National Transportation Safety Board

Office of Marine Safety

Washington, D.C. 20594

Group Chairman's Factual Report

Nautical Group

SS *El Faro*

DCA16MM001

Michael Kucharski

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1 Accident Information

Vessel:	SS *El Faro*
Accident Number:	DCA16MM001
Date:	October 1, 2015
Time:	0739 eastern daylight time[1]
Location:	North Atlantic Ocean, 40 nautical miles northeast of Acklins and Crooked Island, Bahamas 23.3925° N, 73.9029° W
Accident type:	Sinking
Complement:	27 crew, 6 supernumeraries

2 Nautical Group

Chairman	Michael Kucharski Office of Marine Safety National Transportation Safety Board Washington, DC 20594
Member—US Coast Guard	CDR [redacted] Inspections and Investigations Branch (dpi)
Member—TOTE Services, Inc.	Captain Kevin Stith Master, TOTE Services
Member—American Bureau of Shipping	Michael J. Millar District Principal Southeastern USA
Member—Herbert Engineering Corporation	Spencer Schilling, President

3 Accident Summary

On Thursday, October 1, 2015, about 0715 eastern daylight time, the US Coast Guard received distress alerts from the 790-foot-long roll-on/roll-off container (Ro/Con) ship *El Faro* (**figure 1**). The US-flagged ship, owned by TOTE Maritime Puerto Rico (formerly Sea Star Line, LLC) and operated by TOTE Services, Inc., was 40 nautical miles northeast of Acklins and

[1] Times in this report are eastern daylight time according to the 24-hour clock.

Crooked Island, Bahamas, and close to the eye of Hurricane Joaquin. The ship was en route from Jacksonville, Florida, to San Juan, Puerto Rico, with a cargo of containers and vehicles. Just minutes before the distress alerts, the *El Faro* master had called TOTE Services' designated person (DP) and reported that a scuttle had popped open on deck two and that there was free communication of water into the No. 3 hold. He said the crew had controlled the ingress of water but the ship was listing 15° and had lost propulsion. The Coast Guard and TOTE Services were unable to reestablish communication with the ship. Twenty-eight US crewmembers, including an off-duty engineering officer sailing as a supernumerary, and five Polish workers were on board.

Figure 1. *El Faro* loaded with containers (photo from TOTE Services).

The Coast Guard, US Navy, and US Air Force dispatched multiple assets to the ship's last known position, but the search was hampered by hurricane-force conditions on scene. On Saturday, October 3, two debris fields were discovered, and on Sunday, October 4, a damaged lifeboat and liferaft were located. The same day, the Coast Guard found a deceased crewmember wearing an immersion suit. A Coast Guard helicopter dropped a locator buoy near the body in the immersion suit and left to investigate reported signs of life elsewhere but then could not relocate

the immersion suit. No signs of life were found, and on Monday, October 5, two oil slicks were discovered. The Coast Guard determined that *El Faro* was lost and declared the event a major marine casualty. The Coast Guard suspended the unsuccessful search for survivors at sundown on Wednesday, October 7.

4 Investigation

The National Transportation Safety Board (NTSB) learned of the accident from the Coast Guard on the afternoon of October 1. A team of five investigators, a board member, and support staff launched from NTSB headquarters on October 6 and arrived on scene in Jacksonville later the same day. The investigation was led by the NTSB. Parties to the investigation were the Coast Guard, TOTE Services, the American Bureau of Shipping, the National Weather Service, Harding Safety USA (Palfinger), and Herbert Engineering. The on-scene portion of the investigation was completed on October 15. Additional interviews by the NTSB nautical investigation group were conducted at various locations in 2015, 2016, and 2017.

Because the sunken *El Faro* could not be physically examined, investigators visited the vessel's sister ship, *El Yunque*, on four occasions (in October and December 2015, September 2016, and January 2017) to observe and document its structure and arrangements. Representatives of the Coast Guard, ABS, and TOTE Services were present at each visit. The Coast Guard convened three Marine Board of Investigation (MBI) hearings in Jacksonville after the accident (February 16–26, 2016; May 16–27, 2016; and February 6–17, 2017). The NTSB participated fully in the hearings.

The voyage data recorder (VDR) carried on *El Faro* was recovered from the wreckage in August 2016. Over 26 hours of parametric data and audio files were accessed from the VDR's

memory module. In December 2016, the NTSB released a transcript of the audio recordings made on the vessel's bridge during the last 26 hours before the sinking. The transcript is more than 500 pages long.

5 Vessel Description

El Faro was classified as a cargo ship but was more precisely described as a Ro/Con vessel. A Ro/Con vessel has separate areas for both lift-on/lift-off container stowage and stowage for roll-on/roll-off cargo (Ro/Ro) such as trailers and automobiles. *El Faro* had dedicated container stowage on the upper deck and Ro/Ro stowage on its lower decks.

The ship sailed on a weekly liner service between Jacksonville and San Juan. At the time of the sinking, the company ran *El Yunque* on the same route, operating on an opposite schedule. Both vessels were *Ponce*-class vessels built at Sun Shipbuilding and Dry Dock Company in Chester, Pennsylvania. *El Faro* was built in 1975, *El Yunque* a year later. Details about *El Faro* and the accident are shown in the **table**.

Table. Particulars of vessel and details of accident.

Vessel Name	**SS *El Faro***
Owner/Operator	TOTE Maritime Puerto Rico/TOTE Services
Port of Registry	San Juan
Flag	United States
Type	Cargo—Ro/Con
Built	1975
Official number	561732
Classification society	American Bureau of Shipping
Construction	Steel, reduced scantlings
Draft	30 feet (9.1 meters)
Length	790 feet (240.8 meters)
Beam	105 feet (32.0 meters)
Gross/net tonnage	31,515/21,473

Engine power and type	Steam turbine, 30,000 shaft horsepower, single screw
Service speed	20 knots
Cargo	Containers and rolling cargo
Fuel capacity	11,757 barrels
Fresh water capacity	410 long tons[2]
Ballast water capacity	4,623 long tons
Persons on board	33
Fatalities	33
Damage cost	Estimated $36 million

The house (navigation bridge and living quarters) on *El Faro* was in the aft part of the vessel (refer to **figure 1**). As shown in **figure 2**, the main engine room spaces were in the vicinity of the house, extending down from the stack, through the upper decks of the house area, and down to the lowest level of the watertight envelope—that is, the area enclosed by the hull and the second deck. *El Faro* had five upper decks, a main deck, and three lower decks. The main and second decks sloped or sheered toward the house from the bow and stern.

[2] One long ton = 2,240 pounds.

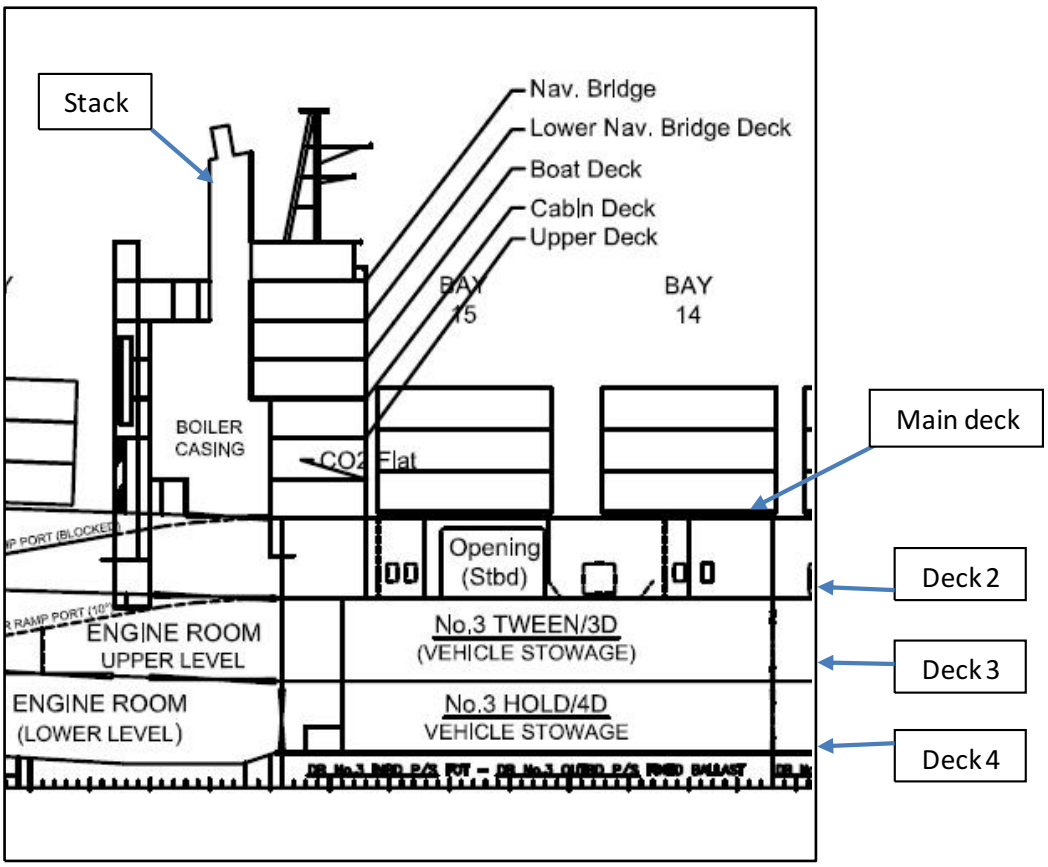


Figure 2. Vessel cross section showing location of navigation bridge, upper decks, main deck, three lower decks, engine room, boiler, and stack.

6 Vessel Manning

The vessel was owned by TOTE Maritime Puerto Rico and operated under a management contract with TOTE Services. TOTE Services acquired the personnel to crew the vessel from two maritime unions, American Maritime Officers and Seafarers International Union. Both TOTE Maritime Puerto Rico and TOTE Services were direct and indirect subsidiaries of TOTE Inc. and TOTE Inc. was a subsidiary of Saltchuk Resources, Inc.

El Faro's Coast Guard certificate of inspection required a minimum manning of 17 officers and seamen. TOTE Services regularly manned *El Faro* with a crew of 26, which was in excess of the minimum requirements. The regular crew of 26 was divided into three departments: deck, engine, and steward. The captain, or master, was in overall charge of the vessel and was not a

member of any of the three departments. One additional third engineer (who could not depart the vessel because his relief arrived late) and six shoreside workers, or riding crew, sailed with *El Faro* on the accident voyage. The riding crew was preparing the ship for conversion back to a Ro/Ro vessel (containers would no longer be lifted on and off) for use in the Alaska trade. Five of the riding crew were Polish nationals. The sixth was an off-duty TOTE Services chief engineer who signed on to supervise the Polish workers.

The duties of *El Faro*'s master and of personnel in the ship's various departments were defined in the company's vessel operations manual (OMV), which also laid out shipboard policies and procedures. The master and deck department personnel were covered in section 5 of the OMV. The OMV was part of the company's overall safety, quality, and environmental (SQE) management system, also known as the safety management system (see section 12).

6.1 Duties of Master

According to the OMV, the master was the company's shipboard representative, charged with ensuring that the vessel operated in accordance with the company's policies and objectives and with applicable law, and the "master of the vessel had overriding responsibility for the safe operation of the vessel and the authority and discretion to take whatever action he/she considered appropriate in the best interest of the crew, vessel, and marine environment." As described in the OMV sections 2.2.1 and 5.1, the master's responsibilities included the following:

- Safe operation and navigation of the vessel.
- Ensuring that a proper voyage passage plan was kept.
- Maintaining minimum reserve stability.
- Overseeing the welfare and safety of the crew.

- Managing the vessel's budget and payroll.
- Ensuring that required maintenance and requisitioning were done.
- Ensuring that a proper deck logbook (with required entries) was kept.[3]
- Managing the steward and engine departments.
- Managing the interaction between shoreside personnel and the vessel and maintaining proper communications, both shipboard and to outside entities.
- Making sure crewmembers properly performed their jobs.

Former *El Faro* masters testified that they reported directly to the TOTE Services port engineer.[4] When investigators asked the port engineer what his direct responsibilities were in regards to the implementation of the TOTE Services safety management system, the port engineer replied: "my job is to oversee the captain and chief engineer to ensure they are complying with the SMS system."[5] A flowchart in the OMV titled "Vessel to Shore Relationship" shows the master reported to the "vice president of labor relations," the ISM designated person," and the "V.P. Government/V.P. Commercial."[6] These positions then reported directly to the TOTE Services president. Personnel reporting directly to the master were the chief mate, chief engineer, and chief steward.

6.2 Duties of Deck Department

During the accident voyage, the deck department consisted of three officers and nine other crewmembers. According to former *El Faro* crewmembers interviewed as part of the

[3] Checking weathertight doors was a required entry.

[4] NTSB interviews and MBI transcripts.

[5] MBI 1 transcript, testimony of port engineer, p. 123.

[6] a) Flowchart information from OMV section 2.2.2.1, "Organizational Flow Charts;" b) TOTE Services had a director of labor relations and not a vice president of labor relations.

investigation and to information in the vessel's deck logbooks, the deck department was mainly responsible for the following:

- Cargo-related stowage and securing matters.
- Safe navigation of the vessel.
- Proper mooring of the vessel.
- Maintaining adequate stability for the vessel.
- Overall maintenance and preservation of deck-related areas.

6.2.1 Chief Mate

The chief mate was the head of the deck department and reported directly to the master. He was considered by the company to be a master in training. The chief mate's primary responsibilities, as outlined in section 5.1.2 of the OMV, were as follows:

- Supervise the day-to-day operations of the deck department.
- Ensure that cargo was properly loaded, cared for while on the vessel, and discharged.
- Manage the operation and coordinate maintenance of deck equipment.
- Be completely familiar with the vessel's stability/cargo computation system; calculate the vessel's stability, making sure its metacentric height (GM), load line, shear forces, and bending moments were all within safe limits.[7]
- Maintain and manage deck-related preventive maintenance in accordance with the ship's maintenance management system.

[7] GM is a measure of the initial static stability of a floating body. *Load lines* are marks at the midpoint along each side of a vessel's hull that establish a safe minimum distance between the waterline under a full load and the uppermost continuous watertight deck. A *bending moment* is the reaction of a structure to an external force (or *moment*) that causes the structure to bend.

- Stand a bridge watch, as officer in charge of the navigational watch, while the vessel was at sea.

While at sea, the chief mate generally stood the 0400–0800 and 1600–2000 watches. On *El Faro*'s last port call to Jacksonville, the chief mate shifted from his regular at-sea watch schedule to prepare the ship and oversee cargo operations. He was on call during ongoing cargo operations. Longshore operations took place between 1300 and 2100 on September 28 and between 0800 and 1930 on September 29.

6.2.2 Second Mate

The second mate was the navigation officer, was assigned to the 0000–0400 and 1200–1600 sea watch as officer in charge of a navigational watch and was primarily responsible for "the bridge navigational equipment, general bridge maintenance, and the inventory of associated supplies."[8] Additional duties included "keeping of the vessel's charts and publications" and preparation of the voyage passage plan.[9] While off-watch at sea the second mate also checked cargo, as directed by the chief mate. When the ship was in port, the second mate stood a 6-hour on/6-hour off watch rotation and generally assisted the chief mate by making sure the vessel was secure at the berth and overseeing cargo loading and discharge. The second mate (or third mate) would also take offshore (side away from the dock) midship draft readings in port and report them to the bridge.[10]

[8] OMV, section 5.1.3.

[9] OMV, section 5.1.3.

[10] Reading the drafts entailed looking at the side of the vessel and observing the water level as measured by markings on the hull. The draft of a ship is the vertical distance between the waterline and the bottom of the hull.

Generally, the second mate reported directly to the chief mate, the department head of the deck department. However, while officer in charge of a navigational watch, the second mate would report directly to the master for navigation and route planning. All officers in charge of a navigational watch were required to update the deck logbook while on watch. The chief mate also made entries, outside of his normal bridge watch hours, such as when the large watertight doors were secured for sea and when cargo was secured or checked. Required deck logbook entries, according to the OMV section 5.2.2, included changes of watch, course changes, weather, and inspections of weathertight doors at departure (see **appendix** for list of required entries).

6.2.3 Third Mate

The third mate stood bridge watches at sea and was the officer in charge of a navigational watch from 0800 to 1200 and from 2000 to 2400. After watch, the third mate checked the vessel's lifesaving and emergency equipment for compliance with regulations and company standards. When in port, the third mate stood a 6-hour cargo watch and then had 6 hours off. The third mate rotated with the second mate and shared the same port duties—that is, making sure the vessel was secured properly to the dock and overseeing the safe loading and securing of the cargo. Generally, the third mate reported directly to the chief mate. However, while officer in charge of a navigational watch, the third mate would report directly to the master for navigation and route planning. All officers in charge of a navigational watch were required to update the deck logbook while on watch. The chief mate also made entries, outside of his normal bridge watch hours, such as when the large watertight doors were secured for sea and when cargo was secured or checked. The third mate (or second mate) would also take offshore midship draft readings and report them to the bridge.

Deck watch officers, while not on watch or performing off-watch duties, would rest in accordance with the requirements of the Seafarer's Training, Certification, and Watchkeeping (STCW) code.

6.2.4 Nonofficer Deck Personnel

The deck department had six nonofficer members (known as ratings), a boatswain (bosun), and five able seamen (ABs). The bosun was the foreman of the ABs and reported directly to the chief mate. The bosun had direct oversight of daily maintenance on deck-related equipment.[11] As part of their normal routine, deck department ratings also performed functions related to ship operations, such as preparing for port, mooring and unmooring, and securing for sea. Two of the ABs were dayworkers who generally worked between 0800 and 1700 and rested or worked (on an overtime basis) on deck-related maintenance or operational duties. The remaining three ABs stood bridge or in-port watches (usually one AB per watch).

While on bridge watch, and as guided by the officer in charge of a navigational watch, the ABs served as lookouts or helmsmen. While in port, they stood gangway or security watch and tended the mooring lines or wires. When off watch, the ABs rested (in accordance with STCW code requirements), worked on the maintenance of deck items, or participated in operational duties (such as docking or undocking, preparing for port, and securing for sea.)

[11] Maintenance of deck items was generally limited to the overhaul or lubrication of external moving parts, wires, and appurtenances to lifesaving gear, mooring tackle and gear, watertight and weathertight openings, and cargo-handling and securing equipment, fixtures, or gear. Maintenance also included the cleaning, preparation for painting, and painting of exterior and interior surfaces of non-engine spaces.

7 Shoreside Manning

The main offices of both TOTE Services and TOTE Maritime Puerto Rico were in Jacksonville. The duties of TOTE Services shoreside personnel were outlined in job descriptions maintained by human resources at TOTE Services. The duties of TOTE Maritime Puerto Rico personnel were outlined in job descriptions maintained by the human resources of TOTE Maritime Puerto Rico.

7.1 TOTE Services Personnel

TOTE Services provided management services to TOTE Maritime Puerto Rico as well as other ship owners, primarily in the following areas:[12]

- Operations
- Engineering
- Contracts
- Communications oversight
- Safety
- Purchasing
- Personnel and labor administration
- Insurance procurement
- Claim administration

7.1.1 Port Engineer

Every TOTE Services vessel was assigned a port engineer, "responsible for the management and supervision of every aspect of assigned commercial vessels while they are in Port, at sea and in dry-dock." Responsibilities included coordinating "with Captains and the Chief

[12] SQE shoreside manual, section 4.1.

Engineers to manage vessel repairs, maintenance and requisitioning for spares, goods, and services" and advising "vessel's Senior Officers in order to maintain operational capabilities of the vessel."[13] *El Faro*'s port engineer told the marine board, "The ship deals with me directly." TOTE Services did not employ port captains (who generally oversee port operations and day-to-day ship operations) for its vessels.[14] The *El Faro* port engineer described himself as "a combination of Port Engineer/Port Captain."[15]

El Faro's port engineer stated that he did not assess the vessel's voyage plans and believed that no one was directly responsible for reviewing the vessel's position reports. Three former masters of *El Faro* told investigators that they reported to or through the vessel's port engineer.[16] As part of his duties, the port engineer liaised with the TOTE Services manager of safety and operations to ensure that "the Master and the three shipboard departments (Deck, Engine and Steward) are given all necessary support, directives and authority enabling them to perform their duties properly and safely observing company policy, national regulations and international conventions."[17]

7.1.2 Manager of Safety and Operations

According to the job description summary for this position that was provided to investigators, the manager, safety, & operations: "assists in the supervision and operation of both the active and deactivated fleet with specific attention to safety, performance, and adherence to the laws and regulations of the countries in which documented, as well as areas where vessels trade.

[13] Job description, port engineer, p. 1.

[14] TOTE Services employed a port captain for its sea-based radar (SBX) station.

[15] MBI 1 transcript, port engineer testimony, p. 120.

[16] NTSB interviews of three past masters of *El Faro*.

[17] SQE manual, section 4.1.2.

Performs any and all such duties as may be assigned by the Company, and specifically by the Director, Safety & Services. Incumbent will frequently interface with upper levels of management and must be able to make sound business decisions, both administrative and technical, affecting vast resources of material and manpower by performing the following duties."

The manager of safety and operations assisted "in the supervision and operation of the . . . fleet," which included vessel "adherence to the laws and regulations of the countries in which documented," and ensured "vessel compliance with company standards and policies."[18] The manager of safety and operations reported directly to TOTE Services' director of marine safety and services. When asked what operations the manager of safety and operations was involved with, the director replied: "It would strictly be with anything involving the safety side of that."[19]

According to the OMV, the manager of safety and operations or the TOTE Services operations department was to be contacted by the master before letting go (leaving port) to discuss any excessive uncorrected list or trim, if the master determined that it did not present a danger to the intended passage. An excessive uncorrected list was defined as greater than 2° and an excessive uncorrected trim as more than 2 feet by the head or more than 10 feet by the stern. The determination to sail with a list or excessive trim was to be documented in the deck log.[20] According to the testimony of the pilot and Tote Maritime Puerto Rico terminal manager, *El Faro* did not have a list when it left the dock on the accident voyage.

[18] Job description, TOTE Services manager, safety, & operations, p. 1.

[19] MBI 1 transcript, testimony of TOTE Services director of marine safety and services, p. 104.

[20] OMV, section 10.13.7.3, "Vessel Safe for Sea (excessive list)." As described in OMV section 5.1.2, the chief mate was to determine the source of an excessive trim or list and "reconcile the situation with the available ballast capacity."

The manager testified that, as part of his job, he performed (or arranged for someone from the company or a third party to perform) audits to ensure that vessel personnel complied with the company's safety management system.[21] The manager stated that, during his 2-year tenure with the company, one underway audit had been performed by a port engineer while aboard one of their military ships.[22] He said that he was unsure whether voyage or passage plans were checked during any audits of *El Faro* prior to his 2015 audit of the vessel, and he did not include a review of the passage plans during his 2015 audit.

The manager further testified that some of the vessels TOTE Services managed for other companies used a weather routing system, and he confirmed that it tracked a vessel's position against that of nearby weather. He said that the TOTE Maritime Puerto Rico ships did not use that tracking system and that no one at TOTE Services had the specific task of monitoring tropical weather for these vessels. When questioned by the marine board as to how he assessed, from a safety perspective, the loading of a vessel to make sure the work was done correctly at the terminals, the manager stated: "That's up to the Captain of the vessel, I don't get involved."[23]

Although the manager's job description did not mention DP duties and the OMV stated that the "manager of marine safety and certification" was the DP, the manager of safety and operations testified that he was the DP. According to the International Safety Management (ISM) Code, the DP was "to provide a link between the company and those on board" and should have "direct access to the highest level of management." [24] The ISM code further states: "The

[21] MBI 1 transcript, testimony of manager of safety and operations, p. 12.

[22] Underway audits are not required by the ISM code.

[23] MBI 1 transcript, testimony of manager of safety and operations, p. 15.

[24] ISM code, section 4. The ISM code is described in detail in section 12, "Safety Management System." The full name of the code is International Management Code for the Safe Operation of Ships and for Pollution Prevention.

responsibility and authority of the designated person or persons should include monitoring the safety and pollution prevention aspects of the operation of each ship and to ensure that adequate resources and shore based support are applied, as required."

A collateral duty of the manager of safety and operations was to coordinate the emergency response team.

7.2 TOTE Maritime Puerto Rico Personnel

7.2.1 Terminal Manager

The stated purpose of the terminal manager's job was to "manage safe, efficient, cost effective terminal operations to facilitate the movement of all cargo types."[25] One of the main duties and responsibilities of the terminal manager was to "manage all weather and significant events (Vessel Delays) through appropriate channels." A collateral duty was to ensure that the three terminal cargo scales were properly calibrated. According to records reviewed by investigators, the cargo scales were "accurate and operating correctly" when last inspected on September 23, 2015.[26]

7.2.2 Manager of Marine Operations

When *El Faro* was berthed at its Jacksonville terminal, deck department personnel typically interfaced with the TOTE Maritime Puerto Rico manager of marine operations. The manager of marine operations reported directly to the terminal manager. His main duties and responsibilities included overseeing proper stowage, loading, and discharging of the vessel;

[25] Job description, TOTE Maritime Puerto Rico terminal manager, p. 1. Docket items contain job descriptions for TOTE Maritime Puerto Rico terminal manager, manager of marine operations, TOTE Services manager of safety operations, and port engineer.

[26] TOTE Maritime Puerto Rico quarterly Jacksonville scale inspection report.

stability calculations; vessel inspections, including cargo securing fittings and lashing gear; and weather forecasting and reporting. According to the manager of marine operations' testimony, he regularly interfaced with ship personnel during the course of the vessel's stay in Jacksonville, kept vessel personnel informed about the loadout, was readily available to ship personnel, and he addressed any concerns of the master and chief mate as to the loading and stability of the vessel. According to his job description, he was also required to "cover for the Port Engineer as needed."[27] When asked if he used the TOTE Services safety management system, he said, "No, I do not."[28] When asked if TOTE Maritime Puerto Rico had their own safety management system or ISO 9001 certification he replied: "I am unaware of TOTE Maritime having that."[29] According to the testimony of the Vice President of Operations for TOTE Maritime Puerto Rico "we have over the last 2 years been working on a safety management program through ISO."[30]

CargoMax is a software application developed by Herbert–ABS Software Solutions, LLC. According to the developer, the program "quickly and precisely calculates ship stability and stress characteristics based on any loading condition specified by the user." The manager of marine operations stated that he had no formal training in ship stability or formal CargoMax training before *El Faro* sank, but when he joined the company he received training on the program from three individuals who were very experienced in CargoMax. After the sinking, he received CargoMax training for the company's two new liquefied natural gas container vessels.[31]

[27] Job description, TOTE Maritime Puerto Rico manager of marine operations, p. 1.
[28] TOTE Maritime Puerto Rico manager of marine operations MBI 1 transcript, p. 209.
[29] TOTE Maritime Puerto Rico manager of marine operations MBI 1 transcript, p. 209.
[30] MBI 2 testimony of TOTE Maritime Puerto Rico VP of Operations, Page 83.
[31] MBI 1 testimony of TOTE Maritime Puerto Rico Manager of Marine Operations, p. 217.

While cargo was being loaded onto *El Faro* in Jacksonville before the accident voyage, the manager of mariner operations was on vacation. The terminal manager testified at the first marine board hearings that he performed the duties of the vacationing manager. The terminal manager said that he did not discuss weather with the master of *El Faro*. He also said that the longshoremen lashed the Ro/Ro cargo for bad weather, that vessel personnel did not ask for additional lashings to be placed on the cargo, and that he did not read the vessel's drafts at departure.[32]

7.3 Stevedores and Longshoremen

Stevedore and longshore personnel in Jacksonville were provided by PORTUS Stevedoring, LLC. PORTUS personnel worked under the direct oversight of TOTE Maritime Puerto Rico's terminal manager and manager of marine operations. Stevedoring personnel were responsible for the planning and oversight of discharging, loading, and securing cargo. While a vessel was at the dock, the stevedores and longshoremen discharged, loaded, and secured cargo as directed by the vessel's chief mate and other deck officers. Longshoremen ran the cranes, drove the trucks and automobiles, and lashed or unlashed the cargo. All longshore personnel were members of the Seafarer's International Union. Stevedoring personnel from PORTUS claimed no union affiliation.

During *El Faro*'s September 27–29 port call in Jacksonville, stevedoring personnel who worked on the vessel included two vessel superintendent/planners and one vessel foreman (or vessel supervisor).[33] One of the superintendent/planners ordered and managed the labor for the port call. The work normally involved going back and forth to the ship and checking with the vessel superintendent to make sure the longshore work was done properly. The other

[32] MBI 1 testimony of TOTE Maritime Puerto Rico Manager of Marine Operations, p. 160.

[33] NTSB interviews of PORTUS personnel

superintendent worked on the pre-stow and final-stow plans. The vessel foreman spent most of his time on the ship. He worked directly with union longshore laborers to make sure checkers, drivers, crane operators, and lashers performed their tasks properly.

During *El Faro*'s last call in Jacksonville, the longshoreman responsible for supervising the lashers (those who actually placed lashings on the cargo) was the "head lasher."[34]

8 Cargo

As required by the *International Convention for the Safety of Life at Sea 1974*, as amended (SOLAS 74), and the *Code of Safe Practice for Cargo Stowage and Securing* (CSS code), the cargo on *El Faro* should have been loaded, stowed, and secured in accordance with an approved cargo securing manual.[35] Both the SOLAS convention and the CSS code are instruments of the International Maritime Organization (IMO). The international requirements for cargo securing manuals are incorporated in Coast Guard regulations at Title 33 *Code of Federal Regulations* (CFR) 97.120. *El Faro*'s manual was developed by Herbert Engineering Corporation and approved by ABS on January 20, 2006.[36]

8.1 Type Carried

According to *El Faro*'s cargo securing manual, containers were considered standardized cargo. Forty-foot Ro/Ro trailers (whether commercial over-the-road trailers equipped with wheels or containers secured to wheeled frames, called flatracks, and wheeled chassis) and automobiles

[34] MBI 2 testimony of PORTUS head lasher during *El Faro*'s last call to Jacksonville.

[35] SOLAS 74, chapter VI, part A, regulation 5.6, and CSS Code, section 1.6. The original CSS Code was adopted by IMO in 1991. IMO's Maritime Safety Committee issued subsequent guidelines (termed circulars) that amended the CSS Code. The 2003 edition of the CSS Code incorporated earlier circulars and was in effect when *El Faro*'s cargo securing manual was submitted for review in 2005.

[36] The Coast Guard has oversight of the approvals granted by ABS on its behalf.

were considered semi-standardized cargo. All other cargo units were considered non-standarized. The containers and trailers carried goods commonly found in stores, homes, and factories. Some containers and trailers were refrigerated and generally carried food items that needed to be chilled or frozen. The refrigerated containers and trailers were often equipped with a third-party monitoring system (called WAMS) that sent operational information ashore to the shippers of the containers using cell phone towers and signals

El Faro's cargo manifest listed all the cargo in the containers and trailers and all other cargoes stowed aboard the vessel such as (but not limited to) automobiles, backhoes, and boats on trailers.[37] Besides containers and Ro/Ro cargo, *El Faro* also carried liquid fructose, which was kept in six storage tanks, each tank having the capacity of two railroad cars, located in the two forward lower holds of the ship. Any cargo considered dangerous (as defined by US regulations) was listed on the vessel's dangerous cargo manifest.[38]

At 2148 on September 29, as required by the vessel's OMV section 11.5.3.3, the master sent a departure report to TOTE Services after *El Faro* had cast off its last line in Jacksonville (at 2007) and after the pilot had left the ship at the sea buoy in the harbor entrance (at 2144). In his report, the master detailed the cargo as follows: 238 electric reefers (refrigerated containers), 118 trailers, 149 autos, 15 not-in-container cargo (NICs), 391 containers, and 4 fructose tanks. The total tonnage was 11,045 long tons. The master also recorded 345 long tons of potable water aboard.

[37] The *cargo manifest* is a document that lists information about a ship's cargo such as bills of lading, quantities, package units, consignees, consignors, shippers, and weights.

[38] Title 46 *CFR* part 148 and Title 49 *CFR* subtitle B, chapter I, subchapter C, part 172, subpart B.

8.2 Arrangement on Vessel

El Faro's Ro/Ro cargo was distributed and stowed throughout the vessel in six vertical compartments, or holds. The holds were designated by the letters A through F, starting forward and working aft. Each hold had three horizontal decks. From top to bottom, they were the second deck, the tween deck or third deck, and the lower hold or No. 4 deck.[39] The bottom two decks in each vertical hold were watertight as a single unit. That is, the third deck and fourth decks were not watertight between each other but were watertight as a single unit.

Six boundaries gave watertight integrity to the vertical hold areas on the third and fourth decks. The boundaries were the port and starboard sides (hull) of the ship on the second deck, the bottom or tank top, and the forward and aft watertight bulkheads of the hold. The cargo stowed upon the second deck, the highest deck where Ro/Ro cargo could be loaded, was stowed in a non-watertight area.

Cargo containers were stacked in tiers on the main deck in areas called bays. According to the cargo securing manual, *El Faro* had 20 container bays numbered forward to aft. The vessel carried containers in 20-, 40-, 45-, 48-, and 53-foot lengths, as shown in **figure 3.** No tier was stacked more than three containers high on southbound trips to San Juan.

[39] To avoid confusion over the location of a deck or hold, this report uses an alphanumeric system consistent with that often used by shipboard and terminal personnel. For example, the location of cargo loaded on the third deck of A-hold would be 3A.

Figure 3. Cargo stowage arrangement and capacity plan (from *El Faro* cargo securing manual).

8.3 Stowing and Securing

Cargo aboard *El Faro* was required to be secured according to the cargo securing manual. The vessel's stevedore, PORTUS Stevedoring, was contracted to TOTE Maritime Puerto Rico to provide personnel to plan the stowage, loading and unloading, and securing of all cargo onboard *El Faro*. Before the ship arrived in port, PORTUS developed a prestow plan showing where projected cargo (based on bookings) would be placed on the vessel. The prestow plan was discussed with TOTE Maritime Puerto Rico managers, and adjustments were made as needed. When the vessel arrived alongside and cargo work began, a PORTUS superintendent or planner would enter the stow positions and cargo information for each unit of cargo into a computerized

cargo loading and stowage program called Spinnaker.[40] The program would then develop the actual or final stow plan.

As loading of the cargo areas progressed (holds or decks for Ro/Ro cargo, bays for container cargo), the TOTE Maritime Puerto Rico marine operations manager or terminal manager would enter the cargo weights and positions into the CargoMax computer program. CargoMax would calculate the list, trim, drafts, and stability of the vessel.[41] The container buildout section of the CargoMax computer also determined whether container lashing arrangements and stack weights complied with the cargo securing manual.[42] The program was not designed to calculate the sufficiency of lashing arrangements for any of the Ro/Ro cargo. CargoMax stability calculations would be checked by the chief mate just before sailing. PORTUS longshoremen worked with the vessel's deck officers (mainly the chief mate) to ensure that there were no stowage or securing problems.

El Faro had two cargo securing systems. One system was used for containerized, or standardized cargo, and the other was used for Ro/Ro cargo, both semistandardized and nonstandardized. According to the cargo securing manual, each system had cargo securing devices that were either fixed or portable. The fixed securing devices were permanently welded to the

[40] PORTUS vessel superintendent/planner interview, October 12, 2015, pp 6-8; TOTE Maritime Puerto Rico terminal manager interview (2nd), October 13, 2015, pp 7, 9, 12, 17.

[41] Under SOLAS, the Intact Stability Code, ABS, and Coast Guard regulations, CargoMax software and the computer in which it resided was considered a shipboard "stability instrument." or an "on board electronic stability computer." According to the Intact Stability Code, a stability instrument should have flag approval. The CargoMax software was approved by ABS, for stability portions of the program, on behalf of the Coast Guard. However, the software version being used on *El Faro* during the accident voyage had not been submitted to ABS for review following minor updates to interface features which did not impact stability calculations. Computations in CargoMax were predicated on calculations used in the vessel's class-approved trim and stability booklet. TOTE Maritime Puerto Rico's CargoMaxprogramused ashore was not approved, yet required approval, by the classification society.

[42] The container buildout section of CargoMax did not, and was not required to, have class approval.

decks or bulkheads, while the portable devices could be shifted from one cargo unit to another and were used for "lashing, securing, or supporting" the cargo units.[43]

8.3.1 Container (Standardized) Cargo

Deck sockets were fixed securing devices used to secure the bottom tier of containers to the ship. The deck sockets were welded to securing beams that were welded to the deck, or alternatively, were welded directly to the deck. The beams and sockets were placed according to container length.[44] The lowest or bottom tier of a stack of containers was secured to the fixed deck sockets using portable securing devices called twistlocks (**figure 4**). A twistlock was secured at each of the four corners of a container. The container on the second tier was secured to the top of the bottom container using another set of twistlocks attached to the four corners of the container on the second tier. The third container tier was then secured to the top of the second container tier with another set of four twistlocks installed at the corners of the two containers.

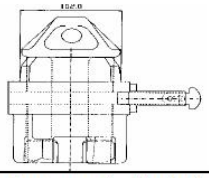
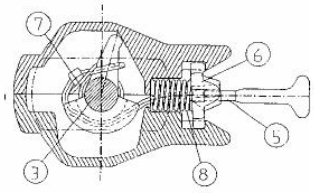
P3	Conventional Twistlock 	All Set Marine Lashing 1346 LL Or similar with same rating	760	67,320 Tension	112,200 Tension
P4	Semi-Automatic Twistlock 	All Set Marine Lashing C5AM / C5AM-DF	2100	67,320 Tension	112,200 Tension

Figure 4. Twistlocks used on *El Faro* (chart from cargo securing manual, appendix 7).

[43] Cargo securing manual, section 4.0.

[44] Appendix 6 of the cargo securing manual contains a more-detailed description of locations.

Each stack could be further secured using lashing rods and turnbuckles attached to padeyes, which were welded to the deck or to securing beams on the deck. Photos taken in October 2015 of the lashing arrangements on *El Yunque*, are shown in **figures 5, 6, and 7.**

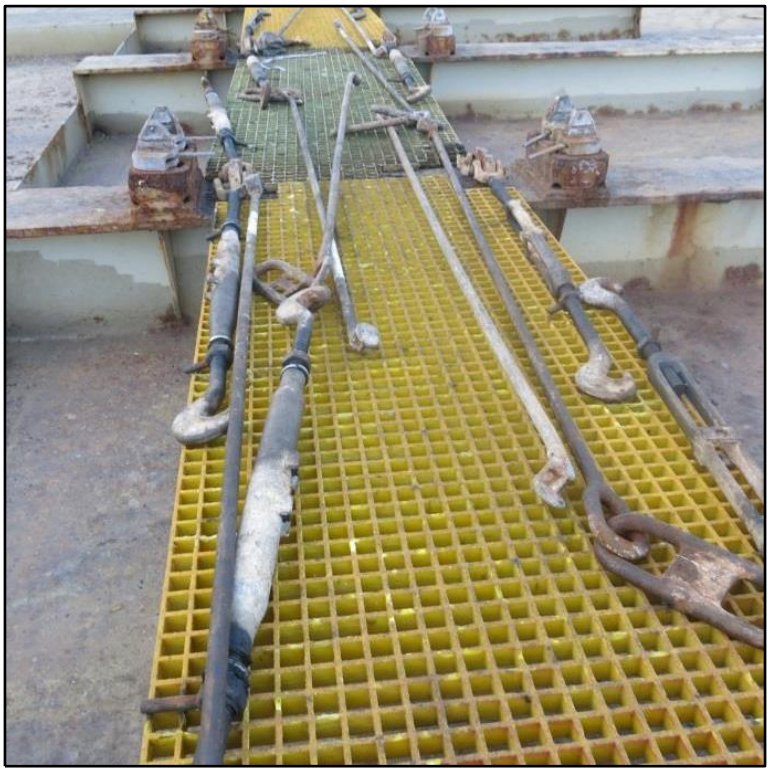


Figure 5. Foreground: lashing rods and turnbuckles for lashing containers. Background: twist locks inserted into deck sockets welded to deck beams (photo taken on *El Yunque*).

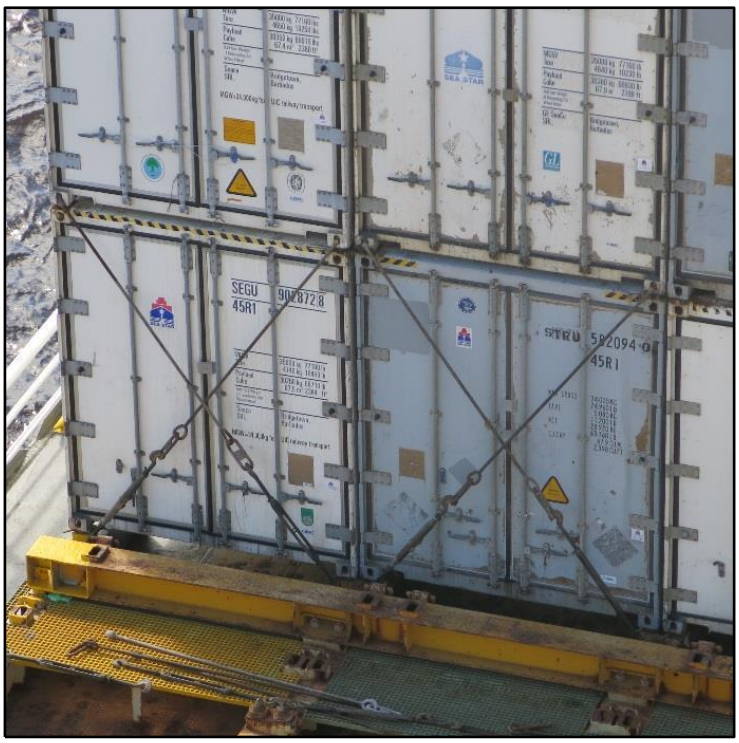


Figure 6. Two outboard containers (main deck, forward, port side) with lashing rods and turnbuckles fitted (photo taken on *El Yunque*).

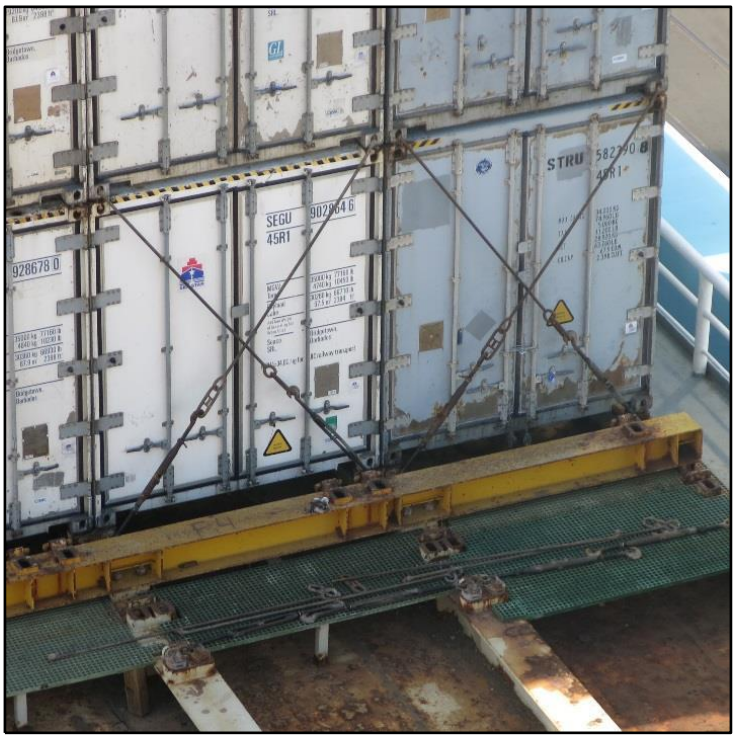


Figure 7. Two outboard containers (main deck, forward, starboard side) with lashing rods and turnbuckles fitted (photo taken on *El Yunque).*

8.3.2 Ro/Ro (Semistandardized) Cargo

Semistandardized Ro/Ro cargo such as 40-foot trailers and autos was secured to the vessel using two types of securing arrangements.[45] The first was a portable securing device called a Roloc box. The kingpin at the front end of a trailer fit into a locking receiver device (equipped with what the cargo securing manual called a "standard fifth wheel hitch as is used on highway trailers") on top of the Roloc box **(figure 8)**.[46] According to the cargo securing manual, the Roloc box would then be attached to a fixed securing device on the deck of the ship called a Roloc deck socket or button (**figures 9** and **10**).

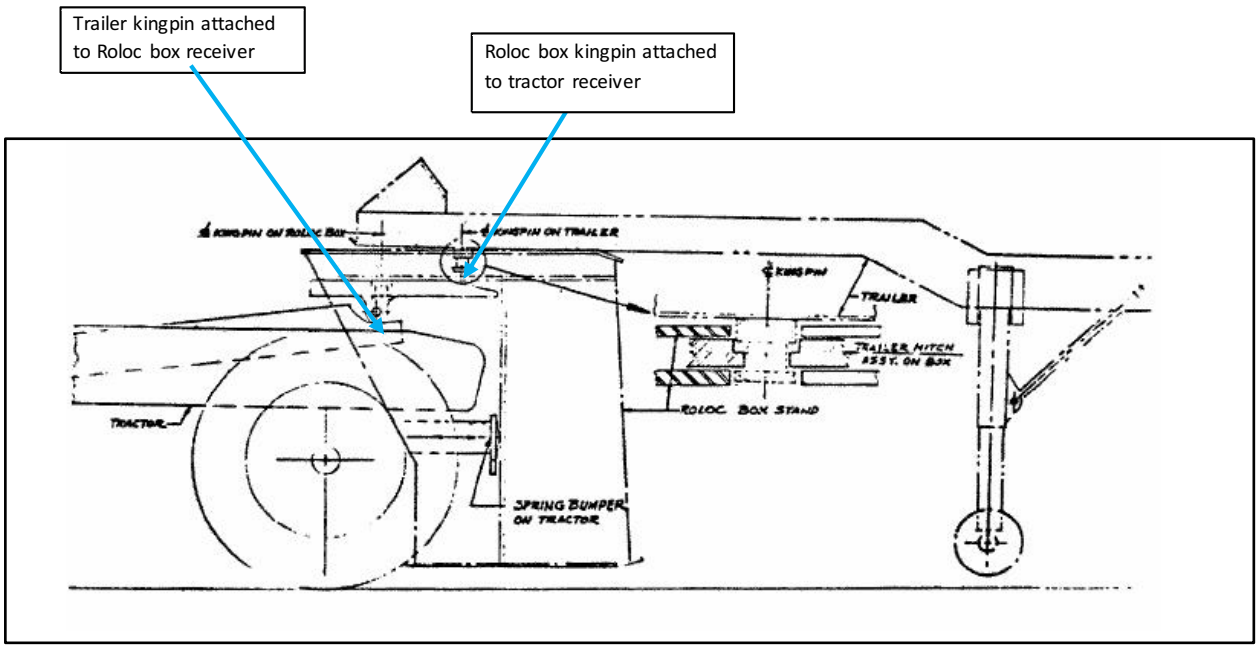


Figure 8. Roloc box diagram showing kingpin of trailer fitted into receiver of Roloc and kingpin of Roloc fitted into receiver of tractor (illustration from cargo securing manual).

[45] According to MBI 2 testimony of Herbert Engineering's president, semistandarized cargo included 40-foot, 45-foot, and 53-foot trailers and automobiles.

[46] Cargo securing manual, section 6.3.5, "Attachment of Roloc Boxes to Trailers."

Figure 9. Front end of trailer on top of Roloc box, with Roloc fitted to button on deck (photo taken on *El Yunque*).

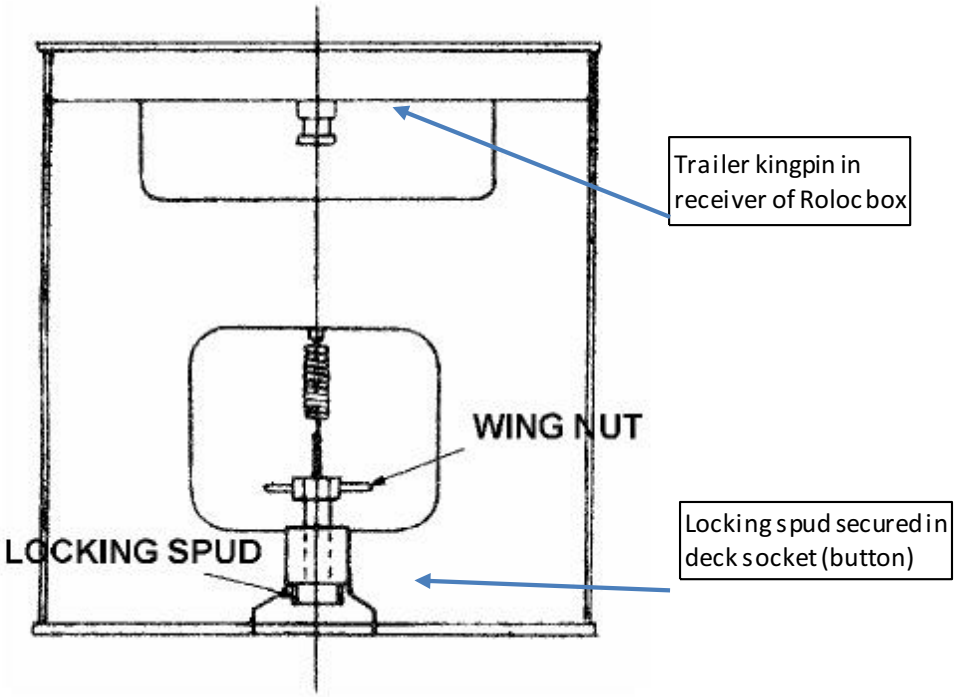


Figure 10. Schematic of Roloc box attached to Roloc deck socket or "button" (illustration from cargo securing manual).

The second method of securing a trailer to the deck of the ship was by using portable securing devices (chains and tensioners) leading from a securing point on the trailer to fixed securing devices on the deck (the cargo securing manual, section 6.2.2, outlines trailer-lashing

procedures). The chain and tensioner unit was called a lashing, and the combined lashing and fixed securing device was called a lashing arrangement. Fixed securing devices on the deck of the ship were either D-rings or cloverleafs cut through the deck (**figures 11** and **12**).[47]

Figure 11. Left: two D-rings, one with lashing chain around it and the other with no attachments. Right: hook secured to cloverleaf cutout (white area) in deck (photos taken on *El Yunque*).

Figure 12. Chain and tensioner attached to front end of trailer and to D-rings on deck (photo taken on *El Yunque*)

[47] Cargo securing manual, appendix 4.

El Faro's cargo securing manual required additional portable securing devices under certain trailer stowage conditions, such as:

(1) When a trailer was stowed fore/aft with the Roloc box oriented normally but with the D-rings located so that a lead from the rear was not possible.

(2) When a trailer was stowed fore/aft with a Roloc box oriented at an angle of 30° or more to the axis of the trailer but with a rear lead possible on the rear lashings.

(3) If a trailer was stowed fore/aft on a ramp with a Roloc Box, oriented normally.

(4) Or for any trailer stowed athwartship.

The cargo securing manual also recommended placing additional lashings on items such as backhoes, front-end loaders, and farm equipment. The manual did not specify or recommend additional lashings for adverse or heavy-weather conditions. The manual stated that the guidance provided did not rule out the principles of good seamanship, that it could not replace experience in stowage and securing practice, and that Sea Star's Fleet Operations Department was responsible for maintaining this procedure.

Automobiles, considered semistandardized cargo in the cargo securing manual, were to be lashed using portable securing devices consisting of fiber rope or nylon strapping attached to steel tensioners that were fitted with hooks at both ends (**figure 13**). Four lashings were to be run, one from each corner of the vehicle, to the fixed D-rings or cloverleafs on the deck (**figure 14**). A variation of that securing arrangement, not included in the cargo securing manual, was to run lashings from the four corners of the automobile to a long chain. The long chain ran across the width of the ship and was secured to D-rings at either end. In some instances, the long chain that

ran across the width of the ship was passed through a D-ring before it was secured to D-rings at either end. Variations observed on *El Yunque* in October 2015 are shown in **figures 15** through **18**.

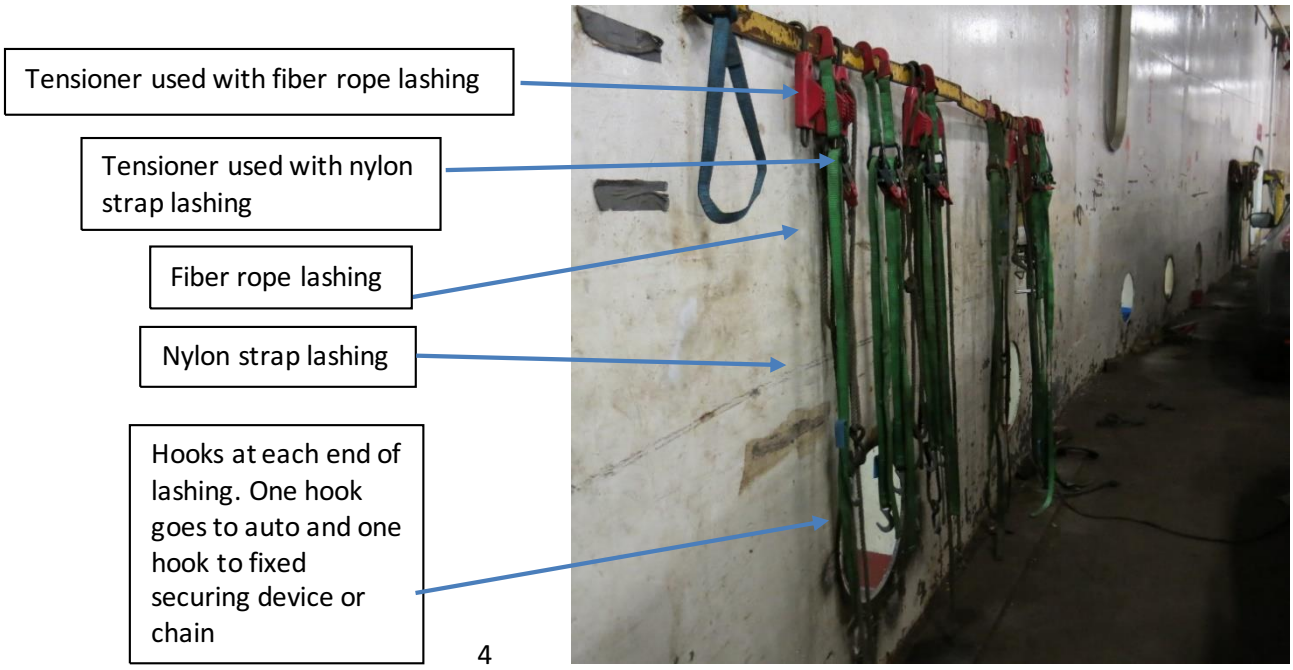


Figure 13. Types of car lashings (photo taken on *El Yunque*).

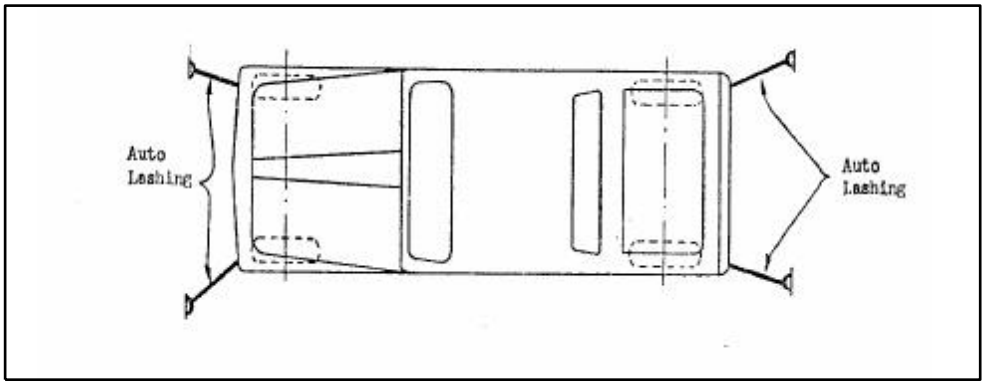


Figure 14. Automobile-lashing arrangement specified for *El Faro* (illustration from cargo securing manual, section 6.2.3).

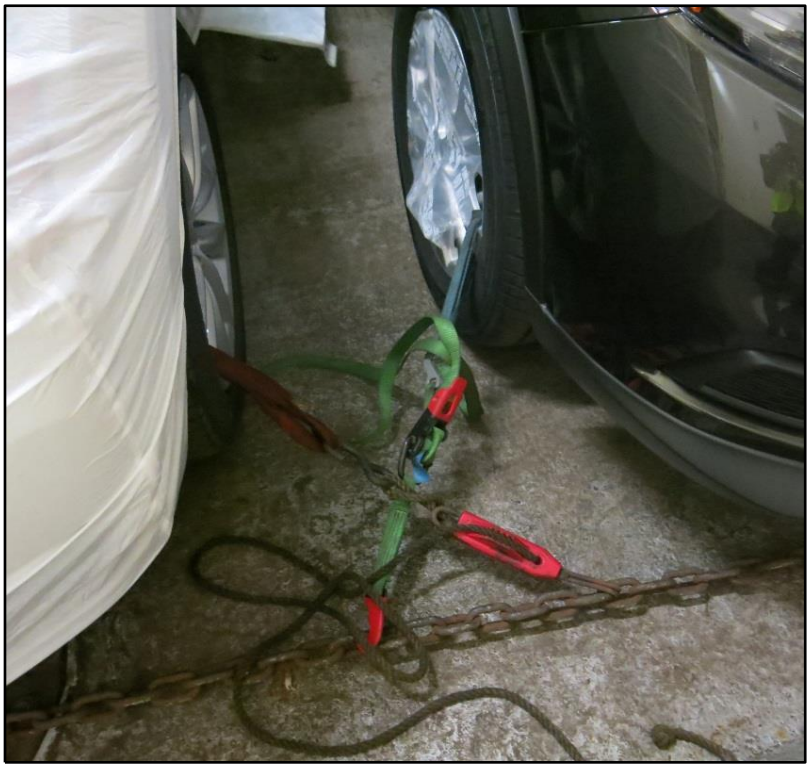


Figure 15. Lashings for two vehicles connected to one chain (*El Yunque*).

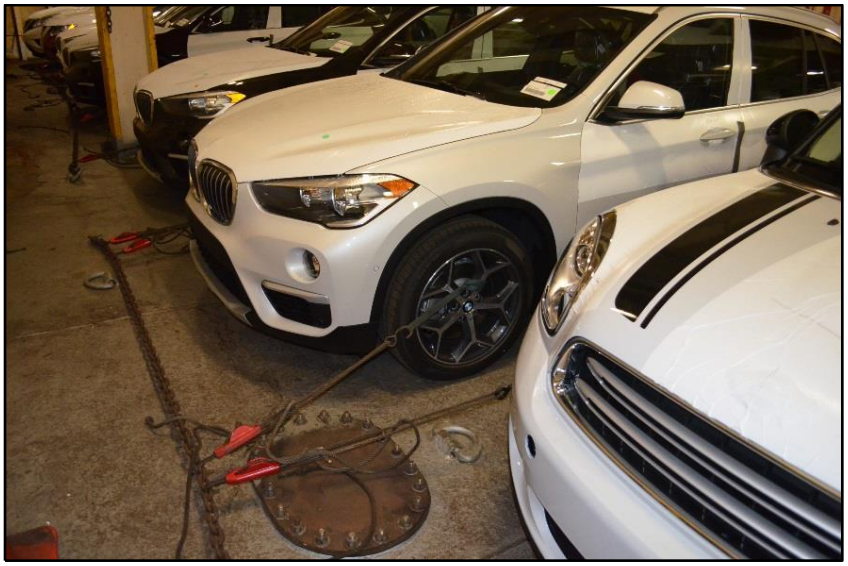


Figure 16. Automobiles lashed to chains running across ship (No. 5 hold of *El Yunque*).

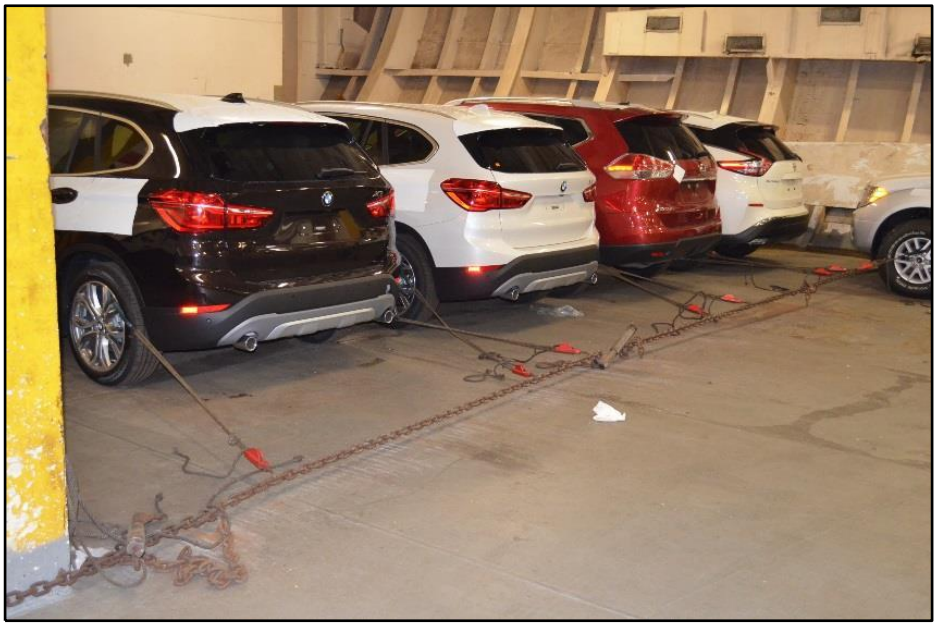


Figure 17. Two automobiles lashed to one length of chain (No. 5 hold of *El Yunque*).

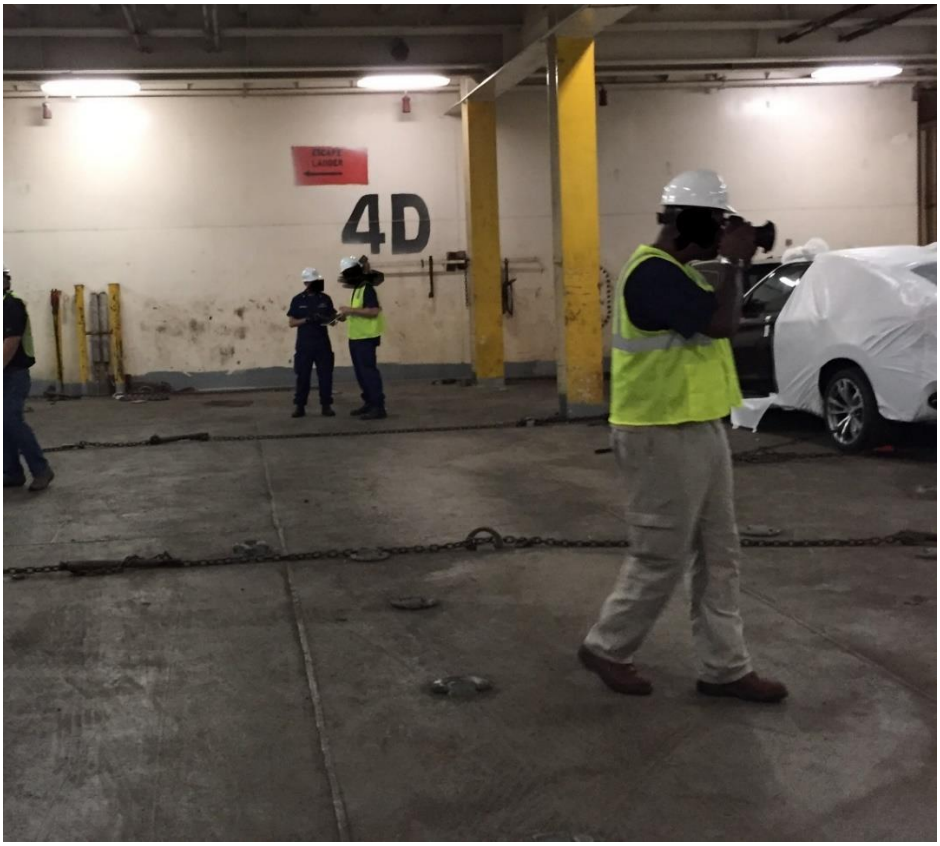


Figure 18. Automobile-lashing variation with chains running across ship (No. 3 hold of *El Yunque*).

8.3.3 Nonstandardized Cargo

Cargo other than standardized or semistandardized was considered nonstandardized in *El Faro*'s cargo securing manual. Cargo such as backhoes, bulldozers, and boat trailers was considered nonstandardized. Nonstandardized cargo, if not wheeled, could be loaded aboard by crane and then lashed directly to the fixed securing devices on the deck. If wheeled, it could be driven on like other Ro/Ro cargo. Nonstandardized cargo that was driven aboard was lashed in a similar fashion to semistandardized cargo, in accordance with the "Stowage and Securing of Non-Standardized Cargo" section of the cargo securing manual. Such cargo required an evaluation or calculation of the sufficiency of the securing arrangements. According to the cargo securing manual, the sufficiency of the lashings for nonstandarized cargo was to be evaluated using the method in annex 13 of the CSS code or the rule of thumb method. The latter method, according to the CSS code, did not include the "adverse effects of lashing angles and non-homogenous distribution of forces among securing devices nor the favorable effect of friction." [48]

8.3.4 Securing Cargo Before and During Accident Voyage

At Jacksonville. TOTE Maritime Puerto Rico personnel testified during the first marine board hearing that longshoremen placed extra lashings called "hurricane" lashings or "bad weather" lashings on *El Faro*'s Ro/Ro cargo during the port call preceding the accident. [49] The vessel supervisor for that voyage stated that a hurricane lashing profile was used year-round for *Ponce*-class vessels beginning in 2006. [50] According to the PORTUS vessel supervisor,[51] the hurricane profile called for the following: (1) All Ro/Ro trailers with Roloc boxes not secured on

[48] Annex 13 to the CSS code was issued in 1994.

[49] TOTE Maritime Puerto Rico terminal manager MBI 1 transcript, pp. 157, 160, 218.

[50] PORTUS vessel supervisor MBI 1 transcript, p 157.

[51] PORTUS vessel supervisor MBI 1 transcript, pages 158 and 159.

a button, no matter where they were located, were to receive a total of six chain lashings instead of the two chains used for an "on-button" stow. (2) The two rows of Ro/Ro cargo along the perimeter of the ship, if on Roloc boxes and the boxes were on-button, were to be lashed with four lashings instead of two. (3) All Ro/Ro trailers on Roloc boxes, forward of hold B and aft of hold D and regardless of deck, were to receive four chains instead of two. At marine board 3, the Tote Maritime Puerto Rico operations manager was shown a copy of a document containing a section titled "SSL EL Class heavy weather lashing requirements – RoRo" and he confirmed cargo was secured in accordance with this document.

Four former masters, with over 20 years' captain experience sailing on *Ponce*-class vessels stated that they were unaware or didn't recall if *Ponce*-class vessels were lashed according to a storm or hurricane profile year-round. They did state that if ship personnel requested it, the longshoremen would add more lashings. A former chief mate and master of *El Faro* stated he believed the longshoremen lashed for heavy weather year-round. On the VDR transcript, the third mate on *El Faro* stated that they "didn't ask the longshoremen for storm lashes, which we should have." The AB on the 0800–1200 watch agreed with him.[52]

At Sea. The unlicensed sailors, or ratings, in the deck department did not, as part of their daily routine, check to see if cargo lashings were secure at sea. According to a previous *El Faro* bosun, "the Second Officer would go around and check the lashings." And "if it was—if there was a time when we rocked a little more than normal and there was lashing were a little looser, then

[52] VDR transcript, p. 255.

she could ask for my help and I would send the whole—all the day-men and I would go around with our lashing bars and help her tighten the lashings."[53]

The VDR recorded the master and chief mate discussing lashings. The master directed the chief to "take a hard look at some of that cargo down there" and to "delegate the men (to look at) the lashings as you deem necessary."[54] When the master asked the chief mate if he had "enough lashings on hand," the mate stated that he had not looked at the lashing inventory.[55]

The VDR captured another conversation between the third mate and the AB on watch in which they questioned the lack of extra lashings on *El Faro*. [56]

Appendixes 4 and 7 to the cargo securing manual listed the quantities of securing devices carried aboard.[57] The manual required the securing devices to be inventoried every 2 months. The last *El Faro* lashing gear inventory provided to investigators was for April 24, 2015 (**figure 19**).[58] According to the inventory, the vessel had the following in excess of the required quantities listed in the cargo securing manual:

- 261 trailer barrel binders.
- 259 half-inch lashing chains with hooks.
- 443 rope and hook-type car lashings.

[53] Off-duty bosun MBI 1 transcript, p.116.
[54] VDR transcript, p. 55.
[55] VDR transcript, p. 55.
[56] VDR transcript, p. 260.
[57] See also cargo securing manual, section 5.1 and 5.2, "Cargo Securing Devices."
[58] *El Faro* lashing gear inventory, April 25, 2015.

- 10 Roloc box buttons.

The inventory noted that the vessel was short of the following quantities required by the cargo securing manual:

- 86 fixed-base manual twistlocks.
- 1014 semiautomatic twistlocks.
- 170 lashing rods.
- 488 container-lashing turnbuckles.

EL FARO Lashing Gear Inventory Date: 04/24/15

Type of Gear	Minimum Inventory	Date	On board (Good order)	On board (Bad order)	Total	Amount Required
Fixed base manual twist locks	760	04/24/15	674	30	704	86
Semi-automatic twist locks	2100	04/24/15	1086	12	1098	1014
Lashing rods	760	04/24/15	590	0	590	170
Container lashing turnbuckles	760	04/24/15	272	9	281	488
Container lashing poles	10	04/24/15	15	0	15	-5
Trailer barrel binders	420	04/24/15	681	4	685	-261
1/2" lashing chain w/ hooks	420	04/24/15	679	3	682	-259
Rope & hook type car lashing	220	04/24/15	663	0	663	-443
50 ton HDG D rings & collars	25	04/24/15	20 Rings / 0 Collars			
Rolloc box buttons	10	04/24/15	20		20	-10

ADDITIONAL LASHING TO MEET MINIMUM INVENTORY MAINTAINED SHORESIDE IN JACKSONVILLE
NOTE: EXTRA BIN OF APPROX 250 SEMI - AUTO TWISTLOCKS WAS ADDED TO LASHING GEAR RACK.

NOT ABLE TO COUNT LASHING RACK STOWED 3 HIGH

LOCATION	CAR LASHING	CHAINS	BINDER
2ND DECK	113	352	364
3A	19	59	60
3B	63	47	33
3C	0	51	55
3D	0	66	69
4B	37	16	18
4C	134	49	51
4D	130	21	25
5 HOLD	167	18	6
TOTALS	663	679	681

Figure 19. *El Faro* lashing gear inventory for April 24, 2015.

8.3.5 Adherence to Stability Requirements

The company's OMV tasked the master with the overall safety and stability of the vessel and the chief mate with calculating stability.[59] The vessel's trim and stability booklet, in conjunction with the vessel's loading computer (CargoMax), was to be consulted for maintaining

[59] OMV section 5.7. Detailed calculations of *El Faro*'s stability are found in the factual report of the naval architecture investigation group.

proper stability.[60] According to Title 46 CFR 170.110(d), "consideration must be given to including the following information" in a stability booklet:

(1) A general description of the vessel, including lightweight data.

(2) Instructions on the use of the booklet.

(3) General arrangement plans showing watertight compartments, closures, vents, downflooding angles, and allowable deck loadings.

(4) Hydrostatic curves or tables.

(5) Capacity plan showing capacities and vertical, longitudinal, and transverse centers of gravity of stowage spaces and tanks.

(6) Tank sounding tables showing capacities, vertical centers of gravity, and longitudinal centers of gravity in graduated intervals and showing free surface data for each tank.[61]

(7) Information on loading restrictions, such as a maximum KG [height of vertical center of gravity above the keel] or minimum GM curve that can be used to determine compliance with applicable intact and damage stability criteria.

(8) Examples of loading conditions.

(9) A rapid and simple means for evaluating other loading conditions.

(10) A brief description of the stability calculations done including assumptions.

(11) General precautions for preventing unintentional flooding.

(12) A table of contents and index for the booklet.

[60] *El Faro* trim and stability booklet, May 31, 2007.

[61] According to ABS, the free surface requirements that are in the trim and stability book are in the book as a conservative measure for the stability calculations. See ABS May 16, 2016, MBI 2 testimony, at page 164.

(13) Each ship condition which, if damage occurs, may require cross-flooding for survival and information concerning the use of any special cross-flooding fittings.

(14) The amount and location of fixed ballast.

(15) Any other necessary guidance for the safe operation of the vessel under normal and emergency conditions.

(16) For each self-propelled hopper dredge with a working freeboard, the maximum specific gravity allowed for dredge spoil.

The stated objective of *El Faro*'s trim and stability booklet was to "aid personnel in using this booklet and to provide the necessary operation information of maintaining satisfactory stability."[62] OMV section 5.1.1 directed the master to establish the vessel's "safe working parameters" for excessive list/trim during cargo load/discharge operations and for minimum reserve stability requirements.[63]

The OMV required the master to contact the "Operations Dept. and/or TSI Manager of Marine Safety & Compliance to discuss the situation" if the vessel had an uncorrected list of greater than 2 degrees, but the master felt it was safe to depart the port.[64] On the accident voyage, the vessel did not have an excessive uncorrected list of greater than 2 degrees leaving port, but about 3 hours before the vessel sank, *El Faro* experienced an increasing list. No one on shore was notified until approximately 40 minutes before the vessel foundered. Investigators reviewed company guidelines and found no guidance relating to reporting an uncorrected list when the vessel was at sea.

[62] Trim and stability booklet, p. 6.
[63] OMV, section 5.1.1.
[64] OMV, section 10.13.7.3.

From interviews with various ship and shore personnel, investigators learned that *El Faro* masters established a 6-inch stability margin (GM in excess of the required stability) for departing from Jacksonville. According to the masters interviewed, that would allow the *Ponce*-class vessels to arrive in San Juan with at least the minimum required stability. Section 5.7 of the OMV advised the master to "review the vessel's stability and consider the possibility to taking additional ballast or transferring cargo . . . when a vessel encounters heavy weather." The terminal manager of TOTE Maritime Puerto Rico stated that he had no discussion with *El Faro*'s master about increasing the stability margin because of the weather before the vessel departed on September 29.[65]

Regulation 10 of the International Load Line Convention required the vessel owner to "furnish the master with approved information and instructions for loading and ballasting this vessel to provide guidance as to stability of the vessel under varying conditions of service."[66] ABS representatives described the trim and stability booklet as "a manual on board that to give (*sic*) guidance to the Master to enable him to let him or her to load the vessel in accordance with the required intact and applicable damage stability criteria."[67]

Revision B to *El Faro*'s trim and stability booklet was approved on December 9, 2005. That revision captured changes made to the vessel to allow it to load containers. The revision was described as follows: "Added Deck Containers, Removed Spar Deck, Added Permanent Ballast,

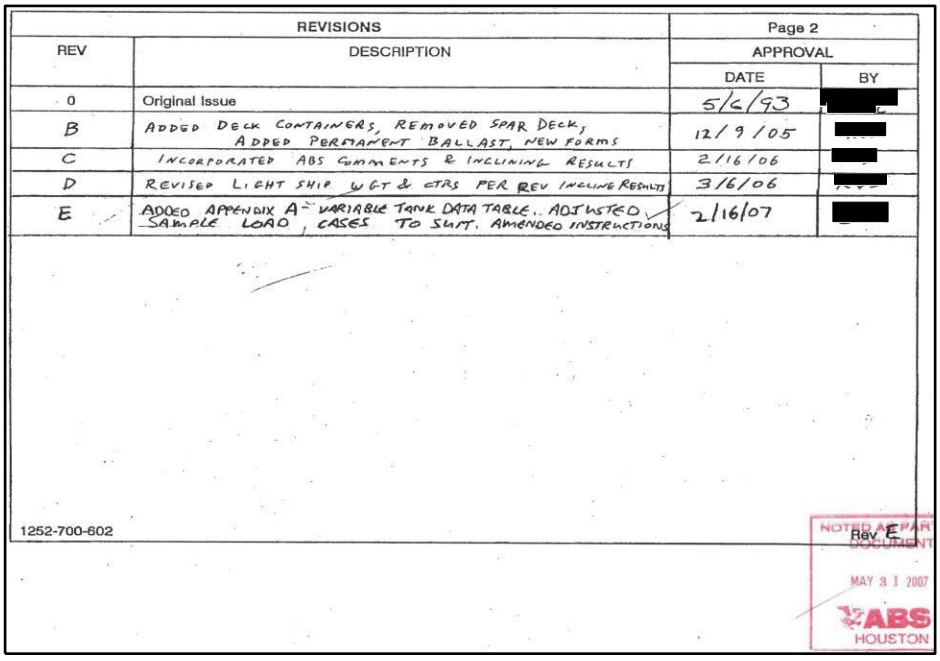
[65] There is no regulatory requirement to have a "stability margin" or sail with a metacentric height (GM) in excess of what was regulatorily required.

[66] Wording to this effect was included in the vessel's load line certificate.

[67] ABS chief engineer of statutes, MBI 2 testimony, May 19, 2016, p. 158.

New Forms."[68] The vessel's load line was raised in March 2006 to allow it to carry containers.[69] According to ABS, raising the load line by 2 feet increased the vessel's draft by 2 feet and allowed the vessel to sit deeper in the water.[70]

When asked if the load line change was noted in the vessel's trim and stability booklet, ABS testified: "We made sure it was documented in the booklet and the guidance for the Master."[71] Investigators reviewed the entire trim and stability book; which included the revisions page (**figure 20**) and the "Instructions for Roll-on-Roll-off Vessel Trim and Stability" in *El Faro*'s trim and stability booklet (**figures 21a, b, and c**); and found no mention of changes to the vessel's load line.



REVISIONS		Page 2	
REV	DESCRIPTION	APPROVAL	
		DATE	BY
0	Original Issue	5/6/93	[redacted]
B	ADDED DECK CONTAINERS, REMOVED SPAR DECK, ADDED PERMANENT BALLAST, NEW FORMS	12/9/05	[redacted]
C	INCORPORATED ABS COMMENTS & INCLINING RESULTS	2/16/06	[redacted]
D	REVISED LIGHT SHIP WGT & CTRS PER REV INCLINE RESULTS	3/6/06	[redacted]
E	ADDED APPENDIX A - VARIABLE TANK DATA TABLE. ADJUSTED SAMPLE LOAD CASES TO SUIT. AMENDED INSTRUCTIONS	2/16/07	[redacted]

1252-700-602

Rev E

NOTED AS PAR DOCUMENT

MAY 31 2007

ABS HOUSTON

Figure 20. Revisions page of *El Faro*'s trim and stability booklet.

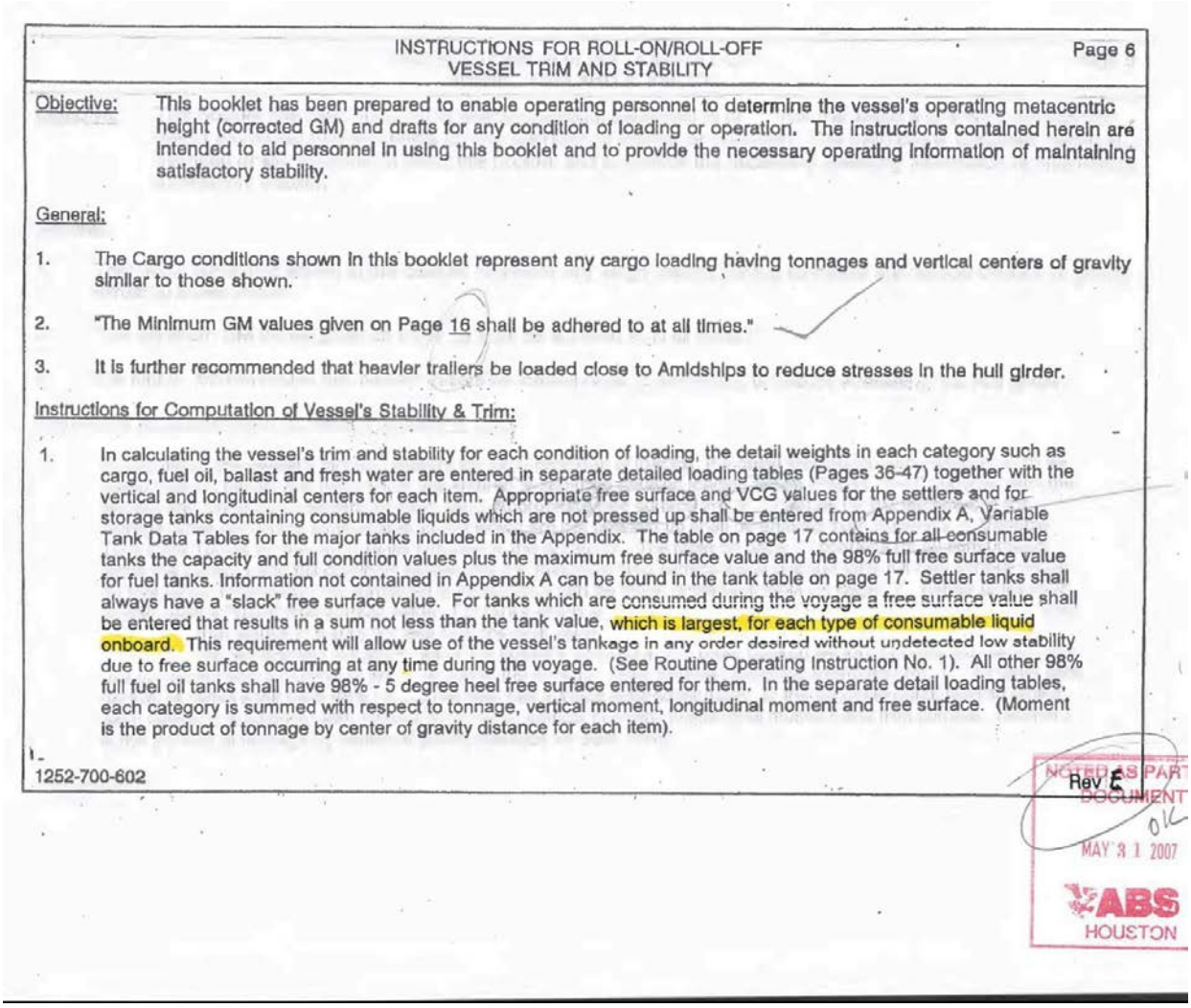
[68] *El Faro* trim and stability booklet.

[69] ABS chief engineer of statutes, MBI 2 testimony, May 19, 2016, p. 140; and ABS letter and telefaxes dated March 22, 2006; February 22; and December 29, 2005.

[70] ABS chief engineer of statutes, MBI 2 testimony, May 19, 2016, pp. 179-180.

[71] ABS chief engineer of statutes, MBI 2 testimony, May 20, 2016, p. 7.

Investigators compared *El Faro*'s ABS approved trim and stability booklet and the specific section on "routine operating instructions" (see **figure 21b**) to the considerations listed in Title 46 *CFR* 170.110 (d) and found that the book addressed items (1), (2), (4), (5), (6), (7), (8), (9), (10), (12), (14), and (15).



INSTRUCTIONS FOR ROLL-ON/ROLL-OFF
VESSEL TRIM AND STABILITY

Page 6

Objective: This booklet has been prepared to enable operating personnel to determine the vessel's operating metacentric height (corrected GM) and drafts for any condition of loading or operation. The instructions contained herein are intended to aid personnel in using this booklet and to provide the necessary operating information of maintaining satisfactory stability.

General:

1. The Cargo conditions shown in this booklet represent any cargo loading having tonnages and vertical centers of gravity similar to those shown.
2. "The Minimum GM values given on Page 16 shall be adhered to at all times."
3. It is further recommended that heavier trailers be loaded close to Amidships to reduce stresses in the hull girder.

Instructions for Computation of Vessel's Stability & Trim:

1. In calculating the vessel's trim and stability for each condition of loading, the detail weights in each category such as cargo, fuel oil, ballast and fresh water are entered in separate detailed loading tables (Pages 36-47) together with the vertical and longitudinal centers for each item. Appropriate free surface and VCG values for the settlers and for storage tanks containing consumable liquids which are not pressed up shall be entered from Appendix A, Variable Tank Data Tables for the major tanks included in the Appendix. The table on page 17 contains for all consumable tanks the capacity and full condition values plus the maximum free surface value and the 98% full free surface value for fuel tanks. Information not contained in Appendix A can be found in the tank table on page 17. Settler tanks shall always have a "slack" free surface value. For tanks which are consumed during the voyage a free surface value shall be entered that results in a sum not less than the tank value, which is largest, for each type of consumable liquid onboard. This requirement will allow use of the vessel's tankage in any order desired without undetected low stability due to free surface occurring at any time during the voyage. (See Routine Operating Instruction No. 1). All other 98% full fuel oil tanks shall have 98% - 5 degree heel free surface entered for them. In the separate detail loading tables, each category is summed with respect to tonnage, vertical moment, longitudinal moment and free surface. (Moment is the product of tonnage by center of gravity distance for each item).

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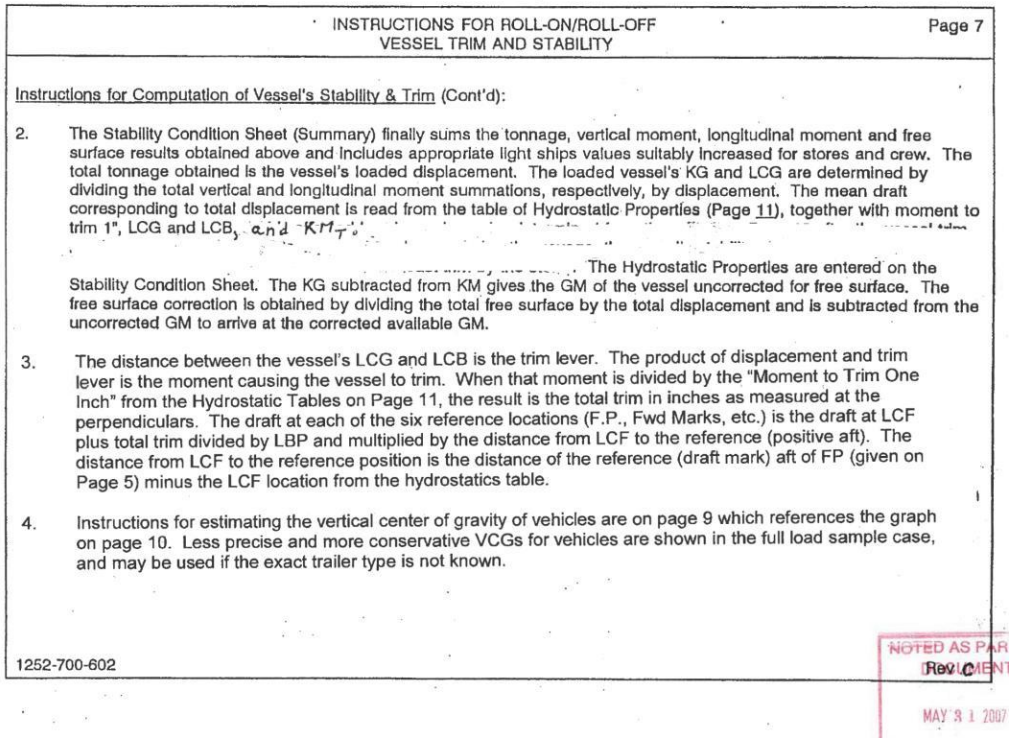
Figure 21a. Instructions in *El Faro*'s trim and stability booklet.



INSTRUCTIONS FOR ROLL-ON/ROLL-OFF
VESSEL TRIM AND STABILITY

Page 7

Instructions for Computation of Vessel's Stability & Trim (Cont'd):

2. The Stability Condition Sheet (Summary) finally sums the tonnage, vertical moment, longitudinal moment and free surface results obtained above and includes appropriate light ships values suitably increased for stores and crew. The total tonnage obtained is the vessel's loaded displacement. The loaded vessel's KG and LCG are determined by dividing the total vertical and longitudinal moment summations, respectively, by displacement. The mean draft corresponding to total displacement is read from the table of Hydrostatic Properties (Page 11), together with moment to trim 1", LCG and LCB, and KMT's.

. The Hydrostatic Properties are entered on the Stability Condition Sheet. The KG subtracted from KM gives the GM of the vessel uncorrected for free surface. The free surface correction is obtained by dividing the total free surface by the total displacement and is subtracted from the uncorrected GM to arrive at the corrected available GM.

3. The distance between the vessel's LCG and LCB is the trim lever. The product of displacement and trim lever is the moment causing the vessel to trim. When that moment is divided by the "Moment to Trim One Inch" from the Hydrostatic Tables on Page 11, the result is the total trim in inches as measured at the perpendiculars. The draft at each of the six reference locations (F.P., Fwd Marks, etc.) is the draft at LCF plus total trim divided by LBP and multiplied by the distance from LCF to the reference (positive aft). The distance from LCF to the reference position is the distance of the reference (draft mark) aft of FP (given on Page 5) minus the LCF location from the hydrostatics table.

4. Instructions for estimating the vertical center of gravity of vehicles are on page 9 which references the graph on page 10. Less precise and more conservative VCGs for vehicles are shown in the full load sample case, and may be used if the exact trailer type is not known.

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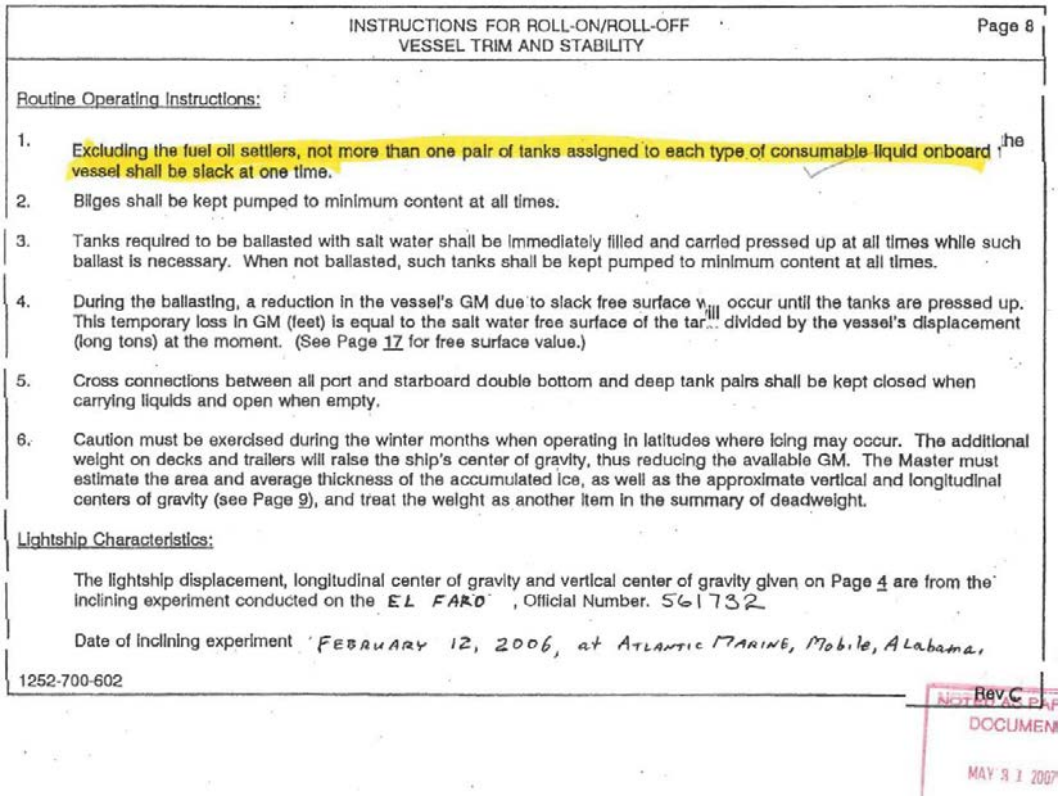
Figure 21b. Instructions in *El Faro*'s trim and stability booklet (cont).



INSTRUCTIONS FOR ROLL-ON/ROLL-OFF
VESSEL TRIM AND STABILITY

Page 8

Routine Operating Instructions:

1. Excluding the fuel oil settlers, not more than one pair of tanks assigned to each type of consumable liquid onboard the vessel shall be slack at one time.

2. Bilges shall be kept pumped to minimum content at all times.

3. Tanks required to be ballasted with salt water shall be immediately filled and carried pressed up at all times while such ballast is necessary. When not ballasted, such tanks shall be kept pumped to minimum content at all times.

4. During the ballasting, a reduction in the vessel's GM due to slack free surface will occur until the tanks are pressed up. This temporary loss in GM (feet) is equal to the salt water free surface of the tank divided by the vessel's displacement (long tons) at the moment. (See Page 17 for free surface value.)

5. Cross connections between all port and starboard double bottom and deep tank pairs shall be kept closed when carrying liquids and open when empty.

6. Caution must be exercised during the winter months when operating in latitudes where icing may occur. The additional weight on decks and trailers will raise the ship's center of gravity, thus reducing the available GM. The Master must estimate the area and average thickness of the accumulated ice, as well as the approximate vertical and longitudinal centers of gravity (see Page 9), and treat the weight as another item in the summary of deadweight.

Lightship Characteristics:

The lightship displacement, longitudinal center of gravity and vertical center of gravity given on Page 4 are from the inclining experiment conducted on the EL FARO, Official Number. 561732

Date of inclining experiment FEBRUARY 12, 2006, at ATLANTIC MARINE, Mobile, Alabama.

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MAY 31 2007

Figure 21c. Instructions in *El Faro*'s trim and stability booklet (cont).

ABS stated that unintentional flooding "would be the entrance of water into the watertight and weather tight envelope of the vessel" and that water entering the vents or fire dampers on the hull of the vessel would be considered unintentional flooding.[72] When asked the rationale for not including guidance on general precautions for preventing unintentional flooding, a consideration under Title 46 CFR 170.110(d)(11), ABS responded: "The damage control plan does—is supposed to have all the openings on board the vessel and their means of operations. So again, that's already considered in the damage control plan."[73]

In subsequent testimony, ABS representatives stated that they did not know whether there was a damage control plan for *El Faro*.[74] Investigators asked TOTE Services for a damage control plan for the vessel but did not receive one.

The *El Faro* experienced a significant port list after vessel personnel shifted ballast and changed course to counter a substantial starboard windheel and flooding. In 1977, the Coast Guard released Navigation and Vessel Inspection Circular (NVIC) 4-77 entitled *Shifting Weights or Counter Flooding During Emergency Situations*. The NVIC stated: "The stability information for all vessels should contain an appropriate section emphasizing the importance of the master making every effort to determine the cause of a vessel's list before taking corrective action. In instances where the master can definitely ascertain that off-center flooding has occurred and that a cargo shift has not occurred, counterflooding or shifting weights to bring the vessel to the upright position may be the correct action. In other instances, such measures may be detrimental to the

[72] ABS chief engineer of statutes, MBI 2 testimony, May 19, 2016, p. 181.

[73] ABS chief engineer of statutes, MBI 2 testimony, May 19, 2016, p. 181.

[74] a) Testimony from ABS chief engineer of statutes MBI 2 testimony, May 20, 2016, p. 34. b) A vessel is required to have a damage control plan (DCP) per SOLAS, but it is not required to be reviewed/approved by the classification society.

survival of the vessel."[75] At the third marine board hearings, ABS was questioned on some of the wording to be included in trim and stability books, as suggested by the Coast Guard NVIC 4-77, regarding actions taken by the master to bring a vessel to an upright position. Investigators asked: "Is there anything in the trim and stability booklet which mentions this, you know, this action—stability information that the Coast Guard recommended back in 1977?" ABS replied: "I've seen in a lot of trim and stability booklets a caution note to the master to determine the cause of any list before taking any corrective action . . . normally that's been the extent of any guidance to any of the masters. Unfortunately, that is not in this book."[76]

8.3.6 National Cargo Bureau Review

After the accident, NTSB asked the National Cargo Bureau (NCB) to review the sufficiency of *El Faro*'s cargo securing manual and the sufficiency of cargo securement for certain suspect cargoes carried on the accident voyage. Suspect cargos included all containers on the main deck, all high or heavy Ro/Ro cargo, all cargo on the second deck, all cargo stowed athwartship, and all automobiles stowed in the 3 lower hold (cargo area 4D). NCB issued a report, TOTE Services responded to the report, and NCB replied with a supplemental report.[77] The NCB was also asked to compute the failure point for the lashings of the suspect cargo, but NCB stated that it would not be able to do so. The NTSB will calculate the failure point of suspect cargoes, including the failure point of lashings in 3 hold.

[75] Coast Guard, *Shifting Weights or Counter Flooding During Emergency Situations*, NVIC 4-77, December 2, 1977.

[76] ABS chief engineer of statutes MBI 3 testimony, p. 114.

[77] NCB's report, TOTE Services' response, and NCB's supplemental report are found in the official docket.

9 Bridge Equipment

El Faro carried navigation, radio, and safety equipment in accordance with the SOLAS 74. The vessel was certificated to travel in all areas of the world, except the polar regions. Required navigation and radio (communication) equipment for *El Faro* was listed on the ABS "Record of Approved Cargo Ship Safety Certificate" and on the Federal Communications Commission (FCC) "Record of Equipment of Radio Facilities for Compliance with the International Convention for the Safety of Life at Sea, as Amended in 1988." Compliance issues related to navigation equipment were monitored and surveyed by ABS. The vessel was inspected for compliance with FCC regulations by Imtech Marine USA, a shore-based maintenance provider (private contractor).

Former *El Faro* officers told investigators that the vessel carried bridge equipment in addition to what was required in the above certificates. In October 2015, investigators requested a list of all *El Faro*'s bridge equipment that was not listed on either certificate, similar to the bridge equipment list obtained for *El Yunque*. A list was provided as an exhibit for marine board 3 held in February 2017. According to the ABS safety certificate, navigation equipment on *El Faro* included the following:

- Two radars (a 3 cm Raytheon radar and a 10 cm Furuno radar).
- One automatic radar-plotting aid (ARPA).
- Two gyrocompasses.
- One magnetic compass.
- One rudder angle indicator.
- One rate-of-turn indicator.
- One rpm indicator.
- An autopilot for the steering system.

- One automatic information system (AIS).
- One echo (depth) sounder.
- One simplified voyage data recorder (S-VDR.)

In addition to the radars listed above, the vessel had a 3-cm radar manufactured by Furuno. The vessel also had a SOLAS-required ship security and alert system (SSAS.) The ABS safety certificate (form E) states that the vessel was "provided" with a receiver for a global-based navigation satellite system. The vessel had two global positioning system (GPS) receivers used for navigation and entering waypoints,[78] which could obtain differential GPS signals. *El Faro* used paper charts to meet SOLAS carriage requirements.

9.1 Weather Observation

According to Imtec Marine records, *El Faro* carried two R. M. Young model 05106 (marine model) wind monitors and two R. M. Young model 06206 Wind Tracker display units, both installed before 2009. No records for maintenance or replacement of the wind observation equipment were provided to investigators.

The wind sensors, which measured relative wind speed and direction, were attached to separate steel poles mounted over the forward part of the bridge. The displays were mounted on a bulkhead above the port side of the chart table. According to records, wind speed and direction data were transmitted to the VDR when it was tested in 2014.[79]

[78] Previous *El Faro* second mate interview, p. 31.

[79] Sperry Marine annual performance test, December 2, 2014.

According National Weather Service records, *El Faro* had a Belfort aneroid barometer and an ALS digital barometer/barograph aboard.[80] The instruments are discussed in greater detail in the factual report of the meteorology investigation group.

Previous *El Faro* deck officers stated that the vessel carried anemometers. Parametric data obtained from the vessel's VDR showed that wind speed and direction were recorded. However, on the VDR audio recording, *El Faro*'s master, chief mate, and second mate are heard questioning the reliability of the wind speed and stating that the wind direction was "not good" and that "we don't have (any) anemometer."[81]

9.2 Command and Control

A Kawasaki electrohydraulic steering system, located in the steering gear room, was remotely controlled from the bridge by a C. Plath Navipilot V marine autopilot system or a C. Plath Navipilot AD II (**figure 22**)—TOTE Services submitted manuals for both systems in response to information requests. The control processes of both systems allowed the vessel to be steered manually (hand-steered) or in autopilot mode. In autopilot mode, the vessel received input from one of the vessel's gyrocompasses and steered a gyrocompass heading. Settings to the autopilot could be selected at the master unit on the bridge. The settings allowed ship navigation personnel to change the response time or sensitivity of rudder movement. Both systems were equipped with visual and audible alarms to warn bridge personnel when the vessel was off course by an operator-defined amount.[82]

[80] NWS *Ship Worksheet* for *El Faro,* attachment 32 to the factual report of the meteorology group chairman.

[81] VDR transcript, pp. 54, 125, and 397.

[82] Manuals for C Plath Navipilot V marine autopilot and C Plath Navipilot AD II.

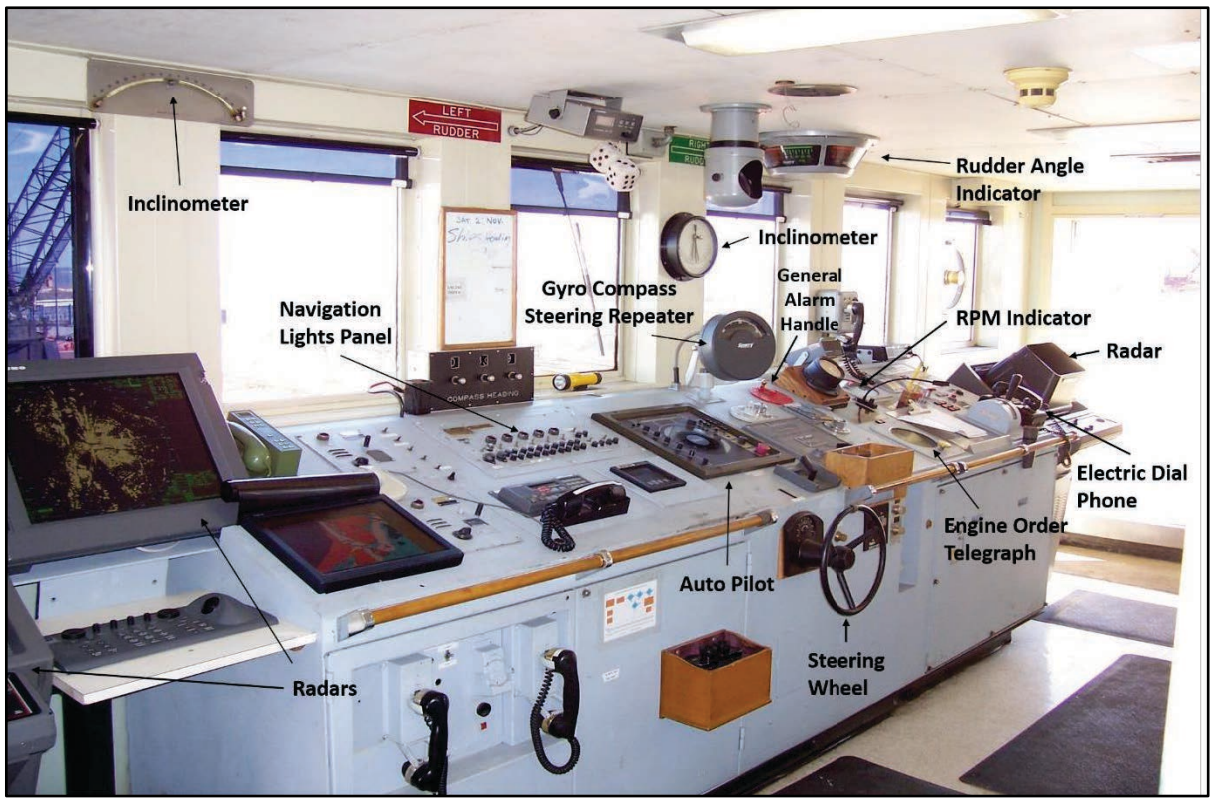


Figure 22. Bridge console on *El Faro*, viewed from port to starboard.

Propeller rpm and direction of rotation (forward or astern) were generally ordered by means of the engine order telegraph when the vessel operated at speeds of less than 80 rpm (**figure 22**). An order such as full ahead corresponded to a predetermined rpm. When the engine room received the order, engineers manually changed the throttle/directional setting of the steam inlet to the main engine. Sea speed was generally ordered between pilot stations when the vessel was not expected to maneuver. The ordered rpm was usually decided by the master in consultation with the chief engineer.[83]

[83] Former master NTSB interview, p. 79.

10 Communication Equipment

El Faro carried different types of equipment for communicating internally and externally. The mode of internal communication was generally based on the location of the parties. The type of equipment used for external communication was generally based on the location of the vessel. Although any mode of communication could be used for routine or emergency communications, external communications of an emergency nature had a dedicated transmission system, the Global Maritime Distress and Safety System (GMDSS). According to FCC requirements, the GMDSS on *El Faro* included primary and secondary means of communication.[84]

10.1 External

10.1.1 GMDSS

El Faro's primary equipment for alerting or communicating with external rescue or safety entities under the GMDSS consisted of very high frequency (VHF) radio, medium- and high-frequency radio, and Inmarsat-C satellite transmission. The radio and Inmarsat-C systems could both send and receive signals. The equipment could also receive weather information.

Secondary GMDSS alerting of a distress nature was via the vessel's emergency position indicating radio beacon (EPIRB), which is discussed in the factual report of the survival factors investigation group. The EPIRB transmitted the ship's position to rescuers and was not equipped to receive signals.

[84] As noted earlier, *El Faro* held an FCC cargo ship safety radio certificate, which had an accompanying record of equipment.

A major component of the GMDSS carried on *El Faro* was navigational telex (NAVTEX). The system received navigation, safety, and weather broadcasts via medium-frequency radio and printed text messages on a teletype printer on the vessel's bridge.

10.1.2 Other

As required by federal and international regulations, *El Faro* carried the maritime navigation safety communication system known as automatic information system (AIS).[85] AIS, which uses VHF radio transmissions, broadcasts information about the host ship and receives information about other ships in the receiver's range. Through AIS, *El Faro*'s position, course, and speed could be tracked by other vessels, shore-based stations, and satellites.

Routine external message traffic, for both voice and data transmission, was sent by either regular cell phone service or the vessel's Inmarsat-B FleetBroadband service. The FleetBroadband equipment on *El Faro* was a Globe iFusion model i250.[86] According to the Inmarsat installation report, one handset, located on the bridge, was available to make satellite voice phone calls using FleetBroadband. That was the only phone the crew could access when the vessel was at sea and cell phone coverage was no longer available. Permission to use the phone was at the master's discretion, according to a former master.[87] When the vessel traveled to the Middle East in 2000–2003 under a former name, it had an Iridium Satellite LLC phone system with which the crew

[85] Regulations for AIS are found at Title 33 *CFR* 164.46 and SOLAS chapter V, regulation 19.

[86] Inmarsat annexes to contract AM-SEA532, June 20, 2014, Sea Star Line; and Inmarsat *El Faro* installation report.

[87] MBI 3 transcript, February 16, 2017, vol. 9..

could make private collect credit card phone calls.[88] The system was removed when the vessel entered the Puerto Rico trade.

Sending emails via the FleetBroadband satellite service was the primary means of communicating between ship and shore when *El Faro* was at sea. According to TOTE Services, the vessel's email server utilized equipment, provided by Globe Wireless, LLC, to communicate with a satellite that relayed the information to shore. A Rydex software program provided the interface between the vessel's server and the Globe equipment. Emails to and from the vessel were kept in the Globe Wireless queue and transferred to and from the vessel on set schedules. The master, or his designee, could also send or receive emails outside of the regularly scheduled, but the Fleet Broadband server, located two decks below the navigation bridge, had to be accessed to alter the schedule. From the testimonies of former deck officers on *El Faro*, the master was the only one who acted to send and receive emails outside regularly scheduled transmissions.[89]

The master, chief mate, chief engineer, first engineer, and bridge each had individual email addresses. One email address was shared by the rest of the crew. The crew's email address could be accessed by all those on board, and emails sent to or from that address could be read by anyone on board. The master had the capability to monitor all incoming and outgoing emails sent or received via the FleetBroadband service. Records show a monthly average of 2,303 emails sent to and from *El Faro* between April and September of 2015.[90] The email address with the most activity

[88] NTSB interview of former *El Faro* master. Iridium Satellite LLC became Iridium Communications in 2009. The company operates over 60 communications satellites.

[89] Former *El Faro* second mate transcript of testimony from MBI 1, pp. 87-88. Former *El Faro* master/mate transcript of testimony, October 7, 2015, pp. 30-31. NTSB interview of former *El Faro* master, transcript, pp 438-439.

[90] Globe Archive client email server records.

during that period was the master's. TOTE Services did not purchase access to the internet as part of Inmarsat's services to *El Faro*.

The vessel received weather information from the Bon Voyage System (BVS) via emails sent through the FleetBroadband service. The master's email address was the only one that received BVS weather information on *El Faro*. (Weather information is discussed in depth in the factual report of the meteorology investigation group.)

The vessel had another mode of external communication, the SSAS. Although not part of GMDSS, the system is part of the SOLAS carriage requirements for a vessel of *El Faro*'s size. The SSAS was placed aboard mainly to warn the company and the vessel's flag state (in *El Faro*'s case, the Coast Guard) of a security or emergency on a vessel such as a terrorist or pirate attack.[91] Among other things, an SSAS message includes the time and the ship's course, speed, and position.

10.2 Internal

El Faro had four primary means of internal communication capable of carrying two-way conversations: dial (electric) telephone, sound-powered telephone, public address or talk-back system, and portable handheld radios ("walkie-talkies"). Electric telephones, also called house phones, were located at fixed locations about the ship, including the bridge and the engine room. The sound-powered telephone was the only system capable of working without any external power source or battery. Walkie-talkies were the primary means of communicating with personnel when they were mobile or moving about the ship. The main control unit for the talk-back system was on the bridge, and satellite or remote units were located at the bridge wings, engine room, lifeboat

[91] SSAS message sent from *El Faro* during the accident went to Coast Guard and to TOTE Services DP.

stations, forward and aft mooring stations, crew dining room, crew lounge, officers' lounge, and officers' dining room. The system was similar to an intercom and could be operated hands-free.

As required by SOLAS, the vessel also had a class-approved general alarm system, whistle, and watch call system. The latter was used to wake bridge watchstanders. These items could be used to send one-way signals to the crew during emergencies.

11 Maintenance of Deck Equipment and Deck Areas

The deck department aboard *El Faro* was tasked with maintaining the exterior surfaces of all deck-related (non-engine) machinery; fixed cargo and portable securing gear; safety, emergency, and lifesaving gear; and corrosion-resistant coverings and coatings of exterior decks and bulkheads (by chipping, wire-brushing, priming, and painting). Deck department personnel also lubricated the fall wires for the lifeboat davits, the standing rigging (cargo ramp arms, mast support wires), and the exposed parts of deck machinery. According to TOTE Services personnel and former *El Faro* crew, maintenance of deck equipment was tracked using AMOS (a preventive maintenance system management software developed by SpecTec), shipboard computers, or paper lists.

11.1 Cargo Securing Devices

11.1.1 Overview

Appendix 2**,** chapter 2, section 2.3 of the 2003 CSS code contained guidance on what inspection and maintenance procedures should be included in a cargo securing manual. Items that should be included were:

(1) Routine visual examinations of components being utilized.

(2) Periodic examinations/retesting as required by the Administration. When required, the cargo securing devices concerned should be subjected to inspections by the Administration.

(3) Document actions to inspect and maintain the ship's cargo securing devices. Entries should be made in a recordbook, which should be kept with the Cargo Securing Manual. This recordbook should contain

(a) Procedures for accepting, maintaining and repairing or rejecting cargo securing devices; and a

(b) Record of inspections.

El Faro's cargo securing manual classified all cargo securing devices as either fixed or portable. The manual specified procedures for inspecting, maintaining, and repairing portable securing devices and procedures for inspecting fixed cargo securing devices.[92] According to testimony of several former *El Faro* crewmembers, securing devices were visually inspected frequently.

The manual did not contain maintenance or repair procedures for fixed securing devices but stated: "Cargo securing devices requiring maintenance or repair shall be forwarded to Sea Star" (previous name of the company that owned *El Faro*).[93] Former *El Faro* crewmembers stated that fixed securing devices were generally maintained by the ship's personnel (as outlined below) and replaced by ship personnel or outside contractors. Contractor services were arranged through the

[92] Cargo securing devices, section 5.3 of cargo securing manual, "Inspection and Maintenance."
[93] Cargo securing manual, section 5.3.

vessel's port engineer. Portable securing devices were generally maintained by shoreside personnel.

Section 5.3.3 of the cargo securing manual contained a table called a "Log for Maintenance of Cargo Securing Equipment." At the bottom of the log was the following remark: "Equipment being brought on or off the vessel, as well as new acquisition, should be recorded." This log contained a column titled "inspection/maint. carried out" and a column titled "test result." None of the former crewmembers interviewed or questioned had ever seen this table used, and no explanation was given as to what "test result" meant. Investigators asked for records of repairs to fixed securing devices and none were provided. According to ABS, there were no class or Coast Guard requirements (the Coast Guard is the "Administration" listed in the regulations) to test any of the fixed securing devices. When investigators asked if ABS had any interest in surveying repairs to fixed securing devices such as D-rings and buttons, ABS replied that they did not but that they did have an interest in the welding of the device to the ship's structure and its effect on the structure. ABS also stated that they did not survey or examine fixed securing devices, such as buttons and D-rings, during class periodic surveys.[94] During an NTSB interview of a former master aboard *El Faro,* investigators learned that a test was made of all buttons on the vessel's Ro/Ro decks. This test involved the use of a fabricated tool that tested for wear and tear and to confirm that the button was the correct size. The master left the vessel in July 2013 and was unaware whether the practice continued. [95] The 2003 CSS code states: "All ships should maintain a record

[94] MBI 1 transcript of ABS assistant chief surveyor, Americas Division, p. 99.

[95] Former master NTSB interview.

book, which should contain the procedures for accepting, maintaining and repairing or rejecting of cargo securing devices. The record should also contain a record of inspections." [96]

The OMV stated: "The Chief Mate shall be responsible for maintenance to the cargo gear. This includes lubrication, rust prevention, and mechanical repairs." [97] According to the TOTE Maritime Puerto Rico marine operations manager, the chief mate would ask him to supply spares to the fixed securing devices when needed. [98]

The off-duty chief engineer who oversaw the riding gang on *El Faro*'s last voyage prepared a report for TOTE Services that recommended removing and replacing all worn buttons and D-rings on the second deck so they would conform to the original stow plan. [99] In a June 30, 2015, email to *El Faro*'s master, the chief mate stated: "various D-ring and collars need to be replaced on the 2nd deck ramp area and the chief engineer was informed. Chief Engineer, Electricians, and Chief Mate commenced D-ring and collar repairs 17 May 2015." It is unclear from the records provided if the repairs were completed.

Investigators also reviewed handover notes between the vessel's chief mates indicating that repairs to buttons and D-rings were being made; and emails between *El Faro* chief mates and company shoreside personnel pertaining to ordering buttons and D-rings. During NTSB interviews and marine board hearings, investigators questioned ship and TOTE personnel about repairs to fixed securing devices, such as buttons and D-rings, and the inspection of fixed cargo securing devices. All sources indicated that visual inspections and repairs were made to fixed securing

[96] Annex 2 to 2003 CSS code.
[97] OMV, section 13.5.3.
[98] MBI 1 testimony of TOTE Maritime Puerto Rico marine operations manager, p. 210.
[99] MBI exhibit 53, "SS *El Faro* Survey Report for Alaska Service Retrofit," p. 32.

devices such as buttons and D-rings, but that cargo securing devices were not tracked in AMOS. The company did not produce any maintenance records or records of inspection for securing devices. Investigators therefore could not determine when the cargo securing devices were inspected or which devices were inspected, and which equipment was repaired or replaced.

11.1.2 Portable Devices

The cargo securing manual contained detailed instructions for the inspection and maintenance of portable securing devices. Broken or damaged lashings, binders, twistlocks, and lashing bars/rods were to be immediately taken out of service and placed in a receptacle for sending ashore. Once ashore, they were repaired or replaced as needed. According to the OMV, the chief mate was responsible for all cargo-related gear. As part of that responsibility, cargo lashings were to be "maintained as required or recommended by the manufacturer or the routine practices of good seamanship," and light oil lubrication of turnbuckles and binders was recommended. [100] Based on testimony from former crewmembers, the portable securing devices were regularly greased and maintained by the deck department crew.

11.1.3 Fixed Devices

According to the cargo securing manual, fixed securing devices were to be "visibly inspected routinely (at least once every other voyage) for damage such as cracking and deformation." [101] The manual did not describe what maintenance was to be performed on the fixed securing devices or what action was to be taken if cracked or deformed fixed securing devices were found. Although the manual discussed wastage of portable securing device components, no treatment of fixed securing devices wastage was found in the manual. Section 5.3.3 treated

[100] OMV, section 13.6.1.

[101] Cargo securing manual, section 5.3.3.

inspection requirements for ship's structure/fixed securing devices. A "Log for Maintenance of Cargo Securing Equipment" was included in this section. TOTE Services stated they did not use these log sheets and they provided investigators with monthly cargo gear inspection reports which, on two dates, referenced ongoing repairs to the fixed securing devices.

One of the vessel's chief engineers conducted a survey of fixed securing devices in preparation for the transition to the Alaska trade. He stated the need to "crop and renew all wasted buttons and frozen D-rings that are in correct positions and are unusable" on the main deck before the vessel reentered the Alaska trade.[102] He also recommended "removing and replacing worn buttons and D-rings as needed to conform to original stow plan" on the second deck.

According to the testimony of one of *El Faro*'s previous chief mates, the bosun was given a monthly list of items to grease; the fixed securing devices were part of the greasing routine.[103] An off-duty ship's bosun stated that sledgehammers and pry bars were used to free D-rings. The vessel's port engineer told the first marine board that the D-rings " . . . . constantly get run over by the trucks and trailers so they take a pounding. So they need regular maintenance. We replace them as needed."[104] The bosun stated that engine room personnel would remove the old devices (cut off and grind down the remaining parts welded to the deck) and then install new ones.

11.2 Bridge Equipment

The second mate was tasked in the OMV with ensuring that the bridge navigational equipment was in good working order and properly maintained.[105] According to a former

[102] "SS *El Faro* Survey Report for Alaskan Service Retrofit," section II.C.
[103] Former *El Faro* chief mate interview, MBI 1 transcript, p. 52, lines 15-23.
[104] TOTE Services port engineer MBI 1 interview, February 26, 2016, p. 154, lines 1-3.
[105] OMV, section 10.4.1.

crewmember, the second mate would notify the master if repair work needed to be done.[106] The OMV stated that the chief engineer was "responsible for the proper operation and maintenance of all vessel equipment, machinery, and systems."[107] The following SOLAS-required equipment was installed or present on *El Faro's* bridge, according to an AMOS list:[108]

- Public address system, crew call box
- Radar antennas
- Gyrocompass
- Navigation light panel
- Radar, 3 cm
- Radar, 10 cm
- Radio direction finder
- Sounder, depth
- Spotlight
- Timer, whistle
- Dial phone
- Sound-powered phone
- Alarm system, general

[106] Former *El Faro* second mate, MBI 1 transcript of interview, p. 38.

[107] OMV, section 6.1.1.

[108] The equipment was listed on the cargo ship safety equipment certificate, form E

Although the above equipment was listed in AMOS, maintenance was not captured here but, according to TOTE Services, maintenance was effected by third party contractors. The OMV required the radio operator to keep a "good journal/log" and for repairs made by the radio officer/electronic technician or other personnel to be entered in this journal/log. [109] *El Faro* had no radio operator position.

11.2.1 GMDSS and Electronics

GMDSS-required equipment was regularly tested and inspected by the vessel's personnel and surveyed (annually) by Imtech Marine USA.[110] Simple maintenance was carried out by ship's personnel. More complex maintenance and repairs to the equipment were made by shore-based technicians licensed by the FCC, which also required an annual survey or inspection of the GMDSS equipment. *El Faro* successfully completed its last survey, by the FCC approved surveyor, on January 26, 2015. The manufacturer's test of the SSAS was confirmed by an Imtech Marine technician.

Most of the electronic bridge equipment, not captured under the GMDSS license, was also repaired or maintained by shore-based companies. Such equipment included the ship's electric telephone system, hand-held UHF radios, talk-back system, sound-powered telephones, and S-VDR. The S-VDR was tested and maintained by the manufacturer, Sperry Marine. The S-VDR is discussed in the factual report of the electronic data investigation group.

[109] OMV, section 7.4.

[110] Imtech Marine USA was also the company that usually maintained the vessel's GMDSS equipment.

11.2.2 Navigation, Weather, and Command and Control Items

The TOTE Services port engineer testified that the vessel's navigation, bridge, and communication equipment was checked by professional vendors.[111] Investigators were unable to determine the status of any of this equipment when the vessel departed on the accident voyage TOTE services indicated some of the records, like the equipment service records and GMDSS log book, were onboard the vessel and were lost. Investigators also note that many items of navigation, communication and command and control were regularly tested as part of the required pre-arrival and pre-departure checks of this equipment.

According to the ship's GMDSS maintenance provider, TOTE Services shoreside personnel would ask the company to repair bridge equipment. A search of Imtech Marine's database back to 2009 showed no record of maintenance on the ship's anemometers. The instruction manual for the Young wind sensors contained a maintenance section with directions for replacing the directional potentiometer and the vertical shaft bearings. [112] The manufacturer informed investigators that the vertical shaft bearings usually lasted 2 to 3 years, and that the potentiometer would need replacement every 3 to 4 years.

According to a former chief mate who left the vessel on August 11, 2015, at least one anemometer worked on the vessel. A former second mate, who left *El Faro* in September approximately 2 to 3 weeks before the vessel was lost and who had been on the vessel for a total of about 2 years, testified that he was unaware of any maintenance on the anemometers. A past *El Faro* third mate, who left the vessel on September 22, 2015, told investigators that an

[111] MBI 1, testimony of TOTE Services port engineer, p. 122.

[112] Young Meteorological Instruments, instructions for wind monitor MA (marine model) 05106.

anemometer was working but the wind vane had a consistent offset to port of approximately 20 degrees. *El Faro*'s port engineer told the first marine board that the anemometer was not working 3 to 4 months before the accident, but that the master did not ask him to correct the problem.[113]

As documented on the VDR recording, officers on the bridge of *El Faro* had difficulty determining wind direction and speed. At about 0510 the morning of the sinking, an officer asked the master what the wind speed was. The master said, "We don't know. We don't have (any) anemometer." (See parametric data treatment contained in recorder group chairman's factual report.)

Repairs to the Fleet Broadband system were the owner's responsibility and, if needed, Inmarsat would work with the vessel owner to arrange repairs. According to the manufacturer, no planned maintenance was required for the system.[114] There were no reported problems with it during the accident voyage.

11.2.3 Other Communication Equipment

Elements of the dial telephone, sound-powered telephone, public address system, and general alarm systems were included. AMOS records provided to investigators show no maintenance or repairs on those systems.

11.3 Mooring and Other Deck-Related Equipment

Preventive maintenance and cleaning of deck machinery such as ramp winches, mooring winches, and anchor windlasses were tracked in AMOS. Greasing and cleaning of other deck-

[113] MBI 1 transcript, testimony of port engineer, p. 176.

[114] NTSB record of telephone calls to Inmarsat vice president regarding maintenance of Fleet Broadband system, November 21, 2016, and January 6, 2017.

related machinery, tackle, and gear were listed in the ship's deck work logbook. According to testimony and statements from former officers and crew, the maintenance work was part of the regular routine of the deck department. A former bosun on *El Faro* testified that deck department ratings maintained and lubricated the watertight doors, except for the large cargo watertight doors. He stated that one of the "officers or engineers" worked on the large cargo watertight doors. [115]

Investigators reviewed entries in the ship's deck department work log for work performed between May 9, 2014, and August 31, 2015 (the only deck work logbook pages submitted to investigators). Entries for repairs or maintenance to deck scuttles and watertight doors were found on 11 separate dates. According to the logbook, on January 9, 2014, scuttles and watertight doors were tested by ABS, and on January 10, 2014, a log entry was made for repairs to watertight doors and scuttles. No deck work logbook entries were found for inspecting scuttles or watertight doors but a former *El Faro* master stated chalk tests were performed on watertight doors (evidence of which was later confirmed by an ABS surveyor).[116] The vessel's port engineer also testified that the crew would use ladders to inspect the gaskets to the large watertight doors.

Large cargo watertight doors were included in AMOS. A review of the AMOS records provided to investigators showed that unplanned maintenance was performed on two of the doors in 2014. No other entries were found. Scuttles were not included in AMOS. During the vessel's Coast Guard inspection on March 6, 2015, one of the inspectors spot-checked the scuttles. He told investigators that he did not see excessive wear or anything out of the ordinary.[117]

[115] MBI 1 transcript, p. 114.

[116] NTSB 11/1/2015 interview of former *El Faro* master; port engineer MBI 3 testimony.

[117] MBI 2 transcript, May 25, 2016, p. 52.

11.4 Safety and Lifesaving Equipment

Preventive maintenance to safety and lifesaving gear was entered into AMOS and also captured in the deck department work log. Further treatment of the topic is found in the factual report of the survival factors investigation group.

11.5 Maintenance of Interior and Exterior Non-engine Spaces

Maintenance of the exterior and interior surfaces of non-engine and non-galley spaces was the responsibility of the deck department ratings. Maintenance included cleaning, sweeping, washing, preparing surfaces for painting (chipping, brushing, scraping, priming), and painting. The ratings also renewed or repaired mooring lines and wires as needed.

12 Safety Management System

A safety management system is a structured, documented system developed to enhance the safe operation of vessels, prevent human injury or loss of life, and avoid damage to the environment. With a safety management system, ship owners and operators are encouraged to resolve safety problems before casualties or incidents occur.

12.1 Background

In the early 1990s, the IMO began developing guidelines for safe ship management that later became known as the ISM code. The stated purpose of the ISM code is "to provide an international standard for the safe management and operation of ships and for pollution prevention." In May 1994, IMO members, including the United States, adopted the ISM code as chapter IX of SOLAS, which went into force on July 1, 1998. On that date, the ISM code became mandatory for the following vessels on international voyages: passenger ships and tankers, bulk

carriers, and cargo high-speed craft of 500 gross tons or more. For other cargo ships and mobile offshore drilling units of 500 gross tons or more, the code came into force on July 1, 2002.

In October 1996, Congress revised Title 46 *US Code* chapter 32 ("Management of Vessels") to incorporate the ISM code into the laws of the United States. On December 24, 1997, the Coast Guard issued final regulations for implementing the ISM code (Title 33 *CFR* 96, "Rules for the Safe Operation of Vessels and Safety Management Systems"). The final rule became effective on January 23, 1998. The objectives of a safety management system are listed in Title 33 CFR 96.230 as follows:

- Provide for safe practices in vessel operation and a safe working environment onboard the type of vessel the system is developed for.
- Establish and implement safeguards against all identified risks.
- Establish and implement actions to continuously improve safety management skills of personnel ashore and aboard vessels, including preparation for emergencies related to both safety and environmental protection.
- Ensure compliance with mandatory rules and regulations.

12.1.1 Main Elements

A safety management system aims to create a "culture of safety" throughout an organization by documenting a vessel owner's operational policy, chain of authority, and operational and emergency procedures; specifying the responsibilities of the owner or operator, managers, and masters; and outlining procedures for management review, internal audits, and correction of nonconformities (failure to adhere to procedures or regulations). Procedures are compiled in a safety management manual and a copy, bound or in electronic form, is kept on board

the vessel. A person or persons are designated in writing to monitor the safety management system, and managers conduct regular audits to ensure that employees follow the procedures. Checklists are supplied for critical areas. When deficiencies or nonconformities or an accident or near miss occurs, corrective action is taken until the problem is resolved, and the problem is documented from start to finish.[118]

12.1.2 Application

The federal regulations for safety management systems apply to US vessels "engaged on a foreign voyage" that carry more than 12 passengers or that are tankers, bulk freight vessels, freight vessels, or mobile offshore drilling units of 500 gross tons or more (Title 33 CFR 96.210). Operators whose vessels fall under the federal regulations must hold a valid Document of Compliance certificate and a Safety Management Certificate as evidence of compliance with the ISM code (Title 33 CFR 96 subpart C). Organizations can be authorized by the Coast Guard to act on behalf of the United States to perform safety management audits and certification (Title 33 CFR 96 subpart D).

A complete list of documents required for a safety management system under federal regulations is found at Title 33 CFR 96.250. Briefly, they include the following:

- Safety and environmental impact statements, which are to be carried out and kept current at all levels.
- Statements of responsibilities and authority.
- Designation, in writing, of a person or persons to monitor the safety management system.

[118] *Federal Register*, vol. 62, no. 84 (May 1, 1997), p. 23705.

- Written statements defining the master's responsibilities and authorities.
- Written statements that the master has overriding responsibility and authority to make vessel decisions.
- Personnel procedures and resources available on shore and on board ship.
- Vessel safety and pollution prevention operation plans and instructions for key shipboard operations.
- Emergency preparedness procedures.
- Reporting procedures on required actions.
- Vessel maintenance procedures.
- Safety management system document and data maintenance.
- Safety management system internal audits that verify the vessel's safety and pollution-prevention activities.

12.1.3 Audit Requirements

The ISM code requires companies to demonstrate how safety is managed on shore and on its vessels, through both internal and external audits. Internal audits allow companies to measure the effectiveness of their own systems. Companies prepare their own internal procedures for auditing their safety management systems, setting out the objectives, scope, and responsibilities involved. They develop an audit schedule that specifies which ships and office locations to audit and target dates for carrying out and completing the audits. Reporting lines are defined and reports are distributed to all relevant personnel.

External audits are performed at the request of the operating company by an approved outside organization, usually a marine classification society, for a fee paid to the auditor by the

requesting company. The external auditor reviews the results of the operating company's internal audits and all elements of its management system. The auditor questions management and vessel crews about their knowledge of the system, examines safety records, and verifies that procedures are followed. It may take an entire day to audit one vessel. If the audit is successful, a Safety Management Certificate is issued and the ship can continue operations. If critical areas have deficiencies, a vessel operator can lose its Document of Compliance.[119]

12.2 System on *El Faro*

El Faro met the requirements of the ISM code through its enrollment in the Coast Guard's Alternate Compliance Program (ACP).[120] *El Faro* had a current Safety Management Certificate and TOTE Services had a current Document of Compliance indicating compliance with the requirements of the code. The primary documents comprising the TOTE Services ISM quality management system (the safety, quality, and environmental [SQE] or safety management system) were the operations manual–vessel (OMV) and the emergency preparedness manual–vessel (EPMV). Both documents were kept in electronic form on the vessel and, according to the document control page of the OMV, one hard copy was given to the master. TOTE Services has stated that an additional hard copy was given to the chief engineer.

The EPMV included a section on job hazard analysis and risk assessment.[121] According to the EPMV, every task required a job hazard analysis. The OMV also had a simple formula which stated: "Risk = Frequency x Consequence" and went on to say these were "very subjective terms."

[119] Coast Guard, *Guidance Regarding Voluntary Compliance with the International Management Code for the Safe Operation of Ships and for Pollution Prevention (International Safety Management [ISM] Code)*, NVIC 5-99 (Washington, DC: US Department of Transportation, 1999).

[120] See the factual report of the engineering investigation group for a full description of the ACP.

[121] EPMV, section 4.

Over 25 tasks and operations were included in the EPMV, as well as a simple risk-assessment formula. When asked by the marine board how the formula worked and if it involved numbers, the TOTE Services manager of safety and operations stated that he never used it. When investigators asked him if a matrix with numbers and colors was assigned to jobs in the company's risk analysis, he replied that the company, over the past year, had developed a new risk assessment tool with a matrix, colors, and numbers. [122]

12.3 Voyage Planning

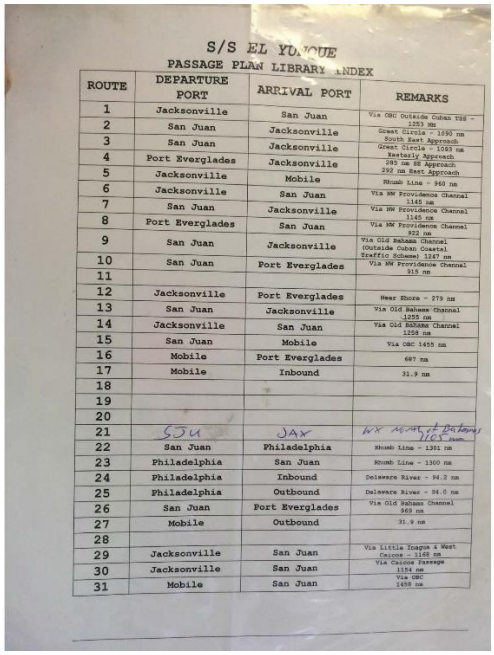
According to the OMV, the master was responsible for the "development and implementation of the vessel's passage plan," and the second mate was tasked with assisting the master in that function.[123] The passage plan had two components: the voyage passage plan and the port passage plan.[124] Required information on a voyage passage plan included fuel (bunker) at departure, fuel at arrival, and weather forecasting.[125] Voyage and port passage plans were not sent ashore for review by TOTE Services personnel, nor were they required to be. The TOTE Services manager of safety and operations told the first marine board that he was unsure whether voyage passage plans were reviewed during vessel audits.[126]

El Faro's typical voyage took the vessel from Jacksonville, proceeding east of San Salvador Island, Bahamas, to arrive off San Juan. Small adjustments were made to the vessel's

[122] MBI 3 testimony of manager, safety, & operations. Pgs. 1196–1198.
[123] OMV, section 5.1.3.
[124] OMV, section 10.7.1.
[125] OMV, section 10.7.1, and STCW chapter VIII, section A-VIII/2, part 2.
[126] TOTE Services manager, safety, & operations MBI 1 testimony, p. 49.

course or track along the way. As one of *El Faro*'s former navigation officers stated: "It's 131/310, one line . . . it's not like it's a complicated voyage plan."[127]

A library of voyage passage plans, similar to those followed on *El Faro,* was found on *El Yunque* in October 2015 (**figure 23**). The library contained a voyage passage plan believed to be similar to *El Faro*'s passage plan for the accident voyage. [128] The library also contained alternate routes for the vessel, such as using the Northwest Providence Channel or the Old Bahama Channel. Investigators requested from TOTE Services a copy of the voyage plan *El Faro* intended to follow on the accident voyage, but because the vessel was not required to send voyage plans ashore, it was not provided. According to comments from Tote Services received in their technical review of this factual report, the voyage plan was likely lost aboard the vessel.



S/S EL YUNQUE
PASSAGE PLAN LIBRARY INDEX

ROUTE	DEPARTURE PORT	ARRIVAL PORT	REMARKS
1	Jacksonville	San Juan	Via OBC Outside Cuban TSS - 1353 NM
2	San Juan	Jacksonville	Great Circle - 1093 nm South East Approach
3	San Juan	Jacksonville	Great Circle - 1093 nm Easterly Approach
4	Port Everglades	Jacksonville	385 nm SE Approach 292 nm East Approach
5	Jacksonville	Mobile	Rhumb Line - 960 nm
6	Jacksonville	San Juan	Via NW Providence Channel 1145 nm
7	San Juan	Jacksonville	Via NW Providence Channel 1145 nm
8	Port Everglades	San Juan	Via NW Providence Channel 922 nm
9	San Juan	Jacksonville	Via Old Bahama Channel (Outside Cuban Coastal Traffic Scheme) 1247 nm
10	San Juan	Port Everglades	Via NW Providence Channel 919 nm
11			
12	Jacksonville	Port Everglades	Near Shore - 279 nm
13	San Juan	Jacksonville	Via Old Bahama Channel 1255 nm
14	Jacksonville	San Juan	Via Old Bahama Channel 1258 nm
15	San Juan	Mobile	Via OBC 1455 nm
16	Mobile	Port Everglades	687 nm
17	Mobile	Inbound	31.9 nm
18			
19			
20			
21	SJU	JAX	WX Mona, Bahama 1101 nm
22	San Juan	Philadelphia	Rhumb Line - 1301 nm
23	Philadelphia	San Juan	Rhumb Line - 1300 nm
24	Philadelphia	Inbound	Delaware River - 94.2 nm
25	Philadelphia	Outbound	Delaware River - 94.0 nm
26	San Juan	Port Everglades	Via Old Bahama Channel 960 nm
27	Mobile	Outbound	31.9 nm
28			
29	Jacksonville	San Juan	Via Little Inagua & West Caicos - 1148 nm
30	Jacksonville	San Juan	Via Caicos Passage 1154 nm
31	Mobile	San Juan	Via OBC 1458 nm

Figure 23. Voyage passage plans for *El Yunque*.

[127] A reference to a vessel's heading, in degrees. *El Faro* followed a course of 131° or 310°, depending on whether it was traveling southeast to San Juan or northwest to Jacksonville. From former *El Faro* second mate NTSB interview, p. 20.

[128] Former *El Faro* third mate MBI 3 testimony.

12.2 Departure from Port

On September 28, the day before *El Faro* left Jacksonville, there were no storm watches posted for the port of Jacksonville. An unnamed tropical depression announced by the National Hurricane Center the day before had strengthened into a tropical storm and been named Joaquin. The port of Jacksonville (along with all the ports of northeast and east central Florida) was in port hurricane condition 4, as set by Coast Guard Sector Jacksonville. According to the Port Heavy Weather Plan for northeast and east central Florida, as developed by the harbor safety committee for the area, a port hurricane condition "describes the relative threat of severe weather impacting the ports of Jacksonville, Fernandina, and Canaveral, and the action to be taken in the port at various stages . . ." as further described in the plan.[129] Under the plan, port hurricane condition 4 is the lowest state of readiness for the port during hurricane season (June 1 through November 30) and the purpose of setting this condition is to "ensure all preparations are complete to implement heavy weather plans."[130]

Coast Guard Sector Jacksonville's 2015 Port Heavy Weather Plan contained detailed instructions to follow on the approach of a hurricane. The plan recommended leaving port if a hurricane was approaching but left the decision to the master whether to remain in Jacksonville or depart. If a master desired to keep his vessel in port under heightened hurricane watch/warning conditions, the master had to justify that decision and obtain Coast Guard permission to remain.

The contingency plan referenced the Navy's *Hurricane Havens Handbook*.[131] The handbook deems the port of Jacksonville (including Blount Island, where *El Faro* docked) a poor

[129] 2015 port heavy weather plan for northeast and east central Florida, chapter 1.
[130] 2015 port heavy weather plan for northeast and east central Florida, p. 3-6.
[131] https://www.nrlmry.navy.mil/portguides/html/hurricanehavens/blount_island/summary.htm.

hurricane haven, mainly because the low-lying topography provides little shelter from winds and storm surges and the area is on the preferred tropical cyclone track. When sortieing port under a hurricane threat, the handbook recommends that vessels leave in ample time and head eastward, so as to pass north and east of the storm. A second recommended option is for vessels to head south, so as to pass west and south of the storm.

Company procedures and guidelines were silent about whether a vessel should remain in port or put out to sea when a storm was approaching. Company officials told investigators that the decision was left to the master. *El Faro*'s port engineer testified that he and the master discussed a tropical storm that was brewing when they ate dinner together the night before the vessel departed Jacksonville. There is no evidence that *El Faro*'s master discussed Joaquin with any other TOTE Services or TOTE Maritime Puerto Rico personnel before departing on the accident voyage.

12.4 Monitoring Ship Movements and Weather

Investigators asked company officials if TOTE had any system or process in place to monitor ship movements, especially during times when a vessel would be entering into or would be near heavy weather. The TOTE Services vice president of marine operations told the first marine board that he did not know if there was someone in his organization who "may actually know where the ship is . . . through some kind of computer tracking system or some alternate means of communication."[132] According to the TOTE Services director of marine services and safety, the person "directly responsible to monitor the departure messages, arrival messages, and noon reports" of the vessel was the vessel's port engineer.[133] The vessel's port engineer said that

[132] MBI 1 testimony of TOTE Services vice president of marine operations, p. 53.
[133] MBI 1 testimony of TOTE Services director of marine services and safety, p. 124.

he believed he saw *El Faro*'s noon position report for September 30, 2015. [134] The port engineer was asked: "Do you know who is directly responsible for reviewing the position reports of the vessel so that the vessel's position can be tracked at any time within the TOTE organization?" The port engineer replied: "I don't believe anyone does that, sir."[135]

The TOTE Services manager of safety and operations was asked whether a "storm was plotted against the position of the ship just to see relatively how they were doing," and he replied, "not necessarily." He stated that "we know the position at times based on their noon position." [136] The last noon report of *El Faro* contained the vessel's position approximately 18 hours before it lost propulsion. The manager was asked at the first marine board: "From a safety perspective, does anybody in the company have a specific task with monitoring tropical weather?" He replied, "No, sir."[137] In further testimony, the manager stated that some of the ships TOTE Services managed had a different weather-routing system.[138] With that system, he stated: "You can go online, you can see how accurate these ships are and you can actually see where the storms are and there as well."[139]

[134] According to OMV section 11.5.3, a noon position report was a routine message sent by the ship to the company while at sea. It contained about 50 data fields, including the vessel's position, course, speed, distance to go, and estimated time of arrival. It also included environmental information about the wind, swells, and waves. Other routine reports were the departure report and the arrival report.

[135] MBI 1 testimony of TOTE Services port engineer, p. 158.

[136] MBI 1 testimony of TOTE Services manager, safety, & operations, pp. 45-46.

[137] MBI 1 testimony of TOTE Services manager, safety, & operations, p. 13.

[138] TOTE Services managed ships that were owned by American Roll-On-Roll-Off Carriers, Inc., a different company from Tote Maritime Puerto Rico.

[139] MBI 1 testimony of TOTE Services manager, safety, & operations, p. 46.

12.5 Preparing Vessel for Sea

12.5.1 General

Investigators reviewed the company's safety management documents to ascertain what guidance was in place to assist shipboard personnel in preparing or securing a vessel for sea. "Secure vessel for sea on departure" was listed as a special/critical operation in section 15.5 of the OMV.[140] That section referred the reader to additional sections, such as OMV 5.22 and OMV 10.13.7.3. Investigators could not find section 5.22 in the OMV. OMV section 10.13.7.3 is titled "Vessel Safe for Sea (excessive list)." Notwithstanding its title, section 10.13.7.3 stated that the chief mate was responsible for ensuring that all cargo, supplies, materials, watertight doors, and hatches were secure but gave no guidance on what those duties entailed. Section 15.5 of the OMV states: "checklists as identified in OMV 16.1, and forms in 'Forms Addendum' to the OMV will be utilized to assure compliance with established procedures." Investigators reviewed OMV section 16.1 and the OMV forms addendum but did not find a checklist for securing a vessel for sea at departure.

As specified in the OMV, "the duties of securing the vessel for sea, proper stowage of lines and securing equipment shall also be assigned to the bosun through the chief mate." [141] One of *El Faro*'s former bosuns testified to the marine board that his routine after leaving port was to secure the bow and then secure lockers and doors on the main deck, on his way back to the bosun's locker. He also stated that he would personally check and dog the scuttles. His other activities

[140] OMV, section 15.5.
[141] OMV, section 5.1.6.

included securing the gangway and the stores crane.[142] A former chief mate and second mate also stated the second deck scuttles were closed by the bosun when leaving port.[143]

The ratings in the deck department did not usually check lashings at sea. The second mate always checked them and, if the second mate found lashings needed tightening or if extra lashings were needed, he or she would ask the bosun to have the deck department take care of this need.[144] However, according to a former *El Faro* chief mate, it was a regular routine for the deck department to check lashings the first day after the vessel left port.[145]

A review of the deck department work log (an electronic spreadsheet) from May 9, 2014, through September 5, 2015, shows entries titled "secure for sea" from July 1, 2014, through August 5, 2015, but there were no entries after the August 5 entry.[146] According to a former bosun, securing for sea when departing port included securing the bow, the anchors, gangway, crane, and dogging scuttles. He also told investigators that he typically reported the work performed to the chief mate. The deck department work log contained no specific entries for securing cargo, watertight doors, or scuttles.

Investigators reviewed *El Faro* deck log (the deck log is another document kept on the bridge and updated by the officers in charge of the navigational watch) pages for the month of August 2015 and noted the following log entry made prior to departing port: "W/T doors & hatches secured for sea." Per OMV section 5.2.2, "inspecting weathertight doors @ departure" was a

[142] Former permanent *El Faro* bosun, MBI 1 testimony, pp. 112-113.
[143] Former chief mate 12/6/15 NTSB testimony, page 59; former second mate 12/6/15 testimony, Pp 53-54,72.
[144] Former permanent *El Faro* bosun, MBI 1 testimony, pp. 112-113.
[145] Former *El Faro* chief mate MBI 3 testimony, p. 74.
[146] The deck department work log is found in the public docket for this accident.

required entry in the deck logbook. Investigators did not find any deck logbook entries relating to the inspection of weathertight doors at departure.

12.5.2 Watertight Integrity

According to the OMV, the chief mate was "responsible that all watertight doors and hatches are secure."[147] The cargo operations section of the OMV stated: "All watertight doors and hatches are to be properly secured for sea prior to departure."[148] The OMV also required the master to "record the establishment of watertight integrity in the Official Logbook."

Official logbooks are required on vessels making an international voyage between foreign ports.[149] The vessel did not carry an official logbook because it was on a coastwise voyage from one US port to another. If the master of a vessel is not required to carry an official logbook, then Title 46 CFR 97/35-3(b) requires the master or person in charge of the vessel to "maintain, on board, an unofficial logbook or record in any form desired for the purposes of making entries therein as required by law or regulations in this subchapter." *El Faro* deck officers kept a deck logbook. Investigators consistently found log entries stating "W/T [watertight] doors and hatches secured for sea" when the vessel departed the dock.

According to the deck logbook entries reviewed by investigators, large cargo area watertight doors that trailers could pass through were opened in port (**figure 24**) and secured before departure, as required by the OMV. The doors provided watertight integrity below the second deck and between cargo holds. Smaller man-size watertight doors were built into the large cargo watertight doors (**figure 25**).

[147] OMV, section 10.13.7.3, "Vessel Safe for Sea (excessive list.)"
[148] OMV, section 13.4.
[149] Title 46 *CFR* 97.35-3.

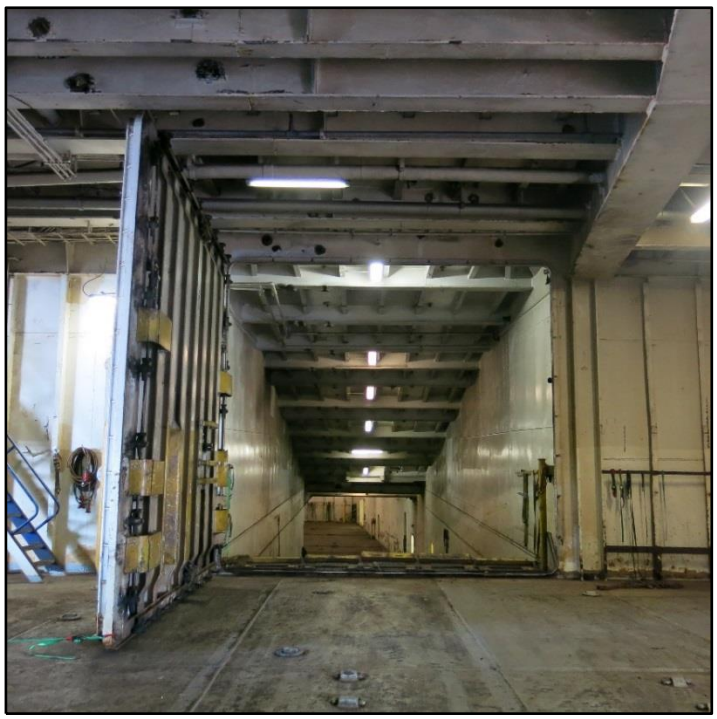


Figure 24. *El Yunque* cargo watertight door to 5 hold, looking aft (door in open position).

Figure 25. *El Yunque* cargo watertight door (with man-size watertight door) to 5 hold, looking starboard to port (doors shown in open position).

Man-size watertight doors also led to the house, deck lockers, and some engine spaces. In addition, each watertight cargo hold had two man-size watertight doors called scuttles that had a "pivoting motion about . . . one horizontal edge."[150] The scuttles on *El Faro* were hinged at one side and opened upward onto the second deck. To achieve watertight integrity, a scuttle was secured by closing the steel cover horizontal to the deck and turning a wheel. Through a linkage system, the wheel moved four steel pegs (dogs) to seal the scuttle tight and prevent water from entering the hold.

One of *El Faro*'s former bosuns testified that he believed a person could not tell by looking at a closed scuttle whether the wheel had been turned to engage the dogs and seal the hatch.[151] A former chief mate and master of *El Faro* stated: "You would have to grab the handle of it and see if it was locked or unlocked." Immediately below each scuttle opening was a vertical steel ladder that allowed crewmembers to climb into the hold or climb out of (escape from) the hold.

Scuttles for the 3 hold were located on the second deck, forward on the port side and aft on the starboard side (**figure 26**). The *El Faro* master was recorded on the VDR stating that a "scuttle popped open," or "a scuttle was left open or popped open."[152] The steel plates or covers to the scuttles were characterized by crew and officers as being "heavy," "difficult to open," "having a good weight to them," and "not easy to pop open, even if the wheel is not turned."[153] A former chief mate and master on *El Faro* stated that he had "never seen one pop open on its own." Another former master of *El Faro*, who had nearly 27 years' experience as master or chief mate on *El Faro*

[150] MSC.1/Circular.1464, "Unified Interpretations of SOLAS Chapters II-1 and XII," section 1.5.

[151] Former *El Faro* bosun, MBI 1 testimony, p. 116.

[152] VDR transcript, pp. 428 and 467.

[153] Former master of *El Faro* NTSB interview, p. 297; former bosun MBI 3 testimony, p. 125; former *El Faro* chief mate NTSB interview, pp. 66-67.

and other vessels of the *Ponce*-class, stated when asked about the scuttles: "I don't see a wave getting in there and lifting it. Even if it was not dogged."[154]

Figure 26. *El Faro* second deck near 3 hold aft starboard scuttle (photo by former second mate on vessel).

SOLAS chapter II-1, part B-4 ("Stability Management"), regulation 22 ("Prevention and control of water ingress, etc."), permits a watertight door to be "opened during navigation to permit the passage of passengers or crew, or when work in the immediate vicinity of the door necessitates it being opened." The regulation continues: "The door must be immediately closed when transit through the door is complete or when the task which necessitated it being open is finished."[155] SOLAS also requires authorization by the officer of the watch for the "use of access doors and hatch covers intended to ensure the watertight integrity of internal openings."[156]

[154] Former *El Faro* chief mate NTSB interview, p. 67; former *El Faro* master MBI 2 testimony, p. 7; former *El Faro* master NTSB interview, pp. 297, 298.

[155] SOLAS chapter II-1, part B-4, regulation 22, paragraph 3.

[156] SOLAS chapter II-1, part B-4, regulation 24, paragraph 4.

SOLAS chapter II-1, part B-4, regulation 22, paragraph 13 states: "Hinged doors, portable plates, sidescuttles, gangway, cargo and bunkering ports and other openings, which are required by these regulations to be kept closed during navigation, shall be closed before the ship leaves port. The time of closing and the time of opening (if permissible under these regulations) shall be recorded in such log-book as may be prescribed by the Administration."

According to testimony from former officers and ratings, the scuttles were regularly opened at sea to permit crew to enter the hold to inspect cargo or make repairs. A former second mate testified that the watch was notified of the opening or closing of scuttles, but no entry was made in the deck logbook.[157] A former third mate stated he recalled someone calling the bridge when the scuttles were opened or closed, but he could not recall if the opening and closing of the scuttles were logged.[158] A review of *El Faro*'s deck logbooks for August 2015 showed no log entries for opening or closing scuttles, hatches, or watertight doors while the vessel was at sea.

According to the testimony of several former officers and ratings on *El Faro,* man-size watertight doors were found open when the vessel was at sea.[159] Investigators found no information or guidance in the company's safety management documents regarding opening and closing of watertight doors, hatches, or scuttles while the vessel was at sea.

El Faro was equipped with an indicator panel for the large cargo watertight doors. The panel was in the fire control room, six decks below the navigation bridge. The panel did not include alarms or lights for man-size watertight doors or scuttles, but it had lights to indicate whether the

[157] Former *El Faro* second mate MBI 1 testimony, p. 87.

[158] Former *El Faro* third mate MBI 3 testimony, p. 870.

[159] Former *El Faro* master NTSB interview, pp. 84, 86, 87; former *El Faro* chief mate NTSB interview, p. 59; former *El Faro* second mate MBI 1testimony, pp. 70, 85-87, 92.

large cargo doors were opened or closed. There was no watertight door alarm panel on the bridge or at the engine operation platform.

12.5.3 Preparation for Adverse Weather

The complete wording of the vessel's OMV, section 10.8.2 ("Adverse Weather"), stated:

> 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 vessel's equipment to prevent any damage to the equipment or vessel. The Master shall take whatever action is necessary to prevent any 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.

The master of *El Faro* ordered two course changes to increase the distance between the vessel and Hurricane Joaquin. One was at about 0640 on September 30 and the other change occurred at about 1919 the same day.[160] Investigators found an email, sent by the master at 1022 the morning of September 30, stating that he had adjusted course to stay 65 miles from the hurricane.

Investigators learned that *El Faro* operated on the same route in August 2015 while tropical storm Erika was in the vicinity. TOTE Services' manager of safety and operations sent an email to the master of the vessel that stated, in part: "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."[161] *El Faro*'s master replied with the following:

[160] VDR transcript, pp. 44, 214

[161] TOTE Services manager of safety and operations email to master of *El Faro*, August 27, 2015 (2107 UTC).

As per the most recent BVS weather file and related marine weather radio broadcasts, the El Faro has been transiting the "Old Bahama Channel" en route to San Juan, Puerto Rico. Although this route does add an additional 160nm, I am confident that it offers a safer sea passage compared to our normal offshore route. It also allows for the options to hove to and or jog west of Puerto Rico as Erika tracks either north or south of the island. Our speed has increased to 20k since departing the Gulf Stream and our eta is showing 08/28/1300. I reached out to the San Juan Pilots regarding vessel traffic scheduling once the port reopens. I was informed that the "All Clear" would be issued only after several meetings and surveys have been conducted. It was advised that the El Faro maintain position in close proximity to the pilot station for first come, first serve scheduling of vessel traffic and this is exactly what I plan to do. I anticipate the weather to start deteriorating late on 08/27/15 and continue into the morning of 08/28/15, with ESE winds around 40k and seas 10'-12' slightly off the port bow. We have been securing our cargo with additional storm lashings as needed. All departments have been instructed to secure their areas and I will keep you duly notified throughout the remainder of the voyage.

On the afternoon of September 30, 2015, *El Faro*'s master sent an email to Tote Services shoreside management which stated:

Per the latest BVS weather file and NWS Hurricane Center Miami, FL.

Center of Hurricane Joaquin 24.7n, 72.6w.
Direction and Speed: South Westerly at 5k.
Barometric Pressure: 971 mb.
Winds: 50k with gust up to 70k.
Seas: 12'-14' throughout tonight and into tomorrow morning are expected.

I have monitored Hurricane Joaquin tracking erratically for the better part of a week. Sometime after 009/30/0200 she began her SW'ly track. Early this morning I adjusted our direct normal route in a more SSE'ly direction towards San Juan, Puerto Rico, which will put us 65+/- nm south of the eye. Joaquin appears to be

tracking now as forecasted and I anticipate us being on the back side of her by 10/01/0800.

Present conditions are favorable and we are making good speed. All departments have been duly notified as before. I have indicated a later than normal arrival time in San Juan, Puerto Rico., anticipating some loss in speed throughout the night. I will update the eta tomorrow morning during our regular pre-arrival report to SJP, etc.

Question
I would like transit the Ol' Bahama Channel on our return northbound leg to Jacksonville, FL.?

This route adds an additional 160 nm to the route, for a total of 1,261 nm. We'll need to make around 21k for our scheduled 10/05/1045 arrival time at the Jacksonville Pilot Station.

This precaution will take the uncertainty of Joaquin's forecasted track and as you can see, she really develops into formidable weather pattern on 10/03/-05/15. I am confident that Joaquin will track in a northerly direction once reaching the gulf stream current.

I will wait for your reply before transiting the Ol' Bahama Channel on our return leg to Jacksonville, Fl. Should you have any questions or concerns, kindly contact this vessel."

Later that day, the Tote Services director of ship management's reply stated: "Capt Mike, Diversion request through Ol' Bahamas Channel understood and authorized. Thank you for the heads up."

13 Emergency Response Assistance from Outside Sources

13.1 Rapid Response Damage Assistance

TOTE Services subscribed to the Rapid Response Damage Assistance (RRDA) program offered by ABS. Using the system was not required. The program assesses a vessel's condition during emergencies, and according to ABS, "provides rapid response damage assessment support during an emergency incident affecting an enrolled vessel's stability and hull strength."[162] A user's manual was provided to the company. Activating the RRDA system required clients "to establish verbal communication."[163]

The TOTE Services manager of safety and operations stated that "to the best of [his] knowledge," a placard was sent to *El Faro* with information on how to access the system. The manager also testified that he believed the system was in the OMV. When asked if the program was available to the ship, the manager replied that it was, but that he was not sure whether an operating manual was provided to the ship or of what was actually provided to the vessel for the system.[164] When the TOTE director of safety was asked if the ship had access to the system or if the RRDA process was captured in the OMV or the EPMV, he stated: "I honestly don't know how that would work. I'm not sure."[165]

On its final voyage, *El Faro* did not seek assistance from the RRDA team. The company contacted the RRDA sometime after the DP received his last telephone call from the ship. According to testimony from the TOTE Services manager of safety and operations, no shoreside or shipboard drills were held using the RRDA program.

[162] RRDA user's manual (vehicle carrier), section 1.1.
[163] RRDA user's manual, section 2.1.
[164] TOTE Services manager of safety and operations, MBI 1 testimony, p. 105.
[165] TOTE Services director of marine services and safety, MBI 1 testimony, p. 106.

13.2 Other Sources

The vessel's emergency preparedness manual included an emergency procedure in case of flooding. It referred vessel personnel to the "ship's stability information to determine what action is necessary to improve buoyancy." The manual stated: "Intact spaces have to be evacuated and securely battened down. This include[s] any void spaces below the water line and other spaces which could contribute to the ship's buoyance if the ship settled in the water." The manual also advised the master to obtain "detailed information about the location and extent of damage" and to send the information to company headquarters so that the shoreside emergency response team (coordinated by manager of safety and operations) could "assess buoyancy and structural effects of flooding and . . . advise the Master of ways to limit stress."[166]

[166] EPMV, section 8.

Appendix

Required Deck Logbook Entries

5.2.2 REQUIRED DECK LOG BOOK ENTRIES (NOT ALL INCLUSIVE)

Adverse Weather Avoidance Measures
Aft Steering Manned
Alarms (GPS/RADAR) while at anchor
Alcohol / Drug Testing
Anchor Let Go / Away
Anchor Location
Arrival / Departure
Arrival Passage Report Data
Boats Alongside / Away
Boom Deployed / Removed
Bunker, Barge Alongside / Away
Bunker, Commence / Complete
Bunker, Hose conn. / disconn.
Bunker, Quantity rec'd., supplier, SG
Bunker, Quan. Aboard-
Arrival/Sailing/Noon
Cargo Damage
Cargo Ops, Commence/Complete
Cargo Ops, Stop / Resume
Cargo Tanks Entered
Cargo Tanks Found 'Safe for Entry'
Change of Master
Change of Watch
Contraband / Stowaway Searches
Course Changes (significant)
Crew Change Indoctrination
Draft - Arrival / Departure & daily in port
Draft After Shifting Ballast
Drills, ALL
Economic Pollution Zone, Entering
Eng. Rm-Reduced RPM or other event (w/cause)
Equipment Tests, Daily Equipment
Escort Tugs Tethered / Let Go
Escort(s) on Station / Released
First / Last Line
Free Pratique Granted
Fresh Water Aboard - Arrival
Fresh Water Aboard - Departure
FWE /SBE
Gangway Aboard / Away
Gear Test (dept./re-arr./@ noon at sea)
Gyro, Monthly Changeover
Hot Work Performed
Hose (cargo), First
Connected/Disconnected
Hose (cargo), Last
Connected/Disconnected
Injuries to Crew Members
Inspections, Sanitary
Inspection, Cargo Gear
Inspections, Lifeboats / Emerg. Equip.
Inspections, Tank
Landmarks, Time and Distance Abeam
Lifeboat, Fuel changed, Wires Inspected
Master Turnover
Mooring Arrangement (1'ST OF EACH MONTH) Names, Helmsman, Standby,
Deck Watch
Noon Passage Report Data
Noon Steering Motor Changeover
Notice of Readiness Tendered
Pilot Aboard / Away
Port Departed / Port Bound
Propeller Clearance
Pratique Granted
QI Notification Drill (Quarterly+annual after hrs)
Radio Audio Alarms / 2182 & 500 khz
Reduced Visibility
Salinity of Water
Sea Trial (Master/CE Conference)
Security Related Events/Drills
Shifting Ballast While Underway
Speed/Courses Changes - Adverse
Weather
SOLAS Manual Review (12/31)
Stability Verified prior departure
Storing, Commence / Complete
Testing, Oil Water Content monitor
Testing, Pressure on COW lines
Tug Alongside / Away
Tug Made Fast / Let Go
Vessel Clear Berth
Vessel damage
VTS System, Enter / Exit
Weather information (end of each watch)
Weather tight doors inspected @ departure