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# STEAM SHIP EL FARO (O.N. 561732)
# SINKING AND LOSS OF THE VESSEL
# WITH 33 PERSONS MISSING AND PRESUMED DECEASED
# NORTHEAST OF ACKLINS AND CROOKED ISLAND, BAHAMAS
# ON OCTOBER 1, 2015

## MARINE BOARD'S REPORT

1. Executive Summary

The loss of the U.S. flagged cargo vessel EL FARO, along with its 33 member crew, ranks as one of the worst maritime disasters in U.S. history, and resulted in the highest death toll from a U.S. commercial vessel sinking in almost 40 years. At the time of the sinking, EL FARO was on a U.S. domestic voyage with a full load of containers and roll-on roll-off cargo bound from Jacksonville, Florida to San Juan, Puerto Rico. As EL FARO departed port on September 29, 2015, a tropical weather system that had formed east of the Bahamas Islands was rapidly intensifying in strength. The storm system evolved into Hurricane Joaquin and defied weather forecasts and standard Atlantic Basin hurricane tracking by traveling southwest. As various weather updates were received onboard EL FARO, the Master directed the ship southward of the direct course to San Juan, which was the normal route.

The Master's southern deviation ultimately steered EL FARO almost directly towards the strengthening hurricane. As EL FARO began to encounter heavy seas and winds associated with the outer bands of Hurricane Joaquin, the vessel sustained a prolonged starboard list and began intermittently taking water into the interior of the ship. Shortly after 5:30 AM on the morning of October 1, 2015, flooding was identified in one of the vessel's large cargo holds. At the same time, EL FARO engineers were struggling to maintain propulsion as the list and motion of the vessel increased. After making a turn to shift the vessel's list to port, in order to close an open scuttle, EL FARO lost propulsion and began drifting beam to the hurricane force winds and seas. At approximately 7:00 AM, without propulsion and with uncontrolled flooding, the Master notified his company and signaled distress using EL FARO's satellite distress communication system. Shortly after signaling distress, the Master ordered abandon ship. The vessel, at the time, was near the eye of Hurricane Joaquin, which had strengthened to a Category 3 storm. Rescue assets began search operations, and included a U.S. Air National Guard hurricane tracking aircraft overflight of the vessel's last known position. After hurricane conditions subsided, the Coast Guard commenced additional search operations, with assistance from commercial assets contracted by the vessel's owner. The search located EL FARO debris and one deceased crewmember. No survivors were located during these search and rescue operations.

On October 31, 2015, a U.S. Navy surface asset contracted by the NTSB, using side-scan sonar, located the main wreckage of EL FARO at a depth of over 15,000 feet. EL FARO's voyage data recorder was successfully recovered from EL FARO's debris field on August 15, 2016, and it contained 26-hours of bridge audio recordings as well as other critical navigation data that were used by the MBI to help determine the circumstances leading up to this tragic incident.

Over the course of the investigation the MBI relied on visits to EL FARO's sister vessel, EL YUNQUE, to help understand the internal configuration of the PONCE class vessels and also identify operational and maintenance issues that could have impacted both vessels.

The scope of the MBI was expanded to include the entire Coast Guard Alternate Compliance Program after Authorized Class Society performance and regulatory oversight concerns were noted for EL FARO, EL YUNQUE, and several additional U.S. flagged vessels in the program.

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2. Preliminary Statement

This marine casualty investigation was conducted and this report was submitted in accordance with 46 Code of Federal Regulations (CFR) § 4.09, and under the authority of 46 United States Code (U.S.C.) Chapter 63. Under 46 U.S.C. § 6308, no part of a report of a marine casualty investigation, including findings of fact, opinions, recommendations, deliberations, or conclusions, shall be admissible as evidence or subject to discovery in any civil or administrative proceedings, other than an administrative proceeding initiated by the United States.

The Chairman of the Marine Board of Investigation (MBI) was Captain Jason D. Neubauer, United States Coast Guard (Coast Guard) Office of Investigations and Analysis. The MBI's legal advisor was Mr. Jeff Bray, Coast Guard Office of Maritime and International Law. Members of the MBI were: CDR Matthew J. Denning and Mr. G. Keith Fawcett, Coast Guard Investigations National Center of Expertise. Technical Advisors to the MBI were: CDR Michael Odom and CDR Michael Venturella, Coast Guard Traveling Inspection Staff; Dr. Jeffrey Stettler and LT Michael Comerford, Coast Guard Marine Safety Center; and Mr. Paul Webb, Coast Guard District Seventeen Search and Rescue Specialist. The MBI's Recorder was LCDR Damian Yemma, Coast Guard Investigations National Center of Expertise, and the Media Liaison was Mrs. Alana Miller, Coast Guard Office of Public Affairs.

The following organizations and person were designated as Parties-in-Interest (PII) in this investigation: TOTE Incorporated, as the parent corporation of the vessel's owner and operator; ABS, as the authorized classification society of EL FARO; Herbert Engineering Corporation, as the naval architecture firm for the owner and operator; and Ms. Teresa Davidson, as next of kin for Captain Michael Davidson, Master, EL FARO.

The MBI held three public hearing sessions in Jacksonville, Florida, in February and May 2016, and February 2017; 76 witnesses testified during 30 days of hearings. All witnesses appeared as requested, and PII representatives participated throughout the hearings. PIIs and witnesses cooperated with all investigation requests.

The National Transportation Safety Board (NTSB) was the lead federal agency for initial evidence collection activities, and led all efforts to recover and transcribe the vessel's voyage data recorder (VDR). The NTSB participated in all hearing sessions, and the MBI and NTSB shared all evidence and factual material gathered throughout the course of their investigations. However, the MBI and NSTB worked separately during the analysis phase of their respective investigations in order to prepare independent conclusions and recommendations.

Unless otherwise noted, references to time in this report are in Eastern Daylight Time, Coordinated Universal Time (UTC) offset minus 4 hours.

TOTE Maritime Puerto Rico (TMPR) was EL FARO's owner responsible for managing the movement of cargo between Jacksonville, Florida, and San Juan, Puerto Rico. TOTE Services Inc. (TSI) operated and crewed EL FARO. Both TSI and TMPR are subsidiary companies of TOTE Inc. Throughout the report, these two companies will be collectively referred to as TOTE, unless otherwise specified.

In addition to the Safety Recommendations in Section 10 of this report, the MBI will also prepare lessons learned, which are advisories for vessel owners, operators, crew members, and other interested parties. The Coast Guard will release these lessons learned in a separate report.

Throughout the investigation, recommendations, information and unique insight into the loss of EL FARO were provided to the MBI through the ELFARO@uscg.mil email address. These emails provided great assistance to the MBI, and selected correspondence will be included in the Coast Guard's MISLE database for this activity.

3. List of Acronyms

| | |
|---|---|
| 1A/E | 1st Assistant Engineer |
| 2A/E | 2nd Assistant Engineer |
| 2/M | 2nd Mate |
| 3A/E | 3rd Assistant Engineer |
| 3/M | 3rd Mate |
| AB | Able Seaman |
| ABS | American Bureau of Shipping |
| ACP | Alternate Compliance Program |
| ACS | Authorized Classification Society |
| BVS | Bon Voyage System |
| CDO | Command Duty Officer |
| C/E | Chief Engineer |
| CEO | Chief Executive Officer |
| CFR | Code of Federal Regulations |
| C/M | Chief Mate |
| CPA | Closest Point of Approach |
| CSM | Cargo Securing Manual |
| COI | Certificate of Inspection |
| DPA | Designated Person Ashore |
| EPIRB | Emergency Position Indicating Radio Beacon |
| EPMV | Emergency Preparedness Manual - Vessel |
| GEO | Geostationary Earth Orbiting |
| GM | Metacentric Height |
| GMDSS | Global Maritime Distress and Safety System |
| HEC | Herbert Engineering Corporation |
| IACS | International Association of Classification Societies |
| ICCL | International Convention on Load Lines |
| ILLC | International Load Line Certificate |
| ISM | International Safety Management |
| KW | Kilowatt |
| LEO | Low Earth Orbiting |
| LES | Land Earth Station |
| LO/LO | Lift-On/Lift-Off |
| LRIT | Long Range Identification and Tracking |
| LUT | Local User Terminal |
| MBI | Marine Board of Investigation |
| MSM | Marine Safety Manual |
| MEO | Mid Earth Orbiting |
| MISLE | Marine Information for Safety and Law Enforcement |
| MSC | Marine Safety Center |
| NAIS | National Automated Identification System |
| NCS | Network Coordination Station |
| NHC | National Hurricane Center |
| NOAA | National Oceanographic and Atmospheric Administration |

| | |
|---|---|
| NTSB | National Transportation Safety Board |
| NVIC | Navigation and Vessel Inspection Circular |
| OCMI | Officer In Charge, Marine Inspection |
| OMV | Operations Manual -Vessel |
| OPBAT | Operations Bahamas and Turks and Caicos |
| OUC | Operations Unit Controller |
| PII | Party in Interest |
| P/E | Port Engineer |
| P/M | Port Mate |
| PSI | Pounds Per Square Inch |
| QMED | Qualified Member of the Engine Department |
| RCC | Rescue Coordination Center |
| RO/RO | Roll on/Roll off |
| RPM | Revolutions Per Minute |
| S.S. | Steam Ship |
| SAR | Search and Rescue |
| SART | Search and Rescue Transponder |
| SLDMB | Self Locating Datum Marker Buoy |
| SMC | Search and Rescue Mission Coordinator |
| SMS | Safety Management System |
| SOLAS | International Convention for the Safety of Life at Sea |
| SRR | Search and Rescue Region |
| SSAS | Ship Security Alert System |
| SSL | Sea Star Lines |
| STCW | Standards of Training, Certification, and Watchkeeping |
| SUC | Situation Unit Controller |
| S-VDR | Simplified Voyage Data Recorder |
| T&S | Trim and Stability |
| TMPR | TOTE Maritime Puerto Rico |
| TS | Tropical Storm |
| TSI | TOTE Services Inc. |
| USMCC | United States Mission Control Center |
| U.S.C. | United States Code |
| USCG | United States Coast Guard |
| UTC | Coordinated Universal Time |
| VDR | Voyage Data Recorder |
| VHF | Very High Frequency |
| VP | Vice President |

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## 5. Vessel Involved in the Incident

**Figure 1. S.S. EL FARO. (Source: TOTE)**

| | |
|---|---|
| **Official Name** | EL FARO |
| **Official Number** | 561732 |
| **Flag** | United States |
| **Service** | Freight Ship |
| **Type** | RO/RO and Container |
| **Build Year** | 1975 |
| **Gross Registered Tons** | 17,527 |
| **Length overall** | 790 feet |
| **Beam** | 92 feet |

| | |
|---|---|
| **Molded Draft** | 42 feet |
| **Propulsion** | Steam Turbine |
| **Ahead Horsepower** | 30,000 BHP |
| **Maximum Speed** | 24 knots |
| **Boilers** | 2 Babcock & Wilcox Co. |
| **General Boiler Type** | Water Tube with Natural Circulation |
| **Owner** | TOTE Maritime Puerto Rico (formerly Sea Star Line, LLC)<br>Jacksonville, Florida |
| **Operator** | TOTE Services, Inc.<br>Jacksonville, Florida |
| **Classification Society** | ABS |
| **Date of Enrollment in ACP** | February 27, 2006 |
| **Inspection Subchapter** | I – Cargo and Miscellaneous Vessels |
| **Certification Date** | February 22, 2011 |
| **Expiration Date** | February 22, 2016 |
| **Hailing Port** | San Juan, Puerto Rico |
| **Route** | Between San Juan, Puerto Rico and Jacksonville, Florida |
| **Builder** | Sun Shipbuilding and Drydock |
| **Construction** | Welded Steel |
| **Furnace** | Pressure Firing with Oil Two Divided |
| **Design Pressure** | 1,070 PSI |
| **Generator Prime Mover** | Two Terry Steam Turbines |
| **Rated Horsepower** | 2,000 KW |
| **Operating Speed** | 7,024 RPM |
| **Marine A.C. Generator** | Two General Electric |
| **Volts** | 450 V |
| **Emergency Power Generation** | 350 KW Delco A.C. Generator |
| **Emergency Power Prime Mover** | Detroit Diesel V-71 |
| **Steering Gear** | Electro-hydraulic |
| **Manning During Accident Voyage** | 27 Crew and 6 Supernumeraries |
| **Cargo Aboard During Accident Voyage** | Electric Reefers with Logs – 238<br>Dry – 3<br>Trailer – 118<br>Autos – 149<br>Not in Containers – 15<br>Containers – 391<br>Other – 4<br>Fructose – 600.9 Long tons<br>Total Tonnage – 11,045.9 Long Tons |

6. Persons Missing and Presumed Deceased

All persons on board EL FARO at the time of the casualty, listed below in alphabetical order, are missing and presumed deceased, as determined by the Coast Guard Sector Commander and Officer In Charge, Marine Inspection (OCMI), Jacksonville, Florida on October 14, 2015.

| **Name** | **Sex** | **Age** | **Position** |
|---|---|---|---|
| Louis M. Champa | M | 51 | Qualified Member of the Engine Department |
| Roosevelt L. Clark | M | 38 | Utility Person |
| Sylvester C. Crawford Jr. | M | 40 | Qualified Member of the Engine Department |
| Michael C. Davidson | M | 53 | Master |
| Brookie L. Davis | M | 63 | Able Seaman |
| Keith W. Griffin | M | 33 | 1st Assistant Engineer |
| Frank J. Hamm III | M | 49 | Able Seaman |
| Joe E. Hargrove | M | 65 | Oiler |
| Carey J. Hatch | M | 49 | Able Seaman |
| Michael L. Holland | M | 25 | 3rd Assistant Engineer |
| Jack E. Jackson | M | 60 | Able Seaman |
| Jackie R. Jones, Jr. | M | 38 | Able Seaman |
| Lonnie S. Jordan | M | 35 | Messman |
| Piotr M. Krause | M | 27 | Supernumerary/Riding Crew |
| Mitchell T. Kuflik | M | 26 | 3 rd Assistant Engineer |
| Roan R. Lightfoot | M | 54 | Bosun |
| Jeffrey A. Mathias | M | 42 | Supernumerary/Riding Crew Supervisor |
| Dylan O. Meklin | M | 23 | 3 rd Assistant Engineer |
| Marcin P. Nita | M | 34 | Supernumerary/Riding Crew |
| Jan P. Podgórski | M | 43 | Supernumerary/Riding Crew |
| James P. Porter | M | 40 | Utility Person |
| Richard J. Pusatere | M | 34 | Chief Engineer |
| Theodore E. Quammie | M | 67 | Steward |
| Danielle L. Randolph | F | 34 | 2nd Mate |
| Jeremie H. Riehm | M | 46 | 3rd Mate |
| LaShawn L. Rivera | M | 32 | Chief Cook |
| Howard J. Schoenly | M | 51 | 2nd Assistant Engineer |
| Steven W. Schultz | M | 54 | Chief Mate |
| German A. Solar-Cortes | M | 51 | Oiler |
| Anthony S. Thomas | M | 47 | Oiler |
| Andrzej R. Truszkowski | M | 51 | Supernumerary/Riding Crew |
| Mariette Wright | F | 51 | Utility Person |
| Rafal A. Zdobych | M | 42 | Supernumerary/Riding Crew |

7. Findings of Fact

7.1. The Incident

**Monday, September 28, 2015**

EL FARO arrived at the Jacksonville Sea Buoy at 10:36 AM on a voyage from San Juan, Puerto Rico, and docked at the Blount Island terminal at 12:42 PM, starboard side to the pier. The terminal was operated by PORTUS stevedoring.

Upon docking, the stevedores and longshoremen began unloading the ship. The cargo consisted of both load on/load off (LO/LO) containerized cargo and roll on/roll off (RO/RO) wheeled cargo on trailers or chassis. After the unloading was complete, stevedores and longshoremen began loading cargo for the voyage back to San Juan. They loaded containers on the upper deck and drove RO/RO cargo into the holds below deck via cargo ramps. Once the RO/RO cargo was placed in a stowed position, lashing gangs secured the cargo with chains and other lashing gear, pursuant to the vessel's cargo securing procedures. PORTUS personnel lashed the cargo with supervisors overseeing the cargo operations on the vessel's decks.

PORTUS personnel developed the stow plan using the Spinnaker® software, and TOTE personnel in the terminal operations branch input cargo weight and other information into the CargoMax® stability software. During the September 28, 2015 loading of EL FARO, the TMPR Marine Operations Manager was on vacation and his duties were assumed by the TMPR Terminal Manager.

The mates aboard EL FARO were responsible for ensuring the cargo was properly loaded and secured, and the Chief Mate (C/M) had the overall responsibility for the safe loading of cargo. TOTE had previously hired Port Mates (P/M) in San Juan and Jacksonville to assist the ship's mates with in-port duties. However, after September 1, 2015, TOTE did not provide P/Ms in Jacksonville. The crew of EL FARO had difficulty keeping up with the pace of cargo loading, which continued until shortly before EL FARO departed Jacksonville.

On September 28, service technicians from Harding Safety Inc. boarded EL FARO to replace the clutches on the port and starboard life boat davit system. The technicians completed this work on September 29, shortly before EL FARO departed. Neither the Coast Guard nor ABS was notified of the life boat davit repairs prior to EL FARO departing Jacksonville.

The southbound voyage to San Juan, Puerto Rico was designated voyage *185S*; *185* indicated the sequential number of the voyage, and *S* indicated the direction - southbound.

A well-defined surface low that had been strengthening in the Western Atlantic since 2:00 PM on September 26, 2015, was upgraded to Tropical Depression 11 at 8:00 PM on September 27, 2015. Tropical Depression 11 intermittently intensified during EL FARO's port call in Jacksonville and it was upgraded to Tropical Storm (TS) Joaquin in a public advisory issued by the National Hurricane Center (NHC) at 10:36 PM on September 28, 2015. At the time, TS

Joaquin was approximately 295 nautical miles northeast of San Salvador and heading in a southwesterly direction at a speed of about 4 knots.

**Tuesday, September 29, 2015**

The Master monitored the developing storm system as he considered route options for the trip to San Juan. In general, onboard EL FARO, the Second Mate (2/M) was responsible for developing the voyage plan, which the Master reviewed and approved. EL FARO's normal southerly route, which it sailed weekly, took the ship from the sea buoy at Jacksonville, Florida directly to San Juan, Puerto Rico; a distance of approximately 1,100 nautical miles. In late August 2015, with tropical systems Erika and Danny in the vicinity of the eastern Bahamas, the same Master took EL FARO on a diverted path through the Old Bahama Channel to San Juan. Although the Old Bahama Channel added about 160 nautical miles to the length of the voyage, the route provided better protection from storm generated waves in the open waters of the Atlantic Ocean.

At 10:03 AM, the Master received a text message advising him of the storm from an off-duty EL FARO 2/M who had recently sailed on the vessel. The Master sent a response text acknowledging he was aware of the storm. At 6:31 PM, the off-duty 2/M sent a follow-up text to the Master specifically inquiring about the intended route plan to avoid TS Joaquin. The Master responded that he intended to take the normal, direct route to San Juan. The off-duty 2/M sent a final text reminding the Master about available alternate routes, including mid-transit voyage alternatives to the Old Bahama Channel, if that became necessary.

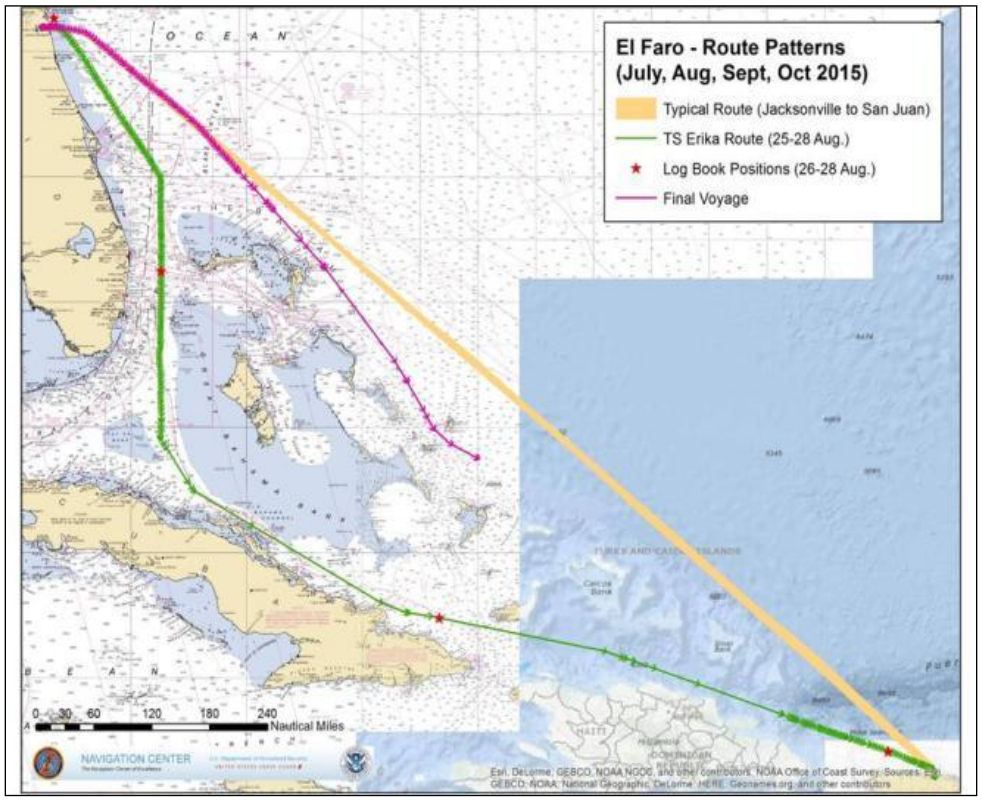


**Figure 2. EL FARO's typical southerly route, deviation route during TS Erika, and final voyage route.**

The C/M's standing orders for loading and unloading operations required that the mates pay attention to any developing list during cargo loading, and to contact the C/M if the list exceeded 2.5 degrees. On the afternoon of September 29, the TMPR Terminal Manager noted a starboard list greater than he had ever observed during loading. As a result, the TMPR Terminal Manager took a photograph of the list and alerted the stevedores to immediately load containers onto the ship's port side to correct the list. Later analysis of the photograph by a Coast Guard engineer determined the list was approximately four degrees. Based on the Terminal Manager's alert, the stevedores loaded cargo on the port side and corrected the list before EL FARO sailed.

**Figure 3. Photograph taken by TMPR Terminal Manager on September 29, 2015, showing starboard list of approximately 4 degrees during loading operations prior to the final voyage.**

A TSI Port Engineer (P/E) had dinner with the Master onboard EL FARO; he was the last TOTE shore side management employee to visit EL FARO prior to the casualty. The P/E testified that he and the Master discussed the tropical storm that was developing, but that the Master had no specific concerns about weather; the P/E could not recall any discussions about the planned route. The P/E also testified that he was stressed by the amount of work he needed to get accomplished during EL FARO's final voyage, in preparation for the vessel's scheduled dry docking in Tacoma, WA. He specifically referenced the installation of new winches, power cables, and a glycol heating system for ramp deicing.

At the time of the accident voyage, EL FARO was in the process of converting its cargo carrying arrangements in preparation for a move back to the Alaskan RO/RO trade. A TOTE labor supervisor onboard EL FARO managed a team of five Polish workers, who were onboard to conduct the conversion work. TOTE planned to complete the conversion at EL FARO's next scheduled yard period in December 2015. Four of the Polish workers spoke and understood very limited English, and relied on the fifth Polish member to serve as a translator between themselves and the Riding Crew Supervisor and EL FARO crew members. The Polish workers

were not provided a safety indoctrination or Basic Safety Training (BST) before sailing on EL FARO.

At 6:37 PM, the Master downloaded a Bon Voyage System (BVS) weather package from the Inmarsat email system. BVS is an Applied Weather Technologies (AWT) product that uses weather data from the National Hurricane Center (NHC), and other sources, to graphically display anticipated weather conditions along the vessel's intended or planned route. BVS emails were regularly sent to the Master's shipboard email account; the Master then had to manually forward them to the bridge for use by the navigational watchstanders.

AWT had a subscription-based routing service to help vessels avoid heavy weather. TOTE did not subscribe to that service at the time of the accident voyage. BVS also had a tropical update feature which would automatically email tropical updates to a ship, generally within one hour of the NHC issuing a new Tropical Cyclone Forecast/Advisory. EL FARO did not have this feature activated during the final voyage.

Loading operations ended at 6:54 PM, and the vessel was fully loaded as indicated in the vessel details section of this report. Prior to departure, the TMPR Terminal Manager provided the EL FARO C/M with the CargoMax® load case file on a portable flash memory storage device.[1]

**Figure 4. EL FARO computer rendering showing the vessel in the departure condition, with mean draft 30.1 feet, 0 degree list, and the stern trimmed down 5.0 feet. Illustration produced by the USCG Marine Safety Center.**

As the ship was readied to sail, the Docking Master and the Jacksonville Pilot boarded and conducted a standard Pilot/Master exchange, with no discrepancies noted or discussed. At 8:06 PM, EL FARO pulled away from the pier. EL FARO's typical scheduled departure time from Jacksonville was 7:00 PM. As the ship made the 70-minute transit to the sea buoy, the Pilot and Master engaged in casual conversation, including a brief discussion about TS Joaquin. At 9:48

[1] On October 1, after EL FARO was reported missing, the TMPR Terminal Manager noted an error in the CargoMax® stability calculations for the departure loading condition, and created a revised report that lowered the vessel's stability margin by 0.16 feet.

PM, the Pilot disembarked and the ship cleared the sea buoy en route to San Juan. EL FARO sent a departure report to shore side TOTE personnel, which did not include any indication of the Master's intended route to San Juan.

When EL FARO departed Jacksonville, the lube oil level in the sump that served the steam turbines and the main reduction gear was 24.6". The recommended operating level in the Machinery Operating Manual was 27", and the approved lube oil sump plan indicated that the operating range was 18"-33". TOTE had no guidance or policy that required maintaining the recommended 27" operating level.

Former TOTE crew members testified that fire dampers for the cargo hold ventilation system on EL FARO were only closed in the event of a cargo hold fire, and were otherwise left open, even in heavy weather conditions. Leaving the fire dampers open for cargo holds that carry vehicles with fuel was done to prevent flammable vapors from accumulating in accordance with SOLAS II-2 Regulation 20 and 46 CFR § 92.15-10.

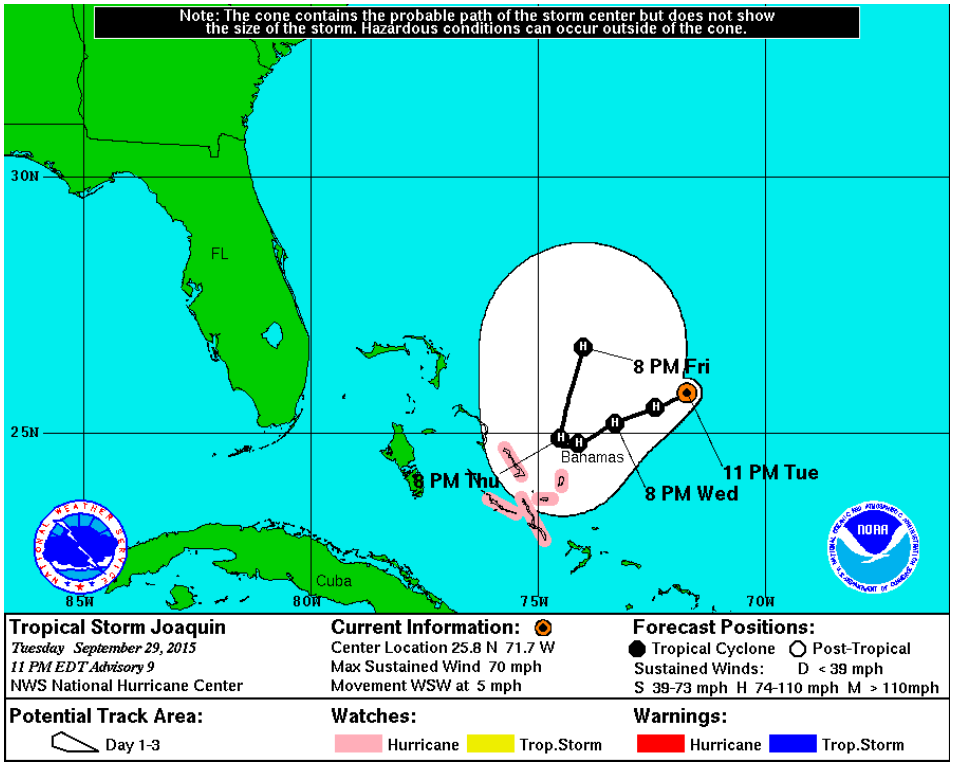


**Figure 5. NHC Tropical Storm Joaquin Advisory 9, 11 PM EDT September 29, 2015, 3 day cone.**

As EL FARO headed to sea, TS Joaquin was located about 365 nautical miles east of the Northwestern Bahamas and was moving west-southwest at 4 knots. Starting at 4:51 PM on September 29, the NHC advisories began to indicate that TS Joaquin could impact the Bahamas as a hurricane. All prior NHC advisories had predicted that TS Joaquin would change to a northerly heading and not impact the Bahamas. The NHC's 11:00 PM advisory confirmed that TS Joaquin would continue to strengthen and remain on a southwesterly track for the next couple days. As a result, Joaquin's first hurricane watch was established for the central Bahamas.

At 11:29 PM, the Master downloaded a BVS weather package from the Inmarsat email system.

During the accident voyage, EL FARO sent a departure report and noon position reports, as required by TOTE's Operations Manual – Vessel (OMV). These messages were not required to indicate the route that EL FARO would take, and the subject was not indicated in the Master's remarks sections.

## Wednesday, September 30, 2015

At 2:00 AM, the NHC upgraded TS Joaquin to a Category 1 Hurricane.

EL FARO's Voyage Data Recorder (VDR) provided audio and parametric data beginning at 5:36 AM.[2] The VDR recorded audio from the bridge of EL FARO and voyage data such as the ship's position, speed, heading, course-over-ground, and radar images.[3]

**Figure 6. Photograph of EL FARO's bridge. (Photograph provided by TOTE)**

At 6:08 AM, the Master downloaded a BVS weather package from the Inmarsat email system. This package contained a duplicate NHC trackline for Hurricane Joaquin from the

[2] EL FARO's VDR was designed to record data on a continuous loop that was required to capture at least 12-hours of data prior to an accident that cuts power to the device. When EL FARO sank its VDR contained 26-hours of data starting at 5:36 AM on September 30, 2015.

[3] For the remainder of this section of the report, all quotes and references to discussions onboard EL FARO were taken from the NTSB transcript of the VDR audio recording, unless otherwise noted.

previously issued data package that was downloaded at 11:29 PM on September 29. However, the BVS weather package did contain the most current wind and wave data.[4]

At 06:13 AM, the Master and C/M observed that they would be southwest of the hurricane the following day, based on the forecast information they were reviewing. They decided to alter course further to the south to open up the closest point of approach (CPA) to the hurricane.

At 10:17 AM, the Master received a satellite email message from the Master of EL YUNQUE, who was northbound en route to Jacksonville from San Juan. EL YUNQUE's Master asked about EL FARO's plans and intentions for the storm. EL FARO's Master responded at 11:10 AM that he was watching the storm and had altered course slightly to the south.

At 11:21 AM, EL YUNQUE's Master responded to the Master of EL FARO, "[t]hat's good to hear. Hopefully, it will turn to the North soon. As we passed to the west of it we recorded a 100 knot relative wind gust. Luckily, it was coming from directly ahead."

At 11:24 AM, the Master downloaded a BVS weather package from the Inmarsat email system.

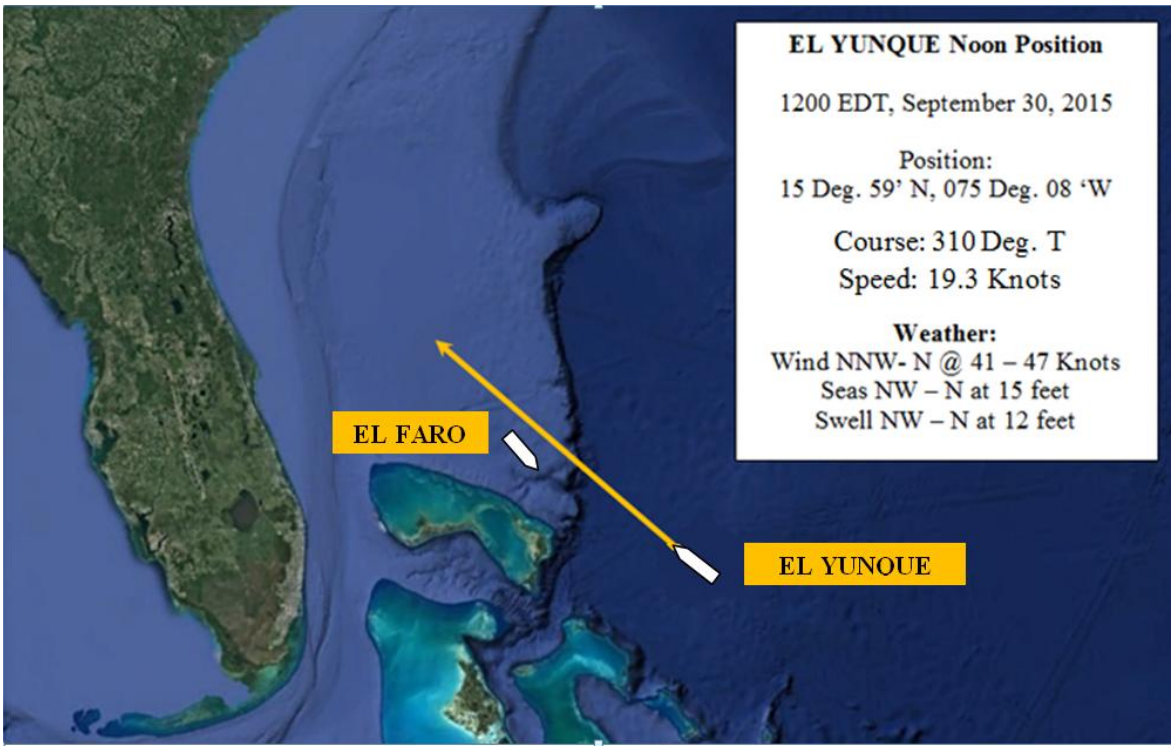


**Figure 7. Noon positions of EL YUNQUE and EL FARO on September 30, 2015; information from noon report of EL YUNQUE**

At 1:22 PM, EL FARO's Master transmitted a noon report email to shore. This report noted "precautions observed regarding Hurricane Joaquin." Around the same time, the Master also

[4] Refer to Weather background section for forecast graphics and additional detail.

sent a more detailed email to TOTE management personnel indicating he had monitored the storm, adjusted the route, and intended to pass south of the storm at a distance of +/- 65 nautical miles. He anticipated being on the backside of the storm by 8:00 AM on October 1.

In this email, the Master also stated he would like to take the Old Bahama Channel on the return trip from San Juan, and that he would await a reply from the company before making a final decision on the return voyage. EL FARO received a reply from the TSI Director of Ship Management at 4:09 PM stating, "[d]iversion request through Ol' Bahamas Channel understood and authorized. Thank you for the heads up." At this time, the TSI Director of Ship Management was in California attending to construction issues regarding TOTE's new MARLIN class ships.

At 1:55 PM, the 2/M discussed preparing a voluntary weather observation report due to their anticipated proximity to the storm.[5] The 2/M sent this observation message at 2:21 PM, but erroneously transcribed EL FARO's position, placing the ship over mainland Cuba.

At 2:14 PM, the Master and 2/M heard a VHF sécurité broadcast from a Coast Guard aircraft, relaying an NHC hurricane warning for the Bahamas, which requested that mariners use extreme caution.[6]

Around 3:50 PM, EL YUNQUE and EL FARO passed each other at a distance of approximately 33 nautical miles. The two bridge watches contacted one another and carried on a short conversation on VHF radio, including a brief discussion of Hurricane Joaquin.

At 5:47 PM, the Master downloaded the most current BVS weather package via satellite email. The Master sent this weather package to the bridge computer at 6:51 PM, and then went to the bridge to discuss the storm and voyage plan with the C/M. The Master and C/M decided on a new track for the ship that would take it further to the south, passing between the islands of San Salvador and Rum Cay. The C/M proposed extending the course to sail south of Samana Cay; however, the Master decided that would not be necessary and instead directed the route between San Salvador and Rum Cay but north of Samana Cay. The Master stated this route was simpler for the watch because it involved one course change, as opposed to two.

The 3/M arrived on the bridge to relieve the C/M at 7:43 PM.

At 7:52 PM, the Master discussed the storm with the oncoming AB, who asked if the storm was going to intensify. The Master responded that they had picked a new route to get away from "the low." At 8:00 PM, Joaquin was a category 3 Hurricane with winds estimated at 100 knots.

[5] Ships may send at-sea weather observations to a national meteorological service, such as NOAA's National Weather Service. Scientists can then use this information for forecasting and climate study. For more information on the Voluntary Observing Ship Program, see http://www.vos.noaa.gov/.
[6] A sécurité broadcast is safety message that reports important navigational and meteorological warnings or other unusual events that might impact maritime activities.

The Master left the bridge around 8:00 PM. Before leaving, he told the 3/M that he would be awake for the better part of the 3/M's watch. The Master's voice was not detected on the bridge again until 4:09 AM the next morning.

At 11:04 PM, there was a new BVS weather package available for download on EL FARO. However, satellite email transmission records show that this email was not downloaded to EL FARO until 4:45 AM on the morning of October 1.

At 11:05 PM the 3/M called the Master on the house phone[7] after reviewing the SAT-C weather report, which arrived at 10:53 PM. He advised the Master that the hurricane's maximum winds were 100 miles per hour[8] and that the storm was advancing toward their trackline. During this call the 3/M twice told the Master that he thought the Master might want to look at the weather report. The Master did not come to the bridge. The 3/M told the Master he would get more specific information, and called the Master again at 11:13 PM. He advised the Master that EL FARO would be 22 miles from the hurricane's center at 4:00 AM the next morning, and that winds were "one hundred with gusts to one-twenty and strengthening." The 3/M suggested altering course to the south at 2:00 AM to increase the distance between EL FARO and the hurricane.

After his phone conversation with the Master ended, the 3/M told the Able Seaman (AB) on watch that the Master thought they would be south of the storm "by then" and the wind would not be an issue because EL FARO would be in the southwest quadrant of the hurricane. The 3/M stated that he trusted the Master, but still expressed concern regarding EL FARO's closest point of approach to the hurricane. For the remainder of his watch, the 3/M continued to sail EL FARO along the Master's planned course.

Between 11:45 PM and shortly after midnight, the 3/M and 2/M conducted watch relief and discussed the hurricane, current route, and other route options.

## Thursday, October 1, 2015

At 12:26 AM the 2/M received a SAT-C weather update and began planning an alternate route to the south through Crooked Island Passage, then joining the easterly Old Bahama Channel route to the ship's destination in San Juan. The 2/M plotted the course change to begin at 2:00 AM.

At 1:15 AM, the 2/M heard on the commercial satellite radio that Joaquin was upgraded to a Category 3 hurricane. At 1:18 AM, as EL FARO transited out of the lee of San Salvador Island, the AB stated "biggest one since I've been up here" when discussing the ship's rolling. The 2/M questioned why they are rolling if they were between the islands.

[7] The "house phone," or electric telephone, is an internal ship's phone. It is referred to as "ET" in the NTSB VDR transcript.
[8] The SAT-C weather report indicated that the wind speed was actually 100 *knots*, or approximately 115 miles per hour.

At 1:20 AM, the 2/M called the Master and advised him of the upgraded hurricane category. The 2/M also proposed altering course directly south, starting at 2:00 AM. The 2/M stated that the proposed course would take them through "all these * shallow areas." After speaking to the Master, the 2/M told the AB on watch that "he said to run it." The 2/M also later told the AB that it sounded like the Master was sound asleep. There is no indication the 2/M made any further calls to the Master during the watch.

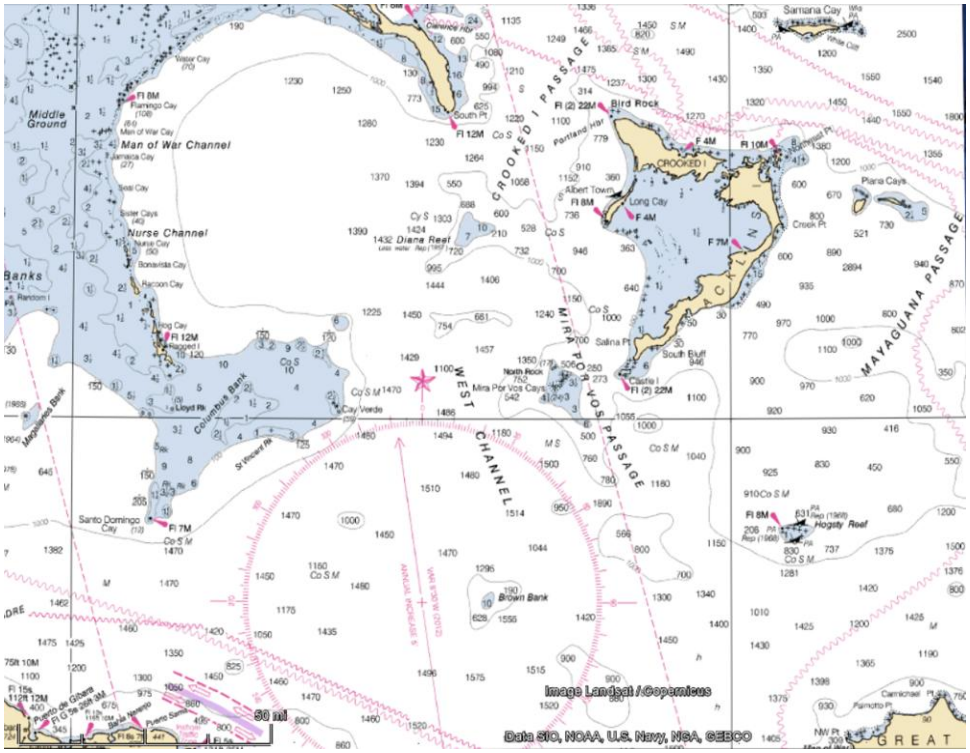

**Figure 8. Google Earth NOAA raster nautical chart image of Crooked Island Passage.**

At 1:24 AM, as EL FARO passed between San Salvador and Rum Cay, the 2/M told the AB to begin the course change to 116 degrees as the Master previously planned. Shortly after making the turn, the AB made a comment about wind heel.

At 1:29 AM, the 2/M remarked "startin' to hear the wind now." U.S. Navy weather analysis indicated that, around this time at EL FARO's position, seas were 14', swells were 10', and wind speed was 55 knots at 320 degrees.[9] The 2/M also noted that EL FARO had lost a little speed.

At 1:40 AM, the 2/M and the AB discussed drills, and the 2/M commented that "nobody ever takes these-the drills-seriously," and that no one actually checks to make sure their survival suits fit.

At 2:11 AM, the 2/M noted "green water on the bow," and the AB commented that he could hear "clanking going on."

[9] Per U.S. Navy Hindcast information provided by Senior Meteorologist, Fleet Weather Center Norfolk.

As EL FARO's heading changed and the weather conditions worsened, EL FARO's speed began to drop. At 2:15 AM, the AB noted that the speed was down to 16 knots, from about 20 knots.

At 2:47 AM, the 2/M and the AB on watch discussed that the Master was not on the bridge, the 2/M stated: "He said he was gonna come up. When I asked him that – he said that yesterday. He said that today he said he would probably be up here."

At 2:50 AM, the AB described hearing an internal thump. The AB and the 2/M then discussed that things were likely breaking free inside the superstructure.

At around 2:54 AM, a sound consistent with the steering stand alarm was heard on the bridge. The 2/M questioned whether the vessel was off course and the AB responded that it was. The 2/M then noted that the steering alarm was set to sound when the vessel was three degrees off course. This alarm was heard a few more times during the 2/M's watch. The 2/M made minor course corrections to keep EL FARO on course.

The C/M came to the bridge to relieve the 2/M at 3:44 AM. The watch relief was complete and the 2/M departed the bridge at about 3:48 AM. A portion of the watch relief was unintelligible on the VDR audio, and the exact watch relief procedures conducted could not be determined by the MBI. The 2/M did tell the C/M that the Second Assistant Engineer (2A/E) was blowing tubes, that she called the Master, and that the ship was holding her heading good, but may lose heading a little when the ship took good slams and pitches.

Immediately after getting off watch, the 2/M typed three short emails to family and friends stating that the ship was heading into Hurricane Joaquin.

Shortly after relieving the watch, the C/M began to make incremental heading changes to port, in an attempt to reacquire the planned 116 degree trackline. The steering alarm sounded persistently for several minutes and the AB commented on the difficulty of keeping the heading steady. The vessel was in auto pilot at this time.

At 3:47 AM, the C/M made a comment to the AB that "it's hard to tell which way the wind's blowing' huh?" followed by "I assume that we're heelin' to starboard (must be blowin') port to starboard."

At 3:50 AM, the AB watch relief takes place and the 4:00 to 8:00 AB remains on watch for the remainder of the voyage.

At 3:55 AM, a Third Assistant Engineer (3A/E) who stood the midnight to 4:00 AM engine room watch came to the bridge through 2nd deck, and told the C/M that some cords on the reefer containers on 2nd deck were "cut."

At 4:05, the C/M stated that they were steering "up like thirty degrees into the wind."

At 4:09 AM, the Master arrived on the bridge. The Master remarked that "there is nothing bad about this ride," and that he was "sleepin' like a baby." The Master and C/M agreed that the

conditions were similar to "every day in Alaska." The Master also observed that the ship was not rolling, pitching, or pounding. The C/M told the Master that he turned off the off-course alarm because it was sounding repeatedly.

At 4:12 AM, the C/M told the Master he was trying to make good on the previously planned 116 degree course. The Master and C/M also discussed the wind on the port bow, and the Master stated that "the only way to do a counter on this is to fill the port side ramp tank up."[10]

At 4:15 AM, the Master questioned whether the ship was starting to slow down. He contacted the engine room on the house phone and after hanging up, commented "blowin' tubes."

At 4:24 AM, the C/M reported a barometer reading of 970 millibars to the Master and then followed-up by stating "think it's gunna go down (before it goes up)." The Master responded to the C/M that "we won't be goin' through the eye."

At 4:27 AM, the C/M noted 100 RPMs and the Master commented that they need the RPMs. A few minutes later the C/M responded "this might be as high as it's gunna go."

At 4:34 AM, the C/M called the engine room to remind them that the weather decks were secured, and that he did not want anyone coming up from 2nd deck like the 3A/E had earlier. The Master departed the bridge and went to the galley.

At 4:36 AM the C/M received a call on the house phone from the Chief Engineer (C/E), reporting that a container was leaning over on the 2nd deck. A few minutes later at 4:40 AM, the C/E called the C/M again and reported an issue with "the list and oil levels." The C/M called the Master in the galley, and the Master returned to the bridge. After calling the engine room and speaking with the 2A/E, the Master stated, "He wants to take the list off, so let's put it in hand steering."

At 4:44 AM, the Master commented "* * just the list. The sumps are actin' up *. To be expected." The C/M replied "yeah the oil sumps I understand." Between approximately 4:45 AM and 5:05 AM, the Master and C/M make a series of heading adjustments to orient the vessel's bow nearly directly into the wind in order to reduce the wind heel effects on the vessel so that the engineers could troubleshoot the problems the starboard list was having on the lube oil system.

[10] The ramp tanks are used to correct list during cargo loading in port, and are effective to correct a list of less than 2 degrees.

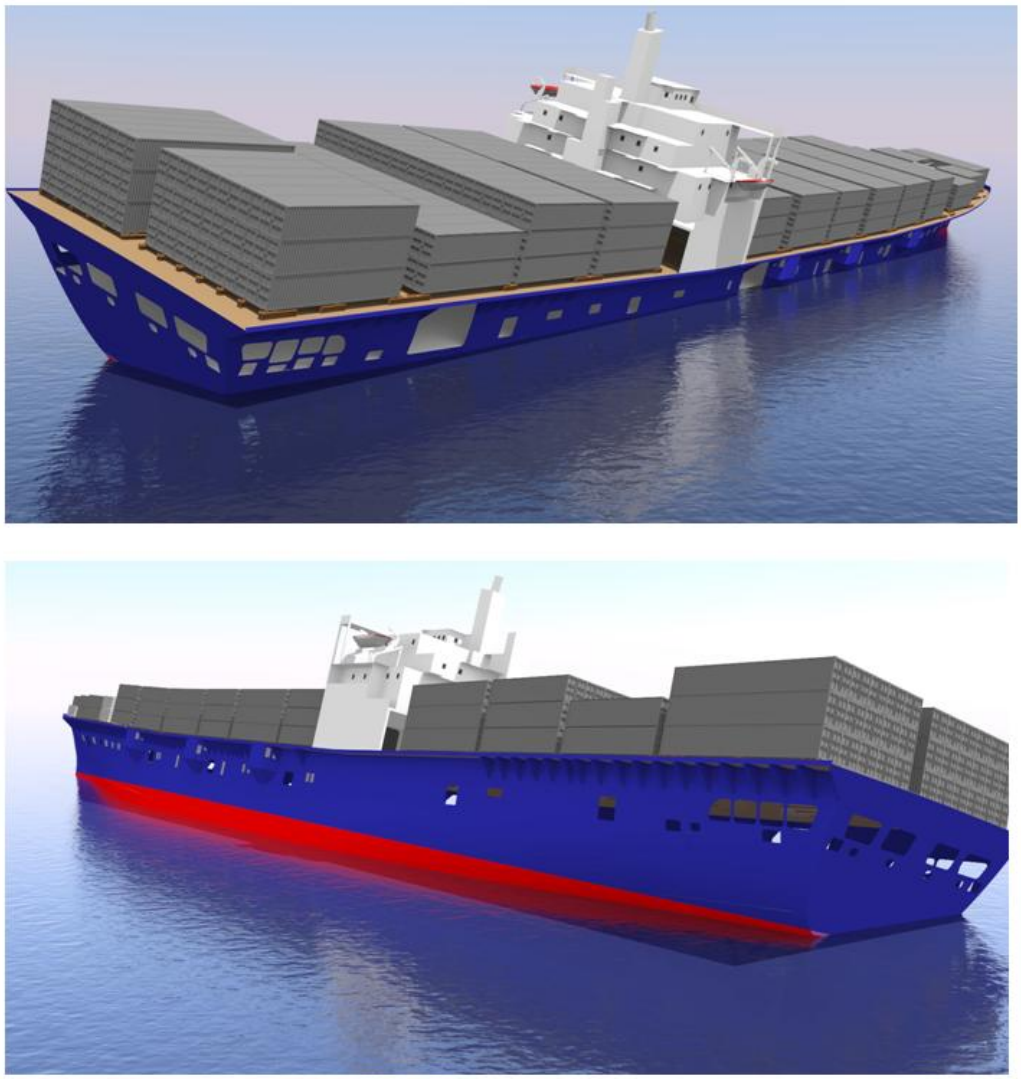

**Figure 9. EL FARO computer rendering with 15 degree starboard list and trimmed down by the stern 5.8 feet, due to flooding of Hold 3 estimated at 20% and wind heel. Illustration produced by the USCG Marine Safety Center.**

At 4:45 AM, the Inmarsat email system showed that the 11:00 PM BVS weather package was downloaded to the Master's email address.

Also at 4:45 AM, the C/M noted that the barometric pressure was "down to 960 millibars." SAT-C and NHC weather information indicated that the barometric pressure in the eye of Joaquin was estimated to be 950 millibars.

At 4:46 AM, the Master took the conn and issued helm commands to the AB. Shortly after that, EL FARO received a SAT-C weather update. This update indicated that the barometric pressure in the eye of Joaquin was estimated to be 948 millibars and max sustained winds of 105 knots.

At 4:57 AM, the Master went below to check the satellite email system. Before leaving the bridge, he told the C/M to steer in the general direction of 050 degrees.

At 5:01 AM, the C/M stated that he was expecting the wind to come around to the bow and then to the starboard side. He also noted that the ship was still heeling.

By 5:02 AM, the Master had returned to the bridge, and stated he sent the BVS weather package to the bridge. He stated there were conflicting reports about the center of the storm and questioned whether the barometer was coming up. The C/M replied that the pressure was still 960.

At 5:04 AM, the Master ordered the rudder hard right and then eased to right twenty. He then commented "Our biggest enemy here right now is we can't see. That's our biggest enemy."

At 5:06 AM, the Master commented that they were trying to get back on their original course and remarked that they were on the back side of the storm.

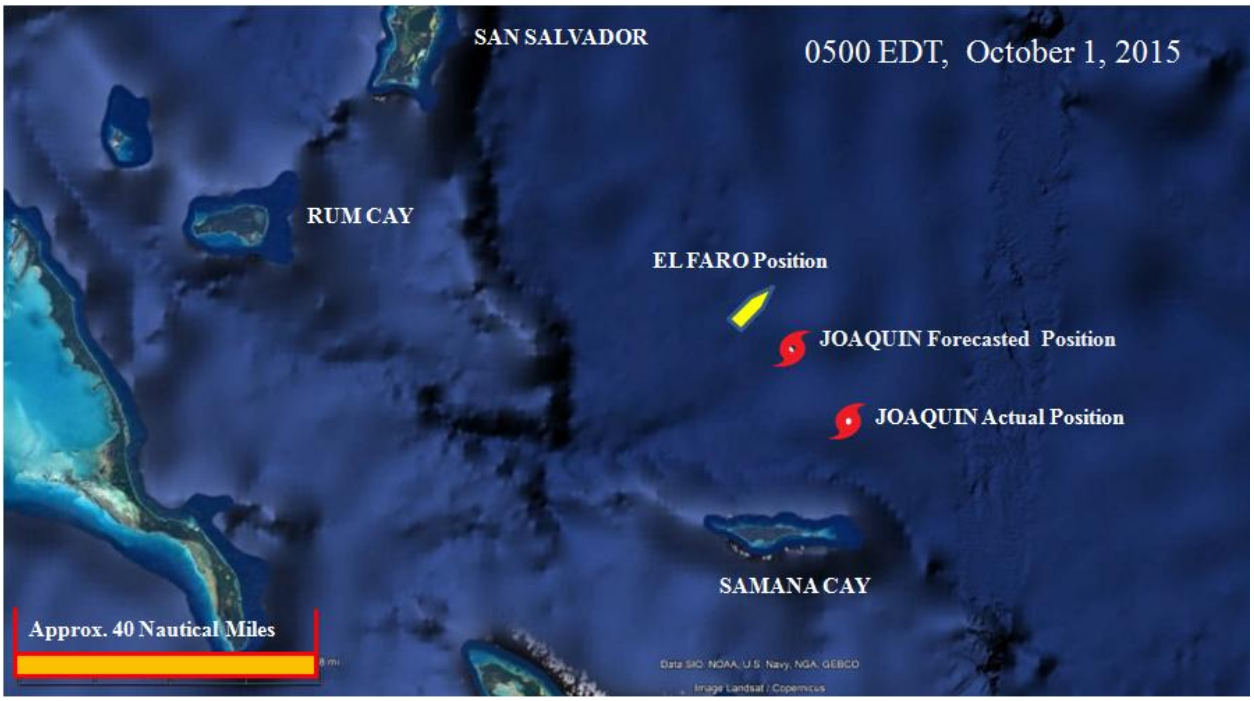


**Figure 10. Google Earth image showing the 5:00 AM positions of EL FARO, the center of Hurricane Joaquin as detailed in NHC Advisory 14, and the center of Hurricane Joaquin determined during a NHC post-storm 'best track' analysis.**

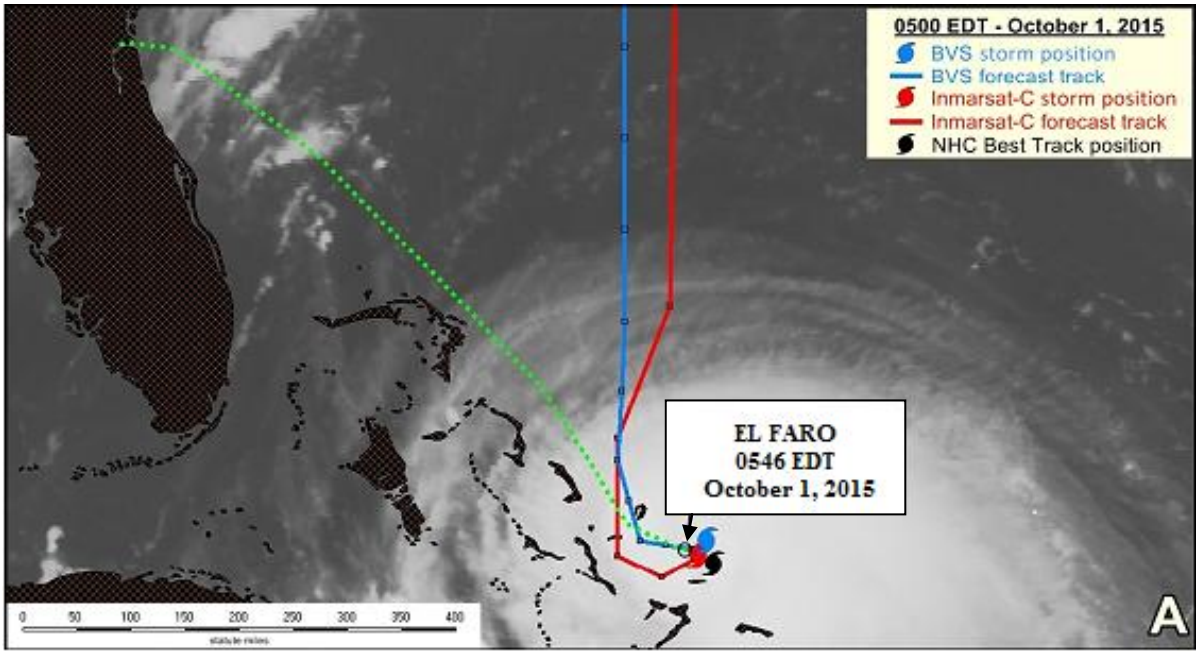


**Figure 11. 5:00 AM October 1, 2015 image showing the approximate relationship between EL FARO and forecasted storm positions. The extent of the weather system is also visible. (Source: NTSB Weather Factual Report)**

Shortly after this comment the Riding Crew Supervisor arrived on the bridge. He stated that the ship's list was unusual and he had never seen the ship "hang" like it was. He and the Master discussed the effect of the list on the lube oil levels. A few minutes later, the C/E called the Master and discussed the effects of the list.

At 5:22 AM, the C/M reported that the barometer was reading 950 millibars.[11] This barometer reading was the lowest level recorded by the VDR during the accident voyage. This pressure reading placed EL FARO close to the eye of Hurricane Joaquin, which at that time had a minimum estimated pressure of 948 millibars.

At 5:30 AM, the C/M noted a change in the relative wind direction as the spray was hitting them directly instead of going across the beam. He also remarked about taking water on the stern.

At 5:43 AM, the Master received a call on the house phone reporting water in Hold 3. He directed the C/M to go below to assess the situation. Before leaving the bridge, the C/M answered a call on the house phone and discussed the source and amount of flooding, and use of the bilge pumps. The Master took the phone from the C/M and acknowledged that the bilge pump was running and water was still rising.

A minute later the Master made the comment, "We got cars loose. Yeah." According to the cargo manifest documents for voyage 185S there were 50[12] automobiles in the lowest level of that hold. The vehicles were strapped to chains that ran across the width of the ship. The average

[11] The VDR Transcription Team was undecided on whether the reading was passed as 950 or 951 MB. Regardless, the reading was the lowest pressure recorded on the VDR during the accident voyage.
[12] MBI Exhibit 069, p. 30.

weight used for each automobile in the cargo documentation was 1.5 long tons[13] (3,360-LBS). The C/M then left the bridge to get the off-duty 3A/E and investigate the flooding.

At 5:48 AM, the Master called the C/E and directed him to begin transferring from the starboard ramp tank to port.

At 5:52 AM, the Master received a call on the house phone informing him that the source of the flooding was an open scuttle. He then turned the ship to port to put the wind on the starboard side and induce a port list. The Master ordered this maneuver to enable the crew to access the partially flooded 2nd deck in order to secure the cargo Hold 3 scuttle on the starboard side. A post-casualty analysis noted that the configuration of the lube oil sump suction valve, which was offset 22" to starboard of centerline, was susceptible to losing suction during a port list.

At 5:55 AM, the C/M called the Master on a UHF radio and reported a flooded hold on the starboard side with knee deep water.

By 5:56 AM the ship was on a new heading of 350 degrees with the wind on the starboard side and the ship listing to port. The Master then called the engine room and told them to stop transferring ballast from starboard to port ramp tanks.

At 5:59 AM, the 2/M returned to the bridge and the Master told the 2/M that "a scuttle popped open and there's a little bit of water on in three hold, they're pumping it out right now."

Based on radar and VDR parametric data, EL FARO's propulsion was reduced just prior to 6:00 AM. Around this time, EL FARO's heading was approximately due north, but the vessel started to be set in a westerly direction.

[13] MBI Transcript February 20, 2016, p. 176.

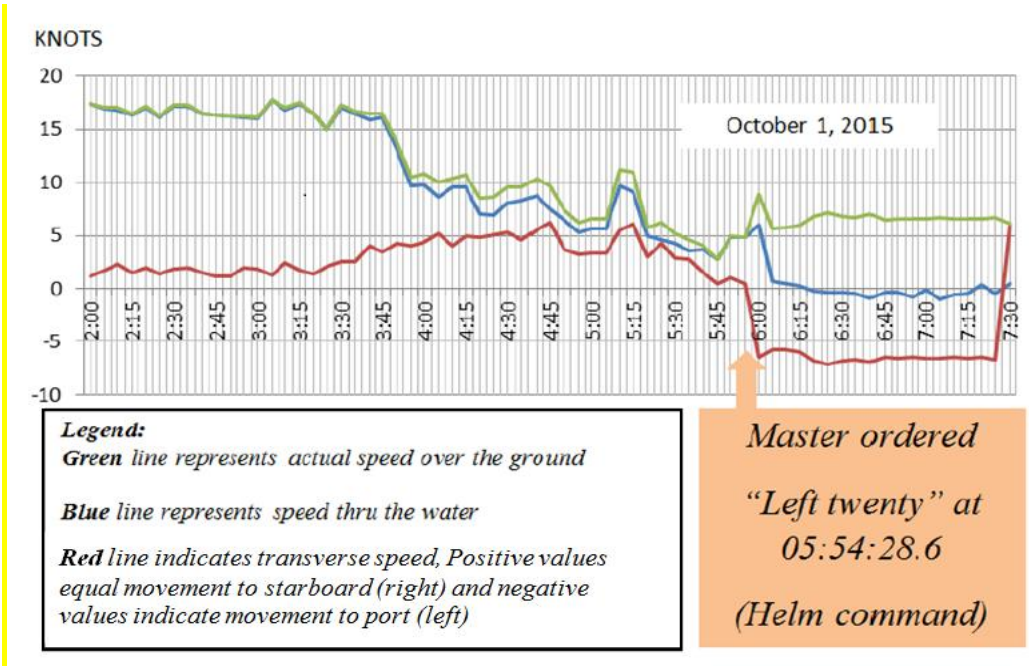


**Figure 12. Graph of EL FARO's speed over ground and speed through the water on October 1, 2015.**

Shortly after, at 6:00 AM, the Master received simultaneous calls on the house phone and UHF radio. The Master responded to the engine room with a question, "(all through) the ventilation?" He then stated to the engine room, "Want me to bring it back over to starboard?" and "bring it back roll back over to starboard." The C/M was heard on the UHF radio reporting to the Master that the scuttle was secured.

The first discussion on the VDR audio regarding the actual loss of propulsion was at approximately 6:04 AM when the 2/M noted a reduction in RPMs and questioned whether the bridge or engine room initiated the reduction.

The C/M returned to the bridge at 6:04 AM and explained to the Master that when he was on the 3rd deck, he had seen water coming down through the scuttle, but he could not see whether cars had broken free on fourth deck. The Master told him to return to the 3rd deck to look into the 4th deck of Hold 3. The Master also continued to issue helm commands to the AB.

At 6:09 AM, satellite email transmission records show that the most recent BVS weather package was downloaded on EL FARO. This was the 5:00 AM BVS weather package.

At 6:12 AM, the Master remarked that he did not like the list, followed by "I think we just lost the plant."

At 6:16 AM, the engine room called the Master on the house phone, and the Master asked if there was "any chance of gettin' it back online?"

At 6:19 AM, the Master called the engine room and ordered shifting ballast from port to starboard ramp tanks. This was the first of several requests from the Master to transfer ramp tank ballast to the starboard side.

At 6:21 AM, the Master received a call on the house phone from a 3A/E. The Master questioned whether there was any way to tell if he had suction and was pumping a hold.

At 6:24 AM, the Master called back to the engine room and spoke with a 3A/E to get an update and to confirm they were pumping ballast from port to starboard ramp tanks. During the call the Master confirmed that a 3A/E was pumping on the hold.

At approximately 6:30 AM, the 3/M and 2/M were on the bridge and the 2/M began to draft a Global Maritime Distress and Safety System (GMDSS) message to alert the rescue agencies of the ship's situation.

At 6:34 AM, after calling the C/E, the Master stated, "They're gettin' that boiler back up. They're gettin' lube oil pressure up."

At 6:40 AM, the Master sent the C/M below to check the condition of Hold 3.

At 6:44 AM, the Master and the engine room communicated, and the Master remarked to the AB that "you got some turns now." However, at 6:48 AM, the Master told the AB at the helm that there were not any RPMs. VDR parametric and radar data during this time does not show any changes in heading, course over ground, or speed over ground that would indicate a restoration of propulsion.

At 6:52 AM, the Master went below. After he left, someone called the bridge looking for the Master and the caller was told to try contacting him in his office.

The Master returned to the bridge at around 6:54 AM. He called the C/E on the house phone for a status check. After the call, he stated to the 2/M that the engineers were having a hard time getting "it" back online because of the list.

At 6:59 AM, the Master attempted to contact the TSI Designated Person Ashore (DPA), and left a voice mail. At that time the DPA had been out of the office for a few days and was not aware of EL FARO's position in relation to Hurricane Joaquin. No other shore side TOTE personnel were actively monitoring EL FARO's position in relation to the hurricane.

The Master then called the Emergency Call Center. After speaking with the call center operators for approximately seven minutes, the Master was connected to the TSI DPA at 7:07 AM. The Master briefed the DPA with the details of the situation on EL FARO, including that that the engineers could not get lube oil pressure on the plant, they had no main engine, they had a 10-15 degree port list, they were not gaining ground pumping out the hold, and that they were in survival mode but were not planning to abandon the ship. The Master also briefed the DPA on the weather conditions, including that the barometric pressure was 958.8 millibars.

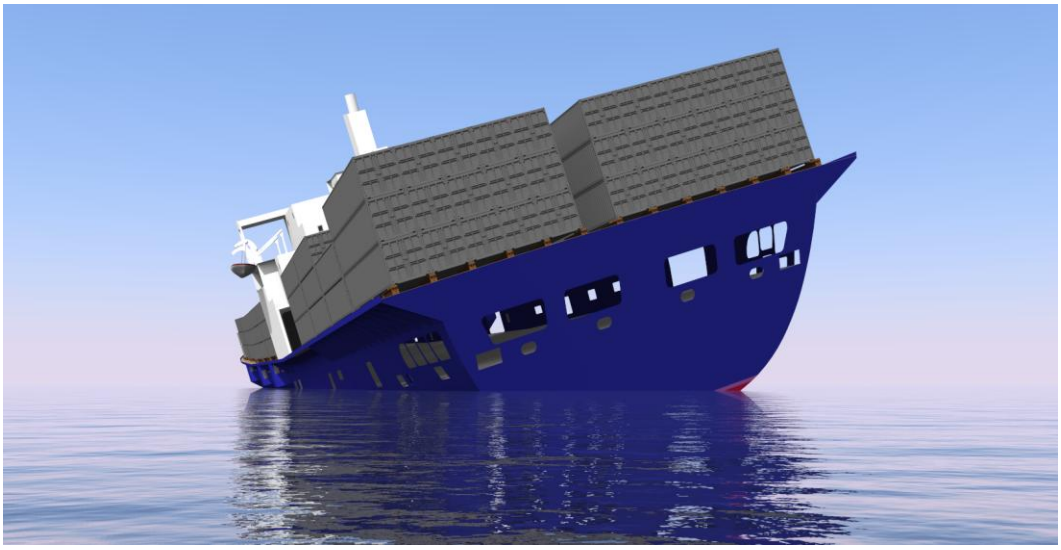

**Figure 13. EL FARO computer rendering showing list to port of 18 degrees with departure trim 5.8 feet by the stern due to flooding of Hold 3 estimated at 20% and wind heel. Illustration produced by the USCG Marine Safety Center.**

The Master ended the call with the DPA at 7:12 AM and immediately instructed the 2/M to send the GMDSS message to communicate the distress to the shore side rescue agencies. The Ships Security Alert System (SSAS) was also activated.[14]

At 7:14 AM, the C/M told the Master that the water level was rising. The C/M told the Master that the C/E mentioned the fire main as a potential source of flooding. The C/M tightly dogged the door on 3rd deck and the Master told him not to open it again.

At 7:15 AM, the Coast Guard Atlantic Area Command Center in Portsmouth, Virginia, received EL FARO's GMDSS and SSAS alert messages.

At 7:16 AM, the C/M talked to the C/E on the house phone. After this call, the C/M stated there was a bilge alarm going off in Hold 2A, but that he would not go on 2nd deck to check that. The Master then called the C/E and agreed that the list was getting worse.

At 7:18 AM, the Master and C/M discussed cars floating or bobbing in Hold 3. The Master asked whether there was anything near the fire main. The C/M responded that the water level was too high, and the fire main was right below dark black water. The Master and C/M then discussed isolating the fire main in the engine room as an option for controlling the flooding. The Master spoke with the First Assistant Engineer (1A/E) on the house phone and asked if the 1A/E could isolate the fire main.

At 7:23 AM, the Master talked to a crew member on the house phone, and was not able to answer a question about EL FARO's downflooding angle. The Master also stated they still had reserve buoyancy and stability. He next stated that he was going to ring the general alarm to wake or get everybody up.

[14] The SSAS is an alert system primarily intended for use in cases of piracy, terrorism, or other security-related issues.

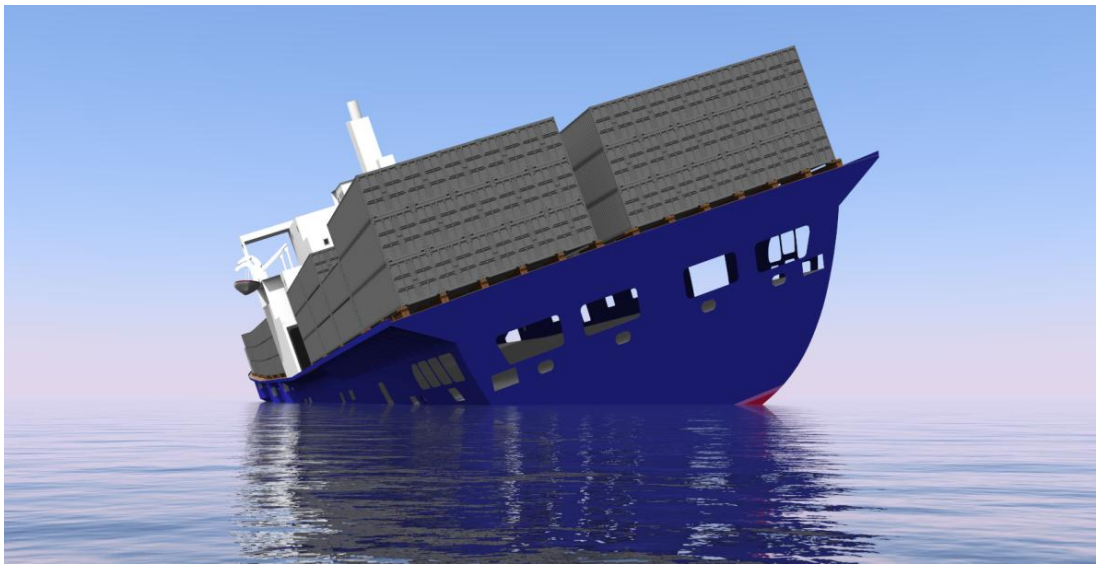

**Figure 14. EL FARO modeling with 20 degree port list and departure trim down by the stern at 5.8 feet due to flooding of Hold 3 estimated at 20% and wind heel. Illustration produced by the USCG Marine Safety Center.**

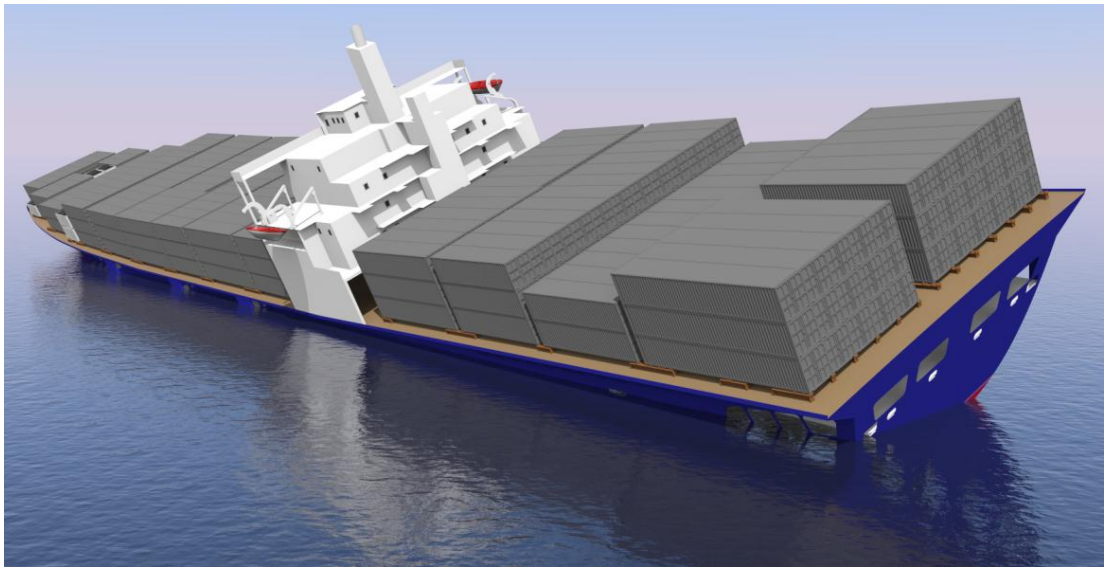

**Figure 15. EL FARO computer rendering with 25 degrees port list and departure trim of down by the stern at 5.8 feet due to flooding of Hold 3 estimated at 20% and wind heel. Illustration produced by the USCG Marine Safety Center.**

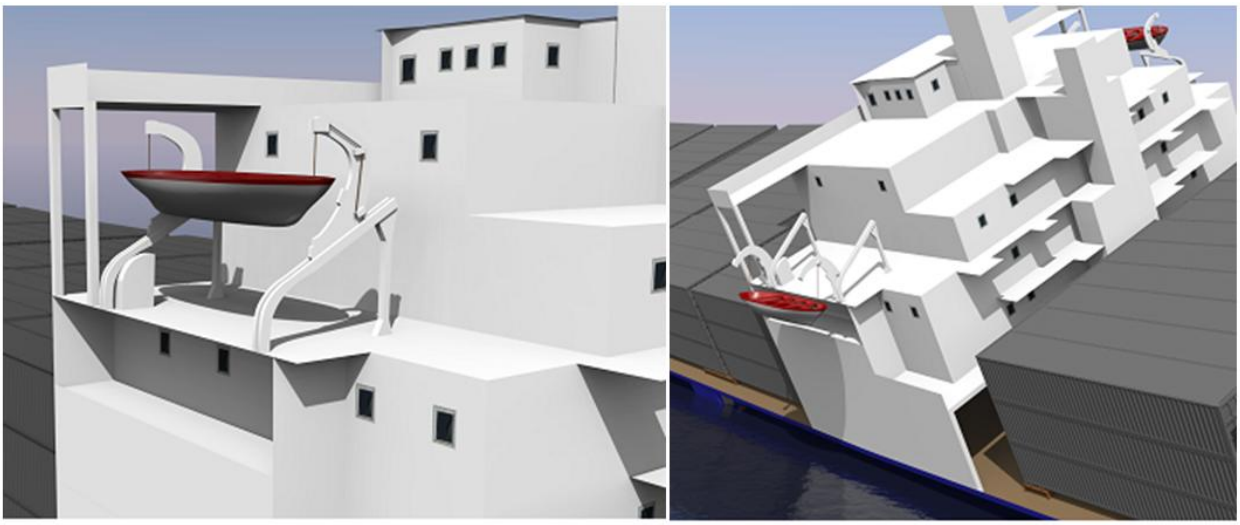

**Figure 16. EL FARO computer rendering. On the left, the port lifeboat is shown in the davit in its normally stowed position with EL FARO on an even keel. On the right, the lifeboat is shown lowered to the embarkation deck with EL FARO listing 25 degrees to port. There is no evidence that the use of the lifeboats was discussed by the crew. Large life rafts were stored in close proximity to the lifeboats. Illustration produced by the USCG Marine Safety Center.**

At 7:24 AM, the DPA contacted the Coast Guard Atlantic Area Command Center by phone to report EL FARO's situation. The Coast Guard Atlantic Area Command Center collected his contact information and passed it, via email at 7:33 AM, to the Coast Guard District Seven Command Center in Miami, Florida.

At 7:25 AM, the Master asked the C/M to make a round on the 2nd deck. The C/M responded that he would open a door and look, but would not go out on 2nd deck.

At 7:26 AM, the Master called the C/M on the radio and told him that he was going to ring the general alarm, and to get muster while he was down there. The Master then called the engine room on the house phone and told them he was going to ring the general alarm, but they did not have to-or were not going to-abandon ship yet. The general alarm was then heard on the VDR audio at 7:27 AM.

At 7:28 AM, the Master communicated with the C/M on the radio, and made an unintelligible remark about the starboard side. The C/M asked the Master if he was getting ready to abandon ship and the Master responded, "Yeah what I'd like to make sure everybody has is their immersion suits and uh-stand by. Get a good head count. Good head count."

At 7:29 AM, the 2/M on the bridge yelled about containers in the water, and the Master directed the ringing of the abandon ship alarm. The 2/M departed the bridge to get a life vest, and the Master and the AB requested that the 2/M return with vests for them.

At 7:30 AM, the Master twice stated, "Bow is down."

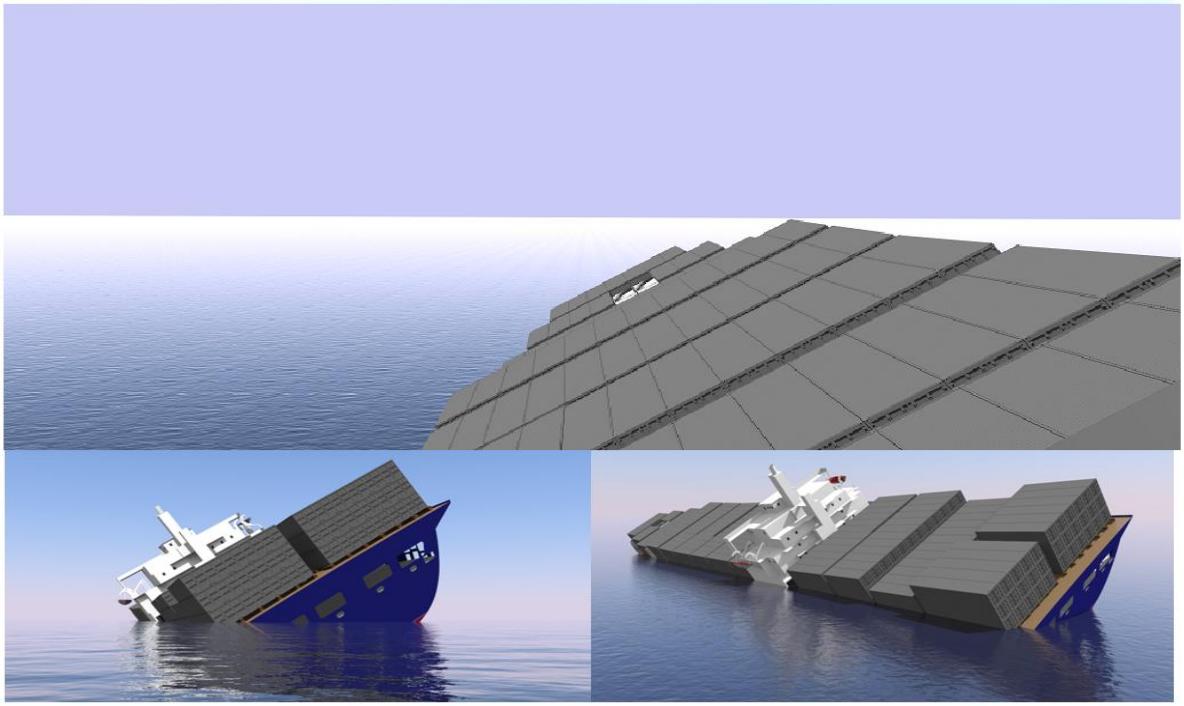

**Figure 17. EL FARO computer renderings showing the vessel with progressive flooding and wind heel, listing to port at 35 degrees with 5.0 feet aft trim and 37.0 foot draft amidships. The upper illustration simulates a view forward from the starboard side of the navigation bridge which was the assumed location of the vessel Master when the Master makes the "bow is down" statement at 7:30 AM on the VDR audio transcript. Illustration produced by the USCG Marine Safety Center.**

At 7:31 AM, the Master communicated with the C/M over the radio to have personnel get into their rafts, throw the rafts into the water, get off the ship and stay together. There was no discussion of the lifeboats or preparation of the lifeboats for abandoning ship heard on the VDR.

At 7:33 AM, the Coast Guard District Seven (D7) Command Center contacted the TSI DPA by phone. The D7 Operations Unit Controller (OUC) reviewed the information the TSI DPA had previously provided to the Coast Guard Atlantic Area Command Center—that EL FARO was disabled, the source of flooding was secured, and the crew was attempting to dewater. The D7 OUC told the TSI DPA that based on this information; they were not in a distress phase because the ship was not at risk of sinking. The D7 OUC also told the TSI DPA that in this type of situation—non-distress, in foreign territorial waters—it is generally up to the company to provide tug assistance. The TSI DPA stated he would contact their salvage service. The D7 OUC stated he would try to contact the ship for an update, and would call the TSI DPA back with more information. The Coast Guard was never able to establish contact directly with EL FARO.

For the remainder of the VDR Audio, the Master is heard repeatedly trying to encourage the AB who had been manning the helm to "get to safety." At 7:36 AM, the Master told the AB to "work your way up here." At 7:37, the Master twice yelled out for the location of lifejackets on the bridge. At 7:38 AM, the AB yelled to the Master that his feet were slipping and he needed a ladder; the Master responded that they did not have a ladder or line.

The audio recording ends at 7:39:41 AM on October 1, 2015. At that time the Master is still heard on the bridge attempting to encourage the AB to "come this way."

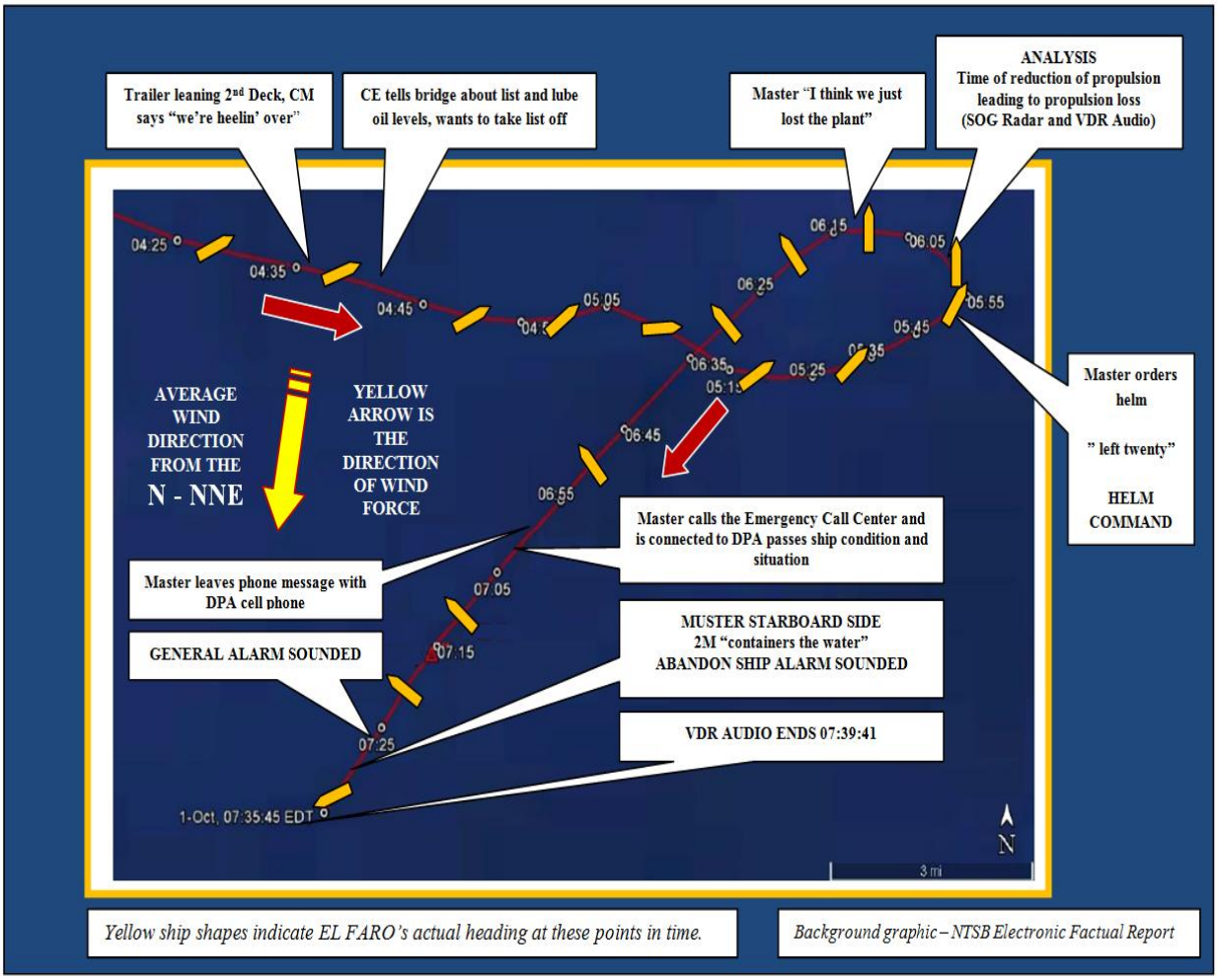


**Figure 18. Illustration of significant events between 4:20 AM on October 1 and the sinking, showing ship heading and course over ground.**

EL FARO's last recorded position on the VDR parametric data, at 7:35 AM, was 23-23.4N, 073-54.0W. The main wreckage of EL FARO was located on October 31, 2015, approximately one nautical mile away, in position 23-22.9N, 073-54.9W, and at a depth of approximately 15,400 feet.

The post analysis conducted by the National Hurricane Center found that at 8:00 AM on October 1, Joaquin was a Category 4 Hurricane with an estimated sustained wind speed of 115 knots.

Two flights conducted by Air National Guard Hurricane Hunters, which were flying observation missions, conducted VHF radio call outs and radar searches for the EL FARO, with negative results. However, because of the weather conditions in the last reported position of EL FARO, no aircraft or surface assets were able to get a visual assessment of the area until October 3, 2015.

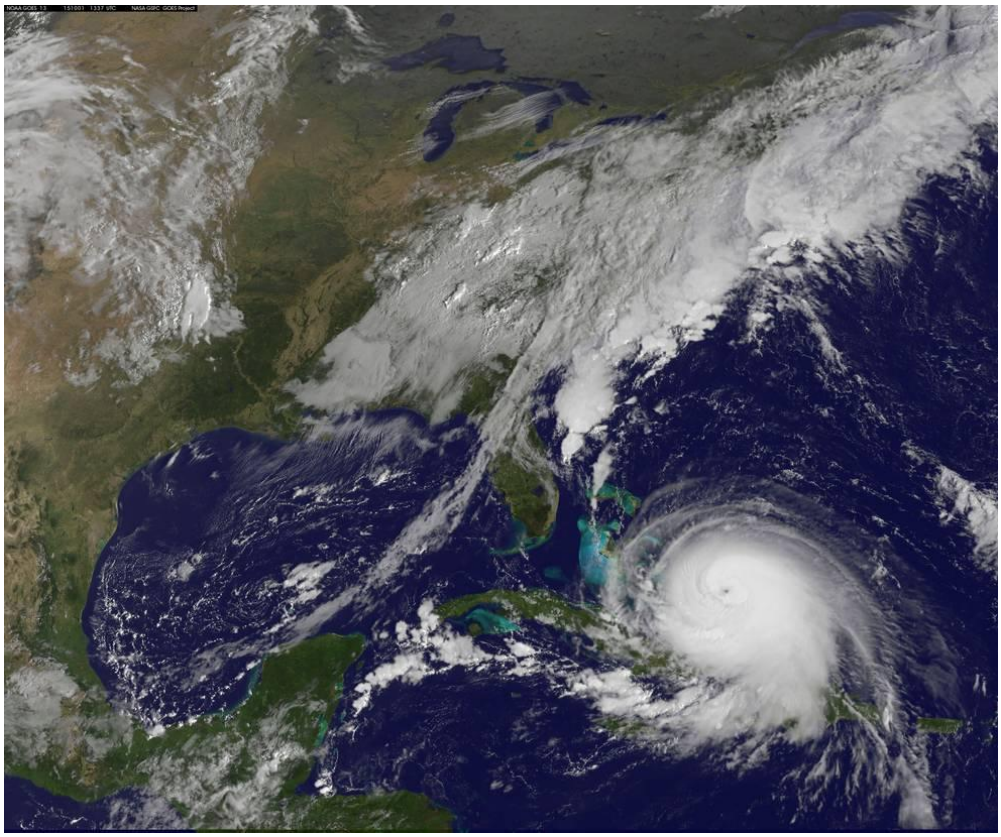

**Figure 19. Image of Joaquin affecting the Bahamas on October 1 at 8:55 AM. (Source: https://www.nasa.gov/feature/goddard/joaquin-atlantic-ocean)**

The first aircraft on scene on October 3, a U.S. Air National Guard Hurricane Hunter, noted the presence of an oil sheen and debris field. On October 4, a Coast Guard helicopter located an individual in a survival suit. A Coast Guard rescue swimmer entered the water and determined that the individual was deceased, but he was unable to identify or recover the body. On October 5th, the Coast Guard declared that EL FARO was sunk and transitioned to searching for survivors in the water. At sunset on Wednesday, October 7, 2015, the Coast Guard suspended active searching for the survivors of EL FARO. The search activities covered 195,602 square nautical miles using surface and aviation assets. TOTE-contracted surface and aviation assets continued to conduct searches for survivors and the recovery of surface debris. No survivors or other bodies were located. More detailed information on the search and rescue activities involved in this case are included in the Search and Rescue section of this report.

On October 14, 2015, the Sector Commander, Coast Guard Sector Jacksonville, declared that all persons onboard EL FARO were missing and presumed deceased.

## 7.2. Additional/Supporting Information

### 7.2.1. TOTE Corporate and Operational Framework

TSI and TMPR offices are located in Jacksonville, Florida. TOTE, Inc., the parent company to TSI, TMPR, TOTE Shipholding, and TOTE Maritime Alaska, is headquartered in New Jersey.

TOTE, Inc. is a subsidiary of Saltchuk, which owns a diverse range of companies.[15] At the time of the accident, EL FARO was engaged in domestic trade between Jacksonville, Florida and San Juan, Puerto Rico. Leading up to the accident TOTE operated two vessels in the Puerto Rican trade and two in the Alaskan trade.

In 1985, Sea Star Line formed to provide a trade connection from the United States mainland to Puerto Rico. At one time the company operated three PONCE class ships, which were engaged primarily in Jones Act trade. The three steamships were EL MORRO, EL FARO and EL YUNQUE; EL MORRO was taken out of service by TOTE and scrapped prior to the accident voyage. Through 2013, Sea Star maintained nautical operations support personnel ashore to support PONCE class operations. A number of these personnel had backgrounds in nautical operations and related training from maritime academies. These shore side support personnel provided technical and marine operations support to vessel crews, and also conducted internal audits. During adverse weather, the nautical operations shore side support personnel would interact with and assist ship's Masters with voyage planning, assessment of risk, development of vessel specific heavy weather plans and monitoring of anticipated heavy weather in relation to the intended voyage plan.[16]

TOTE Inc. began reorganizing in mid-2013, which resulted in fewer personnel assigned to provide shore side nautical operations support. A team of managers with deck officer experience was replaced by a single position with the title of TSI Marine Operations Manager, which was located in the Jacksonville office. The person in this position at the time of the accident voyage never held a Merchant Mariner Credential (MMC). He had filled the position since 2008.[17]

During the reorganization, the remaining PONCE class shore side management support was focused on the marine engineering side. MBI testimony indicated that the TSI President could be called upon to provide advice and guidance to Masters as needed, but that rarely if ever occurred. The TSI Vice President (VP) of Commercial Operations operated out of the Tacoma, Washington TOTE Maritime Alaska office.

Sea Star Line changed its name to TOTE Maritime Puerto Rico (TMPR) in September 2015. At the time of the accident TMPR owned EL FARO and EL YUNQUE. TOTE Inc. formed TOTE Shipholding in December 2012, and contracted to build two new liquefied natural gas (LNG) dual-fuel powered vessels, designed to replace the PONCE class vessels on the Puerto Rico trade route. These two new MARLIN class ships were slated to be ISLA BELLA and PERLA DEL CARIBE. In order to bring the new vessels into service, TOTE Inc. and TSI personnel were delegated additional duties beyond their day-to-day management of the PONCE fleet. As an example, the Director of Safety and Services[18] was tasked with oversight of the LNG fuel issues as the new ships were outfitted. The oversight included fuel tanks, shore side fueling, and permit approvals for the new fueling systems. In MBI testimony the Director of Safety and Services stated that the percentage of time he worked on the MARLIN class ships varied and that it was cyclical, but could represent up to 85% of his total workload at times.

[15] https://www.saltchuk.com/sc-directory.
[16] NTSB Interview transcript, Former Manager of Safety and Operations, DPA, March 27, 2017.
[17] MBI Transcript February 20, 2016, p. 171.
[18] MBI Transcript February 17, 2016, p. 87.

During 2015, through to the accident voyage, TOTE was using a number of tugs and barges to move cargo to and from Puerto Rico, in addition to the PONCE class vessels. The TOTE Inc. Director of Ship Management was responsible for managing both the PONCE vessels and the tug and barge cargo operation.[19] Additionally, in late August and throughout September 2015, he was managing issues related to stern bearing problems encountered during sea trials of ISLA BELLA. The issue necessitated a trip to San Francisco drydock for diagnosis and repair of the problem.

TSI's safety department was comprised of the Manager of Safety and Operations/DPA and an Assistant Manager of Safety and Operations/Property Manager. These two personnel were responsible for overseeing a fleet of 25 vessels that operated globally. A position described as Safety and Ops Coordinator was listed on the TSI March 31, 2015, organization chart.[20] This position was annotated as "TBD" (to be determined) on the organization chart and remained unfilled at the time of the accident. A candidate had been interviewed for the position and MBI testimony[21] from the Manager of Safety and Operations indicated that in August 2015 a decision was made to not fill that position. As a result, the duties that were intended for that position were distributed among existing personnel within TSI.

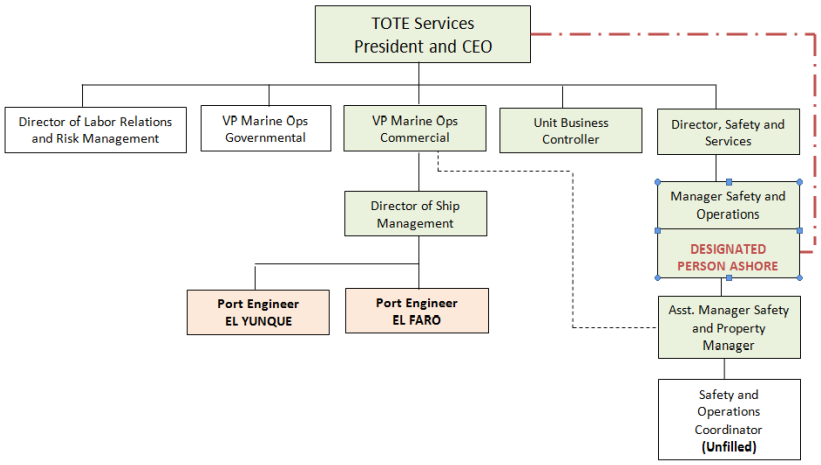


**Figure 20. TSI simplified organization chart at the time of casualty.**

Both TSI and TMPR experienced an increased workload as a result of the new MARLIN class LNG ships. This workload included obtaining the necessary permits and approvals for the fueling, procedures, and terminal operations. TSI personnel were also engaged in the final preparations for delivery and acceptance of the two new vessels, including working on issues related to loading and stowage plans for the fully containerized cargo as the new ships were not designed to handle RO/RO cargo. In 2014 TOTE began examining crewing options for the new vessels. After the launching of the MARLIN class ships the company needed to expand its marine labor force. As the MARLIN class ships were being placed into service, TOTE planned to shift EL FARO to the West Coast of the United Stated to act as a relief ship on the Alaskan

[19] MBI Exhibit 004, p. 63.
[20] MBI Exhibit 047, p. 9.
[21] MBI Transcript February 20, 2016, p. 24.

run while the two ORCA class ships assigned to that run entered the shipyard. Once in the shipyard, these ORCA class ships were scheduled to have their main propulsion engines replaced with engines that could run on LNG fuel or traditional marine fuel.

In late spring of 2015, TSI began formal efforts to crew the two new MARLIN class ships; this had to occur while simultaneously continuing to crew EL FARO and EL YUNQUE, as well as the other vessels in the fleet. Crew members selected for the new ships had to undergo special training on LNG fuel safety.

7.2.1.1. Operational Framework for EL FARO

The TSI Operations Manual – Vessel (OMV), Rev. 21, which was in effect at the time of the accident, described the operational framework onboard EL FARO, as well as the interface between shipboard and shore side operations. The chart below displays the vessel to shore reporting relationship.

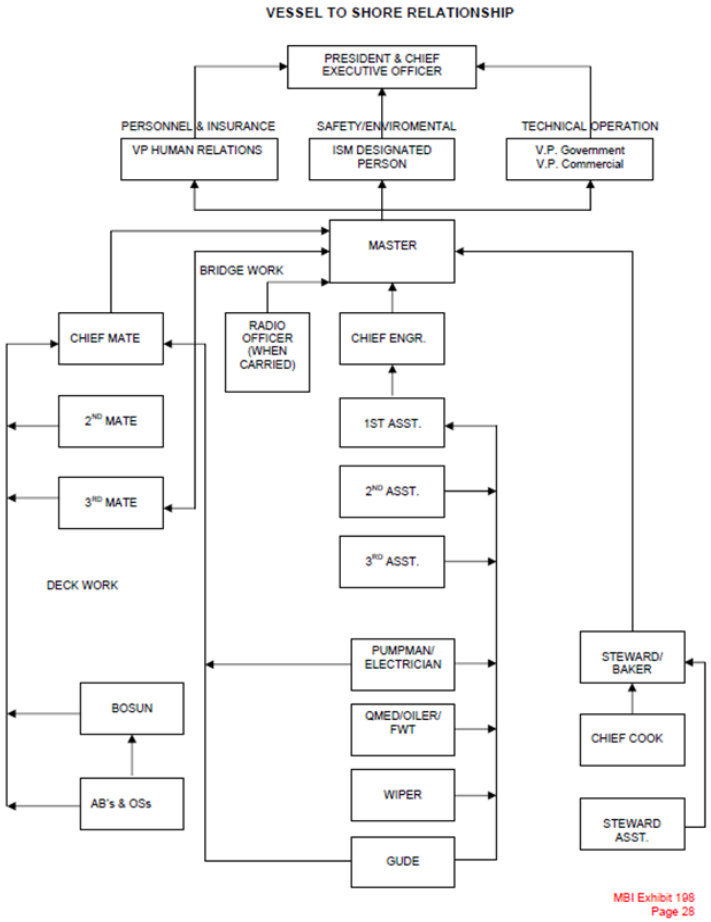


**Figure 21. Vessel to shore relationship, from OMV. (Source: MBI Exhibit 198)**

Onboard the ship unlicensed crew reported to junior officers based on the department in which they worked. Engineering crew reported to the C/E while deck crew reported to the C/M. During the accident voyage, a Polish riding crew was onboard working on the Alaskan

conversion project. This conversion was being performed to return EL FARO to a configuration where it would only carry RO/RO cargo. The work included installing fittings and winches for loading ramps, a heating system to provide deicing for vehicle ramps, as well as electrical wiring for the new equipment. The Polish workers were supervised by a supernumerary EL FARO C/E who was onboard solely for that purpose. The Riding Crew Supervisor ensured that the conversion work remained on schedule and that the quality of the work conformed to TSI's expectations.

EL FARO's C/E and C/M reported to the Master. The OMV (Fig. 11) indicated a direct reporting relationship between the Master and various corporate officers, as well as between the Master and the International safety Management (ISM) designated person for safety and environmental matters. The OMV did not, however, indicate a reporting relationship between the Master and the TSI P/E, despite that being the person the Master interacted with on day-to-day operational matters while EL FARO was in Jacksonville. The P/Es working at the time of the accident voyage primarily had a marine engineering background, with minimal nautical operations expertise. P/Es were responsible for conducting annual evaluations of the Masters and the C/Es. The annual evaluation[22] was designed to assess the Master's competency in voyage planning, navigation, cargo loading and stability assessment, oversight of the safety of vessel operations, and several other performance dimensions.

The P/Es reported to the Director of Ship Management – Commercial, who was also a marine engineer. Finally, the Director of Ship Management – Commercial reported to the VP of Commercial Operations who is located in the TSI Tacoma Washington office. The VP of Commercial Operations did not have a marine operations background or Merchant Mariner Credential. In MBI testimony the TSI witnesses stated that they expected EL FARO to operate autonomously without oversight from TOTE. The Director of Ship Management – Commercial testified in the MBI:[23]

> *The Master operates autonomously. There's multiple lines of responsibility. There's multiple lines of people he can address issues to, but the Master is the Master of the ship.*

Multiple witnesses testified that Masters were primarily responsible for the safety of the vessel, and operated autonomously in regard to ship routing, speed, and other voyage decisions. Shore side management was not required to approve these decisions.[24] The TOTE OMV states the following:

> *Master is responsible for managing and protecting the Company's interests in all phases of the vessel's operation. TSI staff personnel are available for consultation and/or assistance and can be contacted at any time, including nights, weekends and holidays.*[25]

[22] MBI Exhibit 424.
[23] MBI Transcript February 19, 2016, p. 13.
[24] MBI Transcript February 14, 2016, p. 51, 62, and February 13, 2017, p. 1060.
[25] MBI Exhibit 198, p. 107.

Whenever a tropical weather system directly or indirectly impacted the port of Jacksonville or San Juan, TOTE implemented a Port Hurricane Plan in order to safeguard its shore side assets. This included measures to ensure the protection of personnel, critical equipment (e.g., gantry cranes), cargo and other company assets. However, there was no similar hurricane plan in place to protect underway TOTE vessels that could potentially encounter adverse weather conditions. There was also no vessel-specific heavy weather plan produced for EL FARO.

In late August 2015, two tropical weather systems in the Atlantic Ocean impacted the Puerto Rican trade operations. During that same time period, a West Coast sea trial in the Port of San Diego for TOTE's first LNG fueled vessel, ISLA BELLA, identified a problem with the vessel's shaft bearings. ISLA BELLA was drydocked in San Francisco in September 2015 to resolve the shaft alignment and bearing issues. Upon completion of repairs, ISLA BELLA departed drydock for further sea trials on September 29, 2015, the same day EL FARO departed Jacksonville on the accident voyage. Delivery of the MARLIN class ships required considerable attention from TOTE management in the months leading up to and also during the accident voyage. ISLA BELLA's delayed delivery created cascading effects that impacted the ORCA class ship conversion[26] and TOTE operations on the Puerto Rico run.

While underway EL FARO communicated with shore side personnel by means of a satellite communication system called Inmarsat. In MBI testimony, TSI stated that they did not maintain a list of people who would monitor EL FARO's departure, arrival and noon report email messages. The TOTE VP Ops – Commercial stated that "he was not aware of particular shore side person who had the specific duty to monitor EL FARO email reports."[27] As a result, EL FARO's Inmarsat emails were sent to a number of individuals at TSI and TMPR who would collectively monitor the vessel's status and individually reply as needed.

### 7.2.2. Regulatory Framework

#### 7.2.2.1. Coastwise Transportation of Merchandise

EL FARO carried cargo between the United States ports of Jacksonville, Florida and San Juan, Puerto Rico, and was therefore required to comply with U.S. laws regarding coastwise transportation of merchandise, commonly known as the Jones Act.[28]

Under the Jones Act, all cargo shipped to Puerto Rico from a port in the United States must be carried onboard a vessel that is owned by citizens of the United States and that has a Coast Guard issued Certificate of Documentation with a coastwise endorsement. Other than some limited exceptions, only vessels built in the United States qualify for a coastwise endorsement.[29]

[26] The ORCA ships were the ships in trade between Washington and Alaska. The plan was for these ships to be converted to a dual fuel LNG power plant. EL FARO was to be the relief ship that would fill in for each of the ORCA ships as they were converted to the LNG fuel. Once the first of the new MARLIN ships arrived in Jacksonville this would free up EL FARO to head to a planned yard period in the Tacoma area for reconversion back to the Alaska configuration. Then EL FARO would enter service on the Washington to Alaska run relieving one of the ORCAs at a time to begin their repowering to LNG.
[27] MBI Transcript, February 16, 2016, p. 50.
[28] 46 U.S.C. §§ 55101, 55102, 19 CFR § 4.80.
[29] 46 U.S.C. § 12112 and 46 U.S.C. § 12103.

7.2.2.2. Coast Guard Inspection of Domestic Commercial Vessels

46 U.S.C. Chapter 33 requires that certain vessels possess a Coast Guard issued Certificate of Inspection (COI). A COI is issued to a vessel once it satisfactorily completes an inspection for certification. A vessel must be maintained in a safe operating condition in order to retain a COI. An OCMI may issue a Temporary COI, valid for up to one year, pending issuance of the permanent COI, which is valid for five years from the original issue date of the Temporary COI.[30] COIs are only issued when the OCMI determines that a vessel complies with all applicable statutes and regulations and that it can be operated safely without endangering life, property or the environment.

7.2.2.3. Alternate Compliance Program (ACP)

The ACP is a voluntary system that allows owners of U.S. vessels to obtain a COI based on inspections conducted by an Authorized Classification Society (ACS). Under this program, an ACS is authorized to conduct certain functions and certifications on U.S. flagged vessels on behalf of the Coast Guard.[31]

The Coast Guard began implementing the ACP in 1995, following requests from the U.S. maritime industry to reduce the duplication of effort between Coast Guard inspections and classification society surveys, which caused extra costs to U.S. vessel owners.[32] A task force of Coast Guard and American Bureau of Shipping (ABS) representatives determined that compliance with ABS classification rules, SOLAS, and MARPOL 73/78 would satisfy the majority of U.S. regulatory requirements. The Coast Guard and ABS developed a U.S. Supplement to the ABS rules to address any identified gaps between SOLAS, ABS Rules, and Coast Guard regulations. The Coast Guard concluded that compliance with the ABS rules, international conventions, and the U.S. Supplement to the ABS rules would provide a level of safety equivalent to federal requirements. Under ACP policy, the U.S. Supplement is required to be updated annually and the ACS and Coast Guard were jointly responsible for making the updates. The updates were necessary to cover any new domestic regulations and compliance gaps identified by ACS surveyors or Coast Guard Marine Inspectors in the field. At the time of EL FARO's sinking, the U.S. Supplement for ABS had last been updated in April 2011. The Coast Guard also has U.S. Supplements for other ACSs authorized to participate in the ACP. When asked during MBI testimony whether the U.S. Supplements were being updated according to Coast Guard policy, the Chief of the Coast Guard's Office of Design and Engineering Standards responded:

> *The simple fact of the matter is that we are strained by resources to keep up with those reviews. So we have Supplements that are pending review we just haven't gained a lot of ground on that. But when we do, that is the process that we go through.*

All U.S. vessels enrolled in ACP are required to comply with international SOLAS requirements for international voyages. EL FARO was enrolled in the ACP at the time of the

[30] MSM Volume II, Section B1.B.1.
[31] NVIC 2-95 Ch. 2.
[32] 61 Federal Register 68510, December 27, 1996.

accident voyage and ABS was the vessel's Classification Society, responsible for performing the certification functions delegated to it by the Coast Guard under the program.

EL FARO was enrolled into the ACP on February 27, 2006.[33] Based on its enrollment date, EL FARO was required to comply with applicable SOLAS conventions, ABS Steel Vessel Rules, and the June 2003 U.S. Supplement to ABS Rules for Steel Vessels Certificated for International Voyages.

7.2.2.3.1. ACP Roles and Responsibilities

The owner of a vessel is responsible for ensuring its vessels are maintained and continually operated in compliance with all applicable statutes and regulations; this remains the case with the ACP. As a result of a vessel being accepted and enrolled in the ACP, the ACS assumes responsibility from the Coast Guard for verifying that a vessel maintains substantial compliance with applicable standards. The ACS also issues international certificates and documentation attesting to the vessel's compliance. Additionally, the International Safety Management Code, 2014 (ISM Code), is applicable to all vessels enrolled in the ACP. Per the ISM Code, the Recognized Organization (RO) is responsible for issuing the Safety Management Certificate (SMC) and conducting annual external audits that verify compliance with the company Safety Management System (SMS). ABS was the RO for TOTE. The Coast Guard retains authority and primary responsibility for certain activities for vessels enrolled in the ACP, including approval of security plans, major conversion determinations, ballast water management compliance, marine casualty investigations, and enforcement actions.[34]

The Coast Guard conducts an annual examination onboard each vessel enrolled in the ACP. This examination, which is more limited in scope than a traditional Coast Guard inspection of a non-ACP vessel, includes a general walk-though of the vessel, an examination of the vessel's certificates and crew documents, an evaluation of crew member proficiency during emergency drills, and a verification of the vessel's security plan. The primary objective of the Coast Guard annual examination is to ensure the ACS is meeting its obligations under the ACP. The Coast Guard ACP Freight Vessel Examination Booklet[35] contains an extensive list of items Coast Guard Marine Inspectors may check during an annual examination of an ACP vessel.

In addition to the annual examination, the Coast Guard can also conduct oversight activities at the discretion of the local OCMI where an ACP vessel is operating. For non-passenger ACP vessels, the Coast Guard Headquarters Office of Commercial Vessel Compliance (CG-CVC) can also mandate additional oversight examinations based on an annual risk assessment that is conducted on every vessel enrolled in the ACP.

In accordance with Coast Guard policy, deficiencies found during a Coast Guard inspection of a non-ACP U.S. vessel are documented through the use of a Record of Merchant Marine Inspection Requirements (Coast Guard form CG-835), which is issued to a vessel's owner or representative. All CG-835s are logged into the Coast Guard's MISLE database, which creates a

[33] MBI Exhibit 020.
[34] For a complete list of inspection activities retained by the Coast Guard, see section B9.F of MSM Volume II.
[35] MBI Exhibit 226.

permanent record of the discrepancy detected while also tracking the corrective actions performed to rectify the discrepancy. If the Coast Guard discovers deficiencies during an examination of an ACP vessel, the Marine Inspector notifies the ACS. Coast Guard policy dictates that the issuance of a CG-835 to an ACP vessel owner is a "last resort after all other corrective measures have proven impractical or if a classification society surveyor is not immediately available to attend the vessel."[36] Thus, CG-835s are generally not issued to ACP vessel operators. As a result, deficiencies are not recorded in the Coast Guard's MISLE database for the majority of Coast Guard detected deficiencies on ACP vessels, and corrective actions are not tracked.

Although an ACS is delegated the authority to conduct ACP inspections, only the Coast Guard can deny issuance or revoke vessel certificates for non-compliance.

Prior to the loss of EL FARO in October 2015, the Coast Guard Headquarters Traveling Inspection Staff began a review and evaluation of the ACP by attending annual examinations of vessels determined by CG-CVC to be in the high risk category. The Traveling Inspection Staff accelerated their evaluation of ACP vessels after the sinking of EL FARO, and their findings are discussed in a September 6, 2016, report from the Chief Traveling Inspector to the Assistant Commandant for Prevention Policy.[37] The report discussed several ACP concerns including communication problems between Coast Guard Marine Inspectors and ACS surveyors, a lack of training for Coast Guard Marine Inspectors regarding ACS rules and survey procedures, an absence of standardized training or qualification requirements for ACS surveyors, and confusion regarding the various ACS Supplements. The report also made several recommendations including the development of more specific guidance on the ACP for Coast Guard field units, ACSs, owners, and operators of U.S. vessels enrolled in the ACP.

After the sinking of EL FARO, the Traveling Inspection Staff continued their review and evaluation of ACP vessels. Vessels were selected based on age, compliance history, and propulsion type, and additional ACP vessels were visited at the request of local Coast Guard OCMIs. Several of the ACP vessels inspected during this review were found to be in substantially substandard condition. The substandard vessels frequently lacked ACS or Coast Guard issued deficiency records that would have been expected to accurately reflect the material conditions found on the vessels. Prior to Coast Guard Traveler Inspector visits, it was concluded by data/record review that the vessels were in full compliance. Three vessels visited were subsequently scrapped by the owner as a result of Coast Guard issued deficiencies and two others were issued no-sail deficiencies temporarily removing them from service until serious safety issues were resolved. Significant safety and structural deficiencies were found on other vessels visited by the Traveling Inspection Staff during 2016. During MBI testimony the Chief of the Coast Guard's Traveling Inspection Staff confirmed that his inspectors found safety deficiencies on approximately15 deep draft vessels[38] they visited during this review.

[36] NVIC 2-95 Change 2, p. 10.
[37] MBI Exhibit 329.
[38] A records check conducted by the Traveling Inspection Staff in September 2017 located 14 visit records for the timeframe referenced in the testimony including visits to 10 ACP vessels, 4 Military Security Program (MSP) vessels, and one Coast Guard inspected vessel.

In Calendar Year 2016, the Coast Guard Office of Investigations and Analysis determined that there were 110 active U.S. flagged general dry cargo and RO/RO vessels enrolled in the ACP. During that year, Coast Guard OCMIs were required to intervene and issue a no-sail order to a vessel within that fleet on 13 occasions.

The Coast Guard does not publish a Domestic Vessel annual report and the domestic no-sail rate for vessels enrolled in ACP is not tracked or published. The Coast Guard also does not have a process in place to track or hold accountable an ACS performing ACP inspections on its behalf when the Coast Guard issues a no-sail order for safety violations detected during a follow-on Coast Guard ACP oversight exam.

In contrast, when foreign vessels are detained in a U.S. port after a Coast Guard Port State Control examination, the overall detention rates for each flag administration are tracked and published by the Coast Guard Office of Commercial Vessel Compliance in an annual Port State Control Report.[39] In addition, after a foreign vessel is detained for a safety issue, the Office of Commercial Vessel Compliance conducts an analysis to determine if the vessel's Recognized Organization[40] should be associated with the detention for not detecting a safety issue. Foreign vessels that use Recognized Organizations with a high rate of associated detentions receive points on a targeting matrix that can lead to additional Coast Guard Port State Control exams.

7.2.2.3.2. Inspections of EL FARO's Safety Equipment and Crew Proficiency Under ACP

EL FARO did not conduct required underway operational tests of its lifeboats during the last inspection for certification prior to the accident voyage. At the time of the last inspection, ACP policy dictated that the Coast Guard was responsible for observing the operational lifeboat tests in the water and assessing the crew's performance during those tests, which were supposed to be conducted during the ACP oversight examination.

In MBI testimony a Coast Guard Marine Inspector[41] who examined EL FARO provided the following background on the testing of the lifeboats:

> ***Question:*** *Page 66 is part of a checklist on ACP statutory surveys to be done in conjunction with initial MAS[42] and renewal safety equipment surveys. It's listed as not Coast Guard approved in the front of the supplement, but as we heard from ABS surveyors in previous testimony it is included as part of their exams. On page 66 under life boat operational test Part 3, specifically number 1 under Part 3 it indicates in A that Coast Guard inspectors will have a crew proficiency test to conduct during their boarding. At that time the crew must operate each boat in the water and the following test will be carried out. Can you comment on whether that is something that Sector San Juan does during alternate compliance program exams? And is that in any inspection guidance the Coast Guard publishes?*

[39] MBI Exhibit 436.
[40] Recognized Organization is a term used to describe a Classification Society which is issuing statutory certificates on a flag administration's behalf.
[41] MBI Transcript May 25, 2016, pp. 18 - 19.
[42] MAS = Mandatory Annual Survey (source www.eagle.org).

> ***WITNESS:*** *It's in the 840[43] book for us to do the drills. And usually on the life boat we've actually – there was some guidance that came out for internationally about doing the lifeboat test. They're kind of dangerous. So usually what we do is just lower the life boat to the water and have them bring it back up. We don't do the dock side boat. Because it wouldn't be safe to do so. If something happened to the davit or something you would damage the life boat or hit the dock.*
>
> ***Question:*** *So you would say it's not part of the Coast Guard ACP oversight exam to conduct a crew proficiency test with the boat in the water?*
>
> ***WITNESS:*** *We currently don't do that. Like I said we stopped doing that because of the guidance that we got on the port state side of not putting the crew into the boat into the water because of the dangers.*

And:[44]

> ***WITNESS:*** *I know that ABS as part of their exam is supposed to lower the vessel, uh lower the boats. So since we're doing the oversight I don't see – didn't see any real need to take them all the way to the water just to – prove proficiency to make sure that they can lower the boats. And the crew's also required every three months to actually lower the boat to the water and operate it, so.*

Coast Guard procedures[45] to determine the effectiveness of shipboard safety equipment on U.S. commercial vessels require that the lifeboats be lowered to the rail, boarded by crew, lowered to the water, released and then operated in the water. There is a provision for modifying the procedure due to weather; however, deviations from the requirement for a full abandon ship drill are required to be documented and the drill performed at a later date. The Coast Guard procedures for testing lifeboats on foreign vessels under the Port State Control program allow the scope of the lifeboat tests to be reduced.

The 2011 U.S. Supplement to the ABS rules for steel vessels[46] on international voyage contains a check sheet for ABS statutory surveys. The note states,

> *III. Lifeboat Operational Tests*
>
> *1. Proper operation of the propelling gear and/or motors was demonstrated. (IMO allows this testing to be carried out while the boat is secured in the falls.)*
>
> > *a. The CG inspectors will have a crew proficiency test to conduct during their boarding. At that time, the crew must operate each boat in the water, and the following tests will be carried out:*

[43] "840 book" is a job aid for Coast Guard Marine Inspectors.
[44] MBI Transcript May 25, 2016, p. 67.
[45] MSM Volume II Section B Chapter 1 section v. pp. B1-131.
[46] MBI Exhibit 113, p. 66.

*Note: The CG inspectors will have a crew proficiency test to conduct during their boarding. At that time, the crew must operate each boat in the water, and the following tests will be carried out: Note: The USCG will accept load tests done by ABS.*

| | | | | |
|---|---|---|---|---|
| 4. | Each motor lifeboat and hand-propelled boat was operated at full speed both ahead and astern. | ☐ | ☐ | |
| 5. | Each installed system, such as any powered bilge pump or water spray system, was successfully operated. | ☐ | ☐ | |
| 6. | Compass readings were compared with several known bearings. | ☐ | ☐ | |
| 7. | Each air tank buoyancy unit was visually inspected and appears fit for service. | ☐ | ☐ | ☐ |
| | *Note: In case of doubt, air tanks may be tested for air-tightness per Marine Safety Manual, Chapter 6, Section R.* | | | |
| 8. | Water tanks were inspected and confirmed watertight. | ☐ | ☐ | |
| | *Note: This should be demonstrated by either an airtight test or filling with water and watching for leaks. Refer to Marine Safety Manual, Chapter 6, Section R.* | | | |
| 9. | Batteries for engine starting and searchlights have a means for recharging, which are in satisfactory condition. | ☐ | ☐ | |
| 10. | The condition and quantity of survival equipment was checked as per the standard ABS check sheets. | ☐ | ☐ | |

### 7.2.3. Safety Management System (SMS)

As a result of being enrolled in the ACP, EL FARO was required to be in compliance with the ISM Code. TOTE had an SMS in effect at the time of the accident, which was designed to ensure the company provided procedures for the safety of operations onboard EL FARO. The SMS consisted of the Operations Manual – Vessel (OMV, rev. 21, Aug 2015), and the Emergency Preparedness Manual – Vessel (EPMV, rev. 13, Apr 2014). There were no specific SMS manuals that provided guidance to management for shore-based operations of the company.

The ISM Code, Part A section 1.2.2.2 requires that each maritime "Company" assess all identified risk to its ships, personnel, and the environment and establish safeguards. In TOTE's EPMV there were sections that provided guidance for the loss of propulsion, flooding, and abandoning ship. At the time of the accident TOTE had not formally identified weather as a risk to its ships as part of its SMS. In the General Section of the document, Section 5 EMERGENCY PROCEDURES, 5.1 GENERAL there was the following explanation:

> *The object of this section is to assist the Master in making decisions when confronted with a perilous situation. It is reasonable to assume that few people will reach for this manual in the time of an emergency, therefore, excerpts from this section should be used as drill scenarios to promulgate policy and procedures before an incident is at hand.*

There are sections in the SMS (OMV)[47] that discuss various operations related to weather conditions such as:

> *10.8.1 General.....Rev. 13 1/08*

[47] MBI Exhibit 025.

*10.8.2 Adverse Weather.....Rev. 0 3/96*
*10.8.3 Additional Ballast in Heavy Weather .....Rev. 0 3/96*
*10.8.4 Weather Routing .....Rev. 15 9/09*
*10.8.5 Adverse Conditions While at Anchor or Moored .....Rev. 8 7/02*

The only section directly related to the navigation of the vessel to reduce the risks associated with severe weather is in the EPMV.[48] Specifically, Section 5.12 [49]SEVERE WEATHER contained the following information:

*5.12 SEVERE WEATHER*

*5.12.1 IN PORT*

*Masters are advised to always berth their vessels with the most severe conditions in mind. Special attention should be paid to the time of the year and the locale of the vessel. The deck officers should be familiar with prevailing winds and storm track probabilities.*

*In the event the vessel is in port during a severe storm, the Master is to assess the situation and confer with the HQ Office who will clear the vessels' actions (when necessary) with the local MSC (Military Sealift Command) representative or charterer, before moving the vessel.*

*(In most cases the MSC representative will have access to USN weather information and the USN weather routing service.) Masters must take advantage of all information available and act in accordance with the owner's representative's /MSC's directions. If, in the opinion of the Master, an unwise course of action is advised, he/she shall alert TSI Headquarters and the Manager of Marine Safety & Compliance will liaison with MSC Headquarters and work for a quick resolution of the matter.*

*5.12.2 AT SEA*

*Severe weather is to be avoided where possible by altering the track of the vessel. Instruction for maneuvering in extreme weather can be found in "The American Practical Navigator" HO Pub. #9.*

Section 8.1 and 8.3 of the ISM Code state that companies should identify potential emergency shipboard situations and establish procedure to respond to them. Additionally, the SMS should provide for measures ensuring that the company's organization can respond at any time to hazards, accidents, and emergency situations involving its ships. The code refers to International Maritime Organization (IMO) resolution A.852(20), which has been superseded by IMO resolution A.1072(28) as guidance for the development of an "Integrated System of Contingency Plans." The Coast Guard has provided no guidance to either companies or ROs

[48] MBI Exhibit 026.
[49] MBI Exhibit 026.

representing the Coast Guard that addresses the development of integrated contingency plans for responding to shipboard emergencies.

If a company does identify potential shipboard emergencies, such as weather or near miss incidents, the company should establish programs for drills and exercises to prepare for those emergency actions. At the time of the accident voyage the Coast Guard did not require, and ABS provided no guidance on, which shipboard emergencies should be considered in the SMS. As a result, TOTE only conducted drills and exercises in accordance with basic SOLAS requirements.

MBI testimony from TOTE's Director of Safety and Services indicated that one of the purposes of TOTE's internal audits[50] was to verify that all regulatory drills and exercises were properly completed and logged. There is no record that TOTE shore side management completed evaluations or internal audits, as required by the ISM Code, to ensure that emergency drills and exercises involving shore side response were effective and that the crew members were competent in their knowledge of assigned watch, quarter, and station bill duties, or that TOTE management was prepared for responding to emergency situations involving its fleet.

The MBI examined EL FARO's training, drills, and logs related to shipboard training. Unsigned electronic logs covering the latter half of 2015 were substituted for hardcopy logs that were lost during the sinking of EL FARO. The actual paper records provided were signed and the duration of the training and drills was noted. In addition, some of the electronic records contained the duration of the drills.

The following findings were noted from EL FARO's logs:

- There was no record for 2015 of a lifeboat being lowered to the water, released, and operated in the water.
- The 2nd Quarter 2015 Non-Crew Indoctrination log does not list the signatures for two shipriders who were on a voyage of EL FARO from April 17 - 20, 2015. There was no record that they were provided their non-crew indoctrination.
- The electronic Safety Drills/Training forms (TSI-V-ADM-024 Rev. 2/13) for August 20, 2015; August 27, 2015; August 27, 2015; September 3, 2015; and September 10, 2015 did not contain the names of the Polish Riding Crew in the list of names in attendance for the safety drills listed. Records for the following safety drills were obtained and reviewed: fire, abandon ship with boat lowering to embarkation desk, container fire, and a medical emergency.
- A drill on June 4, 2015, which included a fire drill with rigging of hoses, conducting whistleblower /respirator training/MSDS review/HAZMAT and HAZWOPER training and abandon ship and lowering of the boat to the embarkation deck, was listed as 30 minutes in duration.

[50] MBI Transcript February 17, 2016, p. 89.

The VDR[51] transcript contains comments from the crew relating to the performance and efficiency of drills. The following conversation occurred on watch between the 2/M and AB at 1:40 AM on October 1, 2015:

> ***2/M :*** *[sound of quick laugh] Usually people don't take the whole umm– uh– survival suit– safety meeting thing very seriously. Then it's "yeah– whatever. it fits" but nobody actually sees to see if their survival suit fits. I think today would be a good day [sound of laugh] for– for– for the fire and boat drill– just be like– "so we just wanna make sure everyone's survival suit fits" and then with the storm people are gunna (go/be like) "holy* [expletive]. *I really need to see if my survival suit fits– for reaaal." [laughter throughout]*
>
> ***2/M****: Nobody ever takes these– the drills– seriously.*
>
> ***AB****: No. Still have to do'em.*

Guidance for International Association of Class Societies[52] (IACS) Auditors to the ISM Code No. 41 section 8 (2005), provides examples of emergency situations auditors should sample. These include the use of an integrated vessel and shore side plans for damage from heavy weather, flooding, abandoning ship, or loss of propulsion. ABS, as the RO for TOTE vessels, is a member of IACS, and should follow the procedures established in IACS guidance. ABS, as RO, issued the Safety Management Certificate to EL FARO and the Document of Compliance to TOTE on behalf of the Coast Guard. As the RO, ABS completed external audits to ensure the Safety Management System was implemented and effective.[53] These audits were completed by taking a sampling of each section of the ISM code and verifying compliance through objective evidence. The specific samples that were chosen for review were determined by the ABS Lead Auditor. ABS external auditors did not engage with TOTE management regarding the development of integrated contingency plans and drills and exercises for emergency situations that EL FARO encountered during the accident voyage, including loss of propulsion, flooding, and heavy weather.

IACS Recommendation 41, (Rev. 4, Dec 2005) Guidance for IACS Audits to the ISM Code,[54] states the following:

> *8 EMERGENCY PREPAREDNESS*
>
> *8.1 The Company should establish procedures to identify, describe, and respond to potential emergency shipboard situations.*
>
> *8.2 The Company should establish programs for drills and exercises to prepare for emergency actions.*

[51] MBI Exhibit 266.
[52] http://www.iacs.org.uk/.
[53] 33 CFR § 96.320.
[54] http://www.iacs.org.uk/publications/recommendations/rec-41-rev4-corr1-cln/.

*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.*

*Usually the following scenarios should be addressed by emergency plans as required by the specific ship types:*
*- structural failure / heavy weather damage*
*- failure of main propulsion*
*- steering gear failure*
*- electrical power failure*
*- collision*
*- grounding / stranding*
*- shifting of cargo*
*- cargo / oil spillage / jettison **
*- flooding*
*- fire / explosion*
*- abandoning ship*
*- man over board*
*- search and rescue operations*
*- serious injury*
*- piracy / terrorism **
*- helicopter rescue operations*

Coast Guard Marine Inspectors did not issues any deficiencies or pass any safety related concerns to ABS after conducting EL FARO safety drills with the crew during the last annual ACP examination prior to the accident. The Coast Guard examiners did not require EL FARO's lifeboats to be operated in the water during the final ACP examination. ABS did not identify any concerns related to lifesaving gear or drills after conducting the last compliance survey on EL FARO nor did they require launching or witness the lifeboats operating in the water.

TOTE maintained an Emergency Response Manual (ERM) [55] that included emergency contacts for two types of vessel operational emergencies:

*Section 8: Oil Spill Response Procedures and Contacts*
*Section 10: Security Emergency Procedures and Contacts*

TOTE's ERM did not contain information related to any operational safety related emergencies including adverse weather, flooding, loss of stability, cargo shifting, or abandon ship.

On February 1, 2016, Coast Guard Traveling Inspectors and ABS surveyors conducted a Document of Compliance (DOC) Audit of TOTE Services Inc. to check SMS compliance. The audit resulted in the issuance of five non-conformities including the following items:

[55] MBI Exhibit 385.

- TSI did not document incident and investigation records as required by company procedure EPMV -10 (Rev 14 8/15) for three incidents including the sinking of the EL FARO.
- TSI representatives did not complete an annual "Vessel Inspection" or the "Ship Visit Report" for eight vessels.
- Cargo hold fire detection system maintenance records for the RO/RO COURAGE were found past due prior to a fire incident in June 2015.[56]

At the conclusion of the audit, TSI's full term DOC was suspended and ABS issued a short term (90-day) DOC due to the identified non-conformities and observations. The DOC audit included a walkthrough of EL YUNQUE. Additional details on issues identified by the attending Coast Guard Traveling Inspector during the EL YUNQUE visit are included in Section 7.2.9 of this Report of Investigation.

7.2.4. Construction, Modification, and Conversion

Sun Shipbuilding in Chester, Pennsylvania built a series of ten RO/RO "trailerships" between 1967 and 1977. While the ships were built for several different owners with minor differences in configurations to accommodate different trade routes, these ships were designated as the PONCE DE LEON class[57] of ships. All of these ships were arranged as "shelter deck" vessels with a semi-enclosed cargo deck intended to facilitate loading and stowage of vehicular cargo. EL FARO was originally named PUERTO RICO and also operated as the NORTHERN LIGHTS from 1991-2006 in the Alaska Trade. It was the seventh ship in the PONCE class. EL FARO's keel was laid in 1974 and construction completed in 1975, with an original length of 700 feet.

In 1992, EL FARO underwent a conversion at the Atlantic Marine Shipyard in Mobile, Alabama. This conversion included the addition of a 90-foot mid-body section between frames 134 and 135 that added a cargo hold (designated Hold 2A), a new spar deck to carry additional trailered containers, and 1,830 long tons of iron ore fixed ballast in one pair of double bottom tanks. Due to the lengthening and increase in cargo carrying capacity, the Coast Guard determined the mid-body insert to be a major conversion, which required the vessel to be brought up to current standards to the extent considered reasonable and practicable by the local Coast Guard OCMI. As part of the major conversion determination, the Coast Guard approved a request to have ABS conduct plan review and inspection on behalf of the Coast Guard. [58] Additionally, since the vessel was issued international certificates for foreign voyages and was required to comply with SOLAS requirements, it was also directed that all modifications to the vessel comply with the most recent SOLAS amendments (SOLAS 1974, as amended). This included meeting new IMO probabilistic damage stability standards, among other SOLAS amendments.

EL FARO completed another conversion in 2006 to carry lift-on/lift-off (LO/LO) container stacks on the main deck to facilitate service between East Coast ports and Puerto Rico. The

[56] The June 2, 2015 fire occurred in the RO/RO COURAGE's main cargo hold while the vessel was transiting the English Channel. The fire caused $100M in damage and led to the vessel being sold for scrap in March 2016.
[57] Referred to as 'PONCE Class' throughout this Report of Investigation.
[58] MBI Exhibit 422.

conversion, which also took place at Atlantic Marine Shipyard, included removal of the spar deck, structural reinforcement of the main deck, addition of container support foundations and structures, and an additional 4,875 long tons of iron ore fixed ballast in the remaining two additional pairs of double bottom ballast tanks.

The Coast Guard Marine Safety Center (MSC) did not designate the 2005-2006 conversion as a major conversion. According to available documentation regarding the determination, the Coast Guard originally designated the proposed project as a major conversion in 2002.[59] The Vice President for Marine Operations at TOTEM Ocean Trailer Express subsequently sent a series of requests for reconsideration to the MSC explaining that the NORTHERN LIGHTS (EL FARO) intended only to increase its container cargo volume, referred to as forty-foot equivalent units (FEU) and twenty-foot equivalent units (TEU). In a reconsideration request letter dated March 22, 2004, VP for Marine Operations stated:

> *A vessel's cargo carrying capacity is defined by its load line and stability characteristics, not by an FEU or TEU number count. Further, I know of no international or U.S. safety or environmental protection requirements that are based on TEU/FEU count…Only the load line is the measure of capacity.*

The MSC overturned its original determination in a November 8, 2004 letter that confirmed EL FARO's proposed conversion to a LO/LO configuration would not be treated as a major conversion. Although earlier MSC letters had voiced concerns about the potential for an increase to EL FARO's cargo carrying capacity, the Coast Guard's final non-major conversion determination letter did not include any restrictions related to increasing cargo capacity during the conversion. After the 2006 conversion, EL FARO's total cargo loading capacity changed and the vessel's maximum allowable draft was increased by over 2-feet. The change also reduced the vessel's freeboard which lowered hull openings by the same distance. The MSC's decision to not classify the conversion as a major modification meant EL FARO was not required to conform to applicable 2006 U.S. and international standards (e.g., CFR, ABS SVR, and SOLAS) in conjunction with the conversion work.

During MBI testimony a former EL FARO Master with 25 year of total service as Master on PONCE class vessels in the Alaskan and Puerto Rican trade provided the following description of the PONCE class vessel handling characteristics:

> *The Sea Star ships when you talk about structure they were RO/CONs. So the containers were on the upper decks. And with a heavy load of cargo they would be a tender ship as opposed to a stiffer ship in the Alaska service. They had a higher GM. So and a tender ship if a little bit more of a different animal to handle especially in rough weather and other conditions.*

The former EL FARO Master provided the following MBI testimony when asked about conditions he experienced in calm weather and seas near the end of his voyages to Puerto Rico:

[59] MBI Exhibit 013.

> *What I observed with the ship was a very slow return, it was a – the ship was becoming even more tender on arrival then it was when it left. You could even feel the ship list, I shouldn't say list, but lean over as she rolled from a rudder command alone, let alone rolling with a heavy swell. And because it was slow to right itself you could feel the ship respond more difficulty. And there's always a concern that she's not going to right herself adequately for other conditions. So we felt it important to build in a safety margin in case any other conditions changed during the voyage. That you needed that safety margin to preserve the stability of the ship. And for the routine voyage we had decided that decimal 5, 0.5 foot above the minimum safe GM would be adequate.*

Between April 23, 2014 and May 9, 2014, an ABS Surveyor attended a modification survey in Jacksonville, Florida for the installation of fructose tanks aboard EL FARO. These modifications, which were carried out in Hold 1 and Hold 2 at the inner bottom tank tops between frames 64 and 127, included six 53-ft, 18,000 gallon horizontal ISO shipping container tanks carrying fructose. Coast Guard inspectors from Sector Jacksonville did not attend the vessel during the modification, nor did they note any modifications to EL FARO during the next annual ACP examination. The tanks were permanently installed with piping, pumps, and support structure in accordance with ABS-approved drawings.[60] According to the drawings, two tanks were placed in Hold 1 and four tanks were placed in Hold 2. Despite the weight added to the vessel, no changes were made to the ABS-approved Trim and Stability Booklet or the ABS-approved CargoMax software. ABS's Chief Engineer for Statutes stated during MBI testimony that the weight change should have been submitted to ABS for evaluation and the Trim and Stability Booklet and CargoMax software should have been updated.[61] Under the guidelines of the Coast Guard MSC Marine Technical Note (MTN) 04-95, a detailed weight change can be accepted in lieu of a deadweight survey or inclining experiment when the aggregate weight change does not exceed 2% of a vessel's lightship. ABS's Chief Engineer for Statutes stated that the empty weight of the fructose tanks was approximately 100 tons, or approximately 0.5% of the light ship weight.[62] The additional estimated weight of the fructose tanks on EL FARO was accounted for in CargoMax by inserting RO/RO cargo items at the relevant locations. Specifically, the fructose tanks were accounted for with six approximately 100 long ton trailers in Holds 4A and 4B in EL FARO's departure condition.[63]

As EL FARO's Puerto Rico operations continued in 2015, TOTE made a decision to prepare EL FARO for Alaskan Trade operations as a relief vessel to support TOTE's planned ORCA vessel conversions. Prior to reentering service on the West Coast, EL FARO needed to convert its configuration back to carrying only RO/RO cargo. A plan was drafted for the conversion which included the installation of additional ramps, winches, wiring and a heating system to prevent ramp icing. In August 2015, a foreign riding crew comprised of Polish nationals was brought aboard EL FARO to start the conversion work while the vessel was operating. The five Polish workers included laborers, welders, and electricians, who worked under the supervision of a TOTE Riding Crew Supervisor. On September 13, 2015, the Riding Crew Supervisor sent an email to TOTE Services personnel ashore detailing progress already made on the conversion of

[60] MBI Exhibit 104.
[61] MBI Transcript May 20, 2016, pp. 32-33.
[62] MBI Transcript May 20, 2016, p. 47.
[63] MBI Exhibit 059, p. 8.

EL FARO back to the Alaska RO/RO only service.[64] TOTE P/Es directed the Riding Crew Supervisor to complete as much conversion work as possible ahead of an EL FARO dry dock period scheduled for October 2015. As a result, the riding crew continued working while underway on EL FARO through September, including during part of the accident voyage while transiting southbound toward Puerto Rico.

During MBI testimony, ABS's Chief Engineer for Statutes stated that ABS was not aware of the weight changes associated with the conversion work and he clarified that his office should have been made aware.[65]

### 7.2.5. Load Line, Stability, and Structures

#### 7.2.5.1. Load Line

*Load line* is the formal term given to the mark located amidships on both sides of a ship to clearly display the limiting draft to which a vessel may be loaded. The limiting draft is obtained from the required minimum freeboard, which is the vertical distance from the uppermost continuous weathertight deck (normally the freeboard deck) to the load line mark amidships.[66]

The International Convention on Load Lines 1966 (ICCL), as modified by the protocol of 1988, requires the load line mark for all ships with keel laid after July 21, 1968. Coast Guard implementing regulations are contained in 46 CFR Part 42. Under these regulations, and 46 U.S.C. § 5107, ABS is designated as the assigning authority for load lines. As the assigning authority, ABS is empowered to assign load lines and issue certificates, perform surveys required for load line assignments, and determine that the position and manner of marking vessels is in accordance with applicable requirements. The Coast Guard has no direct role in load line assignment other than providing oversight. The MSC has responsibility for carrying out oversight of the load line assignments made on the behalf of the Coast Guard.[67] [68]

At the time of the accident voyage, EL FARO had a valid International Load Line Certificate (ILLC) issued by ABS on January 29, 2011, which assigned a summer load line molded draft of 30'-1-5/16" (30'-2-3/8" keel draft) corresponding to a 1966 Type "B" vessel freeboard of 12'-0-15/16" from the 2nd deck.[69] Prior to EL FARO's 2005-2006 conversion to LO/LO service, the assigned summer load line molded draft was 28'-0" (28'-1-1/8" keel draft) corresponding to a freeboard of 14'-1-3/8" from the deck.

EL FARO was provided with an original ABS Form LL-11-D, Survey for Load Lines, on November 10, 1974. At that time, EL FARO had not yet been extended through insertion of a mid-body plug and it was operating as a RO/RO ship only. The LL-11-D was based on

[64] MBI Exhibit 054.
[65] MBI Transcript May 20, 2016, p. 33.
[66] Cleary, W.A., and Ritola, A.P., Ship Design and Construction (Chapter IV: Load Line Assignment), Society of Naval Architects and Marine Engineers (SNAME), New York, 1980.
[67] MBI Exhibit 421.
[68] NVIC No. 10-85, Oversight of Technical and Administrative Aspects of Load Line Assignment, dated October 24, 1985.
[69] MBI Exhibit 260.

application of the International Convention on Load Lines (ICLL), 1966, which was adopted on April 5, 1966, and entered into force on July 21, 1968. At the time of the document's issuance, EL FARO had the following ICLL Regulation 19 ventilators identified in exposed positions on the freeboard or 2nd deck:

- 18-8'3" x 3'6"
- 2-8'3" x 3'7"
- 2-6'0" x 4'8"

Eight ventilators were provided with 3/8" steel "weathertight" fire dampers with double locking handles. Those eight ventilators were provided with 8-foot coamings which were "specially supported" as they exceeded 35-1/2 inches in height. The other fourteen ventilators were provided with hinged watertight covers with drop bolts.[70] Weathertight closing appliances were required for these exposed "position 1" ventilator openings because the coamings did not exceed 14.8 feet above EL FARO's exposed freeboard deck. The 8-foot coamings exceeded the minimum required height of 35-1/2 inches for "position 1" openings. As such, the exposed ventilators, including their coamings and closing appliances, did exceed the requirements of ICCL 1966 Regulation 19.

As discussed in Section 7.2.4., EL FARO completed a major conversion at the Atlantic Marine Shipyard in Mobile, Alabama in 1993. As part of this conversion, a 90-foot mid-body section was added, which included an additional cargo hold (designated as Hold 2A). Two new exhaust ventilators and two new supply ventilators were added as part of Hold 2A. The exhaust ventilators were provided with weathertight fire dampers with double locking handles and the supply ventilators were provided with watertight fire dampers with double locking handles. The watertight supply dampers had gaskets around the openings that provided a complete watertight closure.[71]

The ABS New York Office provided a Circular of Instruction "Survey for Load Lines, Form LL-11-D Record of Conditions of Assignment,"[72] to all exclusive and non-exclusive surveyors on November 22, 1982. The document provided the following direction:

> *When completing this form the freeboard deck…must be maintained weathertight. Weathertight means that in any sea condition water will not enter into the ship. A practical test for weathertightness is hose testing.*

The circular also included the following statement on what can constitute a weathertight appliance:

> *It should be noted that a fire damper alone generally does not suffice as a weathertight closing appliance.*

[70] Form LL 11-C EL FARO.
[71] H.T. McVey and Associates Drawing No. 027-100-1 Rev 1 "General Arrangement" and Sun Shipbuilding & Dry Dock Company "Ventil'n Arrang't Holds 2A and 3."
[72] MBI Exhibit 342.

In 1990, the Coast Guard commissioned ABS to prepare a report that integrated U.S. load line regulations and policies, ABS and IACS interpretations, IMO circulars, and the International Convention on Load Lines (ICLL) into a single reference document. The *Load Line Technical Manual* was created as a result of that effort. It sets forth the technical procedures for evaluating, calculating, and assigning ICLL load lines using Coast Guard and ABS policies where the Convention leaves certain requirements "to the satisfaction of the Administration," or is open to interpretation. The Load Line Technical Manual states the following, with regard to ventilator closures for positions 1 and 2:

> *Fire dampers of the normal type are not considered as meeting the minimum requirement unless they are strongly constructed, gasketed, and capable of being secured weathertight.*[73]

ABS was unable to find an updated form LL-11-D applicable to EL FARO's 1992-1993 major conversion, which would have included additional ventilators for Hold 2A. However, ABS checklists from past surveys on EL FARO indicate that the form was updated following the conversion.[74]

The "weathertight" fire dampers in EL FARO's exhaust ventilators were not gasketed, but were still considered by ABS and the Coast Guard to be weathertight and acceptable as dual use closures.[75] The weathertight designation remained in place for EL FARO's ungasketed fire dampers after the vessel's 1993 major conversion. The major conversion occurred after the 1982 surveyor guidance and 1990 Load Line Technical Manual both stated that fire dampers should not be considered as weathertight closures.

The Coast Guard Traveling Inspection staff and Sector Puget Sound conducted targeted inspections of EL FARO's sister ship EL YUNQUE's ventilators and closures, after the sinking of EL FARO. The examination of the exhaust and supply ventilators revealed gaskets missing from supply dampers, gasket flanges wasted, holes in ventilators including coamings, holes in the side shell in way of ventilator openings, and weathertight and watertight dampers that would not fully close. The resulting work list associated with the exhaust and supply ventilation ducts contributed to TOTE's decision to scrap EL YUNQUE.[76]

7.2.5.2. Intact and Damage Stability

EL FARO met applicable intact and damage stability requirements for the accident voyage that departed Jacksonville on September 29, 2015. However the vessel was operated very close to the maximum load line draft, with minimal stability margin beyond its required metacentric height (GM).[77] EL FARO's past conversions reduced its ballasting options, leaving little flexibility for improving stability at sea if necessary due to heavy weather or flooding.

[73] Load Line Technical Manual Chapter 3 p. 147.
[74] MBI Transcript February 10, 2017, p. 921.
[75] Sun Shipbuilding & Dry Dock Company "Ventil'n Arrang't Holds 2A and 3."
[76] MBI Exhibit 295.
[77] MSC Report.

At the time of the casualty, EL FARO was subject to intact stability requirements of 46 CFR § 170.170 (the GM "weather" criteria); and EL FARO met those requirements on the accident voyage. EL FARO departed Jacksonville on the accident voyage with a GM approximately 0.64 feet greater than the minimum required GM.[78] The difference between the minimum required GM and the calculated GM for a vessel is referred to as the vessel's GM margin. EL FARO's GM margin was reduced to approximately 0.3 feet at the time the vessel lost propulsion on the morning of October 1, 2015.[79]

As operated and loaded for the accident voyage, EL FARO's stability would not have met the stability criteria for a new cargo ship, as the vessel did not meet the righting arm criteria for new cargo ships based on limited available area (righting energy) above 30 degrees of heel and an insufficient angle of maximum righting arm (see Figure A from Figure Sheet).[80] In order to fully meet the intact stability criteria of Part A of the 2008 IS Code at the full load draft, the minimum required GM would be approximately 6.8 feet, which is 2.5 feet greater than the GM of the actual departure loading condition of the accident voyage. However, paragraph 2.2.3 of Part A of the 2008 IS Code provides that "alternate criteria based on an equivalent level of safety may be applied subject to the approval of the administration" if obtaining the required 25 degree angle for maximum righting arm is "not practicable." Thus, the Coast Guard can permit a relaxation of the limiting criteria for minimum angle of maximum righting arm (25 degrees) on a case-by-case basis for new cargo ships.

When EL FARO underwent its major conversion in 1992-1993, it was required to meet the probabilistic damage stability standard of SOLAS 1990. During the 1992-1993 conversion, ABS completed, reviewed, and approved a SOLAS probabilistic damage stability analyses,[81] and it was confirmed that the limiting stability criteria for EL FARO was the intact GM criteria (46 CFR § 170.170) for all loading conditions. Based on MBI testimony, Herbert Engineering Corporation (HEC), did not complete a new damage stability analysis to confirm that the limiting criteria would remain the intact stability criteria for all loading conditions[82] after the 2005-2006 conversion, and ABS had no records of a damage stability analysis being completed.[83] A damage stability analysis should have been conducted because the 2005-2006 LO/LO conversion increased EL FARO's load line draft by more than 2 feet. The increased load line draft invalidated the previous damage stability analysis completed in 1993.

During MBI testimony,[84] the ABS Chief Engineer for Statutes submitted results of an ABS SOLAS probabilistic damage stability analysis performed on EL FARO in May 2016,[85] where he applied the damage stability standards of SOLAS 1990, which would have been applicable in 2005-2006. This analysis determined that GM values of approximately 2.9 feet at both the load line and partial load line drafts (30.11 and 26.02 feet), would attain the required subdivision index of 0.60. MSC completed a similar analysis and obtained similar results, but with a slightly

[78] MSC Report.
[79] MSC Report.
[80] MSC Report.
[81] MBI Exhibit 265.
[82] MBI Transcript May 23, 2016, p. 39.
[83] MBI Transcript May 19, 2016, p. 152.
[84] Id, at p. 151.
[85] MBI Exhibit 166.

higher minimum GM value of 3.3 feet.[86] This suggests that for most EL FARO load conditions with two or more tiers of containers loaded, the limiting stability criteria would be the intact stability criteria (46 CFR § 170.170), but for some load conditions with less than two tiers of containers loaded, the limiting stability criteria could be the damage stability criteria. The potential for damage stability to be the limiting criteria was not reflected on the minimum required GM curves in EL FARO's T&S Booklet.[87] However, for the full load departure condition of the accident voyage, since the majority of container stacks were three tiers high, the limiting stability criteria was the intact stability criteria (46 CFR § 170.170), which was properly reflected in EL FARO's T&S Booklet and incorporated in its CargoMax stability software.

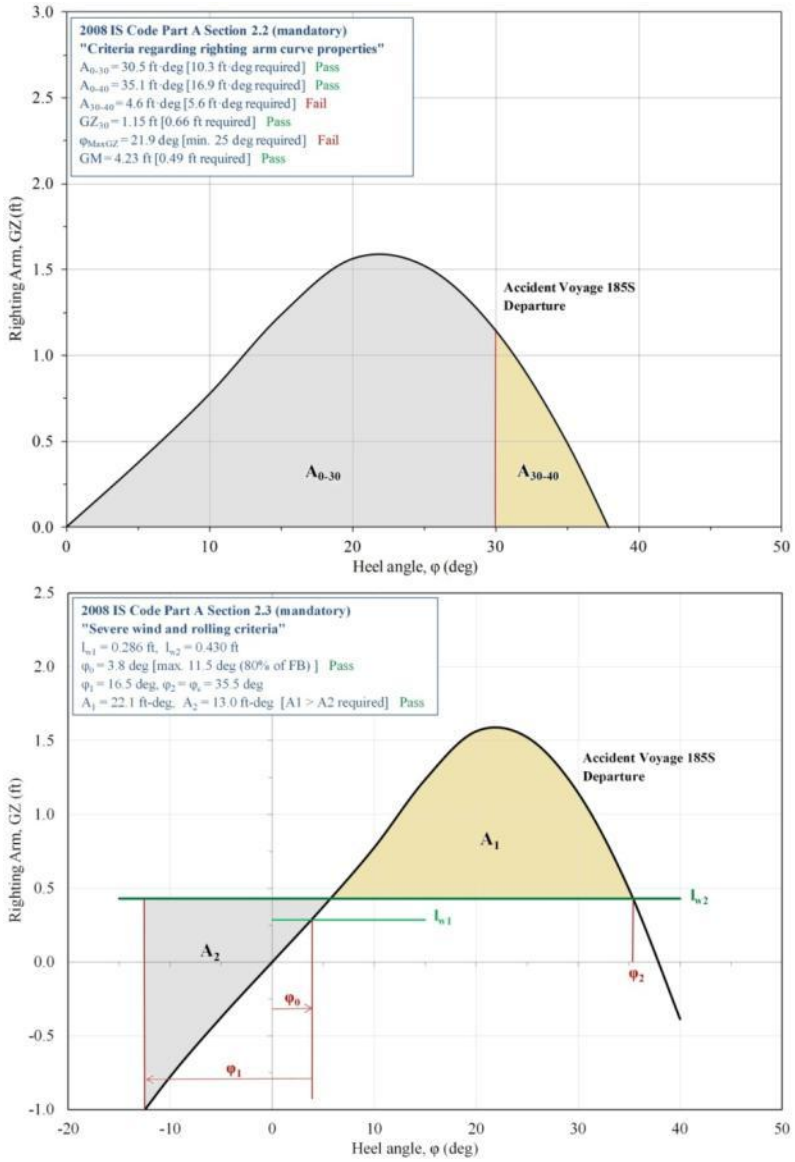


**Figure 22. Application of 2008 IS Code righting arm criteria to the accident voyage departure loading condition. (Source: Figure 5-8 of the MSC report)**

[86] MSC Report.
[87] MBI Exhibit 008.

7.2.5.3. Onboard Software for Vessel Loading, Stability, Strength, and Cargo Securing

U.S. flagged vessels require a stability booklet (also referred to as a trim and stability booklet, or T&S booklet) in accordance with 46 CFR Subchapter S and the 2008 IS Code,[88] as applicable. In either case, the stability booklet must contain sufficient information to enable the master to operate the vessel in compliance with the applicable intact and damage stability requirements. For EL FARO, the most recent T&S Booklet, Rev E dated February 14, 2007,[89] was approved by ABS, on behalf of the Coast Guard.[90]

Onboard stability software, also referred to as a "stability instrument," was used on EL FARO. The software was used to calculate the loading condition and stability of the vessel to ensure that stability requirements specified for the ship in the stability booklet were met in an operational loading condition. Under both 46 CFR Subchapter S and the 2008 IS Code, stability software may be used only as a supplement (or adjunct) to the stability booklet. The stability and loading software CargoMax was approved by ABS, on behalf of the Coast Guard, for use on EL FARO.[91]

Recent amendments to several IMO instruments applicable to oil, chemical, and gas carriers make the use of approved stability software mandatory onboard those types of ships, when constructed after July 1, 2016. Flag Administrations (the Coast Guard for U.S. vessels), are required to approve such software.[92] There is no requirement for the use of stability software by other types of vessels; however, if vessels subject to the 2008 IS Code use stability software as a supplement to the stability booklet, then the software would be subject to the approval of the Administration.[93] Specific technical guidelines for review and approval of stability software are provided in IMO MSC.1/Circ.1229,[94] and in classification society rules, which are based on IACS Unified Requirement L5.[95]

A loading manual is a document containing sufficient information to enable the master of a vessel to arrange for the loading and ballasting of the vessel in a manner that avoids the creation of any unacceptable stresses to the vessel's structure.[96] Loading manuals are a requirement of vessel classification and became a requirement for all classed sea-going ships of 65-meters in length and above contracted for construction on or after July 1, 1998.[97] Since EL FARO was

[88] Annex 2 of Resolution MSC.267(85) (MSC 85/26/Add.1), "Adoption of the International Code on Intact Stability, 2008 (2008 IS Code)", Adopted December 4, 2008, International Maritime Organization (IMO).
[89] MBI Exhibit 008.
[90] MBI Exhibit 253.
[91] MBI Exhibit 254.
[92] IMO MSC.370(93), Amendments to the International Code for the Construction and Equipment of Ships Carrying Liquefied Gasses in Bulk (IGC Code), adopted May 22, 2014.
[93] Annex 2 of Resolution MSC.267(85) (MSC 85/26/Add.1), "Adoption of the International Code on Intact Stability, 2008 (2008 IS Code)", Adopted December 4, 2008, International Maritime Organization (IMO), at paragraph 2.1.6.
[94] IMO MSC.1/Circ.1229, Guidelines for Approval of Stability Instruments, adopted January 11, 2007.
[95] International Association of Class Societies (IACS) Unified Requirement L5: Onboard Computers for Stability Calculations, Corr. 1, dated 2006.
[96] ABS Rules for Building and Classing Steel Vessels (2013), American Bureau of Shipping.
[97] IACS Unified Requirement (UR) S, Requirements Concerning Strength of Ships, International Association of Classification Societies, 2016.

constructed in 1974-1975, there was no requirement for a loading manual and no loading manual existed for the vessel.[98]

A "loading instrument" is computer software which can be used to ascertain that still-water bending moments, shear forces and, where applicable, still-water torsional moments and lateral loads at specified points along the length of the vessel will not exceed the specified values in any load or ballast condition.[99] In addition to an approved loading manual, an approved loading instrument is required for classed "Category I" ships of 100-meters in length and above.[100] While not required by classification, the CargoMax software for EL FARO contained features for loading and hull strength for the associated bending moments and shear forces.[101] However, since there was no requirement for EL FARO to have a loading manual, and no loading manual existed, the loading and hull strength assessment features in CargoMax for EL FARO were not specifically reviewed and approved by ABS.[102]

Under Chapter VI of SOLAS and Coast Guard Navigation and Vessel Inspection Circular (NVIC) 10-97,[103] effective December 31, 1997, all U.S. flagged cargo vessels of 500 gross tons or more engaged in international trade, except those engaged solely in the transport of bulk solid or liquid cargoes, which are equipped with cargo securing systems or individual securing arrangements, must have onboard a Cargo Securing Manual (CSM) that has been approved by the vessel's flag state administration. The Coast Guard has delegated this approval authority to ACSs including ABS, and the National Cargo Bureau (NCB).[104]

EL FARO had an ABS-approved CSM.[105] Specific minimum requirements and guidelines for preparation of CSMs are provided in the IMO Code of Safe Practice for Cargo Stowage and Securing (CSS Code), as amended,[106] and specific approval procedures for U.S. flagged vessels are provided in NVIC 10-97. In addition to the minimum requirements and guidelines provided in the CSS Code, class societies may issue class-specific guidance and requirements for container loading and securing. For example, ABS issued voluntary certification requirements for classed vessels seeking special notation in the ABS Guide for Certification of Container Securing Systems.[107] [108] This guide, originally written in 1988 and updated in 2010, includes detailed requirements for container securing systems, loading and lashing calculation procedures, and effective April 1, 2014, includes specific requirements for ABS "certification" of onboard computer software for container loading and lashing calculations for vessels desiring the special

[98] MBI Transcript May 20, 2016, p. 156.
[99] ABS Rules for Building and Classing Steel Vessels (2013), American Bureau of Shipping.
[100] IACS Unified Requirement (UR) S, Requirements Concerning Strength of Ships, International Association of Classification Societies, 2016.
[101] MBI Exhibit 261.
[102] MBI Transcript May 20, 2016, p.116.
[103] NVIC 10-97, Guidelines for Cargo Securing Manual Approval, dated November 7, 1997.
[104] *Id*.
[105] MBI Exhibit 040.
[106] Resolution A.714(17), Code for Safe Practice for Cargo Stowage and Securing (CSS Code), Adopted November 6, 1991 (IMO).
[107] MBI Exhibit 173.
[108] MBI Exhibit 175.

class notation. See the Nautical Operations section of this report for additional discussion about cargo loading and securing requirements and practices.

Other than class-specific guides that provide for some voluntary review and "certification" of onboard computers for container loading and lashing calculations for vessels desiring the special class notation, there is no U.S. or international requirement for review, verification, validation, or approval of computer software for cargo loading and lashing calculations. Nor has the Coast Guard published policy or guidance on the subject. It was noted during MBI testimony that the CargoMax software used onboard EL FARO had not been reviewed and approved by ABS or the Coast Guard for loading and container securing calculations,[109] yet the crew and shore side operations personnel relied on the CargoMax software to complete those calculations.[110] [111] [112] [113] [114]

7.2.5.4. Structures

EL FARO's primary ship structures met all applicable regulatory and classification society (ABS) structural requirements.[115]

7.2.6. Engineering

Details of the complete EL FARO engineering system can be found in the NTSB Engineering Factual Report DCA16MM001, which is at the NTSB Docket.[116] Relevant components of EL FARO engineering systems related to the accident voyage are discussed in this section.

The MBI examined EL FARO's sister vessel EL YUNQUE to provide familiarization with the general layout of EL FARO's engine room. EL YUNQUE was a PONCE class vessel similar to EL FARO in design, although EL YUNQUE's hull did not undergo a major modification to add a ninety foot mid-body section as EL FARO did. EL YUNQUE was operated in the same service and on the same run from Jacksonville to San Juan. Examination of EL YUNQUE provided insight into the condition and operation of EL FARO engineering systems. EL YUNQUE was enrolled in the ACP and was surveyed and examined by the same ABS surveyors and Coast Guard Marine Inspectors as EL FARO.

7.2.6.1. Boiler System and Associated Components

The MBI found no indication that a failure of EL FARO's boiler system or its related components contributed to the loss of propulsion on the accident voyage. There was, however, MBI testimony about repairs done to EL FARO's boiler system components such as drain lines

[109] MBI Transcript May 23, 2016, p. 149.
[110] MBI Transcript February 18, 2016, p. 10.
[111] MBI Transcript February 20, 2016, p. 115.
[112] MBI Transcript February 24, 2016, p. 137.
[113] MBI Transcript February 25, 2016, p. 8.
[114] MBI Transcript May 16, 2016, p. 61.
[115] MSC Report.
[116] *https://dms.ntsb.gov/pubdms/search/hitlist.cfm?docketID=58116.*

in the superheated steam piping and boiler economizer tubes. These late August 2015 repairs to the economizer tubes were conducted by a certified welder from Jacksonville Machine Repair and the post repair pressure test was witnessed by an ABS surveyor to verify the integrity of the repairs. The surveyor required a test pressure below the operating pressure of the boiler piping, which while authorized under ABS Rules for Surveys of Vessels, is below the pressure that would be required by Coast Guard regulations for repairs to boiler piping, which is a minimum of 1.25[117] times the maximum allowable operating pressure. ABS rules do not require any pressure during a test; it is at the discretion of the Surveyor. The ABS Surveyor testified:

> *So based on no specific requirements in the rules for the hydro it's my opinion that it would be unsafe to test it above the operating. Keep in mind that new equipment that hasn't been in service for over 40 years, a test pressure in excess of operating would be satisfactory. But for a vessel that's been operating – for a boiler that's been operating over 40 years, in my opinion it could lead to an unsafe situation.*[118]

Additional repairs made to an EL FARO superheated steam piping drain line on August 24, 2015 were not reported to ABS or the Coast Guard. There was also MBI testimony and email traffic from crew members and a third-party vendor that identified boiler repair items to be completed at EL FARO's shipyard period scheduled for late 2015.

Automated Identification System (AIS), VDR audio transcript, and VDR parametric data[119] indicate EL FARO was steaming, as ordered by the Master, at maximum sea speed for the majority of the accident voyage. EL FARO maintained an average speed of more than 20 knots until approximately 1:30 AM on the morning of the accident. EL FARO steamed at nearly maximum available rpm from departure in Jacksonville until the main propulsion system shutdown approximately one hour and thirty minutes before the VDR audio stopped recording. There is no indication from the VDR audio transcript that a reduction in speed was ordered by the bridge at any time. The only time that the ship's speed was intentionally reduced was to accomplish the routine engineering procedure of "blowing tubes."

The 2A/E was responsible for blowing the tubes during underway watches which were daily from 4:00 to 8:00 AM and PM. To blow tubes, steam from the boiler is routed to soot blowers mounted on the boilers in order to blow accumulated soot off the boiler tubes. This is necessary to maintain the boilers' heat transfer efficiency and reduce the potential for a soot fire within the boiler. Soot blowers utilize steam; therefore there is less steam available for main propulsion during the procedure which results in a reduction of shaft RPM. This operation results in a reduction of speed of about 2 to 3 knots for a short period of time.

[117] 46 CFR § T 61.15-5.
[118] MBI Transcript May 19, 2016, p. 130.
[119] Parametric data is the sensor data from EL FARO's VDR. This data includes the course, speed, position and other information that was contained in EL FARO's VDR capsule.

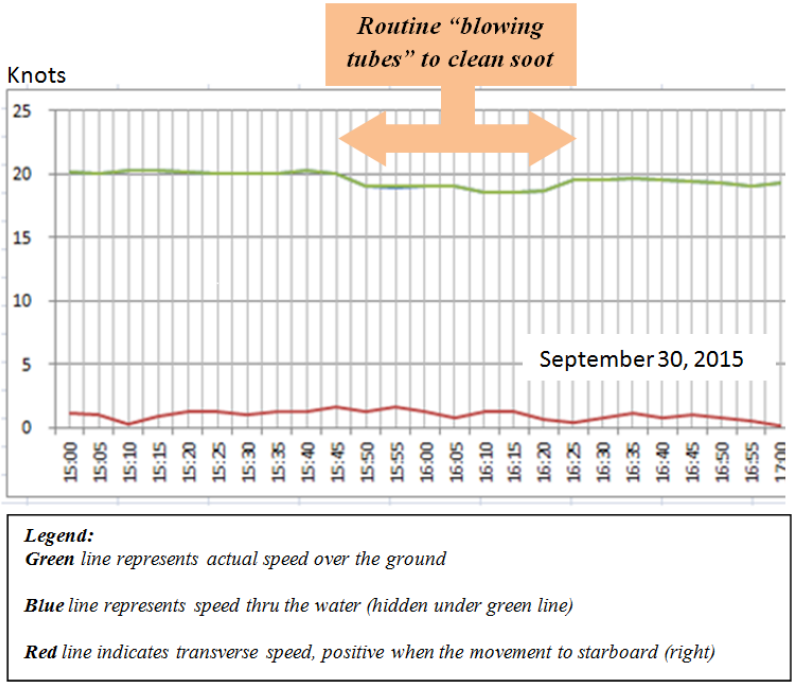


**Figure 23. Speed graph from EL FARO showing the typical reduction in speed that resulted from "blowing tubes."**

On the morning of the accident at 3:46 AM, the 2/M made the following remark to the C/M while discussing shaft speed reductions:

*Bout max they can give us with the Second Assistant Engineer blowin soot right now*.

At 4:16 AM the Master called the engine room and at the end of the conversation the Master remarked to the bridge:

*Blowin tubes.*

The typical operation for blowing tubes on EL FARO appeared to last approximately 30 minutes. At 4:33 AM there is a conversation between C/M and Master related to the RPMs, the C/M made the following comment:

*This (the RPMs) might be as high as it's gunna go.*

The Master responded:

*Yeah. That might possibly be it.*

The VDR audio contains the first reference relating to engineering difficulties at 4:40 AM:

*The chief engineer just called and (then/they) called back again (yeah) something about the list and oil levels * * *.*

The VDR parametric data and the VDR radar images indicate that propulsion in terms of effective force of the propeller stopped at approximately 6:00 AM. In later sections of the audio transcript the Master made comments relating to the "boiler," including the following statement to the C/M at 6:34 AM:

*(They're just uh)– they're gettin' that boiler back up. They('re) gettin' lube oil pressure up.*[120]

The MBI could not find any evidence corroborating the first part of the Master's statement, which infers that a boiler was down. Nor is there evidence to suggest that the boiler or boiler system components were compromised or failed. The comment from the master that the boiler will be coming back online is not supported by any other evidence or engineering conversations throughout the VDR. However, there is evidence corroborating problems created by the list of the ship and the associated problems with the lube oil system due that list. In a 7:07 AM satellite phone conversation with the TOTE DPA, the Master stated:

*The engineers cannot get lube oil pressure on the plant therefore we've got no main engine.*

The Master did not mention a boiler failure while briefing the situation to TOTE's answering service and the TOTE DPA.

7.2.6.2. Bilge and Ballast System

EL FARO's bilge system linked each cargo hold to the engine room with independent piping to facilitate the removal of water from each cargo hold. The system took suction from a "rose box" or sump, which was recessed below the plane of the bottom of the hold and covered with a perforated plate that helped to prevent clogging while dewatering the hold. These rose boxes were located approximately 8 to 10-feet inboard from both the port and starboard sides in each cargo hold. The control panel for the bilge system was located in the engine room near the control station. This system was supplied with power from the ship service switchboard and could also be supplied by the emergency switchboard. The cargo holds were fitted with bilge high level alarms, which were not required by Coast Guard regulations. The bilge level alarm sensors were located in each cargo hold just above each rose box. There was no bilge high level alarm panel on the navigation bridge of EL FARO, the engine room's watch procedure was to acknowledge the bilge high level alarm and immediately notify the bridge watch. The bilge high level alarms in the cargo holds were installed on EL FARO in 2012 prior to an extended layup period in Baltimore, MD.

The bilge high level alarms were routinely tested by ABS surveyors, Coast Guard Marine Inspectors, and vessel crew, by manually raising the bilge high level alarm float switch and

[120] MBI Exhibit 266.

waiting for acknowledgement from the engineer. The MBI heard testimony that no deficiencies were ever discovered during these tests and that the bilge high level alarm system was maintained in satisfactory condition. Additionally, prior crew and the service technician who installed the system testified that there was no easy way to disable the system and it remained on at all times while underway and in port.

At 5:43 AM the Master made the following statements while talking on the house phone:

*We (got) a prrroooblem.*

*Three hold? Ok.*

*I'll send the mate down. Yeah.*

Immediately after discussing Hold 3 on the house phone the Master directed the C/M to address flooding in Hold 3 with the following statement:

*Watch your step– go down to three hold– go down to three hold. * down there * start the pumping right now * (probably just) water * * *.*

The Master made the following comments on the VDR audio transcript starting at 5:44 AM:[121]

*We got cars loose. Yeah.*

*I'll go knock on his door. It's unsafe to go down in the cargo hold with gear adrift like that (it's just not safe/ it's a disaster) * * *. (Not gunna let them bang themselves up) * **.*

The bilge pump system provided a maximum dewatering capacity of 950 GPM at 28.5 PSI. The arrangement of the pumps and piping allowed for the pumping of more than one hold at a time.

EL FARO had fixed ballast consisting of heavy slurry in its ballast tanks. The only ballast tanks available to change heel were ramp tanks. These two small tanks were used to make minor adjustments to the list of the vessel to facilitate the angle of the loading ramp during cargo operations while in port. Shifting all of the water ballast from one ramp take to the other (e.g., starboard to port) would only make a relatively minor change of less than two degrees in the vessel's heel. The volume of each ramp tank was 150 long tons of water.

The Master first mentioned ramp tanks as a means to correct for list during the following conversation with the C/M starting at 4:12 AM on October 1, 2015:

***Master:*** *Port side yeah.*
***C/M:*** *(Yeah/wind).*
***Master:*** *The only way to do a counter on this is to fill the port side*

[121] Included in Attachment 1 to Addendum, VDR – Audio Transcript dated August 8, 2017.

*ramp tank up.*

***C/M:*** ** * * (Starboard to port) * * * (no places for any others).*

***Master:*** *Yeah.*

***C/M:*** *Heel is not bad.*

At 5:47 AM, the Master asked about the possibility of reducing the list by shifting ballast between the port and starboard ramp tanks:

*Bilge pump running water rising. Okay. Can we pump from the starboard ramp tanks to port?*

At 5:48 AM, the Master gave the following order to the C/E on the house phone:

*Hey chief– [@Master] here just want to make sure you're down– you're in the engine room * * alright. Now go ahead transfer * starboard ramp tank to port.*

The shift of ballast to the port side ramp tank was an attempt to correct the starboard list condition that the crew attributed to wind heel. The effect of the wind blowing on the exposed side of the vessel is called "induced wind heel." At 5:52 AM, the Master began to change EL FARO's heading to port in order to bring the bow across the prevailing direction of the wind and put the wind on the starboard side to shift the wind heel from starboard to port. This was done to enable the crew to access the partially flooded 2nd deck in order to secure the cargo Hold 3 scuttle on the starboard side.

At 5:56 AM, the Master reported the following via portable radio:

*Alright mate chief mate we got it listing over to port……*

When the Master induced EL FARO into a port list, the available ramp tank ballast was being pumped into the port ramp tank. The ballasted port ramp tank added to the heeling effects of the hurricane force winds acting on EL FARO's starboard side. At 5:57:33 AM, the Master told the engine room to stop transferring ballast from starboard to port and then repeated the order 16 seconds later.

At 6:03 AM, the 2/M asked the following question on the bridge regarding the main propulsion:

*Did we come down on the RPM or did they do that*?

At 6:10 AM, the following exchange between the Master and C/M occurred on portable radios:

***Master-UHF:*** *Alright. That's good. * and transfer over to the starboard ramp tank * * starboard.*

***C/M-UHF:*** ** * port to starboard ramp tank.*

At 6:12 AM, the Master made the following statement on the bridge:

*I'm not liking this list.*

Less than a minute later he made the following statement:

*I think we just lost the plant.*

The VDR radar screen images indicated that EL FARO experienced a significant reduction of forward speed at about 6:00 AM. The radar screen images provided the first indication of a total loss of propulsion.

7.2.6.3. Emergency Fire Pump System

EL FARO was equipped with a fire pump system that included an emergency fire pump. The electric emergency fire pump and its associated piping were located in the aft most area on the starboard side of cargo Hold 3. The sea chest where seawater entered the system was located below the loaded waterline in the starboard side of the hull in Hold 3. From this single suction point, the 6 – 8 inch pipe went to a skin valve[122] that could be remotely operated manually by a long reach rod, which allowed for manipulation from EL FARO's 2nd deck. There were no other remote means to close or open the valve. The emergency fire pump piping extended from the skin valve to the suction side of the pump and then discharged into the fire main system. There were vertical pipes or guards in place to prevent cargo from striking the pump, valve, and piping.

At 7:14 AM on October 1, 2015, the Master and the C/M discussed the emergency fire pump as a possible source of the rising water level in Hold 3. The C/M relayed to the Master a conversation he had with the C/E:

** (at) first the chief said something hit the fire main. Got it ruptured. Hard.*

After the Master asked if there was a way to secure the fire main the C/M responded:

*We don't know if they've (seen/still have) any pressure on the fire main or not. Don't know where s'sea- between the sea suction and the hull or what uh but anything I say is a guess.*

The Master and C/M continued discussing the emergency fire main and the fact that cars were floating in the vicinity of the piping. At 7:18 AM the C/M made the following statement when asked by the Master if he could see anything near the fire main:

*(When/I mean) I saw the water level's too high (the) fire main's right below the water dark black water.*

[122] The first valve inboard from the through hull fitting.

The Master and C/M then had a discussion that the engine room should isolate the fire main from the engine room. At 7:19 AM, the Master made the following statement to the 1 A/E on the house phone:

> *Yea can you…isolate the fire main from down in the uh engine room? The fire pump? Isolate it? 'Cause that may be the root cause of the water comin' in.*

There is no indication that EL FARO's crew was ever able to determine if the Hold 3 flooding was caused by damage to the emergency fire main.

### 7.2.7. Lube Oil System

EL FARO's lube oil system lubricated the bearings for the main propulsion high and low pressure steam turbines and the main reduction gear. The uninterrupted flow of oil to the bearings was critical to reducing friction and to cooling the bearings. Without the flow of oil the bearings would quickly fail and the ship would suffer an irreparable propulsion casualty. The loss of lube oil pressure would cause the propulsion main turbine to automatically shut down through the loss of pressure that was required to hold the main steam throttle valve open.

A detailed explanation of EL FARO's Lube Oil System is included in the Coast Guard's MSC LUBE OIL MODELING AND ANALYSES OF THE S.S. EL FARO.[123]

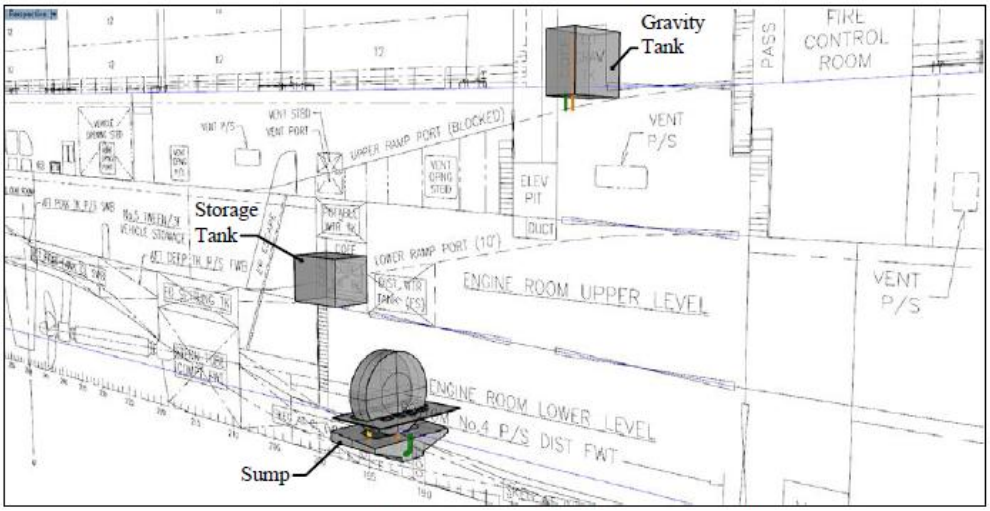


**Figure 24. Inboard profile taken from a general arrangement drawing for EL FARO (MBI Exhibit 007).[124]**

[123] MBI Exhibit 412.

[124] The MSC concluded that the drawing contains vertical scaling errors (see Section 2.2 of MSC Technical Report "SS EL FARO Stability and Structures" dated March 22, 2017. Accordingly, while useful for visualization purposes, this drawing was not used for the lube oil modeling and analysis work. This figure shows the modeled components in their correct locations relative to the vessel's baseline as depicted in the drawing.

7.2.7.1. Lube Oil System Design

At the time of EL FARO's construction, the 1973 ABS Rules for Building and Classing Steel Vessels were applicable. Those rules[125] required lubricating-oil systems "to be so arranged that they will function satisfactorily when the vessel is permanently inclined to an angle of 15 degrees athwartship and 5 degrees fore and aft."

EL FARO's original pre-build lubricating oil system sump, illustrated in Sun Drawing Number 663-904-100,[126] was altered during construction of the vessel. The sump level was changed to a High Level Capacity of 2,020 gallons, the Operating Level Capacity was changed from 900 to 1,426 gallons and the Low Level Capacity was changed from 750 to724 gallons. This mid-build change also lowered the overall Sump Design Capacity from 4,250 to 2,870 gallons. The drawing indicates these alterations received approval from the Coast Guard on October 19, 1972, then approval by ABS on October 24, 1972. The modifications applied to Sun Shipbuilding Hulls 662-664, but were extended to include EL FARO, Hull 670.

The lube oil sump levels corresponded to soundings[127] of 33" (High Level Capacity), 27" (Operating Level Capacity), 18" (Low Level Capacity), and 40" (Sump Design Capacity). The operating range for the lube oil sump was 18" to 33".[128] The lubricating oil system had 8" steel suction piping, which took suction from the lube oil sump though an 8" pipe with a flared end called a "bellmouth." The bellmouth faced down and took suction 10" above the bottom of the lube oil sump. The center of the bellmouth was approximately 22" to starboard of centerline, and approximately 24" from the after bulkhead of the lube oil sump. Both lube oil service pumps took suction through this bellmouth.

Sun Drawing Number 663-904-100 alteration five, item one, indicates there was a five and eight inch connection added for a future emergency Lube Oil pump. However, the MBI found no indication that EL FARO was equipped with an emergency lube oil pump.

ABS and the Coast Guard approved Sun Drawing Number 663-904-100. In the PII's Joint Response to MSC's Technical Reports,[129] ABS stated that the lube oil system was compliant with the 1973 Steel Vessel Rules, and that due to the location of the lube oil sump suction, the worst case scenario for maintaining suction to the bellmouth was a port list with forward trim. The ABS review examined the maximum angle of inclination requirement at the sump's normal (nominal) fill level, of 27" Operating Level Capacity, as indicated on the drawing. ABS stated that the Steel Vessel Rules do not require the lube oil system to function with both the worst case angle of inclination of 15 degrees athwartship and 5 degrees fore and aft and the sump oil level at the Low Level Capacity. ABS stated that the Steel Vessel Rules do not require the application of "additive faults."

[125] MBI Exhibit 276.
[126] MBI Exhibit 352.
[127] Physical measurements of the level of liquid in a tank measured in inches.
[128] MBI Exhibit 350.
[129] MBI Exhibit 418.

The Coast Guard MSC Lube Oil Modeling and Analysis[130] demonstrated that the 18" Low Level Capacity shown on the drawing, when combined with a 15 degree port list, would result in the main lube oil sump suction bellmouth coming out of the oil. It also demonstrated that lube oil pocketing would occur in the lube oil gravity tank based on a port list condition, due to a 33" offset of the supply and overflow piping to starboard inside the lube oil gravity tank.

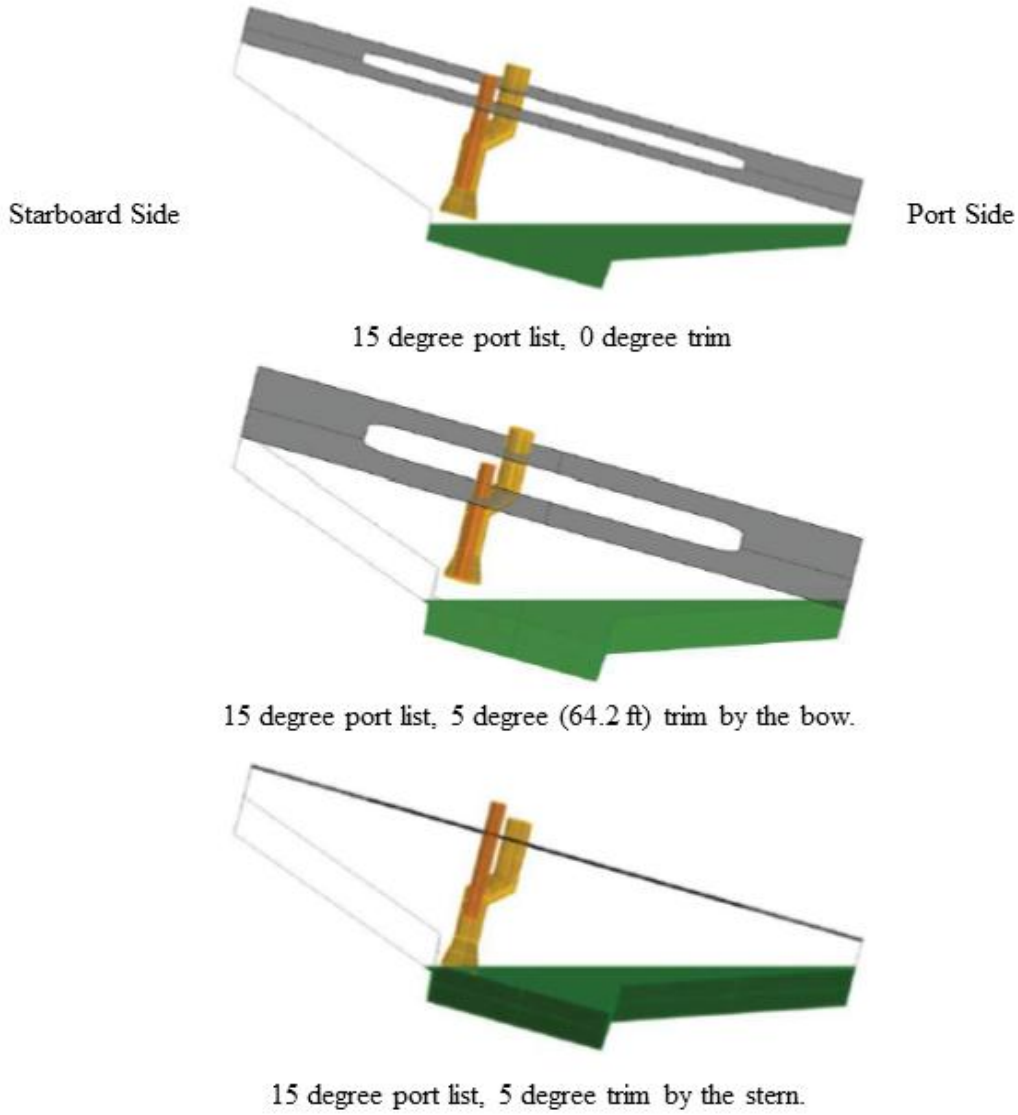


**Figure 25. End views of the lube oil sump for the design low level capacity at 15 degree port list and differing trims.**

[130] MBI Exhibit 412.

7.2.7.2. Lube Oil Volumes

A former EL FARO C/E testified at the MBI that during his tenure with Sea Star Lines (1998-2013), standard operating procedures were to operate with a lubricating oil sump level between 28 to 32 inches.[131] He testified that he normally kept the sump level higher to prevent the loss of lube oil suction. He further testified that during his time on EL FARO, the level was sometimes increased, at the direction of a C/E, to a higher level of 30"-32" for voyages where heavy weather was anticipated. The former C/E recalled needing to add an inch or two of oil to the sump once a quarter to compensate for normal oil consumption.

EL YUNQUE's Machine Operating Manual[132] states, "[w]hen necessary, add lube oil from the storage/settling tank to the sump, via purifier, to maintain the normal level at 27 inches. Record the amount added in the logbook." EL YUNQUE's Machine Operating Manual was used as a reference by the MBI because EL FARO's manual was not available and likely lost at sea. Between April 25, 2015, and September 1, 2015, the lube oil sump level on EL FARO gradually declined to a level of about 25". [133] There was a loss of lube oil[134] from the sump on July 20, 2015, due to an unknown cause, which resulted in the sounding dropping from 25" to 22". The sump was filled via the lube oil purifier on July 21, 2015; 289 gallons were added to bring the sounding back to 25".

At the time of EL FARO's departure on the accident voyage, the lube oil sump level was recorded in CargoMax[135] as 4.2 LT, 33.8%, or 163.8 $FT^3$. The CargoMax[136] departure condition indicated 1,225 gallons in the lube oil sump, which equated to a sounding of 24.6".

7.2.7.3. Lube Oil Pumps

EL FARO's lube oil service system was equipped with two positive displacement screw-type lube oil service pumps. The lube oil service pumps drew oil from the main reduction gear sump to provide the system with the appropriate supply pressure needed to lubricate the main propulsion turbine and reduction gear bearings. The lube oil service pumps had mechanical type seals. The forward main lube oil service pump was to have its mechanical seal replaced during a scheduled shipyard period[137] in October 2015. The aft main lube oil service pump was scheduled to be rebuilt or replaced because the pressure was running at 3 PSI[138] lower than the forward pump. A former EL FARO C/E[139] provided the following MBI testimony:

> *If a seal fails, you will usually get oil out the top of the pump on these particular pumps, and it would start collecting. Also you would start losing efficiency of that pump."*

[131] MBI Transcript February 08, 2017, pp. 45, 61-64.
[132] MBI Exhibit 384.
[133] MBI Exhibit 341.
[134] MBI Exhibit 387.
[135] MBI Exhibit 059.
[136] MBI Exhibit 323.
[137] MBI Exhibit 414.
[138] psi = pounds per square inch (a unit of pressure)
[139] MBI Transcript February 08, 2017, p. 47.

The TOTE Director of Safety and Marine Operations,[140] a former P/E, provided the following testimony:

> *If you lose oil on your seals, you're going to lose that— you're more likely to start pulling air in through your seals, also.*

He also stated that a pump could pull enough air in through the lost seal to cause the pump to lose prime completely.

7.2.7.4. Lube Oil Loss of Suction and Related Issues on the Accident Voyage

The following bridge conversations related to EL FARO's main propulsion unit are from the VDR audio transcript on the morning of October 1, 2015.[141]

At 4:39 AM, the C/E called the bridge and informed the C/M that the sumps were acting up due to the starboard list condition of EL FARO. Shortly after, the Master and the C/E spoke on the house phone and the C/E requested the bridge take action to remove the list.

One minute later the C/M called the Master and stated:

> *The C/E just called and (then/they) called back again (yeah) something about the list and oil levels * * *. Can't even see the (level/bubble).*

At 4:43 AM, the C/M directed the AB on the helm to put the ship in hand steering.

At 4:44 AM, the Master stated the following to an unidentified crew member on the house phone:

> *Alright. Shut her down.*

Shortly thereafter, the Master stated the following to the C/M on the bridge:

> *Just the list. The sumps are actin' up *. To be expected.*

A former EL FARO C/E testified:

> *There was the lube oil discharge low pressure alarm, and there's a low level alarm in the gravity tank and the main sump. There would also be alarms on the main unit themselves, the turbine bearings themselves if there was an issue there. Plus temperature alarms in case the temperature started getting too high, you would have a high temperature alarm.*[142]

[140] MBI Transcript February 13, 2017, p. 35.
[141] MBI Exhibit 266.
[142] MBI Transcript February 08, 2017, p. 477.

At 5:11 AM, the Master had a discussion with the Riding Crew Supervisor regarding the list and its impacts on lube oil system. The Riding Crew Supervisor stated that the vessel list could result in "the low pressure alarm on the lube oil."

At 5:14 AM, the Master directed the AB on helm watch to steer a course of 050 degrees.

At 5:15 AM, the Master continued his discussion with the Riding Crew Supervisor, and mentioned his earlier conversation with the C/E, stating "he's got a problem, like you said, a low level."

At 5:18 AM, the C/M mentions "(eighteen) degree list on."[143]

The Coast Guard MSC Lube Oil Modeling and Analyses of EL FARO[144] demonstrated that the lube oil system suction pipe bell mouth opening in the lube oil sump tank, using the 24.6" departure sounding obtained from the CargoMax entry, would have broken above the lube oil surface, resulting in a potential loss of suction at an 18° static list to port (see figures 9 and 10 below).

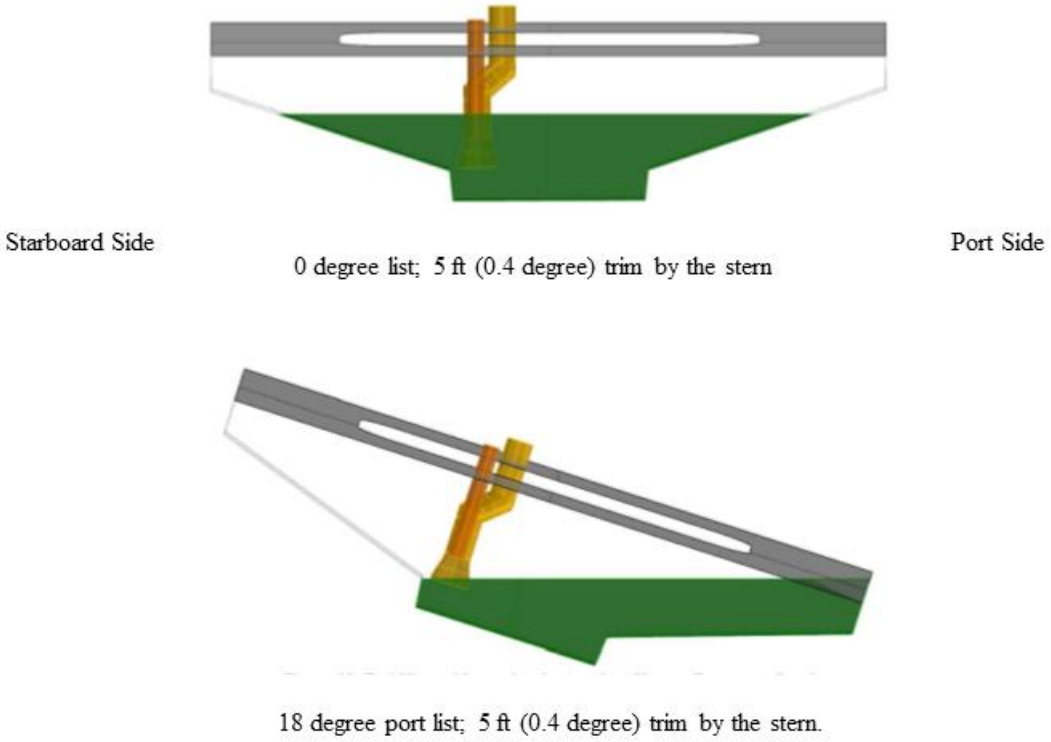


**Figure 26. End views of sump for the accident voyage departure loading condition at 0 degree and 18 degree port list.**

[143] From the NTSB VDR Audio Transcript forward, "( ) = Questionable insertion – the group either could not agree or was uncertain of a spoken word or phrase."
[144] MBI Exhibit 412.

At 5:47 AM, the Master was talking on the house phone and he made the following statement "Bilge pump running water rising. Okay. Can we pump from the starboard ramp tanks to port?" This would be an attempt to shift the limited amount of ballast from the starboard side ballast tank to the port side ballast tank in an attempt to overcome the list.

At 5:52 AM, the Master decided to turn the ship to port to get the wind on the starboard side, to induce a port list and enable the crew to access the partially flooded 2nd deck in order to secure the cargo Hold 3 scuttle on the starboard side.

At 5:57 AM, the Master told the engine room on the house phone, "[a]lright we got a nice port list can you stop transferring? From starboard to port segregated ballast (from/the) ramp tanks."

At 6:03 AM, the 2/M noted a loss of RPMs.

At 6:13 AM, the Master stated, "I think we just lost the plant."

At 6:57 AM, the Master mentioned to the 2/M that the engineers were having trouble getting the engines back online "because of the list."

At 7:07 AM, the Master spoke to the DPA and stated, "[w]e have a very– very– healthy port list. The engineers cannot get lube oil pressure on the plant therefore we've got no main engine." During the course of the conversation with the DPA the Master estimated the list at 15 degrees.

At 7:10 AM, the 2/M answered a house phone call from the C/E while the Master was talking with the DPA on the satellite phone. When the Master finished the call with the DPA, the 2/M relayed that the C/E said he could not regain propulsion due to the current listing condition.

At 7:17 AM, the C/E and the Master agreed that the list was getting worse.

The VDR transcript indicated a static list of 15 to possibly 18 degrees. The list described by various crew members is relatively permanent based on wind heel and free surface effect of water in Hold 3. There was additional motion of the ship caused by sea swell and lateral resistance to the waves, which combined to increase the angle of the ship in relation to an even keel.

7.2.8. EL FARO Compliance History

EL FARO was enrolled in the Coast Guard's ACP on February 27, 2006, with ABS as the ACS.

The complete record of the Coast Guard EL FARO MISLE inspection history, beginning in 2005, is included in Coast Guard MBI Exhibit 127. The following is a listing of pertinent items from EL FARO's compliance history:

Coast Guard Marine Inspectors from Sector San Juan conducted the last ACP Annual Oversight examination of EL FARO on March 6, 2015. The Coast Guard Marine Inspectors endorsed the COI as well as the International Ship Security Certificate after finding one deficiency that was converted to an ABS Condition of Class and later cleared by ABS.

On March 14, 2015, EL FARO reported a loss of propulsion to Coast Guard Sector San Juan. The incident occurred immediately following the San Juan pilot disembarking the vessel, which was outbound en route for Jacksonville, Florida. An investigation determined that an Oiler[145] mistakenly closed the lube oil outlet valve instead of the salt water cooling valve. The error caused the flow of lube oil to the main turbine and gravity tank to stop. EL FARO's crew responded by securing the main turbine and locking the shaft to prevent bearing damage.

On May 9, 2014, an ABS Surveyor attended EL FARO in Jacksonville, Florida to survey modifications carried out in way of Holds 1 and 2 inner bottom tank tops between frames 64 and 127. The modifications were made to accommodate the installation of six, 53-foot, 18,000 gallon horizontal fructose shipping container tanks, including associated piping and support structures.

On September 8, 2015, an ABS Surveyor attended EL FARO in Jacksonville, Florida for the purpose of verifying repairs made to the port boiler economizer tubes after the vessel experienced leaks in seven tubes. The surveyor determined the repairs were satisfactory after examining them and pressure testing them to 800 PSI. No other findings were noted and the vessel was cleared to sail.

During MBI testimony the ABS surveyor who conducted the repair survey on the EL FARO's port boiler economizer stated that she had not previously conducted any new construction or in service boiler tests. When asked what qualifications ABS required to conduct a boiler repair survey, the surveyor stated that ABS required that a surveyor complete two "repair tasks." The surveyor provided the following clarification regarding what constituted a repair task:

> *So the task is just repair. Repair surveys from piping to machinery to structure it's the same survey task.*

EL FARO was scheduled to be added to the 2016 ACP Targeted Vessel List. This is a Coast Guard list of approximately 10% of vessels enrolled in the ACP that show the most potential for being at risk of marine casualties due to factors such as age, ship type, and marine casualty history. The 2016 ACP Targeted Vessel List was intended to cover fiscal year 2016, but it was still undergoing internal routing at Coast Guard Headquarters when EL FARO sank on October 1, 2015. Vessels on the targeted list are subject to additional oversight at the 6-month mark of the ACP examination cycle. The scope of examination can be increased if Coast Guard inspectors find safety issues on board targeted vessels. In addition, both the Coast Guard and the classification society are required to attend drydock examinations for targeted vessels. The

[145] Junior level engine room watch stander.

classification society can conduct the required 3-year drydock examinations on behalf of the Coast Guard if a vessel is not on the targeted list.

The MBI noted that the majority of EL FARO's inspections, surveys, and examinations were conducted by either ABS Surveyors or Coast Marine Inspectors; they were rarely conducted by both ABS and the Coast Guard at the same time. The Chief of the Coast Guard's Office of Commercial Vessel Compliance testified during the MBI that ACP policy did not require a minimum level of Coast Guard oversight exams to be conducted in conjunction with an ACS inspection.

When asked by the MBI if the Coast Guard and ABS attended EL FARO together for field inspections, the Assistant Chief Surveyor of the Americas Division stated that he was aware of several instances where the compliance inspections were done separately.

When asked if it was valuable for the Coast Guard and ABS to align their inspections and Coast Guard oversight examinations during MBI testimony, the ABS Assistant Chief Surveyor of the Americas Division answered:

> *Yes for training I think it can help both sides and also for two sets of eyes is always better than one.*

7.2.9. EL YUNQUE Compliance History

EL YUNQUE was enrolled in the Coast Guard's ACP on May 4, 1999, with ABS serving as the ACS. EL YUNQUE was identified in the Coast Guard ACP Risk Assessment and Targeting Message for Fiscal Years 2014, 2015, and 2016, due to multiple reportable marine casualties. EL YUNQUE was considered a similar vessel to EL FARO, as it was configured to carry the same cargo and operated by the same company to conduct Puerto Rico trade.

A detailed compliance history for EL YUNQUE can be found in MBI Exhibits 363 and 369. The following is a listing of pertinent events from EL YUNQUE's compliance history:

On March 17 and 18, 2014, Coast Guard Sector Miami Marine Inspectors attended EL YUNQUE in dry dock at the Grand Bahamas Shipyard in Freeport Bahamas. They witnessed water tight door testing with high pressure water on cargo doors number 4, 5, 6, and 7 that separated the cargo holds on the vessel's 3rd deck. All of the cargo doors failed initial testing due to severe leakage at the top of the doors and around the dogs.

On December 15, 2015, the Coast Guard conducted an ACP oversight exam on EL YUNQUE. The oversight exam was conducted on a six-month cycle because EL YUNQUE was on the Coast Guard ACP Targeted Vessel List. During the exam the Coast Guard identified several missing or severely corroded piping areas throughout the lower cargo deck's sprinkler system, and several missing or damaged piping, horns, and nozzles on the CO2 fixed firefighting system serving RO/RO cargo spaces. The Coast Guard issued a no-sail order as a result of the firefighting deficiencies and requested that ABS issue conditions of class for nine other unrelated discrepancies.

On December 16, 2015, ABS cleared the no-sail order after witnessing repairs to the fixed firefighting systems. The surveyor also issued a condition of class to allow additional repairs to be completed on an extended timetable.

On December 22, 2015, Coast Guard Sector Jacksonville Marine Inspectors attended EL YUNQUE and noted the following sprinkler system discrepancies: three pin hole leaks in main line, several sections of cargo deck were dry after an operational test of the system, numerous sprinkler heads were clogged or not spraying correctly, and two sprinkler branches were completely fractured. Coast Guard Marine Inspectors subsequently witnessed failing sprinkler tests on EL YUNQUE on December 24, 2015; January 4, 2016; January 12, 2016; and January 18, 2016. On January 26, 2016, the Coast Guard determined that the sprinkler system was sufficiently repaired; however, the attending Sector Jacksonville Marine Inspector issued EL YUNQUE the following vessel inspection requirement (CG-835) due to the ongoing maintenance concerns on the vessel:

> *Several break downs have been observed with fundamental systems that enhance shipboard safety on board the vessel to include damaged and unrepaired CO2 fire fighting system in cargo spaces, clogged and completely wasted second deck sprinkler system piping, major rudder post seal leaks, and inoperative steering room ventilation. These shortfalls are an indication that a properly implemented preventative and corrective maintenance system, to include adequate documentation, does not exist on board the vessel. An internal SMS audit was performed on board the vessel on December 22, 2015 which did not properly address the lack of effective and systematic implementation of the vessel's SMS in this regard. Therefore, it is recommended that the Recognized Organization conduct an external audit to rectify deficits in the suitability to achieve the objectives of the company's SMS.*

On February, 1, 2016, three Coast Guard Traveling Inspectors attended EL YUNQUE as part of an ISM DOC Annual Audit of TOTE, which took place in Jacksonville, Florida. ABS led the DOC audit and provided three auditors, including the District Principal Surveyor. A Sector Jacksonville Coast Guard Marine Inspector also attended the audit as an observer. The Coast Guard does not normally participate in DOC audits; however, the Coast Guard Traveling Inspectors requested to be added to the team for TOTE's audit due to the previously identified maintenance concerns and the sinking of EL FARO four months earlier.

Part of the DOC audit included a general walk-through of EL YUNQUE, and the Traveling Inspectors requested that TOTE open up a starboard exhaust ventilation trunk serving cargo Hold 3 for inspection. The Traveling Inspectors noted severe corrosion within the ventilation trunk and they subsequently conducted testing of the soundness of the internal structure of the trunk. This test, which was performed in a typical manner using a hammer, resulted in a hole through baffle plating that was required to be watertight (see Figure 27). As the Traveling Inspectors were discussing expansion of their inspection to additional ventilation trunks, the senior Traveling Inspector received a cell phone call from the Sector Jacksonville Commanding Officer. The Sector Commander, as the OCMI for the Port of Jacksonville, ordered the Traveling Inspectors to stop further inspection and hammer testing of EL YUNQUE's ventilation

trunks because it exceeded the scope of the DOC audit; the Traveling Inspectors complied with that order. However, the Senior Traveling Inspector suspected that the potential for long-standing corrosion existed for the other ventilation trunks and voiced a concern that the wastage could present a down flooding risk if the vessel experienced severe rolls. As a result, the Traveling Inspectors requested that Sector Jacksonville conduct a follow-up inspection to check additional trunks for conditions similar to that of Hold 3's starboard exhaust vent trunk.

**Figure 27. Examples of wastage found within an EL YUNQUE ventilation trunk that were found by Coast Guard Traveling Marine Inspectors during a February 1, 2016, DOC audit of TOTE.**

Under ACP protocols, Sector Jacksonville's Marine Inspector conferred with ABS and requested they oversee repairs to the ventilations trunks for Hold 3, check the condition of the other ventilation trunks, and issue conditions of class as necessary. ABS concurred with the Marine Inspector's concerns and required de-scaling and temporary repairs to the ventilation trunk casings that were identified as corroded during the DOC audit. On February 2, 2016, ABS surveyed temporary repairs to the holed and wasted areas in way of the port and starboard exhaust ventilation trunks for Hold 3[146] including the following items:

- The lower 24" of the louver chamber's inboard bulkhead was cropped and renewed.
- An opening around the side shell longitudinal angle in the transverse baffle plate was closed.
- Drainage holes on both port and starboard trunks (smaller and larger) were satisfactorily closed up.

The ABS surveyor gave TOTE 30 days, until March 2, 2016, to make permanent repairs to the Hold 3 ventilation ducts and EL YUNQUE continued to operate between Jacksonville and San Juan. On February 9, 2016, ABS advised Sector Jacksonville that the temporary repairs had been completed to EL YUNQUE's port and starboard ventilation trunks that were identified as corroded on February 1, 2016. In March 2016, TOTE relocated EL YUNQUE to Seattle, Washington and started the process of converting the vessel back to its original RO/RO configuration for Alaskan service.

[146] MBI Exhibit 363, pp. 24-26, is the ABS Class Survey report for the temporary repairs to the No. 3 Cargo Hold ventilation trunks. The report erroneously describes that the repairs were done to ducts serving No. 4 Cargo Hold.

During MBI testimony on May 19, 2016, the ABS surveyor who conducted the February 2016, repair survey on EL YUNQUE stated the following when asked if problems were detected in other ventilation trunks:

> *So after this was discovered we looked at the port side as well and then we sampled other trunks to verify that they were in good condition. This one that you have pictures of is the only one that was found in this condition with regards to the corrosion*.

From March 18 to August 14, 2016, Coast Guard Sector Puget Sound Marine Inspectors made several visits to EL YUNQUE and, despite the February 2016, ABS survey and testimony from the ABS surveyor, recorded the following pertinent findings:

- April 6-12, 2016: Directed extensive third party gauging for multiple suspect locations on the main deck. Found evidence of long-standing and uncorrected wastage.
- May 20, 2016: Examined supply vents for the Holds 1-3 port and starboard (6 total). Observed gaskets missing; holes in vent ducts; gasket flanges wasted; and holes in the side shell in way of vent inlets (see figure 28). Required all items to be added to the work list.
- August 14, 2016: TOTE halted work and requested to place the vessel in a lay-up vessel to be scrapped.
- December 23, 2016: Received notification that the vessel arrived at Brownsville, TX. Changed vessel status to "scrapped" in the Coast Guard's MISLE database.

**Figure 28. Photographs taken by Coast Guard Traveling Inspectors during an October 2016 visit to EL YUNQUE in Tacoma, WA showing examples of corrosion within the vessel's exhaust ventilation trunks. (U.S. Coast Guard photographs)**

### 7.2.10. Nautical Operations

#### 7.2.10.1. Cargo Operations in Jacksonville – General Process and Responsibilities

Typical container cargo for EL FARO included 20-foot, 40-foot, and 53-foot intermodal containers. Refrigerated containers, commonly referred to as "reefer" containers or "reefers," were powered by connecting to the ship's electrical supply or separate generator packs. Typical RO/RO cargo for EL FARO included wheeled vehicles such as trailers on chassis and automobiles, as well as nonstandard rolling cargo such as boat trailers and large construction

equipment. EL FARO was also fitted with six 53-foot ISO tank containers on the lower deck in the two forward cargo holds. These "tanktainers" were used to carry a viscous liquid product called fructose from Jacksonville to San Juan, each tank had the capacity to carry 18,000 gallons.[147]

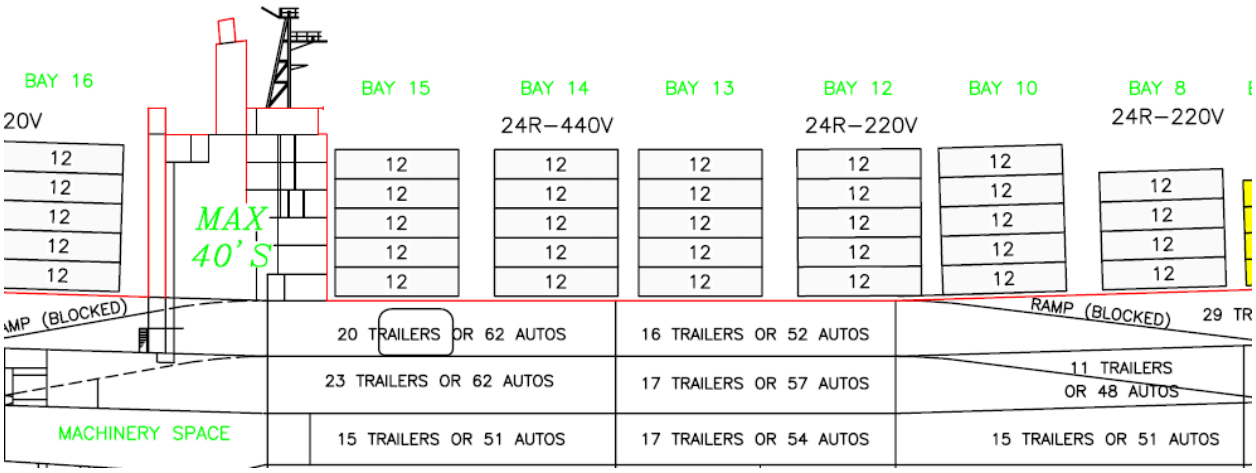


**Figure 29. Partial vessel cross-section showing vertical location of container and RO/RO cargo.**

When EL FARO arrived in Jacksonville a RO/RO ramp was attached to the side of the ship and trucks came aboard the ship to begin to hook up to and drive the cargo ashore. At the same time, gantry cranes on the pier would lower a special hoisting apparatus to latch on to the top of containers to lift them off the ship and move them to shore.

After cargo originating from San Juan was removed from the ship, the loading of cargo bound for San Juan would commence. Trailers and other vehicles were driven aboard the vessel using the ramps and would be placed into the position specified in the stow plan. Simultaneously, pier side gantry cranes would load containers onboard the ship. The process of securing the cargo is described later in this section.

As these simultaneous cargo loading operations took place, hoses would pump fructose to the tanks in the forward part of the ship.

Cargo discharging and loading operations in Jacksonville were managed by TOTE Maritime Puerto Rico (TMPR). TMPR's Marine Operations Manager was typically responsible for overseeing the proper execution of the following activities:[148]

- stowage, loading, and discharging of vessels;
- stability calculations;
- inspections of lashing gear and cargo securing fittings;
- monitoring vessel stability, stress, and trim calculations prior to, during, and at completion of cargo operations;

[147] MBI Exhibit 014.
[148] MBI Exhibit 372. Job description includes other duties and responsibilities not listed here.

- developing, maintaining, and modifying vessel stowage documents;
- coordinating vessel and terminal activities with port operations and vessel crew members to ensure vessels adhered as closely as possible to voyage schedules.

TMPR personnel worked with PORTUS Stevedoring personnel to conduct the cargo discharging and loading operations. PORTUS personnel utilized the computer program called Spinnaker to determine where each cargo unit would be placed based on volume and weight, they then created a stow plan which was updated throughout the operation.[149] TMPR used this information to manually enter weights of the cargo into the CargoMax computer program, which was used for stability calculations.[150]

The C/M on a merchant vessel is typically responsible for monitoring cargo and stability matters. The C/M on EL FARO was responsible for providing a final cargo and stability report to the Master.[151] While cargo was being discharged and loaded, the Mate on watch was responsible for supervising the lashing performed by stevedores.[152] The Mates on EL FARO stood the following watch schedule while in-port: [153]

- 2/M: 0000-0600 / 1200-1800;
- 3/M: 0600-1800 / 1800-2400;
- C/M: 0600-1800.

Port Mates (P/Ms) often provided assistance to Mates with their in-port duties, including but not limited to supervising the stevedores and ensuring that cargo was secured in accordance with the CSM. While P/Ms were provided for most port calls through August 2015, there were no P/Ms provided for EL FARO in Jacksonville after September 1, 2015. P/Ms continued to be provided in the Port of San Juan.

While standing the bridge watch on September 29, 2015, the 3/M made the following statements to his AB regarding Jacksonville cargo loading operations:[154]

> *(He) showed up after the fact. You know these you know wha– what's changed is. I mean granted obviously I missed something but man I could not (expletive) keep up I had (EL FARO General Utility, Deck, and Engineer worker) helping me. He couldn't keep up. I was helping him plug in and I didn't have time to get all the temps down and the ramp came off everything just happened in quick succession for a couple of reasons– I guess five hold didn't get finished up and until the last minute so all of the reefers that would have been already in and plugged in there weren't there they all just came on at the end. Yeah we just we had this perfect storm of shii– of (expletive) problems. We– we used to have a Port Mate and now we don't. We have a guy from PORTUS– a longshoreman– now we don't.*

[149] MBI Transcript February 20, 2016, p. 115.
[150] MBI Transcript February 20, 2016, p. 115.
[151] MBI Transcript February 20, 2016, p. 127.
[152] MBI Transcript February 19, 2016, p. 99.
[153] MBI Exhibit 283, p. 5.
[154] MBI Exhibit 266, p. 67.

*Then we lost our electrician and this guy wants to basically wash his hands of second deck and just have it all handed to him. * * (Alternate EL FARO Electrician) would always be that system of check where he would come down and make sure that every reefer was good and then he would call up— you'd hear him on the radio— "okay this— I got this many reefers and they're all good." That doesn't happen anymore.*

*Yeah he's slow so he doesn't have time to (expletive) work— well— to do anything down there so he doesn't think it's his responsibility and no one has told him otherwise. So. He'll sit up there under— sit down up there and say they're too busy to come down you know like most of the (expletive)— I go up there— I make the rounds on main deck and most of the time they ain't doin' (expletive).*

*It's (expletive) insane down there. The other thing is (Ex EL FARO 2/M) when we were northbound he would go set all the plugs up. Well that's not happening anymore either there's just (expletive) extension cords everywhere— it's a mess down there. It— it's— everything is falling apart. And yeah I'm (expletive) up, but I'm doin' the best I can and— I'm not the part of the equation that's changed. I'm doin' what I've always done, but it's just not enough anymore. ** The Mate said, "Oh well next time call for help."*

The AB standing watch with the 3/M made the following response:

*All the extra people that are supposed to be doin' it are all gone ashore.*

7.2.10.1.1. Cargo Securing, also Known as "Lashing"

The IMO issued Guidelines for the preparation of the CSM in MSC/Circ. 745 dated June 13, 1996. This Circular was subsequently superseded by MSC.1/Circ.1353, but was in effect at the time that EL FARO's CSM was approved. The Circular was included in its entirety in the 2003 Edition of the IMO Code of Safe Practice for Cargo Stowage and Securing (CSS Code).[155]

The CSM for EL FARO[156] was prepared by HEC and approved by ABS on behalf of the Coast Guard. EL FARO's CSM included the following:

- The Master shall ensure that cargo carried in the vessel is stowed and secured in a manner that takes into account the prevailing conditions and the general principles of safe stowage.
- This Cargo Securing Manual specifies the arrangements and cargo securing devices provided on board the ship for the correct application to, and the securing of, cargo units, containers, vehicles and other entities, based on transverse, longitudinal and vertical forces which may arise during adverse weather and sea conditions.
- The safe stowage and securing of cargoes depends on proper planning, execution, and supervision.

[155] MBI Exhibit 290.
[156] MBI Exhibit 040.

- Personnel planning and supervising the stowage and securing of cargo shall have a sound practical knowledge of the application and content of this Cargo Securing Manual.
- Decisions for the stowage and securing of cargo shall be based on the most severe weather conditions that may be reasonably expected by experience for the intended voyage.
- Ship-handling decisions made by the Master, especially in heavy weather conditions, shall take into account the type and stowage position of the cargo and the securing arrangements.
- Fixed cargo securing devices shall be visibly inspected routinely (at least once every other voyage) for damage such as cracking or deformation. In way of fixed cargo securing devices, the ship's structure that is visible shall be inspected at least once every six months for damage such as cracking or deformation.
- The principal means of preventing the improper stowage and securing of cargoes is through proper supervision of the loading operation and inspection of the stowage. Care shall be taken in planning and supervising the stowage and securing of cargoes in order to prevent cargo sliding, tipping, racking, collapsing, etc.
- It is important that all lashings be carefully examined and tightened at the beginning of the voyage as the vibration and working of the ship causes the cargo to settle and compress. They shall be further examined daily during the voyage and tightened as necessary.
- If cargo shifts or lashings become slack during the voyage, appropriate remedial action shall be taken. However, cargo shift is likely to occur in adverse weather conditions. Sending crew members to release or tighten lashings on a moving or shifting cargo in these conditions may represent a greater hazard than retaining a shifted load.

Representatives of the National Cargo Bureau (NCB) testified during the MBI that EL FARO's CSM had errors and inconsistencies. The NCB witnesses also stated that the CSM was confusing to them. However, the NCB witnesses did testify that if EL FARO cargo was secured in accordance with the CSM, the NCB would consider the cargo properly secured.[157]

Although longshoremen conduct the work of loading and securing cargo, it is ultimately the Master's responsibility to ensure that the cargo carried aboard the vessel is stowed and secured in accordance with the vessel's CSM.[158]

Containers on the main deck were attached to fixed base sockets using either conventional or semi-automatic twistlocks at all four corners of the container. Any container stacked above the bottom-most container was then attached to that container using twistlocks at all four corners. Some container stacks were also secured using lashing rods and tensioners, which were attached to the bottom casting on the 2nd tier container and to a padeye on the vessel's deck. There were a variety of factors that went into a determination whether to use lashing rods, including weights of container stacks and the forces and accelerations they would be subject to due to wind and the motions of the vessel. Generally, for standard enclosed containers, one-high and two-high deck container stacks needed only twistlocks, and no lashing rods were required. Three, four, and

[157] MBI Transcript February 8-9, 2017, p. 575.
[158] MBI Exhibit 040, p. 4, para 3.0 "Responsibility."

five-high deck container stacks may have required lashing rods if the container weights exceeded the limits of the "no lash" system. CargoMax software performed calculations and indicated which lashings were necessary to ensure compliance with the CSM.

The following illustrations show the typical "single lash" and "no lash" arrangements described above:

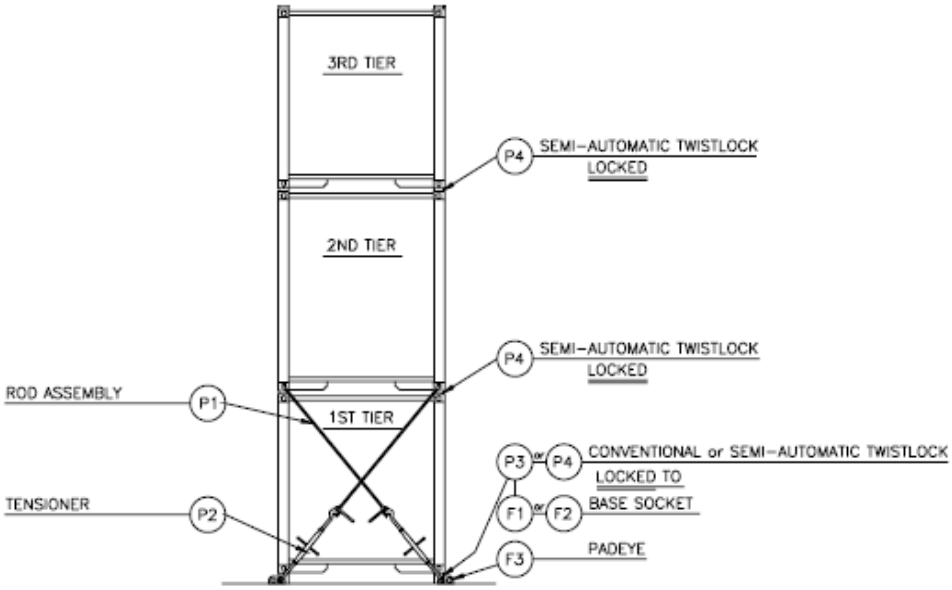


**Figure 30. Typical single lash arrangement for container cargo on the main deck. (MBI Exhibit 040, Cargo Securing Manual)**

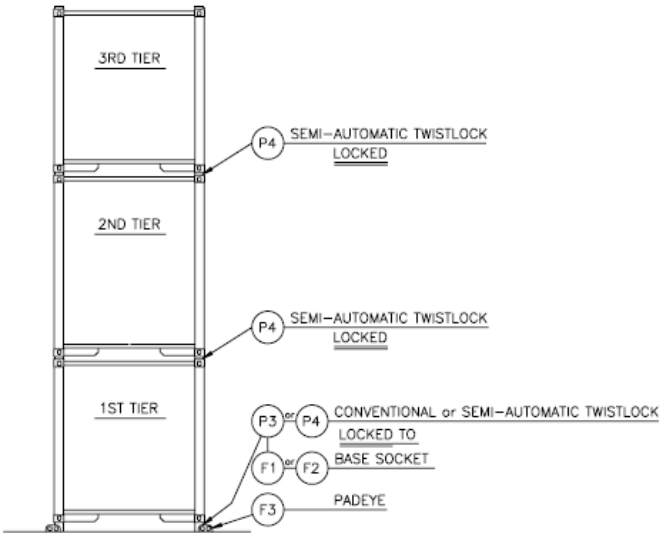


**Figure 31. Typical no lash arrangement for container cargo on the main deck. (MBI Exhibit 040, Cargo Securing Manual)**

Several MBI witnesses[159] testified about a "Lashing Manual," which was apparently an unofficial guide prepared by an unknown person. This unofficial lashing manual contained copies of many of the pages from the approved CSM, but contained additional diagrams and images which do not appear in the CSM. One such reference is called the "SSL EL Class Minimum Lashing Requirements – LoLo," which is a one-page diagram illustrating which containers should be lashed.[160] MBI testimony from PORTUS employees indicated they were unaware of the "lashing manual." However, TOTE's reply to the NCB report indicated the company did use the principles contained in "lashing manual" as guidelines for securing containers.

EL FARO's CSM stated that automobiles stored below decks should have their emergency brakes set and that four auto lashings were to be used, one at each corner.

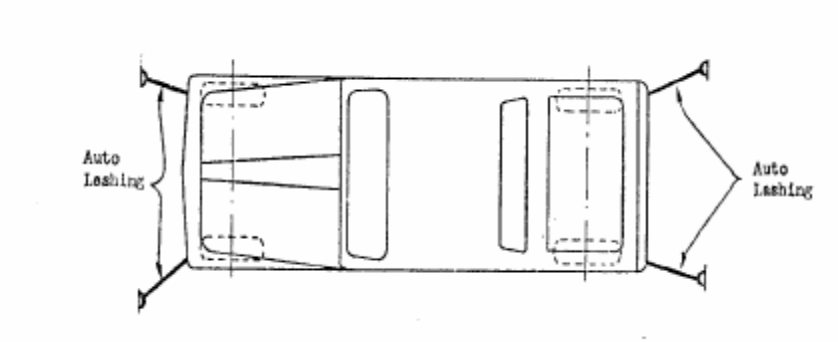


**Figure 32. Image from Cargo Securing Manual for vehicles stored below the main deck. (MBI Exhibit 040)**

The above image from the CSM shows auto lashings attached directly to D-rings secured to the deck. On EL FARO, a long chain running athwartships was secured to D-rings at each side. Auto lashings were secured to these chains instead of to individual D-rings.

[159] MBI Transcript February 19, 2016, p. 166 and February 20, 2016, p. 155.
[160] MBI Exhibit 042, p. 9.

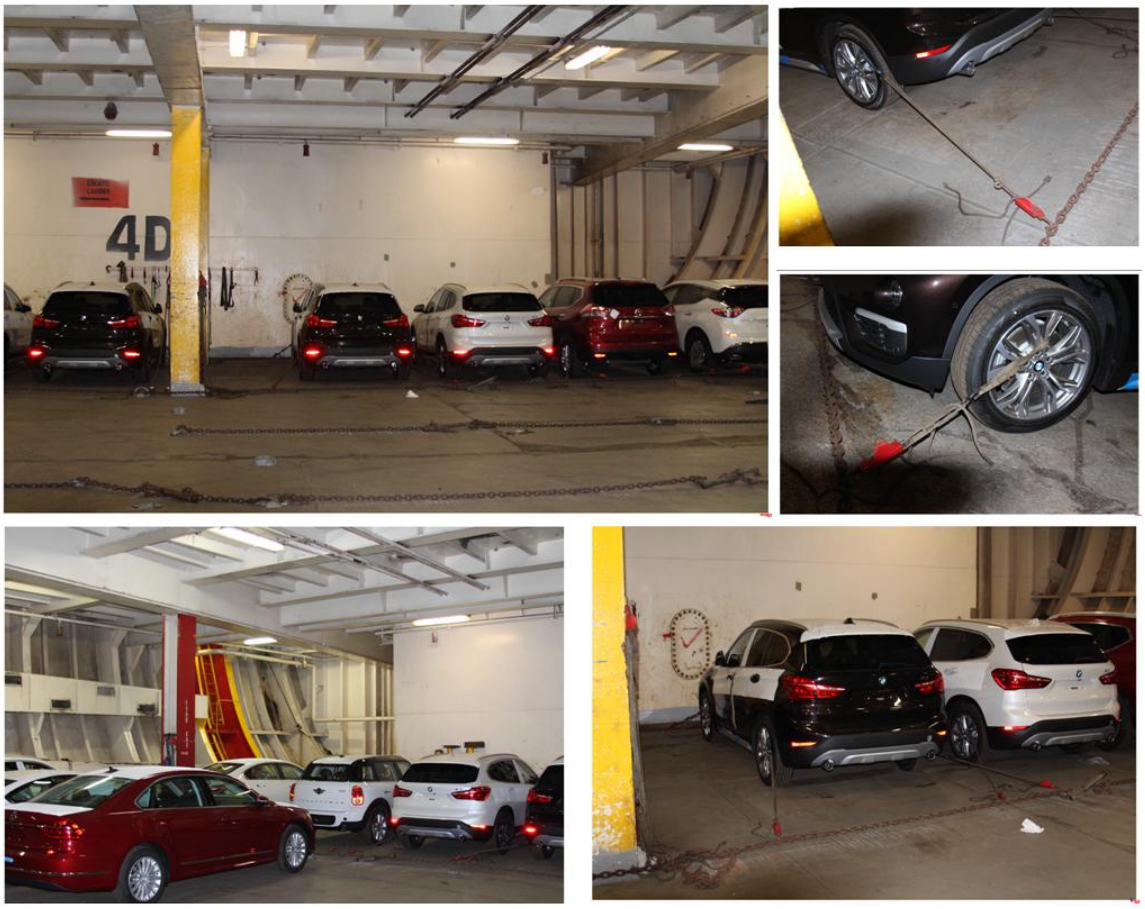


**Figure 33. Select Coast Guard photographs from MBI Exhibit 109 that show examples of vehicle lashing methods aboard EL YUNQUE on December 1, 2015.**

According to the CSM, wheeled vehicles such as trailer vans, flatbed trailers, and containers on chassis were driven aboard, parked, and secured to fittings installed on deck. Trailers were required to be secured to the deck using ROLOC boxes and lashings. ROLOC boxes were secured to the deck at dedicated sockets, which are commonly referred to as "buttons." The locking spud on the ROLOC box was inserted into the hole in the deck socket and rotated to lock it in place. A wing nut could be adjusted to tighten the ROLOC box to the deck.[161]

[161] MBI Exhibit 040.

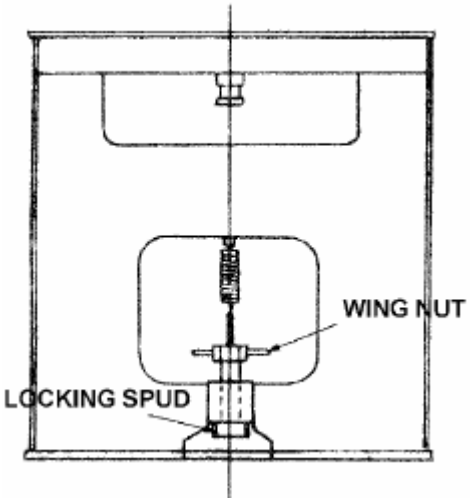


Figure 34. Cross section through ROLOC box (MBI Exhibit 040).

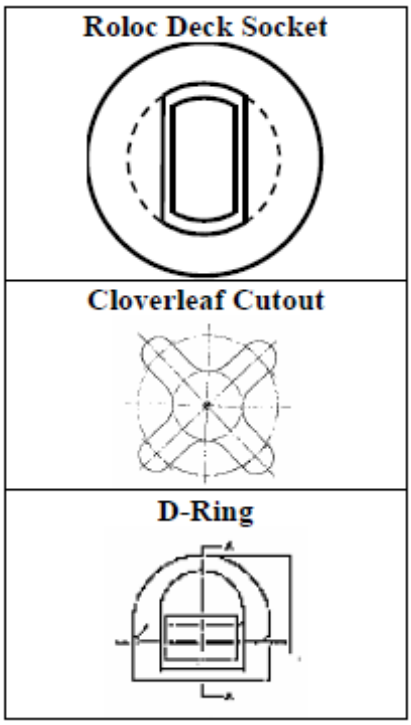


Figure 35. Fixed securing devices for RO/RO cargo (MBI Exhibit 040).
ROLOC Deck Sockets are commonly referred to as "buttons."

The number of lashings required for trailers depended upon whether the trailer was oriented in a fore and aft direction (i.e., parallel to a line running between the ship's bow and stern) or in an athwartship direction (i.e., perpendicular to the ship).

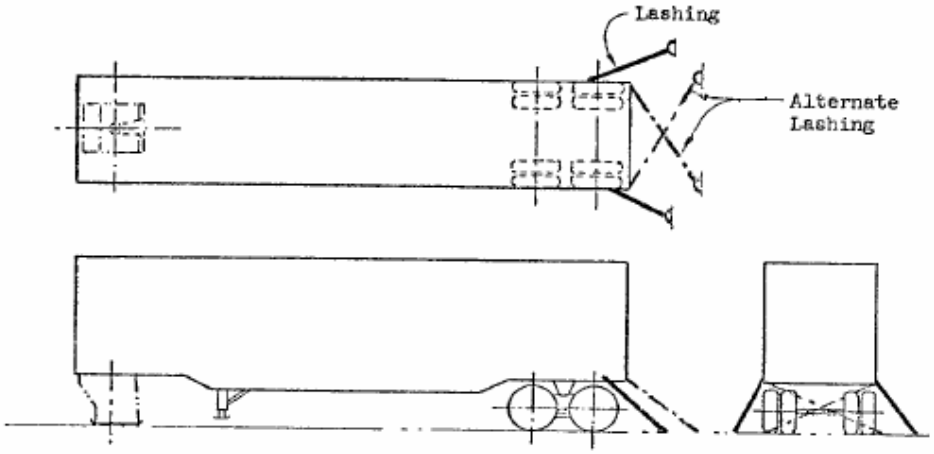


Figure 36. Fore/Aft stowage with a ROLOC Box, oriented normally. (MBI Exhibit 040)

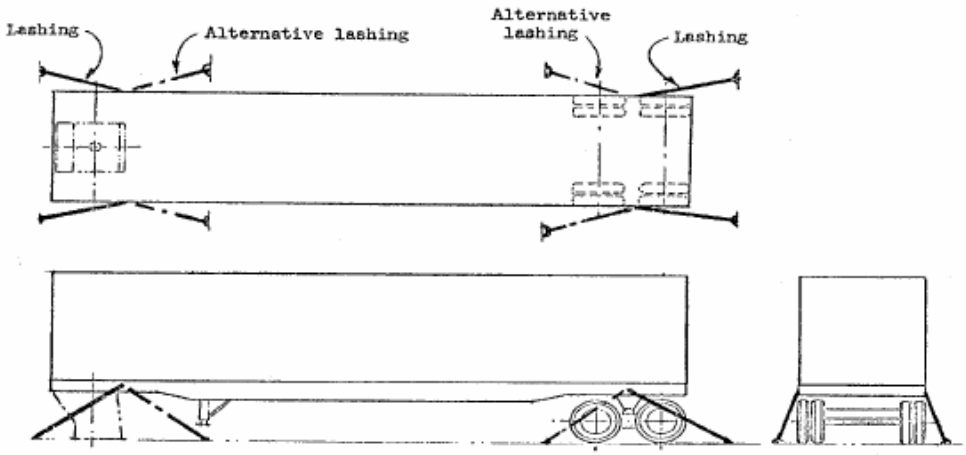


Figure 37. Athwartship stowage with a ROLOC box, oriented normally. (MBI Exhibit 040)

The PORTUS head lasher provided MBI testimony on how RO/RO cargo was secured for EL FARO's final voyage, and he supplemented his testimony by providing a diagram[162] illustrating how each cargo unit would have been lashed.

The head lasher indicated that it was not always possible to land the ROLOC boxes on a button and he indicated that this was particularly true on EL FARO's 2nd deck, which had fewer buttons as compared to EL YUNQUE.[163] The MBI was unable to determine precisely how many trailers stowed on EL FARO were off button during the final voyage due to conflicting testimony on the issue. However, it was determined that at least three trailers on 2nd deck were not attached to a button and that as many as 40 trailers may not have been attached to a button.

[162] MBI Exhibit 289.
[163] MBI Transcript May 23, 2016, p. 203.

When a trailer had to be secured off-button, the CSM stated that the instructions for non-standardized cargo (including the Advanced Calculation Method described in the *Code of Safe Practice for Cargo Stowage and Securing* (CSS Code)[164] and Appendix 17 of the CSM) should be followed in order to determine the appropriate lashing arrangements.[165] Multiple former EL FARO crew members, TMPR personnel, and PORTUS personnel, testified that they had never performed the calculations described in the Advanced Calculation Method. Instead, the standard cargo securing practice was to apply two additional chains (six lashings total) to the forward end of a trailer in the vicinity of the ROLOC box in lieu of it being attached to the button.[166]

According to NCB testimony,[167] the use of six lashings in lieu of attaching a ROLOC box to a button would likely be considered satisfactory for many trailers. However, the weight of heavier trailers stowed off button could exceed this type of securing arrangement. This was particularly true if lashings were applied as shown in TOTE Lashing Manual photos.[168] These photos show lashings which were not consistent with the requirements in the CSM, including attaching hooks to cargo in an improper manner and running lashings at excessive angles. A report prepared by the NCB concluded that EL FARO's rolling action in heavy weather would have likely caused some trailer lashings to fail, which could also have led to a domino effect of progressive lashing failures as shifting trailers fell against adjacent trailers.

EL FARO's VDR audio transcript indicated that at least one trailer was "leaning" as early as 4:37 AM on October 1, 2015. As EL FARO proceeded eastward, the weather became more severe, increasing the likelihood of additional lashing failures. At 5:54 AM, after the vessel had already experienced green water on the 2nd deck and intermittent flooding into one or more cargo holds, the Master altered course to port in order to intentionally put the wind on the vessel's starboard side and shift the vessel from a starboard list to a port list. This sudden shift, combined with free surface conditions due to flood waters and loose debris, would have put a shock load and additional stress on the lashings.[169]

During MBI testimony, the PORTUS Services foreman who supervised EL FARO's lashing gangs during cargo loading prior to the accident voyage stated that he had never seen a copy of EL FARO's current lashing manual or approved CSM.

7.2.10.1.2. Stability calculations during loading operations

Shore side personnel used computer software called Terminal Operating System (TOS) to manage vessel cargoes as they arrived at the terminal gate and were moved through the terminal on their way to the ship. There were three scales at the gates to weigh the incoming cargo so that

[164] MBI Exhibit 189.
[165] MBI Exhibit 40, Section 6.1.
[166] MBI Exhibit 354.
[167] MBI Transcript February 08-09, 2017, p. 589.
[168] MBI Exhibit 042.
[169] Navigation and Vessel Inspection Circular (NVIC) 4-77 discusses the danger of shifting weights or counter flooding when a vessel experiences a permanent heel due to a combination of shifting cargo and flooding water; https://www.uscg.mil/hq/cg5/nvic/pdf/1970s/n4-77.pdf

the weights could be entered into the CargoMax software in order to calculate allowable stack weights and vessel trim and stability. This software is described in more detail in the Load Line, Stability, and Structures section of this report. According to MBI testimony,[170] trucks bringing the cargo to the facility were weighed the first time they came to the facility in order to remove the weight of the truck and trailer from the combined calculated weight of the truck and cargo. The terminal maintained a record of that initial weight and applied the same weight to subsequent calculations rather than weighing the truck each time it came to the facility. Potential differences in the fuel level of the truck were not considered for each arrival. According to testimony,[171] containers and NIC cargo would have their weights rounded to the nearest thousand pounds and automobiles were always estimated to weigh 1.5-long tons, or 3,300-pounds each.

Stability calculations were conducted by TMPR shore side personnel throughout the loading operation using CargoMax software.[172] These duties were normally the responsibility of the Marine Operations Manager, who had regular interaction and communication with vessel crew members throughout cargo operations. However, during EL FARO's final port call these duties were carried out by the Terminal Manager because the Marine Operations Manager was on vacation.[173] Neither the Marine Operations Manager nor the Terminal Manager had received any formal training on vessel stability or the CargoMax software and they each learned to use the software via on-the-job training from prior Sea Star employees.[174]

TOTE had not established any written policies or checklists to ensure that the tasks performed by the TMPR personnel were completed in the same manner for each vessel port call. The Terminal Manager testified that he had filled in for the Marine Operations Manager less than ten times per year. The Terminal Manager's testimony also indicated that he did not clearly understand the lashing margin and strength margin fields in CargoMax.[175] Additionally, as TOTE worked with ABS Rapid Response Damage Assessment team during the response to the loss of EL FARO, it was discovered that the CargoMax load case for the departure condition that was printed at 5:56 PM on September 29, 2015, and delivered to EL FARO's crew, contained an error in lube oil and fuel oil quantities.[176] After EL FARO was reported missing on October 1, 2015, the TMPR Terminal Manager generated a revised CargoMax departure condition load case for EL FARO that corrected the lube oil and fuel oil quantities. The corrected CargoMax report printed at 11:48 AM on October 1, 2015, calculated a GM margin of 0.64 feet, which was 0.16 feet less than the GM margin on the CargoMax load report that was delivered to EL FARO's crew prior to their departure on the accident voyage.

The typical practice for EL FARO and EL YUNQUE was to calculate stability and have a minimum GM margin for safety at sea. This was an informal arrangement and there was no written policy for terminal operators or vessel crews to reference. This GM margin for routine voyages was described as 0.5 feet, which accounted for a GM decrease of approximately 0.25

[170] MBI Transcript February 20, 2016, p. 138.
[171] MBI Transcript February 20, 2016, p. 176.
[172] MBI Transcript February 18, 2016, p. 16.
[173] MBI Transcript February 20, 2016, p. 1713.
[174] MBI Transcript February 18, 2016, p. 121.
[175] MBI Transcript February 20, 2016, p. 67.
[176] MBI Transcript February 20, 2016, p. 152.

feet due to fuel burn during a typical voyage to San Juan. The GM margin helped to ensure that the vessels did not fall below their required GM while underway.

TOTE's SMS manuals state that the vessel's stability is to be verified and found safe for sea "prior to the departure from the loading port."[177] The final printed stow plans, dangerous cargo manifest, and electronic CargoMax load case file, which was calculated ashore, were typically provided to the C/M approximately 30 to 45 minutes prior to vessel departure. This common practice for TOTE vessels in the port of Jacksonville left little time for the C/M and Master to verify the loading information and stability calculations prior to departing the dock, and MBI witnesses indicated that the CargoMax report verifications would sometimes occur after the vessel was underway.

The TMPR Terminal Manager testified that while EL FARO was being loaded during its final port call, he did not have discussions with the crew regarding heavy weather. The Terminal Manager also testified that there were no discussions related to potentially reducing EL FARO's cargo load or increasing the GM margin in preparation for the heavy weather.[178]

EL FARO's crew was required to take the forward, aft, and midship drafts of the ship on both sides prior to departure. This procedure would validate that the Cargo Max calculations being performed by TMPR shore side personnel matched actual observed conditions. Drafts for the dockside of the ship were typically recorded by the C/M and the Terminal Manager. A bucket was used to take a water sample from the St. Johns River. The water sample would then be analyzed by a hydrometer to determine the salinity of the water around the ship. This salinity would then be used to calculate the expected ocean draft for the vessel. MBI testimony indicated that it was difficult to observe EL FARO's offshore midship draft due to the location of the draft marks and there was no standard practice in place to obtain the offshore midship draft. When the Terminal Manager met with the C/M immediately prior to EL FARO's final departure, the C/M had already taken the drafts. EL FARO's departure message indicated that the last Ro-Ro cargo came aboard at 6:30 PM on September 29, 2015, and the last of the Lo-Lo cargo came aboard at 6:54 PM.

7.2.10.2. Voyage Planning

On August 20, 2015, the TSI Manager of Safety and Operations sent out a Safety Alert,[179] 15-008 entitled "Hurricane Danny." This alert contained information about Danny and also included a storm forecast for the 2015 hurricane season. The alert ended with the following statement:

> *This is a reminder that ALL our vessels, in all oceans, should review their general and vessel specific heavy weather procedures and be prepared for the unexpected occurrence.*

[177] MBI Exhibit 025, pp. 129-130.
[178] MBI Transcript February 20, 2016, p. 125.
[179] MBI Exhibit 045.

EL FARO did not have any vessel specific heavy weather procedures, whereas the Ready Reserve Fleet (Military Sealift Command) vessels operated by TSI did have specific heavy weather procedures. The President of TSI provided the following MBI testimony:

> *I would expect that our Masters based on this would go back to the – refer to the operating manual for vessels and then refer to their own professional references that guide them in acumen of being the enormously competent mariners that they are and we hold them to be based on their credentials.*[180]

On August 26, 2015, EL FARO transited the Old Bahama Channel while en route to San Juan, Puerto Rico, in an attempt to avoid Tropical Storm Erika. During that voyage the TSI Manager of Safety and Operations sent an email to the Master of EL FARO[181] which included the following statement:

> *…to ensure we are all on same page and nothing is missed in the risk assessments and action area, please send me a detailed email with your preparedness / avoidance plans and update daily until all clear.*[182]

The TSI Manager of Safety Operations testified that he did not remember why he asked for daily updates and avoidance plans other than because he wanted to be kept informed.[183] The Manager of Safety and Operations was out of the office when EL FARO was departing Jacksonville on September 29, 2015, and he did not pass on his DPA duties to another TOTE manager while he was traveling.

EL FARO's P/E had dinner with the Master onboard EL FARO prior to the vessel's departure from Jacksonville on September 29, 2015. The P/E testified that during their dinner the Master indicated that he was aware that a tropical storm was brewing, but that he was not concerned about "major weather." In an email to TOTE executives on the afternoon of October 1, 2015, the same P/E stated that weather was not a topic of conversation while he was interacting with the Master. The MBI could not find evidence indicating that any other members of TOTE management had discussions or inquired with the Master regarding potential safety precautions for heavy weather ahead of the EL FARO's final voyage. In his September 30, 2015 noon position report email, the Master noted "[p]recautions observed regarding Hurricane Joaquin," but he did not go into specifics as to what precautions were being taken.[184]

EL FARO and EL YUNQUE usually took the most direct and economical route from Jacksonville to San Juan, which was a course of 131 degrees.[185] Additional routes available to the vessels included:

- Straits of Florida to Old Bahama Channel;

[180] MBI Transcript February 16, 2016, p. 28.
[181] The Master of EL FARO during TS ERIKA voyage was the same Master onboard for the accident voyage.
[182] MBI Exhibit 004, p. 30.
[183] MBI Transcript February 20, 2016, p. 94.
[184] MBI Exhibit 004.
[185] MBI Transcript February 16, 2016, p. 49.

- Straits of Florida to Northwest Providence Channel to Northeast Providence Channel;
- Normal route of 131 then Northeast Providence Channel, Northwest Providence Channel, Straits of Florida, and Old Bahama Channel (this route involves significant back-tracking, but is an option);
- Normal route of 131 then Crooked Island Passage.

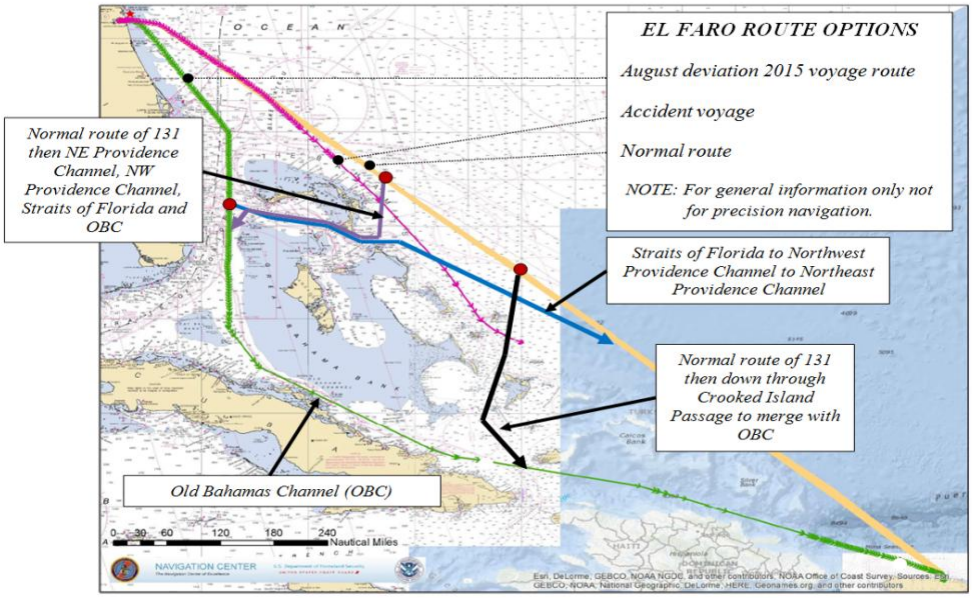


**Figure 38. EL FARO route options for the accident voyage (Source Coast Guard)**

According to MBI testimony from TOTE company officials their vessel Masters: [186]

- have total responsibility for all voyage planning and routing decisions.
- operate autonomously, and are free to choose whichever route they feel is safe.
- are the experts in the safe operation of the vessel which includes voyage planning elements that would be associated with evaluating environmental conditions.
- are the "nautical experts" within TSI.
- do not need permission to change the vessel's route.

The Master of EL FARO was not required to consult with TSI on the route the vessel would take. The Manager of Safety and Operations testified that no one at TOTE except for vessel crew had the specific task of monitoring weather and making weather assessments.[187] As EL FARO departed Jacksonville on the accident voyage, no one at TSI monitored EL FARO's position until the first noon report was received onshore about 16 hours after departure.

According to testimony from a prior TOTE Master, EL FARO used to have a document referred to as a "hurricane plan," which discussed additional routes that could be used to avoid a

[186] MBI Transcript February 16, 2016, pp. 48-50.
[187] MBI Transcript February 20, 2016, p. 13.

storm.[188] No evidence or testimony was provided to indicate that this hurricane plan was incorporated into TOTE's SMS or any other procedures.

There were no general or vessel specific heavy weather procedures for EL FARO or EL YUNQUE, with the exception of the general guidance contained in the SMS manuals.

The Operations Manual – Vessel stated:

- The Master is responsible for the monitoring and analysis of the weather along the vessel's intended track. Current weather conditions, outlooks, and predications must be considered in the planning and undertaking of a voyage. The Master should use all available means to determine the weather that the vessel may encounter on a given voyage.[189]

- The Master shall be very careful that the vessel is properly handled during periods of adverse weather. Before encountering heavy weather, the Master should take proper precautions to safely stow and secure all the vessel's equipment to prevent any damage to the equipment or vessel. The Master shall take whatever action is necessary to prevent excessive damage to the vessel from heavy weather. The Master shall advise the HQ Office of speed reductions and/or course changes due to adverse weather.[190]

MBI testimony from TOTE employees indicated that the notification of a course deviation to avoid a storm was solely for the purpose of informing shore side management regarding an updated arrival time so that they could in turn advise customers, tugs, pilots, and stevedores at the destination port.[191] An EL YUNQUE Master testified that his understanding was that this notice is advisory in nature and that Masters didn't need company permission to transit an alternate route.[192]

Guidance provided in EL FARO's OMV contained a section titled "Weather Routing,"[193] but it refers to the Bon Voyage System provided by Applied Weather Technology, which was not a routing service and only provided graphical weather information.[194]

Guidance provided in EL FARO's EMPV contained the following information: [195]

> *5.12.2 AT SEA*
> *Severe weather is to be avoided where possible by altering the track of the vessel. Instruction for maneuvering in extreme weather can be found in "The American Practical Navigator" HO Pub. #9.*[196]

[188] MBI Transcript February 06, 2017, p. 1599.
[189] MBI Exhibit 025, OMV Section 10.8.1, p. 217.
[190] MBI Exhibit 025, OMV Section 10.8.2, p. 218.
[191] MBI Transcript February 16, 2016, p. 60.
[192] MBI Transcript February 16, 2016, p. 51.
[193] MBI Exhibit 025, p. 218.
[194] MBI Transcript February 16, 2016, p. 108.
[195] MBI Exhibit 026, p. 107.
[196] MBI Exhibit 026, p. 107.

This widely used publication describes the principles and factors of navigation including piloting, electronic navigation, celestial navigation, mathematics, safety, oceanography, and meteorology.[197]

The American Practical Navigator has been continuously updated since its publication in 1802 and the version in place during the accident voyage included the following passages:

> ***3509. Locating the Center of a Tropical Cyclone***
> *If intelligent action is to be taken to avoid the full fury of a tropical cyclone, early determination of its location and direction of travel relative to the vessel is essential. The bulletins and forecasts are an excellent general guide, but they are not infallible, and may be sufficiently in error to induce a mariner in a critical position to alter course so as to unwittingly increase the danger to his vessel. Often it is possible, using only those observations made aboard ship, to obtain a sufficiently close approximation to enable the vessel to maneuver to the best advantage.*
>
> *The winds are probably the best guide to the direction of the center of a tropical cyclone. The circulation is cyclonic, but because of the steep pressure gradient near the center, the winds there blow with greater violence and are more nearly circular than in extratropical cyclones. According to* ***Buys Ballot's law****, an observer whose back is to the wind has the low pressure on his left in the Northern Hemisphere, and on his right in the Southern Hemisphere.*
>
> ***3511. Maneuvering to Avoid the Storm Center***
> *A plot of successive positions of the storm center should indicate the semicircle in which a vessel is located. However, if this is based upon weather bulletins, it may not be a reliable guide because of the lag between the observations upon which the bulletin is based and the time of reception of the bulletin, with the ever-present possibility of a change in the direction of the storm. The use of radar eliminates this lag at short range, but the return may not be a true indication of the center.* ***Perhaps the most reliable guide is the wind.*** *Within the cyclonic circulation, a wind shifting to the right in the northern hemisphere and to the left in the southern hemisphere indicates the vessel is probably in the dangerous semicircle. A steady wind shift opposite to this indicates the vessel is probably in the less dangerous semicircle.*

Comments recorded on EL FARO's VDR during the early morning hours of October 1, 2015, indicated that the bridge crew was not able to accurately determine the direction or speed of the winds they were encountering because visibility was poor and they did not have a working anemometer.

[197] Full document available at https://msi.nga.mil/NGAPortal/.

7.2.11. Weather

The MBI was unable to accurately determine the weather conditions encountered by the crew on EL FARO at the time the VDR ended at approximately 7:40 AM on October 1, 2015.

The last estimated wind speed was made by the C/M[198] at 6:09 PM on September 30, 2015, when he stated:

> *I'm gonna log it as force six[199] here.*

Throughout the morning of October 1, 2015, crew members on the bridge of EL FARO, including the Master, made statements indicating that they were having trouble assessing weather conditions due to limited visibility. The last known description of sea conditions and a barometer reading were discussed on the bridge as the Master called TOTE's DPA. At 7:10 AM the Master made the following statement while talking on the bridge satellite phone:

> *(The) swell is out the northeast. A solid— solid ten to twelve feet (over) spray high winds very poor visibility that's the best I can give ya right now— I'll give ya barometric pressure.*

The Master then asked the 2/M to provide the barometric pressure and she responded that it was 958.8 millibars (MB). The barometer had been dropping throughout the morning of the accident voyage. At 4:24 AM the C/M reported to the Master that the barometric pressure was at 970 MB. At 4:45 AM, the C/M informed the Master that the pressure had dropped to 960 MB. A short while later at 5:03 AM, the C/M appeared to tell the Master that the level was still at 960 MB when the Master inquired if the barometer was coming back up. At 5:22 AM, the C/M reported to the Master that the barometer was at 950 or 951 MB. That reading, which was the lowest recorded on EL FARO's VDR, placed EL FARO close to the eye of Hurricane Joaquin which had a minimum estimated pressure of 948 MB at the time.

An Air National Guard Hurricane Hunter aircraft extrapolated that minimum central pressure of Hurricane Joaquin was 942 MB at 8:00 AM on October 1, 2015, with maximum sustained winds of 120 MPH and higher gusts. Hurricane force winds were estimated to extend out approximately 35 NM from the center of storm.[200]

7.2.11.1. Development of Hurricane Joaquin

A tropical cyclone was first forecasted as a tropical depression on September 28, and reached maximum intensity on October 3, 2015. A major hurricane is defined as a Category 3 Hurricane or greater, which means 96 knots of wind or greater. The NHC stated that Joaquin was rare in that it achieved major hurricane status after forming in a non-tropical region.[201] The Branch

[198] MBI Exhibit 266, p. 182.
[199] Beaufort Storm Force number defined as a strong breeze which starts to create large waves. White foam crests becoming more extensive and some spray is probable.
[200] NHC Hurricane Joaquin Intermediate Advisory Number 14A.
[201] NHC Tropical Cyclone Report Hurricane Joaquin, Ronnie Berg, January 12, 2016.

Chief of the Hurricane Specialist Unit testified that Joaquin was particularly difficult to predict for several reasons. One of the greatest challenges in accurately predicting Joaquin was a significant divergence in the early model guidance. The NHC Annual Summary[202] for the 2015 Hurricane Seasons describes Hurricane Joaquin in this manner:

> *Joaquin's formation is notable in that the cyclone did not have tropical origins, which is rare for a major hurricane. The incipient disturbance can be traced back to 8 September when a weak mid- to upper-level low developed over the eastern Atlantic Ocean west-southwest of the Canary Islands. A piece of this system moved westward across the Atlantic for over a week, and amplified into a more significant mid- to upper-level low over the central Atlantic northeast of the Leeward Islands on 19 September. This feature continued to move westward for several more days and gradually acquired more vertical depth, with a small but well-defined surface low developing on 26 September about 350 n mi east-northeast of San Salvador Island in the central Bahamas. A tropical depression formed two days later on 28 September.*

A moderate northerly shear at higher elevations made it difficult to reconcile the environmental conditions. As the storm developed, the forecasting models slowly converged and the model guidance began to indicate the initial southwesterly direction of the storm.[203] In MBI testimony the NHC Branch Chief Hurricane Specialist stated: [204]

> *It's rare for storms to take a southward component of motion. It's particularly rare in sort of the heart of hurricane season. That sort of behavior is more common as you get towards the tail end of the season in particular as the genesis areas tend to show up further north. But having that southward motion is unusual. Having a storm strengthen when it's moving southward is even more unusual. Southward moving storms rarely strengthen in the way that we saw with Joaquin.*

EL FARO departed Jacksonville, Florida on the evening of September 29, 2015. The NHC published 42 public forecasts and advisories for tropical cyclone Joaquin, from September 28, through October 8, 2015. The first forecast and advisory, which predicted that Joaquin would develop into a Category 1 hurricane (winds 64 knots or greater), was released to the public at 4:41 PM on September 29, 2015. This forecast predicted that the storm would achieve Category 1 level winds by 2:00 PM on September 30, 2015, and the maximum forecasted 80-knot winds would be observed by 2:00 PM on October 2, 2015.[205] The first forecast and advisory to predict that Joaquin would become a major hurricane was released by the NHC on September 30, 2015, at 10:53 AM. This message predicted that a maximum wind of 100 knots would be observed by 8:00 AM on October 3, 2015. The NHC Branch Chief testified that on September 30 and into October 1, 2015, Hurricane Joaquin underwent a rapid intensification.[206] No more than 12 hours later, the NHC published Public Forecast and Advisory #13, which predicted that the storm

[202] MBI Exhibit 197.
[203] MBI Transcript May 17, 2016, p. 172.
[204] MBI Transcript May 17, 2016, p. 137.
[205] http://www.nhc.noaa.gov/archive/2015/JOAQUIN.shtml.
[206] MBI Transcript May 17, 2016, p. 169.

would rapidly intensify and that it would have winds as great as 110 knots by 8:00 AM on October 1, 2015.[207]

7.2.11.2. National Hurricane Center –Tropical Cyclone Intensity Forecasting

The Branch Chief for the NHC's Hurricane Specialist Unit testified at the MBI that predicting the intensity of Hurricane Joaquin was very difficult due to wind shear. He stated:

> *Wind shear refers to the difference in wind flow in the lower part of the atmosphere relative to the upper part of the atmosphere. So if the winds are blowing in roughly the same direction at roughly the same speed as you go from the bottom of the hurricane to the top, then we say that's a low wind shear environment. If there's high wind shear, then either the wind speed is very different or more commonly the wind direction at the top is blowing very differently than wind direction at the bottom. We know that when there's a lot of wind shear that it's pretty easy to predict the behavior of a tropical cyclone. The thunderstorms get ripped off, the storm becomes shallow, it tends to weaken, it tends to move with the lower layer of flow. We also have a pretty good handle on things when the wind shear is very low. When the wind shear is very low there's an opportunity for the storm to hold together vertically if the moisture is right and the underlying sea surface is right, then you know we can get lots of intensification. The – one of our biggest challenges is trying to sort out what's going to happen at intermediate levels of shear. When you have the thunderstorm activity and the tropical cyclone is trying to keep the storm vertically coherent, wind shear is trying to tear it apart and the forecaster has to decide based on the guidance that he has which of those two competing factors is going to win. And in those situations the – getting the intensity forecast right and getting the track forecast right really go hand-and- hand. If you don't get the intensity right you're probably not going to get the track right because the storm is now going to be steered by a flow at a different layer of the atmosphere. So that was certainly the problem in the first few forecasts for Joaquin where we were expecting very high levels of shear. We expected that the storm was not going to handle that shear very well and basically become very shallow and move off to the West and Northwest in the shallow flow. Joaquin didn't cooperate with that particular line of thinking. It, for whatever reason, and to this day can't really tell you why it did so, but that storm was particularly resistant to the wind shear. Now maybe, we – maybe there was less shear out there than we thought. Or perhaps there was something about the dynamics of that particular storm that allowed it to resist. But that was the basic challenge in trying to figure out how that storm was going to respond to the shear that was being imposed on it. And that affected both the intensity forecast and the track forecast.*

Tropical Cyclone Joaquin developed into a Category 4 Hurricane on the Saffir-Simpson Hurricane Wind Scale on October 3, 2015. The Saffir-Simpson Hurricane Wind Scale uses a description to help people understand the catastrophic damage that will occur; it does not consider damage to vessels or maritime infrastructure.

[207] MBI Exhibit 153.

| | | |
|---|---|---|
| 4<br>(major) | 130-156 mph<br>113-136 knots<br>209-251 km/hr | Catastrophic damage will occur: Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months. |

7.2.11.3. Prediction Errors with Hurricane Joaquin

In MBI testimony[208] the NHC Branch Chief for the Hurricane Specialist Unit stated:

> *The initial forecast for Joaquin had errors that were much larger than normal. So for example the 3 day forecast that would have verified the morning of October 1st had a track error…it was 536 miles. So the 3 day forecast verifying it at 8:00 AM October 1st. That's an extraordinarily large area. That's really about 1 in 100 type of track error. The 48-hour track forecast that verified at the same time had an error of 180 miles and that's something like a 90 or 95th percentile of error. So it's certainly a very large error. By the time one day it was a 62 mile error, the 1 day forecast was verified at 8:00 AM and that's more in line, at least close to what the average was. So the earlier forecast, track forecast had errors that were much larger than normal for us. The same was true with the intensity errors. The 3 day intensity error that verified at that time was 80 knots too low. The 2 day forecast that verified at that time was 60 knots too low. And the 1 day was 30 knots too low. So the forecast called for a relatively weak system, the initial forecast called for a relatively weak system to head off to the west and northwest and this instead it moved west southward and southward and strengthened.*

[208] MBI Transcript May 17, 2016, p. 178.

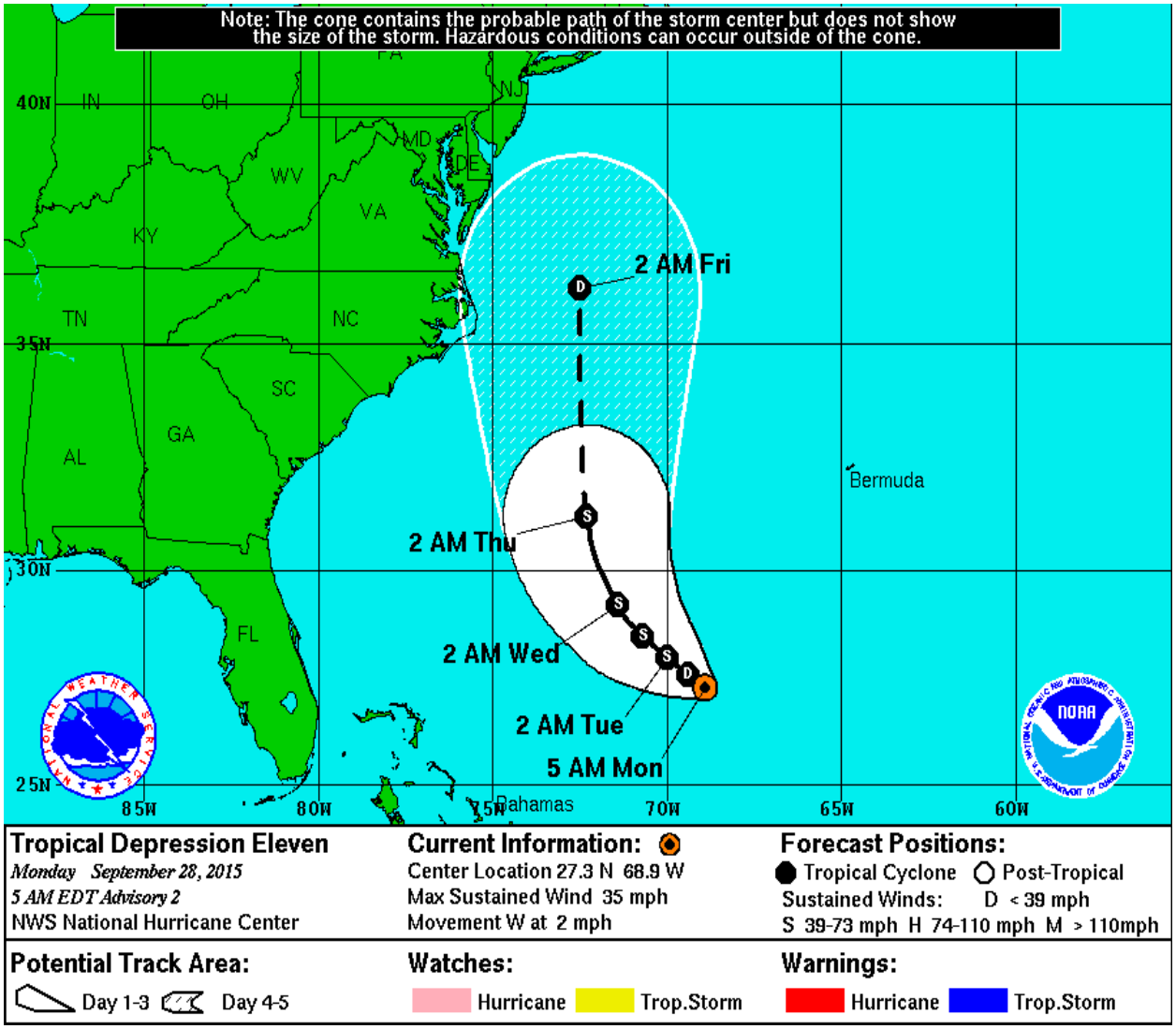


**Figure 39. NHC Tropical Depression Eleven 5 AM EDT Advisory 2 with 5-day Cone and Warnings dated September 28, 2015. Early forecasts for the storm that would become Hurricane Joaquin indicated the system would head in a Northwesterly direction. The 2 AM Thu projection of a Tropical Storm off the coast of South Carolina correlates to the morning of the accident voyage (October 1, 2015).**

### 7.2.11.4. Unique Characteristics of Hurricane Joaquin (Storm Quadrants)

Tropical cyclone forecasts are accompanied by quadrants, which indicate the largest expected radii for wind and seas. The quadrants are listed by cardinal[209] or primary intercardinal directions[210] and are meant to cover the graphical areas 45 degrees to either side of the listed direction. For a normal, fully developed hurricane moving in a northerly direction, the quadrants to the right side of the direction of storm movement tend to be larger in range than the left side of the storm. However, for Hurricane Joaquin it was noted that the larger quadrants were depicted on the east side of the storm despite the southwesterly track of the storm. The NHC Hurricane

[209] Cardinal directions include North, East, South and West.
[210] Primary intercardinal directions include Northeast, Southeast, Southwest and Northwest.

Specialist Unit was asked about this in a follow up interview and they stated that Hurricane Joaquin had an unusual asymmetry that resulted in displacement of the wind fields from the southwest. As a result, as the storm progressed on its southwesterly course, the wind fields were forced tighter to the storm on the leading edge, and expanded further out on the trailing edge. Examples of the resulting quadrants are shown below in the graphical overlay of the 11:00 EDT September 30, 2015, forecast and advisory.

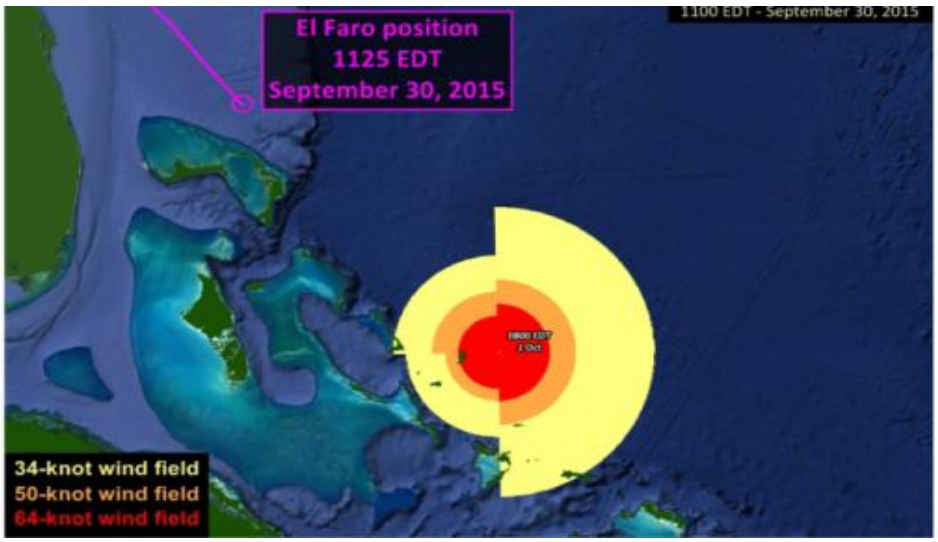


**Figure 40. EL FARO position at 1125 EDT September 30, 2015 showing relationship with Hurricane Joaquin wind fields. (Source: NTSB Weather Factual Report)**

7.2.11.5. NOAA Weather –Tropical Cyclone Related Products

The NHC, which is a division of the National Weather Service under NOAA, develops several messages specifically for tropical cyclone events. These messages include the Tropical Weather Outlook, Tropical Weather Discussion, Tropical Cyclone Public Advisory, Tropical Cyclone Forecast and Advisory, and Tropical Cyclone Updates. The Tropical Weather Outlook (AWIPS header TWOAT[1-5] for Atlantic systems) is both a textual[211] and graphical product. The textual product provides all the active tropical cyclones and disturbances, along with the probability of formation for the next five days. This product is published at the nominal times of 0000Z, 0600Z, 1200Z and 1800Z.[212]

The Tropical Cyclone Discussion (AWIPS header TCDAT[1-5] for Atlantic systems) provides a free script textual product where the forecaster discusses the reasoning for the forecast and analysis. The Tropical Cyclone Discussion is issued at nominal times of 0300Z, 0900Z, 1500Z, and 2100Z.[213]

[211] A textual product conveys the weather information on the printed page relying on the reader to assess the information.
[212] EDT, which was in effect on October 1, 2015, can be obtained by subtracting 4-hours from the zulu times (e.g., 1200Z converts to 8:00 AM EDT).
[213] MBI Exhibit 152 contains copies of the TCDAT messages released before the sinking of EL FARO.

The Tropical Weather Discussion (TWDAT for the Atlantic systems) describes all the major synoptic weather features and significant areas of disturbance in the tropics. This message provides insight regarding the current state of the atmosphere, expected trends for decision making, significant weather, the meteorologist's reasoning for the forecast, model performance, and, in some cases, degree of confidence. This message is released at nominal times of 0005Z, 0605Z, 1205Z, and 1805Z.[214]

The Tropical Cyclone Public Advisory (AWIPS header TCPAT[1-5] for Atlantic systems) lists all current watches and warnings for a tropical or subtropical cyclone with its position (latitude and longitude), course, speed, max sustained winds, estimated central pressure at the center of the storm, and distance from a selected land point. This message may also include information such as storm tides, rainfall, or tornadoes associated with the cyclone, as well as other pertinent information. The Tropical Weather Discussion is published on a nominal schedule of 0300Z, 0900Z, 1500Z, and 2100Z.[215]

The Tropical Cyclone Forecast and Advisory (AWIPS header TCMAT[1-5] for Atlantic systems) is a text product that contains a list of the watches and warnings for a tropical and sub-tropical cyclone. It contains the storm's current center position (latitude and longitude), course, speed, maximum winds, barometric pressure, and, in some cases, the current diameter of the storm's eye wall. It also provides projected tropical cyclone geographical positions, the maximum wind speed and wind speed probability cones for 34 knot, 50 knot, and 64 knot wind speeds. The NHC publishes a minimum of four Tropical Cyclone Forecast and Advisories each day for tropical cyclones. The nominal release times for those forecast and advisories are 0300Z, 0900Z, 1500Z, and 2100Z.[216]

The NHC also issues intermediate advisories to update a storm's position, course, and speed. Intermediate advisories do not update the complete forecast, so the forecasted track and cone of probability remain unchanged from the previous forecast and advisory. The intermediate advisories are issued at nominal times three hours after the regular forecast and advisory, and they are normally issued when there is a coastal watch or warning in effect.

When there is a change in a Tropical Cyclone, the NHC can issue a corrected forecast and advisory. If the forecaster deems it necessary, they can also issue a Special Forecast and advisory when there is an unexpected significant change in the cyclone. The special forecast and advisory is distinct from the intermediate advisory in that it develops a full suite of forecasts resulting in an updated trackline for a forecasted storm.

The High Seas Forecast (AWIPS header HSFAT[1-2] for the North Atlantic) provides sea state analysis for various regions of the ocean. The High Seas Forecast message that is broadcasted to mariners includes the information presented in both HSFAT1 for the West Atlantic and HSFAT2 for the Tropical Atlantic, so this forecast contained information about Tropical Cyclone Joaquin. For the area east of the Bahamas during this event, a portion of the important information from the High Seas Forecast included current position, course, and speed

[214] MBI Exhibit 155.
[215] MBI Exhibit 162.
[216] NOAA Marine Text Forecasts and Products Listing webpage; http://www.nws.noaa.gov/om/marine/forecast.htm.

of Joaquin; seas; swell direction; and a 24 and 48-hour forecast. The High Seas Forecast, which is made available to mariners, is issued at nominal times of 0430Z, 1030Z, 1630Z, and 2230Z.[217]

The Marine Offshore Waters Forecast (AWIPS header OFFNT3 for the Southwest and Tropical North Atlantic and Caribbean Sea) is a text product describing the winds, seas, and predominant weather events in predefined areas. It also provides a synopsis of significant weather, trends, or expectations. The Marine Offshore Forecast for the Southwest and Tropical North Atlantic and Caribbean Sea is issued at nominal times of 0330Z, 0930Z, 1530Z, and 2130Z.[218] The applicable zones for the area east of Florida are shown below.[219] A condensed version of this weather message is broadcasted as a digital voice recording via High Frequency by Coast Guard.[220]

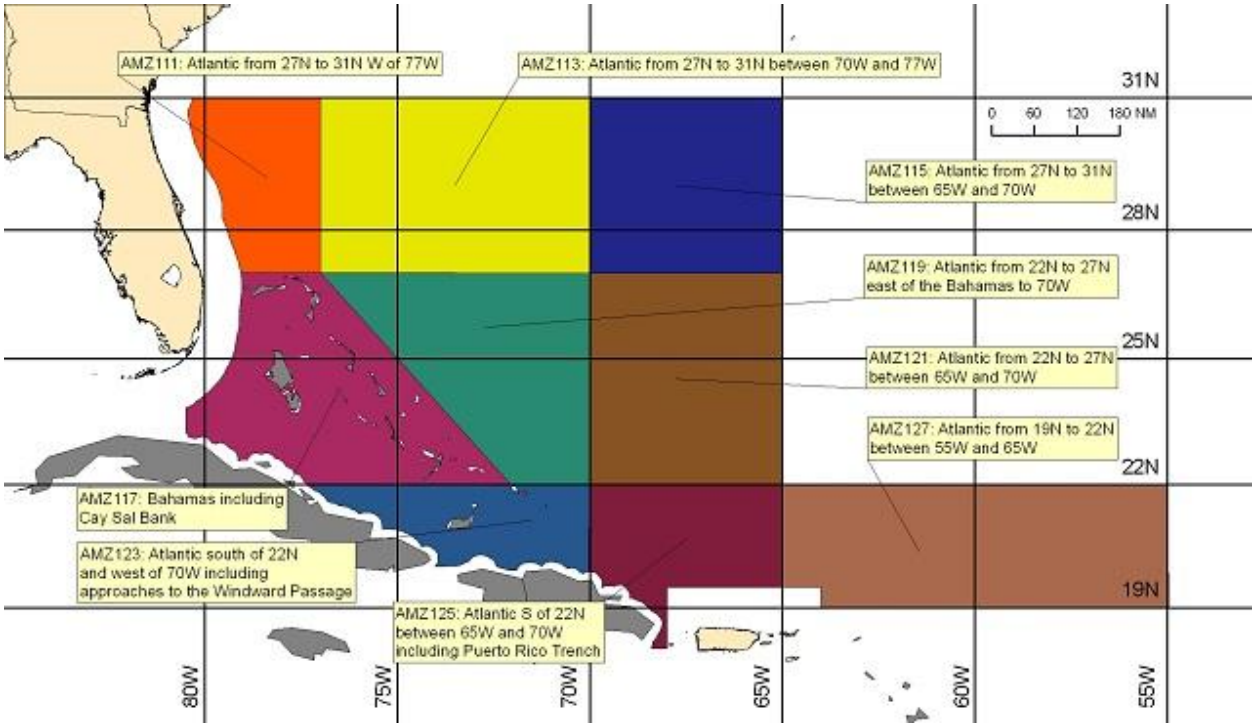


**Figure 41. The gridded zones pertaining to each Offshore Waters Forecast area (AWIPS header PWSAT[1-5] for the Atlantic).**

The Marine Weather Discussion (AWIPS header MIMATS for the Atlantic and Gulf of Mexico) provides the forecaster a venue to discuss general trends and information on the performance of the models. This message is published online twice daily with nominal release times of 0600Z and 1800Z.[221]

[217] MBI Exhibit 151.
[218] NOAA Marine Text Forecasts and Products Listing webpage; http://www.nws.noaa.gov/om/marine/forecast.htm.
[219] http://www.nws.noaa.gov/om/marine/zone/off/offnt3amz.htm.
[220] MBI Exhibit 299.
[221] MBI Exhibit 160.

7.2.11.6. Transmittal of Marine Weather Forecasts to Ships

NOAA is the primary federal agency that publishes marine weather forecasts; it uses several means to distribute weather products to mariners. These methods include online weather graphical and textual resources, NOAA near shore very high frequency (VHF) radio, NAVTEX, high frequency voice broadcasts (HF-VOBRA), weather fax, and Inmarsat SafetyNet (also known as Sat-C) messages.

Ships underway can receive NOAA marine weather forecasts, as well as forecasts from a variety of commercially available sources. Some of these sources include satellite television (TV) packages, satellite radio packages, commercial forecasting services, marine weather routing services, and several other services. EL FARO was equipped to receive weather information from Inmarsat Sat-C communications, NAVTEX, HF-VOBRA, weather fax, satellite TV services, satellite radio services, and Inmarsat-C on-demand weather forecasting services.[222] During the ship's port calls, and while transiting close to shore, the ship could use the full range of broadcast media as well as wireless or cellular access to all of the available weather forecasting technology such as the Weather Channel © and Weather Underground©. During EL FARO's accident voyage the Coast Guard had aircraft on patrol over the eastern Bahamas broadcasting information about the developing tropical system and the associated watches and warnings on Ch. 16 VHF- FM. (156.8 MHZ). The Coast Guard aircraft VHF radio broadcast was heard by watch standers on EL FARO's bridge.

The crew of EL FARO utilized Sat-C weather messages, a commercial satellite TV provider, and a commercial weather forecasting service[223] provided by Applied Weather Technology (AWT).[224] AWT provided EL FARO with the Bon Voyage System (BVS).[225] There were also indications that the crew on EL FARO listened to Sirius-XM satellite radio to get updates on the status of Hurricane Joaquin.[226]

7.2.11.6.1. Maritime Safety Information – Inmarsat SafetyNet (Sat-C) Weather Messages

SOLAS approved vessels on international voyages are required to be outfitted with a Global Maritime Distress and Safety System (GMDSS), capable of receiving Maritime Safety Information (MSI). MSI includes priority weather messages related to tropical cyclones. The National Weather Service (NWS), a NOAA Office, has a contract with Satcom Direct Government, Inc. to broadcast certain weather messages to GMDSS Inmarsat capable marine operators. NWS makes some weather messages available to Satcom Direct Government, Inc. which then releases them via a land-earth station.

EL FARO was outfitted with a Furuno type Sat-C terminal to receive GMDSS MSI. This terminal was configured with an audible alarm for priority messages and configured to print priority weather messages automatically on a manufacturer supplied printer. EL FARO is

[222] MBI Exhibit 043, p. 1 and MBI Exhibit 266.
[223] MBI Exhibit 266.
[224] AWT is now called "StormGeo."
[225] MBI Exhibit 268.
[226] MBI Exhibit 266.

believed to have been outfitted with the same GMDSS suite as EL YUNQUE, which was outfitted with a FELCOM 15 GMDSS[227] console and Furuno PP-510 heat printer.[228] On EL FARO's VDR the GMDSS alarm and printer could be heard at various times that correlated with the broadcast times of three distinct weather messages. These messages were the Tropical Weather Outlook, Tropical Cyclone Forecast and Advisory, and the High Seas Forecast.[229]

7.2.11.6.2. Weather Messages Not Broadcasted via GMDSS (Available only over the internet)

Several messages that contain information pertinent to tropical cyclones are not released to mariners via Inmarsat. If mariners do not have internet access, they are incapable of receiving all of the messages. Of the messages mentioned in this report, the TCPAT, TCDAT, TWDAT, and the TCUAT are not released via GMDSS alert systems. Intermediate advisories and special forecast and advisories are also not released via GMDSS alert systems. Bandwidth limitations preclude some commercial marine operations from full access to the internet, which limits their ability to receive these additional products in a timely manner. One limited option available is to use NOAA's on-demand, free FTPmail. However, FTPmail requires the user to develop a command script to be sent to a NOAA server which queries the server for the requested message and returns it to the sender. EL FARO did not have full internet service onboard and there was no indication that the crew accessed the additional products available from the NOAA FTP site.

7.2.11.6.3. Commercial Weather Service – Bon Voyage System

EL FARO used the commercially available weather and sea state forecasting provided by AWT. AWT produced BVS, a proprietary graphical interface software system. BVS is designed to provide crews with useful tools to help plan voyage routes, taking into account the predicted oceanographic and atmospheric conditions. This system is graphical and the user can control the number of layers, and thereby the amount of information viewed at one time in the forecast package. Some of these layers include seas, swell, rogue waves, winds, current, barometric pressure, and even piracy warnings. The user can also perform route optimization analysis by configuring BVS with their vessel type, speed, fuel consumption rates, and intended tracklines in order to view potential effects on the ship due to weather.

Former EL FARO crew members testified that they had the BVS system properly installed on the bridge and on the Master's stateroom computer.[230] The system was designed to send weather packages via email on a routine basis. The weather packages were developed by AWT using proprietary forecasting models, WaveWatchIII,[231] and the Global Forecast System (GFS) model. The inputs to their overarching model begin six times a day and it takes approximately nine hours before a completed product is emailed to a customer. If a tropical cyclone forecast and advisory is issued during the run time window, the data taken directly from the NHC will be incorporated into AWT's model while blending the data taken from the NHC tropical cyclone

[227] MBI Exhibit 043, p. 1.
[228] MBI Exhibit 301, p. 1.
[229] MBI Exhibits 266 and 268.
[230] MBI Transcript February 19, 2016, p. 106.
[231] WaveWatchIII is a wave prediction model developed and maintained by National Centers for Environmental Prediction office of NOAA.

forecast and advisory. The end product in that instance would be the atmospheric and oceanographic forecasts generated from AWT's model, with the information from the NHC forecast and advisory overlaid so the mariner has a graphical means to interpret the current conditions.

AWT recommended that their users, at a minimum, request weather packages at nominal release times of 0300Z, 0900Z, 1500Z, and 2100Z. Due to the processing time, the recommended delivery schedule caused users to receive their weather product with the overlay of the NHC forecast and advisory from the previous nominal release time six hours prior. For example, if a mariner used the recommended delivery time and received a weather package at 0900Z, they would actually be viewing the 0300Z NHC forecast and advisory even though NHC was set to release its next forecast and advisory at 0900Z. If a mariner wanted to get the updated track, the BVS program had a set up option available to receive "Tropical Updates." If that option was selected at set up, AWT sent a follow up weather package normally within an hour of the NHC's newest forecast and advisory to update the mariner's graphical overlay. This updated weather package does not change the oceanographic or atmospheric model data provided in the previous weather package, but it does update the tropical cyclone overlay data. MBI testimony from several TOTE officials and crew members revealed that EL FARO did not have the Tropical Updates active on its BVS.

AWT provided the Coast Guard with copies of the data files that were transmitted to EL FARO for the days leading up to the incident, including copies of the Tropical Updates that could have been made available to EL FARO if they had selected that option during the system's initial setup. The AIS trackline for EL FARO was replicated into the BVS software and used to examine the forecasted weather as EL FARO transited along its accident voyage trackline.[232] Below are several screenshots from BVS. For each, the approximate location of the ship around the time of product dissemination is noted with a ship's symbol, the AIS trackline of EL FARO is shown, and the forecasted trackline of Joaquin is shown.

[232] MBI Exhibit 172.

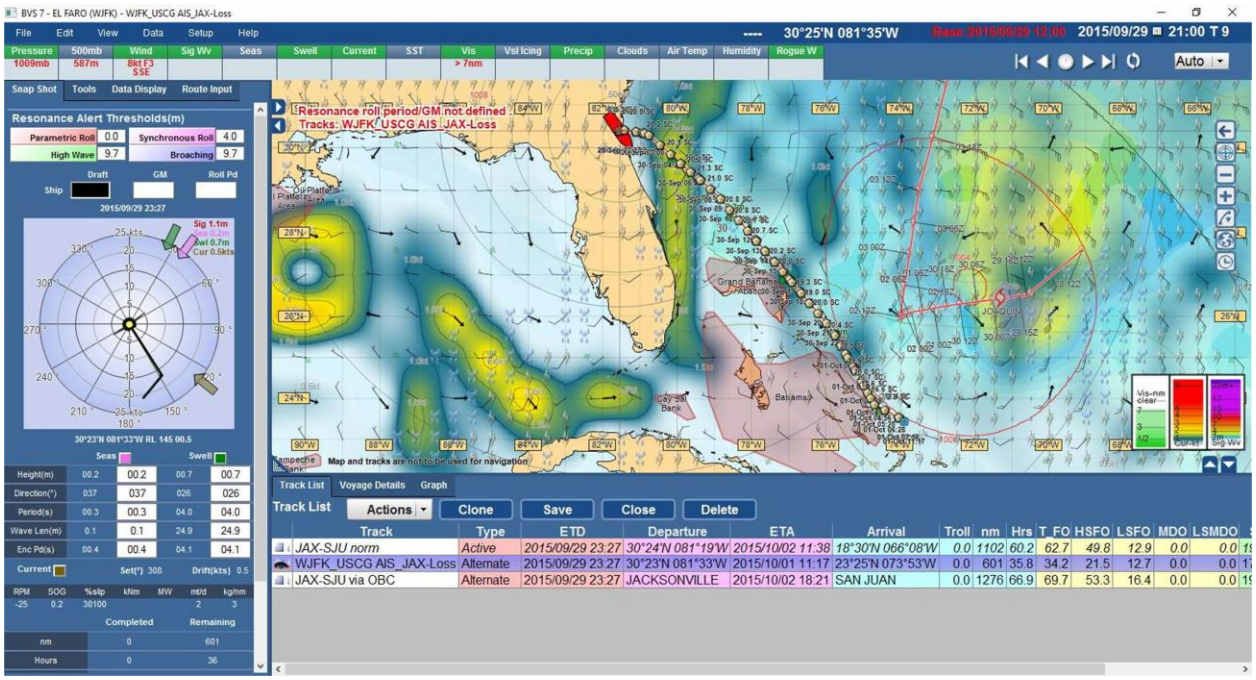


**Figure 42. BVS weather package transmitted to EL FARO at 5:04 PM and downloaded at 6:37 PM on September 29, 2015.**

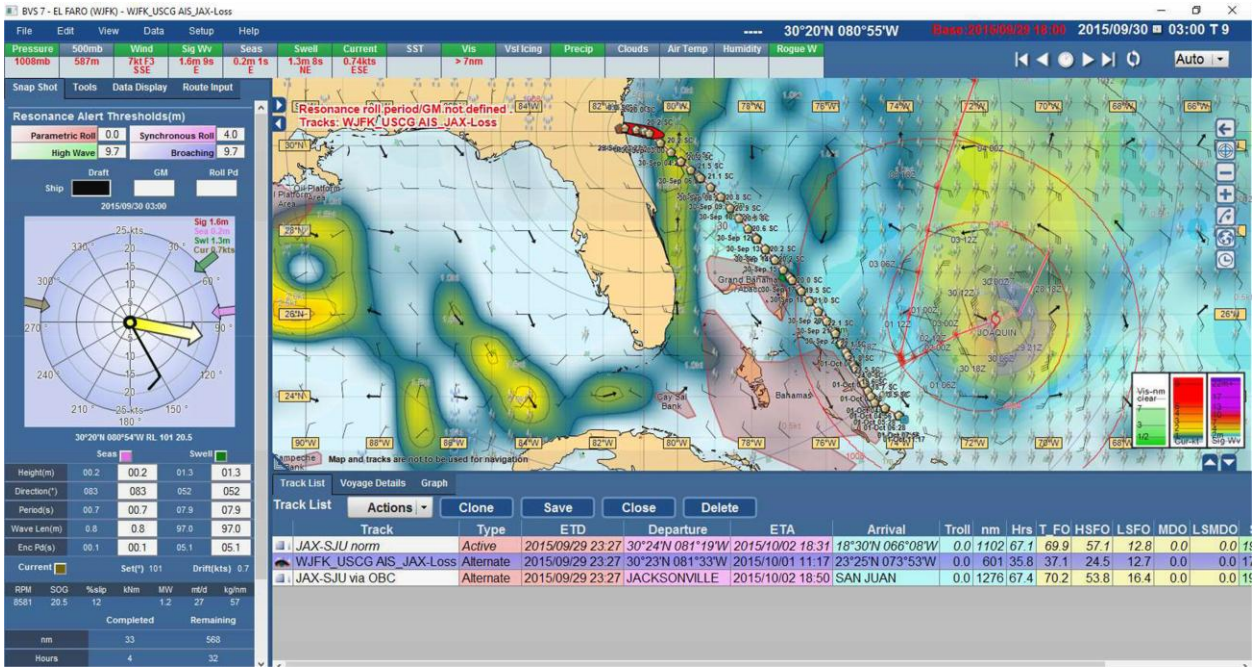


**Figure 43. BVS weather package transmitted to EL FARO at 11:04 PM and downloaded at 11:29 PM on September 29, 2015.**

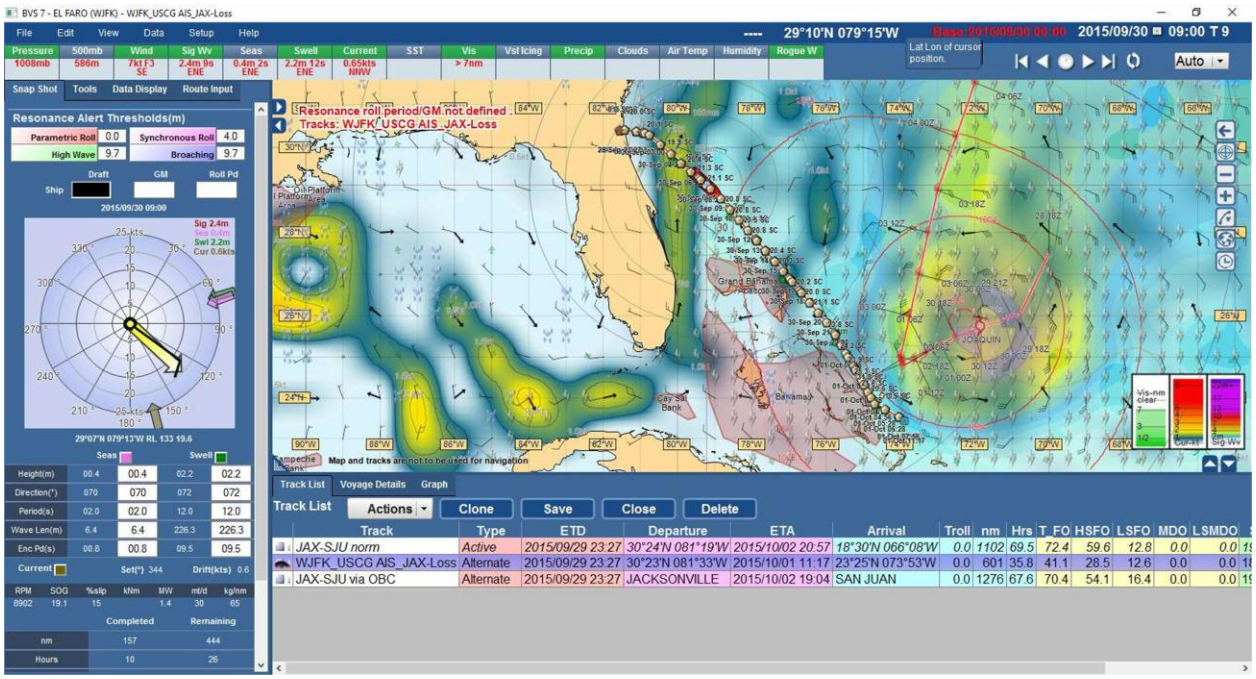


**Figure 44. BVS weather package transmitted to EL FARO at 5:04 AM and downloaded at 6:08 AM on September 30, 2015.**

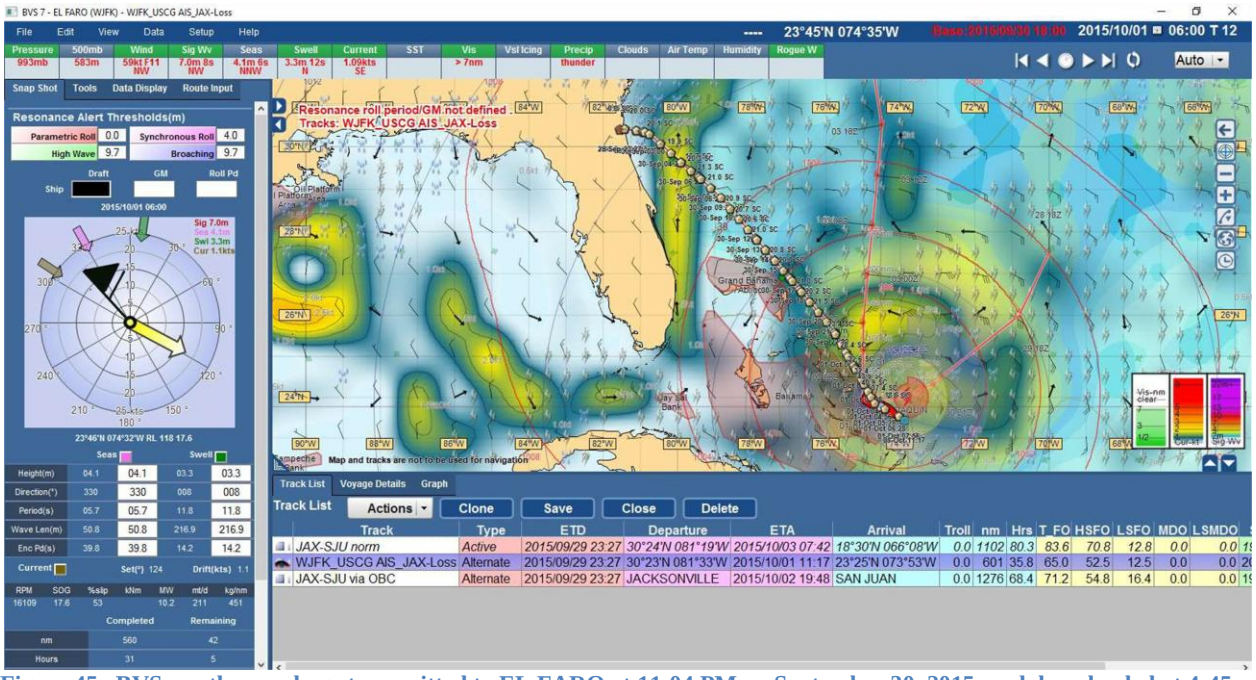


**Figure 45. BVS weather package transmitted to EL FARO at 11:04 PM on September 30, 2015, and downloaded at 4:45 AM on October 1, 2015.**

During the testimony from AWT, it was discovered that there was an error in one weather package sent on September 30, 2015. The message sent at about 0900Z (5:00 AM EDT) contained the same NHC forecast and advisory overlaid from the previous weather package sent at 0300Z (11:00 PM EDT) on September 29, 2015. The 0300Z weather package contained the

NHC forecast and advisory information published at the nominal time of 2100Z on September 29, 2015. This error meant that the 0900Z BVS weather package that was sent to EL FARO on September 30, 2015, still contained the NHC forecast and advisory from 12 hours prior. However, the 0900Z weather forecast with the duplicate NHC forecast did include properly updated oceanographic and atmospheric model data generated by AWT.[233] The repeated hurricane forecast that was replicated in the error can be seen in the graphics above.

Beginning at about 6:14 AM on September 30, 2015, the C/M and Master discussed the weather and potentially altering EL FARO's trackline.[234] The route chosen provided two waypoints, waypoints "Alpha" and "Bravo." The resulting trackline was then entered into BVS. The BVS screenshot below shows the new route with the weather forecast that was downloaded at 6:08 AM on September 30, 2015. This was the BVS forecast data package that was available to the Master and C/M at the time they were choosing waypoints "Alpha" and "Bravo." The Tropical Cyclone forecasted track depicted in this package delivered to EL FARO is the duplicate report showing the NHC's forecast from 5:00 PM on September 29, 2015.

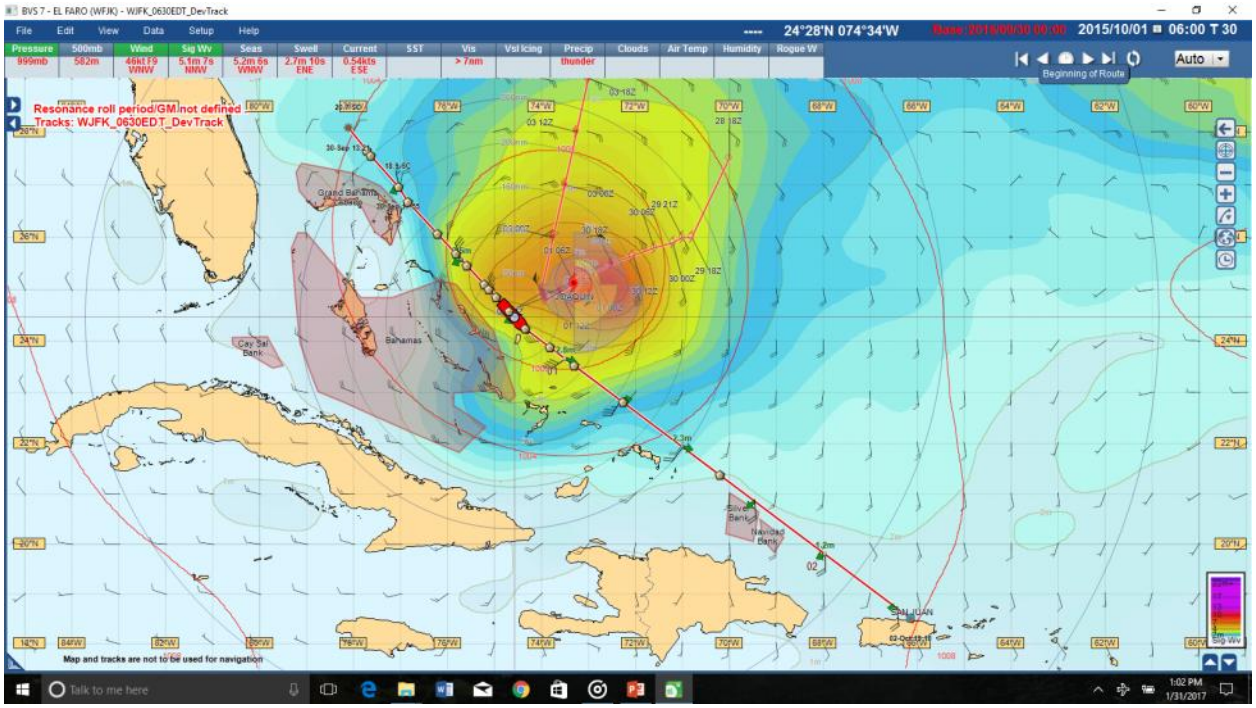


**Figure 46. BVS screenshot of EL FARO's adjusted route along with the weather forecast downloaded at 6:08 AM on September 30, 2015.**

7.2.11.6.4. Marine Weather Radio Broadcasts: Coast Guard Fixed Wing Aircraft

At 2:14 PM[235] on September 30, 2015, the bridge crew heard this message from a Coast Guard patrol aircraft, tail number CG-2310:

[233] MBI Transcript May 19, 2016, p. 10.
[234] MBI Exhibit 266, pp. 19-30.
[235] MBI Exhibit 266, p. 129.

*Sécurité. Sécurité. Sécurité. * * * The National Hurricane Center has issued a hurricane warning for the central Bahamas including Cat Island– Exuma– Long Island– Rum Cay– San Salvador. The National Hurricane Center has issued a hurricane watch for northwestern Bahamas including the Abaco– the (Canary) Islands– Bimini– (Elliotbrook)– Grand Bahama Island and New Providence. The Coast Guard requests all * mariners use extreme caution for * *. The United States Coast Guard aircraft standing by on channel sixteen.*

At 2:38 PM, there was another broadcast picked up on the VHF radio on EL FARO's bridge that was similar to the previous broadcast. Due to the nature of the storm, a decision was made by the Coast Guard to have its fixed wing patrol aircraft make broadcasts regarding Joaquin on its flight track. During the flight, five vessels responded to the aircraft sécurité asking for additional information regarding the call outs about Joaquin. EL FARO was not one of the five vessels.

#### 7.2.11.6.5. Marine Weather Message Radio Broadcasts: Coast Guard Communications Command

The Coast Guard has a Memorandum of Understanding (MOU) with NOAA to disseminate certain weather messages via various Coast Guard radio broadcast systems. The MOU is managed by a joint-agency working group which is referred to as UNCLOG.[236] NOAA and the Coast Guard have UNCLOG meetings quarterly where they discuss improvements or changes in weather dissemination. The Coast Guard unit responsible for releasing these messages for the Atlantic Area and Gulf of Mexico (except for Puerto Rico), is Coast Guard Communications Command (COMMCOM). These communications include NAVTEX, high-frequency voice broadcast (HF-VOBRA), high-frequency simplex teletype over radio (HF-SITOR), and weather fax. On behalf of NOAA, the Coast Guard broadcasts the offshore forecast and advisory, high seas forecast, tropical cyclone forecast and advisory, the tropical weather outlook, and weather faxes.

Prior to the summer of 2015, NOAA sent their weather messages directly to the Coast Guard. In the summer of 2015, NOAA could no longer access the Coast Guard's messaging system because the Coast Guard shifted to Command and Control Official Information Exchange (C2OIX) messages to align with the Department of Defense (DOD) policies. As a result, NOAA lost the ability to send their weather messages directly to the Coast Guard for transmission. To remedy this, the Coast Guard established an agreement with the Navy Fleet Weather Center (FWC-N) in which the Navy would access NOAA PORTS,[237] download the NOAA weather messages, and forward them to the Coast Guard for dissemination. This agreement was in effect during EL FARO's accident voyage.

When the Coast Guard receives the forwarded weather messages from the Navy, they are input into an automated distribution system. Any messages that will be voice broadcast are automatically converted into a digitized voice product. The messages are then queued for

[236] USCG-NOAA/NWS Coordination Liaison Group.
[237] Physical Oceanographic Real-Time System (PORTS) is a system managed by National Ocean Service office of NOAA designed to promote navigation safety by providing real-time tide, current and forecast data.

broadcast from a pre-designated antenna on shore. In the Atlantic, the Coast Guard has antennae in Boston, MA; Chesapeake, VA; Charleston, SC; Miami, FL; New Orleans, LA; and San Juan, PR. The high seas forecast, tropical cyclone forecast and advisory messages, and the tropical weather outlook are only scheduled to be broadcasted as HF-VOBRA messages from Chesapeake, VA and New Orleans, LA. The Offshore Forecast for sea area 20 (OFFN20) was broadcast as a NAVTEX message from Miami, FL and it also contained some limited information about tropical cyclone Joaquin. The OFFN20 is a condensed radio broadcast version of OFFNT3 (Marine Offshore Waters Forecast) with the same coverage zone as shown previously.

Coast Guard COMMCOM electronic logs of message release times are only required, per Coast Guard policy, to be maintained for 30 days, the logs are then deleted. The MBI contacted COMMCOM after the 30-day window, and therefore, many of the weather message logs were no longer available. COMMCOM did find an archived image[238] of their log client server record for September 30, and October 1; 19 weather messages could not be verified as sent and 2 weather messages were logged as having been missed. Of these messages, 11 messages contained information about tropical cyclone Joaquin. During MBI testimony, COMMCOM's Commanding Officer stated that the unit was running a Continuity of Operations (COOP) exercise[239] during the dates being reviewed. During this COOP exercise, they transferred control of their antenna to a server located in Pt. Reyes, CA. As a result, there was no way to determine if these messages were actually missed transmissions. Other messages that were grouped in these missing messages were sent and recorded during these periods when the COOP exercise occurred.[240]

COMMCOM does not maintain an exact schedule of when a particular weather broadcast will be delivered. COMMCOM did have a schedule showing which time windows each message was intended to be sent; however, the schedule was not made widely available to the public. According to testimony, mariners may access some information about when these messages are scheduled for broadcast from NOAA websites,[241] through Coast Guard NAVCEN's website,[242] or Nautical Pub No. 117.[243] However, the two-page compressed COMMCOM schedule that shows the entire broadcast schedule along with frequencies and windows of broadcasts was not available for public download.

There was no evidence on the VDR that the crew of EL FARO made attempts to receive COMMCOM's high frequency radio messages.[244] During MBI testimony, a former EL FARO Master stated that he did not use EL FARO's high frequency radio to receive COMMCOM broadcasts during his time on the vessel.

[238] MBI Exhibit 300.
[239] A COOP exercise tests the readiness of Coast Guard units to withstand the interruption of normal operations due to natural disaster or similar threat.
[240] MBI Transcript February 07, 2017, p. 314. CDR Crider was not the Commanding Officer assigned to COMMCOM on the date of the accident.
[241] http://www.nws.noaa.gov/om/marine/hfvoice.htm.
[242] https://www.navcen.uscg.gov/?pageName=mtMsi.
[243] NGA Publication No. 117, Radio Navigational Aids, 2014 Edition.
[244] MBI Exhibit 266.

7.2.11.6.6. EL FARO Shipboard Weather Measurement Devices

EL FARO was fitted with weather measurement instruments, including a digital and an analog recording barometer. Crew members mentioned barometric readings in millibars several times on the VDR. There was also an anemometer to measure wind speed and direction, but it was not properly functioning in the time period leading up to and including the accident voyage.[245]

The Master gave the following response to the C/M on September 30, 2015, after being asked if the anemometer wind velocity reading could be used:

*I wouldn't trust it.*

After being questioned about the wind speed at 5:10 AM on October 1, 2015, the Master responded with the following statement:

*We don't know. We don't have (any) anemometer.*[246]

During MBI testimony, a former EL FARO 2/M who served on EL FARO during the summer of 2015 stated that the vessel's only anemometer was not working when he was onboard. When asked for how long, he replied:

*I want to say 2 to 3 months, maybe longer because I was on vacation for a while. But at least 2 to 3 months.*

EL FARO's radars could be used to monitor sea and swell conditions as well as cloud and rain patterns. However, the only evidence the MBI could find indicating that the crew may have used the radar to monitor the storm was a brief exchange on the bridge of EL FARO at 3:27 AM on October 1, 2015, when the AB made the following statements:

*Think there's something (ahead/out there).*

*Look at that radar.*

*It's just getting' bigger— our path is going right through it.*

7.2.11.6.7. NOAA Voluntary Observing Ship (VOS) Program

The mission of the VOS program[247] is to collect and disseminate critical real-time maritime weather observations through the recruitment and support of ships. This fulfills national needs and international agreements supporting commerce, forecasts and warning programs, and the

[245] MBI Exhibit 301 lists under bridge equipment lists a "Wind Tracker" (anemometer) identified as manufactured by Young. R.M. Young. Young manufactures various models of "wind monitors" which measure the speed and direction of the wind.
[246] MBI Exhibit 266, p. 398.
[247] NOAA Voluntary Observing Ship (VOS) Program Internet Site.

safety of life at sea worldwide. Further, it is designed to help define the global climate and help measure extreme weather events, climate variability, and long-term climate changes.

VOS operates at no cost to participating vessels; NWS pays communication charges, observing equipment, and reporting supplies.

During a tropical cyclone, NOAA asks ships that transit within 300 miles of the movement of the storm's eye to make 3 hourly reports under the VOS Program. While it is not encouraged to be within 300 miles, the in situ data points are highly valuable in validating the forecast products. Ships in close proximity to tropical cyclones are able to provide validation for the NHC products being developed as the ships are able to make timely weather observations and then transmit them to NOAA.

EL FARO participated in the VOS program. Onboard EL FARO, as well as most participating vessels, the process required a bridge officer to draft a special formatted message for release to NOAA using the vessel's email server. In order to facilitate the process, NOAA Port Meteorological Officers provide training to crews upon request, and provide a computer program[248] that facilitates the formatting of the message. Once in the program, the officer filing the observation would follow the step-by-step instructions by making weather observations and looking at the computer program to come up with the appropriate answers. The observer would look at wind speed and direction, swell height, sea state, barometric tendency, cloud cover and other information. Although EL FARO was outfitted with an anemometer, the observations filed by EL FARO's crew during 2015 voyages generally noted that wind direction and speed were given as estimates instead of recorded measurements. The NTSB Factual Weather Report makes the following statement:

> *The NWS provided metadata on anemometer installations and wind reporting practices for all ships (active and inactive) in the US VOS Program database (current as of October 12, 2016). With regard to wind observing practice, approximately 99 percent of the vessels in the database (who did not have a "NULL" indicator for wind observing practice) were identified as using anemometers rather than visual estimation techniques for assessing the wind information they provide in ship reports.*

In July, August and September of 2015, there was a decrease in EL FARO's participation in the VOS program, only one report was filed for the month of September. On the accident voyage, the 2/M made the observation and prepared a VOS report on her watch. At 2:16 PM[249] on September 30, 2015, the 2/M made the following statement about her VOS report:

> *I sent a weather report I hope it works 'cause I've never had to do it before. Oh but it's for fourteen hundred and eighteen hundred weather report. Uh (send as) an email (I guess) * *.*

The Master then responded to the 2/M that she should email it out.

[248] TurboWin/AMVER software, publically accessible at http://www.vos.noaa.gov/turbowin_amver.shtml.
[249] MBI Exhibit 266, p. 130.

Upon receipt of EL FARO's weather observation report on the afternoon of September 30, 2015, the NWS forecasters discounted it because the ship's geographic coordinates contained in the message placed EL FARO over the mainland of Cuba.[250] This error in EL FARO's latitude and longitude made the observations unusable.

During MBI testimony the NHC's Hurricane Specialist Unit Branch Chief provided the following statement when asked if he could monitor vessels on the high seas:[251]

> *We see ship observations plotted on our display. So if a ship is reporting an observation we will see that. If a ship is not reporting weather observations then I think it's extremely unlikely that any of the hurricane forecasters would know about it.*

When asked about seeing vessels on the NHC display in close proximity to Hurricane Joaquin, he stated:

> *I have no recollection of seeing any. The forecasters who worked on shift might, but I don't.*

### 7.2.12. Safety Culture

#### 7.2.12.1. TSI Quarterly Safety Meetings

TSI held corporate safety meetings on a quarterly basis; this practice was in place in 2015.[252] Each quarter a safety newsletter was produced and the corporate meeting required that a sign-in sheet be filled out by the attendees. A review of these sign-in sheets found that while P/Es and senior officers from other TOTE vessels participated in the quarterly meetings, none of the P/Es or crew members from EL FARO or EL YUNQUE called into or participated.

The TOTE Newsletter lists the following examples under the category of "incidents" for the period that was reviewed: anchor brake, flooding, oil spill and loss of containments.

#### 7.2.12.2. The Designated Person Ashore

The Manager of Safety and Operations served as the TSI DPA, and in that capacity he had a direct line of communication to the TSI President. The DPA was responsible for an overall fleet of approximately 25 vessels. This included 14 active vessels and 10 vessels in a ready status which were not active. Although the Director of Safety and Services was designated the alternate DPA, TOTE expected the DPA to be responsible and on duty at all times. There was no evidence presented to indicate that the alternate DPA had been utilized to fill in for the DPA when the DPA was not in the office. The DPA's emergency telephone contact number was clearly identified onboard EL FARO and the 24-hour phone numbers and the backup phone number to the Emergency Call Center were posted in numerous locations onboard the vessel.

[250] MBI Exhibit 277.
[251] MBI Transcript May 17, 2016, p. 193.
[252] MBI Exhibit 061.

In February 2014, TOTE brought in a new Manager of Safety and Operations and DPA to work out of the Jacksonville TSI offices. The previous Manager of Safety and Operations/DPA left TOTE in May 2014. As part of the transition, the departing DPA prepared detailed turnover notes. These notes[253] contained job aids, best practices, and procedures, some of which were in the form of decision matrices. One of these decision matrices detailed the procedures for *Routine Daily Duties.*[254] That matrix or flow chart showed the processes related to vessel operations and the tracking of vessel movements.

The DPA job description is contained in the OMV:[255]

> *2.2.2 DESIGNATED PERSON*
>
> *The concept of a "designated person" is intended to provide the shipboard crew an additional option to express a safety concern if he/she is of the opinion that an unsafe condition or practice is not being satisfactorily addressed within the shipboard chain of command in a timely manner.*
>
> *In order to implement and monitor the ISM program, to ensure the safe operation of TSI's fleet and to provide a link between the company and the vessel, TSI has designated the Manager, Safety & Operations as the ISM Designated Person. His/her responsibilities and authority include monitoring of the safe operation and environmental protection aspects of the operation of TSI's fleet and that adequate resources and shore side support are applied.*
>
> *He/she has direct access to the President who represents the Executive Group. When performing as ISM Designated person, he/she shall act independently from other assigned responsibilities. The name and telephone number of the ISM Designated Person shall be posted in a relevant location selected by the Master. The post up should include the statement found in this section.*
>
> *Home and emergency contact numbers are located in OMV Section 11.6.*
>
> ***SHOULD A CONFLICT OF INTEREST OCCUR WITH THE DESIGNATED PERSON'S RESPONSIBILITIES WITHIN THE COMPANY, OR THE MASTER DEEMS THE ISM DESIGNATED PERSON TO BE NON-RESPONSIVE, THE MASTER HAS THE AUTHORITY TO CONTACT THE TSI VICE PRESIDENT/GEN. MGR., WHO UPON BEING CONTACTED WILL ASSUME ISM DESIGNATED PERSON RESPONSIBILITIES.***

MBI testimony from a former EL FARO crew member indicated that there was reluctance on the part of the TOTE vessel crew members to contact the DPA because of a general perception that raising issues could result in retaliatory action by TOTE. [256] While at sea, EL FARO crew

[253] MBI Exhibit 471.
[254] MBI Exhibit 417.
[255] MBI Exhibit 025, pp. 27-28.
[256] MBI Transcript February 14, 2017, p. 176.

members did not have the ability to anonymously communicate with the DPA. Confidential communications could only take place in proximity to shore using a crew member's personal cell phone or other communication device. When a vessel was at sea out of cell tower range, crew members would have to use satellite email or the vessel's satellite phone which was located on the bridge. In order to use the satellite phone, the crew would have to ask the Master for permission. Communications made on the ship's email equipment were not private and an Inmarsat email sent to the DPA from the ship could be reviewed by the Master in the ship's email server prior to release. The Master released the Inmarsat emails to shore in a batch, which could delay the delivery of an email that was drafted by a crew member voicing an urgent safety concern.

7.2.12.3. Safety and Operations Department

A partial list of the duties for the Manager of the Safety and Operations is listed below:

> *Coordinates with Marine Personnel Department to insure the assignment of properly licensed and capable individuals to man the vessels. Evaluates deck officers assigned to TSI fleet.*
>
> *Conduct shipboard security and safety assessments as necessary to meet SMS and regulatory obligations. Identifies risks to personnel, the environment and the ships and recommends corrective actions to sr. mgt.*
>
> *Participate in the investigation of accidents and injurers* [sic] *and cooperates in the preparation of material and evidence for organization use in hearings, lawsuits, and insurance investigations.*
>
> *SUPERVISORY RESPONSIBILITIES:*
>
> *Manage officers on managed fleet who supervise a total of 250 or more seagoing personnel on the active vessels. Is responsible for the overall direction, coordination, and evaluation of this unit.*[257]

The Manager of Safety and Operations did not evaluate EL FARO's Master or deck officers who were on board for the accident voyage. Neither he, nor TOTE, identified adverse weather as a potential risk to TSI vessels.

The Manager of the Safety and Operations, who was also the DPA at the time of the accident, had previously held a Merchant Mariner Credential as a Master of Steam or Motor Vessels of Any Gross Tons Upon Oceans, and was issued a Continuity Credential in July 2015.

The Safety Department sent out periodic Safety Alerts and Operations Memos to the fleet. The Operations Memos were described as interim notifications of important content that would eventually be incorporated as updates to the SMS.[258] Once the content of the Operations Memo

[257] MBI Exhibit 006, pp. 18-20.
[258] MBI Transcript February 17, 2016, p. 27.

was incorporated into either the OMV or the EPMV, the Operations Memo would be cancelled. The Safety Department also created Safety Alerts to disseminate critical information to TOTE vessels and crew.

An example of this alert is Safety Alert 15-008 (Hurricane Danny), which advised TOTE vessels about the formation of Hurricane Danny. The Alert also advised *ships in all oceans to review their vessel specific heavy weather procedures.* [259]

EL FARO had no vessel specific heavy weather procedure, plan, or checklist.

7.2.12.4. Internal Audits

Internal safety audits were a component of the TOTE SMS and an internal audit was performed on EL FARO on an annual basis. Audits were announced in advance and a list of items to be audited was also provided in advance. The audits normally occurred during cargo operations, there were no recent audits performed while the vessel was underway. There was no TOTE requirement to conduct audits to assess crew's proficiency while a ship was at sea conducting operations. The last internal audit for EL FARO took place on March 4, 2015.[260] A significant focus of the audit involved reviewing paperwork. A security audit was also performed at the same time. The Safety Manager signed the internal audit report for the last audit on June 4, 2015. There were no significant findings noted in relation to the actual operation of the vessel. The audit report did not indicate whether STCW rest records, medical logs, officer or crew evaluations, or other logs and records were examined and validated to determine the effectiveness of operations. For example, there was no record to show that an examination of the STCW rest records was completed in conjunction with a comparison to ship's logs, overtime, and payroll records to determine the accuracy of the crew's documentation of their required rest periods.

7.2.12.5. Determination and Notification of Safety Issues by TOTE

The TOTE OMV[261] states:

> *NEAR MISS REPORTING*
>
> *A "Near Miss" is defined by the IMO as "a sequence of events and/or conditions that could have resulted in loss. This loss was prevented by a fortuitous break in the causal chain of events and/or conditions."*
>
> *The ultimate objective of near miss reporting and investigating is to identify areas of concern and implement appropriate corrective actions to avoid future losses. To do so, requires that reports are generated, shared, read and acted upon.*

[259] MBI Exhibit 045.
[260] MBI Exhibit 311.
[261] MBI Exhibit 025, pp. 187-188.

*The reporting of a "Near Miss" may result, depending on potential severity of the incident or the materials involved, in the issuance of a Corrective Action Response. TSI is trying to learn from those incidents where a safety or mechanical issue is discovered and an incident averted. Near misses are not viewed by TSI as poor performance. Rather they are viewed as a necessary part of a functional and working QMS.*

*The sharing of the experience gained from "near misses" is critical. The on board safety committee shall review "near-misses" as they occur using the TSI form [TSI-V-SAF-027]. The Master (or person in charge of the vessel), shall forward the report to TSI Safety & Operations Dept by e-mail. TSI will review and disseminate to all appropriate vessels and related parties.*

The OMV also contained the following direction:

*The scope of near miss reporting is unlimited. All phases of vessel operation will be part of the near miss reporting concept. Some areas of special concern would include the following:*

- *Mooring operations*
- *Cargo operations*
- *Navigation of the vessel*
- *Critical operations*
- *Maneuvering*
- *Underway repairs*
- *Bunkering operations*
- *Shipyard periods*
- *Heavy weather precautions*
- *Port arrivals/departures*
- *Storing operations*
- *Confined Space entry*

*An ergonomic fix should also be reported as a near miss. If your vessel has discovered an actual or potential hazard and a way to eliminate this hazard through an adaptat*ion or *minor modification, the 'fix' should be shared with the other vessels in the fleet.*

During the MBI, senior TOTE officials testified that the Master of EL FARO had the overall responsibility for the safe loading and securing of cargo on the ship. There was no evidence presented to indicate that anyone else provided safety oversight of the actual terminal-to-ship operations. In mid-September 2015, there was as incident where the Master of EL FARO stopped the loading of the ship due to an excessive list that developed while loading. The C/M onboard at the time sent an email containing the following observation:

*Over the past few weeks the Captain and I have routinely needed to advise the SJU ops team of the vessels list and insist that steps be taken to remedy the problem….. An excessive list creates many large risks for the vessel and her equipment.*

During this incident the Master stopped cargo and performed a root cause analysis investigation to identify the causes of the problem. Both terminals were notified as well as management executives in TMPR. The Manager of Safety and Operations and TSI management were not notified of this safety related issue that involved the interaction between EL FARO and the San Juan terminal. Another excessive list incident due to improper cargo loading operations occurred in Jacksonville on September 29, 2015, as EL FARO was loading for the accident

voyage. In this second incident, there was no record of the Master stopping cargo. While the TOTE OMV discusses "excessive list," there are no specific procedures or checklists offering guidance on evaluating the safety impacts the excessive list might have on the vessel, dock side equipment (e.g., mooring appliances, loading ramps), or cargo.

During the summer of 2015, EL FARO was provided with Port Mates (P/Ms) to assist the ships' officers with cargo operations and other duties while in port. After September 1, 2015, TOTE stopped providing P/Ms to EL FARO in Jacksonville. TSI's Manager of Safety and Operations testified at the MBI that he was not aware of discussions about the absence of the P/Ms or what TOTE was doing, if anything, to get P/Ms back aboard EL FARO. Safety personnel were not involved in any discussions related to the absence of P/Ms for EL FARO.[262]

The assessment of an incident, near miss, or accident, was a duty of the Manager of Safety and Operations, as outlined in the SMS for TSI. This responsibility was shared with the Master of a TOTE ship. The EPMV made the following statement in Section 10.1:

> *GENERAL*
> *It is the responsibility of the vessel senior officers to ensure that accidents and incidents are thoroughly investigated and documented. This section is provided to assist the on board investigator with the process.*
>
> *It must also be noted that investigation of accidents and incidents involving non-crew members must be pursued with equal vigor. This includes passengers, contractors, guests, and longshoremen.*

During late 2014, an EL FARO C/M (not present on the accident voyage) was found sleeping on watch at sea on multiple occasions. Two different EL FARO Masters caught the individual sleeping on watch. However, the Masters did not make notifications to shore side labor relations or safety department personnel when the problem was detected. In mid-July 2015 almost nine months after the issue was initially identified, a notification was made to the DPA via an anonymous text message,[263] which included crew member commentary and photos. The person who contacted the DPA indicated that the issue was serious and that they intended to notify the Coast Guard. The DPA notified the TSI's VP of Operations. After a preliminary discussion, TOTE management decided that the matter would be handled by the human resources department,[264] and the issue was classed as a human resource problem. The DPA stated in MBI testimony that he believed that Labor Relations conducted an investigation.

The EMPV[265] contained a section that addressed investigation of incidents or accidents. The following distinction was made regarding an "incident":

> *For TSI's purposes, an incident is separated from an accident in that it involves damage to the vessel, cargo / machinery, or could cause significant harm to the environment.*

[262] MBI Transcript February 13-14, 2017, p. 1149.
[263] MBI Exhibit 282.
[264] MBI Transcript February 14, 2017, p. 1173.
[265] MBI Exhibit 026, pp. 168-171.

*10.7 USE OF FORM **TSI-V-SAF-012A***

*The primary use of this guide is as a day-to-day safety management tool for each ship. The intent is not to scrutinize the ship's performance as this could inhibit the development of honest reporting and the all important "no blame" culture.*

*Nevertheless, lessons learned on one ship may prevent accidents on another. The on-board Safety Committee shall summarize important findings on the last page of **TSI-V-SAF-012** and forward the report to the HQ Office in the Accident or Incident Package for inclusion in the total pool of safety wisdom. The TSI Manager of Marine Safety & Compliance will review all recommendations and make any appropriate comments or recommendations, returning a copy of the findings to the vessel.*

*This guide should not be used only for investigating serious accidents. Valuable lessons are to be learned from studying minor accidents and near misses, which often could have had more serious consequences, but for sheer good luck.*

The DPA, in his email correspondence with the VP of Commercial Ops, indicated that the central issue regarding the crew member allegedly caught sleeping was whether the anonymous report was viable and that there were *"a few different issues."* The DPA's email did not address potential impacts to the safety of the vessel and crew from the sleeping officer. In an email to the VP of Commercial Ops, the DPA wrote that he did not feel a full investigation was needed due to a lack of specific details.

An assessment of the human factors aspect of the sleeping incidents is discussed in the Human Factors section of this report. The MBI could find no record of the incidents in EL FARO logs, mariner evaluation forms and personnel files, or any other documentation produced by TOTE for the involved C/M or Masters. At the final MBI hearing in February 2017, TOTE produced a letter of warning[266] that was issued to the C/M for sleeping on watch. It was determined during subsequent MBI testimony that the C/M admitted to sleeping on watch and signed a letter of warning proffered by the Director of Labor Relations when he was confronted with the allegations.

7.2.12.6. Safety Culture Considerations Affecting EL FARO's Accident Voyage

7.2.12.6.1. Bridge Team Management

MBI testimony from several former EL FARO crew members indicated that the accident voyage Master's management style was primarily one-on-one interaction with his deck officers. A new TOTE Master who trained under EL FARO's Master stated the following when asked whether he gathered the navigation officers together as a group to talk about voyage plans, weather, and duties to protect the ship:

[266] MBI Exhibit 401.

> *I wouldn't say all at once as a formal meeting. I believe, you know when we got underway and preparing to get underway, he communicated those topics to each one of individually. Any night orders that he may have had. I found that he spent a lot of time on the bridge, at least with me.*[267]

Former EL FARO crew members testified that they did not personally participate in Bridge Team Management processes under the Master.

While standing watch during the accident voyage on September 30, 2015, the 3/M called the Master at 11:05 PM and again at 11:38 PM, to discuss a text-based SAT-C weather report that was received on the bridge at 10:56 PM. The 3/M stated that EL FARO was projected to be 22 miles from Joaquin's center at around 4:00 AM the next morning. During the calls the 3/M suggests three times that the Master might want to review or verify the new weather information. However, the Master did not come to the bridge and there is no indication in the VDR audio that the Master reviewed the SAT-C weather report.

7.2.12.6.2. Navigation Equipment

At the time of the accident voyage EL FARO was operating with an anemometer that had not been working[268] properly for an extended period of time. An anemometer is an instrument that allows for the accurate determination of relative wind direction and speed. Simple conversion of the relative wind speed and direction yields the true wind speed and direction, which are essential factors in determining the position of a tropical system in low visibility conditions. During MBI testimony EL FARO's P/E testified that either the Master or an EL FARO Mate, he could not recall which, told him the anemometer was not working around June of 2015. When asked if actions were taken to correct the issue, the P/E answered:

> *No, sir. If the Captain wanted it fixed he would have put in a work order for it and it would have got fixed.*

The MBI found no evidence indicating that the crew of EL FARO submitted a work order request to repair the anemometer after the verbal notification in June 2015.

7.2.12.6.3. Shore Side Support

EL FARO relied on TMPR for the following:

- safe loading of cargo, including dangerous or hazardous cargo,
- securing of unique loads,
- the weighing of cargo, and
- many other issues related to vessel loading and unloading operations.

[267] MBI Transcript May 24, 2016, p. 42.
[268] MBI Transcript February 18, 2016, p. 57.

There was no "safety department" within the TMPR corporate organization.[269] There was a "risk management" component in the TMPR organization, but that component did not examine or address the safety of terminal operations as they related to the vessels. The TMPR VP of Cargo Service[270] testified that she could not recall if there were specific Saltchuk University[271] training, safety meetings, or other guidance specifically related to the safety of cargo operations.

7.2.12.6.4. Riding Crew

On EL FARO's accident voyage, four of the five Polish riding crew members did not speak English, and none of them received the required training on muster location for abandon ship, alarms, emergency procedures, and lifesaving equipment familiarization. The Polish riding crew also did not receive the indoctrination for non-crew and contractors, which was required by TOTE policy. The NTSB collected information from the spouses and families of the deceased riding crew as part of its investigation. The spouse of one Polish riding crew member provided the following response in an NTSB questionnaire:[272]

> *After he boarded the boat, my husband was in despair about the conditions there. He told me it was dirty and hot because the air conditioning was not working. He was happy that he had managed to get a cabin with a fan. He also said he had never seen or worked on a hulk like this. While he was working, rust was falling into his eyes. He didn't go through any training about boat safety, such as an evacuation drill.*
>
> *My husband wasn't telling me about weather conditions because he knew I was worrying a lot. During my husband's voyage on the El Faro there were two tropical storms that I found out about only after they were over. My husband was trying to calm me down and he was telling me not to worry because their Captain was prudent and he in such situations would always steer in between islands, which was safer.*[273]

7.2.12.6.5. Lifesaving Equipment

EL FARO's Station Bill[274] states:

> *1) Each person, upon boarding the vessel, shall familiarize himself with his assigned location, in the event of an emergency.*
> *2) All crew members shall be thoroughly familiar with the duties they are assigned to perform in the event of an emergency.*
> *3) Each person on board shall participate in emergency drills and shall be properly dressed, including a properly donned life preserver.*

[269] MBI Exhibit 047.
[270] MBI Transcript May 27, 2016, p. 20.
[271] Saltchuk University – a corporate in house training program that is requires specific personnel in the office setting to complete 12 training class per year on a wide variety of topics.
[272] NTSB Human Factor Factual report July 26, 2017.
[273] The questionnaire response was translated to English by the U. S. State Department.
[274] MBI Exhibit 326.

On the VDR transcript, both the 2/M and Master are heard making statements questioning whether there were lifejackets on the bridge and where they were stowed. The 2/M first commented on this around 1:46 AM on October 1, 2015, and the Master's comments were made around 7:30 AM just prior to the sinking. Under 46 CFR § 199.70(b)(2)(iv), additional lifejackets for watch personnel must be stowed on the bridge because it is a manned watch location. A former C/M and Master of EL FARO testified during the MBI that he believed there were lifejackets stowed on the bridge while he was onboard.

7.2.13. Human Factors

7.2.13.1. TOTE –Marine Personnel

7.2.13.1.1. TOTE Drug and Alcohol Policy

The TSI OMV states:

> *TSI's company policy prohibits the use of alcohol, narcotics or drugs on company vessels or reporting for work under the influence of these substances. It is, and has been, TSI's expressed intent to actively discourage all forms of illegal drug activities. This includes the use, sale, traffic and possession of drugs. Persons should also note that use of prescription drugs by anyone other than the person listed on the prescription or in the Medical Logbook is prohibited by law and TSI policy. (Crew members shall advise the Master at sign-on of all current Prescriptions).*[275]

The OMV does not address the use of over-the-counter medication by crew members.

The TSI Crewing Manager stated in testimony that TSI maintained a "[z]ero tolerance drug and alcohol policy."[276]

TSI marine personnel participated in a random testing program for illegal drugs. The TSI OMV states:

> *When a vessel is selected for random drug testing, the following procedures must be observed in order to comply with AMS's, Coast Guard reviewed, compliance plan. The TSI Manager, Safety & Operations will contact the Captain (or person in charge of the vessel) 24 hours prior to the scheduled collection to inform him/her of the pending collection*.[277]

The TSI coordinator for the random testing program notified EL FARO of an upcoming random drug test via email at 10:15 AM on September 25, 2015.[278] The email except below shows that the notification exceeded TSI's 24 hour limit described in company policy:

[275] MBI Exhibit 025, p. 103.
[276] MBI Transcript February 16, 2017, p. 1583.
[277] MBI Exhibit 025, p. 101.
[278] MBI Exhibit 301, p. 10.

*Sent: Friday, September 25, 2015 10:15 AM*
*To: capt@vessel.com*
*Cc*: *Manager, Safety and Operations/ DPA; Sea Star Port Engineer, EL YUNQUE; Sea Star Port Engineer, EL FARO*
*Subject: Random Drug TEST - El Faro*
*Good Morning,*
*The El Faro has been selected for a random Drug Test. It is scheduled for arrival in Jacksonville on Monday Morning Sept 28, 2015 The collector will be in touch with you P/E for port access requirements and to confirm the arrival schedule.*

Ultimately the testing scheduled for September 28, 2015, did not take place because the collection company was not able to meet the vessel and conduct testing.

7.2.13.1.2. TOTE Medical Screenings for Crew Reporting Aboard

The TSI OMV addresses medical reporting procedures for oncoming crew members:

*The Master is responsible for having each crew member complete a statement of physical condition form when joining or being reassigned to the vessel. This form is to be completed by each crew member who joins your vessel in a sailing capacity. (It does not have to be completed for port standbys or reliefs.) Any and all returning crew members are to complete this form each and every time they return - the fact that they completed it once is not sufficient*.[279]

In MBI Testimony, a previous TOTE Master described a system whereby mariners would receive a physical before reporting to the vessel. In that testimony he stated:

*The new required physical for all crew members administered by Anderson Kelley seems to be working good, this should weed out the personnel that aren't physically able to do their jobs or have preexisting conditions that they don't write on their sign-on forms*.[280]

There is no evidence that the requirement for crew to obtain physical exams was still in effect for EL FARO crew members on the accident voyage.

The unlicensed crew members on EL FARO were provided a "Fitness for Duty Certification" as part of the Seafarer's Health and Benefit Plan for their union, the Seaman's International Union (SIU). This certification remained valid for one year from date of issuance.

The officers of EL FARO were required to complete a physical for their Coast Guard credential renewal at five year intervals.

[279] MBI Exhibit 025, p. 281.
[280] MBI Transcript February 16, 2017, p. 1663.

7.2.13.1.3. EL FARO's Accident Voyage Master

EL FARO's Master was properly credentialed by the Coast Guard. His MMC allowed for service as Master on vessels of unlimited tonnage upon ocean routes. He held his Master's unlimited credential since July 2001 and was on the fourth issuance of this officer level credential. His credentials also included an endorsement for pilotage of Prince William Sound in Alaska. His previous experience was in the tanker trade in the Pacific Northwest and the RO/RO trade on the Atlantic Ocean.

An examination of the records for EL FARO officers, including the Master, revealed that personnel evaluations, disciplinary records, and other required forms were missing from the personnel files.[281] A former EL FARO Master who resigned in August 2015 testified during the MBI that he was not aware of a process for conducting his evaluations.[282]

Prior to rejoining TOTE in 2013, EL FARO's Master worked as a Master for another company starting in 2010. In a NTSB Interview of the Master's spouse focusing on why the Master left his previous employer she stated:

> *So he ordered two tugs to move the ship and when he came back from vacation they weren't too happy with the bill and told him he was no longer employed*.[283]

When the Master approached TSI for employment in 2013, he was asked why he left his previous employer. TSI's Crewing Manager testified during the MBI that the Master told her he had "resigned."[284]

The interview of the TSI Crewing Manager and a review of TOTE's personnel records indicated the Master left the previous employer as a Master and came to work at TSI as a 3/M in May 2013. He was initially assigned to a vessel in Hawaii, the cargo vessel PACIFIC TRACKER as the 3/M.

The TSI Crewing Manager indicated that she did not check references or conduct a background check on the Master from his tenure at his previous employer. The Crewing Manager also testified that work histories were not typically checked for marine employees being hired.[285]

The sudden termination of senior officers on EL MORRO in mid-summer 2013 ultimately provided the Master an opportunity to move up and fill the position as EL MORRO's Master. The Master took command of EL MORRO in July 2013. At the end of the rating year in October

[281] Evaluations were required by TOTE to be conducted for unlicensed to C/M positions at the completion of service period. In the case of the Master and C/Es the evaluations were to be conducted annually with a two step review process, Port Engineer and then Director of Ship Management. In the case of the Master's evaluation this would be conducted by marine engineers.
[282] MBI Transcript May 16, 2016, p. 34.
[283] NTSB Testimony – 4 – Transcript of Interview of Wife of EL FARO Captain, January 05, 2016.
[284] MBI Transcript February 16, 2017, p. 22.
[285] MBI Transcript February 16, 2017, pp. 1561-1562.

2013, he was evaluated as Master for one rotation period on the vessel. During his employment at TOTE, the Master received a total of two incomplete evaluations. In October 2013, he was rated as Master on EL MORRO including a rating of "exceptional" in the categories "safety awareness" and "vessel safety record" and in "cooperation with technical manager." In the performance dimensions of "cargo familiarity or eng. plant familiarity" he was rated as "good." In the remaining categories he was given numerical ratings from 4 to 4.5 which were defined as "very good."[286] Although TOTE's evaluation system required a second level reviewer, the Master's July 2013 evaluation had no input from, and was not signed by the second level reviewer.

The Master took command of EL FARO in May 2014. His 2014 evaluation was completed by EL FARO's P/E and the Master was rated "exceptional" in all of the completed areas for the evaluation.[287] The "5" ratings were the highest numerical rating. As with the 2013 evaluation, the Master's May 2014 evaluation form was not forwarded to the Director of Ship Management for input or final approval. As a result, the performance dimension labeled "cooperation with technical manager" was not graded. Neither the 2013 nor the 2014 evaluations were completed in accordance with TSI policy, and neither were discussed with the Master as the evaluated employee.

In the DPA turnover notes dated January 20, 2014, one of the duties of the Safety Manager was to perform evaluations for senior officers every fall.[288] The Director of Labor Relations testified as to why the Master's final evaluation was incomplete:

> *Not 100 percent certain, but I think it was– knowing about it, it was somewhere lost on the hand off between the Port Engineer and the Director of Ship Management. Because it had been executed at least by the Port Engineer*.[289]

In the middle of 2014, construction of the MARLIN class ships was progressing, and TSI began considering crewing options. In May 2015 EL FARO's Master was being considered for a position as Master on one of the new MARLIN class ships. A team of senior TOTE officials was formed to select crews for the vessels and the team gathered comments on the various candidates. The team did not select the Master, based on negative comments that were received, including comments related to his suitability for command. The TSI Crewing Manager, in a May 26, 2015 email to the Director of Labor of Relations, who was also on the interview team, gave examples of comments[290] considered by the interview team:

> *Regarding* [the Master]:
>
> *There was a report several months ago that he had not been making rounds on deck/ cargo spaces. He was on vacation at the time this was brought to our attention. The situation was monitored upon his return to the vessel and it was noted he had been*

[286] MBI Exhibit 424.
[287] MBI Exhibit 052.
[288] MBI Exhibit 006.
[289] MBI Transcript February 17, 2016, p. 155.
[290] MBI Exhibit 005.

*making rounds to check on any work in progress and overall condition of the vessel. I still do not feel as though this is being done consistently, but the only true way to monitor this situation is to enlist spies onboard the vessel to "rat him out" so to speak if he is wearing a path between the bridge, his office and the galley. This becomes something that is very hard to prove when the vessel is at sea, but is a concern.*
*Dwindling confidence in his abilities as a leader overall.*

*This situation is being monitored at this time. Any failure to handle future issues properly will result in a verbal or written warning and progressive discipline to ensure the EL FARO is being properly managed, but I would not recommend him for a position on the Marlins.*

The Crewing Manager testified that the email quoted above represented the consensus of the TOTE interview team that conducted the interview for the Master[291] rather than her personal assessment of the Master's attributes.

When the Master was not selected to a position on a MARLIN class ship, he sent an email in July 2015 to the TMPR President, asking to use the President as a reference for other possible jobs. As the MARLIN master selection process was still ongoing at the time, the TMPR President interacted with TSI, the result of which was the Master being given another interview for the MARLIN class ships. The TSI President communicated that the Master should be considered for a position as Master of one of the new ships. In advance of this interview there was an email exchange[292] between the Director of Ship Management and the VP Marine Ops. The Director of Ship Management email included the following statement about the Master:

*Subject: Re: Confidential Master Candidate*

*He's a stateroom Captain. I'm not sure he knows what the deck looks like. Least engaged of all four Captains in the deck operation.*

The VP Marine Ops provided the following response in a reply email:

*Needless to say I'm not happy about this message; but we just have to work through it. Can you provide me with some simple talking points why we didn't select him? Not active, not on deck, all talk no action, so on and so forth. Keep this confidential.*

Despite the concerns voiced in the emails, a decision was made, after the second interview, to give the Master an assignment as Master of the second new MARLIN class ship, PERLA DEL CARIBE.

In August 2015, the TSI President sent the following email to the TMPR President:

*After a thorough assessment of* [the Master], *I am pleased to inform you that* [the Master], *will be offered the position of Master in Marlin 496.* [the Master], *will be*

[291] MBI Transcript February 16, 2017, p. 27.
[292] MBI Exhibit 005, p. 14.

> *assuming Master of EF on Tues, so it affords to meet with* [the Master], *F2F to convey our desire for him to sail Master in 496. Would you be available on Tuesday to kindly join me so we can deliver the positive news together?*
>
> *Following delivery of the positive news,* [*VP of Marine Operations Commercial] and I intend to stay behind in order to provide* [the Master], *feedback garnered from the operational team during the interview process. I think it will serve as constructive insight for* [the Master], *to further enhance his operational effectiveness as he moves forward with our TOTE Maritime team.*

The plan was for TSI Management to deliver the positive news, in person, at EL FARO's Jacksonville port call on August 11, 2015. Prior to this occurring, however, the Director of Labor Relations and the Crewing Manager sought out the TSI President and expressed unknown concerns relating to the Master's selection. During MBI testimony the Crewing Manager stated:[293]

> *The general points that were raised were different points that had been discussed with several people in the selection committee and they were raised again at that time with* [*TSI President*]. *And then a discussion took place after that I was not – that I didn't participate in.*

It is unclear through evidence or testimony if the Master was ever told of the fact that he was not selected for any position on a MARLIN class ship. On September 24, 2015, the Master sent an email to one of his immediate family members stating:

> *I have no idea if I am even going on the Marlin Class vessels yet.*[294]

In 2015 there were recommendations made that the Master should receive two verbal warnings related to performance of duties as Master of EL FARO. In both cases these warnings were intended to be formal written warnings. In one instance, the Master was notified that minor steel repairs were supposed to be undertaken. These repairs were not completed in a timely manner; this incident resulted in a January 2015 proposal for a written warning to be issued to the Master and C/E. The MBI found no written warning despite the fact that the VP Ops later stated the following in an email:

> *They need to be written up. This is unacceptable.*[295]

The second incident where a written warning was discussed for the Master related to the case of an EL FARO C/M (not the C/M on the accident voyage) repeatedly sleeping on watch. The incidents occurred on EL FARO while the ship was underway. Both the accident voyage Master and a Master who resigned in August 2015 were aware that the C/M was sleeping on watch.

[293] MBI Transcript February 15, 2017, p. 38.
[294] MBI Exhibit 302, p. 9.
[295] MBI Exhibit 005, p. 5.

During the EL FARO's accident voyage on September 30, 2015, at 8:50 PM the 3/M made the following statements on the bridge to his AB in regard to the past incidents involving the sleeping C/M:[296]

> *Like [ex EL FARO C/M]— the first time he fell asleep on watch— he must have been "huh that was kind of nice and refreshing."*
>
> *Then he got caught and nothing happened. Then he caught again and nothing happened.*
>
> *[Expletive] kept on doing it.*

Despite being caught by both two EL FARO Masters, there is no evidence to indicate that the Masters informed TSI management or the DPA about the incidents.

7.2.13.1.4. Evaluation of Other EL FARO and EL YUNQUE Officers

The junior deck officers on the accident voyage were not evaluated in accordance with company policy in terms of the required frequency. In late August 2015, a crewing assistant notified[297] the crewing manager that she had not received evaluations for the company ships as required. The crewing manager asked for a list of the vessels that were not in compliance with the TOTE evaluation policy. The assistant subsequently provided a list of vessels and neither EL FARO nor EL YUNQUE was included on the list despite having mariners on board who were overdue.

The evaluation record for officers on EL FARO was as follows:

| Accident Voyage Officers EL FARO | |
|---|---|
| Position | Last Evaluation Produced |
| Chief Mate | June 2015[298] |
| Second Mate | November 2011 |
| Third Mate | February 2014 |
| Chief Engineer | October 2014 |
| First Assistant Engineer | June 2015 |
| Second Assistant Engineer | May 2015 |
| Third Assistant Engineer (1) | January 2015 |
| Third Assistant Engineer (2) | November 2015 |
| Third Assistant Engineer (3) | N/A |

Overall the average rating for these officers was very good to excellent with some exceptions.

On October 2, 2014, EL YUNQUE's P/E, who would later become the TOTE's Director of Ship Management – Commercial, sent an email that included in the following statement along with his completed evaluations for EL YUNQUE's senior officers:

[296] MBI Exhibit 266, p. 253.
[297] MBI Exhibit 178.
[298] Evaluated on EL YUNQUE for the positions of 2/M and 3/M.

*My honest evaluations will kill motivation for the following individuals. I know we have to word them very carefully. These are draft comments. I don't want to finalize these comments until we're all in agreement that you have no plans to take them to the Marlins. Feel free to add to the below.*[299]

7.2.13.1.5. Attrition in the Senior Officer Positions aboard EL FARO and EL YUNQUE

In late summer of 2015, two TOTE masters resigned; one from EL YUNQUE and one from EL FARO.[300] One of the permanent Masters of EL FARO resigned and departed EL FARO on August 4, 2015. On August 3, 2015, the Crewing Manager sent an email[301] to the Director of Labor Relations and stated that one of the reasons he resigned was:

*....and all of the Drama* (sic) *that is going on aboard the EL FARO he decided to resign.*

The attrition, coupled with the demotion of an EL FARO C/M for sleeping on watch, caused a shuffling of officers to fill positions on EL FARO. To backfill crewing needs, a 2/M (with an unlimited Master credential) was brought over to EL FARO to sail as C/M. In the months of August and September 2015, EL FARO had four people sail as C/M, the last being the C/M who moved over from EL YUNQUE from his former position as 2/M.[302] That C/M sailed on the accident voyage.

7.2.13.1.6. Training and Certification of other EL FARO Officers

An examination of the Coast Guard records for EL FARO officers indicated that there were no deficits in the required Coast Guard training for the officers on the accident voyage.

The training for EL FARO 3A/Es was conducted at the maritime academies. Their particular training focused on marine engineering. The engineers graduated with 3A/E marine engineer licenses for motor and steam propulsion. Some engineers also received an endorsement for gas turbine propulsion systems.

The MMC endorsements for EL FARO engineers on the accident voyage were:

- One 3A/E had: 3A/E of steam, motor, or gas turbine vessels of any horsepower.
- Two other 3A/Es had: 3A/E of motor or steam vessels of any horsepower.

All 3A/Es attended Maine Maritime Academy. The training ship for that school is the "State of Maine," which is a diesel powered ship. Only one of these 3A/Es sailed on a steam powered ship during the course of their sea cruise training. The 3A/E that joined the vessel on the accident departure day did not have practical maritime experience on a steam powered vessel prior to signing on EL FARO. Once aboard EL FARO, the intent was to pair the newly reporting

[299] MBI Exhibit 423.
[300] MBI Exhibit 005, p. 42.
[301] MBI Exhibit 305, p. 1.
[302] MBI Exhibit 005, p. 42.

3A/E with another experienced steam 3A/E to provide onboard orientation and familiarization with the steam plant and the engineering systems on EL FARO. The newly reporting 3 A/E was an extra engineer not required by the EL FARO's Certificate of Inspection.

7.2.13.1.7. TOTE – Cargo Operations, Port Mates, and Fatigue

Each time EL FARO arrived in Jacksonville, the ship's crew would unload cargo and then begin the process of loading and securing cargo. The efficiency of the vessel's arrivals and departures was noted on a TOTE management spreadsheet. These statistics indicated 100% attainment of the goal if the ship departed or arrived within a scheduled two hour window.

To assist in the cargo loading and unloading, an additional P/M was routinely brought aboard while EL FARO was in both Jacksonville and San Juan. The P/Ms served two functions. First, they directly assisted with the oversight of cargo securing and lashing, second, they provided the full time Mates with in port rest periods to mitigate the effects of fatigue. Typically the 2/M and 3/M would stand 6-hours on and 6-hours off watch rotation while in port, and the C/M would stand a 6:00 AM to 6:00 PM watch in port. During MBI testimony, a former EL FARO C/M described the need for a P/M as "essential," and there were multiple[303] internal TOTE emails related to the need for the P/Ms on EL FARO.

At one point, the Marine Operations Manager emailed that he thought about getting the appropriate Merchant Mariner Credential so he could fulfill the duties of the P/M. The P/M that served on September 1, 2015 would be the last P/M employed on EL FARO in Jacksonville. TOTE had difficulty locating qualified P/Ms, however, the issue was not raised above the level of the Marine Operations Manager at the Jacksonville Terminal. There is no evidence that the absence of the P/Ms and the potential impacts to the safety of EL FARO were communicated to TSI management beyond the terminal during the pre-accident timeframe starting on September 1, 2015.

While standing watch on the bridge of EL FARO on September 30, 2015, the 3/M made several statements to the AB regarding lack of P/Ms and the resulting effect on cargo operations. Section 7.2.10.1. of this report includes those statements.

7.2.13.1.8. TOTE – Training for Marine Personnel

TOTE required training for its marine personnel under the supervision of the Safety and Operations Department and the Master of EL FARO. This training was accomplished through shipboard drills, safety, and ISM Code safety committee meetings, and through TOTE's tracked training. Evidence shows that this training adhered to the frequency and schedule published by the company. Tracked training could cover a wide variety of relevant subjects and sign up and tracking sheets were provided.[304]

In addition to shipboard training, marine personnel were required to attend professional training for the maintenance of their Coast Guard issued MMCs. TOTE did not provide

[303] MBI Exhibit 303.
[304] MBI Exhibit 355.

additional enhanced training, with the exception of LNG Safety Awareness Training for personnel designated for assignment on the new LNG fueled MARLIN class ships. This specialized training was a requirement for crew on the new LNG fueled ships.

In March 2015, EL FARO's Master attended two classes during his time ashore. This training was comprised of Radar Refresher Training which is required at five year intervals, as well as Leadership and Management Training, which is an STCW training requirement. The Leadership and Management Course at the STAR Center in Dania Beach, Florida covered the following subjects:

Leadership and Management:

- Decision Making
- Strategic Planning, Task and Workload Management
- Effective Resource Management Onboard
- Effective Communications
- Assertiveness, Leadership and Motivation
- Obtaining and Maintaining Situational Leadership

Leadership in the Maritime Environment:

- Personnel Management and Administration
- Operations, Drills and Training
- Maintenance and Dry-docking
- International Maritime Conventions and Recommendations and National Legislation
- Safety and Environmental Leadership in the Maritime Industry
- Development, implementation and oversight of standard operating procedures

TOTE did not provide enhanced training for EL FARO officers such as emergency ship handling, heavy weather ship handling, damage control, weather training or other optional training courses designed to enhance expertise for handling the variety of special situations that may be encountered at sea. There was no specialized training provided to EL FARO officers covering stability or cargo securing.

7.2.13.1.9. EL FARO – Functioning of Bridge Team (Resource) Management (BTM)

In numerous instances on EL FARO's VDR transcript[305] the Master used the words "low" and "storm" when discussing Hurricane Joaquin with other crew members. The Master was never heard using the words "hurricane" or "tropical storm" on the VDR audio or in recorded calls to shore.

At 1:20 AM on October 1, 2015, the 2/M made the following statement to the AB on watch after hearing on the satellite radio that Hurricane Joaquin had been upgraded to a Category 3 storm:

[305] MBI Exhibit 266.

*I'm gunna give the captain a call and see if he wants to come up and (look at it) *.*

The 2/M passed the following update to the Master on the house phone a minute later:

*Right now my uh– trackline I have zero-two hundred– alter course straight south and then (we'll) * go through all these * shallow areas. Umm (and the next) course change (will/gunna) be (through the Bahamas) and then (just gunna) turn * * *.*

The total conversation lasted 2 minutes and 7 seconds and the Master did not come to the bridge following the call.[306] Immediately after the call, the 2/M informed the AB that they were going to run the course that had been planned out the night before. At 1:24 AM the 2/M directed the AB to start easing EL FARO to port in order to slowly obtain a course of 116 degrees true directly toward their planned destination of San Juan, Puerto Rico. The Master did not come to the bridge until 4:09 AM.

At 1:43 AM[307] the AB on watch reported seeing unidentified flashes of light on the ship and discussed the possible causes of the flashes with the 2/M. The Master was not notified of the unidentified flashes of light.

At 2:11 AM the AB reported that there was clanking going on during a period of time when there were also comments about green (seawater as opposed to spray) water on the bow. The Master was not notified of the clanking sounds or the green water on the bow.

At 2:53 AM the first steering alarm [308]was heard on the bridge. This alarm indicated that the ship was more than three degrees off course.[309] At 3:20 AM, the steering alarm began to be sound more frequently. At 3:21 AM the 2/M made the following statement to the AB:

*Yeah– she's goin'– she's goin' left– she's got right rudder.*

When the 2/M turned over the watch to the C/M at approximately 3:47 AM, there was no evidence on the VDR that she briefed him on the thumps and clanking noises heard and the unidentified flashes observed occurring on the forward portion of the ship. The 2/M did not notify the Master of the steering alarms she experienced during her watch or the difficulties she encountered while trying to maintain course in worsening wind and sea conditions.

7.2.13.1.10. INTEC Polish Riding Crew

The TSI OMV[310] stated the following:

[306] EL FARO's VDR indicated that the Master came to the bridge at 4:09 AM on October 01, 2015.
[307] MBI Exhibit 266, p. 318.
[308] MBI Exhibit 266, p. 336.
[309] MBI Exhibit 266, p. 337.
[310] MBI Exhibit 025, p. 86.

> *All persons covered by the 'underway' section, shall be included in the "new crew member indoctrination procedures" described in OMV 3.2.1 and shall sign the "Non- Crew Indoctrination" log stating that they have been given appropriate emergency instruction. In addition all persons covered by this section shall complete "Seaman's Statement of Physical Condition," [TSI-PER-005].*

Beginning on August 18, 2015, there was a Polish "riding crew" onboard EL FARO to conduct the Alaska service conversion work. This crew worked under the direction of an off duty EL FARO C/E, who was working on a contracted basis. Only one member of the Polish riding was fully fluent in English and that individual served as the interpreter for the other four members of the riding crew. No other provisions were made by TOTE officials or EL FARO crew members to mitigate the language barriers faced by the riding crew members and there were no safety or work instructions provided in Polish.

On the departure day of the accident voyage, two members of the riding crew that had been on EL FARO during previous voyages were relieved and returned to Poland. They had been onboard EL FARO since the start of the conversion work in mid-August. During the MBI hearings, a riding crew witness testified that when he arrived on EL FARO he was not aware it was Atlantic Hurricane season. He also testified that he received a general orientation of the vessel and completed a medical questionnaire, but did not receive a safety briefing, don a life jacket or immersion suit, or receive information about his muster station and lifeboat assignment.

When asked by the MBI if he attended safety drills the former Polish riding crew member stated:[311]

> *We did not participate in those— we did not participate in those drills because they did not apply to us.*

A spouse of one of the deceased Polish riding crew members also provided the following response to an NTSB questionnaire:

> *He didn't go through any training about boat safety, such as an evacuation drill.*

A former EL FARO Bosun also testified during the MBI that he did not see the Polish ship riders at any drills, including boat drills.[312]

Safety familiarization and basic safety training requirements of the International Convention of Training, Certification, and Watchkeeping for Seafarers (STCW), 1978, are mandated by law.[313] There was no evidence presented that Coast Guard approved basic safety training was completed by the riding crew, in accordance with STCW Regulation VI/1 and 46 CFR § 15.1105.

[311] MBI Transcript February 15, 2017, p. 22.
[312] MBI Transcript February 23, 2017, p. 135.
[313] 46 U.S.C. § 8106(a)(4).

7.2.13.1.11. Fatigue and STCW Rest Requirements

TOTE employed a medical firm, Andersen-Kelly, to certify mariners as fit for duty before signing onboard a ship.[314] The Master was responsible for evaluating the medical information that was provided by mariners as they checked in aboard the vessel, to determine if there were any current medical issues or medication issues that would render the seafarer unfit for duty.

Merchant mariners are required to take a physical every five years as part of the process to renew their MMC. Mariners must document that they have seen a medical practitioner and obtained a physical. In the Application for Merchant Mariner Medical Certificate (CG-719K (01/09), OMB. 1625-0040) questionnaire portion of the document on page 4 of 9 there is a section on Medications, Section III. The 2015 version of the form included these instructions:

> *Credential applicants who are required to complete a general medical exam are required to report all prescription medications prescribed, filled or refilled and/or taken within 30 days prior to the date that the applicant signs the CG· 719K. In addition all prescription medications, and all non-prescription (over-the-counter) medications including dietary supplements and vitamins that were used for a period of 30 or more days within the last 90 days prior to the date that the applicant signs the CG· 719K or approved equivalent form must also be reported.*
>
> *The information reported by the applicant must be verified by the verifying medical practitioner or other qualified medical practitioner to the satisfaction of the verifying medical practitioner to include the following two items.*
>
> *1. Report all medications (prescription and non-prescription), dietary supplements, and vitamins.*
>
> *2. Include dosages of every substance reported on this form. as well as the condition for which each substance is taken.*
>
> *Additional sheets may be added by the applicant and/or qualified medical practitioner if needed to complete this section (include applicant name and date of birth on each additional sheet).*

On the morning of October 1, 2015, at 1:05 AM the 2/M made the following statement to the AB about how she avoided hearing all the noise created by the riding crew:[315]

> *Well I wasn't awake for that.– Nope. Ear plugs– Zzzquil. That Zzzquil knocks me out. I love it– It's just when it wears out– I wake up.*

The February 25, 2015, CG-719K submitted by EL FARO's 2/M listed "none*"* in the "Medications or over the counter (OTC)" section.[316]

[314] MBI Transcript February 16, 2017, p. 1663.
[315] MBI Exhibit 266, p. 301.
[316] Coast Guard National Maritime Center; Mariner files.

Coast Guard NVIC 04-08 Change 2, which came into effect in 2016, after the loss of EL FARO, states the following:

> *25 APR 2016*
> *COMMANDANT CHANGE NOTICE 16700.4*
> *Subj: CH-2 TO MEDICAL AND PHYSICAL EVALUATION GUIDELINES FOR MERCHANT MARINER CREDENTIALS, NVIC 04-08, COMDTPUB 16700.4*
> *Ref: (a) Marine Safety Manual, Volume III, Marine Industry Personnel, COMDTINST.*
>
> *Important Safety Warning.*
>
> *Certain medications, whether prescription or over-the-counter, have known impairing effects and their labels warn about risk of drowsiness and caution against use while driving or operating hazardous machinery.*
>
> *The nature of shipboard life and shipboard operations is such that mariners may be subject to unexpected or emergency response duties associated with vessel, crew, or passenger safety, prevention of pollution and maritime security at any time while aboard a vessel.*
>
> *In the interest of safety of life and property at sea, the Coast Guard views shipboard life and the attendant shipboard duties that can arise without warning, as safety sensitive duties that are analogous to operating hazardous machinery. As such:*
>
> *1. Mariners are advised to discuss all medication use with their treating providers and to inform them of the safety sensitive nature of their credential; and 2. Mariners are cautioned against acting under the authority of their credential while under the influence of medications that:*
>
> *a. can cause drowsiness, or*
>
> *b. can impair cognitive ability, judgment or reaction time, or c. carry warnings that caution against driving or operating heavy machinery.*
>
> *3. Mariners are advised that they are considered to be acting under the authority of the credential, for the purposes of this Enclosure, anytime they are aboard a vessel in a situation to which 46 CFR § 5.57(a) applies, even when off-watch or while asleep, or any time they are subject to recall for duty or emergency response.*

In an NTSB interview[317] a friend of the 2/M stated the following:

[317] NTSB Interview Testimony, 4 – Transcript of Witness Interviews, Friends of 2/M, November 04, 2015.

*NTSB: With the captain that was on board the ship during the accident,* [the Master], *did you ever get any indication that she either enjoyed -- or how she felt working with him or for him?*

*Witness: She couldn't stand it. She was exhausted. There were a lot of weird rules put in place that they had to be on the 12 hours, and it couldn't be the 8 to 12. It was strict 12. She was always exhausted and tired.*

On September 28, 2015, the 2/M sent the friend quoted above the following text message:

*I'm getting a headache now. Time to sleep for the little bit I have. Then midnight to 06 watch. Then back up to make all my phone calls for moving. Grrrrr.*

On the VDR transcript[318] the 2/M made the following statement while standing the bridge watch at 3:30 PM on September 30, 2015:

*(Alright) so I called 'em up yesterday. I didn't get much sleep yesterday because I was on the phone with everyone. The fuel company canceled my account fuel up that thing– I'm not payin' for somebody else's fuel.*

On the VDR transcript[319] the 2/M came onto the bridge at 4:46 PM on September 30, 2015, and relieved the C/M so he could eat dinner. The relief watch lasted approximately 30 minutes.

The 2/M's at sea schedule indicated on STCW records for a August 25, 2015, EL FARO voyage was as follows:[320]

*Watch at sea 0000-0400/1200-1600*
*Deck Maintenance schedule at sea is 0800-1130*
*Rest Period at sea is 0400-0800 and 1600-2400*[321]

The IMO [322] makes the following statements about fatigue:

*GUIDELINES ON FATIGUE INTRODUCTION*

*Fatigue can be defined in many ways. However, it is generally described as a state of feeling tired, weary, or sleepy that results from prolonged mental or physical work, extended periods of anxiety, exposure to harsh environments, or loss of sleep. The result of fatigue is impaired performance and diminished alertness.*

*However, recent accident data and research point to fatigue as a cause of and/or contributor to human error precisely because of its impact on performance. Human*

[318] MBI Exhibit 266, p. 136.
[319] MBI Exhibit 266, p. 169.
[320] MBI Exhibit 283.
[321] MBI Exhibit 283, p. 5.
[322] IMO MSC/ Circ. 1014, Ref T2/4.2, dated June 12, 2001.

*error resulting from fatigue is now widely perceived as the cause of numerous marine casualties, including one of the worst maritime environmental disasters in the last century, the Exxon Valdez.*

*The negative effects of fatigue present a disastrous risk to the safety of human life, damage to the environment, and property. Because shipping is a very technical and specialized industry, these negative effects are exponentially increased, thereby requiring seafarers' constant alertness and intense concentration.*

*2. DEFINING FATIGUE: There is no universally accepted technical definition for fatigue. However, common to all the definitions is degradation of human performance. The following definition is found in IMO's MSC/Circ.813/MEPC/Circ.330, List of Human Element Common terms:*

*A reduction in physical and/or mental capability as the result of physical, mental or emotional exertion which may impair nearly all physical abilities including: strength; speed; reaction time; coordination; decision making; or balance.*

Furthermore MSC/Circ.1014 ANNEX on page 10 states:

*Fatigue is known to detrimentally affect a person's performance and may reduce individual and crew effectiveness and efficiency; decrease productivity; lower standards of work and may lead to errors being made. Unless steps are taken to alleviate the fatigue, it will remain long after the period of sustained attention, posing a hazard to ship safety.*

During the MBI proceedings several witnesses[323] could not explain who within the TOTE organization was responsible for providing oversight of evaluations, medical forms, disciplinary records, and other records, including STCW records pertaining to the required work rest history for mariners.[324]

Specific rules apply to mariners who serve as deck watch officers, they are required to get six hours of rest in the twelve hours immediately before getting underway.[325] [326]

A former 2/M and 3/M on EL FARO stated during MBI testimony that he was not aware of the legal requirement for a rest prior to taking the deck watch immediately before going to sea.[327] This requirement was not captured in any TSI produced form.[328] The requirement was also not factored into EL FARO's automatic STCW required work/rest calculation formulas.

[323] MBI Transcript February 16, 2016, p. 14.
[324] The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) 1978 sets qualification standards for masters, officer and watch personnel on seagoing ships.
[325] MBI Exhibit 304.
[326] 46 U.S.C. § 8104.
[327] MBI Transcript February 9-10, 2017, p. 812.
[328] MBI Exhibit 283.

The purpose of the STCW rest requirement is to combat the effects of fatigue that can have an adverse impact on the cognitive thinking and the performance of watchstanders.

The MBI examined a sampling of STCW work rest histories to determine if the 46 U.S.C. § 8104 requirements were met during past voyages for EL FARO bridge officers. The MBI detected three potential violations of the rest provisions in the twelve hours immediately prior to departing port. STCW samples for the accident voyage 3/M were examined from July 7, July 14, and September 1, 2015, and the rest periods varied between 5.5 hours and 4 hours[329] for the 12 hour period immediately prior to getting underway.

A review of the STCW records also detected violations for the rest requirements mandating six hours of continuous rest in a 24 hour period that are contained in 46 CFR § 15.1111. These violations occurred in the months of August and September 2015.

During the MBI,[330] a former EL FARO AB provided the following statement about STCW recordkeeping:

> *You're not going to hear, because just like I said, they make good money, and there's ways around everything. Even the STCW just being honest. There's ways around it because they got a program on the ship where once you put your hours in and it don't line up, get red, it turns red. So the only thing you have to do is just go around and fixing numbers and you're back.*

STCW compliance was managed by shipboard personnel with minimal oversight by TOTE management. The Safety Manager[331] indicated during MBI testimony that TOTE would review STCW records if something was brought to the Safety Department's attention. In a TOTE internal audit report of EL FARO conducted in early 2015, there was no mention of a review of STCW work rest logs. The MBI was unable to obtain records for the STCW work rest logs for the weeks prior to the accident voyage as they were only maintained onboard EL FARO.

7.2.13.1.12. EL FARO – Distractions Caused By the Crewing of the MARLIN Class Ships

Distractions arose during TOTE's selection process for the MARLIN class crews and each person that was selected for a position was asked to sign a non-disclosure agreement. The bridge officers and C/E on the accident voyage had not been selected to go to the new ships. The Master of EL FARO was also unsure whether he would receive his desired position on the MARLIN class ships. On the accident voyage VDR transcript the Master and the C/M discussed concerns about their future with TOTE around 7:00 PM on September 30, 2015:

> ***C/M:*** *I hear what you're saying Captain. I'm in line for the choppin' block...*
>
> ***Master:*** *Yeah. Same here.*

[329] MBI Exhibit 283.
[330] MBI Transcript February 14, 2017, p. 1360.
[331] MBI Transcript February 14, 2017, p. 1189.

***C/M:*** *... I'm waitin' to get screwed.*

***Master:*** *Same here.*

***C/M:*** *I don't know what's gunna happen to me.*

7.2.13.1.13. EL FARO – Bridge Officer Human Factor Issues

Since 2014, including at the time of the accident voyage, there were no expectations at TOTE that the Master of EL FARO share or discuss the intended route for a particular voyage with shore side TOTE mangers, even during hurricane season. A former DPA and Marine Operations Manager testified that prior to 2014 it was standard practice for TOTE to be apprised of the route and plans for a vessel ahead of a voyage with expected heavy weather. When asked if there was ever pushback from a Master to inform the company of his voyage plans the former marine manager said that he had previously told a master that if he did not tell him his plans and intentions he would have another master relieve that master in two hours. [332]

Along with the lack of shore side oversight, there were also internal shipboard communication issues. During the last nighttime watches on EL FARO prior to the accident, the VDR recorded several critical communications from the bridge watch officers to the Master.

At 11:05 PM on September 30, 2015, the 3/M called the Master and made the following statements:

*Hey captain sorry to wake ya.*

*Naw– nothin' and uh the latest weather just came in.– And umm– thought you might wanna take a look at it.*

*So– (yeah) if you have a chance.*
*Just lookin' at the forecast and lookin' at our trackline. Which way it's goin' and uhhh– thought you might wanna take a look at it.*

*Uhh well it's– the– the– the current forecast has it uhh– max winds um a hundred miles– an hour. At the center.– Umm and if I'm lookin' at this right– um– and it's moving at– at two-three-zero at uh five knots. So I assume it stays on that same– moves that same direction for say the next five hours. And uh so it's advancing toward our trackline– and uhh– puts us real close to it. Umm you know like– I could be more specific– I could um– plot that out. But it's gunna be like real close (and). And uh– don't know. Uh– uh I can give ya a better number and call ya back. We're lookin' a meet it at say like four o'clock in the morning. (You know).*

As the 3/M was conversing with the Master, the inbound email with the BVS weather attachment arrived in the Master's email inbox. The 3/M and 2/M were expecting the BVS

[332] NTSB Interview of Captain Harry Rogers.

weather update to be forwarded to the bridge computer for their review and potential action. The Master did not forward the 11 PM BVS package to the bridge until the next morning at 4:45 AM.

Just before watch relief at 11:13 PM the 3/M called the Master again and made the following statements while discussing Hurricane Joaquin:

> *(Okay) it's (3/M) again.*
>
> *So– at oh–four hundred we'll be twenty-two miles from the center. With uh max one hundred with gusts to one-twenty and strengthening so– the option that we do have– umm from what I can see– is at oh-two hundred we could head south. And that would open it up some– so I mean of course I'd want you to verify what I'm seeing. I do understand you expect us not get into the quadrant dead ahead and (expose) us. Just so you know that– that's how that's how close we'll be.– You're welcome.*

The Master did not come to the bridge after the call and the 3/M and AB had the following conversation on the bridge regarding the call:

> ***3/M:*** *It'll be at that strength according to the forecast– twenty miles from the center.*
>
> ***AB:*** [Expletive].
>
> ***3/M:*** *What he's saying is "well– we'll be in the southwest quadrant. Wind will be comin' from the north."— So.*
>
> ***AB:*** *Nantucket sleigh ride.* [A term used in the whaling era that described the wild ride incurred by sailors immediately after harpooning a whale.]
>
> ***3/M:*** *I trust what he's saying– It's just being twenty miles away from hundred knot winds– this doesn't even sound right.*

The 2/M also called the Master at 1:20 AM on October 1, 2015, during her bridge watch to discuss Hurricane Joaquin after learning that the storm had been upgraded to Category 3. During the call the Master instructed the 2/M to take the voyage route that had been planned the night before. Specific details from the call our included in Section 7.2.13.3.1. of this report.

The 2/M and the AB on the 0000 – 0400 watch were closely monitoring the clock as the weather worsened and the time until their watch relief approached. At 2:54 AM, the AB on watch stated:

> *Just hold out baby– We ain't got but an hour to go.*[333]

[333] MBI Exhibit 266, p. 338.

At 3:28 AM, after the AB stated that EL FARO's path would be going right through a large storm signature on the radar, the 2/M responded:

> *It's good (just keep bein' like) fifteen more minutes. (Keep it)* [AB] *and then we're off.*[334]

When the C/M relieved the 2/M's watch at 3:44 AM on October 1, 2015, the relief process lasted less than three minutes. During the relief the 2/M did not mention problems that had been encountered with the autopilot system or unidentified flashes that the AB had seen forward on the ship. The 2/M did not mention her 1:20 AM conversation with the Master concerning the intensification of the storm or the Master's response to run the 116 degrees course. The relief process also did not include a discussion about the errors between predicted wind direction and actual observed direction of the hurricane winds, which were discussed at 03:24 AM when the 2/M made the following statement to the AB on the bridge:

> *I think it's shifting. Cause that weather report say tha– uhh– west-southwest wind which we were not getting but I think it's starting to shift west and now it's coming back around. We're gunna start getting it on the starboard side.*[335]

Shortly after coming on the bridge at 4:09 AM on the morning of October 1, 2015, the Master stated to the C/M that he had been "sleepin' like a baby."[336] The VDR transcript contains several references by the Master whereby he notes the difference in perception of the noise and fury of the storm between his cabin and the bridge. At 05:16 AM the Master made the following statements on the bridge:

> *It sounds so much worse up here.*
>
> *When you get down (below) (it's just a lullaby) * * *.*[337]

7.2.13.1.14. TSI – Operational Span of Control

TSI, which operated EL FARO, was a relatively small company that required many of its office personnel to cover multiple duties at the same time. In the months leading up to EL FARO's accident voyage there were corporate discussions about potentially downsizing the office staff further.[338]

The multi-tasking of the TSI staff became more demanding as the new MARLIN class ships were being constructed. Many members of the TSI management and operations teams were tasked with additional duties to bring the new ships into service. As an example, the Director of Safety and Services was involved in MARLIN LNG fueling related issues. During the accident voyage the Crewing Manager was looking for crew for the MARLIN ships and the Director of Ship Management was in California attending to one of the MARLIN class ships in the shipyard.

[334] MBI Exhibit 266, p. 347.
[335] MBI Exhibit 266, p. 347.
[336] MBI Exhibit 266, p. 367.
[337] MBI Exhibit 266, p. 405.
[338] MBI Transcript February 13, 2017, p. 187.

The time-line to complete conversion work on EL FARO also created additional duties for TOTE shore side staff. During MBI testimony EL FARO's P/E stated:

> *Well there's day-to-day operation and then we had a dry docking and also the conversion work. So I had to— basically three jobs going, or two and a half. The dry docking is part of the normal Port Engineer's job, but it's every two to three years. Where this was all happening at once.*

EL FARO's DPA was responsible for a fleet of approximately 25 vessels. These vessels were in active and standby status around the world.

7.2.13.1.15. TOTE Operations –Regular Route, Schedule and Commercial Pressure

EL FARO sailed on what was described as a "liner service." This service included regularly scheduled weekly transits between Jacksonville and San Juan. The route to and from San Juan was called the "Atlantic Route." Deck officers did not receive a direct incentive or bonus for meeting the cargo delivery schedules, but those statistics were advertised to TOTE's customers. TOTE incurred costs from delayed ship arrivals or departures in the form of labor costs for terminal personnel. Per company policy, TOTE's PONCE class vessels were considered to be on schedule if they arrived or departed port within a specified two hour window.

Several former EL FARO and EL YUNQUE crew members testified during the MBI that they had encountered fair weather conditions for the vast majority of voyages for the two year period prior to the accident voyage.

The Master made the following statement on the bridge of EL FARO at 9:23 AM on September 30, 2015:

> *I mean when we went through Erika* [Reference to Tropical Storm Erika] *this last * that's the first real– real storm I've been on with this ship.*[339]

7.2.14. Lifesaving

EL FARO was equipped with the required lifesaving equipment as specified in the vessel's Coast Guard issued COI. This equipment included lifeboats, life rafts, life preservers, survival suits, emergency position indicating radio beacon (EPIRB), search and rescue transponders (SART). EL FARO was also equipped with a Global Maritime Distress and Safety System (GMDSS) radio system, the Ship Security Alert System (SSAS), and a Long Range Identification and Tracking (LRIT) radio system.

[339] MBI Exhibit 266, p. 73.

7.2.14.1. Lifesaving Equipment Training

The operation of lifesaving equipment is required to be incorporated into training,[340] in order that the crew is proficient in its use. Lifesaving equipment can be tested and exercised during the required drills such as an abandon ship drill; it can also be tested during equipment maintenance periods.

The Marine Safety Manual (MSM) Volume II states that it is the Coast Guard's responsibility to determine if the crew can effectively use equipment such as the lifeboats. Coast Guard Marine Inspectors are required to observe the launch of the lifeboats to test the crew's proficiency in the operation of the boats. This includes the lowering of the boat to the water and then the actual operation of the boat in the water. This also includes the operational testing of the diesel powered lifeboat and the manually propelled lifeboat that EL FARO carried. There is a provision to amend the procedures due the adverse weather. In those instances, upon conclusion of the inspection, the attending Coast Guard Marine Inspector is required by policy to document that a full abandon ship drill was not carried out with a notation of what tests remain to be completed at a later date.

An MBI review of emergency drill records for EL FARO indicated that the lifeboats were only lowered to the rail during drills. There was no record the lifeboats being lowered to the water and operated as part of an emergency drill.

A former EL FARO Bosun[341] provided the following MBI testimony about the inspection and testing of one of EL FARO's lifeboats:

> *Okay, again, I did the COIs, and we also lowered our boat, the starboard boat, went down in Puerto Rico into a cradle, a wooden cradle, and we flipped the lever. The davits were operable and I was on the lever. I lowered that boat to second mate, dropped the man ropes. Chief mate and cadet were on the deck, I believe at the time. We lowered down in the cradle, flipped the lever and we brought her back home, and when I say home, I mean it's secured.*

A former EL FARO 2/M testified[342] during the MBI that launching lifeboats in scenarios where EL FARO was heeling over was not discussed during abandon ship drills. The 2/M provided the following description of a typical EL FARO abandon ship drill:

> *In a typical abandoned ship drill we would lower the boats to the deck, embarkation deck which is at feet level, easily can just walk on the boat. We would lower it to the embarkation deck and then restow it.*

ABS was responsible for ensuring EL FARO conducted the operational test of lowering the boat to the water and operating the boat in the water during the Safety Equipment statutory survey. During EL FARO's most recent inspections prior to the accident voyage, the Coast

[340] MSM Volume II, Section B, Chapter 1, section v, pp. B1-B31.
[341] MBI Transcript February 14, 2017, p. 1290.
[342] MBI Transcript February 18, 2016, p. 65.

Guard Marine Inspector witnessed the boat being lowered to the rail. The Marine Inspector did not require that the lifeboats be lowered to the water, released from the davits, or operated underway, because he mistakenly assumed that ABS had witnessed those actions as part of the Safety Equipment statutory survey. The miscommunication between the Coast Guard and ABS extended for several inspection cycles since the ABS surveys and Coast Guard examinations were generally conducted separately on EL FARO.

7.2.14.2. Lifeboats and Launching Systems

EL FARO had two open, gravity davit launched fiberglass lifeboats fitted on the port and starboard sides. Because EL FARO was delivered in 1975, the vessel was required to comply with SOLAS 1960 requirements for lifesaving appliances, including lifeboats. SOLAS 1974 updated the requirements for cargo vessel lifeboats, requiring motorized and enclosed lifeboats for vessels with keel laying dates after July 1, 1986. SOLAS 1974 was not retroactive to older vessels such as EL FARO, and the enclosed lifeboats were not required to be installed on these older vessels as long as the existing gravity davit launching systems could be maintained.

EL FARO's starboard lifeboat, Boat 1, had a capacity of 43 persons and was propelled by the manual movement of levers which in turn operated a propeller. This propulsion system is known as Fleming gear.

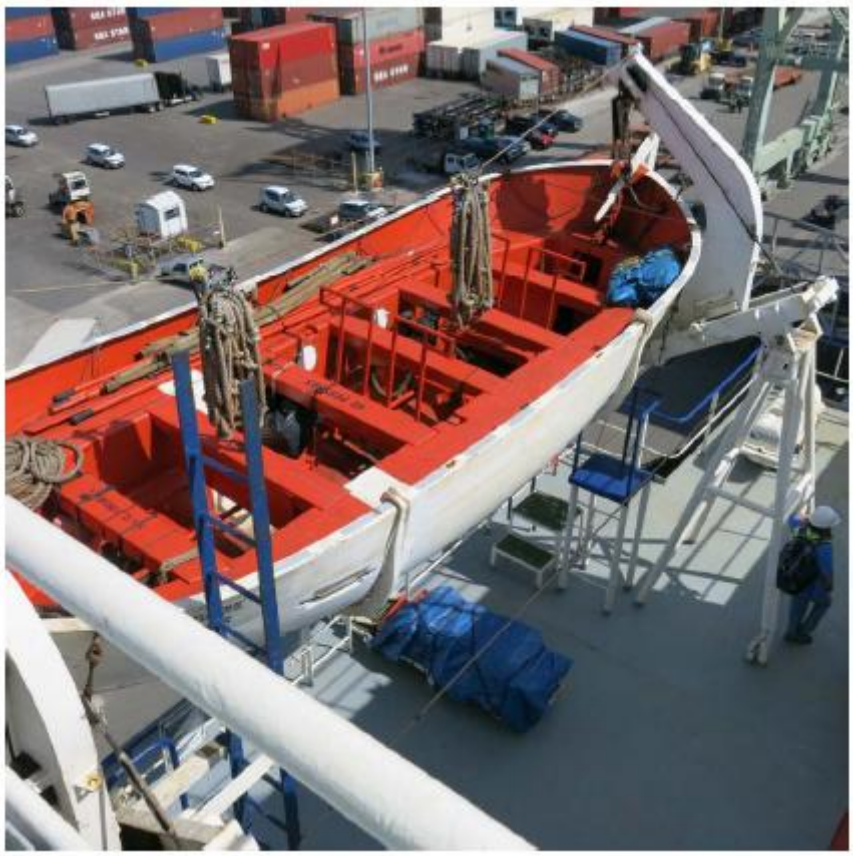

**Figure 47. EL YUNQUE starboard lifeboat. NTSB photo.**

The port lifeboat, Boat 2, had a capacity of 48 persons, was powered by a diesel engine, and was classified as EL FARO's rescue boat. Under standard operating conditions, these lifeboats could be launched by removing the securing devices and lowering them to the embarkation point where assigned personnel could board. Each lifeboat had a deck officer designated to be in command. In actual abandon ship scenarios, one crew member was required to operate the launching appliance controls to lower the boat to the water. That person would then have to use a rope ladder to descend down the side of EL FARO and board the boat in the water. The boat crew would then release the boat hooks and steer the lifeboat away from the side of the ship.

The main limitation for the gravity launching of the boat was the design of the launching system with respect to trim and list.[343] The system was designed to operate with a list up to 15 degrees with a fully loaded boat. The VDR audio recording did not contain any discussion regarding the readying, manning, or use of EL FARO's lifeboats.

After the accident, Boat 1 was discovered floating in EL FARO's debris field, partially submerged with severe damage. It was eventually recovered and transported to shore. Boat 2 was located on the ocean floor, severely damaged, with one end severed and the engine missing. During the MBI, an expert in the field of lifesaving appliances testified that the damage to the two lifeboats was consistent with damage that occurs during sinking, including environmental forces from wind and seas.[344] He stated that, based on their condition, there was no evidence indicating that the crew attempted to launch either lifeboat. Subsea video and still images taken of EL FARO by a remotely operated underwater vehicle showed extensive damage to both boat lifeboat launching systems including twisted davit arms. Some of the images of the sunken port lifeboat showed that a sheering force was applied diagonally to one end of the sunken boat.[345]

On September 28, 2015, the day before the accident voyage departure, two repair technicians boarded EL FARO to replace two free wheel clutches on the lifeboat davits.[346] The technicians completed and tested the repairs on September 29, just prior to EL FARO's departure on the accident voyage. TOTE did not provide ABS or the Coast Guard with notification of these repairs. TOTE's repair plan for the davits was to complete the repairs in port. However, the servicing technician who completed the repairs testified during the MBI that he was asked by TOTE if he could get underway with EL FARO if the repairs were not completed prior to departure from port. The servicing technician testified at the MBI that an EL FARO officer had asked him if he was willing to get underway with the vessel because, "the work was progressing kind of slow just due to age and it was hard to get a part."[347] The davit repairs were subsequently completed prior to departure and the outboard lifeboat was lowered and raised to test the clutch repairs. The starboard lifeboat, which was over the dock, was not lowered. The repair was completed without lowering the boat with the understanding that EL FARO's crew would lower the starboard lifeboat at a later time.

There are commercially available alternatives to the gravity style open top lifeboats that were on EL FARO. One system incorporates a stern mounted lifeboat that slides down a ramp into the

[343] MBI Transcript February 15, 2017, p. 91.
[344] MBI Transcript February 17, 2017, pp. 110-113.
[345] NTSB Survival Factors Factual Report.
[346] MBI Exhibit 074.
[347] MBI Transcript May 26, 2016, p. 20.

water. The boat is closed and fitted with seats that include a restraint system. Once the boat is loaded with passengers properly harnessed in place, the boat operator activates the launching system from inside the lifeboat; no one needs to stay behind on the ship to activate the launching of a stern launched boat. The boat slides down the rail and momentum propels it clear of the ship. The rolling and other motions of the ship have less effect on the ability of the boat to safely launch. Once clear of the ship the lifeboat can motor clear of the accident scene. The following figure illustrates the operation of a stern launched enclosed lifeboat.

**Figure 48. The launching sequence for a gravity launch, free-fall lifeboat arrangement. Upper left, crew enters boat and straps in. Boat is released and enters the water where the kinetic energy propels the boat clear of the ship. The engine is running when the boat enters the water. (Source: Karishma Marine Solutions Pvt Ltd (KARCO), India)**

During MBI testimony the Coast Guard Seventh District Chief of Incident Response Management stated the following when asked if a modern enclosed lifeboat would have changed his assessment of the survivability of EL FARO's crew in hurricane conditions:

*Yes. If— I – in my initial interview if there was one thing that I was wishing that this crew had from the onset of this case was an enclosed lifeboat, self-launching on the rails. But, there is a caveat to that. In that the decision to abandon ship would have had to been made in a timely enough manner for them to clear the vessel. If the ship started to capsize and that was the moment they decided to go, I don't know that it would have made a difference. But if they had the option, in my professional opinion the safest place for that crew to be in those conditions was on the ship. Once that was compromised, in my opinion they did not have any other options. That lifeboat would have given them an option that they could have used earlier.*

7.2.14.3. Life Rafts

**Figure 49. Viking 25 person life raft of the type carried on EL FARO.**

EL FARO was equipped with one 6-man raft forward and two 25-person rafts that were located on the embarkation deck near the after end of the lifeboats. These three rafts were stored in cradles with hydrostatic releasing mechanisms that would enable the rafts to automatically release and inflate should the ship sink. The rafts were equipped with a self-inflating canopy, under hull stability bags, boarding ladder, sea anchor, and survival equipment. The stability bags below the hull of the raft were designed to help stabilize the raft when deployed. These rafts could be automatically released when the vessel sank or could be manually deployed by holding onto the attached painter, throwing the raft into the water, and pulling on the painter. The painter would secure the raft to the boarding location until the raft was boarded. In a calm and stable environment, the embarkation rope ladder would be used by the crew to climb down from the embarkation point to the raft location where the crew would enter the raft. When boarding was complete the painter would be cut or released and the raft would drift free or in ideal conditions be towed away from the ship by the diesel powered lifeboat.

In addition to the required rafts, EL FARO had two additional 25-person rafts in cradles or lashed to the railings near the boat deck.[348] The additional rafts were placed on EL FARO after issues with the davit deck foundations were discovered on EL YUNQUE in mid-summer 2015. These extra rafts were still onboard EL FARO when the ship departed Jacksonville on September 29.

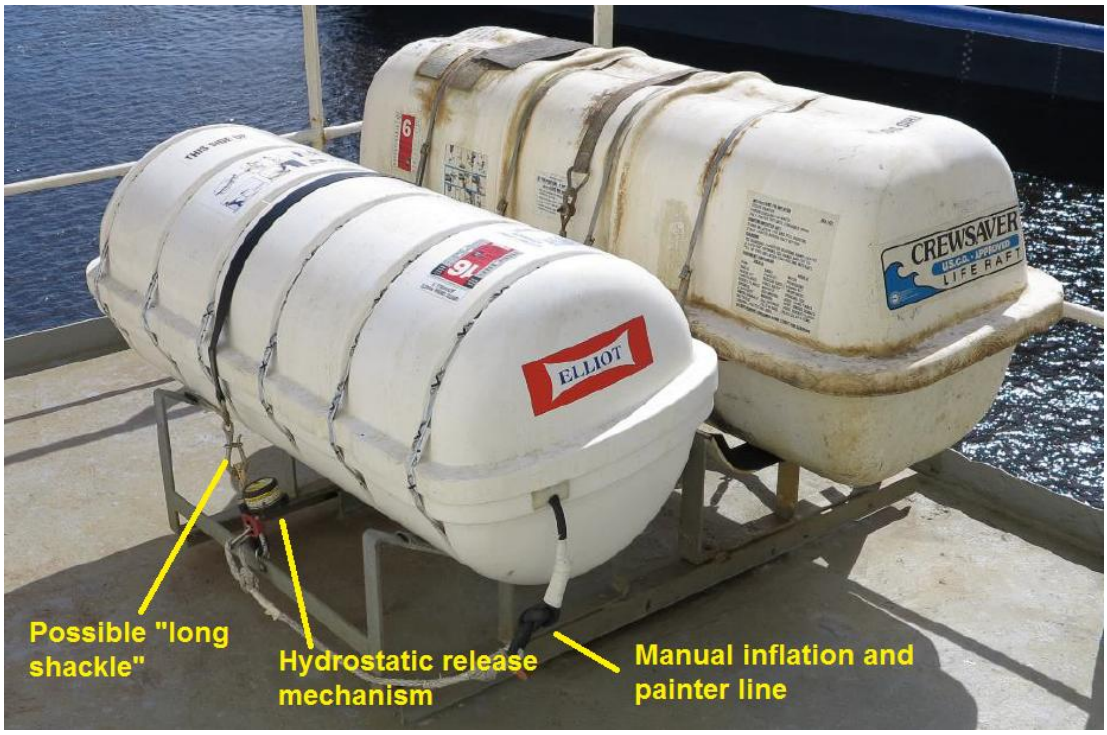


**Figure 50. Required 25 person life raft with extra raft on the port side of EL YUNQUE showing the stowage of the rafts and the hydrostatic release mechanism.**

The Master of EL FARO ordered the bridge watch to sound the abandon ship alarm at 7:29 AM on October 1, 2015. At 7:31 AM, the Master directed the C/M by UHF radio to throw the rafts into the water and for everyone to get off the ship and stay together.

As the crew was attempting to embark the life rafts, EL FARO was listing to port at angles in excess of fifteen degrees. At 5:18 AM the C/M[349] seemed to mention a list of eighteen[350] degrees, although the VDR audio recording could not be deciphered with complete consensus by the NTSB transcription team. The Master also described EL FARO's list as "healthy" while talking to TOTE's DPA on the satellite phone at 7:07 AM. During EL FARO's final moments, the starboard side was the weather side and the wind and seas would have affected the launching of the rafts. The port list of the ship would have brought the portside rafts very close to or possibly immersed in the sea.

[348] MBI Transcript February 19, 2016, pp. 92 and 118.
[349] MBI Exhibit 266, p. 407.
[350] MBI Exhibit 266.

During MBI testimony the Coast Guard Seventh District Chief of Incident Response Management, who also served as the SAR Mission Controller for the EL FARO incident stated the following when describing the challenges of trying to abandon a vessel into a life raft:

> *Similarly the ability to abandon ship into a life raft under good conditions is difficult because you have to get down the freeboard of the ship to the raft if the – if conditions aren't such that you can inflate the raft on deck and have the ship sink out from underneath it, it it's tied off to the ship and the ship's rolling in 30 to 40-foot seas, that's just going to be yanked back and forth. How you get down the side of ship and into a life raft in a survival suit is difficult to imagine. And if the raft isn't tied off to the ship it's just going to blow away, you're not going – you're not going to be able to get to it in those kinds of seas.*

During the Coast Guard's search and rescue phase there were two EL FARO rafts sighted. One was examined by a Coast Guard swimmer for remains and then intentionally sunk to prevent confusing later search and rescue efforts. A second life raft, which was sighted but not investigated, was not able to be relocated. No life rafts were observed in the storage locations on EL FARO during a survey of the wreckage.

7.2.14.4. Life Preservers (Lifejackets)

EL FARO carried Coast Guard approved, Type-1 life preservers, or Personal Floatation Devices (PFDs) that were designed for offshore, commercial service. Each crew member had a PFD located in their stateroom and additional PFDs were required to be located in watch stations such as the navigation bridge, the bow, and the engine room.[351] On the morning of October 1, 2015, the 2/M made a comment to the AB on watch that she did not know if there were life preservers on the bridge. [352] At 7:30 AM, after the abandon ship alarm was sounded, the 2/M asked the Master on the bridge if she could retrieve her vest. The Master made the following response:

> *Yup. Bring mine up too and bring one for [AB].*

The 2/M was not heard again on the VDR after departing to retrieve her vest. At 7:37 AM, just four minutes before EL FARO submerged, the Master yelled the following questions on the bridge:

> *Where are the life preservers (up/on) here?*
>
> *Where are the life preservers on the bridge?*

During emergency drills all crew members, including supernumeraries such as the Polish riding crew, were required to don their life preservers.

[351] MBI Transcript February 26, 2016, p. 138.
[352] MBI Exhibit 266, p. 323.

On September 29, 2015, two Polish riding crew members were relieved onboard EL FARO, they had been on the ship since August 2015. During MBI testimony one of the former riding crew members stated that he did not don a life preserver or an immersion suit during his service on EL FARO. He also stated that he did not participate in drills and that he did not know his muster station or assigned lifeboat.

7.2.14.5. Immersion Suits (Survival Suits)

Survival suits are designed to provide thermal protection to combat the effects of hypothermia, to provide floatation, and to be easily donned. Once they are donned, the wearer's physical performance of routine tasks like walking and manual dexterity for hand and finger functions would be limited.

Each EL FARO immersion suit was stored in a bag. To properly don the suit, the wearer had to lay out the suit in a relatively clear area of the deck. The wearer then put on the suit in the same manner a person would put on a pair of coveralls. Once in the suit, the wearer must zip it up and fasten the face flap over the face. During drills, the crew was expected to don the suit to the satisfaction of a deck officer.

Each crew member on EL FARO had an immersion suit stowed in their berthing area and there were also spare suits located in the engine room, at the bow, and in an internal storeroom.[353] The suits were inspected and pressure tested in August 2015. There were no discernible statements on the VDR that discussed the storage and location of the suits. There was also no VDR evidence indicating that the crew attempted to locate immersion suits on EL FARO's bridge.

At 7:28 AM, just ten minutes prior to the sinking of EL FARO, the Master instructed the C/M via UHF radio to "make sure that everyone has their immersion suits." At the time, the C/M was mustering the crew and preparing to launch the life rafts.

Three EL FARO immersion suits were located during search and rescue activities. One of the suits found floating at sea contained a deceased crew member's remains, which were not able to be identified or recovered. Further details regarding that suit are discussed in the Search and Rescue section of this report. Two other empty immersion suits, found floating on the surface, were recovered and brought ashore. One of the recovered suits was undamaged. The other recovered suit had a large tear at the waist on the front right side extending from the zipper to the side of the suit. The two recovered immersion suits were manufactured in June of 1985.

[353] MBI Transcript February 19, 2016, p. 95.

**Figure 51. One of the two immersion suits that were recovered during the EL FARO search.**

International Organization for Standardization (ISO) 15027 is intended to serve as a minimum performance requirement for manufacturers, purchasers, and users of safety equipment such as immersions suits. The ISO standard seeks to ensure that the equipment provides effective performance in use. It describes the immersion suit as an "abandonment" suit and includes the following guidance:

> *The abandonment suit shall have no features which will be likely to have any detrimental effect on the operation of other life-saving equipment that may be used. In particular, any part of the suit which might pose a snagging hazard shall be suitably covered, protected or restrained.*
>
> *The primary aims in wearing an abandonment suit are:*
> *a) to reduce the risk of cold shock and delay the onset of hypothermia;*
> *b) to enable the user to propel himself in the water and extricate himself from the water without it becoming an encumbrance;*
> *c) to make the user sufficiently conspicuous in the water so as to aid his recovery.*
>
> *Many circumstances may alter the performance of the suit, such as wave action or the wearing of additional equipment. Users, owners, and employers should ensure that equipment is correctly maintained according to the manufacturer's instructions.*

*An abandonment suit may often be worn with a lifejacket as it will provide extra flotation and may help to bring a user to a face-up position.*

Testing protocols for buoyancy and personal dexterity are detailed in 46 CFR § 160.171-17.

7.2.14.6. Other Lifesaving Equipment

EL FARO was equipped with lifesaving equipment including life rings, water lights, buoyant smoke floats, lifeboat VHF radios, [354] pyrotechnic signaling devices, line throwing appliances and small search and rescue transponder (SARTs). Based on the evidence reviewed by the MBI all the equipment listed in this section was available and in serviceable condition at the time of the accident; none of this equipment was discussed on EL FARO's VDR during the accident voyage.

7.2.15. Emergency Communications

7.2.15.1. Initial Emergency Communications

During the initial distress communications phase of the emergency, EL FARO broadcast three distinct distress alerts: Inmarsat C Distress Alert, Ship Security Alert System (SSAS), and SARSAT 406 EPIRB first Alert. The Coast Guard received all three alerts. TOTE's DPA and P/E[355] received the SSAS Inmarsat C message**.**

7.2.15.1.1. Distress Communications by Inmarsat C GMDSS Alert

The initial Inmarsat C "Distress Alert Received" email was sent to the Coast Guard Atlantic Area Command Center (LANT) at approximately 11:13 UTC[356] (7:13 AM EDT) on October 1, 2015, from the Inmarsat C, Land Earth Station (LES)/Network Coordination Station (NCS) in Eik, Norway.[357]

[354] VHF Radios – line of sight handheld battery powered radios.
[355] TOTE Emergency Response Manual (NAU-v1CCI_ERT Manual).
[356] Time estimated, time of receipt of the email was not recorded by the LANTWatch CDO or D7 Initial Notification in MISLE.
[357] Operated by Marlink, formally Astrium Services.

**Subject:** Message from Inmarsat-C Mobile

**Categories:** SAR

Telenor INM-C LES 436820812=FARO X 1-OCT-2015 11:13:20
Ref nr.: 910348 Ocean : AORW

---------- Distress Alert Received ----------
Mobile Terminal No : 436820812
To CES : 001
Position : 23.28'N 73.48'W
Position updated : 10:30 UTC
Nature of distress : Flooding
Course : 235 Speed : 8
Activation : Distress Alert
Position activated : Yes
Course/Speed updated : Yes
---

**Figure 52. Eik NCS/LES - Inmarsat C Distress Alert - EL FARO.**

**Subject:** Distress info

http://10.107.5.32/tss/images/web/ADS_Logo_small.png

DISTRESS INFORMATION SHEET

FROM:

ASTRIUM,
EIK EARTH STATION

EIK TELEPHONE: +47 5140 8000, FAX: +47 5140 2240 EMAIL: EIKVAKT@MARLINK.COM

TO:

NORFOLK

FAX: +1 757 398 6775

PHONE: +1 757 398 6700

ALERT DATE: 2015-10-01

ALERT TIME: 11:13:21

TYPE OF ALERT:

INMARSAT

OCEAN REGION:

AORW

ALERT MODE: DISTRESS

POSITION: 23.28N 73.48W

INMARSAT NUMBER:

436820812

ANSWERBACK:

FARO

VESSEL NAME:

EL FARO

CALL SIGN:

1

**Figure 53. Eik NCS/LES - Inmarsat C Distress Vessel Information Sheet - EL FARO.**

Following the initial report of distress a "Distress Information Sheet" was transmitted to LANTWatch at 07:15 AM. Both the Distress Alert and Information Sheet contained position information on the location of EL FARO; 23 Degrees 28 Minutes North, 73 Degrees 48 Minutes West. The positions were displayed in the messages as 23.28'N 73.48'W and 23.28N 73.48W. This format is: Degrees, period used as separation, Minutes/Decimal Minutes. The Distress Alert also contained course, speed, and nature of distress information.

By policy, the Coast Guard Rescue Coordination Center (RCC) that receives a distress alert is responsible for taking initial action on that emergency.[358] An Inmarsat C Distress Alert received by either Atlantic or Pacific Area Command Centers[359] through the NCS/LES associated with the ocean region the MES distress alert was sent[360] becomes the responsible RCC. The situation is then evaluated to determine which Search and Rescue Region (SRR)[361] has responsibility, and the situation is forwarded on to the responsible SAR Coordinator and RCC.

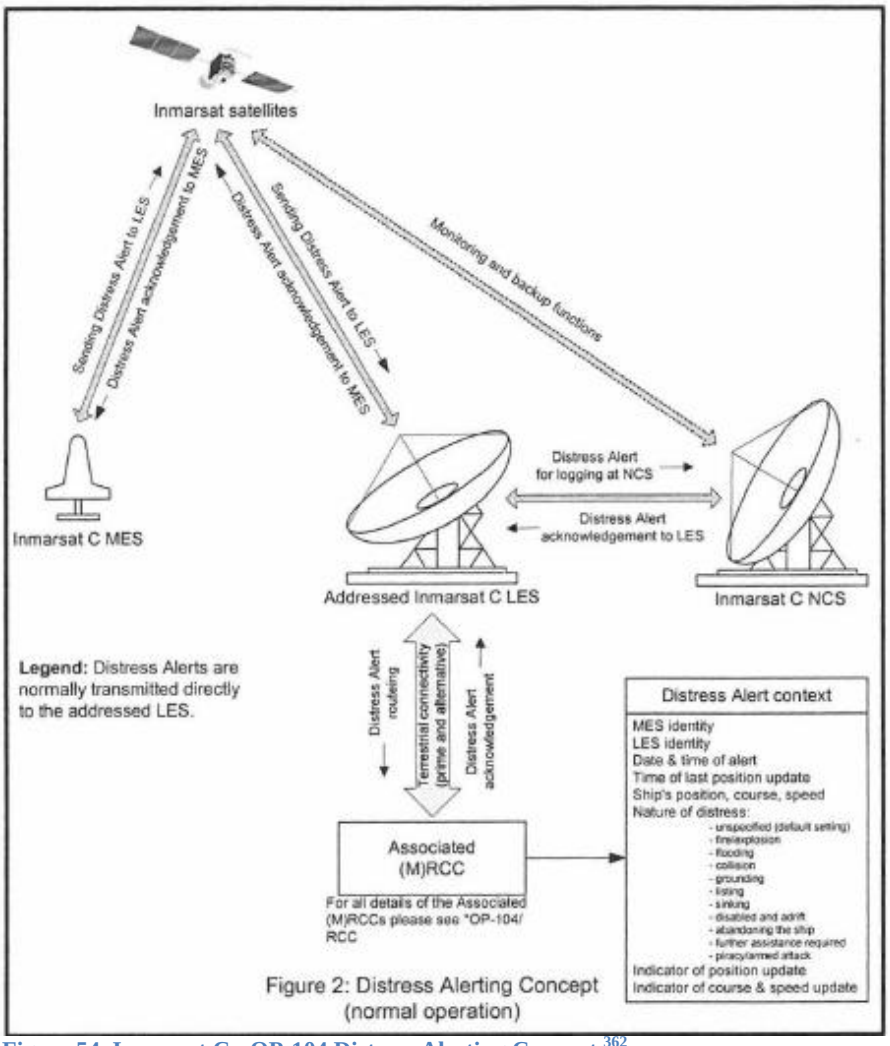


**Figure 54. Inmarsat C - OP-104 Distress Alerting Concept.**[362]

[358] U.S. Coast Guard Addendum to the National SAR Supplement COMDTINST M16130.2 (series) – Section 1.2. SAR Coordination.
[359] *Id*. pp. 2-6, Para 2.1.5.3.
[360] Inmarsat C OP-104 Processing of Ship to Shore Distress Alerts and Handling the Follow-Up Distress Communications.
[361] Search and Rescue Region – U.S. National SAR Supplement to IAMSAR.
[362] Inmarsat C OP-104 Processing of Ship to Shore Distress Alerts and Handling the Follow-Up Distress Communications.

At 7:32 AM, a LANT watch stander sent an email to the Coast Guard Seventh District Command Center (D7CC) with the Distress Information Sheet attached.[363] [364] This email also contained the vessel's position as passed during an earlier phone conversation with TOTE's DPA which was 23°-26.3'N, 073°-51.6'W.

7.2.15.1.2. Inmarsat C Position Discrepancy

In the Distress Alert, the time of the position update was 10:30 UTC (6:30 AM EDT), approximately 43 minutes prior to the actual transmission time of the alert. The distress alert position was 4.88 nautical miles to the northeast of the SSAS position that was transmitted at 11:13:49 UTC (7:13:49 AM EDT).

The FELCOM 15 GMDSS used aboard EL FARO was capable of generating an automatic or manual position depending on the option the operator selected. During the 2/M's preparations to abandon ship, while entering the information on EL FARO's course, speed and nature of distress, she also entered the position. Manually entering the position switched the system's position input from automated to manual. After a manual input is made the system will stop doing automatic positional updates until the unit is cycled through (rebooted).[365]

7.2.15.2. Ships Security Alert System (SSAS) – By Inmarsat C

The SSAS is a covert distress signaling system that can be activated either by SARSAT/COSPAS system or Inmarsat C. This system is designed to be used when a ship is under attack by pirates. Reports are transmitted to receiving authorities that will then determine a proper course of action. For the United States, the receiving authority is the Coast Guard Pacific Area Command Center (RCC Alameda). [366] Distribution of all reports is through RCC Alameda. The Atlantic Area Command Center is also copied on the email reports, through the email group rule set up by RCC Alameda.

When EL FARO's crew prepared to abandon ship, the master informed the DPA that he was going to activate all forms of distress communications, specifically that he was activating the Inmarsat C GMDSS and SSAS units. [367] At 11:13:49 UTC (7:13:49 AM EDT) the SSAS unit was activated, sending one of three reports to the Coast Guard. Following the Coast Guard report, the DPA received a report at 11:15:57 UTC (7:15:57 AM EDT) followed by a secondary emergency response contact identified through the TOTE Emergency Response Manual as the P/E in Tacoma, WA at 11:18:39 UTC[368] (7:18:39 AM EDT).

[363] LANTWATCH Email - Inmarsat C distress: Distress info EL FARO, 48NM East of San Salvador.
[364] D7CC Email to LANTWATCH - Read: Inmarsat C distress: Distress info EL FARO, 48NM East of San Salvador.
[365] NTSB/FURUNO FELCOM 15 Demonstration March 09, 2017.
[366] COMDINSTR M3120.3 Guidance for the Ships Security Alert System (SSAS).
[367] MBI Transcript February 20, 2016, p. 78.
[368] Inm-C 436820812 Log 0000 Sept 28 to 1800 Oct 1, 2015 (160307).

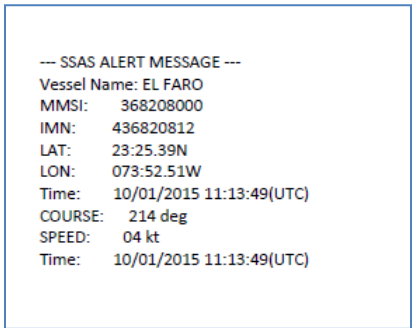


**Figure 55. SSAS report transmitted to U.S. Coast Guard.**

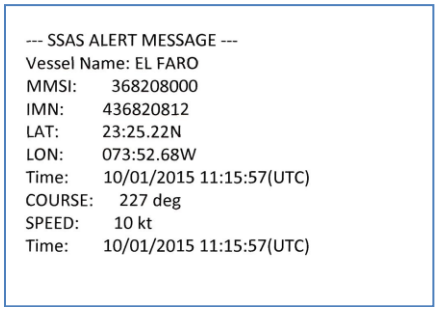


**Figure 56. SSAS report transmitted to TOTE services.**

The SSAS positions are generated automatically using the ship's GPS and they cannot be manually overwritten. Formatting of the position is in Degrees, Minutes/Decimal Minutes and is displayed as DD:MM.mmN, DDD:MM.mmW. There are no degrees or minutes symbols displayed in a SSAS message.

7.2.15.3. SARSAT/COSPAS 406Mhz Distress Alert

EL FARO's 406Mhz Emergency Position Indicating Radio Beacon (EPIRB)[369] was activated at 11:36 UTC (7:36 AM EDT). The D7CC received a 406 Beacon Unlocated First Alert report at 11:39 UTC (7:39 AM EDT).[370] This report was "unlocated" because it did not contain position information; however, it still acted as an alert of EL FARO's distress.

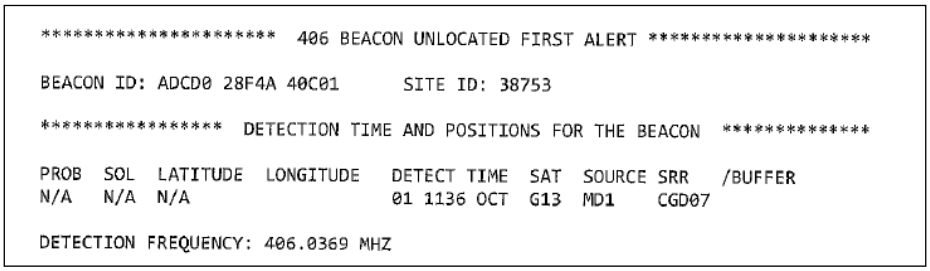


**Figure 57. SARSAT - 406 Beacon unlocated First Alert - EL FARO.**

[369] Model: Jotron Tron 40S MkII Frequency: 406.037 MHz Serial nos.: 09170 (on 1/27/22015 safety survey by Imtech Marine/Radio Holland); ADCDO 28F4A 40C01 (ID FCC registration); 49989 (on ABS certificate) Antenna: omni-directional, 5 watts GPS: none Operating life: minimum 48 hr Battery exp.: 2/1/2019 Release: manual or hydrostatic Bracket: Type FB-6; Serial 03101 Hydrostatic release expires: 2/1/2016 Date Registered: 2/1/2012 Last Update: 12/3/2013 Decal Expires: 12/3/2015 In service: 2/16/2007, Jacksonville FL.

[370] 406 Beacon Unlocated First Alert – USMCC Report to the Coast Guard D7 Command Center.

At the time of EL FARO's accident voyage, NOAA SARSAT[371] system relied on two satellite systems to detect and track active 406Mhz beacons throughout the U.S. and worldwide.[372] These two satellite systems are the geostationary satellites (GOES) and low earth orbiting (LEO) satellites. Geostationary satellites do not normally provide geographic locations, but they provide initial notification of an active beacon and responsible party contact information. If GPS had been embedded in EL FARO's EPIRB, the vessel's position could have been determined in a single satellite pass. However, EL FARO's 406Mhz beacon did not contain embedded GPS.

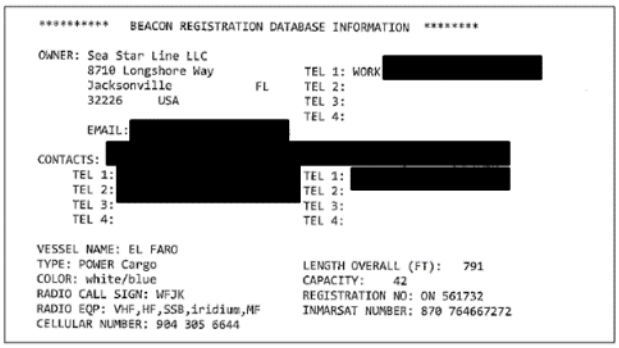


**Figure 58. Beacon registration database information.**

No position was available from the GOES-E Satellite (G13) Geostationary satellite (GEOSAR) that detected the signal from EL FARO's Emergency Position Locating Radio Beacon (EPIRB)[373].

No Low Earth Orbiting Satellites (LEOSAR) were in range of EL FARO during the period of time the beacon was active[374] and therefore no Doppler position could be determined.[375]

[371] Summary of EL FARO final with coverage of satellites final with correction on AIS inputs March 16, 2016.
[372] United States Mission Control Center (USMCC), National Rescue Coordination Center (RCC) and Search and Rescue Point of Contact (SPOC) 406 MHz Alert and Support Messages for the LEOSAR/GEOSAR/MEOSAR (LGM) System.
[373] http://www.sarsat.noaa.gov/sys-diag.html NOAA Search and Rescue Satellite Aided Tracking System Overview.
[374] Summary of EL FARO final with coverage of satellites final with correction on AIS inputs March 16, 2016.
[375] MBI Transcript February 15, 2017, p. 1468.

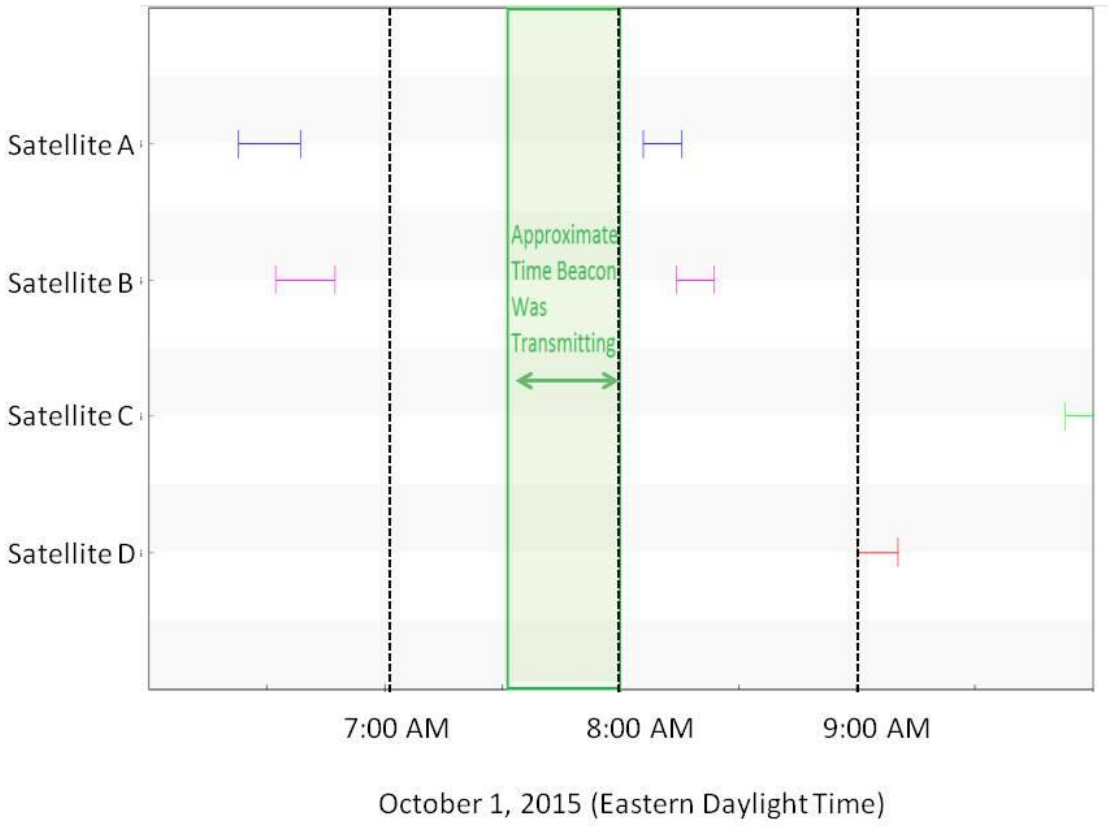


**Figure 59. LEO satellite in view periods.**[376]

The Coast Guard received no other SARSAT alerts, which was by design. The United States Mission Control Center (USMCC)[377] reporting rules are only to send each report type one time, unless there is a change in the information.[378] When the unlocated information for EL FARO was solely received by the GEO Local User Terminal (LUT), they only transmitted the initial report to the Coast Guard.[379] When the EPIRB signal ceases, the report of closure of the site does not occur for 18 hours. The next report expected after an Unlocated SARSAT report is a LEOSAR report (if the signal is within visibility of the LEOSATs) of Ambiguity Unresolved with two potential positions listed.

[376] Summary of EL FARO final with coverage of satellites final with correction on AIS inputs March 16, 2016.
[377] See NOAA Search and Rescue Satellite Aided Tracking webpage: http://www.sarsat.noaa.gov/usmcc.html.
[378] 406 beacon located first alert - ambiguity unresolved: This message is sent when a 406 MHz beacon is first detected with encoded or Doppler position information available, but ambiguity is not resolved.
[379] CG-NTSB Transcript and Errata – Survival – SARSAT Senior Space System Engineer – NOAA, March 04, 2016, pp. 46-47.

| SIT | Message Name / Comments |
|---|---|
| 160 | **406 BEACON UNLOCATED FIRST ALERT**<br><br>This message is sent when a 406 MHz beacon (with registration information or craft identification) is first detected but no encoded or Doppler position information is available. This message is usually sent when a beacon signal is detected first by a Geostationary satellite. Section 3.2.3.8.1 describes distribution procedures for unlocated alerts. |
| 161 | **406 BEACON LOCATED FIRST ALERT (AMBIGUITY UNRESOLVED)**<br><br>This message is sent when a 406 MHz beacon is first detected with encoded or Doppler position information available, but ambiguity is not resolved. |
| 162 | **406 BEACON LOCATED FIRST ALERT UPDATE (AMBIGUITY UNRESOLVED)**<br><br>This message is sent prior to ambiguity resolution when an alert with Doppler location (SIT 161) was previously sent and updated information regarding the A/B probability is available for the same satellite pass. It is only sent if the "A" side probability in the new solution is at least 30% higher than the "A" side probability in the old solution. |

**Figure 60. Alert message types for 406 EPIRBs.**[380]

Two LEOSAR satellites (S7 and S10) [381] did not detect EL FARO's beacon while in view of the area where it sank because they crossed before and after the signal was active. During the time period the EPIRB was active neither satellite was in view. As a result, EL FARO's position could not be determined using the SARSAT system.[382]

### 7.2.15.4. SARSAT Modernization GEO/MEO/LEO

Prior to the accident, NOAA/SARSAT[383] in Suitland, Maryland was in the process of adding capability to the SARSAT system used by the United States as part of the SARSAT/COSPAS System.[384] The network of satellites and ground stations provides mariners with the ability to send automated distress alerts that are monitored and processed by USMCC and transmitted to the Coast Guard for response. Prior to the implementation of MEOSAR, NOAA relied on two types of satellites to receive signals from 406Mhz distress beacons including EPIRBs, ELTs and PLBs. These satellite systems are geostationary (GEO) and low earth polar orbiting (LEO). Because the system relies on the Doppler Effect to calculate vessel positions, only the LEO satellites can provide position information, unless the EPIRB contains GPS capability. When an EPIRB is registered, its Beacon ID hexadecimal serial code is registered to the USMCC database and cross referenced with the owner and point of contact information.[385] Because GEO satellites are in a geostationary orbit with the planet and at a high altitude over the earth, they can receive

[380] USMCC National Rescue Coordination Center (RCC) and Search and Rescue Point of Contact (SPOC) 406MHz Alert and Support Messages 1 May 2013 Version 2.00 Paragraph 2.1.1 Alert Message Types.
[381] CG-NTSB Transcript and Errata – Survival – SARSAT Senior Space System Engineer – NOAA, March 04, 2016, pp. 47-48.
[382] Summary of EL FARO final with coverage of satellites final with correction on AIS inputs March 16, 2016.
[383] http://www.sarsat.noaa.gov/sys-diag.htm NOAA Search and Rescue Satellite Aided Tracking – SARSAT System Overview.
[384] Transcripts and Errata – Survival – SARSAT Senior Space Systems Engineer – NOAA- March 04, 2016.
[385] The BEACON ID is a 15 character hexadecimal code that identifies the 406 MHz beacon. The BEACON ID corresponds to bits 26 to 85 of the 406 MHz message transmitted by the beacon as described in document C/S T.001. For location protocol beacons (which use GPS/navigation input to determine beacon position), the bits of the BEACON ID that contain location are defaulted, so that the same BEACON ID is referenced regardless of its encoded position. The BEACON ID is used to reference USMCC registration data for the beacon. The BEACON ID is useful in discussing a SAR case with other SAR agencies, especially when the other SAR agency does not receive alert messages from the USMCC, since the SITE ID (described below) is specific to the USMCC.

the hexadecimal code, but they have no capability to determine a Doppler location due to their synchronous orbit with the rotation of the earth. GPS capable EPIRBs are the only method for GEOSAR Satellites to receive a position.

There are five LEOSAR satellites operating today. The system is old by satellite standards and within a short span of time many will become inoperable without replacement systems. Because of this, USMCC was testing a Mid-Earth Orbiting (MEOSAR) system[386] when the accident occurred. The MEOSAR system uses the GPS constellation of satellites to determine position of an EPIRB's hexadecimal signal by measuring the time difference of when the signal is received by the satellites.

During the timeframe of EL FARO's casualty the MEOSAR system was not fully operational or monitored in real time by USMCC. The system was under an evaluation process and therefore USMCC had the ability to receive and store data from EL FARO's EPIRB. NOAA/USMCC engineers completed a post-accident review for EL FARO,[387] which provided detailed information on the length of time the beacon was activated, the number of data bursts received, and the relative position of satellites before, during, and after the beacon was active.[388]

| Burst # | Time (UTC) | MD1 | MD2 |
|---|---|---|---|
| 1 | 10/01/15 11:35:05.000 | 1 | |
| 2 | 10/01/15 11:35:55.000 | | |
| 3 | 10/01/15 11:36:45.000 | 1 | 1 |
| 4 | 10/01/15 11:37:35.000 | 1 | |
| 5 | 10/01/15 11:38:25.000 | 1 | |
| 6 | 10/01/15 11:39:15.000 | 1 | |
| 7 | 10/01/15 11:40:05.000 | 1 | 1 |
| 8 | 10/01/15 11:40:55.000 | | 1 |
| 9 | 10/01/15 11:41:45.000 | 1 | |
| 10 | 10/01/15 11:42:35.000 | | 1 |
| 11 | 10/01/15 11:43:25.000 | | 1 |
| 12 | 10/01/15 11:44:15.000 | | |
| 13 | 10/01/15 11:45:05.000 | 1 | |
| 14 | 10/01/15 11:45:55.000 | 1 | 1 |
| 15 | 10/01/15 11:46:45.000 | | |
| 16 | 10/01/15 11:47:35.000 | | 1 |
| 17 | 10/01/15 11:48:25.000 | | |
| 18 | 10/01/15 11:49:15.000 | | |
| 19 | 10/01/15 11:50:05.000 | | 1 |
| 20 | 10/01/15 11:50:55.000 | | |
| 21 | 10/01/15 11:51:45.000 | 1 | 1 |
| 22 | 10/01/15 11:52:35.000 | | 1 |
| 23 | 10/01/15 11:53:25.000 | | 1 |
| 24 | 10/01/15 11:54:15.000 | | |
| 25 | 10/01/15 11:55:05.000 | | |
| 26 | 10/01/15 11:55:55.000 | | |
| 27 | 10/01/15 11:56:45.000 | | |
| 28 | 10/01/15 11:57:35.000 | 1 | |
| 29 | 10/01/15 11:58:25.000 | 1 | 1 |
| 30 | 10/01/15 11:59:15.000 | 1 | 1 |

*Table 1 – MD1 / GOES-E Data – 13 Bursts MD2 / GOES-W Data – 13 Bursts*

**Figure 61. USMCC GOES satellite reception of data transmitted by the EL FARO's EPIRB**

[386] Transcripts and Errata – Survival – SARSAT Senior Space Systems Engineer – NOAA- March 04, 2016, p. 9.
[387] Summary of EL FARO final with coverage of satellites final with correction on AIS inputs March 16, 2016.
[388] *Id*.

USMCC was able to confirm that the beacon was active for 24 minutes and that two LEOSAR satellites passed over the area prior to beacon activation and after the beacon signal ceased. An analysis of the MEOSAR system showed that EL FARO's beacon provided adequate data to create position reports seven times over the 24 minutes the signal was active. These positions were processed by MEOLUTs in Hawaii and Florida, which calculated EL FARO's position within five minutes of beacon transmission.[389] As of December 16, 2016, MEOSAR began operating an Early Operational Capability (EOC) period. As a result, MEOSAR beacon detections are now actively monitored.

7.2.16. Voyage Data Recorder (VDR).

The VDR carriage requirements for EL FARO are contained in Chapter V of the International Convention for the Safety of Life at Sea (SOLAS), Regulation 20. Under that regulation, cargo ships larger than 3,000 gross tons must be equipped with a VDR. Ships larger than 3,000 GT built before July 2002, such as EL FARO, may carry a Simplified VDR (S-VDR).

In 2009, EL FARO was fitted with a Sperry Marine VoyageMaster II VDR, Serial no.: A06032-000937. EL FARO's S-VDR system was in compliance with the existing carriage requirement at the date of installation and at the time of the accident voyage.

A VDR is intended to provide marine casualty investigators with a tool to hear recorded conversations, and to see video as well as critical navigational information that is contained in the VDR memory.

The VDR system collects data from several different feeds. Ships' navigational instruments, such as the global position system (GPS), send data to the VDR control cabinet. From there, the input is recorded and the same data is sent to the VDR capsule. The VDR control cabinet gets its power from the ship's electrical system and if that fails, internal batteries continue to power the VDR system. If a vessel sinks, one of two things happen; either the VDR capsule goes down with the ship with the data stored on a memory card in the VDR capsule, or the VDR capsule detaches from the storage cradle and the VDR capsule floats free. In either case, the VDR capsule is a watertight enclosure that can withstand the environment and the water pressure at the bottom of the ocean. The capsule is fitted with a locator beacon, and in the case of a float-free capsule, also contains a marker light and EPIRB. Both types of VDR capsules are encircled with reflective tape and painted a bright color to facilitate location of the devices. The float-free VDR capsule is a combination unit that combines a GPS equipped EPIRB with the capability of storing at least 48 hours of VDR information.

The S-VDR capsule equipped on EL FARO was designed to stay with the ship for retrieval by a remotely operated underwater vehicle (ROV). It contained the following types of sensor information:[390] geographical position in latitude and longitude, speed, course, rate of turn, and other navigation related data. In addition to this information, the S-VDR also recorded audio

[389] Summary of EL FARO final with coverage of satellites final with correction on AIS inputs March 16, 2016 – Table 3 MEOLUT Input to MEOMCC DB.
[390] For a complete list of the sensor data contained on EL FARO S-VDR see the NTSB Group Electronics Factual Report in the NTSB Docket, DCA16MM001.

from microphones on the navigation bridge and on the exterior bridge wings. There was also an input that captured radar screen still images from one of EL FARO's radars every 15 seconds.

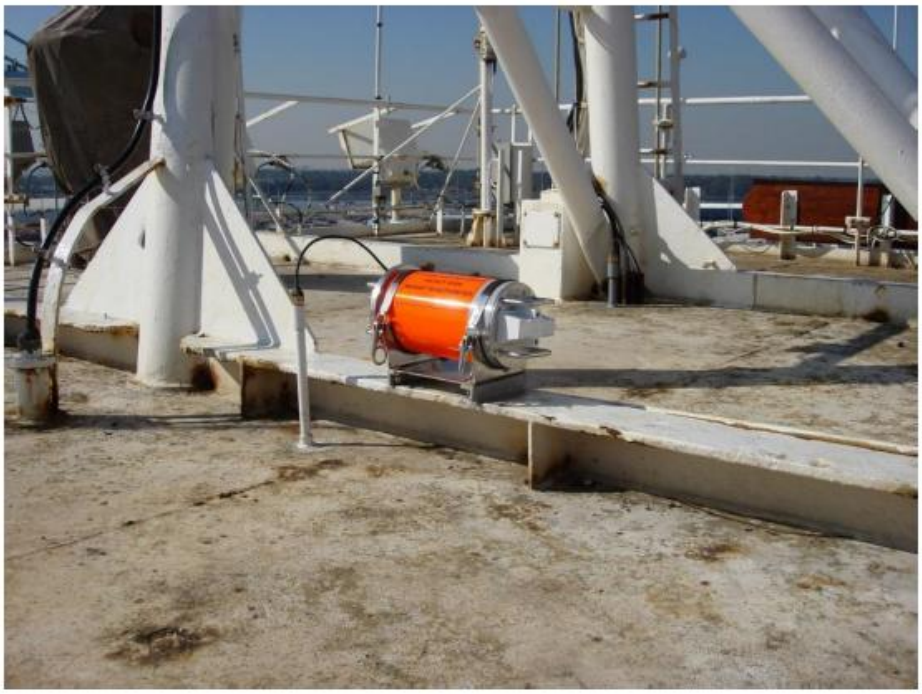

**Figure 62. Archive photo of the EL FARO S-VDR capsule mounted on a beam on the flying bridge, port side. (Source: Radio Holland)**

To aid in the recovery of EL FARO's S-VDR capsule, the recorder contained a water-activated, battery-powered, acoustic beacon. When submerged, the beacon was designed to transmit a signal to aid location and recovery of the unit for at least 30 days. However, the first search for EL FARO's VDR, which was conducted within 30 days of the accident using a towed underwater listening device, could not detect the S-VDR beacon. EL FARO wreckage was discovered using side scan sonar on November 1, 2015.

EL FARO's capsule was mounted on a beam on the deck of the flying bridge, which supported the large mast on the vessel. The capsule was held in the bracket by the required straps fitted with latches and large rings. The system was designed so that in the event recovery was necessary after an accident, an ROV could use its manipulator arms to open the latches by grasping the rings on the latches. After opening the latches the ROV could remove the capsule from the bracket and then bring the capsule to the surface. The capsule also had a single wire bundle which penetrated the deck of the ship and led to the VDR equipment cabinet.

The VDR system for EL FARO was required to be examined during an annual performance test (APT) that was to be carried out by a certified technician. The last APT for EL FARO's S-VDR was completed in December 2014. During the APT, the technician inspected and tested the unit and found the operation of the system satisfactory. The servicing technician did not make a notation regarding potential issues with the VDR input from the anemometer(s). The battery for the acoustic pinger was due to expire in May 2015, which was well before expiration of the APT certificate that was issued after the APT. It was Sperry's policy that the acoustic

pinger battery expiration date must be after the expiration of the APT certificate. The IMO,[391] on the other hand, only required that the battery not be expired at the time of the APT. The acoustic beacon itself was set to expire in May 2015 and the typical service protocol[392] was to change out the beacon itself to ensure reliability. The checklist that the APT technician used to verify proper operation included the notation that the battery should have been replaced as part of the inspection and issuance of the Compliance Certificate.[393]

EL FARO's recorded audio came from six microphones in and around the bridge. The S-VDR's recorded audio from EL FARO's capsule was examined[394] and transcribed by a team led by the NTSB. In general, the recordings from all the microphones contained only poor quality audio recordings. The recorded VHF marine radio channel had a flat signal indicating that the VHF radio set up to be recorded was not activated. NTSB VDR technical experts concluded that Channel M3, covering the port and starboard bridge wings, was not useable.

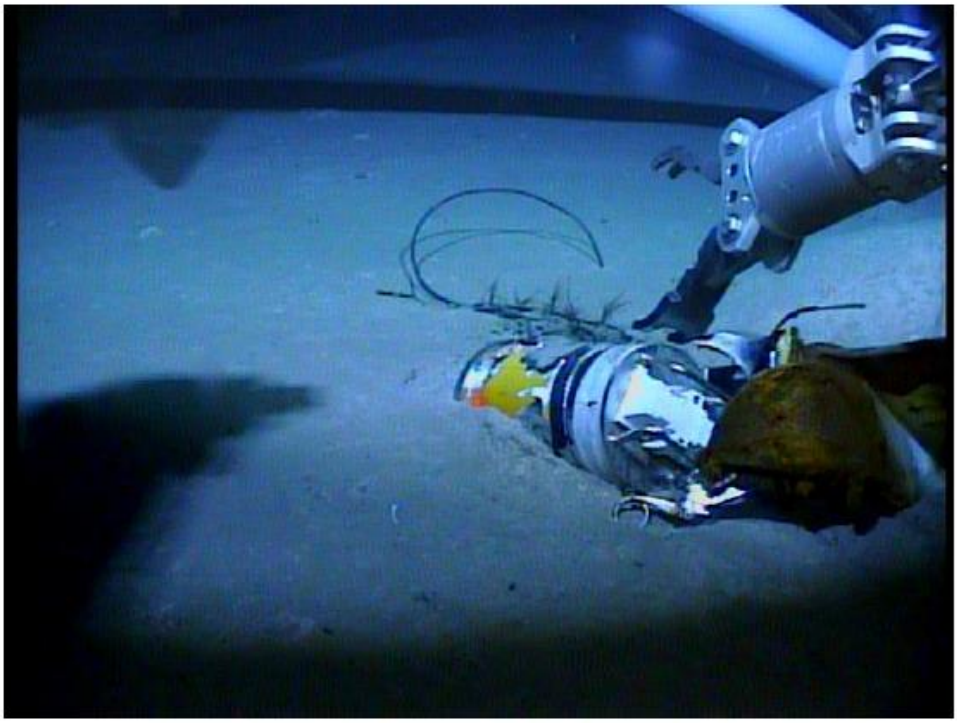

**Figure 63. Remote operating vehicle (ROV) manipulator arm positioned above the EL FARO S-VDR capsule on the sea floor prior to the capsule recovery (Source: U.S. Navy Supervisor of Salvage).**

Following the loss of EL FARO, the NTSB immediately commenced efforts to recover the S-VDR. Three voyages were conducted to the accident site to locate and recover the S-VDR. The first voyage located and documented EL FARO's wreck site, which was located in over 15,000 of water near the last known location of the ship prior to sinking. The second voyage to the

[391] MBI Transcript February 24, 2016, p. 86.
[392] MBI Transcript February 14, 2016, p. 124.
[393] For complete details see Attachment 7, NTSB Group Electronics Factual Report in the NTSB Docket, DCA16MM001.
[394] NTSB Voyage Data Recorder Group Chairman Factual Report.

accident site located the S-VDR capsule near EL FARO's mast, which had broken away from the main wreckage. The capsule's reflective tape aided in locating the capsule on the sandy bottom, as the tape was illuminated by the ROV's camera strobe light system.

Although the VDR was located during the second search mission, the vessel did not have an ROV capable of retrieving the capsule. A final recovery mission was able to secure the capsule on August 8, 2016, and it was preserved and transported to the NTSB laboratory for data recovery and analysis.

7.2.17. EL FARO Wreckage Observations

The wreckage of EL FARO sits at a depth of approximately 15,400 feet, in position 23-22.9N, 073-54.9W.

The primary objective of NTSB's search for EL FARO's wreckage was to recover the S-VDR. However, while doing so, the NTSB was also able to collect imagery of the wreckage on the sea floor. The equipment used for the S-VDR search was too large to enter the interior of EL FARO, and the risk of entangling the ROV's tether was too great to attempt entry into one of EL FARO's large 2nd deck cargo bay openings.

EL FARO's mast was located 1,476 feet from the bow of the vessel, with the radar still affixed and the VDR located near the base of the mast. The S-VDR capsule was recovered intact, and the data it contained provided critical information to the MBI and NTSB investigations.

NTSB Accident Docket DCA16MM001 contains detailed information regarding the VDR search efforts and underwater wreckage observations.

The general configuration of the wreckage on the bottom was mapped on a bathymetric composite image (see Figure 64).

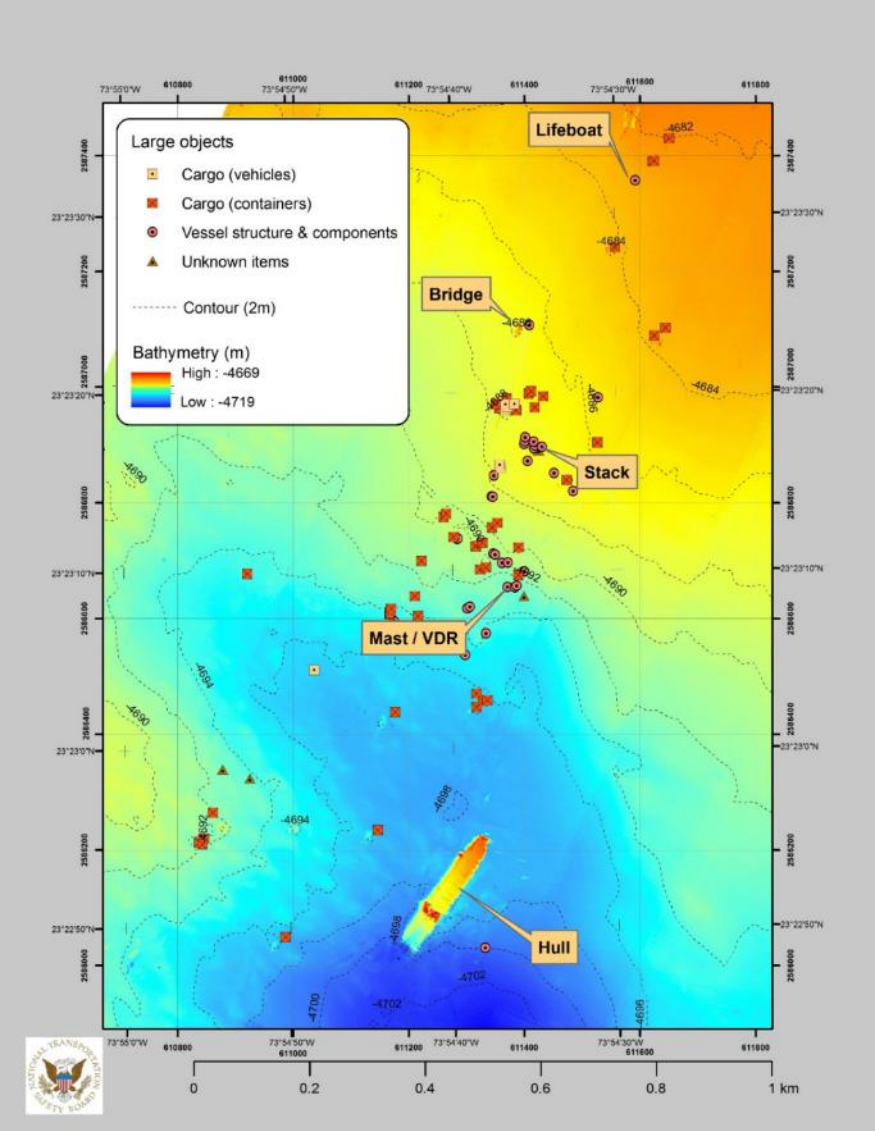


**Figure 64. Composite EL FARO debris field chart (reproduced from NSTB Naval Architecture Group factual report).**

The ship's accommodations space, called the "house," is partially intact, and the majority of that structure remains affixed to the hull. The navigation bridge was separated from the rest of the vessel and was located north of the vessel, as indicated in figure #64. The navigation bridge structure was damaged, but landed upright and structurally intact on the sea floor, about half a mile from the hull. The deck that housed the staterooms and offices for senior officers immediately below the bridge is missing, and the bulkheads for that portion of the superstructure are scattered around the wreck. The rest of the superstructure decks were still affixed to the hull along with ship fixtures, including the lifeboat davits, ladders, and lockers. There were large, arch-shaped scratches noticeable on the vertical surface of the exterior accommodation space on the port side of the vessel, in the vicinity of where the port lifeboat was cradled. The exterior starboard side vertical surface of the accommodation area does not have this same damage, and the starboard lifeboat davits were not as severely damaged as the portside davits.

The hull of EL FARO is sitting on the seafloor in an upright position with the bottom portion buried in the silt of the seabed. The upper portion of the ship's stem and bulbous bow were left exposed with the forward draft marks indicating that about 14 feet of the bow section is buried in the seabed. The remainder of the hull gradually slopes to the stern where the bottom of the stern transom is partially visible. The containers that were located on the upper deck of the vessel are missing and there are a large number of containers located on the seafloor in EL FARO's debris field. The transverse beams and the deck sockets for the container securing mechanisms are intact in some areas and missing and damaged in others. The portion of the hull that is buried in the silt, including the propeller, shaft, and rudder, could not be examined. There was visible damage to the bottom of the transom just above the rudder.

There are several fractures in the hull plating, most notably near bay 16 at frame 200. This crack, which has a maximum width of three feet, extends from the sediment line up to the main deck, and then continues athwartship across the vessel's main deck.

EL FARO's port diesel-powered lifeboat was located on the seafloor in a severely damaged condition, the buoyancy tanks along the interior side of the hull, running fore and aft, are gone, but the hull shape remains mostly intact. The aft end of the port lifeboat was severed off at an oblique angle, in a position where the gripes would have secured the lifeboat in its cradle. The damaged starboard lifeboat was found floating on the surface in EL FARO's debris field during search and rescue efforts, it was recovered and brought to shore for a full survey. The equipment that was used to secure the lifeboats in the launching appliances appears to be lying in close proximity to the hull wreckage. The davit systems for both lifeboats were twisted and heavily damaged by either the hurricane conditions, the forces incurred as the vessel sank to the bottom, or both. The launching rails for the starboard life boat are relatively intact, while the equipment for the port life boat appears more heavily damaged and is hanging off the decks where they were mounted.

**Figure 65. EL FARO Starboard Lifeboat. Heavy damage to the starboard side of the lifeboat is visible. Photo taken at Coast Guard Air Station Miami.**

**Figure 66. EL FARO Starboard Lifeboat. Damage to the port bow of the lifeboat is visible. Photo taken at Coast Guard Air Station Miami.**

### 7.2.18. Search and Rescue

#### 7.2.18.1. Summary of Search and Rescue Efforts

The Coast Guard became aware of EL FARO being in distress at approximately 07:15 AM on October 1, 2015, through an Inmarsat C message and a telephone call with the TSI DPA. The Coast Guard Atlantic Area Command Center (LANTCC)[395] Command Duty Officer (CDO)[396] passed initial information to the Coast Guard Seventh District Command Center (D7CC)[397] Operations Unit Controller (OU)[398] verbally, and followed up their phone conversation with an email that included the Inmarsat C Distress Alert Information Sheet. Following receipt of that email, the D7CC OU contacted the DPA to gather additional information about EL FARO's situation. During this conversation, a satellite distress 406MHz alert was received by D7CC from United States Mission Control Center **(**USMCC).[399] This report, categorized as; 406 Beacon Unlocated First Alert, did not include position information,[400] the EPIRB on EL FARO did not contain an integral GPS, which would have relayed the ship's position to the overhead satellite in a single pass. After receiving the notification from LANTCC, D7 designated the SAR Mission Coordinator (SMC)[401] for the case.

[395] LANTCC, Coast Guard Atlantic Area Command Center Watch.
[396] Atlantic Area Command Duty Officer for the Atlantic Area Commander located in Portsmouth, Va.
[397] District Seven Headquarters, Command Center, located in Miami, Fl.
[398] Command Center Manual M3120.20: Operations Unit; The Operations Unit is responsible for the planning and execution of incident response missions conducted within the AOR. At the different levels of CCs, these responsibilities may translate into different positions.
[399] United States Mission Control Center (USMCC) in Suitland, MD. USMCC is operated by the National Oceanic and Atmospheric Administration.
[400] Coast Guard SARSAT 406MHz Beacon Unlocated First Alert, SS EL FARO Site ID 38753.
[401] Chief of Incident Management Branch (DRM), CGD7.

Over the next six days, until suspension of search activities, the Coast Guard conducted 55 sorties that searched over 709,000 square nautical miles of ocean. The search assets included units from the Coast Guard, Department of Defense, Air National Guard, NOAA, and commercial crafts. The search efforts located EL FARO debris fields and one deceased crew member in a survival suit. The Coast Guard's rescue coordinator for the case testified at the MBI that the Coast Guard helicopter that located the deceased crew member had to temporarily depart the location, after confirming that the crew member was deceased, to check on a report of another immersion suit floating in the water. Before departing to continue the search for survivors, the Coast Guard rescue swimmer marked the crew member's remains with a SLDMB; however, the datum buoy failed to operate and the deceased crew member was not able to be relocated. Upon concluding that the ship had sunk, and after finding no signs of life, the search was suspended at sunset on October 8, 2015.[402]

7.2.18.2. Initial Notification

EL FARO activated its Inmarsat C distress and Ship Security Alert System (SSAS) at 7:13 AM on October 1, 2015,[403] which alerted the LANTCC of the distress situation. LANTCC also received an SSAS report[404] from the Pacific Area Command Center[405] via email at 7:15 AM, which was two minutes after EL FARO activated the system. The position on the SSAS message was 23° 25.39'N and 073° 52.51'W. Upon receiving the alert, the LANTCC CDO notified[406] the D7CC watchstander. LANTCC provided minimal details during the initial call, but stated that EL FARO's position information would be sent by email after the call. At 7:24 AM, as the LANTCC watchstander was in the process of drafting the follow-up email, he received a call from the TSI DPA,[407] who provided further details on EL FARO's situation.

The D7 watch called back the LANTCC duty officer in Portsmouth, Virginia,[408] inquiring about the status of the follow-up email they were expecting. The duty officer stated that more information would follow shortly, including details from the conversation with the TSI DPA, the Inmarsat C Alert, and the SSAS Alert. The LANTCC email was subsequently sent to the D7CC at 7:32 AM,[409] and included an Inmarsat C position of 23°28′N and 073°48′W, the TSI DPA's contact information, and the last position passed from the Master of EL FARO (23° 26.3′N, 073° 51.6′W),[410] which was described as 48 nautical miles east of San Salvador. The Portsmouth based duty officer also notified D7CC of the SSAS alert received from EL FARO, but he failed to include the position from the SSAS message in his email. The LANTCC email notification also contained a MARLINK/ASTRIUM Inmarsat C Distress Vessel Information Sheet that listed a position of 23.28N and 73.48W.

[402] CGD7 Next of Kin Briefing, October 06, 2015.
[403] SSAS Alert Email INMC.eik.com to the Coast Guard.
[404] SSAS Alert Email INMC.eik.com to the Coast Guard.
[405] COMDTINST 3120.3 Guidance For The Ship Security Alert System (SSAS).
[406] MBI Exhibit 033.
[407] MBI Exhibit 032.
[408] D7CC DVL Recording SAR_844084470 (D7CC to LANTWatch).
[409] MBI Exhibit 034.
[410] MBI Exhibit 032.

Following receipt of the LANTCC email report, at approximately 7:38 AM,[411] the D7CC watch contacted the TSI DPA. During this conversation, recorded background audio from the command center picked up a computer generated voice alert stating "Attention Emergency" that is consistent with a Coast Guard SARSAT notification alarm going off within the command center.[412] This alarm was the first notification of the SARSAT activation at 7:36 AM.[413] This 406MHz SARSAT Unlocated First Alert from EL FARO's EPIRB was the only SARSAT alert received by the Coast Guard and it was processed at 7:39 AM. From 7:35 AM to 7:59 AM (a period of 24 minutes) 30 bursts were received by USMCC; however the satellite system that captured those bursts was not being actively monitored at the time of EL FARO's sinking.[414]

7.2.18.3. D7 Miami Initial Actions

The D7 Miami command center watchstander determined the last known position (LKP) of EL FARO by taking the position information received from the Inmarsat C[415] Data Information Sheet and entering it into the Coast Guard Search and Rescue Optimal Planning System (SAROPS).[416] The position was entered into SAROPS as degrees and tenths of degrees, rather than degrees and minutes. Entering the information in degrees and tenths of degrees introduced an error for the initial position that was never corrected during the course of D7CC's case.

The MARLINK[417] Inmarsat C displayed position coordinates formatted as degrees and minutes as DD.MM, with a decimal point used as a separator between the degree and minute value. The Coast Guard Atlantic Area Command Center received two types of reports from MARLINK. One was "Distress Alert"[418] and the other was a "Distress Information Sheet." The LANTCC duty officer only sent the "Distress Information Sheet" to the D7CC and the original "Distress Alert" was not sent. The Distress Alert had a "minute" symbol after the minute digits (DD.MM'N DD.MM'W), while the Distress Information Sheet did not contain the minute symbol. The Distress Alert also contained the following additional data that was not included on the Distress Information Sheet: position update time, nature of distress, course and speed.

The error was introduced into the Inmarsat C LKP because the Distress Information Sheet position of 23.28N, 73.48W was entered directly into the SAROPS. SAROPS automatically converted that format and changed it to degrees, minutes, and decimal minutes (DD-MM.mmN DDD-MM.mmW). As a result, SAROPS plotted EL FARO position as 23-16.8N, 079-28.9W because it was programmed to recognize positions being entered as degrees and tenths of degrees

[411] MBI Exhibit 032.
[412] SAROPS .wav file selections when configuring SARSAT Alerts on the Coast Guard Standard Workstation. CGD7 configures SAROPS/SARSAT for new alert uses AttentionEmergency.wav. Source D7 SAR Specialist.
[413] MBI Exhibit 072.
[414] Summary of EL FARO final with coverage of satellites final with correction on AIS inputs March 16, 2016.
[415] Figure 1 - Marlink - Inmarsat C Distress Vessel Information Sheet – EL FARO.
[416] Search and Rescue Optimal Planning System (SAROPS) is designed to assist with search and rescue planning. SAROPS is built upon the Environmental Systems Research Institute (ESRI) Geographic Information System (ArcGIS).
[417] Marlink - Inmarsat C Distress Vessel Information Sheet – EL FARO – EIK Operation to LANTWATCH October 01, 2015 03:15 PST.
[418] EL FARO Distress Alert Message from 436820812@inmc.eik.com to LANTWATCH Dated October 01, 2015, 7:13AM.

DD.dd. SAROPS did not distinguish the difference between tenths of degrees or minutes in this format.[419] The United States recognizes the format as degrees, decimal degrees[420] and it is the watchstanders responsibility to convert coordinates into that format before entering them into SAROPS.

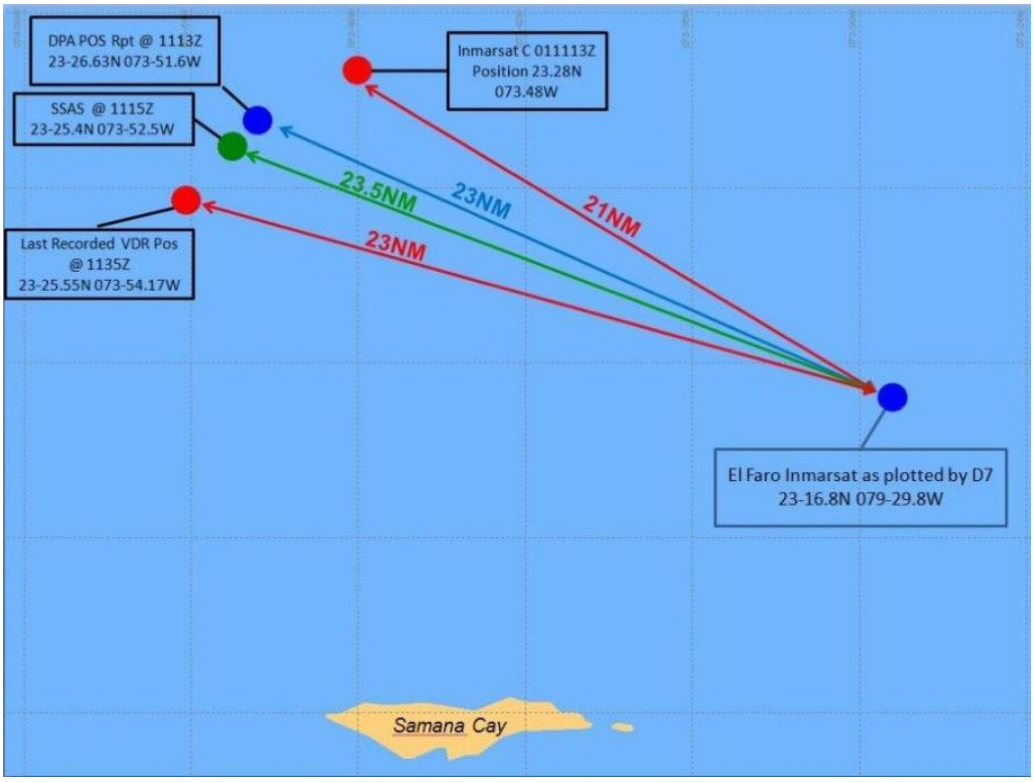


**Figure 67. D7CC electronic alert plot SAROPS. The position entered into SAROPS (displayed on the right) was more than 20 nautical miles away from the actual last known position of EL FARO.**

The SMC has overall responsibility for the response to a search and rescue case, including the final decisions on how to respond effectively to a distress event. The SMC[421] assigned to the EL FARO case was the District Incident Management Branch Chief. According to the timeline entered into the Coast Guard's MISLE database, the SMC was initially briefed on EL FARO's situation at 7:59 AM on October 1, 2015. D7CC watchstanders contacted the nearest aviation facility, located at Great Inagua (GI) in the Bahamas, to determine if a Coast Guard MH-60T medium range helicopter could respond. It was determined that due to the location of the eye of the storm, no aviation assets could respond near EL FARO's LKP on the first day[422] of the emergency. The D7CC watch continued to reach out to other assets, including commercial vessels, in the area to determine if any were available to assist EL FARO. The M/V EMERALD

[419] Coast Guard SAROPS LKP Icon Plotter – EL FARO – Initial Position Explanation PPT – Source Paul Webb, D17 SAR Specialist.
[420] Catastrophic Incident SAR Addendum 3.0 & NSARC - NTSB Hearing Input (030909).
[421] COMDTINST 161302 (series) CG Addendum to the National SAR Supplement 1.2.2 SAR Mission Coordinator (SMC).
[422] MISLE Activity 5733198 1305 (UTC).

EXPRESS,[423] a 180-foot Panamanian flagged RO/RO, was identified using D7CC's AIS as one of the closest possible search assets. However, the EMERALD EXPRESS, which was transiting south of Crooked Island en route to Fort Lauderdale, Florida, responded to the D7CC that they were unable to assist due to the severe hurricane conditions to their east. The D7 watch then requested that the EMERALD EXPRESS make VHF[424] radio callouts to EL FARO.[425] D7CC watchstanders also reached out to Air National Guard (ANG) HC-130J Hurricane Hunters[426] that were flying observation missions over Hurricane Joaquin for NOAA NWS. The two flights covered the area of EL FARO's LKP, and each aircraft conducted VHF radio call outs and radar searches. Due to the 10,000-foot altitude of the callouts, the range of the radio transmissions was much greater than the callouts made by the EMERALD EXPRESS. An ANG HC-130 aircraft, call sign TEAL 75, was the initial aircraft on scene and it reported hearing the EMERALD EXPRESS call out to EL FARO on the radio; however, no voice radio communications with EL FARO were ever established by the EMERALD EXPRESS[427] or TEAL 75. During a debriefing, the TEAL 75 pilot stated that he used surface search radar during his search, but that no surface targets were located.[428]

7.2.18.4. First Coast Guard Search Assets on Scene - October 2, 2015

The Coast Guard was first able to arrive on scene of EL FARO's LKP at first light on October 2, 2015. A Coast Guard Air Station Clearwater, Florida HC-130H aircraft, tail sign CGR1503, arrived on scene and was able to obtain a visual of the ocean's surface. CGR1503 conducted its assigned search in hurricane conditions at altitudes ranging between 2,500 to 3,000-feet. The aircraft sustained damage during the search due to the meteorological conditions it encountered near the LKP, and was forced to return to Coast Guard Air Station Miami. Another Coast Guard aircraft, tail sign CGR6027, also conducted a search on the afternoon of October 2, with no sightings of EL FARO. Because of the extreme weather and risk to the air crews, no further searches were assigned on October 2. However, the ANG Hurricane Hunter C-130[429] continued to conduct communications and radar searches for EL FARO through October 2,[430] while conducting hurricane hunting duties.[431] On the morning of October 3, it was deemed safe enough for aircraft and Coast Guard cutters to commence a coordinated search effort. Seven aircraft from the Coast Guard, Navy and ANG participated in the effort.

[423] D7 DVL Recording SAR_844096302 -M/V EMERALD EXPRESS voice conversation with D7 18-20ft seas, winds 65-70kts.
[424] VHF radio is a ship to ship line of sight radio for short range communications.
[425] MISLE Activity 5733198 1536 (UTC).
[426] 53rd Air Reconnaissance Division, Kessler AFB.
[427] The EMERALD EXPRESS was overcome by Hurricane Joaquin's heavy seas and winds on the afternoon of October 1, 2015. After drifting for two days, storm surge propelled the vessel over Crooked Island and it grounded in a mangrove swamp 21-miles from shore.
[428] Conversation with Major Steven Burton, 53rd Air Reconnaissance Division, Kessler AFB and DVL Conversation SAR_844096982 – 1434 (UTC) ANG C-130 TEAL 75 and D7CC.
[429] TEAL 75.
[430] MBI Transcript 23 February 2016, p. 188.
[431] MISLE Timeline Entry 020853Z October 15, OS1 Overton.

**Figure 68. Air Station Clearwater CGR-1503 - EL FARO search area visual conditions on October 2, 2015.**

7.2.18.5. SAR Planning

Over the first three days of the SAR case, D7CC watchstanders created drift models using SAROPS. The SAROPS is supposed to take into account all of the environmental information available, and to use that data to calculate the drift or projected movement of various search objects. However, the SAROPS was not programmed to accept wind values and other environmental conditions into the drift model that matched the extreme hurricane conditions that were observed on scene by search assets. The D7CC was also hampered because the SAROPS program continuously crashed while the watch was attempting to establish search runs and drift models. Because of these issues, the SMC and the D7 Search and Rescue Specialist[432] had to rely on manual solution methods for drifting search objects, a technique taught in Maritime Search Planning prior to the introduction of computer based modeling.[433] D7 SMC used the manual solution techniques to provide a predicted drift to determine initial search areas for the fixed wing aircraft flying on October 3, 2015.[434] After October 3, as Hurricane Joaquin moved to the north, SAROPS was able to provide search plans until the case was suspended.

7.2.18.6. Search and Rescue Operations

On October 3 and 4, as the weather conditions near the Bahamas improved, SAROPS was able to provide drift information and search patterns for the assets engaged in the search. Additional assets arrived in the search area, including three Coast Guard cutters and several commercial vessels. Search efforts discovered two debris fields during the Bravo Search EPOCH.[435] The Bravo Search Area was located 38 NM southeast of San Salvador and Rum Cay near EL FARO's actual LKP and the second field was centered 78 NM northeast of the LKP. Various types of debris, gear, and cargo were located.

[432] D7 SAR Specialist.
[433] COMDTINST 161302 (series) CG Addendum to the National SAR Supplement H.2 Manual Solution Model.
[434] 1021NTSB-A-Coggeshall October 14, 2015 p. 38.
[435] EPOCH searches are SAROPS "runs". There is one SAROPS run per EPOCH. COMDTINST M161302 (series) CG Addendum to the National SAR Supplement H.4.2.3.

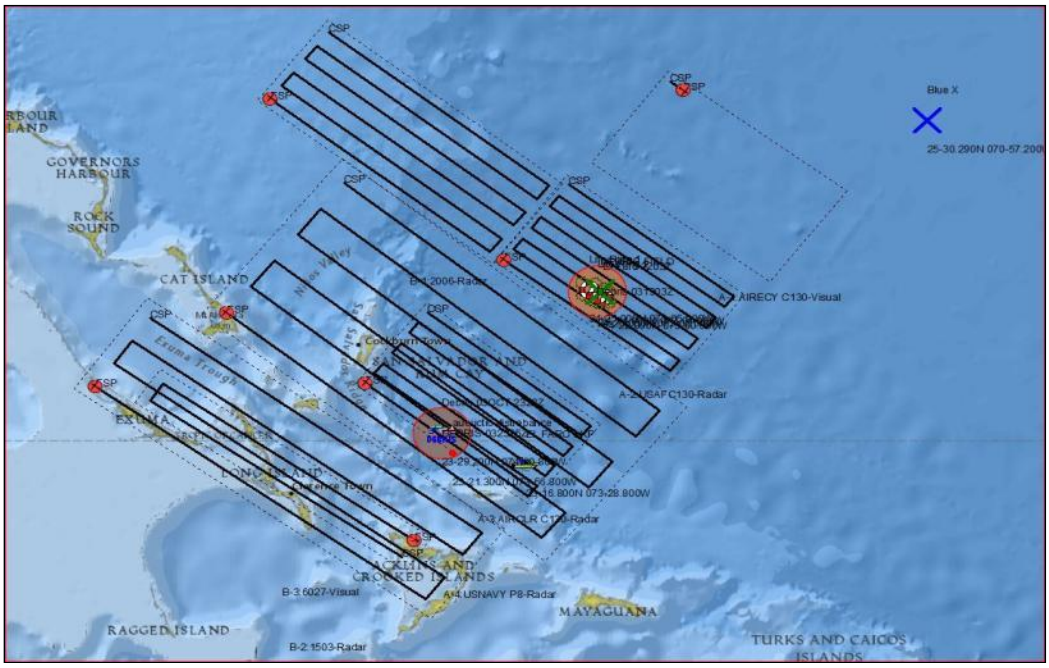


**Figure 69. EL FARO ALPHA and BRAVO search areas.**

On October 4, 2015, search conditions continued to improve. At 4:35 PM a Coast Guard MH-60T helicopter, tail sign CGR6009, was en route to its assigned search area and overflew a floating object identified as an immersion suit, 22 NM east of EL FARO's LKP. CGR6009 lowered a rescue swimmer, who confirmed that there were remains of a deceased EL FARO crew member in the suit. The rescue swimmer was unable determine if the deceased person was male or female due to advanced decomposition. Before any action could be taken to recover the body, the On Scene Commander (OSC) on the Coast Guard Cutter NORTHLAND reported that a Navy P8 aircraft had identified a possible person in the water (PIW) about 20 minutes from the location of the body in the immersion suit. The CGR6009 pilot asked the On Scene Commander (OSC) if they wanted his helicopter to investigate. The OSC concurred and the CGR6009 deployed a SLDMB[436] to mark the location of the deceased victim in the immersion suit. Upon arriving on scene of the reported area of the PIW sighting, the CGR6009 was directed to the location to the possible location by the Navy P8 aircraft. CGR6009 was only able to locate a piece of orange plastic, which was mistaken as a person moving in the water due to wave action. The CGR6009 then returned to the area where the deceased victim was discovered; however, they were unable to relocate the victim, as the SLDMB dropped near the immersion suit failed to activate. After conducting a search of the area CGR6009 had to return to base.[437] The immersion suit and the crew member's remains were never recovered.

If the SLDMB dropped by CGR6009 had activated its data would have been automatically displayed in SAROPS, showing the total drift (actual position of) the SLDMB. The data could have been used by the D7CC to develop a more localized drift for the search object.

[436] ARCOS 43396, ALMIS Mission Record Review, Air Station Clearwater 6009 October 04, 2015.
[437] NTSB Transcripts and Errata – Survival – CG-6009 Pilot in Command, USCG February 11, 2016.

During MBI testimony the Coast Guard SMC for EL FARO stated the following when asked about the reliability of the SLDMB that was used to mark the deceased crew member's location:

*The – generation 2 self-locating datum marker beacons have a 40 to 50 percent failure rate. We're in the process of fielding 3rd generation datum marker beacons.*

**Figure 70. An example of a sample self locating datum marker buoy (SLDMB) plot in SAROPS (Not EL FARO case related).**

From October 4 to October 7 another 42 sorties were conducted. Debris confirmed to be from EL FARO confirmed that the ship had sunk. No survivors or additional bodies were discovered during the search.

7.2.18.7. Case Conclusion

At 7:15 EST on October 7, 2015, the SAR Coordinator granted suspension of search efforts (ACTSUS) based on the diminished chance of crew member survival after six days in the maritime environment and the high coverage of the planned search area.

## 8. Analysis

The analysis section addresses issues that the MBI was unable to definitively classify as facts in Section 7 of this Report of Investigation, due to a lack of sufficient evidence or to conflicting evidence obtained over the course of the investigation.

### 8.1. Forensic Sinking Analyses

The MSC report includes documentation of the MSC hydrostatic analyses of the sinking of EL FARO. The analyses used the MSC's computer model and focused on assessment of righting arms, including righting energy and range of stability considerations, in order to gain insight into the characteristics of vessel dynamics and motions due to wind, waves, and flooding. The effects

of wind are discussed, along with considerations associated with floodwater, including effects of free surface, compartment permeability, and pocketing. The potential sources of flooding of Hold 3 are discussed, including photographs and drawings for reference of the vulnerability to flooding through the cargo hold ventilation openings and potentially through damaged emergency fire pump piping. Potential progressive flooding paths into Hold 2A and other cargo holds are discussed, including downflooding through the cargo hold ventilation system openings and possibly through leakage of the watertight door seals. Analyses of various wind heel and flooding conditions were used to assess likely scenarios leading to the capsizing and sinking of the vessel given the environmental conditions.

The results were highly sensitive to variation in permeability values, and a range of permeability values was used to assess impacts of the variability. The evaluation of flooding required careful consideration of compartment permeability and pocketing effects. For permeability, this includes significant variability in both overall permeability fraction and uniformity throughout the cargo holds. This is especially important when considering containers, where permeability varies significantly depending on the assumed watertight integrity and specific locations of the containers.

The results were also highly sensitive to variations in wind speed, especially in combination with floodwater free surface. Even single compartment flooding of Hold 3, when combined with a wind heel from 70-90 knot beam winds, would result in very small residual righting arms and little residual righting energy (please see Figure 68). This would suggest that it would be highly unlikely that EL FARO could have survived even single compartment uncontrolled flooding of Hold 3, given the wind and sea conditions generated by Hurricane Joaquin.

The report analyzed several potential sources of flooding of Hold 3 and the other cargo holds, including vulnerabilities associated with the cargo hold ventilation system. The MSC report notes that, for the accident voyage loading condition, flooding through the open cargo hold ventilation system would occur at angles of heel or roll as low as 27 degrees. This would likely result in at least intermittent flooding into the cargo holds, as the vessel was subject to a variable wave height on the side shell due to 25-30 foot seas, and also heaved and rolled about the mean heel angle of approximately 15 degrees. If there were vulnerabilities in the cargo hold ventilation trunks due to wastage or unauthorized modifications to bulkheads and baffles plates, the flooding into the cargo hold ventilation trunks could have occurred at an angle less than 27 degrees. The MBI determined that wastage and modifications to EL YUNQUE's cargo ventilation trunks would have led to downflooding on that vessel at angles of heel below the design criteria. The wastage in EL YUNQUE's was considered by the MBI to be longstanding through multiple inspection and dry dock cycles. An MBI review of EL FARO's survey and inspection records could not find evidence detailing that the vessel's ventilation trunks received an internal inspection by TOTE personnel, ABS or the Coast Guard. After the sinking of EL FARO, the Coast Guard Traveling Inspectors discovered a pattern of severely corroded and unserviceable watertight fittings, ducts, and dampers on multiple targeted ACP vessels that they visited during their focused ACP reveiw. As a result, hundreds of fittings were replaced or repaired and several ACP vessels received no-sail orders from the Coast Guard. Based on all the evidence available, there is a high likelihood that EL FARO's ventilation trunks, dampers, cargo

bay doors, and deck scuttles were in a material condition that increased EL FARO's susceptibility to flooding.

Regardless of the initial source or sources of flooding on EL FARO during the accident voyage, the free surface associated with the floodwater in the cargo holds combined with hurricane force winds and seas would have inevitably resulted in the capsizing of the vessel. The capsizing may have been slowed or temporarily arrested as containers on deck began to wash overboard, but as the vessel slowly rolled onto its port side, a large volume of floodwater would have been entering through the ventilation openings into all of the cargo holds and the engine room, resulting in the sinking.

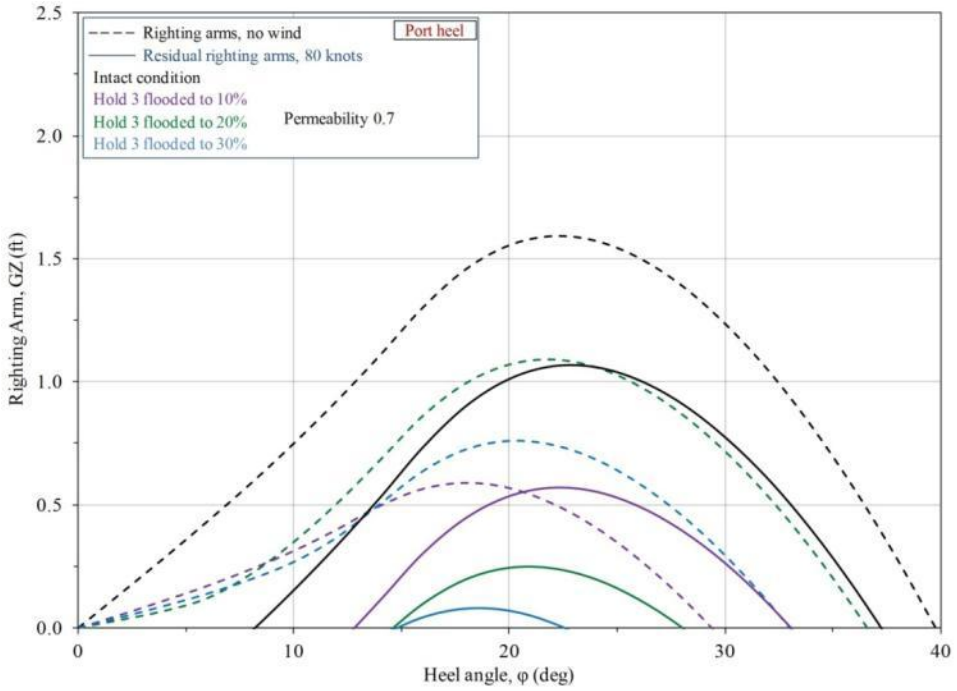


**Figure 71. Righting arms (dashed curves) and residual righting arms (solid curves) with 80 knot beam winds with Hold 3 flooded to 10%, 20%, and 30%. Permeability is 0.7 (Figure 6-24 of the MSC report).**

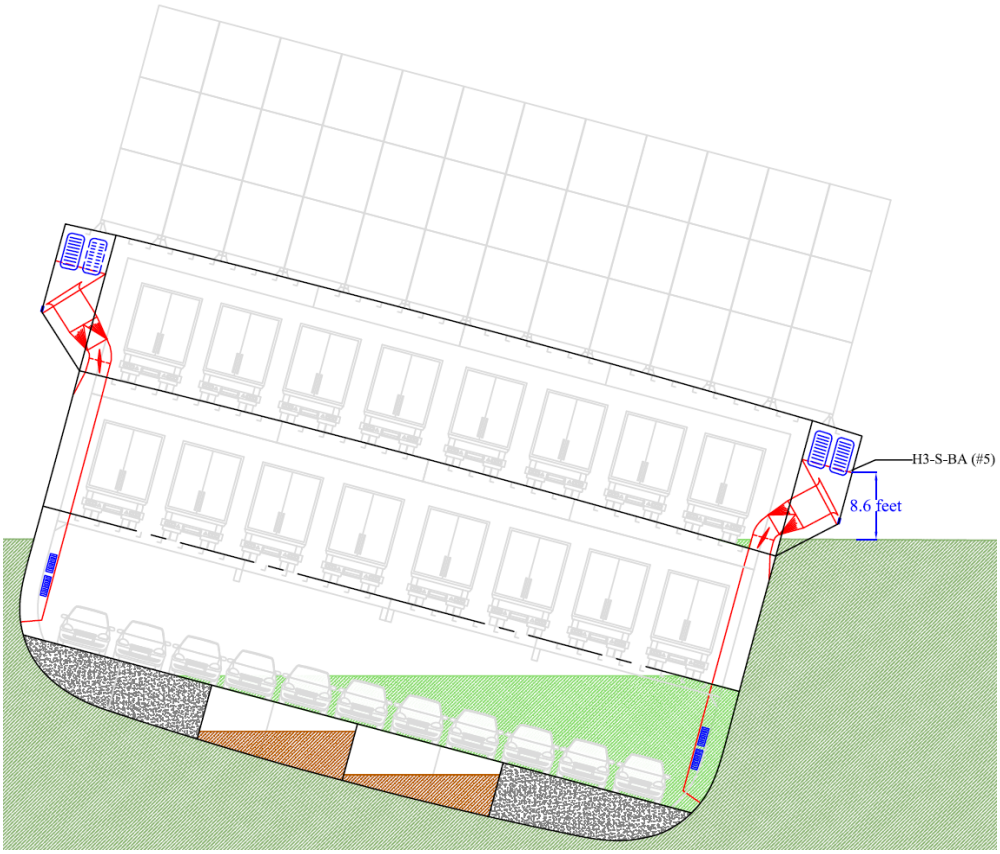


**Figure 72. Section at frame 143 (Hold 3 ventilation supply trunk) with flooding of Hold 3 to 20% with heel angle 15 degrees. Downflooding point at the top of the vertical baffle plate is shown (Figure 6-18 of the MSC report).**

## 8.2. Bilge Pump System Alarms and Associated Components

The flooding of Hold 3 was reported by a house phone call to the bridge at 5:43 AM on the October 1, 2015. The MBI could not determine whether the first report of flooding in Hold 3 came from a bilge high level alarm; or from visual observation of the water in the hold by a crew member. There was a watertight door fitted in the forward bulkhead of the engine room that gave direct access to Hold 3. If the forward engine room watertight door had been open for increased engine room ventilation, which former EL FARO engineers testified was common practice under normal operating conditions, it could have been the means of discovery. If the flooding in Hold 3 activated the bilge high level alarm, the engineers would have received an audible and visual alarm at the bilge high level alarm control panel near the watch station. This alarm could only be silenced by the engineer acknowledging the alarm on the bilge high level alarm control panel. The high level indicator light was designed to remain illuminated until the water level dropped below the float alarm set point.

The exact position and layout of EL FARO's bilge alarm sensors could not be determined because no drawings or plans were produced, and testimony from former EL FARO crew members and a TOTE P/E was not consistent. The bilge high level sensors were estimated to be 2 to 3 inches above the rose box in each cargo hold. The MBI estimates that it would take approximately 1,800 gallons of water to activate the high level bilge alarm with EL FARO in

static and even keel condition. The MBI was unable to determine how EL FARO's persistent starboard list during the early morning hours of October 1, 2015, may have impacted the sounding of the bilge alarms in Hold 3 or other cargo holds.

8.3. Container Conversion (2005-2006), Non-Major Conversion Determination

The MSC's final decision to consider EL FARO's conversion to a combination container and RO/RO vessel as not a major conversion was ultimately based on the "Precedence Principle." Specifically, TOTE argued that the Coast Guard had not previously designated similar conversions of EL FARO's sister vessels EL YUNQUE and EL MORRO, as well as two other Matson steam ships, as major conversions. In addition to the economic cost-benefit that such a conversion would provide, with an increased cargo-carrying capacity, there was also an indication in the correspondence that EL FARO's maximum design or load line draft would be substantially increased. Neither of these facts was used by the Coast Guard to stay with the initial major conversion determination. In their requests for reconsideration, TOTE argued that the vessel's load line (maximum design draft) would be the appropriate measure of cargo capacity, rather than container TEU or FEU, which the Coast Guard had used as the basis for the original major conversion determination. What appears to have been confused in the correspondence and discussion was that the required additional fixed ballast necessary to meet stability criteria with the additional containers on the main deck would necessarily result in a significant increase in the maximum design or load line draft, which is considered by most naval architects to be a principal vessel dimension. It should have been clear to the MSC that the intent of the conversion was to enable the vessel to carry substantially more containerized cargo (otherwise the conversion would not have been economically viable), and this would also require a significant increase of the maximum design or load line draft. Under the definition of "major conversion" in 46 USC § 2101(14a), both the substantial increase in the maximum draft (a principal vessel dimension) and the intent to increase cargo carrying capacity (for economic viability) should have been sufficient justification for a major conversion determination.

Even if the 2005-2006 conversion had been deemed a major conversion, Coast Guard policy dictated that particular requirements to meet current standards were made by the cognizant OCMI on a case-by-case basis, if deemed reasonable and practicable to do so. The Coast Guard policy stated:

> *With the passage of time, existing vessels will be retired and only those built to newer standards will continue in service. For this reason, it is costly and impractical to require existing vessels to be modified each time a safety standard is updated. However, when a major conversion or modification of an existing vessel is planned, there is a definite intent to extend the service life of the vessel. When this is the case, it is appropriate to bring the entire vessel into compliance with the latest safety standards where reasonable and practicable…The entire vessel must meet all current standards, as far as is reasonable and practicable, in effect at the contract date of a major conversion.*

The Coast Guard has minimal guidance available to OCMIs on what should be considered as "reasonable and practicable," after a major conversion is completed. As a result, OCMI imposed

requirements after a major conversion are made on a case-by-case basis, which leads to inconsistencies across the Coast Guard.

Nevertheless, even if it had been deemed reasonable and practicable to require meeting current stability standards in 2006, there would likely have been no change in applicability of the stability standards since the previous major conversion in 1992-1993 (see the MSC report, Appendix 1). For intact stability, the GM criteria of 46 CFR § 170.170 would still have been applicable in 2006, since the 2008 IS Code requiring assessment of righting arms and righting energy implemented with 46 CFR § 170.165 was not applicable until 2011. For damage stability, 1990 SOLAS damage stability standards would still have been applicable in 2006, since the 2009 SOLAS damage stability standards requiring a higher level of safety were not applicable until 2011. However, requiring EL FARO to comply with all of the latest safety standards could have resulted in upgrades in other areas including modern lifesaving appliances.

### 8.4. Flooding of EL FARO

It is not possible to determine exactly when downflooding of EL FARO started, as there were multiple paths for seawater to enter the ship other than the first specific source of flooding that was identified on the VDR as the 2nd Deck starboard scuttle for Hold 3. Other possible sources include hull breaches, watertight openings left open or failing to function properly, or internal failures of the ventilation trunk structures.

#### 8.4.1. Seawater Ingress Other than the 2nd Deck Scuttle for Hold 3

It is not possible to determine if there was flooding within the internal watertight envelope before the discovery of the open scuttle in Hold 3 at 5:43 AM on October 1, 2015. However, there were statements made on the VDR prior to 5:43 AM that indicate EL FARO was likely experiencing free surface effects prior that time. Shortly after taking over the bridge watch at 3:51 AM on the morning of the accident, the C/M stated "don't like this" and then commenced making a series of course changes to improve EL FARO's ride. At 5:11 AM, the C/E who was assigned to supervise the riding crew made the following statement to the Master and C/M on the bridge:

> *I've never seen it list like this— you gotta be takin' more than a container stack *. I've never seen it hang like this.*

The Riding Crew Supervisor appeared to be concerned about the list and handling of EL FARO. He seemed to be speculating that a leaning container stack could be the cause, but it would have been impossible for the crew to visually confirm the conditions of the containers considering the prevailing storm conditions and darkness at that time of the morning. It's likely EL FARO's list and hanging conditions were due to free surface from flooding already occurring within Hold 3, across the 2nd Deck, and possibly other cargo holds.

A ship flooding with seawater, coupled with the sloshing of the free water in the holds, behaves differently than a ship with a typical load and no internal flooding. The rolling of the

ship, the speed of the ship, and other changes in ship's motion characteristics change as the volume of water inside the hull increases.

8.4.2. Downflooding from the Starboard Scuttle into Hold 3

EL FARO's scuttles on the 2nd Deck were secured by closing the scuttle and spinning a hand wheel. Once the hand wheel was spun the hatch was designed to be dogged or secured. There was no way for a crew member to visually determine that the closure was properly secured from a 2nd Deck vantage point. A crew member would have needed to spin the wheel to see if it had been rotated in the proper direction or lift on the heavy scuttle hatch to see if it was secured. While standing watch on at 6:48 PM on September 30, 2015, the C/M made the following comments related to the proper securing of EL FARO's scuttles on the 2nd Deck:

> *I've got to send these guys. I've seen the water chest deep down there on (the) second deck.*
>
> *Yeah it's no joke.*
>
> *Yeah when I said you know those scuttles need to be dogged– not just flipped down. You know– they need to be spun and sealed.*

These comments indicate that there was a need to remind the crew to properly secure the scuttles. The implication from this exchange was that the scuttles were not consistently secured. This situation would also be compounded by having a riding crew aboard who were not given a complete safety briefing detailing the need to secure watertight fittings after use.

There is no way to determine how long the scuttle on the starboard side of Hold 3 was open and allowing seawater to enter the hold. Each cargo hold had a scuttle on the port and starboard side of the hold that led to the 2nd deck. It is possible that the starboard scuttle for Hold 3 was in the down and unsecured position prior to the morning of October 1, 2015, but evaded detection by crew members making rounds on the 2nd deck on the evening of September 30, because it appeared to be closed. At some point the force of water on the 2nd deck, coupled with the movement of debris, likely forced the scuttle into the open position.

The MBI could also not determine how that breach of the watertight envelope was detected by the crew. Based on the large volume initially reported in Hold 3, it is likely that the EL FARO was flooding for an extended period of time, probably in several holds, prior to detection. Detection of the flooding was hindered because the crew lacked the ability to remotely monitor the cargo holds and crew member rounds of the 2nd deck and cargo holds were severely restricted during the heavy weather conditions encountered on the accident voyage due to safety concerns.

8.4.3. Downflooding or Progressive Flooding into Hold 2A

As EL FARO's list steadily increased on the morning of October 1, and the ship settled in to worsening seas, the vessel likely began to take water into Hold 2A through the exhaust and

supply ventilation ducts. The interior material condition of the ventilations trunks, which the MBI determined was likely heavily corroded, could have exacerbated the flooding by an undetermined amount. Flood water could have also passed from hold-to-hold through damaged or worn seals around the large watertight vehicle cargo doors.

8.4.4. Potential Flooding into Hold 3 from Ruptured Emergency Fire Main Piping

At 5:44 AM on October 1, 2015, the Master made the following statement to the C/M after receiving a report about flooding in Hold 3:

*We got cars loose. Yeah.*

The loose cargo shifting in the hold combined with flood water could have resulted in cascading cargo breakaways in the hold.

At 7:17 AM, the Master made the following statement to the C/M just prior to discussing the possibility of damage to the emergency fire main:

*The cars that are floating in 3 Hold…*

The vehicles in Hold 3 were likely adrift and moving around in Hold 3 for at least 90 minutes while EL FARO was transiting through heavy seas with a starboard list. There is a possibility that loose vehicles could have damaged the ship's structure including the emergency fire main piping. The emergency fire pump, which was situated near the aft end of Hold 3 on the starboard side, was comprised of a sea chest, piping, a sea chest valve, strainers, and the emergency fire pump. That system was partially protected by various structures, but it was still vulnerable to damage. Damage to the suction piping would have resulted in flooding considering the sea chest intake was located well below EL FARO's waterline, which would have resulted in water entering Hold 3 at a substantial pressure and volume. The volume would have far exceeded what the bilge system was designed to accommodate. The MBI was unable to accurately determine if damage occurred to this system as comments made by EL FARO's crew regarding the emergency fire main were inclusive. However, after reviewing all of the available evidence, the MBI determined that it is unlikely that a rupture to the emergency fire contributed to the flooding in Hold 3.

8.4.5. Gradual Flooding and Final Flooding of EL FARO

As greater volumes of flood water entered the ship from Hold 3 and Hold 2A, the ship began to settle in the water and the list continued to increase. This was coupled with the angle of the ship's hull in relation to the seas. At some undetermined point shortly after the vessel induced the port list, all of the ventilation trunks were being periodically submerged and water would have begun entering all of the unprotected openings into the watertight spaces of the ship. The fact that EL FARO always operated with its ventilation trunk fire dampers in the open position would have allowed the flooding via the trunks to occur unchecked. There is no mention of attempting to secure the fire dampers on the VDR. The manual closures for the dampers were located on the 2nd Deck of EL FARO along the port and starboard sides of the vessel. When

considering that the 2nd Deck was reportedly flooded with waist deep water, securing the dampers would not have been a viable option for the crew.

## 8.5. Damage Control Knowledge and Effectiveness

EL FARO's side shell openings for the ventilation trunks posed a risk to the vessel when the ship was listing. This risk existed despite the internal baffles and other protective design features within the ventilation trunks. The ventilation trunks were especially vulnerable to a sustained heel because flood water would not drain out of the trunks as effectively and the height of the internal baffle plates would be partially degraded due to the heel. Seawater would enter the openings at greater volumes as the ship was settling into the water due to the weight of the flood water and green water on deck. After losing main propulsion around 6:00 AM on October 1, 2015, the available VDR data indicated that EL FARO was lying in the trough of the seas aligned with the trough, which is an extremely vulnerable position for a ship in high seas. As EL FARO's crew attempted to combat the flooding and discussed the survivability of the ship, the Master and C/M appeared to be uncertain about the ship's downflooding points, bilge system, reserve buoyancy, and stability. At 7:22 AM the Master made the following statements while talking to the engine room on the house phone:

> *It's lookin' pretty nasty. (Uh/on) the downflooding angle? Um that I don't have an answer for (ya).*
>
> *What's it called again?*
>
> *Okay we'll check that. (It's/that's) in the chief's office?*
>
> *Um no. I mean we still got reserve buoyancy and stability.*

Four minutes later the Master ordered the general alarm to be rung to alert the crew to the emergency situation.

## 8.6. Basic Wreckage Analysis

The material condition of EL FARO related to possible damage incurred during the course of the voyage through Hurricane Joaquin was difficult to determine due to the fact that the vessel was subjected to severe forces as it sank to a depth of nearly three miles below the surface of the ocean. In the case of another vessel which sank to a similar depth, the TITANIC, it was estimated that the main sections of the ship sank to the bottom at a speed of approximately 35 – 50 miles per hour.[438] EL FARO's impact with the seafloor and the dynamic motion of the ship as it travelled to the bottom would have imparted significant force to the vessel and the vessel's structures. The bottom of the crumpled transom plating at the stern, where the vessel's name and hailing port are displayed, showed damage that was likely due to the stern, rudder, and propeller shaft striking the bottom first and exerting an upward force on the transom structure at the stern. After contacting the bottom the rest of EL FARO's hull settled into the sea floor, partially burying the hull into the silt on the bottom.

[438] Source: www.titanicfacts.net

One of the aspects of a ship propelled by a steam system was the extreme heat generated by the boiler structures. In the case of EL FARO, the boiler system and components being immersed in seawater could have produced a thermal event where the superheated boiler equipment catastrophically failed as it reacted with the colder seawater flooding into the engine room. The result would have caused a significant thermal pressure wave that that radiated upwards from the engineering spaces. The resulting forces likely caused EL FARO's upper superstructure and the ship's smokestack to detach from the vessel. The ship's bridge and smokestack were located partially damaged but primarily intact on the seafloor near the wreck. Photographs taken by a ROV during the survey of EL FARO's wreckage indicate signs of damage above the boiler casings that are consistent with a catastrophic steam boiler failure.

## 8.7. ACP Effectiveness

After encountering ACP related concerns during the EL FARO investigation, the MBI expanded the scope of its investigation to examine ACP effectiveness for EL YUNQUE and several other U.S. flagged vessels enrolled in the program. After the sinking of EL FARO, the Coast Guard Traveling Inspectors began a focused effort to ascertain the material condition of the ACP vessels targeted by Office of Commercial Vessel Compliance. In addition, several Coast Guard field units reached out to the Traveling Inspectors for assistance with ACP vessels that were known to be operating in a substandard safety condition starting in early 2015 and accelerating after the loss of EL FARO. In October 2016, the Commanding Officer of Coast Guard Activities Europe sent an internal memorandum to the Office of Commercial Vessel Compliance that detailed ACP concerns his inspectors had observed while conducting oversight exams in Western Africa on offshore supply vessels.

In general, the ACP is not currently functioning as envisioned when the Program was created in 1996. The primary shortfalls observed over the course of the MBI include the following:

- An ACP training course for ACS surveyors and Coast Guard inspectors to interact and become familiar with the Program was never implemented.
- ACS surveyors and Coast Guard inspectors are often unfamiliar with the program requirements and the U.S. Supplement.
- The U.S. Supplement for ABS is not being updated on an annual basis and marine inspector identified gaps (e.g., the lack of hydrostatic testing requirements for propulsion boiler repairs) are not being incorporated into the Supplement updates.
- ACS surveyors and Coast Guard inspectors rarely interact in the field during ACP activities and there is no required minimum level of Coast Guard oversight required.
- There is no minimum qualification level required for Coast Guard personnel to conduct ACP oversight exams.
- The Coast Guard does not require marine inspectors to be trained as auditors.
- ABS training requirements for certain inspections activities (e.g., overseeing repairs to a propulsion steam boiler) are far less than the Coast Guard would require for a marine inspector conducting a similar inspection activity.
- ACS surveyors performing ACP inspections are reluctant to hold up a commercial vessel especially for observations that are outside the scope of the survey being performed.

- Coast Guard OCMIs often lack the Prevention experience necessary to make time sensitive decisions to hold up substandard ACP vessels that have been cleared to operate by the ACS – a problem that is exacerbated by the limited number of Jones Act vessels available to perform certain trade routes.
- The Coast Guard Traveling Inspectors are encountering numerous long-standing safety deficiencies when they attend inspections on targeted ACP vessels which have frequently led to those vessels receiving no-sail orders.
- ACS surveyors are not held accountable for performing substandard ACP inspections that miss glaring safety deficiencies and the Coast Guard Office of Commercial Vessel Compliance does not have a system in place to associate an ACS with a substandard inspection they conduct on behalf of the Coast Guard.
- The Coast Guard does not publish an annual report on ACP vessel compliance or ACS performance. The lack of transparency has enabled vessel compliance and surveyor performance issues to continue unabated.
- The Coast Guard MISLE database is not available to ABS surveyors and they are often unaware of outstanding requirements and special notes on the vessels they are surveying.
- The Coast Guard MISLE database is not designed to record and track the results of CG auditing activities.
- A formal Coast Guard course for advanced and specialized marine inspections (e.g., steam propulsion plants) is not available and the Coast Guard Center of Expertise that previously covered Vintage Vessels like the EL FARO was disbanded around 2012.
- The Liaison Officer for the Recognized and Authorized Class Societies (LORACS) billet at Coast Guard Headquarters that previously provided ACSs with a single point of contact for ACP related issues was eliminated in 2012.
- The ACP does not have a designated lead office or individual at Coast Guard Headquarters. As a result, multiple offices share responsibility for overseeing different aspects of the ACP which leads to confusion.

Based on the results of the Coast Guard Traveling Inspector ACP oversight exams that were conducted in 2015 and 2016, it is clear that multiple U.S. cargo vessels were operating for prolonged periods in a substandard material condition. Although the Coast Guard's focused oversight on the ACP targeted vessels corrected the most egregious cases of non-compliance, a seminal change in the overall management and execution of the Program is urgently needed to ensure safe conditions are sustained on the enrolled U.S. commercial vessels.

## 9. Conclusions

### 9.1. Events and Contributing Factors

The Marine Board of Investigation identified the following series of events and associated contributing factors.

#### 9.1.1. Event #1: EL FARO Sailed Within Close Proximity to Hurricane Joaquin

9.1.1.1. TOTE did not ensure the safety of marine operations and failed to provide shore side nautical operations supports to its vessels.

9.1.1.2. TOTE did not identify heavy weather as a risk in the Safety Management System (SMS) and the Coast Guard had not exercised its flag state authority to require identification of specific risks.

9.1.1.3. TOTE and the Master did not adequately identify the risk of heavy weather when preparing, evaluating, and approving the voyage plan prior to departure on the accident voyage.

9.1.1.4. TOTE and the Master and ship's officers were not aware of vessel vulnerabilities and operating limitations in heavy weather conditions.

9.1.1.5. TOTE did not provide the tools and protocols for accurate weather observations. The Master and navigation crew did not adequately or accurately assess and report observed weather conditions.

9.1.1.6. TOTE did not provide adequate support and oversight to the crew of EL FARO during the accident voyage.

9.1.1.7. The National Hurricane Center (NHC) created and distributed tropical weather forecasts for Tropical Storm and Hurricane Joaquin, which in later analysis proved to be inaccurate. Applied Weather Technologies used these inaccurate forecasts to create the Bon Voyage System (BVS) weather packages.

9.1.1.8. The Master and deck officers were not aware of the inherent latency in the BVS data when compared to the NHC forecasts. Additionally, the Master and deck officers were not aware that they received one BVS data package with a redundant hurricane trackline.

9.1.1.9. The Master and deck officers relied primarily on graphical BVS weather forecasts rather than the most current NHC data received via SAT-C. EL FARO crew did not take advantage of BVS's tropical update feature and the ability to send BVS weather information directly to the bridge.

9.1.1.10. The Master did not effectively integrate the use of Bridge Resource Management techniques during the accident voyage. Furthermore, the Master of EL FARO did not order a reduction in the speed or consider the limitations of the engineering plant as EL FARO converged on a rapidly intensifying hurricane. This resulted in loss of propulsion, cargo shifting and flooding.

9.1.1.11. The Master of EL FARO failed to carry out his responsibilities and duties as Captain of the vessel between 8:00 PM on September 30 and 4:00 AM on October 1, 2015. Notably, the Master failed to download the 11:00 PM BVS data package, and failed to act on reports from the 3/M and 2/M regarding the increased severity and narrowing of the closest point of approach to Hurricane Joaquin, and the suggested course changes to the south to increase their distance from the hurricane.

9.1.1.12. The cumulative effects of anxiety, fatigue, and vessel motion from heavy weather degraded the crew's decision making and physical performance of duties during the accident voyage.

9.1.2 Event #2: EL FARO Experienced an Initial Starboard List and Intermittent Flooding

9.1.2.1. EL FARO developed a sustained wind heel to starboard as a result of the course change from 155 degrees to 116 degrees after passing south of San Salvador at approximately 1:30 AM on October 1. The wind heel brought the 2nd deck closer to the water line.

9.1.2.2. Intermittent flooding into one or more cargo holds on EL FARO began at this time. Water was able to enter Hold 3 through the open scuttle, and likely through deteriorated internal structures and open cargo hold ventilation fire dampers, which compromised watertight integrity.

9.1.2.3. The increasing of EL FARO's load line drafts following the 2005-2006 conversion, combined with loading to near full capacity with minimal stability margin, increased the vessel's vulnerability to flooding in heavy weather.

9.1.2.4. Despite the apparent increase in cargo carrying capacity and increase load line draft which would result, the 2005-2006 conversion was not designated as a major conversion by the Coast Guard. Based on the available documentation, the final decision was based on the "Precedence Principle," in that the Coast Guard had previously not designated similar conversions of sister vessels EL YUNQUE and EL MORRO as major conversions.

9.1.2.5. The crew's complacency, lack of training and procedures, and EL FARO's design contributed to the crew's failure to assess whether the vessel's watertight integrity was compromised.

9.1.2.6. EL FARO's conversion in 2005-2006, which converted outboard ballast tanks to fixed ballast, severely limited the vessel's ability to improve stability at sea in the event of heavy weather or flooding.

9.1.2.7. The Master, C/M, and crew did not ensure that stevedores and longshoremen secured cargo in accordance with the Cargo Securing Manual, which contributed to RO/RO cargo breaking free.

9.1.2.8. The practice of sailing with open cargo hold ventilation system fire dampers in accordance with SOLAS II-2, Regulation 20 and U.S. regulations created a downflooding vulnerability which is not adequately considered for the purposes of intact and damage stability, nor for the definitions of weathertight and watertight closures for the purpose of the applicable Load Line Convention.

9.1.2.9. The Coast Guard practice of verbally passing deficiency information to the ACS surveyor without written documentation of the deficient condition resulted in an unknown or incomplete compliance and material condition history of EL FARO.

9.1.3 Event #3: EL FARO experienced a reduction in propulsion

9.1.3.1. EL FARO's reduction in speed, from approximately 16 knots to 9 knots that occurred between 3:45 AM to 4:15 AM on October 1 was the result of the routine blowing of tubes and the C/M making course changes. EL FARO never reached a speed through the water above 10 knots for the remainder of the voyage.

9.1.3.2. EL FARO's departure with a main lube oil sump level of 24.6", which was below the Machinery Operating Manual recommended operating level of 27", reduced the crew's ability to maintain lube oil suction for the main propulsion plant.

9.1.3.3. Prior to 4:36 AM, EL FARO's main propulsion unit developed intermittent lube oil problems due to the starboard list.

9.1.4. Event #4: EL FARO Incurred a Severe Port List and Lost Propulsion

9.1.4.1. At 5:54 AM on October 1, the Master altered course to intentionally put the wind on the vessel's starboard side to induce a port list and enable the C/M to access and close the Hold 3 starboard scuttle. This port list was exacerbated by his previous order to transfer ramp tank ballast to port, and resulted in a port list that was greater than the previous starboard list and a dynamic shifting of cargo and flood water.

9.1.4.2. The port list, combined with the offset of the lube oil suction bellmouth 22" to starboard of centerline, resulted in the loss of lube oil suction and subsequent loss of propulsion at around 6:00 AM.

9.1.4.3. Coast Guard and ABS plan review for EL FARO's lube oil system did not consider the worst case angle of inclination in combination with the full range of lube oil sump operating levels specified in the machinery operating manual. This led the crew to operate with a lube oil sump level within the operating range specified on the Coast Guard and ABS approved drawing, but below the 27" operating level, which was the only level reviewed by ABS.

9.1.4.4. The Master and C/E did not have a complete understanding of the vulnerabilities of the lube oil system design, specifically the offset suction. This lack of understanding hampered their ability to properly operate the ship in the prevailing conditions.

9.1.4.5. TOTE's lack of procedures for storm avoidance and vessel specific heavy weather plans containing engineering operating procedures for heavy weather contributed to the loss of propulsion.

9.1.5. Event #5: EL FARO sank

9.1.5.1. The loss of propulsion resulted in the vessel drifting and aligning with the trough of the sea, exposing the beam of the vessel to the full force of the sea and wind.

9.1.5.2. Even after securing the scuttle to Hold 3, water continued to flood into cargo holds through ventilation openings, and also likely between cargo holds through leaking gaskets on large watertight cargo hold doors.

9.1.5.3. The EL FARO crew did not have adequate knowledge of the ship or ship's systems to identify the sources of the flooding, nor did they have equipment or training to properly respond to the flooding.

9.1.5.4. Even though EL FARO met applicable intact and damage stability standards as loaded for the accident voyage, the vessel could not have survived uncontrolled flooding of even a single cargo hold given the extreme wind and sea conditions encountered in Hurricane Joaquin.

9.1.6. Event #6: All 33 Persons Aboard EL FARO Are Missing and Presumed Deceased

9.1.6.1. A lack of effective training and drills by crew members, and inadequate oversight by TOTE, Coast Guard and ABS, resulted in the crew and riding crew members being unprepared to undertake the proper actions required for surviving in an abandon ship scenario.

9.1.6.2. After 5:43 AM on October 1, the Master failed to recognize the magnitude of the threat presented by the flooding into the hold combined with the heavy weather conditions. The Master did not take appropriate action commensurate with the emergent nature of the situation onboard EL FARO, including alerting the crew and making preparations for abandoning ship.

9.1.6.3. When the Master made the decision to abandon ship, approximately 10 minutes before the vessel sank, he did not make a final distress notification to shore to update his earlier report to TOTE's Designated Person Ashore that they were not abandoning ship. This delayed the Coast Guard's awareness that EL FARO was sinking and the crew was abandoning ship, and impacted the Coast Guard's search and rescue operation.

9.1.6.4. Although EL FARO's open lifeboats met applicable standards (SOLAS 60), they were completely inadequate to be considered as an option for the crew to abandon ship in the prevailing conditions.

9.1.6.5. The Coast Guard's existing Search and Rescue equipment and procedures were unable to effectively mark and track a deceased EL FARO crew member for eventual recovery. As a result the crew member remains missing and unidentified.

9.2. Unsafe Actions or Conditions that Were Not Causal Factors in this Casualty

9.2.1. Other than class specific guides that provide for voluntary review (and certification) of software for container loading and securing calculations for vessels desiring the special class notation, there is no specific U.S. or international requirement for review and approval of software for cargo loading and securing calculations. The Coast Guard also has not published any policy or guidance regarding such software or calculations.

9.2.2. There are no domestic regulations or policy for Coast Guard approval of stability software, and the Coast Guard has not delegated any such approval authority to an ACS.

9.2.3. As a result of TOTE's failure to notify ABS and the Coast Guard about the lifeboat davit repair work on September 28 and 29, 2015, the full materiel condition of the lifeboat davit repairs before EL FARO departed could not be assessed.

9.3. Evidence of Acts subject to Civil Penalty

9.3.1. STCW rest violations – on numerous occasions there were violations for the rest hours prescribed in STCW for deck officers serving onboard EL FARO, these violations were systemic and not addressed by TOTE.

- In particular there were three violations for the requirement contained in 46 U.S.C. § 8104 for a Third Mate on July 7, 2015 and July 14, 2015 and for a different Third Mate on September 1, 2015. This rest requirement is for deck officers to get a minimum of six hours rest in the twelve hours immediately before the vessel goes to sea.

- Furthermore there is evidence that the 3/M did not meet the 6 hours of uninterrupted rest (per 46 CFR § 15.1111) on the following dates: August 5, 8, 22, and September 5 based on the records that were provided by TOTE. The complete STCW work records for the accident voyage are not available due to the loss of the EL FARO.

9.3.2. Potential violation of 46 U.S.C. § 8106(a)(4) – no safety orientation or Coast Guard approved Basic Safety Training (BST) for the Polish riding crew.

9.3.3. Failure to notify the Coast Guard or ABS of repairs to primary lifesaving appliances that were conducted on September 28 and 29, 2015, just prior to EL FARO's departure from Jacksonville on the accident voyage.

9.3.4. Failure to notify the Coast Guard or ABS of repairs to EL FARO's main propulsion boiler superheating piping on August 24, 2015.

10. Safety Recommendations

Recommendation #1 – High Water Alarms. It is recommended that Commandant direct a regulatory initiative to require high water audio and visual alarms, capable of providing audible and visual alarms on the navigation bridge, in cargo holds of dry cargo vessels. Furthermore, it is recommended that Commandant work with the International Maritime Organization (IMO) to amend the applicability of SOLAS Chapter II-1/25 (2015 consolidated) to include all new and existing multi-hold cargo ships.

Recommendation #2 – Ventilators and Other Hull Openings for Cargo Ships. It is recommended that Commandant direct a review of U.S. regulations, international conventions, and technical policy to initiate revisions to ensure that all ventilators or other hull openings, which cannot be closed watertight or are required to remain normally open due to operational reasons such as continuous positive pressure ventilation, should be considered as down-flooding points for intact and damage stability. Additionally, fire dampers or other closures protecting openings required to remain normally open due to operational reasons such as continuous positive pressure ventilation should not be considered weathertight closures for the purpose of the applicable Load Line Convention. These changes should apply to new and existing vessels.

Recommendation #3 – Addressing Safety Concerns Related to Open Lifeboats. It is recommended that Commandant initiate a Legislative Change Proposal and direct a regulatory initiative to eliminate open top gravity launched lifeboats for all oceangoing ships in the U.S. commercial fleet. As an immediate interim safety measure, it is recommended Commandant direct all Officers in Charge of Marine Inspection (OCMIs) to conduct a concentrated inspection campaign on all existing vessels outfitted with gravity launched open lifeboats, including a Coast Guard supervised launching and underway operational test of every lifeboat in service. This concentrated inspection campaign should also ensure that companies have adequately identified and addressed the hazards related to operating with open top gravity launched lifeboats in their identified Safety Management System (SMS) risks.

Recommendation #4 – Indicators for Watertight Closures on Bridge Alarm Panels. It is recommended that Commandant direct a regulatory initiative to require open/close indicators on the bridge of all existing cargo ships, for all watertight closures that are identified as watertight on the conditions of assignment for assignment of load line form for unmanned and cargo spaces. Furthermore, it is recommended that Commandant work with the IMO to amend the applicability of paragraph 3 of SOLAS II-1/13-1 (2015 consolidated) to include all existing cargo ships. This change would require open/close indicators on the bridge of all existing cargo ships, for all watertight closures (e.g., doors, scuttles, fire dampers) that are identified as watertight on the conditions of assignment for assignment of load line form for unmanned compartments and cargo spaces.

Recommendation #5 – Requirement for Closed Circuit Television (CCTV) Camera Installation in Stowage Areas. It is recommended that Commandant direct a regulatory initiative to require the installation of CCTV cameras to monitor unmanned spaces from the bridge cargo vessels, such as cargo holds and steering compartments. Furthermore, it is recommended that Commandant work with the IMO to create a new requirement to install and utilize CCTV cameras, or other similar technology, in cargo stowage areas on cargo ships.

Recommendation #6 – Vessel Weight Change Tracking. It is recommended that Commandant direct a regulatory initiative to require that a company maintain an onboard and shore side record of all incremental vessel weight changes, to track weight changes over time so that the aggregate total may be readily determined.

Recommendation #7 – Approval of Software for Cargo Loading and Securing. It is recommended that Commandant direct a regulatory initiative to require review and approval of software that is used to perform cargo loading and securing calculations. Furthermore, it is recommended that Commandant work with the IMO to implement international requirements for review and approval of such software.

Recommendation #8 - Review and Approval of Stability Software. It is recommended that Commandant update policy to address Coast Guard review and approval of stability software, and delegate review and approval authority to ACSs, where appropriate. This should include establishing specific policy and assigning technical requirements for review and approval of stability software by the Coast Guard, which may be required to review and approve such

software for vessels that do not fall under the Alternate Compliance Program (ACP) or Navigation and Vessel Inspection Circular (NVIC) 3-97 authorities.

Recommendation #9 – Float-free Voyage Data Recorder (VDR) Equipped with an Emergency Position Indicating Radio Beacon (EPIRB). It is recommended that Commandant direct a regulatory initiative to require that all VDR capsules be installed in a float-free arrangement, and contain an integrated EPIRB for all domestic vessels currently required to be equipped with a VDR. Furthermore, it is recommended that Commandant work with the IMO to amend SOLAS V/20 (2015 consolidated) to require this VDR configuration for existing vessels.

Recommendation #10 – Locating and Marking Objects in the Water. It is recommended that Commandant direct an examination of the reliability rate of SLDMBs and other similar technology used during Coast Guard Search and Rescue operations. Additionally, the Coast Guard should develop pre-deployment protocols to conduct circuit testing on beacons prior to deploying them on-scene.

Recommendation #11 – Attachable Beacon for Assisting in Relocating Search Objects that are Initially Unrecoverable. It is recommended that Commandant identify and procure equipment that will provide search and rescue units the ability to attach a radio or Automated Identification System/strobe beacon to a found search object that is not immediately retrievable. This beacon should be able to be quickly activated and attached to the object, and have a lanyard of sufficient length to keep the beacon on the surface of the water if the object sinks below the surface.

Recommendation #12 – Personal Locator Beacon Requirement. It is recommended that Commandant direct a regulatory initiative to require that all Personal Flotation Devices on oceangoing commercial vessels be outfitted with a Personal Locator Beacon.

Recommendation #13 – Anonymous Safety Reporting to Shore for Ships at Sea. It is recommended that Commandant direct the development of a shipboard emergency alert system that would provide an anonymous reporting mechanism for crew members to communicate directly with the Designated Person Ashore or the Coast Guard while the ship is at sea. The system would be in place to report urgent and dire safety concerns that are not being adequately addressed onboard the ship or by shore based company resources in a timely manner.

Recommendation #14 – National Oceanographic and Atmospheric Administration (NOAA) Evaluation of Forecast Staffing and Products for Maritime Interests. It is recommended that Commandant request that NOAA evaluate the effectiveness and responsiveness of current National Weather Service (NWS) tropical cyclone forecast products, specifically in relation to storms that may not make landfall but that may impact maritime interests. To improve service to marine stakeholders the evaluation should consider the inclusion of past track waypoints for the tropical system for a period of 48 hours and a graphical depiction of the forecast model track of the best performing prediction models.

Recommendation #15 – Clarification of Flag State Expectations for SMS Implementation. It is recommended that Commandant direct the development and implementation of policy to make it clear that the Coast Guard has a shared responsibility to assess the adequacy of a company's SMS. This responsibility includes, but is not limited to, assessing identified risks and contingency plans (as described in IMO Resolution A.1072(28)), and ensuring that the duties,

authorities, and qualifications of the Designated Person Ashore and other shore side management who support vessel operations while underway are specifically described.

Recommendation #16 – Damage Control Information for Existing Cargo Vessels. It is recommended that Commandant direct a regulatory initiative to require that all cargo ships have a plan and booklets outlining damage control information. Furthermore, it is recommended that Commandant work with the IMO to amend the applicability of SOLAS Chapter II-1/19 (2015 consolidated), to apply to all existing cargo ships, ensuring these ships have the damage control information.

Recommendation #17 – Ship Specific Damage Control Competency. It is recommended that Commandant direct a regulatory initiative to update 46 CFR to establish damage control training and drill requirements for commercial, inspected vessels. Furthermore, it is recommended that Commandant work with the IMO to amend SOLAS to establish similar requirements.

Recommendation #18 – Evaluation of Mariner Training Institutions and Coast Guard Merchant Mariner Credentialing Process. It is recommended that Commandant direct a review of the EL FARO VDR transcript and this Report of Investigation, specifically focusing on the effectiveness of the Coast Guard credentialing exams and third party provided training including navigation simulators, heavy weather avoidance, cargo lashing/securing, stability, damage control, and bridge resource management. The Coast Guard should use the review to identify potential areas and competencies needing improvement and expeditiously develop a plan to implement those findings into the mariner credentialing process.

Recommendation #19 – Electronic Records and Remote Monitoring of Vessels at Sea. It is recommended that Commandant direct a regulatory initiative to require electronic records and periodic electronic transmission of records and data to shore from oceangoing commercial ships. This requirement would include records such as bridge and engine room logs, Standards of Training Certification and Watchkeeping (STCW) records, significant route changes, critical alarms, and fuel/oil records. The regulation should ensure Coast Guard access to these records regardless of their location. Furthermore, it is recommended that Commandant work with the IMO to amend SOLAS to require this same electronic transmission of records from all oceangoing commercial ships.

Recommendation #20 – Prevention Training Course for Prospective Coast Guard Sector Commanders and Deputies. It is recommended that Commandant explore adding an OCMI segment to Training Center Yorktown's Sector Commander Indoctrination Course for prospective officers who do not have the Prevention Ashore Officer Specialty Code, OAP-10. The recommended OCMI training segment would be similar to the additional Search and Rescue (SAR) Mission Coordinator Course that is currently required for prospective Sector Commanders and Deputies who lack previous SAR experience.

Recommendation #21 – Coast Guard Oversight of ACSs that Conduct ACP Activities. It is recommended that Commandant update NVIC 2-95 and Marine Safety Manual Volume II to require increased frequency of ACS and Third Party Organizations (TPOs) direct oversight by attendance of Coast Guard during Safety Management Certificate and Document of Compliance

audits. Additionally, the Coast Guard shall perform a quality audit specific to the ACS representation and performance on U.S. flag vessels. The Coast Guard personnel conducting the oversight should be fully trained and certified to conduct audits, and given clear authority to issue non-conformities to a vessel, company, or ACS.

Recommendation #22 – ACP Efficiency and Manageability. It is recommended that Commandant direct a regulatory initiative to revise 46 CFR § 8.430 in order to eliminate the use of U.S. Supplements that currently exist for each ACS authorized to conduct all delegated activities. The regulatory revision should clarify that ACS personnel shall default to 46 CFR requirements in circumstances identified in the Critical Ship Safety Systems Table in the Federal Register on February 13, 1998 (63 FR 7495).[439]

Recommendation #23 – ACS Accountability and Transparency. It is recommended that Commandant establish and publish an annual report of domestic vessel compliance. This report shall include domestic vessel no-sail rates for each type of inspected subchapter, and a methodology for associating a Coast Guard-issued no-sail control action with an ACS, for vessels found to have deficiencies or major non-conformities that were misclassified, or not previously identified during an ACS-led inspection or survey.

Recommendation #24 – ACS Surveyor Performance and Interactions with OCMIs. It is recommended that Commandant direct the implementation of a policy requiring that individual ACS surveyors complete an assessment process, approved by the cognizant OCMI, for each type of delegated activity being conducted on behalf of the Coast Guard. The assessment shall ensure vessel surveys and audits meet the Coast Guard marine inspection standard. If an OCMI determines that an ACS surveyor's performance is substandard, that OCMI should be given the authority to revoke the Surveyor's authority to conduct surveys on their behalf.

Recommendation #25 – Competency for Steamship Inspections. It is recommended that Commandant direct a study to explore adding a Steam Plant Inspection course to the Training Center Yorktown curriculum. The course should be required for Coast Guard Marine Inspectors and made available to ACS surveyors who conduct inspections on behalf of the Coast Guard. The steam inspection course could serve as an interim measure until an Advanced Journeyman Course covering steam vessel inspections is implemented (please see Recommendation #26).

Recommendation #26 – Competency for Marine Inspections and ACS Surveyors Conducting Inspections on Behalf of the Coast Guard. It is recommended that Commandant direct the addition of an Advanced Journeyman Inspector course to the Training Center Yorktown curriculum. The course should cover ACS oversight, auditing responsibilities, and the inspection of unique vessel types. The course should be required for senior Coast Guard Marine Inspectors and made available to ACS surveyors who conduct inspections on behalf of the Coast Guard.

Recommendation #27 – Coast Guard Major Conversion Determinations for Vessels. It is recommended that Commandant direct the review of policies and procedures for making and documenting major conversion determinations, including use of the Precedence Principle.

[439] Available at https://www.gpo.gov/fdsys/pkg/FR-1998-02-13/pdf/98-3628.pdf.

Recommendation #28 – Intact and Damage Stability Standards Review. It is recommended that Commandant direct a review of current intact and damage stability standards to improve vessel survivability in extreme wind and sea conditions.

Recommendation #29 – Applying Intact and Damage Stability Standards to Existing Cargo Vessels. It is recommended that Commandant direct a regulatory initiative to require that all existing cargo vessels meet the most current intact and damage stability standards.

Safety Recommendation #30 – Third Party Oversight National Center of Expertise. It is recommended that Commandant consider creation of a Third Party Oversight National Center of Expertise to conduct comprehensive and targeted oversight activities on all third party organizations and ACSs that perform work on behalf of the Coast Guard. The Center of Expertise should be staffed with Subject Matter Experts that are highly trained inspectors, investigators, and auditors with the capability and authority to audit all aspects of third party organizations. As an alternative, the Coast Guard could add a new Third Party Oversight Office at Coast Guard Headquarters with a similar staffing model as the proposed Center of Expertise. The new Third Party Oversight Office could function similar to the Traveling Inspector Office and report directly to the Assistant Commandant for Prevention Policy.

Safety Recommendation #31 – Technical Review of Critical Propulsion System Components. It is recommended that Commandant immediately review a representative sample of existing engineering system plans and implement a policy to ensure future Coast Guard or ACS reviews of such plans consider the full designed operating range when reviewing design elements for critical propulsion system components (e.g., the operating range for lube oil systems should ensure satisfactory function for the full range of allowable oil sump levels and vessel lists.)

11. Administrative Recommendations

Administrative Recommendation #1 – Acquiring DNA Sample for Identification of Human Remains. It is recommended that Commandant direct the development and implementation of Coast Guard policy for the collection of DNA samples by Coast Guard personnel when deceased individuals are unable to be recovered during Search and Rescue cases or post-incident marine casualty investigations. These DNA samples could be used to provide identification of human remains

Administrative Recommendation #2 - VDR Performance Standards. It is recommended that Commandant direct a regulatory initiative to require that all VDRs capture all communications on ship's internal telephone systems. Furthermore, it is recommended that Commandant work with the IMO to amend SOLAS and update performance standards to ensure that all VDRs capture these two-way internal ship communications.

Administrative Recommendation #3 – VDR Data and Audio Access. It is recommended that Commandant initiate a Legislative Change Proposal to amend 46 U.S.C. Chapter 63, to ensure that, notwithstanding NTSB statutory authority, the Coast Guard has full access and ability to use VDR data and audio in marine casualty investigations, regardless of which agency is the investigative lead.

Administrative Recommendation #4 – MISLE Documentation of Deficiencies that the OCMI Refers to an ACS. It is recommended that Commandant require the addition of specific MISLE data fields for documenting deficiencies that the OCMI refers to an ACS for correction. The deficiency should remain open in MISLE until the ACS provides the OCMI who issued the deficiency with a written report documenting corrective action has been completed or the condition has been appropriately recorded in the Class database. This will ensure that vessel compliance history is documented and accessible to Coast Guard Marine Inspectors and investigators.

12. Enforcement Recommendations

Recommendation #1 – TOTE Services Violations. It is recommended that Sector Jacksonville initiate civil penalty action against TOTE Services for the following offenses:

- Failure to comply with the work-rest requirements detailed in 46 U.S.C. § 8104 and 46 CFR § 15.1111 for EL FARO crew members on multiple dates prior to the accident voyage.
- Failure to comply with emergency procedures for special personnel detailed in 46 CFR § 199.180. Specifically, Polish ship rider Mr. Marek Pupp testified that he continued to conduct work on EL FARO during the emergency muster and abandon ship drills.
- Failure to notify the Coast Guard or ABS of repairs to primary lifesaving appliances that were conducted on September 28, 2015 just prior to EL FARO's departure from Jacksonville on the accident voyage.
- Failure to notify the Coast Guard or ABS of repairs to EL FARO's main propulsion boiler superheating piping on August 24, 2015.

Based on the findings of this investigation, the MBI does not recommend any administrative or punitive action against any Coast Guard personnel. The MBI does not recommend any suspension or revocation action against any credentialed mariner. Additionally, the MBI does not recommend criminal prosecution against any person or entity.

JASON D. NEUBAUER
Captain, U.S. Coast Guard
Chairman, Marine Board of Investigation

Enclosures: (1) Marine Board of Investigation Convening Order
(2) Marine Board of Investigation Hearing Witness list
(3) Marine Board of Investigation Exhibit list

Appendices (A) Coast Guard MSC Technical Review and Analysis of the SS EL FARO
(B) Coast Guard MSC Lube Oil Modeling and Analysis