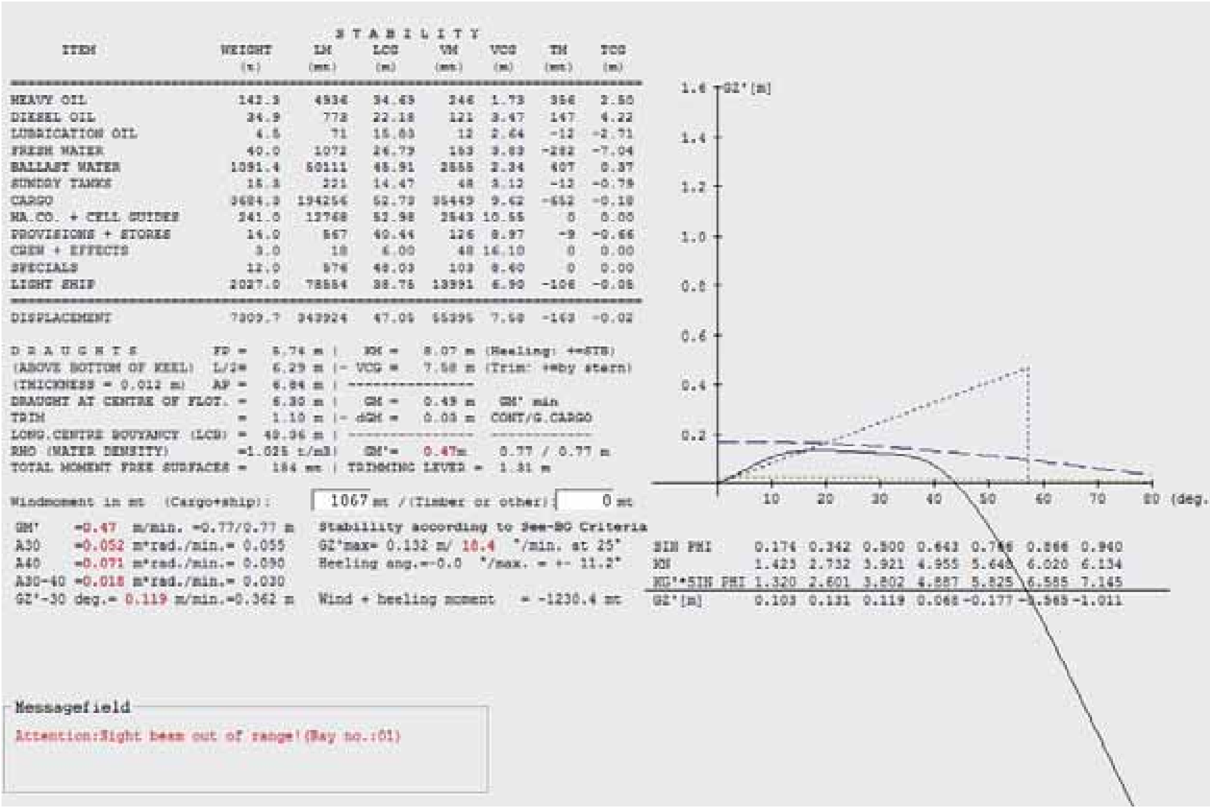
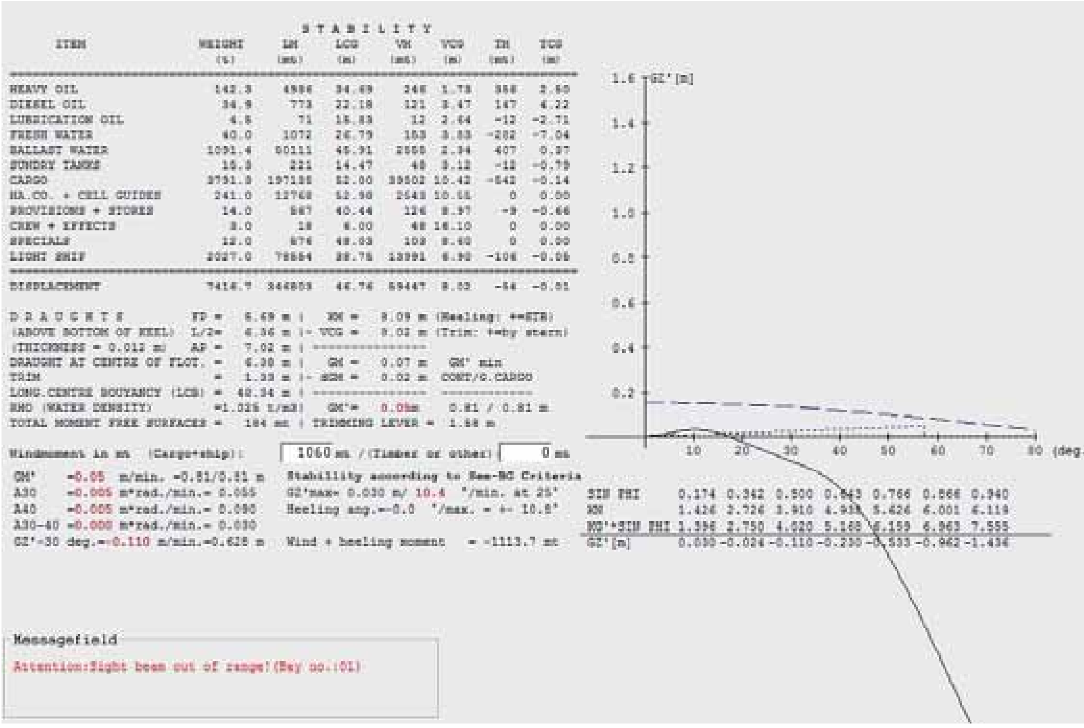


Figure 27. Time of the accident, weights according to the BAPLIE



S T A B I L I T Y

ITEM	WEIGHT (t)	LM (mt)	LCG (m)	VM (mt)	VCG (m)	TM (mt)	TCG (m)
HEAVY OIL	142.3	4986	34.69	246	1.73	356	2.50
DIESEL OIL	34.9	773	22.18	121	3.47	147	4.22
LUBRICATION OIL	4.5	71	15.83	12	2.64	-12	-2.71
FRESH WATER	40.0	1072	26.79	153	3.83	-282	-7.04
BALLAST WATER	1091.4	50111	45.91	2555	2.34	407	0.37
SUNDRY TANKS	15.3	221	14.47	48	3.12	-12	-0.79
CARGO	3791.3	197135	52.00	39502	10.42	-542	-0.14
HA.CO. + CELL GUIDES	241.0	12768	52.98	2543	10.55	0	0.00
PROVISIONS + STORES	14.0	567	40.44	126	8.97	-9	-0.66
CREW + EFFECTS	3.0	18	6.00	48	16.10	0	0.00
SPECIALS	12.0	576	48.00	102	8.60	0	0.00
LIGHT SHIP	2027.0	78564	38.75	13991	6.90	-106	-0.05
DISPLACEMENT	7416.7	346803	46.76	59447	8.02	-56	-0.01

D R A U G H T S FP = 5.69 m | KM = 8.09 m (Heeling: +=STB)
(ABOVE BOTTOM OF KEEL) L/2= 6.36 m |- VCG = 8.02 m (Trim: +=by stern)
(THICKNESS = 0.012 m) AP = 7.02 m | ----------------
DRAUGHT AT CENTRE OF FLOT. = 6.38 m | GM = 0.07 m GM' min
TRIM = 1.33 m |- dGM = 0.02 m CONT/G.CARGO
LONG.CENTRE BOUYANCY (LCB) = 48.34 m | ---------------- ------------
RHO (WATER DENSITY) =1.025 t/m3| GM'= 0.05m 0.81 / 0.81 m
TOTAL MOMENT FREE SURFACES = 184 mt | TRIMMING LEVER = 1.58 m

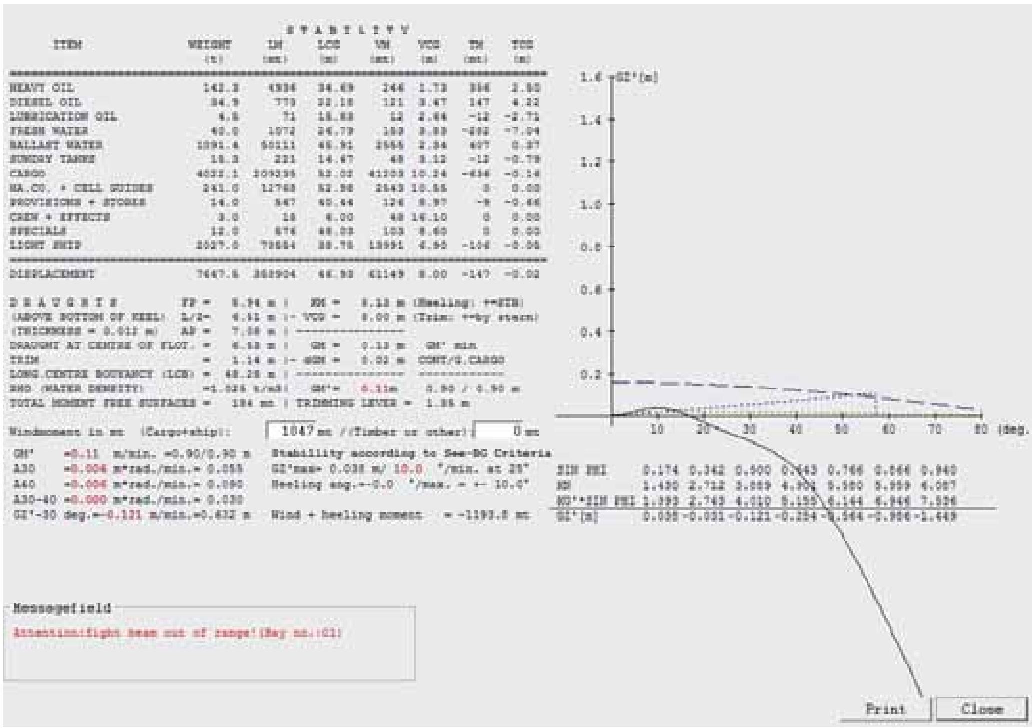
Windmoment in mt (Cargo+ship): 1060 mt /(Timber or other) 0 mt

GM' =0.05 m/min. =0.81/0.81 m
A30 =0.005 m*rad./min.= 0.055
A40 =0.005 m*rad./min.= 0.090
A30-40 =0.000 m*rad./min.= 0.030
GZ'-30 deg.=-0.110 m/min.=0.628 m

Stability according to See-BG Criteria
GZ'max= 0.030 m/ 10.4 °/min. at 25°
Heeling ang.=-0.0 °/max. = +- 10.5°
Wind + heeling moment = -1113.7 mt

SIN PHI	0.174	0.342	0.500	0.643	0.766	0.866	0.940
KN	1.426	2.726	3.910	4.938	5.626	6.001	6.119
KG'*SIN PHI	1.396	2.750	4.020	5.168	6.159	6.963	7.555
GZ'[m]	0.030	-0.024	-0.110	-0.230	-0.533	-0.962	-1.436

Figure 28. Time of the accident, weights manifested in the B/Ls



S T A B I L I T Y

ITEM	WEIGHT (t)	LM (mt)	LCG (m)	VM (mt)	VCG (m)	TM (mt)	TCG (m)
HEAVY OIL	142.3	4936	34.69	246	1.73	356	2.50
DIESEL OIL	34.9	773	22.18	121	3.47	147	4.22
LUBRICATION OIL	4.5	71	15.83	12	2.64	-12	-2.71
FRESH WATER	40.0	1072	26.79	153	3.83	-282	-7.04
BALLAST WATER	1091.4	50111	45.91	2555	2.34	407	0.37
SUNDRY TANKS	15.3	221	14.47	48	3.12	-12	-0.79
CARGO	4022.1	209235	52.02	41203	10.24	-636	-0.16
HA.CO. + CELL GUIDES	241.0	12768	52.98	2543	10.55	0	0.00
PROVISIONS + STORES	14.0	567	40.44	126	8.97	-9	-0.66
CREW + EFFECTS	3.0	18	6.00	48	16.10	0	0.00
SPECIALS	12.0	576	48.00	103	8.60	0	0.00
LIGHT SHIP	2027.0	78564	38.75	13991	6.90	-106	-0.05
DISPLACEMENT	7647.5	358904	46.93	61149	8.00	-147	-0.02

D R A U G H T S FP = 5.94 m | KM = 8.13 m (Heeling: +=STB)
(ABOVE BOTTOM OF KEEL) L/2= 6.51 m |- VCG = 8.00 m (Trim: +=by stern)
(THICKNESS = 0.012 m) AP = 7.08 m | ----------------
DRAUGHT AT CENTRE OF FLOT. = 6.53 m | GM = 0.13 m GM' min
TRIM = 1.14 m |- dGM = 0.02 m CONT/G.CARGO
LONG.CENTRE BOUYANCY (LCB) = 48.28 m | ---------------- ------------
RHO (WATER DENSITY) =1.025 t/m3| GM'= 0.11m 0.90 / 0.90 m
TOTAL MOMENT FREE SURFACES = 184 mt | TRIMMING LEVER = 1.35 m

Windmoment in mt (Cargo+ship): 1047 mt /(Timber or other) 0 mt

GM' =0.11 m/min. =0.90/0.90 m
A30 =0.006 m*rad./min.= 0.055
A40 =0.006 m*rad./min.= 0.090
A30-40 =0.000 m*rad./min.= 0.030
GZ'-30 deg.=-0.121 m/min.=0.632 m

Stability according to See-BG Criteria
GZ'max= 0.038 m/ 10.0 °/min. at 25°
Heeling ang.=-0.0 °/max. = +- 10.0°
Wind + heeling moment = -1193.8 mt

SIN PHI	0.174	0.342	0.500	0.643	0.766	0.866	0.940
KN	1.430	2.712	3.889	4.901	5.580	5.959	6.087
KG'*SIN PHI	1.393	2.743	4.010	5.155	6.144	6.946	7.536
GZ'[m]	0.038	-0.031	-0.121	-0.254	-0.564	-0.986	-1.449

Figure 29. Time of the accident, calculated weights

Anex 3. ORGANIZATIONS THAT COMPRISE THE CIAIM

The organizations that comprise the CIAIM are the Plenary and the Secretariat.

The Plenary

The Plenary Commission is charged with validating the classification of accidents or incidents and approving reports and recommendations provided after a technical investigation has been conducted.

It is comprised of the following personnel:

- The President, appointed by the Minister of Public Works and Transport.
- A board member proposed by the Colegio de Oficiales de la Marina Mercante Española (Spanish Merchant Marine Officers Association), COMME.
- A board member proposed by the Colegio Oficial de Ingenieros Navales y Oceánicos (Official Naval and Oceanic Engineers Association), COIN.
- A board member proposed by the Asociación Española de Titulados Náutico-Pesqueros (Spanish Association of Nautical/Fishing Degree Holders), AETINAPE.
- A board member proposed by the Canal de Experiencias Hidrodinámicas de El Pardo (Public Hydrodynamic Centre for Model Tests), CEHIPAR.
- A board member proposed by the Centre for Public Works Studies and Experimentation, CEDEX.
- A board member proposed by the Secretaría General del Mar del Ministerio de Medio Ambiente y Medio Rural y Marino (Secretariat General of the Sea: Environment and Rural and Marine Affairs Ministry).
- A board member proposed by the Agencia Estatal de Meteorología (State Meteorological Service) AEMET.
- A board member proposed by the Autonomous Community where the accident has occurred.
- The Secretary appointed by the Minister of Public Works and Transport. Will participate in Plenary deliberations with a voice but without voting rights.

The Secretariat

The Secretariat falls under the Plenary Commission Secretary and carries out the investigation work as well as the reports that will be studied and approved afterwards by the Plenary.

The Secretariat is comprised of the following personnel:

- The Commission's Plenary Secretary.
- The investigation team comprised of Career civil servants belonging to the General Administration of the State.
- Administrative and technical personnel assigned to the Secretariat.

* * *