GOBIERNO DE ESPAÑA | MINISTERIO DE FOMENTO | SUBSECRETARÍA DE FOMENTO | COMISIÓN PERMANENTE DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES MARÍTIMOS

CIAIM-34/2014 REPORT

Loss of control, grounding and complete loss of cargo ship LUNO on the breakwater of the outer harbour of Bayonne (France) on 5 February 2014

NOTICE

This report has been drafted by the Spanish Maritime Accident and Incident Investigation Standing Commission (CIAIM - *Comisión Permanente de Investigación de Accidentes e Incidentes Marítimos*), under the provisions of Article 265 of the Consolidated Text of Spanish State Ports and Merchant Marine Act approved by Royal Legislative Decree 2/2011, dated 5 September and by Royal Decree 800/2011, dated 10 June.

The sole objective of the CIAIM when investigating a marine accident and incident is the prevention of future marine accidents through the ascertainment of their causes and circumstances.

This report is not written with litigation in mind and shall be inadmissible in any judicial proceedings whose purpose, or one of its purposes is to attribute or apportion liability or blame.

The use of this document for a purpose other than the prevention of future accidents may lead to erroneous conclusions or misinterpretation.

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1. SUMMARY

Figure 1.LUNO

Figure 2.Accident Area

At approximately 07:00 hours on 5th February, the merchant ship (B/M) LUNO was approaching the harbour pilot station of the Port of Bayonne (Francia) at the Adour River Estuary.

The ship had been sailing from the Port of Pasajes. After a few hours, LUNO had to stop and sail some segments at low speed to arrive at destination in due time.

LUNO had stayed the previous 22 days at "Zamacona Pasajes" shipyard in Pasajes and after that, moored at a commercial port. For this reason, the crew took advantage of the voyage to test both propulsion system and steering gear before reaching the port.

Since the pilots of Bayonne had previously informed that two ships had to be removed prior to LUNO's entry to the port, she made the necessary arrangements to wait, at reduced speed, nearby the estuary.

During this time, swell waves in the area affected the vessel, which suffered strong pitch and roll motions. It was a bad sea state that would become worse according to the weather forecast, as an extratropical cyclon was approaching to the area[1].

At about 09:10 hours, the pilot assigned to LUNO disembarked the ship he had just guided out of the port and requested to LUNO through VHF to manoeuvre to take him aboard. Just before, he had been informed about a propulsion engine failure and once on board, he noticed that a blackout had also occurred. The pilot agreed with the ship's master to contact the Harbour Master's Office of the Port of Bayonne and the CROSS (French Monitoring and Rescue Regional Operational Centre). The aid of two tugboats was requested.

Some minutes later, the crew managed to set the propulsion engine into operation. The master decided to enter to the port after being informed by the chief engineer that the engine could

[1] Named as "PETRA", it was one of a series of low pressure systems affecting large areas of the North Atlantic Ocean and Western Europe, some of which resulted in big storms that crossed the area between January and February 2014.

withstand operation provided that its nominal power was not over 40 to 50 %. The tugboats were waiting for the ship in the Adour River Estuary.

After leaving behind the end of the north sea wall, the main engine stopped again. The effects of strong WNW waves on the ship were boosted by shallow waters and waves breaking towards Adour Estuary. Every subsequent attempt to stop the ship's motion or improve her position was unsuccessful, including actions like urgent assistance provided by a tugboat, which was even about to capsize, or anchors being dropped.

The ship drifted south until running aground on her portside at the breakwater end of the outer harbour at the entrance of Adour channel. A short time later, the ship split in half. The stern half remained crosswise at the mercy of battering waves.

The whole crew waited for two rescue helicopters on the portside wing. The strong ship motion at the mercy of wave trains was preventing their rescue. Then, the rescue team decided to wait until the tide was low as an aid to rescue the crew, finally succeeding on this occasion.

The crew members were rescued by a French Air Force helicopter. The pilot was the last person to be rescued at 13:35 hours. The crew members were checked by the Health Service. The doctors reported an injured person, several contusions and bruises and some cases of hypothermia in early stages.

The ship was carrying approximately 127 m^3 of MDO[2] and 1200 l of lube oil most of which was spilled and spread during the following days by the effects of foul weather. The storm was battering and breaking into pieces the wreckage until only two main pieces remained there, while smaller ones were scattered in the estuary.

Removing tasks lasted several months due to bad weather conditions. Such tasks were completed by the end of May 2014.

1.1. Investigation

This report is the result of a joint investigation of the accident lead by the CIAIM. The *Bureau d'enquêtes sur les événements de mer* (BEAmer) of the Government of France also took part in the investigation as a collaborator.

The CIAIM was notified about the incident on 5th February 2014. On this day, the event was temporarily assigned as "a very serious accident" and it was decided to open an investigation procedure. The plenary session of the CIAIM confirmed the severity level of the accident and the decision to open a safety investigation. Both CIAIM and BEAmer revised this report which, upon their approval, was issued on May 2015.

For this investigation, the CIAIM was supported by the BEAmer, which was continuously in contact with French Maritime and Judicial Authorities, as well as with the company in charge of recovering the ship's remains, for an almost immediate availability of any news on the incident.

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[2] Marine Diesel Oil

BEAmer's investigators also interviewed the members of (R/P) BALEA harbour tug crew, Port Authority and rescuers, among others.

The CIAIM took a statement from the ship's crew on 7th February. Some days later, the pilot who had been onboard could be interviewed, as well as some members of the Bayonne Port Authority. Later, on 19th and 20th March, crew members were taken a testimony again.

The VDR[3] could not be recovered from the ship in order to obtain the data stored in this unit. The ship was equipped with a simplified VDR in accordance with IMO[4] Resolution MSC.163(78), whose final recording medium was a protective capsule of auto release[5] type. This float-free capsule disappeared a short time after the accident. Any locating signal is doubted to have been received at any time from Biarritz airport. Due to the particulars of this accident, should the capsule have been of fixed type, it could have been more easily recovered because of its larger solid construction.

CIAIM's and BEAmer's Investigators were on the beach of Anglet on 11th April 2014 to go into the recovered remains of the ship's stern. However, some of the parts significant to the investigation had vanished, including the whole lower grating and a large part of the engine room content and spaces. Therefore, it was impossible for the investigators to verify the actual condition of the seawater main and, particularly, the main engine cooling system and related systems.

As wreckage recovering tasks had been progressing suitably, the BEAmer could have access to the pipes recovered and stored in a warehouse and surveyed them on 30th May. Examination revealed that any evidence useful to explain the accident had been erased because of the long time they had spent underwater.

The CIAIM is in possession of the maintenance records of the tasks performed in Pasajes Shipyard, in which no evidence can be used to support or reject any speculation. No exceptional event or non-conformance with regulations could be identified, either.

The shipping company NAVIERA MURUETA and LUNO's crew members thoroughly collaborated with the CIAIM.

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[3] Voyage Data Recorder
[4] International Maritime Organisation
[5] In accordance with aforementioned Resolution, "the capsule should be able to transmitting an initial locating signal and further locating homing signal for at least 48 hours over a period of not less than 7 days / 168 hours".

2. FACTUAL INFORMATION

2.1. Overview

Table 1. Ship Particulars

Name	LUNO
Flag	Spain
Identification	Port of Registry: Santa Cruz de Tenerife Vessel's Identification Number at Spanish Registry: 187665 IMO number: 9072329 Call sign: EARP
Type	General Cargo Ship "Other cargo ship" iaw ISM[6] Code.
Main Particulars	• Length overall: 100.65 m • Length between perpendiculars: 94.65 m • Width: 14.80 m • Depth: 7.80 m • Maximum summer draft: 6.01 m • Displacement for maximum summer draft: 4635 t • Deadweight tonnage: 4635 t • Gross tonnage: 3446 GT • Hull material: steel • Propulsion System: Wartsila 6R32D diesel engine, 1470 kW • Controllable Pitch Propeller.
Ownership and Management	As stated on the Safety Management Certificate issued by the Dirección General de la Marina Mercante (Spanish Directorate-general for Merchant Marine), the company was: NAVIERA MURUETA, S.A., located in Bilbao, IMO number 0379121. Registered shipowner: NABILBO SHIPPING, IMO number 1494151
Shipbuilding details	Built in 1993 at Astilleros de Murueta S. A. (Murueta Shipyard) (construction number 183)
Minimum Safe Manning	1 Captain /Master 1 Chief Officer / Chief Mate 1 Second Officer / Second Mate 1 Chief Engineer /Chief Engineer 1 Second Engineer / First Assistant Engineer 3 Seamen (According to Resolution dated 29 November 2001)

[6] International Safety Management Code.

Table 2. Details of the Voyage

Ports of Departure / Stop / Arrival	Departure from the Port of Pasajes Arrival expected at Bayonne (France)
Type of voyage	International
Cargo	Ballast condition
Complement	11 crew members: master, two deck officers, chief engineer and supernumerary chief engineer, first assistant engineer, boatswain, two able-seamen, cook and rating. All of them held required certificates in force.
Documentation	The ship was provided with required certificates.

Table 3. Information on the Incident

Type of incident	Loss of control and subsequent grounding of the vessel.
Date and time	5 February 2014, 10:36 LT
Grounded position	43° 31,550' N; 001° 31,762' W (breakwater of south outer harbour protecting Adour Estuary entry, located between "Plage des Cavaliers" and "Plage de la Barre").
Vessel's Operations and Voyage Segment	Arrival nearby Adour Estuary to enter the Port of Bayonne (France).
Place on board	Loss of control: engine room, lower grating, seawater main and main engine cooling system.
Ship Damage	Grounding , ship splitting in half and subsequent loss of the vessel.
Injuries / missing / fatalities	An injured crewmember treated at hospital in addition to several contusions and some cases of hypothermia in early stages
Pollution	The ship was carrying approximately 127 m^3 of MDO and 1200 l of lube oil, most of which was spilled to the seawater. This hydrocarbon pollution was naturally spread by swell.
Other damage	Damage on board BALEA harbor tug.
Other personal injuries	Rescuers' contusions. No special treatment required.

Table 4. Marine and Weather Conditions

Wind	Detailed in Addendum 4.
Sea State	
Visibility	Good
Tide	High tide occurred at 08:27 hours. Tide elevation was 4.05 m and the tidal coefficient 79. Low tide occurred at 14:27 hours and its elevation was 1.20 m. Considering the location of LUNO when approaching the mouth of Adour river during the lapse of time between the second stop of the LUNO's main engine and the ship's grounding, the vessel was affected by the ebb tidal stream running from shore into the sea and the flood tide, together with wave continuous breaking. Drift cannot be defined accurately for each of the vessel's locations in the estuary until she finally ran aground. According to the pilot's estimation, and considering the ebb tide stream at 8:30 hours, during M/V ANDREA ANON departure manoeuvre, the stream value was about 1 knot. In accordance with simulation and considering the combined effect of swell, tide and wind, 1.5 knots were exceeded in areas of less depth.

Table 5. Land-based Authority's Participation and Emergency Service's Response

Authorities	CROSS Etel, Bayonne Harbour Master's Office, Gendarmerie, French Air Force.
Means	• Gendarmerie's Helo ECU 64 • French Air Force's Helo RAFFUT SAR • BALEA harbour tug
Response quickness	Immediate
Measures	Before grounding: to summon port tugs. After grounding: to summon air rescue service, which succeeded in rescuing the crew.
Results obtained	Crew and pilot on board rescued.

2.2.Description of LUNO's Propulsion and Power Plants

Description

LUNO was equipped with a WARTSILA propulsion engine, 1470kW, and one controllable pitch propeller.

When sailing, the above mentioned engine drove a 480 kW shaft alternator, which provided all equipment and services on board with necessary electric power.

In addition to the shaft alternator, the ship was provided with two auxiliary power units of 184 kW and 95 kW, arranged port and starboardside respectively, which included a VOLVO PENTA motor and an INDAR generator. Both units could provide electric power to the whole ship except for the fore propeller, which could only be operated by the shaft alternator due to its high power requirements (295 kW).

The ship also carried a 50 kW harbour generator set in a storeroom of the ship's bow.

Auxiliary System Connection

The power plant was designed to operate in accordance with amended article 2.2, Chapter II/1, Regulation 53 of the International Convention for the Safety of Life at Sea 1974. See Addendum 2 of this report and hereinafter analysed connection of auxiliary systems.

Seawater was supplied from the seawater main to the cooling system of the auxiliary power units.

2.3. Propulsion Engine Cooling System

Figure 3 shows a simplified diagram of the propulsion engine cooling system. The seawater circuit was depicted in green and seawater in blue.

The propulsion engine was cooled by means of a fresh water close-circuit system divided into a High Temperature (HT)[7] and a Low Temperature (LT)[8] circuit. The fresh water was later cooled in a detached central cooler[9].

[7] The HT circuit cools down cylinders, cylinder heads and turbo charger. The cooling water flows from pump to cylinder sleeves, heads and around valves to reach cutout valve seats in such a way that all these components are efficiently cooled.
[8] The LT circuit comprises an air intake cooler and a lube oil cooler through which a pump equal to the HT one pumps water. A thermostatic valve controls the temperature of the LT circuit at a load conditioned level.
[9] Identified in the diagram of Figure 3 as "fresh water engine exchanger".

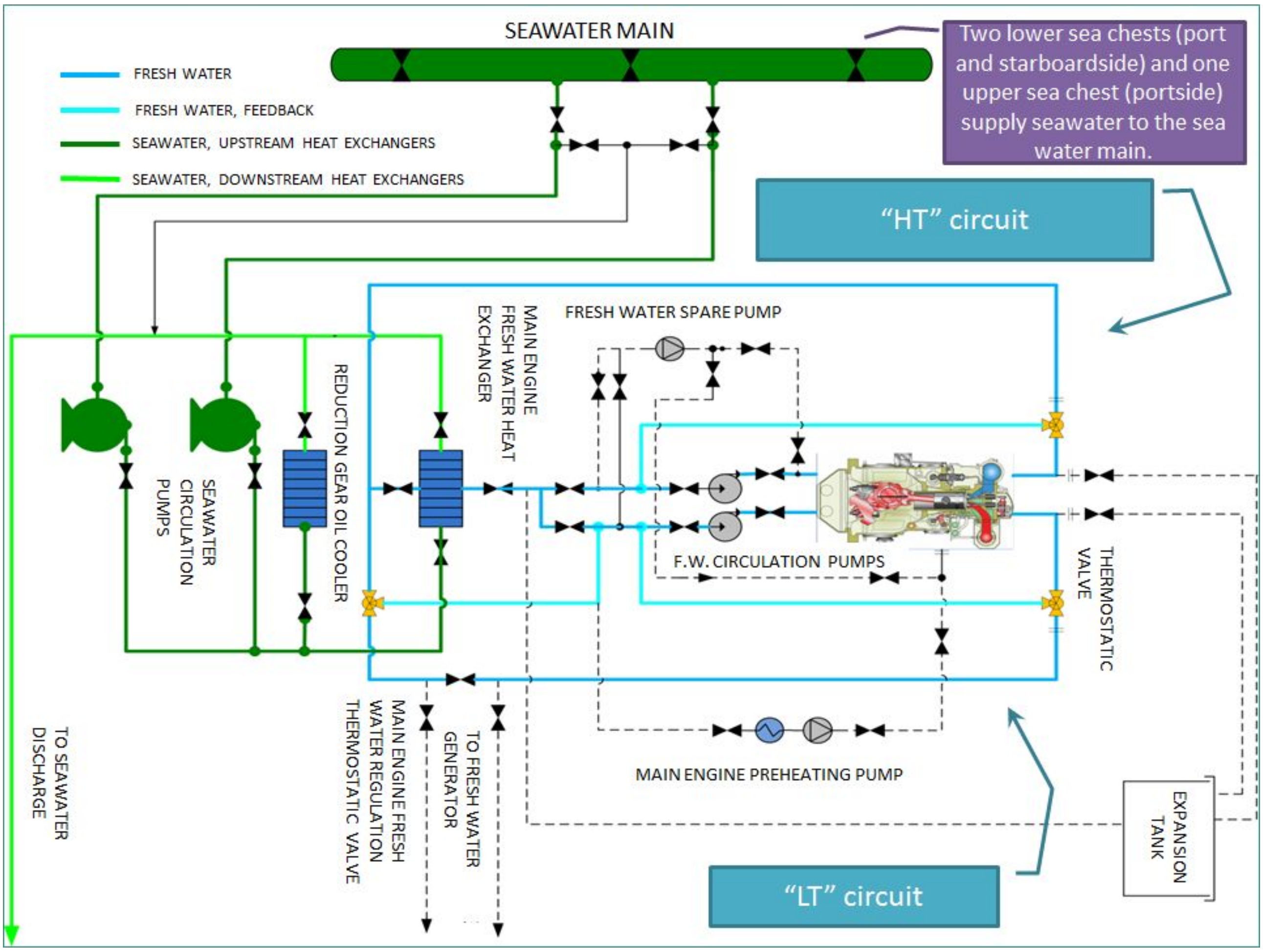

Figure 3.Diagram of LUNO's Propulsion Engine Cooling System.

2.4. High Temperature Alarm System for the Propulsion Engine

Two alarms controlled the temperature of the propulsion engine cooling water. While the first alarm indicated high temperature, the second caused the engine to stop.

Thermostats were placed in a special housing, as shown in Figure 4, from where they could be removed to be checked. The correct disconnect switch temperature is usually stamped on the thermostat whenever it has not be reset for a different temperature value.

The parameters defined as alarm and stop limits were 90ºC and 95ºC respectively, according to WARTSILA (engine manufacturer) drawing "4V50L3102-5/5".

Figure 4.Location of the Sensor whose reading generated a High Temperature Alarm and subsequent Stop of Propulsion Engine Operation.

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3. DETAILED DESCRIPTION

Events have been described based on available data, statements and reports. Referred time is local time

3.1. Background

LUNO arrived at Zamacona Pasajes shipyard in Pasajes (Guipúzcoa) on 9th January 2014 for the scheduled 5-year maintenance plan, in addition to several maintenance and upgrading tasks that should be also implemented. Thus, new statutory and class certificates were finally issued. The ship entered the ship floating dock in the morning of 11th January and left it in the morning of 28th January.

The following and some other tasks[10] were performed at the facilities of Zamacona Pasajes shipyard:

1. Hull painting tasks
2. Replacement of cathodic protection anodes
3. Removal of oil and organic waste
4. Repairing and painting of cargo hold hatches
5. Verification of tail shaft and rudder alignment
6. Assembly and disassembly of tank manholes and plugs
7. <u>Cleaning of sea chest grilles and fore propeller</u>
8. Anchor lines lifting and dropping (replacement of swivel shackles in one anchor)
9. <u>Checking of sea chest valves</u>
10. Checking and ultrasound testing of tail shaft
11. Propeller blade
12. Checking of steering gear swivel rods
13. Checking of anchor windlass brakes
14. Reparation of cargo hold coaming
15. Reparation of fore-starboard hull deformation
16. Ultrasound testing of fore plate
17. Reparation of cargo hold bulkhead skirting and ultrasound testing
18. Support to sewage plant repairing tasks
19. Support to air conditioning plant repairing tasks
20. Walkway load test
21. Closing of cargo hold access cuts
22. Vent pipe spool
23. Repairing of bilge grille in cargo hold
24. Scupper plugs and extended hoses
25. Repairing of a forward storeroom crack

[10] Underlined items denote the ones the CIAM considers as related to the incidents described herein.

26. Hydraulic cylinder nipple in cargo hold cover
27. Reparation of sanitary spaces pipes
28. Replacement of some pipes/tubes
29. Reparation of hydraulic piping in hatchcovers

Both shipyard and ship's personnel performed the maintenance tasks. The personnel of the shipyard specifically performed these tasks in the engine room, among which:

1. Replacement of miscellaneous pipes
2. Checking of bottom valves and discharges

Once the tasks were finished, several ship tests and trials were conducted, including propulsion and steering gear trials at harbour, all of them to the satisfaction of the Harbour Master's Office and *Lloyds Register of Shipping* Classification Society.

The Harbour Master's Office first proceeded to survey and then issued the following certificates:

ITEM	CERTIFICATE / STATUTORY DOCUMENT	DATE OF ISSUE	EXPIRING DATE
1	International Air Pollution Prevention (IAPP) Certificate	31/01/2014	13/02/2019
2	Supplement to the International Air Pollution Prevention (IAPP) Certificate, which contains the Record of Construction and Equipment	30/01/2014	Not applicable (n/a)
3	International Anti-fouling System Certificate	31/01/2014	n/a
4	Special requirements for ships carrying dangerous goods	31/01/2014	13/02/2019
5	Certificate for engine installations likely to be unmanned	31/01/2014	13/02/2019
6	International Oil Pollution Prevention (IOPP) Certificate	31/01/2014	13/02/2019
7	Supplement to the IOPP (Form A). Record of Construction and Equipment for ships other than oil tankers.	31/01/2014	n/a
8	International Sewage Pollution Prevention Certificate	31/01/2014	13/02/2019
9	International Energy Efficiency Certificate	23/01/2014 (issued by DGMM-General Directorate of Merchant Marine)	n/a
10	Supplement to International Energy Efficiency Certificate (IEE Certificate) Record of Construction relating to Energy Efficiency.	23/01/2014 (Issued by DGMM-General Directorate of Merchant Marine)	n/a
11	Certificate of Seaworthiness for ships of 24 meters in length (L) or above	31/01/2014	13/02/2019
12	Ship Security Certificate for Cargo Ship	31/01/2014	13/02/2019

13	Inventory of equipment installed to comply with the International Convention for the Safety of Life at Sea, 1974, amended by protocol 1998 (Form C)	31/01/2014	n/a

The Classification Society of the Ship also issued a new Class Certificate[11] for the ship, dated 3 February 2014, expiring on 13 January 2019 subject to annual and intermediate survey. No class provision or remark was assigned.

In the morning of 31th January, LUNO was moved from the shipyard to a commercial port, where she was moored.

3.2. Description of the voyage Pasajes - Bayonne.

Figure 5 shows:

- LUNO's track from the Port of Pasajes on the 4th at 19:18 hours (waypoint A) until she ran aground on the 5th (waypoint H) at 10:36 hours.
- Combined sea and wave main direction and significant height from 3 to 4 m, maximum wave height from 4.3 m to 5.5 m, mean wave period of 9.5 s and direction of wave propagation to west.
- Location of deep water data buoy in San Sebastián. The data this buoy gathered are considered to show the real sea conditions LUNO withstood until her arrival nearby Bayonne at 07:00 a.m.
- Relevant waypoints where track and/or speed were changed are assigned to consecutive letters B to G.

The vessel had left Pasajes on 4th February. The AIS[12] record registered ship's departure at 19:18 hours. The ship arrived at Pasajes Harbour Mouth at 19:36 hours, where a course of 338º was set and the speed steadily increased up to 9 knots.

[11] Ship's Classification was: ¤100 A1 Strengthened for Heavy Cargoes, ¤ LMC, UMS
[12] *Automatic Identification System*

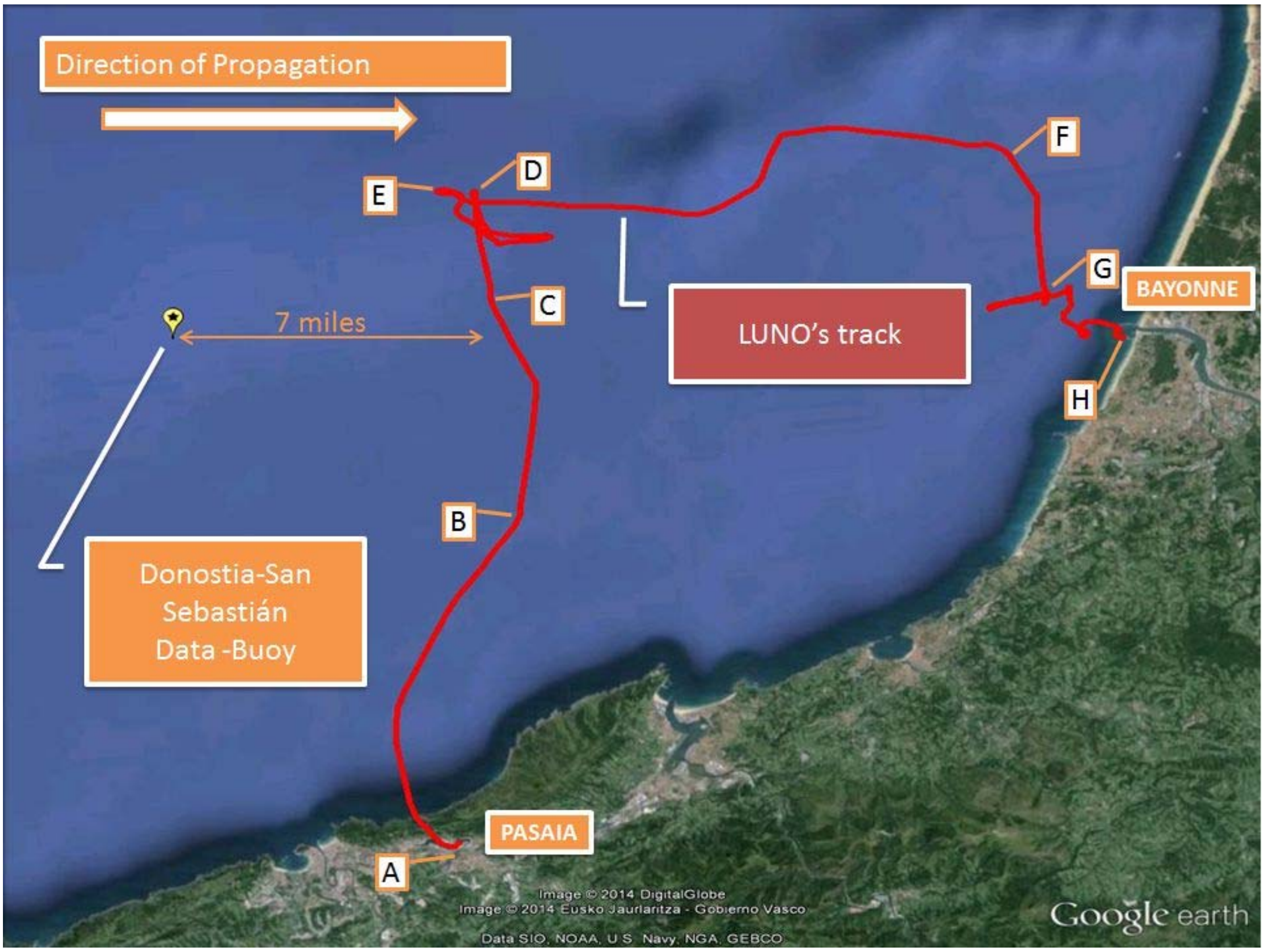

Figure 5.Position of San Sebastián Data Buoy with respect to LUNO's Track

At approximately 20:35 hours (waypoint B), the ship's speed decreased below 6 knots and her track was altered in two segments towards portside. The final average course was then 343°.

At 21:48 hours (waypoint C), the minimum manoeuvring speed was again reduced (below 2 knots), mainly heading northwards until 23:45 hours (waypoint D).

Then, several sharp changes in track and speed took place while tests to check equipment operation, particularly propulsion plant and steering gear, were conducted after leaving the shipyard. The trials included propulsion engine stop and start operations and the use of the steering gear system to the full.

At 01:24 hours (waypoint E), the vessel was altering her course at controlled speed, mainly eastwards, in order to delay her arrival at destination due to the wide time margin available. In this segment, the sea was heading ship's stern and fins, so rolling was not remarkable.

At 05:56 hours (waypoint F) the ship made an alteration of course to south at minimum manoeuvring speed. Previous motions had led the ship to latitudes northward her destination.

The ship maintained that condition until arriving nearby the Bayonne Pilot Station at 07:00 hours, where she was advised to wait (waypoint G).

During this journey, beam sea from west was striking the ship in some segments. Maximum wave height was 4.3 to 5.5 metres.

From E to F, mainly following west-east direction, the ship course headed E while she was "running accross" the storm. The combined wave and ship direction coincided. However wave propagation speed was much higher[13]. Therefore, the ship was "riding" the waves during all this period, causing a "shovelling" effect[14].

The crew stated that the ship "was certainly moving sharply" during some segments of the voyage, but "as usually happens under heavy weather conditions". However, both propulsion and steering gear systems were working without any problem.

3.3. The Accident

Overview

The engineering department crew in charge of manoeuvring usually comprised a chief engineer and first assistant engineer. On this occasion, a supernumerary chief engineer was also on board for a one-month training period after which the chief engineer would be substituted. Engineering department members' expertise was wide at sea, on board this type of vessels and for this sort of engine.

The chief engineer was leading the manoeuvre while the first assistant engineer served the orders with no specific task assigned during the manoeuvring operation.

Engine control spaces were not enclosed, but an open area on the engine platform, portside, where the engine control desk and electric switchboard were arranged.

Communication between navigation bridge and engine control room was established through an interior telephone system with several stations arranged in engine room and steering gear room. When a call from the bridge was received, acoustic and visual alarms were activated in the engine room.

Incident Inventory

The graph in Figure 6 depicts the locations of the ship's GPS antenna arranged at a distance of 94 m to the ship's bow. The various headings of the bow were not marked. The motions of the pilot's boat and the merchant ships assisted by the Pilot Service in Bayonne before LUNO that morning are not indicated, either. No AIS data of BALEA harbor tug are available.

The letters of the graph denote ship milestones from her arrival at the area until she ran aground.

[13] Calculations show a combined sea speed of 28.7 knots for a mean wave period of 9.5 s.
[14] Name used to describe the simultaneous and combined effect of pitching and rolling.

Figure 6.Ship's track from her arrival at the Port of Bayonne surrounding area

The following table includes the explanation of the letter-assigned milestones in the figure. This explanation is based on the statements both pilot and crew provided. Milestone time and place were established according to emitted AIS data[15].

Milestone	Time	Explanation and Remarks
A	07:00	The ship arrived at the area before due time. The Pilot Station informed that the vessel should wait for the pilot to embark until two other ships had left the port, approximately at 09:30 hours. Then, the ship followed several tracks at minimum steering speed: firstly, to clear the river mouth and secondly, to arrive at the time agreed with the pilot station. The first signs of storm were being noticed in the area. Beam waves

[15] The records of the State Ports SHIPLOCUS system were used for this purpose. This system provided full coverage at the area of the accident.

Milestone	Time	Explanation and Remarks
		made the vessel roll strongly. Then, heading was decided to be changed from N-S to E-W while waiting for the pilot. The pilot had began his working hours at 7:30 hours by revising latest weather conditions and analysing an updated weather forecast. As weather conditions were expected to worsen during the second half of the day, Bayonne pilots planned that two pilots would be assigned carry out subsequent procedures according to their scheduled time of completion: 08:30 M/V ANDREA ANON departure, 09:00 M/T STAR CURAÇAO departure; 09:30 B/M LUNO's entry. The chief engineer had been on duty that night. Therefore, the alarm system had been connected to his cabin. The ship held a periodically unattended machinery spaces certificate. The chief engineer had reported the night as calm, with no alarm condition.
	08:00	The crew of the engineering department were already making ready services in the engine room and waiting for manoeuvring instructions.
	09:00	Portside auxiliary engine set into operation. Stand-by engines.
B	09:11	The vessel's speed was increased from 3 knots up to an average speed of approximately 5 knots. A bit earlier, the pilot had requested to set a course of 140° and proceed to enter to the port. Arrangements to take the pilot on board should also be made.
	09:11	The High Temperature (HT) alarm of the fresh water propulsion engine cooling system went off. T= 90ºC[16]
C	09:13	The propulsion engine stopped due to high temperature of the fresh water propulsion engine cooling system. T= 95ºC. Later, the master reported this circumstance to the pilot through the VHF system. The pilot decided to go on board. The ship continued headway, but speed was decreasing. The crew unsuccessfully tried to set the propulsion engine into operation several times. The HT alarm of the fresh water propulsion engine cooling system did not allow the fuel pump to serve the engine.
D	09:16	The pilot embarked LUNO. The master informed the pilot about the engine being stopped due to high cooling water temperature, who also noticed that the rudder was hard to port. Then, the pilot requested the helmsman to steer the

[16] Temperature measurements in fresh and seawater circuits after which incidents occurred were reported by the crew and denote values observed on thermometers.

Milestone	Time	Explanation and Remarks
		rudder amidships, but no response was obtained. As a result, the pilot inferred that not only was the main engine stopped, but a *blackout*[17] had also occurred. Then, the pilot contacted Bayonne Harbour Master's Office and the CROSS Etel[18] and requested the aid of two tugs. From this moment and upon the master's request, the pilot took over coordination with land based authorities and rescue services, as he could speak the local language. A tight cooperation and information exchange channels were established. The master highly appreciated the pilot's knowledge on the local environment.
E	09:18	The ship's speed decreased below 3 knots. At the same time, she was going adrift and abeam sea, listing also to portside. At that time, the GPS calculated course was 135º, while the gyrocompass indicated 179º[19]. From this time on, at a certain moment, two shots of the starboard anchor were dropped to the water in order to prevent the vessel's drifting, but unsuccessfully.
	From 09:11 to 09:33	Engineering personnel verified the operation parameters of propulsion engine and related systems, mainly seawater and sea chest circuit. It was detected: - no thermal difference in the heat exchanger of the cooling system circuit - air was present in the seawater main. - seawater main filters were bled and air was noticed to be continuously expelled.
F	09:33	When the temperature of the secondary cooling water circuit dropped below 95º, the chief engineer started the propulsion engine once again. The shaft alternator was maintained in operation, which involved disconnecting the auxiliary engine and increasing the propulsion engine load. Crew started to heave up the starboard anchor. Then, the ship stopped going adrift and her course was modified to navigate away from the coast. The vessel was sailing now at minimum steering

[17] Some discrepancies arose between pilot and crew on the events observed. The crew insists that no *blackout* took place on this occasion. The emergency power supply fed by batteries located abaft the bridge worked properly.
[18] French Monitoring and Rescue Regional Operation Centre.
[19] Even though it seems feasible that the vessel's violent motion could unbalance the ship's gyroscope, the subsequent satisfactory equipment performance suggests that indicated magnitudes are reasonably approximate measurements.

Milestone	Time	Explanation and Remarks
		speed. The master headed for the engine room to speak to the chief engineer and obtain first-hand information on the situation. The chief engineer expressed his opinion to the master on the propulsion engine capability to withstand operation provided that its nominal power did not exceed 40 to 50% (corresponding to a 4 above 10 propeller pitch) and the need of requesting to be towed. Also, he ignored the failure cause. The situation was assessed by means of several enquiries exchanged among pilot and port authorities and pilot and master. The parties agreed the vessel's entry to port as the best choice.
	09:35	Anchor up. Rudder hard to starboard to set course to NW. Start of manoeuvre. The pilot suggested an entrance route to take advantage of surrounding conditions, approaching the estuary very close to the north sea wall in order to: - enter the estuary following a track distinctly simultaneous with wave trains, which would push ship's motion, - sea and ebb stream would cause the vessel drifting south if heading was not corrected; therefore, should the failure occur again just in the river mouth bar, the vessel's inertial motion would drive her up to the tugs.
G	09:46	LUNO was authorised to be moored at Saint Gobain in the Port of Bayonne. The harbour patrol traffic lights turned green. At the moment, the vessel was 0.87 miles west off the north sea wall. Vessel's speed was over 3 knots.
H	09:47	Vessel's speed between 4 and 5 knots.
I	09:49	Vessel's speed over 5 knots.
J	09:50	Vessel's speed between 4 and 5 knots. As reported by the master, the propeller pitch did not exceed 35% at any moment.
		While the vessel was entering the Adour, the first assistant engineer was in charge of engine operation control and alarm console acknowledgment, while both chief engineer and supernumerary chief engineer tried to identify the origin of the failure. According to their statement, for this purpose: - the air of the seawater main was bled through the drainages of the main filters at both ends. Air was continuously released. - seawater and fresh water circuits in the lower engine room

Milestone	Time	Explanation and Remarks
		grating were checked (pressure, temperature and valve alignment). - the upper discharge valve of the seawater circuit on the boat deck was checked. - the thermostatic heat exchanger valve operation (high temperature side) was checked. - the operation of both the seawater cooling pump and general service pump was checked. The latter started operation automatically in case of failure of the former. Both pumps were working properly[20]. - the overboard seawater discharge valve was disassembled. A shortage of circulating flow was noticed. The condition of the portside upper sea chest valve was not checked. This valve and the other sea chests had been upgraded at the shipyard. The chief engineer had checked the valve when maintenance tasks at the shipyard had been completed, so he assumed that the valve was closed. However, it was not verified whether it was open or closed during the accident.
K	10:00	The fresh water HT alarm of the propulsion engine cooling system went off again in the same way as previously. Later, the engine stopped by second time due to the same causes and once the vessel's bow had left behind the north sea wall end. The ship's propulsion system was not working, but she continued headway under a compromising position in the Adour estuary, only 0.31 miles off the north breakwater end, in the middle of the Adour shoal where the storm wave train crest and trough effect was maximum. According to the pilot, the rudder indicator displayed 5° portside, which caused the vessel to turn portside, heading straight towards the north sea wall. The pilot requested from the tugs sheltered behind the Adour mouth bar to approach in order to push the ship's bow off the sea wall. BALEA approached the area.
L	10:04	The effect of the ebb tide stream of the Adour river exceeded the combined effect of the vessel's inertial motion and wave trains. She started then to move back off the coast. Her bow was heading NE, but steadily drifting N due to the combined ebb tide stream and wave effect. BALEA harbor tug went closer and tried to pay out a towline to the bow, but unsuccessfully. Then, the pilot ordered the tug to push ahead on the fore starboard side so that the vessel's bow would be

[20] Pumps were unprimed.

Milestone	Time	Explanation and Remarks
		moved starboard and far away from the breakwater.

Figure 7.BALEA harbor tug pushing as requested.

M	10:06	BALEA did push on 5 occasions, but each time she was moved away due to the combined effect of the vessel's motion, mouth bar related sea rise and ebb tide stream. On the last occasion, the tugboat tilted up to 70º which almost made her capsize. Swelling dragged her towards the beach. See Figures 7, 8 and 9.

Figure 8.Tugboat 70º Angle of Heel

Figure 9.Tugboat Dragged to Beach

N	10:08	The vessel's bow was away from the sea wall end. The combined effect of wave trains and river ebb tide stream caused the vessel's drifting quasi-parallel to the coast with a course of 200º.
		The pilot decided to conduct the last manoeuvring attempt by dropping the two anchors before they were drifted towards the coast. The pilot asked the master to drop 4 shots of the starboard anchor, then to do the same with the portside anchor and pay out continuously up to 5 shots. At the same time, weather conditions worsened, wave trains reached a height of 6 to 8 m and there was a succession of downpours with violent WNW gusts. The vessel pulled the anchors violently, dragged and went on adrift.
O	10:10	As a result of the violent roll motions, the pilot was notified by BALEA about a damage that prevented them from providing any help. The master informed the pilot saying that "the engine will not start again, water temperature problem".
	10:28	The master ordered "abandon ship", triggered the general alarm and ordered all the crewmembers to head for the bridge wearing their lifejackets and carrying their survival clothing. He recommended not to put them on, as body movements might be restricted[21] under the circumstances they had to face. The master asked the pilot to send out an assistance requirement to the authorities.
P	10:36	The ship's stern was stranded on the breakwater of the south outer harbour of Bayonne Port and her port side drifting against the end of the sea wall. The ship was at the mercy of battering waves, being successively struck and dragged against the breakwater.
	10:40	The vessel's motions in the middle of breaking waves were violent due to wave magnitude and her continuous collision against the sea wall breakwater. The French Gerdarmerie helicopter ECU64 tried to approach the vessel with a hanging rescuer to begin crew rescue operations. The circular arc motion of bridge wing structure and light and antenna masthead with the wires fastening them arranged in the compass deck made impossible for rescue helicopters a safe approach to the bridge wing. After several rescue attempts, in some of which the rescuer hit the antennas and the bridge wing structure, ECU64 desisted. Meanwhile, more and more land based

[21] In this accident, it might be analysed whether the crew should have plunged into the water wearing survival clothing while waves were pounding vessel and breakwater in case their rescue had been imposible by external means, or on the contrary, they should have jumped onto the breakwater to climb up the rocks battered by the sea.

		rescue means were arriving at the area. The pilot was permanently in contact with both authorities and rescuers through his radio-transmitter and mobile phone. In this regard, all LUNO's crewmembers (no exception made) expressed to the investigators their gratitude to the pilot for his excellent behavior and leadership.
	10:42	The ship split into two halves and the vessel's bow was detached.
	10:46	Both master and pilot requested from everybody to go out to the portside wing, in fear of capsizing over starboard side. One of the crew members fell down and his left supercilliary arch was injured, although he could properly answer pilot's questions.
	11:20	SASEMAR informed the company NAVIERA MURUETA about the rescue helicopter (H/S) HELIMER BILBAO heading towards the place of the disaster occurrence. The company phoned the master, who informed that all the crew members were in good condition and laying on the portside bridge wing.
	11:35	The French Air Force Helicopter RAFFUT SAR was hovering. The helicopter rescue attempts failed due to the same reasons applicable to the French Gendarmerie Helicopter. Then, the rescue was decided to be postponed until the tide was low, which would mean smaller wave trains and consequently, less ship's motions. HELIMER BILBAO returned to its base.
	11:45	SASEMAR informed the company about the H/S HELIMER GIJÓN ready to take off.
	12:05	H/S HELIMER GIJÓN flying (iaw SASEMAR emergency report).
	12:45	Rescuers noticed a second vertical breach on the hull, at the level of the navigation bridge base.
		H/S HELIMER GIJON returned to its base, since RAFFUT SAR was to attempt evacuation once again in a few minutes.
	13:00	Improved weather conditions together with the noticeable low tide effect allowed a new rescue attempt by RAFFUT SAR. Considering that weather conditions might worsen, the helo took off carrying a lower fuel load so that all the crew members and pilot could be hoisted and taken on board the helo at a single attempt. The pilot was carefully advised about evacuation details, who, at the same time, informed and organised the crew members.
	13:07	The first crew member was hoisted.
	13:35	The pilot was the last person to be hoisted.

During the following days, the stormy weather was battering and spreading ship's remains until two main parts and a number of smaller pieces were scattered in the estuary.

The shipowner hired the company SVITZER to remove the wreckage. These tasks were carried out during several months, since they had to be stopped due to heavy weather conditions. Finally, they were completed by the end of May 2014.

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4. ANALYSIS

4.1. Cause of the failure

1) The whole propulsion system had been working properly since the vessel had left Pasajes the previous night. No maintenance or setting task had been performed on the seawater system or the fresh water propulsion engine heat exchanger. Propulsion system and steering gear were checked that night, even the main engine was stopped, but no significant event occurred.

2) Before the accident, no operation or maintenance task on the ship that might have modified the previous ship's condition was performed, except for the change into "Stand-by" condition, whose most important milestone was setting the portside auxiliary engine into operation.

3) The HT circuit temperature that hardly usually exceeded 85ºC (82 to 86ºC[22] normal range), reached 90ºC (first high temperature alarm) and soon after surpassed 95ºC. At this moment, the thermostat caused the main engine to stop. This sequence occurred on the two occasions the HT alarm went off and afterwards, the propulsion engine stopped its operation.

4) The engineering personnel detected air in the seawater circuit, more specifically in the seawater main. However, the origin of the air could not be ascertained. On several occasions, the seawater main was bled from the drains arranged on the covers of filter boxes. These boxes were not opened to check the filters, as the filters were assumed to be in perfect condition after the implementation of the five year maintenance plan.

5) The air in the seawater main was finally bled before the engine was started again after stopping by first time and once the cooling water temperature had dropped to normal levels.

6) No unusual or incorrect position of the seawater and heat exchanger valves was detected when checking their open and close condition. However, the open or close condition of the portside upper sea chest was not verified.

7) The operation of the two seawater centrifugal pumps was checked. After verifying no pressure difference between suction and discharge, it was evident that the pumps were working at zero load.

8) In the pursue of confirming this aspect, the crew of the engineering department raised the overboard discharge valve seat of the propulsion engine seawater cooling system. The flow [23] was very scarce, which confirmed that the valves were not primed, i.e., the whole circuit was almost working at zero load.

It was concluded then that a problem concerning the presence of air in the vessel's seawater circuit was preventing the operation of the seawater propulsion engine cooling system.

This problem also involved the auxiliary engine cooling system, whose seawater circuits were also supplied by the air-affected seawater main. This could explain the *blackouts* about which

[22] Data supplied by the crew and confirmed in the minutes of the sea trial.
[23] According to testimonies, the water came out "in a dribble".

the pilot and deck department crew had informed, especially after the engine had stopped by second time.

4.2. Analysis of the Causes for Main Engine to Stop

The CIAIM considers two causes to explain the presence of air inside the seawater main: Insufficient bleeding from the seawater circuit after maintenance at the shipyard or excessive air income into the seawater main through sea chests as a result of ship's motions before the accident. These causes are not mutually exclusive and both may have concurred.

Bleeding of the Seawater Circuit

After leaving a shipyard, the seawater circuit of a ship may contain a certain quantity of air, even if it was suitably bled, since air pockets may remain in inaccessible areas. This air may flow inside the seawater circuit and decrease the cooling capacity of the engine cooling service.

This air can be expelled by normal engine operation or additional bleeding operations. This is a situation which frequently occurs.

It cannot then be disregarded the idea of air becoming trapped in the LUNO's seawater circuit after she had left the shipyard.

Air Income through Sea Chests during Navigation

The CIAIM analysed LUNO's motion while navigating by means of computer simulation, whose purpose was working out whether sea chests could have emerged during navigation on 4th and 5th February.

The vessel had three sea chests converging at a seawater main; two of them were "lower" sea chests and a third portside one was an "upper" sea chest (see Figure 10). The roll angles at which sea chests emerged were 26° degrees for lower sea chests and 16° for the upper one when rolling towards starboard side.

For simulation purposes, significant wave height and period as well as vessel's navigation tracks and speeds since she had left Pasajes until the accident occurred were considered. The ship's load condition, i.e. ballast condition and the position of the sea chests were taken into account.

Addendum 5 shows simulation results. Calculations were performed for only one side and therefore, the lower sea chest related data must be multiplied by two.

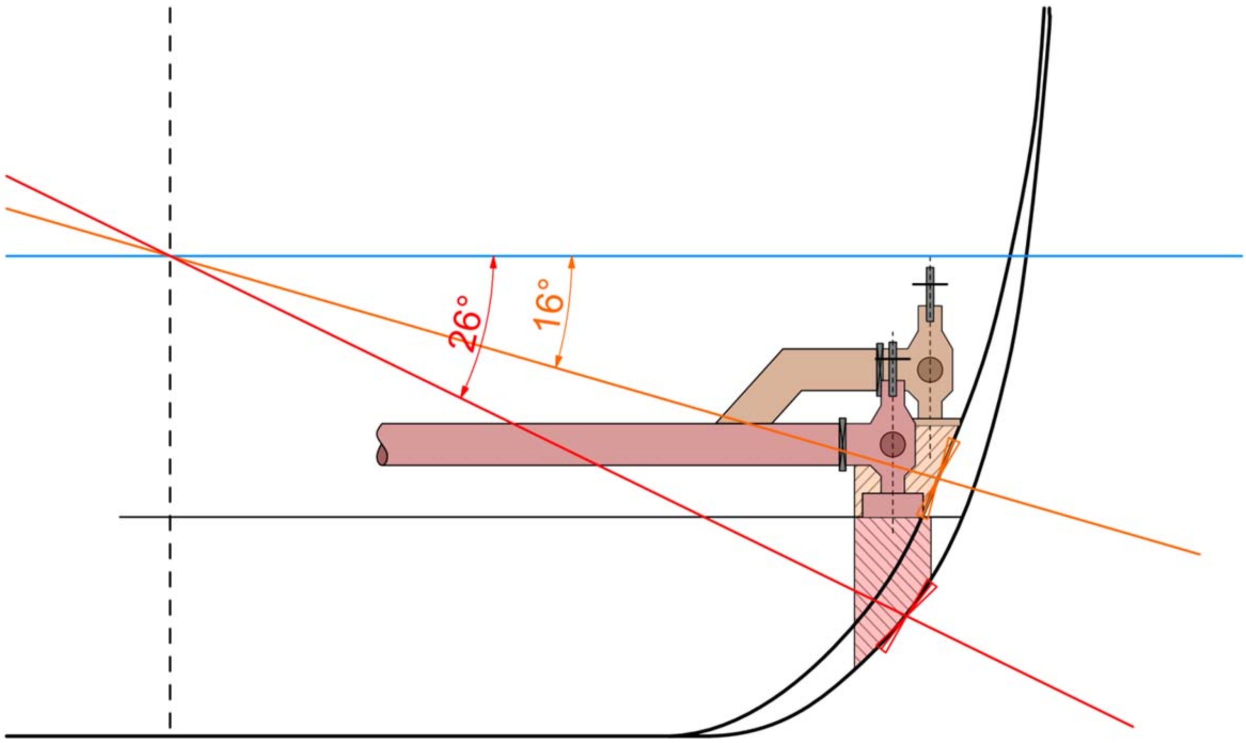

Figure 10.Detail of Upper and Lower LUNO's Sea Chests on Portside. Roll Angles at which Sea Chests were not submerged are indicated.

It can be concluded from calculations that the sea state made the sea chests emerge during the whole voyage of LUNO from Pasajes until her arrival nearby Bayonne. Ship's motions were sharper from 08:54 hours when the ship set course abeam sea to south heading towards the pilot station. Then, lower sea chests emerged up to 68 times in one hour, i.e., at least once per minute[24].

The portside upper sea chest emerged up to 228 times, i.e., 3.8 times per minute.

The failure

On 5th February, just before 08:54 hours, the vessel was stopped and waiting for instructions to take a pilot on board. Her propulsion engine was working and the portside auxiliary power generator in operation.

The effects of the storm coming west became more and more noticeable and were causing hard rolling motions on the vessel whenever she was abeam.

This situation worsened when the ship headed south to meet the pilot.

Rolling motion let sea chests emerge, which made air income easier into the seawater circuit.

[24] This value relates to 09:00 hours. The vessel altered the course to south at 08:54 hours approximately.

Air drawn into the seawater main would create air pockets which might have caused seawater pumps to become unprimed, making it difficult to cool down the fresh water propulsion engine cooling system due to lack of flow.

Sea chest and filter boxes grille checking and cleaning, as well as sea chest valve lightening and painting were among the maintenance tasks performed at the shipyard. For this reason, the chief engineer was certain that dirtiness on filter boxes or a misalignment of sea chest valves were not the cause of the presence of air inside the seawater main.

As a result, the propulsion engine finally stopped at 09:13 hours due to high freshwater outlet temperature in the primary cooling system.

The permanent chief engineer knew where the emergency stop actuator due to high temperature of propulsion engine cylinder head discharge was located and how to cancel this safety measure. However, he thought he had to enquiry the Company's Management before making such decision.

4.3. Considerations concerning Power Plant and Propulsion Engine Set into Operation

Discussion on the *blackouts* noticed by pilot and crew

The pilot explained that the vessel not only suffered a propulsion loss but also some *blackouts* after the two times that the propulsion engine had stopped. On the contrary, the crew members maintain that no *blackout* ever happened. In this sense, some of the circumstances detected could explain this apparent discrepancy.

The ship's electric plant was designed to operate with two parallel-connected generators, which would have prevented that any voltage drop in one of them (shaft alternator) would have caused an electric supply disruption, as the other power generator (port side auxiliary one) was in operation.

However, when the chief engineer provided their official testimony, they mentioned that it was impossible to establish any connection since one of the generators "was expelled" after five minutes. They also explained this as a circumstance that "had always been happening". It can then be inferred the occurrence of a previous unresolved problem.

Therefore, the normal operation mode for LUNO's power plant involved the shaft alternator being continuously connected to the propulsion engine. When manoeuvring, one of the auxiliary engines (usually the portside one with immediate lower capacity) remained started but in *stand-by mode*. In case of failure of the shaft alternator, this auxiliary engine should be automatically connected to the bus bars to make possible propulsion and steering operations, except for the bow propeller.

The power plant operation mode adopted on board definitely meant that there would be a short period with no power supply in the event the propulsion engine would stop.

Thus, the first time the propulsion engine stopped a *blackout* took place, since the shaft alternator remained inefficient until the portside auxiliary engine could be connected. Once the propulsion engine was set into operation, the shaft alternator was again connected and the portside auxiliary engine then disconnected. Therefore, another short period under no power supply condition took place.

For this reason, it is assumed that the steering gear failure noticed by both pilot and crew members were certainly caused by these *blackouts* suffered on board.

Addendum 3 includes an analysis of the ship's electric system. It is then concluded:

1. Navigation with the auxiliary engine connected was safe.
2. Using the shaft alternator was only necessary in case one thruster had to be used.
3. The system design considered the connection of power generators in parallel. This was not the operation mode when LUNO's accident happened.

Attention is drawn to the fact that using the shaft alternator instead of a diesel generator set when the accident happened may have contributed to the occurrence of an overload in the main engine and an excessive increase of temperature levels.

Discussion on the lack of start air alleged in some testimonies

The CIAIM has become aware that one of the crew members suggested a lack of start air as an explanation to the impossibility of starting the engine in the testimony the crew provided before the French Environment Prosecutor Office in charge of the preliminary legal proceedings.

After a detailed analysis of both drawings and available technical information, the CIAIM concluded that the propulsion engine could not be set into operation due to a stop command sent out by thermostat T401, but not to a lack of start air.

4.4. Shipboard Emergency Management

Implemented Emergency Plans and Strategies.

The crew focused their efforts on determining the location of the failure and safeguarding the position of the vessel. However, they could not have limited themselves to these tasks but developed as well an strategy that included some of the following measures:

1. Delaying the vessel's entry to the port in order to have more time available to determine the failure and/or search for alternative solutions.
2. Involving the Company in the problem from the very first moment so that it could have provided both resources and personnel for its resolution.
3. Checking the upper sea chest. Neither the CIAIM nor the BEAmer could verify its close condition or the cleanliness of its base. The crew did not verify the condition of this sea chest, since they were convinced about it having been repaired and checked at the shipyard and therefore, assumed it as appropriate.
4. Bypassing the alarm despite the certainty that such bypass demanded a explicit Company's permission due to the risk of causing serious damage to the ship's engine. This

fact indicated that the engineering department was not totally aware of the seriousness of the situation.

5. Connecting the seawater circulating pump intake to a ballast tank, preferably one at a high position or vertical so that this tank water could bleed the seawater circuit, and this way, allow the operation of the propulsion engine cooling system.

The fact that no strategy had been adopted at all lead to conclude that the emergency preparedness demanded by Article 8[25] of ISM[26] Code had not been fully implemented on board and the communication channels among shipboard departments themselves and with the company did not work properly.

Navigation Bridge to Engineering Team Communication

During the emergency situation, calls to the engine room were reduced to the most under the assumption that the personnel there were doing as much as possible to solve the failure. However, the team at the navigation bridge had to obtain as much information as possible to make appropriate decisions, among them, whether to proceed to enter to the port.

According to the crew statements, it was confirmed that:

- The master went down to the engine room to speak with the chief engineer to ascertain the cause of the failure
- The chief mate was ordered by the master to go down to the engine room to inquire about the progress made and inform on the vessel's compromising situation.
- The master ordered the second mate to go down to the steering gear area once the propulsion engine had stopped by second time and, as a result, a blackout had occurred in order to find out what the problem with the steering gear was and, if necessary, act on the emergency steering gear.

Due to all above, it can be concluded that the events of the LUNO's accident were developed at two different levels:

- nautical, fully conscious of situation, weather conditions and sea state, imminent hazard, etc.
- at the engine room, completely oriented to ascertain the causes of the failure.

Communication with the Company

According to the Company:

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[25] Literally:
"8.1 The Company should identify potential emergency shipboard situations, and establish procedures to respond to them.
8.2 The Company should establish programmes for drills and exercises to prepare for emergency actions.
8.3 The safety management system should provide for measures ensuring that the Company's organization can respond at any time to hazards, accidents and emergency situations involving its ships."

[26] International Management Code for the Safe Operation of Ships and for Pollution Prevention, iaw SOLAS 74/88, Chapter IX.

- Telephone was the means the master used to establish the first communication, in which the situation was reported as it was later than 09:25 hours and after the ship's propulsion engine had been set into operation. Immediately, the master was ordered to request two tugs.
- At 09:28 hours, the master was required again by the Company's Office to request two tugboats urgently so that the vessel could enter under the highest possible safety measures.
- At 09:35 hours, a part of the NAVIERA MURUETA technicians: Technical Director, Mechanical Engineer Inspector, and one of the persons responsible for freight were already on their way to Bayonne to witness the vessel's mooring. The rest of the staff were following through the AIS the vessel's manoeuvring procedures at the office in Bilbao .
- At 10:04 hours the Company's Emergency Plan was activated. ISM procedures were followed.

According to available records:

- 1 hour and 23 minutes passed since the propulsion engine stopped by first time at 09:13 hours until the vessel was stranded at 10:36.
- 36 minutes passed since the propulsion engine stopped by second time, but also permanently, at 10:00 hours and the moment the vessel was stranded.

It can be then inferred that if an initial, immediate and complete communication to provide all the available information had been established from the vessel to the Company, the Company could have deployed its resources and provided alternative solutions or plans considering the situation.

This assumption becomes even more consistent since the number of engineering department members on board is considered to have been insufficient in case of emergency, which implies an even worse scenario under a stressful situation.

Decision making.

1. Neither the chief engineer, nor the engineering department officers adopted any particular strategy except for their attempt to ascertain the cause of the failure. What should have been essential was to prevent the propulsion engine from stopping, verifying as well the gradual change of parameters and implementing alternative solutions so that it would not happened. Later on, the failure could have been quietly investigated.
2. Notwithstanding all above, the reduced number of members of the engineering department should have made both chief engineer and master think thoroughly about the need of a longer period of time to detect the failure. Even though a supernumerary chief engineer was on board, it was his first journey. The first assistant engineer was not used to performing management tasks, since he was dependent on the chief engineer's commands.

3. The chief engineer did not immediately inform or requested aid from the Company through the master. A quick Company and its technicians' response could have provided the stressed crew with some solutions.
4. The chief engineer's assumption about the main engine capability to work provided that 50% of nominal power was not exceeded was not based on real data, since the nature of the failures remained unknown. In addition, that supposition was linked to the master request for two tugboats, which meant the chief engineer himself ignored the cause or the magnitude of the failure. If the chief engineer had known the difficulties the tugboats would face in open sea under such weather conditions and that particular place situation, he might not have formulated such proposal.
5. Having more time for a better assessment of the situation could have lead to adopt alternative plans like cancelling the alarm, if necessary, or supplying the seawater cooling system with water from the upper ballast tanks.
6. The chief engineer did not consider any alternative plan that would help to eliminate or at least reduce hazard. As for cancelling the alarm alternative, the investigation consider the chief engineer as not sufficiently instructed to suggest this solution to the master. The chief engineer was aware of the location of the stop alarm for high temperature in the cylinder head discharge. He also knew how to cancel that safety measure. However, he believed that it was a decision to be inquired to the Company's Management due to the evident hazard of causing serious damage to the engine [27].
7. After the engine stopped by first time, the communications established between navigation bridge and engine room could have been more efficient, contributing this way to a calmer analysis of the emergency and the adoption of suitable measures. For instance, if any person was completely conscious of circumstances and hazards, it was the master. Should he have had all the information available on the chances of overloading the engine at a certain moment, he could have authorized such action[28].
8. The master came to know that the chief engineer had not detected the ultimate cause of the failure in the propulsion engine cooling service. However, he accepted the chief engineer's proposal to use the engine at a rate of 50% performance capacity provided that tugboats were requested.
9. The company was informed with some delay. Furthermore, the Company's emergency plan was initiated after the engine had stopped by second time at the Adour river mouth, but not when the first stop had been reported. Considering the stressful situation lived on

[27] It would make the ship's engine operate under inappropriate temperature conditions, with a subsequent hazard of seizing up.

[28] In accordance with IMS Code, article 5, i.e. "(…) The Company should establish in the safety management system that the master has the overriding authority and the responsibility to make decisions with respect to safety and pollution prevention (…). This statement is included in the Company's SMS documentation. Thus, it can be inferred the need of improving both apprehension and consequences of this provision.

board, especially inside the engine room, the Company's land based personnel should have cooperated with the crew to work out a solution or develop alternative plans.

10. In the subsequent decision making process, the cause of the failure was still unknown and the master was not duly informed about the possibility of bypassing the high temperature alarm or flooding the seawater circuit from upper ballast tanks. Therefore, he finally made a decision based on incomplete data, even though he was not fully aware of this. However, he certainly knew that the tugboats available were not the most suitable ones.

Decision to enter to the Port

The rough weather was becoming noticeable at causing the anchor dragging in the area of the landfall buoy. Considering the propulsion engine failure, entering the port seemed to be the choice most likely to succeed in order to prevent the ship from finally grounding on a beach nearby.

Following the pilot's advice, the master decided to start the manoeuvre to enter to the port, but taking into account the chief engineer's recommendation to request being towed in case the propulsion engine might stop.

Weather and oceanographic available data, including those provided by Anglet, San Sebastian and La Gascogne buoys predicted an imminent worsening of weather conditions in the area, being even likely that the port or ports nearby had to be closed. If LUNO was left to her fate, the failure, whose cause was unknown, might happen again and the vessel, with no chance of receiving aid in the middle of a storm, could be dragged to the coast. Previous accidents in the area such as ROMULUS in 1969, VIRGO Y RUBEN in 1976, CHATON in 1977, FRANZ HALS in 1996 and CAPETAN TZANNIS in 1997 in Bayonne, or MARO in 2008 in Pasajes lead to this concern.

Both master and pilot were convinced about entering to the port as the best option. However, they were also aware that the tugboats on duty at Bayonne Port would have to face serious difficulties to operate in open sea under rough sea conditions on that date and location. Therefore, the only problem for LUNO was crossing the Adour mouth bar without aid until being towed at the inner river mouth.

4.5. Efficiency of Rescue.

Towing means

The tugboats assisting LUNO after the propulsion engine had stopped by second time were inefficient to steer the vessel towards the estuary.

No seagoing tugboat that could have arrived early enough to assist LUNO was available near Bayonne.

Rescue Service

It must be highlighted the prompt response and adequate coordination of rescue services, including the request for help to SASEMAR to deploy all available air resources.

Effects on the Ship's Crew

While waiting to be rescued, the crew was lying on the portside wing or leaning against exterior bulkheads in the fear that the vessel's remains could capsize. In this case, being inside the bridge would have decreased their chances of surviving. Ship's motions were so hard that they could not be erect while waiting for the rescue to become feasible.

During this waiting time, wave impacts on the vessel affected the crew as follows:

1. The continuous change of plane caused by ship's motions together with their violent nature caused minor injuries due to the strenuously efforts made to avoid rolling on the bridge wing or hitting their head against the ship's structure. At least one of the crew members suffered from tendinitis for which he received medical treatment on his feet, as he had made a continuous effort with his feet on a bulkhead.
   At least two of the crew members were wearing a hard hat: this way their heads and necks could better withstand motion, hits and vibration on their body.
2. It was more serious the hypothermia in early stages suffered by some of the crew members due to the continuous splashing on them when waves were breaking against the vessel. Seawater temperature that morning was 13 ºC while air temperature ranged from 9ºC to 10º C. Those crewmembers wearing a raincoat or clothes less susceptible to be soaked were able to withstand splashes much better.

These effects support the importance of wearing a hard hat and warm clothes and shoes[29] enough to stay in a hostile environment during an abandon ship situation, in addition to other adequate personal protection equipment.

5. CONCLUSIONS

1. The immediate cause of the accident was the air present in the seawater propulsion engine cooling circuit. Neither the crew nor the ship's systems detected this undesirable air until the most important resulting effect arose: no cooling in the heat exchanger. The temperature increase caused the first high temperature alarm to trigger and just a few minutes later, the second went off. The first one was a warning alarm while the second protected the propulsion engine integrity by activating a stop command for the fuel propulsion engine supply pump.
2. After simulating the ship's behaviour in waves and analysing the crew's statements, it can be concluded that the air in the seawater main came from the frequent emersion of sea chests during the journey from Pasajes to Bayona. Sea chests were more seriously exposed to air at certain moments, being frequency maximum after 08:54 hours, which lead to the accident consequences.

[29] Preferably safety boots.

3. The portside upper sea chest is likely to have been open or partially open (for instance, an imperfect valve closure due to scale, etc. in the valve seat). The crew did not check this valve condition.
4. The seawater circuit may already have contained a certain quantity of air after leaving the shipyard due to insufficient bleeding or air accumulation in inaccessible parts of the circuit. The air would reduce the main engine cooling capacity, with no consequence until the quantity of air increased due to air income through sea chests.
5. The following factors also contributed to the unfortunate result:
    a) The chief engineer had not envisaged any alternative plan in case the propulsion engine would stop once again.
    b) Apparently, LUNO's master was not considering the likelihood of another failure of the propulsion engine, since he only had received some partial information provided by the chief engineer, who had only recommended not exceeding 50% of main engine nominal power and requesting the aid of tugboats. This evidently involved poor communication channels between the responsible persons of both departments.
    c) The communication between ship and Company, where access to more resources and personnel was available, was unsuitable. The Company's response was not quick enough, either so as to become efficient, especially by helping to identify the technical problem and proposing solutions. This and the other communication problems mentioned in previous paragraphs point out one or two fields to be improved in its Safety Management System.

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6. SAFETY RECOMMENDATIONS

To the Shipping Company Murueta:

1. To revise its Safety Management Procedures, especially the ones concerning communications, resources and authority, not only in relation with ships, but also within the Company and even within the ships. This is essential for contingencies, for which the number of crew members is usually insufficient since it is calculated for ship's operation under normal conditions.
2. To revise its operational procedures, especially the critical ones, to ensure that they are implemented in accordance with regulations, manufacturer specifications and industrial standards.

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Addendum 1 – General Arrangement Drawing

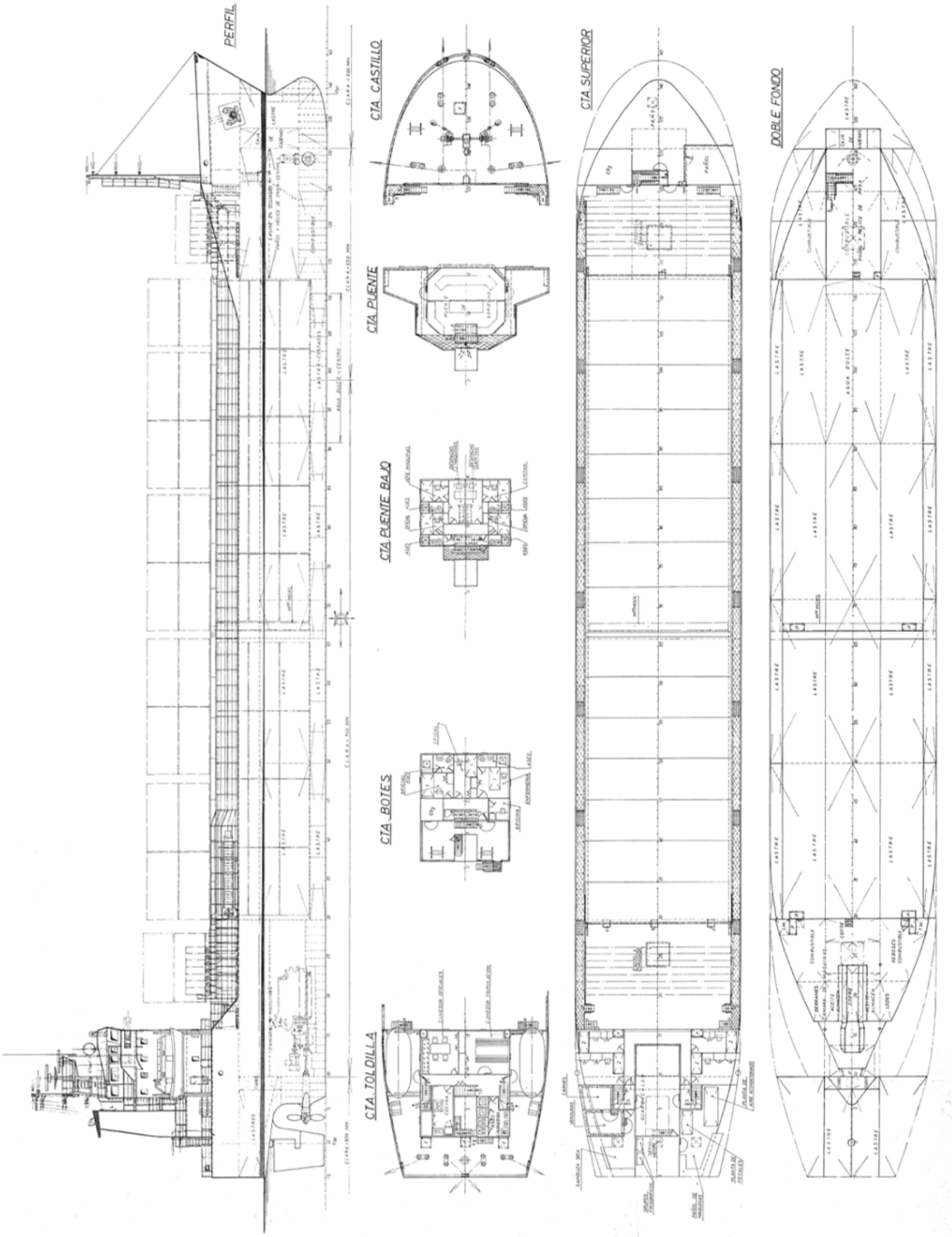

Figure 11.LUNO's General Arrangement Drawing

Addendum 2 – Discussion on the Regulations applicable to LUNO's Propulsion System and Power Plant.

Significant parts of SOLAS 1974 in force in 1992 when LUNO was built and considered relevant for a better understanding of the main hypothesis on the accident have been extracted. More specifically, they concern several provisions of Chapter II/1 regarding "*Construction - Structures, Subdivision and stability, machinery and electrical installations*".

Regulation 26 - General

(…)

3 Means shall be provided whereby normal operation of propulsion machinery can be sustained or restored even though one of the essential auxiliaries becomes inoperative. Special consideration shall be given to the malfunctioning of:

.1 a generating set which serves as a main source of electrical power;

.2 the sources of steam supply;

.3 the boiler feed water systems;

.4 los sistemas de alimentación de combustible líquido para calderas o motores;

.5 the fuel oil supply sisters for boilers or engines;

.6 the sources of water pressure;

.7 a condensate pump and the arrangements to maintain vacuum in condensers;

.8 the mechanical air supply for boilers;

.9 an air compressor and receiver for starting or control purposes;

.10 the hydraulic, pneumatic or electrical means for control in main propulsion machinery including controllable pitch propellers.

However, the Administration, having regard to overall safety considerations, may accept a partial reduction in propulsion capability from normal operation

(…)

6 Main propulsion machinery and all auxiliary machinery essential to the propulsion and the safety of the ship shall, as fitted in the ship, be designed to operate when the ship is upright and when inclined at any angle of list up to and including 15º either way under static conditions and 22.5º under dynamic conditions (rolling) either way and simultaneously inclined dynamically (pitching) 7.5º by bow or stem. (…)."

Afterwards, Regulation 29 regarding steering gear reads:

(…)

5 Main and auxiliary steering gear power units shall be:

.1 arranged to restart automatically when power is restored after a power failure; and

.2 capable of being brought into operation from a position on the navigation bridge. In the event of a power failure to any one of the steering gear power units, an audible and visual alarm shall be given on the navigation bridge.

Part D on Electrical Installations also mentions:

"Regulation 40 General

1 Electrical installations shall be such that:

.1 all electrical auxiliary services necessary for maintaining the ship in normal operational and habitable conditions will be ensured without recourse to the emergency source of electrical power;

.2 electrical services essential for safety will be ensured under various emergency conditions;

(…)"

And finally[30],

"Regulation 5 3- Special requirements for machinery, boiler and electrical installations

1 The special requirements for the machinery, boiler and electrical installations shall be to the satisfaction of the Administration and shall include at least the requirements of this regulation.

2 The main source of electrical power shall comply with the following:

2.1 Where the electrical power can normally be supplied by one generator, suitable load-shedding arrangements shall be provided to ensure the integrity of supplies to services required for propulsion and steering as well as the safety of the ship. In the case of loss of the generator in operation, adequate provision shall be made for automatic starting and connecting to the main switchboard of a stand-by generator of sufficient capacity to permit propulsion and steering and to ensure the safety of the ship with automatic restarting of the essential auxiliaries including, where necessary, sequential operations. The Administration may dispense with this requirement for a ship of less than 1,600 gross tonnage, if it is considered impracticable.

2.*2 If the electrical power is normally supplied by more than one generator simultaneously in parallel operation, provision shall be made, for instance by load shedding, to ensure that, in case of loss of one of these generating sets, the remaining ones are kept in operation without overload to permit propulsion and steering, and to ensure the safety of the ship."*

LUNO complied, or should comply with all that stated in Rule 53, Paragraph 2.2.

[30] Underlined by the CIAIM

Addendum 3 – Consideration on LUNO's Power Plant.

The technical information on the power plant was studied to verify:

- If the power plant was properly operated on board and according to design instructions.
- If special features for use could have some effects on the accident or prevented its avoidance.

The power plant comprised the following major items:

EQUIPMENT	TYPE	kVA (kW)
Generator 1	Shaft Alternator	600 (480)
Generator 2	Auxiliary Engine	230 (184)
Generator 3	Auxiliary Engine	118 (95)
Generator 4	Harbour Generator Set	63 (50)

The following table summarises the power balance under navigation conditions.

Unit	kW
Machinery equipment	**89,37**
Steering equipment	**12,62**
Deck equipment	**18,82**
Accommodation and lighting	**40,22**
TOTAL	**161,03**

According to this power balance, it can be inferred that under usual navigation conditions the power necessary to supply essential navigation, machinery and accommodation services, air conditioning system included, should be 161 kW, upon application of usual coefficients for this type of ships.

This means that, and considering the table above, **Generator 1** or **Generator 2** could provide all the necessary power supply without connecting two units to the bus bars.

Bow thruster operation involved **Generator 1,** as this unit nominal intensity is 530 A. Therefore, the overall requested power also considering the navigation condition could reach 400 kW peaks, with an average consumption close to 280 kW.

Connection and operation in parallel of two units with different power raises load sharing difficulties, which even increase when considering different electric power demands of direct drive motor controllers, since **Generator 1** was the ship's propulsion unit. However, load sharing could be provided actuating on **Generator 2**.

The performance of the semiautomatic synchronising system on board LUNO is not detailed in the documentation the CIAIM revised. However, both parallel connection and load sharing can be inferred from the electric diagrams, as a blackout cannot be assumed as a valid operating system according to this configuration.

Synchronizing and load sharing in automatic connection systems are unmanned operations. However, manual load sharing systems require the fuel engine regulating or supply system to be operated and/or the alternator to be excited.

In case load is not shared properly, one of the alternators may be working as a motor, absorbing load and, as a result, causing the installation to unbalance.

The engineering department officers stated that connection was not possible because one of the alternators "was expelled". They also explained this as a circumstance that "had always been happening". It can then be inferred the occurrence of a previous unresolved problem.

Due to all above, it is assumed that:

1. Entering to the port would have been possible without connecting the shaft alternator to decrease the load of the propulsion engine. Nevertheless, it is impossible to know whether this condition would have meant spending more time until reaching the safe propulsion engine stop temperature.
2. Load sharing difficulties for different control generator units indicated that alternators should not be connected.

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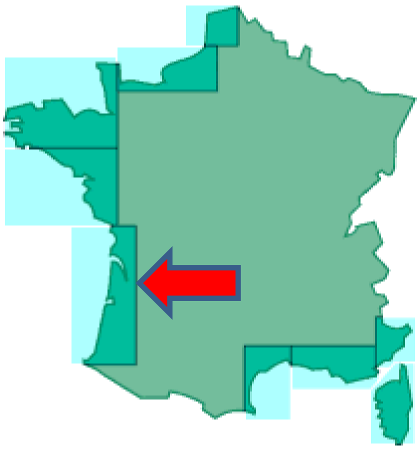
Addendum 4 – Meteorology and Sea State

Weather and maritime conditions were taken out from several Meteo-France bulletins, data buoys nearby and a maritime climate report by the CEDEX (Spanish Center for Civil Engineering Studies and Experimentation) and a report on weather and maritime conditions by AEMET (Spanish State Meteorological Agency).

Marine Weather Bulletin for Coastal Areas. 10-hour weather forecast by Meteo-France[31].



"Aiguillon–Spanish Border Maritime Area"

Weather forecast bulletin up to 20 miles off the coast from "l'anse de lÁiguillon" to the Spanish border.

Caution: under normal weather conditions, wind gusts may surpass 40% average wind speed and waves reach twice the significant wave height.

Special bulleting: Gale warning No. 55

General weather situation on 5 February 2014 at 06:00 hours UTC and development.

Low pressure system moving south British Isles generating a strong flow from the southwest sector. Wind speed will increase during the morning.

Weahter Observation on 5 de February 2014 at 09:00 hours UTC

(...)

Cap Ferret: 41 knot W – SW wind, rough seas, 1000 hPa increasing, cloudy, rain or drizzle, 2 to 5 miles visibility.

Pointe de Socoa: 10 knot W wind with 33 knot gusts, slight sea, 1005 hPa increasing, 5 to 10 mile visibility.

Forecast after midday on Wednesday 5 de February

- Wind from Cap Breton to Spanish border: SW 4 to 6, changing W at night; gusts.
- Sea: rough and locally abeam with NW swell.
- Swell: from NW increasing from 5 to 7 m
- Weather: showers together with strong gusts.
- Visibility: poor while rain pouring down.

[31] Translated by CIAIM for the original document in Spanish language.

Data Buoys Record

Figure 12 shows the location of the three data buoys whose data were used to explain weather development (San Sebastián and Bayonne buoys) and make the decision of authorising LUNO'S entry at Bayonne Port (Gascogne buoy).

Figure 12.Data Buoy Position near Bayonne

Deep Water San Sebastián Bouy Data[32], Data Bouy at 21.4 miles West Bayonne

The ship started the manoeuvre to leave Pasajes at 19:18 on 4th February. The fact of following several track courses was caused by the need of arriving close to the pilot station in due time the following morning. Therefore, the time available for the journey was much longer than the one needed. The ship arrived at Bayonne at 07:00 hours, LT.

Wind and sea conditions in the area will be hereinafter analysed. For this purpose, the data San Sebastián buoy registered will be taken into consideration in order to obtain an estimate of wind and sea state in the area. This buoy is the one closest to the track LUNO followed to reach Bayonne. See Figure 13.

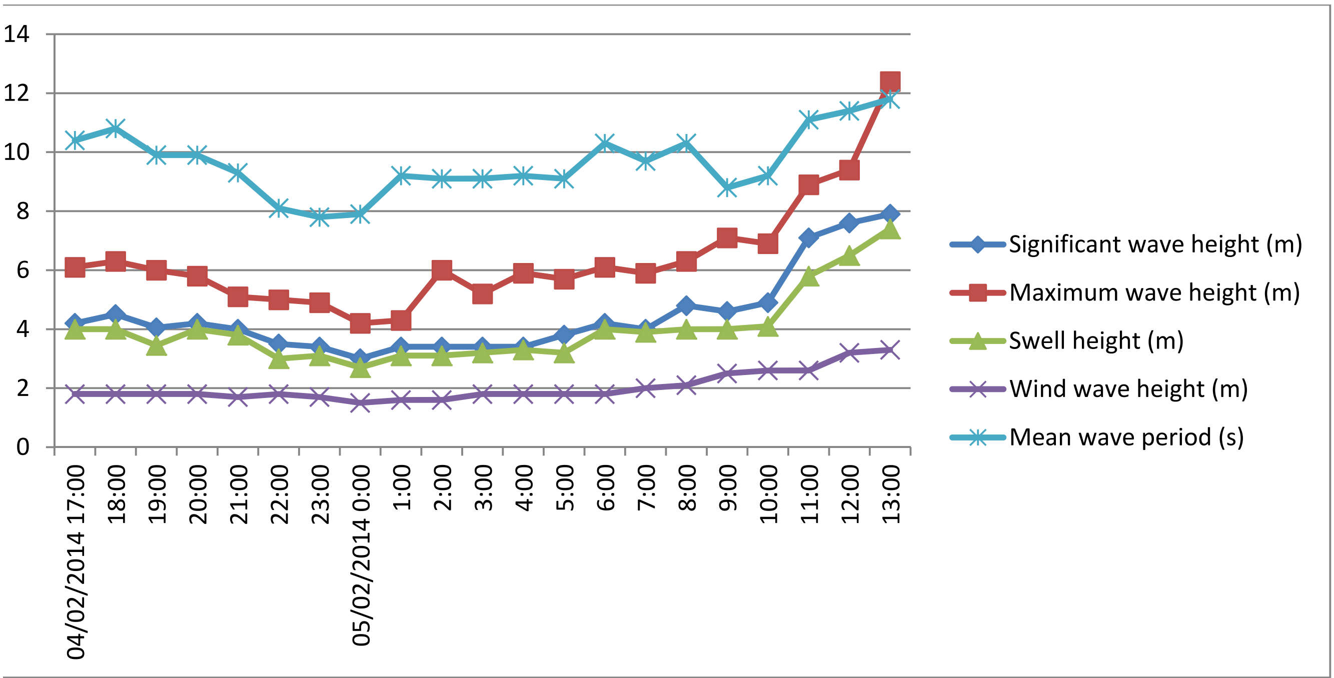


Figure 13.San Sebastián Buoy Data.

After leaving Pasajes at 19:18 hours on 4th February, LUNO was sailing in an area where the combined sea significant height was between 3 and 4 m, maximum wave height 4.3 m to 5.5 m, mean wave period of 9.5 s and direction of wave propagation to west. The wind component of waves was smaller with a significant height of 1.8 m, which veered from WSW to SSW, and finally to W again at 21:30 hours approximately.

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[32] Basque Meteorological Agency (EuskalMet). Anchored at a depth of 600 m, it measures ocean and meteorological parameters every half an hour at San Sebastián geographical longitude.

At 05:00 LT, San Sebastián buoy showed a significant combined wave height of 3.5 m, reaching a maximum height of 5.6 m and a mean wave period of 9.5 s. The main component of combined waves was swell, which in the end was predominant. These conditions prevailed until 07:00 hours, when they steadily worsened until 08:00 hours. At this time, the significant combined wave height was 4.5 m, reaching a maximum height of 6.5 m and a mean wave period of 10 s. These conditions prevailed until 10:00 hours, when their worsening was very fast.

During the period taken into consideration, the direction from which combined waves came was W to veer progressively to WNW. Wind and wave component was from SW in the period concerned to gradually veer to WNW from 06:00 hours onwards.

Since wind and sea conditions were moving from west to east, their worsening is assumed to have reached Bayonne some time later than when it was noticed in the buoy area. This information was available to both pilot and authorities on the Internet.

Data of 06402 –Bayonne buoy[33] located 3.7 miles west of Adour Estuary.

Local time	Hs (Significant Wave Height) (m)	Hmax (Maximum Wave Height) (m)	Peak Period (s)	Direction of Origin (°)	Remarks
07:00	3,0	5,4	12,9	285	Ship's arrival at the area, waiting.
07:30	3,3	6,2	13,0	288	
08:00	3,3	5,8	12,6	290	
08:30	3,3	4,9	11,4	287	
09:00	3,9	6,1	11,9	288	Stand-by engines. Some minutes later, the high temperature alarm went off and the propulsion engine stopped.
09:30	4,0	6,5	11,4	292	A bit later, the engine could be started again.
10:00	4,5	6,0	12,7	290	High temperature alarm activated again. A bit later the propulsion engine stops by second, but last time.
10:30	4,3	6,5	11,8	290	Soon after this time, the ship's bow was stranded at the breakwater.

[33] This buoy belongs to the French Wave Measuring System CANDHIS (*Centre d'Archivage National de Données de Houle In Situ*).

Local time	Hs (Significant Wave Height) (m)	Hmax (Maximum Wave Height) (m)	Peak Period (s)	Direction of Origin (°)	Remarks
11:00	5,0	7,4	12,8	290	
11:30	5,4	8,6	12,9	288	Soon after this time, rescue was decided to be postponed until tide was low.
12:00	5,7	8,6	13,3	285	
12:30	6,2	8,8	14,1	288	
13:00	6,2	9,5	13,9	283	New rescue attempt began.
13:30	7,2	14,2	15,1	290	Soon after this time the whole crew had been rescued.

Data of Gascogne Buoy - UKMOMF

Figure 14 depicts Gascogne buoy data, which is located in the Bay of Biscay (**45°12'2" N 5°0'0" W)** and kept by the British *Met Office* in cooperation with *Météo-France*.

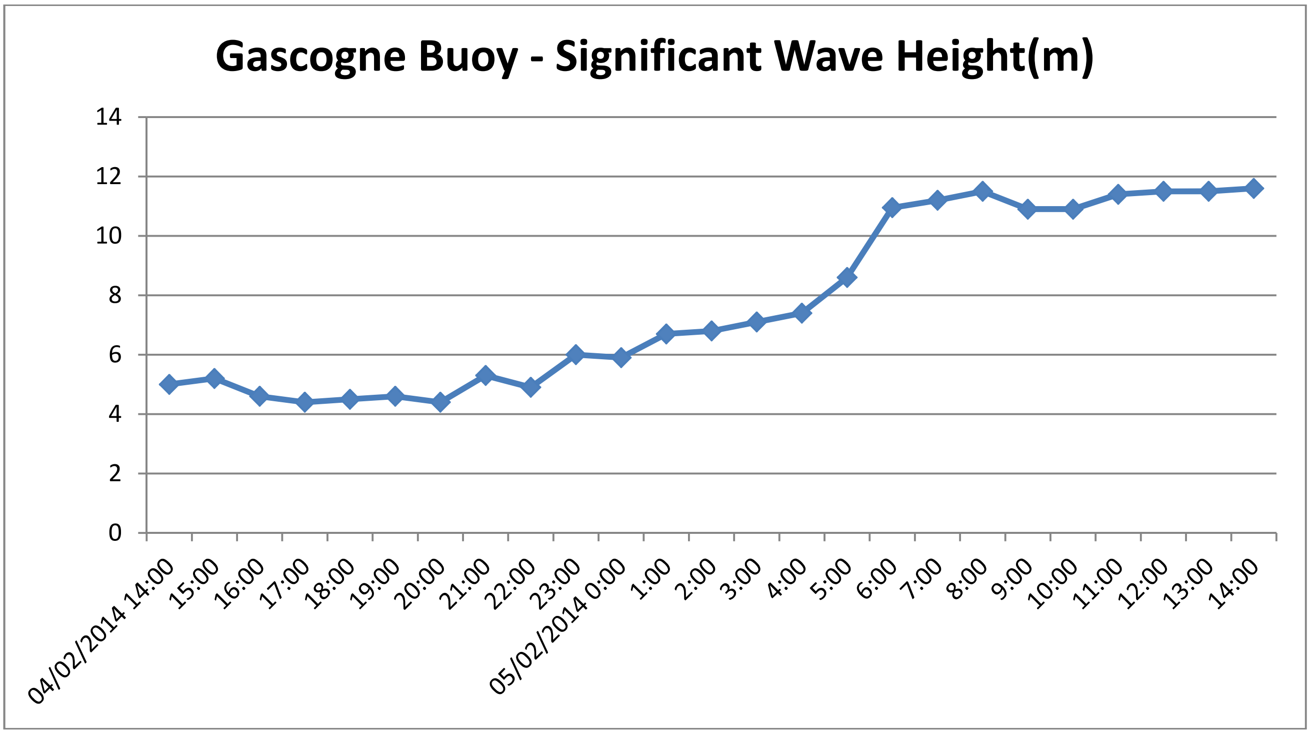

Figure 14.Gascogne Buoy Recorded Data.

The data recorded by this buoy were taken into consideration by Port and Maritime Authorities and the pilot during the information gathering process that finally lead to the decision of authorising LUNO to enter to the Port of Bayonne.

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Addendum 5 – Ship's Motion Simulation Results

Date and Time	Significant Wave Height (m)	Max. Height (m)	Mean Period (s)	Direction of Origin (º)	Average Course (º)	Ship's speed (knots)	Heading (º)	Significant wave Height for calculations (m)	Mean Period for calculations (s)	Lower Sea Chest Emersion (exposure rate per hour)[34]	Upper Sea Chest Emersion (exposure rate per hour)
04/02 19:00	4.05	6	9.9	280	Not applicable	0	Not applicable	4	10	Not applicable	Not applicable
04/02 20:00	4.2	5.8	9.9	280	30	9	70	4	10	11	127
04/02 21:00	4	5.1	9.3	280	0	4.5	100	4	10	18	209
04/02 22:00	3.5	5	8.1	280	several	2.50	several	3.4	8	5	142
04/02 23:00	3.4	4.9	7.8	280	several	2	several	3.4	8	5	141
05/02 00:00[35]	3	4.2	7.9	280	90	3	10	3.4	8	3	94
05/02 00:00	3	4.2	7.9	280	270	3	170	3.4	8	7	202
05/02 01:00	3.4	4.3	9.2	280	110	5.5	10	3.4	9.1	2	66
05/02 02:00	3.4	6	9.1	280	90	2	10	3.4	9.1	3	98
05/02 03:00	3.4	5.2	9.1	280	112.5	1.75	12.5	3.4	9.1	3	101
05/02 04:00	3.4	5.9	9.2	280	145	2.75	45	3.4	9.1	3	95
05/02 05:00	3.8	5.7	9.1	280	140	3.5	40	3.4	9.1	3	87

[34]Values in this column must be multiplied by two so that ship's motion towards both portside and starboard directions are taken into consideration.
[35] At approximately this time, navigation took place E-W, in both directions.

05/02 06:00	4.2	6.1	10.3	280	180	3.5	80	3.4	9.1	4	113
05/02 07:00	4	5.9	9.7	280	190	4	90	3.3	12	3	96
05/02 07:30	3.3	6.2	13	288	230	1.6	122	3.3	12	3	109
05/02 08:00	3.3	5.8	12.6	290	270	1.7	160	3.3	12	4	120
05/02 08:30	3.3	4.9	11.4	287	80	4.5	27	3.3	12	2	61
05/02 09:00	3.9	6.1	11.9	288	203	6.4	95	4.5	12	34	228
05/02 09:30	4	6.5	11.4	292	222	3.2	110	4.5	12	37	246
05/02 10:00	4.5	6	12.7	290	119	5.6	9	4.5	12	18	118
05/02 10:30	4.3	6.5	11.8	290	grounded			4.5	12	grounded	

Simulation does not provide accurate data of the number of times LUNO's bow emerged and sea chests were exposed to the weather. Numbers shown in the table are to be only considered as illustrative.

Data must be understood under rough, but never calm, sea conditions. Considering as an example the value at 00:00 hours for the upper sea chest, number 202 means that ship's motion made possible for this upper sea chest to be exposed to the weather 202 times in an hour, i.e., more than 3 times per minute, which may or may not be coincident with roll angles.

From 22:00 to 00:00 hours, both propulsion engine and steering gear were being checked. Even though upper and lower sea chests emersions per hour are assigned as "average values" it cannot be discarded at all their having been much more frequent and sharper when the ship was abeam while the verification procedures mentioned were being implemented.

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