Accident Investigation Party Submission
NTSB Accident Investigation: DCA16MM001
SS *El Faro*

Date of Accident:	October 1, 2015
Operator:	TOTE Services, Inc.
Owner:	TOTE Maritime Puerto Rico, LLC
Location:	Crooked Island, Bahamas
Date:	August 31, 2017
Submitted by:	Lee Peterson TOTE Party Coordinator

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I. EXECUTIVE SUMMARY

On Tuesday, September 29, 2015, the U.S. flagged TOTE vessel *El Faro* departed Jacksonville, Florida for its weekly southbound voyage to San Juan, Puerto Rico. The vessel sailed with a complement of 33, including 28 crewmembers and five riding crew. At the time of its departure, Tropical Storm Joaquin was developing in the Atlantic, but was not forecast to have a significant impact on the intended voyage to Puerto Rico.

The Master of the *El Faro* was tracking the developing storm and determined that it was appropriate to head on the vessel's typical track to Puerto Rico. During the voyage, as updated weather forecasts were received, the Master appropriately adjusted the vessel's course several times to increase the separation between the developing storm's forecast track and the vessel's planned track. Unfortunately, Joaquin was one of the most inaccurately forecasted storms on record and, in fact, did not behave as forecasted. The errors in the forecast were very significant and unusual -- the National Hurricane Center witness testified that the errors were in the "1 in 100" range. The impact of this on the *El Faro* was that the storm, at each successive forecast, wound up farther south and west than had been predicted, and therefore closer and closer to the *El Faro's* proposed track, even after the track was altered.

By the early morning of October 1, 2015, the *El Faro* was feeling the heavy winds and seas from now Hurricane Joaquin. At approximately 0700 that morning, the Master of *El Faro* reported to shore that the vessel had water in Hold 3, a 15 degree port list, and a loss of propulsion. The Master further reported that the crew was safe, they were pumping the water out of the hold, they were not planning to abandon ship, and the ship's engineers were working on restoring propulsion. There were no further communications with the vessel. However, at approximately 0713, *El Faro* activated various distress alerts. From the Voyage Data Recorder, the Master gave the order to abandon ship at 0729. The United States Coast Guard (and other entities) undertook a heroic search and rescue effort from October 1 to October 7, at which point those efforts were suspended. The *El Faro* was later located in about 15,000 feet of water in the vicinity of its last known position near Crooked Island, Bahamas. The vessel's crew is presumed to have been lost with the vessel.

The lengthy and thorough investigation into the loss of the *El Faro* revealed the following, all of which is explained in further detail in this - submission:

- *El Faro* met all applicable regulatory and class requirements, was fully certificated, and was found by the U.S. Coast Guard and American Bureau of Shipping to be fit for its intended service. The crew was properly trained and qualified and familiar with the twice weekly route between Jacksonville and San Juan. There were trained mariners on the *El Faro* far in excess of the minimum manning required on the vessel. The vessel was in port twice a week in locations that have local US Coast Guard inspection offices.

- The vessel was seaworthy in all respects when she departed Jacksonville. Specifically: (1) the vessel's cargo was properly secured in accordance with applicable standards, (2) the vessel's stability satisfied applicable requirements prior to departure, (3) the vessel's hull and watertight fittings were well maintained and operational, (4) the watertight integrity of the *El Faro* was not compromised, and (5) the engineering plant was in good working order (the few pending engineering maintenance items were routine in nature, raised no safety concerns, and played no role in the loss of the vessel).

- TOTE Services, Inc., *El Faro's* managing company, has an established strong safety culture and a Safety Management System that complied with applicable law and was functioning appropriately. Safety was always deemed paramount, and there were no company pressures to compromise safety to meet a given schedule.

- While the evidence clearly shows that the *El Faro* was well maintained and fully certificated and fit for its intended service, an analysis of the evidence also reveals a series of unfortunate challenges that the *El Faro* encountered, which led to its loss.

- The Master had a reputation as being meticulous and safety conscious. However, he exhibited a lack of situational awareness as the vessel approached the early hours of October 1st, 2015, in part complicated by the significant errors in the weather forecasts. This resulted in the Master not appreciating the most likely location of the storm and the risks it posed to the *El Faro* on its planned route.

- The navigation decisions alone likely would not have resulted in the loss of the vessel as it had a long history of handling very heavy sea conditions, from its prior service in the Alaska trade, albeit in a previous configuration. An unfortunate confluence of events resulted in the vessel not being able to sustain the severe weather conditions presented by Joaquin. As examples, first, a scuttle was likely left unsecured on the second deck, which allowed water into Cargo Hold 3 as the weather worsened. Second, the decision to reverse the list to port, to allow the scuttle to be closed, while it appeared a reasonable decision under the circumstances, in retrospect, likely resulted in the loss of propulsion, as a result of the off center (to starboard) lube oil suction mouth in the lube oil sump. While this system met all design requirements, the off center location of the lube oil suction pipe made it more likely that lube oil suction would be lost when the vessel's heel shifted from starboard to port. Third, without propulsion, and with a heavy list, the vessel was at the mercy of the prevailing wind and sea conditions. This resulted in progressive flooding through the cargo ventilation openings, which also met all design requirements, but made the vessel susceptible to downflooding in the severe conditions encountered by the vessel.

- The wind and wave conditions at the time of the sinking were so extreme that the lifeboats and life rafts could not be safely or reliably launched, thus preventing safe evacuation of the crew.

It is difficult to adequately describe the challenging circumstances faced by those on board the *El Faro*. What we do know is that they acted heroically. We are very proud of the professionalism exhibited by those on the vessel, including their efforts to help each other when the situation worsened. We extend our sincere condolences to the family members of those lost in this tragic accident. We thank the NTSB and the USCG for the time and effort that have been devoted to the investigation by their staffs. The loss of *El Faro* will undoubtedly be extensively studied, and lessons learned from the accident incorporated across the maritime profession. We are committed to learning from this accident, so that similar tragedies can be avoided in the future.

This submission is intended to be a comprehensive assimilation of almost two years of investigation and to contribute to the NTSB's and the Coast Guard's ongoing investigation into the loss of the *El Faro*. We appreciate the opportunity to make this submission.

In light of the highly technical nature of this marine casualty, we worked with several experts in various marine fields throughout the course of this investigation, including engineering, nautical operations, meteorology, and naval architecture. We asked those experts to prepare reports reflecting their assessment of, and opinions regarding, the casualty. Copies of their reports are included as Appendices to this submission. A brief biographical summary for each expert is provided below.

Engineer John P. Daly is owner and principal surveyor of Daly Marine Services, LLC. He conducts surveys and investigations on behalf of vessel owners, underwriters and other interested parties. He has been involved in cases involving, among other things, losses of propulsion and main and auxiliary engine failures. Daly worked as a licensed marine engineer employed on board ocean-going merchant vessels from 1982 through 2010. His experience includes time as Chief Engineer with overall responsibility for the safe operation and maintenance all shipboard equipment. His time as Chief Engineer included four years on a vessel powered by a MAN B&W 12L90 main engine and over nine years as the Chief Engineer of a steam propulsion Ro-Ro vessel outfitted with Babcock & Wilcox boilers and General Electric propulsion turbines and gears. As Chief Engineer, he was involved in creating and implementing operating procedures for his vessel's Safety Management System. His sailing career included time on board the *El Faro* (then known as the *Northern Lights*) and the *Westward Venture*, which was another "Ponce" Class vessel. His formal education includes a Bachelor of Science Degree in Marine Engineering, which he received from the U.S. Merchant Marine Academy in 1982, and a Diploma in Marine Surveying from Lloyds Maritime Academy and North Kent College in 2017.

Professor Charles J. Munsch is a Professor of Naval Architecture at the State University of New York (S.U.N.Y.) Maritime College. He started teaching at the S.U.N.Y. Maritime College in 1976, and served as its Engineering Department Chairperson from 1995 to 2001. He is also an Adjunct Professor of Engineering at the United States Merchant Marine Academy, and former Adjunct Professor of Engineering at the S.U.N.Y. Empire State College and the Pratt Institute. He's worked in various capacities as a naval architecture and marine engineering consultant since 1977. As a practicing Naval Architect and Professor of Naval Architecture at the S.U.N.Y. Maritime College for more than 41 years, Professor Munsch has performed stability analyses on over 200 vessels, and developed Trim & Stability Books, or similar stability guidance for Masters, for over 100 vessels. He's served as instructor for the use of CargoMax software for Chief Mates and Masters for a new class of nine container vessels for a major U.S. flagged carrier. Indeed, for over 30 years Professor Munsch has routinely used CargoMax, HECSALV, MAXSURF, Rhino, and GHS, which are software products used by ship operators and naval architects, in the performance of his professional responsibilities in real world applications and in the classroom. He holds two patents, No. 4171122 “Tensile Reinforcement Bar for Shipping Containers” and No. 4341495, “Container Corner Post Locking Assembly.” Professor Munsch served on ships at sea as a Third, Second, and First Assistant Engineer, as an Engineer on a tugboat, and as Summer Watch Officer and Instructor on the Training Ship EMPIRE STATE intermittently since 1976. Professor Munsch received his Bachelor’s Degree from the S.U.N.Y. Maritime College, and his Master’s Degree from the Stevens Institute of Technology.

Dr. Austin L. Dooley, Ph.D. has more than 36 years of experience in the meteorology and oceanography (M&O) industry. He has a B.S., M.S., and Ph.D., and was a tenured Associate Professor of Meteorology and Oceanography at the State University of New York (S.U.N.Y.) Maritime College before starting to work full time in the M&O industry. He obtained his doctorate degree in oceanography from New York University in 1978. Since that time, Dr. Dooley has worked as a Professor of Meteorology/Oceanography, for commercial weather companies, and as President of Dooley Sea Weather Analysis, Inc., whose offices are maintained at City Island, New York. He is currently an Adjunct Instructor of Meteorology and Oceanography at Purchase College, and formerly worked 13 years as an Adjunct Instructor of Meteorology at the United States Merchant Marine Academy. He has testified under oath in court or deposition as a weather expert in federal district courts. A sampling of cases in which he testified includes the APL CHINA container casualty and PRESTIGE oil spill. Dr. Dooley has also testified to the impacts of Hurricane Katrina and Hurricane/Post Tropical Cyclone Sandy. He obtained his B.S. in Meteorology and Oceanography, and his Third Mate’s License, in 1968 from the S.U.N.Y. Maritime College. He sailed as a deck officer from 1968 to 1980. His highest professional mariner’s licenses are Chief Mate unlimited tonnage oceans, and Master 1600 gross tons or less.

Captain Richard DiNapoli has considerable service as a ship master, tugboat captain, and harbor pilot. He also has served as a senior-level operation executive in companies operating various types of vessels in North Atlantic Ocean waters. He is recognized by federal and state courts throughout the United States as an expert in marine transportation operations upon ocean, coastal, and inland waters. DiNapoli previously served aboard various types of vessels along coastal and oceangoing routes in North Atlantic Ocean waters in all deck officer positions, from Third Officer to Master, and has had multiple first-hand experiences with the presence of hurricanes in way of vessel tracks at sea. Captain DiNapoli is a 1972 graduate of the United States Merchant Marine Academy, and holds a Coast Guard-issued license as Master and First-Class Pilot for vessels of any size.

II. FACTUAL INFORMATION

A. Synopsis

On Tuesday, 29 September, 2015, the U.S. flagged, 790-foot long vessel *El Faro* departed Jacksonville, Florida at 2148 hours[1] for its weekly southbound voyage to San Juan, Puerto Rico. The vessel sailed with a complement of 33, including 28 crewmembers (which included 27 crew and an off-duty engineering officer sailing as a supernumerary) and five Polish riding crew personnel who were performing deck work to the *El Faro* for its planned conversion back to its former use as a full roll-on-roll-off vessel. On Thursday, 01 October, 2015, at approximately 0659, the Master of the *El Faro* reported ingress of water in the number 3 hold, a 15 degree port list, and a loss of propulsion. The Master further reported that the crew was safe, they were pumping the water out of the hold, they were not planning to abandon ship, and the ship's engineers were working on restoring propulsion. At approximately 0713 on 01 October, the *El Faro* activated a Global Maritime Distress and Safety System and Ship Security Alert System distress alert at location 23.28N 73.48W.[2] At 0736, the *El Faro's* EPIRB Alert was detected.[3] Following the EPIRB Alert, there was no further contact with the *El Faro*. Based on its last reported position, the *El Faro* was located within the bands of Hurricane Joaquin.[4] The United States Coast Guard undertook a search and rescue effort between 01 October and 07 October, at which point the effort was suspended. On 31 October, 2015, the hull of the *El Faro* was located in about 15,000 feet of water in the vicinity of its last known position near Crooked Island, Bahamas. The vessel's crew is presumed to have been lost with the vessel.

B. Brief Voyage Timeline/Narrative

The following is a short narrative describing key events during the final voyage, including information regarding weather advisories, voyage milestones, navigational decisions, and certain comments and statements that were transcribed from the VDR recording. Because the VDR transcript is incomplete, contains areas where clear transcription was not possible, and does not contain a recording of all statements made on the vessel (indeed, for a telephone or radio conversation it would only include, at best, what was said by the person on the bridge), this narrative is necessarily incomplete but is based on information from the VDR Transcript and from the reports of TOTE's Meteorological Expert Dr. Austin Dooley (Appendix C) and Navigation Expert Captain Richard DiNapoli (Appendix D).

Date/Time		Event
		SEPTEMBER 29, 2015
17:00		NHC Advisory # 8 is issued, forecasting Joaquin as a tropical storm.
18:53		Captain Davidson sends a text message in response to 2M Charlie Baird's text inquiry (alternate 2M not sailing aboard this voyage), stating: "We'll steam our normal direct route to SJP. No real weather to speak of until the evening of the 30th. All forecasted information indicates Joaquin will remain north of us and

[1] MBI Ex.004, p. 93 – *El Faro* Departure Report 29 September 2015.
[2] MBI Ex.034 – LANTWATCH 01 Oct. 2015 Email to D7 Command Center.
[3] MBI Ex.072 – 406 Beacon Unlocated First Alert.
[4] MBI Ex.033 – LANTCC 01 Oct. 2015 Call to D7 Command Center; Chancery, MBI 02/24/16, pp.42-43.

		by the morning of the 01st we will be on the backside of her. We are on scheduled to depart the dock at 2000 tonight so everything is shaping up in our favor."
20:07		*El Faro* logs "last line" upon departure from its berth in Jacksonville, FL.
21:44		*El Faro* Departure Report indicates the Master reviewed and signed voyage plan. (MBI Ex. 004, pp.92-93)
23:00		NHC Advisory #9 is issued, forecasting Joaquin with 70 knot winds and 12 foot seas.
		<u>SEPTEMBER 30, 2015</u>
05:00		NHC Advisory # 10 issued, forecasting Joaquin with 70 knot winds.
05:36:50.0		VDR transcription begins.
06:05		Captain Davidson notes they will experience "12 to 15 feet", and Chief Mate Shultz responds that "the ship can handle it."
06:16.02.9		Captain Davidson notes that they are "south and west of" Joaquin.
06:25		Captain Davidson changes course to allow for more distance between the vessel and Joaquin, changing from about 133 degrees to about 141 degrees.
06:27.40.4		Captain Davidson states that "once we know what this storm is clearin' up outta here we'll be more assertive towards getting back to the optimum track line."
06:42.20.7		Captain Davidson leaves the bridge to update Chief Engineer on the plan in view of Joaquin.
07:01 to 07:12		Captain Davidson and Chief Mate Shultz discuss the storm and vessel's course, referring to a "little diversion," 40-knot winds do not warrant taking "other drastic option" and noting that weather will deteriorate today.
07:18 to 07:19		Captain Davidson instructs Chief Mate Shultz to inform the crew today that they have some weather and to inspect the cargo and lashings.
07:45 to 07:46		Chief Mate Shultz and Third Mate Riehm discuss ducking Joaquin and that the Ol' Bahama Channel and NW Providence Channel will not do much "because you have to come back out right at the wrong time."
09:23		Captain Davidson discusses with Third Mate Riehm a prior event when he and the vessel went through Erika, noting that the ship is "solid," the "hull is fine," and that the "plant [is] no problem."
11:00		NHC Advisory # 11 is issued, forecasting 80-85 knot winds.
11:09 to 11:12		Third Mate Riehm announces the latest SAT-C weather is "pretty much in line with BVS" regarding direction. Captain Davidson orders that heavy weather precautions should be completed and that they will duck underneath the storm.
12:22		Noon Report transmitted from Captain Davidson indicating an ETA of 10/02/0800, speed over last 24 hours of 19.3K, Wind N3, Sea Condition NNW1, Swell ENE7, and noting that "Precautions observed regarding Hurricane Joaquin." (MBI Ex. 004, pp.98-99)
13:16/22		Captain Davidson emails ashore -- partial content follows: Subject Line: *El Faro* / Vessel Update / Hurricane Joaquin. I have monitored Hurricane Joaquin tracking erratically for the better part of a week. Sometime after 09/30/0200 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. (MBI Ex.004, p.101)
14:16 to 14:17		Captain Davidson tells Second Mate Randolph that by 2 o'clock on her watch she should be south of Joaquin.
17:00		NHC Advisory # 12 is issues, forecasting Joaquin at 85 knot winds.
19:05		Captain Davidson changes course from about 139 degrees to about 150 degrees -- which moves the track further to the south to pass inside of San Salvador Island, and to allow for even more distance between the vessel and Joaquin. Once past San Salvador, the plan was to then return to an east-southeasterly heading on a course of 116 degrees to start bringing the vessel back to its usual track for San Juan.
19:19:19		Captain Davidson notes they are putting more distance "between us and the center of the low."
19:28		Captain Davidson notes that "you don't necessarily have to go down the Old Bahama Channel as there are lots of places to duck into." Chief Mate Shultz acknowledges there is a lot of time for them to decide whether they can or should go through the Crooked Island passage.
19:47:31		Captain Davidson reiterates that San Salvador is going to afford a lot of lee.
19:49:39		Captain Davidson states: "...we'll be passing clear on the backside of it. Just keep steamin' our speed is tremendous right now. The faster we're goin' the better. This will put the wind on the stern a little bit more – it's givin' us a push."
23:00		NHC Advisory #13 is issued, forecasting Joaquin at 110 knot winds.
23:05		Third Mate Riehm calls Captain Davidson to advise of the latest weather received via SAT-C.
23:13		Third Mate Riehm calls Captain Davidson to advise that at 0400 they will be twenty-two miles from the center of Joaquin. He provides option of heading south at 0200.
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1:20 to 01:29		Second Mate Randolph calls Captain Davidson and discusses altering course to head south, sailing through shallow areas and possibly connecting with the Old Bahamas Channel. Captain Davidson orders her to run the original plan and the course is changed to approximately 116 degrees.
03:47 to 03:48		Discussion on the bridge regarding vessel heeling to starboard, wind blowing port to starboard.
04:10 to 04:11		Captain Davidson is on the bridge and comments that there is "nothing bad about this ride" and that the vessel is not "even rollin'," "not even pitchin'," "not pounding."
04:24:23		Captain Davidson states they will not be going through the eye of the storm.
04:40:33		Chief Engineer mentions list and oil levels.

04:43:45		Captain Davidson has a conversation with the engine room regarding their request to “take the list off a bit.”
05:00		NHC Advisory # 14 is issued, forecasting Joaquin with maximum sustained winds of 120 mph.
05:11 to 05:12		Conversation between Chief Mathias (off duty chief engineer riding as supernumerary) and Captain Davidson where Mathias states, “I’ve never seen a list like this … I have never seen it hang like this.” They discuss how the “hanging” affects engineering operations as far as lube oil(s) and, hitting low pressure alarm on the lube oil.
05:18:39		Captain Davidson announces that they are “on the back side of it.”
05:18:54		Chief Mate Shultz notes an 18 degree list.
05:43:36		Captain Davidson receives call on bridge and states “we got a prrroooblem. hold 3? Ok. I’ll send the mate down.”
05:43:47 to 05:47		Discussions on bridge and via onboard phone regarding pumping of water in Hold 3, the scuttle, pumping the bilges, and inquiring whether they can pump from the starboard ramp tanks to port.
05:48:28		Captain Davidson approves beginning transfer from starboard ramp tank to port.
05:52:58		Captain Davidson advises an unknown crew via phone that he is going to “turn the ship and get the wind on the north side right there and get it going more in that direction get everything on the starboard side give us a port list and um see if we’ll have a better look at” the scuttle.
05:55		Discussions between Captain Davidson and Chief Mate Shultz regarding water against the side just enough to flow over the edge of the scuttle (and into Hold 3).
05:59		Captain Davidson advises crew arriving on the bridge that a scuttle popped open and there was a little bit of water in three hold, that they were pumping it out right now and that the Chief Mate and Chief Mathias were closing the scuttle.
06:01		Chief Mate Shultz confirms the scuttle is closed.
06:05		Chief Mate Shultz advises Captain Davidson that he “saw water pouring down through the scuttle from third deck.”
06:10:55		Captain Davidson instructs to transfer from the port to the starboard ramp tank.
06:12:20		Captain Davidson states, “I’m not liking this list.”
06:13:01		Captain Davidson states, “I think we just lost the plant,” referring to the main propulsion unit.
06:18		Captain Davidson comments to Second Mate Randolph that water was coming in through ventilation in the engine room.
06:55:20		Captain Davidson states, “right now we're on the back side of it.”
06:57:32		Second Mate Randolph and Captain Davidson discuss the fact that the engineers are having trouble getting the engine back online due to the list.
06:59:49		Captain Davidson on Fleet Broad Band telephone communications leaves message for the Designated Person Ashore: “Thursday morning zero-seven, got a pretty good list, everybody's safe.”
07:01 to 07:03		Captain Davidson contacts the call center and reports a marine emergency and provides ship information.

07:05:59		Captain Davidson reports to call center that they have a heavy list, they've lost the main propulsion unit, and the engineers cannot get it [propulsion unit] going.
07:06 to 07:12		Captain Davidson through a satellite telephone call with the Designated Person Ashore states: "we have uhh—secured the source of the water coming in to the vessel. uh a scuttle—was blown open uh — by the force of the water perhaps — no one knows. can't tell. uh it's since been closed. however — uh — three hold's got considerable amount of water in it. uh we have a very — very — healthy port list." the engineers cannot get lube oil pressure on the plant therefore we've got no main engine. … "we are taking every measure to take the list off. by that I mean pump out that pump out that hold the best we can but we are not gaining ground at this time."
07:12:53		Second Mate Randolph transmits GMDSS and SSAS messages to Coast Guard. The SSAS message also transmits to TOTE Services, Inc.
07:13:55		Captain Davidson instructs to "wake everybody up."
07:14:17		Captain Davidson and Second Mate Randolph discuss what the chief engineer told her, i.e., that "he can't do anything with this list."
07:14:54 to 07:15:05		Chief Mate mentions he believes the water level is rising and that "(at) first the chief said something hit the fire main. got it ruptured. hard."
07:17:04		Captain Davidson comments he believes the list is getting worse.
07:17:59		Reference to cars floating in three hold.
07:27:16		General alarm is rung.
07:28		Discussion with Captain Davidson regarding getting ready to abandon ship. Captain Davidson wants to make sure everybody has their immersion suits and that they get a good head count.
07:29		On Captain Davidson's order, abandon ship alarm is rung.
07:31		Captain Davidson orders that rafts be thrown into the water and through UHF he announces: "everybody – everybody get off get off the ship stay together."
07:31 to 07:39		Conversation between Captain Davidson and AB on bridge, reveals Captain Davidson's efforts to calm and assist the AB.
07:39:41		End of VDR transcription.

The VDR transcript establishes that between the hours of 0500 and 2000 on September 30th Captain Davidson was on the bridge at least once per hour except for the 1300 hour when he wrote his email to shoreside advising that he had been monitoring Hurricane Joaquin for the better part of a week.

C. Crew Information, Unions, Credentials, Training, Experience

The licensed officers hired by TSI are hired through the American Maritime Officers Union (AMO). (Clark, NTSB 10/12/15, p.4). The unlicensed personnel are hired through the Seafarers International Union (SIU). (Ware, NTSB 10/13/15, pp.35-36).

The Chief mate is primarily responsible for deck operations and the Chief Engineer is primarily responsible for engine operations. Both report to the Master who is responsible for the entire vessel operation.

1. Master - Captain Michael Davidson

Captain Michael Davidson was a U.S. Coast Guard licensed Master Mariner. (Morrell, MBI 02/16/16, p.79). He had been sailing with TOTE or on TOTE-managed vessels as Master since 2008 and was sailing on TMPR vessels since 2013. (Kondracki, MBI 02/17/16, pp.157-158); (Clark, NTSB 10/12/15, pp.28-30). He was selected as Master of the *El Morro* in 2013. (Clark, NTSB 10/12/15, pp.28, 30); (Peterson, MBI 02/17/16, pp.122-123). Captain Davidson enjoyed working with TOTE, he liked the *El Faro* and sailing the Jacksonville-San Juan run, and hoped to continue. (Stith, MBI 05/24/16, p.15).

Captain Davidson's last evaluation with TSI dated 01 October 2014 yielded exceptional performance ratings (i.e., "5s" on a scale of 1-5) for the categories of: (a) Safety Awareness and Vessel Safety Record, (b) Administration, (c) Cargo Familiarity, (d) Situational Judgment, (e) Responsibility, (f) Communication Skills, (g) Overall Competence, (h) Decision Making, (i) Leadership, (j) Initiative, and (k) Cooperation with Customer and Regulatory Agency. (MBI Ex.52); (Fisker-Anderson, MBI 02/17/16, pp.34-36); (Lawrence, MBI 02/20/15, pp.73-74); (Morrell, MBI 02/16/16, pp.74-76). The performance evaluation took into account comments from deck officers who worked with Captain Davidson. (Neeson, MBI 02/26/16, pp.139-140).

The results of this last performance evaluation were confirmed and reiterated by various mariners who personally sailed with Captain Davidson. Comments from these witnesses included:

- Captain Davidson never created an unsafe atmosphere onboard and with respect to voyage planning, communications, navigation, or weather. (Berrios, MBI 02/19/16, p.219). He practiced effective bridge resource management. (Berrios, MBI 02/19/16, p.218). He took time to teach crew about bridge equipment and other vessel functions. (Hearman, MBI 02/14/17, p.1410).

- Captain Davidson was meticulous, methodical, well-organized, prepared, and engaged. (Baird, NTSB 12/06/15, pp.154-156); (USCG Shiprider, NTSB 10/15/15, pp.50-51); (Robinson, MBI 02/23/16, p.18); (Stith, MBI 05/24/16, pp.17,59); (Bryson, NTSB 10/12/15, p.18).

- Captain Davidson had a good working relationship with the crew and officers. (Baird, MBI 02/18/16, p.52); (Thompson, NTSB 12/06/15, pp.107-108); (Vagts, MBI 02/24/16, pp.152-153); (Beisner, MBI 02/25/16, pp.99-100).

- Captain Davidson was very enthusiastic about his job and willing to train others. (Beisner, MBI 02/25/16 p.105). He was considered a "teacher" and fostered open communication. (Berrios, NTSB 12/06/15, pp.35-37); (Stith, MBI 05/24/16, p.58-59).

- Captain Davidson was approachable and maintained an open door policy for all crew. (Stith, MBI 05/24/16, pp.58-59); (Baird, NTSB 12/06/15, p.155); (Walker, MBI 02/23/16, pp.123-124); (Brennan, NTSB 10/08/15, pp.49-50); (Torres, NTSB 12/03/15, pp.31-32); (Beisner, MBI 02/25/16, pp.107-108); (Hearman, MBI 02/14/17, pp.1307-1308).

- The working relationship and communication between Captain Davidson and the engine department was also reported to have been excellent. (Stith, MBI 05/24/16, pp.34-35); (Robinson, MBI 02/23/16, p.24); (Skorapa, NTSB 11/03/15, p.39). Captain Davidson could understand engineering issues when presented to him. (Robinson, MBI 02/23/16, p.7).

- Captain Davidson spent a large amount of time on the bridge and was engaged in operations. (USCG Shiprider, NTSB 10/15/15, pp.50-51); (Beisner, MBI 02/25/16, pp.107-108); (Torres, NTSB 12/03/15, pp.52-53); Walker, MBI 02/23/16, pp.25-26).

- Captain Davidson was cognizant of rest hours and would sometimes take over watches for a few hours and send his mates to rest to ensure they were rested. (Torres, NTSB 12/03/15, pp.52-53); (Ringlein, NTSB 11/03/15, p.58); (Stith, NTSB 10/07/15, pp.92-93).

Captain Davidson's formal training as a mariner began when he attended the Maine Maritime Academy, graduating in 1988 with a degree in nautical science and a minor in marine transportation management, (Human Performance Factual Report, NTSB 06/22/2017, p.11). Captain Davidson's merchant mariner credential endorsed him as master of self-propelled vessels, not including auxiliary sail, of unlimited tonnage upon oceans; as radar observer (unlimited); and as first-class pilot of vessels of unlimited tonnage upon the inland waters of Prince William Sound, Alaska. *Id*.

Captain Davidson spent about 14 years sailing on tankers and more than 10 years sailing on deep-draft cargo vessels. He was first employed with TOTE (then known as Interocean American Shipping) in 2005, sailing as second mate, then chief mate, then master before taking a position with Crowley Liner Services in 2010, where he sailed as master until 2013. He then returned to TOTE in 2013, sailing as a third mate for one tour, then as master on *El Morro* from November 2013 to April 2014. In May 2014, he assumed the position of master on *El Faro* and remained in that position until the subject voyage. He last joined *El Faro* on August 11, 2015. (Human Performance Factual Report, NTSB 06/22/2017, p.12). TSI's Crewing Manager did not contact Crowley to inquire about Captain Davidson's employment history with Crowley as Captain Davidson had previously sailed with TSI with no disciplinary issues. (Clark, MBI 02/16/17 p.1561).

From 2010 to 2015, Captain Davidson's training included the following courses: leadership and management (2015), vessel security officer (2010), electronic chart display and information system (ECDIS) (2011), antipiracy (2010), and radar recertification (2010, 2015). Other endorsements on his certificate relating to safety and survivability were basic firefighting and basic safety training (2001), personal survival techniques (2001), integrated bridge team training (2003), integrated tug/tanker bridge resource management (1998), bridge team management (1995), and a 72-hour course on the Global Maritime Distress and Safety System (GMDSS) in 1998. (Human Performance Factual Report, NTSB 06/22/2017, p.12).

Captain Davidson was Master of the *El Faro* on January 29, 2015 and May 21, 2015 when heavy weather training was given to the crew onboard the *El Faro*. (MBI Ex.355, pp.2-3).

The consensus at the company was that Captain Davidson was a safety conscious, meticulous, and very competent Master. The safety culture onboard and under Capt. Davidson was strong. (Robinson, MBI 02/23/16, pp.16-17; Vagts, MBI 02/24/16, p.152). Safety was more important to Captain Davidson than maintaining sailing schedule. (Ringlein, NTSB 11/03/15, pp.55-85). Captain Davidson had high standards and expectations, was very reliable and considered a "true professional" who took safety very seriously, addressed issues promptly, and the crew knew safety was important to him. (Stith, NTSB 10/07/15, pp.76-77). Captain Davidson made rounds on deck often and, if Captain Davidson noted anything, he would follow the chain of command by telling the Chief Mate, who would inform the crew to address the issue. (Walker, MBI 02/23/16, p.122). Captain Davidson was on the bridge often and made rounds, but due to paperwork responsibilities he was not on the deck as much as the Chief Mate, whose job it is to manage the deck work. (Walker, MBI 02/23/16, p.123). Captain Davidson was very active with cargo operations (Stith, MBI 05/24/16, p.48). Captain Davidson kept an eye on the list and if the vessel had a list of more than two degrees, he called the Chief Mate to find out what was going on. (Stith, MBI 05/24/16, p.48). Captain Davidson was very in tune with cargo operations and he had conversations with shoreside personnel that were doing the cargo planning and preparing the CargoMax, and they would have a discussion about the final stability of the ship. (Stith, MBI 05/24/16, p.48).

LNG Selection Process

Following a selection process involving input from TMPR and TSI management, Captain Davidson was placed on the shortlist for Master of the new Marlin-class/LNG fuel vessels (out of at least 50 other masters in the TSI fleet). (Greene, MBI 02/17/16, pp.78-79). TSI's leadership found Captain Davidson eminently qualified to be Master of one of its LNG fuel vessels. As of 4 August 2015, Captain Davidson was slated to assume command of one of the new Marlin-class LNG vessels. (Greene, MBI, 02/17/16, p.142.); (Kondracki, MBI, 02/17/16 p.157); (Morrell, MBI, 02/16/16, pp.72-73); (MBI Ex.005, p.46). However, by the time of the casualty voyage, TSI had decided to have Captain Davidson stay aboard the *El Faro* when it transferred to the Alaska trade. (Morrell MBI 02/16/16, pp.71-72); (Kondracki NTSB 10/14/15, pp.36-37).

2. Other Officers

a. Chief Mate Steven Shultz

Chief Mate Shultz graduated from the U.S. Merchant Marine Academy in 1984. At the time of the subject voyage, he held a master's license for steam and motor vessels of unlimited gross tonnage. He sailed with TOTE/Interocean American Shipping from 2004 until 2015, serving intermittently as third mate, second mate, and chief mate. In 2011, he started sailing as third mate on the *El Yunque*. He sailed as second mate and chief mate on *El Yunque* until May 2015, when he was assigned to *El Faro*. The subject voyage was his second rotation as chief mate on *El Faro*. (Human Performance Factual Report, NTSB 06/22/2017, p.11).

Chief Mate Shultz' last evaluation dated June 2015 assigned him "excellent" ratings in 8 of 10 categories and "very good" on the remaining two categories. (Human Performance Factual Report, NTSB 06/22/2017, p.11).

b. Second Mate Danielle Randolph

Second Mate Randolph graduated from the Maine Maritime Academy in 2004. She began sailing with TOTE (then Interocean American Shipping) in 2005. She sailed as a third mate on *El Morro* from 2005 until 2013, when she was promoted to second mate. In July 2015, she began sailing as second mate on *El Faro*. (Randolph Personnel File; Human Performance Factual Report, NTSB 06/22/2017, p.14).

c. Third Mate Jeremy Riehm

At the time of the subject voyage, Third Mate Riehm held credentials as a third officer. He began his sailing career in 1993 as an unlicensed mariner (ordinary seaman, wiper, steward's department), working his way up to officer. He obtained his third mate's credentials in December 1998, and his latest renewal was completed in 2013. He was employed consistently with TOTE (and Interocean American Shipping) from 1999 to 2015. He sailed on *El Morro* from 2010 to 2013. He took the third mate position on *El Faro* in May 2014. (Riehm Personnel File; Human Performance Factual Report, NTSB 06/22/2017, pp.15-16)

Third Mate Riehm's last evaluation dated February 2014 assigned him "excellent" ratings in all watch-standing and all deck-related areas. His evaluation was completed and signed by Captain Davidson, who noted that Third Mate Riehm had "the knowledge and skills to sail as second mate if he chooses to do so." (Riehm Personnel File; Human Performance Factual Report, NTSB 06/22/2017, p.16).

d. Chief Engineer Richard Pusatere

Chief Engineer Pusatere graduated from the State University of New York Maritime College in 2003. He was qualified as a chief engineer of steam, motor, and gas turbine propelled vessels of any rating and began his career in 2003, sailing as third and second assistant engineer on a variety of steam-propelled cargo ships. He joined TOTE (then Interocean American Services) in 2008. He sailed on *El Morro* as first assistant engineer in 2011–2012. In 2013, he served briefly as first assistant engineer on *El Yunque* before rejoining *El Morro* as chief engineer. He began working as chief engineer on *El Faro* in April 2014. (Pusatere Personnel File; Human Performance Factual Report, NTSB 06/22/2017, pp.16-18).

e. First Assistant Engineer Keith Griffin

First Assistant Engineer Keith Griffin graduated from the Massachusetts Maritime Academy in 2005. He held credentials as first assistant engineer of steam, motor, and gas turbine propelled vessels of any rating. His first sailing aboard a TOTE vessel was *El Morro*, which he joined as a third assistant engineer in January 2010. (Griffin Personnel File; Human

Performance Factual Report, NTSB 06/22/2017, pp.18-19).

First Assistant Engineer Keith Griffin's last evaluation dated January 2015 assigned him "excellent" ratings in all applicable categories. The evaluating chief engineer further noted that First Assistant Engineer Griffin "has shown he is ready and capable to sail at a higher position and take on more responsibility." (Griffin Personnel File; Human Performance Factual Report, NTSB 06/22/2017, pp.18-19).

f. Second Assistant Engineer Howard Schoenly

Second Assistant Engineer Schoenly held credentials as a second engineer of steam, motor, and gas turbine propelled vessels of any horsepower and began his sailing career in 1990 as an unlicensed mariner. Second Assistant Engineer Schoenly worked his way up to third assistant engineer in 1996 and second in 1998. He had worked as a second assistant engineer on other TOTE vessels since 2003. (Schoenly Personnel File; Human Performance Factual Report, NTSB 06/22/2017, pp.19-20).

Second Assistant Engineer Schoenly's last evaluation dated May 2015 assigned him "excellent" ratings in all applicable areas. The evaluating chief engineer further noted that Second Assistant Engineer Schoenly "is one of the most dependable and hardest working men" he had worked with and "continually stepped up and helped in every possible way." He had been assigned as second assistant engineer on *El Faro* since May 2014. (Schoenly Personnel File; Human Performance Factual Report, NTSB 06/22/2017, pp.19-20).

g. Third Assistant Engineer No. 1 Mitchell Kuflik

Third Assistant Engineer Mitchell Kuflik graduated from the Maine Maritime Academy in 2012. He held credentials as a third engineer of steam and motor vessels of any rating. (Kuflik Personnel File; Human Performance Factual Report, NTSB 06/22/2017, pp.19-20).

Third Assistant Engineer Kuflik's last evaluation dated January 2015 assigned him "excellent" ratings in all but three applicable areas where he was assigned a "very good" rating. Chief Engineer Pusatere, the evaluating chief engineer, further noted that Third Assistant Engineer Kuflik was "a valuable asset to the vessel . . . quick to learn . . . and highly reliable." (Kuflik Personnel File; Human Performance Factual Report, NTSB 06/22/2017, p.21).

h. Third Assistant Engineer No. 2 Michael Holland

Third Assistant Engineer Michael Holland graduated from the Maine Maritime Academy in 2012. He was qualified as a third engineer of steam, motor, or gas turbine vessels of any horsepower. He had been employed by TOTE since May 2014. (Holland Personnel File; Human Performance Factual Report, NTSB 06/22/2017, p.22).

Third Assistant Engineer Holland's last evaluation dated October 2014 assigned him "very good" ratings in four applicable areas (cooperation, leadership, knowledge of TOTE policy and procedures, and personal conduct and performance). He was assigned "good" ratings in the remaining evaluation categories. (Holland Personnel File; Human Performance Factual Report, NTSB 06/22/2017, pp.22-23).

i. Third Assistant Engineer No. 3 Dylan Meklin

Third Assistant Engineer Dylan Meklin graduated from the Maine Maritime Academy in 2014. He was qualified as a third assistant engineer of steam and motor propelled vessels. (NTSB Docket No.267; Meklin Personnel File; Human Performance Factual Report, NTSB 06/22/2017, p.23).

3. Crew

The remaining 17 crewmembers aboard the *El Faro* were all properly credentialed mariners. (Human Performance Factual Report, NTSB 06/22/2017, p.23). Most of the *El Faro* unlicensed personnel held "A" seniority with the SIU. This was the most senior designation in the SIU. In order to obtain "A" seniority, a mariner must have at least eight years with the union and meet other requirements including cumulative days at sea. (Ware, NTSB 10/13/15, pp.35-36).

4. Riding Crew (and extra engineering officer on board)

TSI hired riding crew through its outside contractor, Imtech. The workers provided by Imtech were highly skilled and diligent. TSI viewed Imtech as a good service partner. (Fisker-Andersen, MBI 02/19/16, pp.45-46). As a general practice, Imtech provided, at a minimum, one worker fluent in English. Oftentimes other workers in the riding crew were proficient in English. (Fisker-Andersen, MBI 02/19/16, p.45). If workers were not proficient in English, instruction would be provided to a Polish worker who spoke English, and that worker would in turn translate for the other Polish workers. (Pupp, MBI 02/15/17, pp.1426-1427).

During the subject voyage, the *El Faro* sailed with two Chief Engineers as one of them (Jeff Mathias) was supervising the work being done by the riding crew. (Robinson, MBI 02/23/16, p.64). There were no insurmountable language barrier issues with the Polish riding crew that was aboard the *El Faro*. Their foreman spoke English very well, and the work was getting done to Chief Engineer Jeff Mathias' satisfaction. (Neeson, MBI 02/26/16, p.201). Chief Engineer Mathias took the riding crew around the vessel to show them what needed to be done and for general familiarity with the vessel. (Pupp, MBI 02/15/17, pp.1441-1444).

The riding crew aboard the *El Faro* was not tasked with any repairs or modifications or any work on any portion of the propulsion systems, including the boilers, main turbines, turbo generators, and reduction gear. (Neeson, NTSB 10/08/15, p.15); (Pupp, MBI 02/15/17, p. 23).

5. Licensing, Hiring and Training Generally

All masters on TSI-managed vessels are credentialed and licensed by the USCG. (Greene, MBI 02/17/16, p.19); (Morrell, MBI 02/16/16, pp.78-79). During its selection process for masters, TSI reviews a candidate's U.S. Coast Guard master's license and nautical experience. (Kondracki, NTSB 10/14/15, p.34) The unions provide the training for officers and crew members aboard TSI vessels. (Kondracki, NTSB 10/14/15, p.18). The unions and the U.S. Coast Guard act as TSI's service partners in developing and setting up training courses. (Kondracki, NTSB 10/14/15, p.59). TSI's training program requires all licensed officers to complete training, including onboard training that includes various safety topics, procedures, and equipment demonstrations. This training is tracked by the Masters who submit records on a quarterly basis to TSI's Manager of Safety and Marine Operations. (Kondracki, MBI 02/17/16, pp.153-154).

The Coast Guard did not require deck officers, or other personnel, to take any specific formal heavy-weather training courses, and TOTE did not specifically require such training courses. However, mariners were provided informal heavy weather training onboard the *El Faro* (and other TOTE vessels), as part of TOTE's onboard training program. For example, heavy weather training was completed onboard the *El Faro*, during Captain Davidson's tenure, on January 29, 2015, and May 21, 2015, and focused on general heavy weather training for all those onboard. Although TOTE was not required to ensure that officers obtained additional training outside of what was legally mandated by the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) and Coast Guard regulations, various aspects of TOTE's training program, such as the on-board heavy weather training noted above, exceeded these legal requirements. (MBI Ex.355 Safety Training 1-29-15); (MBI Ex.355 Safety Training 2nd Quarter); (MBI Ex.400 TSI Indoctrination Guidelines and Logs).

TSI's training program for its mariners consisted of four parts: (1) indoctrination when the seaman comes aboard; (2) onboard Safety Training and Drills; (3) on-board Tracked Training and Safety meetings; and (4) Certificated Training Ashore (STCW or license requirements). TOTE Training Addendum, Sec. 2.0 at p. 1 of 3 (Attachment 1).

TSI has a good reputation among union workers. (Ware, NTSB 10/13/15, p.48). TOTE has a record of being better at safety than the rest in the industry. (Loftfield, NTSB 10/09/15, p.54); (Axelsson, NTSB 11/03/15, pp.145-147). According to former crewmember Evan Bradley, "[i]f something's not right or unsafe, report it, and that's the way I understood TOTE to be." (Bradley, MBI 02/14/17, p.1259). Prior to the *El Faro's* last voyage, none of the union members voiced any safety concerns with the *El Faro* to Archie Ware, SIU supervisor. (Ware, NTSB 10/13/15, p.44).

D. Owner / Operator Information / TOTE Organizational Structure

1. General Background Information

Prior to 2012, there were three operating companies under the TOTE umbrella: (1) Totem Ocean Trailer Express, serving the Pacific Northwest to Anchorage, Alaska; (2) Sea Star Line serving Philadelphia and Jacksonville to Puerto Rico; and (3) Inter-Ocean American Shipping, which provided crewing and SMS services to the two companies. By the time of the casualty, these companies had undergone a reorganization of their administrative, technical, and maritime functions. (Keller, MBI 05/26/16, pp.50-67).

TOTE, Inc. was the parent company of TOTE Maritime Puerto Rico (TMPR) f/k/a Sea Star Line, TOTE Maritime Alaska f/k/a Totem Ocean Trailer Express, and TOTE Services, Inc. (TSI). (MBI Ex.145 - Organizational Chart/TOTE Leadership Team).

TSI handled the technical management of TMPR (formerly Sea Star Line) and TOTE Maritime Alaska (formerly Totem Ocean Trailer Express) on January 1, 2014. (Greene, MBI 02/17/16, p.40). Retired Navy Admiral, Phil Greene, was hired as President to run TSI in February 2013. (Keller, MBI 05/26/16, p.56); (Greene, MBI 02/17/16, pp.4, 39).

As a part of its operations, TSI manages approximately 24 vessels worldwide for third parties. TMPR is one of these third-party clients. TSI operates the TMPR vessels under a standard BIMCO[5] ship management agreement (a SHIPMAN Agreement). (Greene, MBI 02/17/16, p.70). A ship management agreement may include crew, technical and commercial management as well as insurance arrangements in respect of a ship. With respect to the agreement for vessel management between TSI and TMPR at the time of the casualty, TSI was responsible for supplying and placement of the crew, provision of vessel management, fueling, obtaining all required certifications, and vessel maintenance. (Nolan, MBI 02/18/16, p.122); (Morrell, MBI 02/16/16, p.55). TSI supported masters and vessels when they needed anything. (Loftfield, MBI 02/18/16, p.176).

Sea Star Line, LLC, now known as TMPR, was the registered owner of the *El Faro*. (Greene, MBI 02/17/16, pp.47-48); (Nolan, MBI 02/18/16, p.112).

The trade between Jacksonville, Florida and Puerto Rico was serviced at different times by TOTE-owned sister steamships including the *El Morro*, *El Yunque*, and *El Faro*. The *El Faro* joined the Puerto Rico trade in May 2014 when the *El Morro* was scrapped. (Morrell, MBI 02/16/16, p.19). When Horizon Lines exited the trade in December 2014, TOTE chartered four barges and tugs to transport the increased volume of cargo to Puerto Rico. (Morrell, MBI 02/16/16, pp.19-20). The tugs and barges operated under their own, independent Safety Management System (SMS), not TSI's SMS. (Fisker-Andersen, MBI 02/19/16, pp.48-49). The TMPR-owned vessels were generally fully utilized with respect to cargo carrying capacity southbound, but the barges were not always full. (Nolan, MBI 02/18/16, p.124). Less than half of the cargo moving to Puerto Rico was carried by TOTE vessels. (Nolan, MBI 02/18/16, p.130).

The *El Faro*, formerly known as the *Northern Lights*, previously serviced the Alaska trade, was then chartered for military cargo by the U.S. Government in Operation Iraqi Freedom from 2000-2003, and eventually went on to sail the Puerto Rico trade (as discussed above). (Morrell, MBI 02/16/16, p.21). The *El Faro* had a good reputation within the industry. (Hearn, NTSB 03/30/16, p.226). Its machinery was known to be in superior condition. (Loftfield, MBI 02/18/16, pp.190-191). Prior to the casualty, the plan was for the *El Faro* to enter dry dock in November 2015 in the Grand Bahamas. It was scheduled to be prepared to sail as a relief vessel in the Alaska trade commencing in early 2016. (Morrell, MBI 02/16/16, pp.25-32). The plan was for the *El Faro* to sail as a relief vessel in the Alaska trade for a few months in 2016, and possibly again for another period in 2017, to allow the vessels in that trade to be converted to

[5] The largest of the international shipping associations representing shipowners.

handle LNG fuel. (Morrell, MBI 02/16/16, p.32).

2. TOTE Services, Inc. (TSI) - Function / Shoreside Personnel

TSI port engineers were assigned to each vessel and reported on a day-to-day basis to Jim Fisker-Anderson, Director of Ship Management. Fisker-Anderson began working for Totem Ocean Trailer in 2008 as a port engineer. He was promoted to Director of Marine and Terminal Operations and then to Director of Ship Management in January 2015. He has worked in the maritime industry for over 25 years and holds a First Assistant Engineer's license, steam and motor unlimited. (Fisker-Anderson, MBI 02/19/16, p.4-5).

Fisker-Anderson reported to Phil Morrell, Vice-President of Marine Operations, Commercial. Morrell has worked for decades in shoreside operations, including shipyard construction, terminal operations, and vessel equipment budgeting and repair. (Morrell, MBI 02/16/16, pp.11, 34).

Morrell reported to Phil Greene, President. Phil Greene is a retired rear admiral and the former superintendent of the United States Merchant Marine Academy. (Greene, MBI 02/17/16, pp.4-5). Admiral Greene is a 1978 graduate of the U.S. Merchant Marine Academy. He holds a Masters unlimited, all oceans Coast Guard license. (Greene, MBI 02/17/16, p.5).

Captain John Lawrence, Manager of Safety and Operations and the Designated Person Ashore (DP) for the *El Faro*, was responsible for overseeing TSI's safety, environmental, and other regulatory compliance programs. (Lawrence, MBI 02/20/16, p.4). In his role as the DP for TSI, Captain Lawrence reported directly to Phil Greene. (Lawrence, MBI 02/20/16, p.6). Captain Lawrence otherwise reported to Lee Peterson, the Director of Safety and Services. (MBI Ex.145 - Organizational Chart/TOTE Leadership Team). Peterson has over 24 years of experience sailing with the Merchant Marine in the engine department. (Peterson, MBI 02/16/16, p.82). He is a 1979 graduate of the U.S. Merchant Marine Academy. He ran his own business inspecting steam turbine mechanical drive systems before joining TOTE. (Peterson, NTSB 10/14/15, p.7). Peterson joined Sea Star Line as a port engineer in 2010 and was promoted to Director of Marine Services of TSI in January 2014. (Peterson, NTSB 10/14/15, p.8).

Captain Lawrence's contact information was posted on all TSI-managed vessels, as the DP. (Peterson, NTSB 10/14/15, p.67); (Lawrence, MBI 02/20/2016, pp.10-11). Captain Lawrence graduated from the U.S. Merchant Marine Academy in 1975, sailed for 14 years, two of which he sailed as Master of deep sea vessels. He's held a Masters unlimited, all oceans Coast Guard license, for 33 years. (Lawrence, MBI 02/20/16, pp.4-5).

There were no prohibitions against crew members having their own cell phones or using satellite phones if they wanted or needed to make a confidential call to the DP. (Lawrence, MBI 02/14/17, p.1193). When he was away, Captain Lawrence's practice was to send out an email stating that Peterson would be the acting DP. (Peterson, NTSB 10/14/15, p.67).

The Masters' and the vessels' first point of contact ashore was the port engineers, although there was direct access to the DP or any other company personnel, as required. (Keller, MBI 05/26/16, p.65). Port engineers provided assistance to the vessel in terms of maintenance, supply of spare parts, supplies, monitoring inspections/surveys, monitoring vessel certificates, arranging for vendors to facilitate any necessary repairs, and for providing other shore support. (Weinbecker, MBI 05/26/16, pp.121-122); (Greene, MBI 02/17/16, p.65). For the Jacksonville to Puerto Rico run, there was (and is) one dedicated port engineer for each vessel, and a backup port engineer was (and is) assigned should the primary port engineer be unavailable. (Weinbecker, MBI 05/26/16, p.122).

The port engineers worked very closely with the Master, Chief Engineer, and Chief Mate, exchanging information regarding the vessel's operations on a regular basis, through weekly visits to the vessel and more frequent email, or when necessary, phone communications. (Fisker-Andersen, MBI 02/19/16, pp.9-10, 33). The Masters and Chief Mates also communicated with Captain Lawrence. (Lawrence, MBI 02/20/2016, p.55).

Tim Neeson was the assigned port engineer for the *El Faro*. (Neeson, MBI 02/26/16, p.121). He boarded the *El Faro* every Monday and Tuesday when the ship was in Jacksonville and occasionally visited it in San Juan. (Neeson, MBI 02/26/16, pp.124-125). Neeson graduated from California Maritime in 1976. He sailed for 28 years which included sailing on steam and diesel ships and obtaining a Chief Engineer, steam and motor unlimited any sea, any horsepower, license. (Neeson, NTSB 10/08/15, pp.3-4); (Neeson, MBI 02/26/16, pp.120-121).

3. TOTE Maritime Puerto Rico (TMPR) - Shoreside Personnel

Ronald Rodriguez was the Jacksonville Terminal Manager. (Rodriguez, MBI 02/20/16, p.111). Rodriguez oversaw the day-to-day terminal operations which included stevedoring operations when a vessel was in port. (Rodriguez, MBI 02/20/16, p.111). Rodriguez filled-in for Don Matthews, Marine Operations Manager, whenever Matthews was away. (Rodriguez, NTSB 12/04/15, pp.38-39). Mr. Rodriguez was very experienced in the use of CargoMax. Ronald Rodriguez received in-house training on the use of CargoMax that lasted one week, roughly 4 hours each day. (Rodriguez, MBI 02/20/16, p.140). He started using CargoMax when he was in South Florida in 2006 or 2007. He was the person to use it during their operations in Philadelphia and again in San Juan in 2011. When he was assigned to Jacksonville, he used it when he filled in for Don Matthews. (Rodriguez, NTSB 12/04/15, pp.38-39). In 2011, he went to San Juan and taught others how to use CargoMax. (Rodriguez, MBI 02/20/16, p.135).

Ronald Rodriguez has 28 years of experience working with stevedore loading and vessel and terminal operations. (Rodriguez, MBI 02/20/16, p.111). He began working for Sea Star Line in 2002. (Rodriguez, NTSB 10/08/15, pp.5-6); (Matthews, MBI 02/20/16, p.171).

Don Matthews was the Marine Operations Manager for the Jacksonville terminal. (Matthews, MBI 02/20/16, p.169). Matthews was in constant contact with the Master throughout the loading of cargo process relating to loading status and stability. (Matthews, NTSB 12/02/15, p.63); (Stith, MBI 05/24/16, p.48). Mr. Matthews engaged in regular communications between shoreside and vessels while underway, which often took the form of departure, noon, and arrival reports. (Matthews, MBI 02/17/17, p.1694). Don Matthews' marine experience started in 1981 in the Transportation Corps of the U.S. Army, including loading of Ro-Ro vessels for unit deployment. (Matthews, MBI 02/20/16, p.170). He became part of Sea Star Line when it purchased Navieras in 2002 and held roughly the same position with Sea Star Line until 2008 when he moved into the marine operations department. (Matthews, MBI 02/20/16, pp.170-71).

Alyse Lisk was the Vice President of Cargo Services. (Lisk, NTSB 12/02/15, p.4). She focused on the operations of TMPR which included customer bookings, customer service, documentation, invoices, and internal and external communications in connection with the business process. (Lisk, MBI 05/27/16, p. 4); (Lisk, NTSB 12/02/15, p.26).

Jim Wagstaff was the Vice President of Operations. (Wagstaff, NTSB 12/04/15, p.31). He managed the preparation of the terminal to receive cargo, which included receiving information from the Marine Operations Manager. (Wagstaff, MBI 05/18/16, pp.73, 78 -80). Jim Wagstaff was working as the Vice President of Operations since 2012. He previously worked on terminal and the maintenance and repair levels, with 15-16 years of experience working in maintenance areas. (Wagstaff, NTSB 12/04/15, p.31).

4. ISO Standards 18001, 9001, and 14001

At the time of the accident voyage, TMPR had been assessed as conforming to the requirements of ISO Standards 9001, 14001 and 18001. (Wagstaff MBI 05/18/16, p.105); (Nolan, MBI 02/18/16, p.126). See also attached certifications (Attachment 2).

E. Vessel Regulatory Framework

As a cargo vessel, the *El Faro* was subject to inspection under 46 CFR Subchapter I. However, the *EL Faro* was enrolled in the Alternate Compliance Program (ACP). Under the ACP program, classification society rules, international conventions, and an approved U.S. Supplement provide an alternative that is deemed equivalent to the U.S. Code of Federal Regulations (CFR). Compliance with this equivalent alternative standard is administered through surveys and inspections conducted by authorized classification society surveyors, including ABS. (Hannon, 05/25/16, pp.96-97); (Hawkins MBI 05/27/16, p.30). The ACP program is authorized and implemented pursuant to applicable law and regulation. (46 CFR Part 8, Subpart D). Specifically, a January 1995 Memorandum of Understanding (MOU) delegates authority and sets guidelines for cooperation between the Coast Guard and the American Bureau of Shipping (ABS) with respect to the initial and subsequent inspections for certification and periodic re-inspections or examinations of vessels of the United States, as defined by 46 U.S.C. §2101(46), both in the United States and in foreign countries, in the review and approval of plans, the tonnage measurement of vessels, and in associated activities. (MBI Ex.111, p.1).

The requirements set forth in the ACP Supplement defines the regulatory gap that exists between U.S. federal regulations on the one hand, and the international conventions and classification rules on the other. In this regard, adherence to the requirements to the ACP supplement ensures that vessels that are classed and have valid international certificates issued by the classification society satisfy a standard equivalent to U.S. regulations. (Hawkins, 05/27/16, p.32; 46 CFR § 8.430). In simplified form, this framework can be represented as follows:

CFR = CLASS RULES + INTERNATIONAL STANDARDS + SUPPLEMENT

(MBI Ex.234, p.1).

1. ABS Role

By regulation, the classification society participating in the ACP program must draft and submit the ACP Supplement to the Coast Guard for review and approval. 46 CFR § 8.430. It is then the Coast Guard's responsibility to review and approve it or request modifications. (Hawkins 05/27/16, p.65; MBI Ex.234)

The Coast Guard delegates to ABS, as its agent, the authority to conduct the initial inspection for certification, subsequent inspection for certification, periodic re-inspection and examination, including drydock examinations, and the authority to issue and endorse certain certificates for vessels documented as vessels of the United States. (MBI Ex.111, p.3)

2. U.S. Coast Guard Role

Based on surveys conducted by ABS and the resulting certificates issued by ABS that demonstrate the vessel complies with applicable international treaties and agreements, the classification society's class rules, and the U.S. Supplement prepared by the classification society and accepted by the Coast Guard, the cognizant Coast Guard inspection office will issue a Certificate of Inspection (COI) to the vessel, authorizing it to operate in its intended service. 46 CFR § 8.440(c).

The *El Faro's* last COI was issued on February 22, 2011 and was valid for a period of five years. (MBI Ex.20, p.1.) The Coast Guard also conducts various oversight inspections and other oversight activities, to oversee the work of classification societies in connection with the ACP program. In this regard, the *El Faro's* last annual ACP oversight examination was performed by the Coast Guard on March 6, 2015. (MBI Ex.127, p.120).

F. Vessel Information

1. Vessel Description

a. Construction/modification history

The *El Faro* was built in 1975 at Sun Shipbuilding and Dry Dock in Chester, PA as a *roll on-roll off* (Ro-Ro) ship, designed to transport automobiles, trucks, trailers, etc. (MBI Ex.112, p.6). In 1991, TOTE purchased the *El Faro* (then named *Puerto Rico*, later renamed *Northern Lights* and then *El Faro).*

In 1992, the U.S. Coast Guard evaluated this proposed lengthening of the *El Faro* and determined that the proposed changes constituted a major conversion, pursuant to applicable

U.S. law.[6] (MBI Ex.422, p.1). In 1993, *El Faro* was lengthened by adding 90 feet of parallel mid-body at Alabama Shipyard, Inc. (MBI Ex.112, p.6).

In 2005-2006 the then-named *S/S Northern Lights* had its spar deck removed and was reconfigured to transport containers, in addition to Ro-Ro cargo below the main deck. The 2006 conversion was not considered a major conversion under U.S. law. (MBI Ex.13, p.1.)

b. 1992 Major Conversion Determination and Regulatory Impact

As a general matter, as maritime safety regulations develop over time, many regulations are applied prospectively only and therefore may not apply to certificated vessels already in service when the regulation is adopted. The policy reason for this is, "it is costly and impractical to require existing vessels to be modified each time a safety standard is updated." (Coast Guard Navigation & Vessel Inspection Circular 10-81, at p.3). However, in the course of a vessel's life, it may be desirable from a vessel owner's perspective to make physical modifications to the vessel, in order to enhance its performance or capabilities. When such a modification: (a) substantially changes the dimensions or carrying capacity of the vessel; (b) changes the type of the vessel; (c) substantially prolongs the life of the vessel; or (d) so changes the vessel that it is essentially a new vessel, as determined by the Coast Guard, the modifications are considered a "major conversion" under U.S. law. 46 U.S.C.§ 2101 (14a). In the case of a major conversion, "it is appropriate to bring the entire vessel into compliance with the latest safety standards where reasonable and practicable" to do so, again as determined by the Coast Guard. (Coast Guard Navigation & Vessel Inspection Circular 10-81, at p.3).

Thus, the effect of the 1992 major conversion determination was that the Coast Guard required that the vessel satisfy regulatory standards in place at the time of the conversion, to the extent it was deemed "reasonable and practicable" by the Coast Guard to impose the new standard. On November 20, 1992, the Coast Guard determined that, "[a]s a practical matter, all aspects of the vessel not being modified may remain as is, but whenever equipment such as lifeboats, needs replacement, they must meet the most recent standards." (MBI Ex. 422, p.2). Through a notice in the federal register, the Coast Guard applied the SOLAS Probabilistic Damage Stability Requirements to cargo vessels newly constructed, and cargo vessels undergoing major conversions, after February 1, 1992, such as the then *Northern Lights*. (MBI Ex.422, p.4).

c. The 2006 Conversion

In 2006, the vessel was modified to carry containers on deck and Ro-Ro below deck; this was not considered a major conversion by the Coast Guard. Accordingly, these modifications did not change the regulations that applied to the vessel.

2. TSI Safety Management System

In carrying out its vessel management responsibilities, TSI had a SMS (SMS), which was applicable to the *El Faro's* shipboard operations. It consisted of a comprehensive set of

[6] 46 USC § 2101(14a).

procedures for conducting vessel operations, responding to emergencies, and conducting drills and training onboard TOTE's vessels. TSI's SMS was audited and certified under the ISM Code and issued a Document of Compliance; the *El Faro*'s onboard SMS was also audited and certified under the ISM Code and issued a Safety Management Certificate. See attached Safety Management Certificate and Document of Compliance (Attachment 3). In addition, TSI exceeded the minimum regulatory requirements by obtaining certification of its SMS under ISO 9001 for quality assurance, and ISO 14001 for environmental compliance. (Lawrence, MBI 02/20/16, pp.50-51; MBI Ex.25, p.24).

These SMS procedures for TSI managed vessels are primarily set forth in the Operations Manual for Vessels (OMV), the Emergency Preparedness Manual - Vessels (EPMV), and the Forms Addendum. (MBI Ex.25, 26, 198, and 336).

a. OMV - Overview and Key Provisions

The OMV sets forth operational procedures for TSI vessel personnel to follow, with goals of operating its vessels with the utmost regard to safety of its employees, prevention of pollution, and quality of service. (MBI Ex.25, p.24.) Some of the key provisions relevant to the investigation are generally discussed below, and addressed in greater detail in other sections, as applicable.

i. **Cargo Loading and Stability**

Under the vessel's SMS, the Master is ultimately responsible for the loading and stability of the vessel, with assistance from the Chief Mate. The Chief Mate is generally responsible for overseeing cargo operations, with the assistance of other mates, the stevedores, and other shoreside personnel. The OMV sets forth general procedures to be employed to ensure the vessel satisfies applicable stability requirements and that cargo is properly secured. (MBI Ex.198, pp.123, 299).

ii. **Securing Vessel for Sea and Securing of Cargo**

The Chief Mate is generally responsible to the Master for securing the vessel for sea, carrying out this responsibility by assigning duties to the Bosun and others in the deck department. (MBI Ex.198, p.113).

iii. **Pre-Departure and Pre-Arrival Checklist**

There was a pre-departure checklist on the bridge, Checklist 16A, which was required to be followed upon departure from and arrival into port. (Berrios, MBI 02/19/16, pp.101-102); (MBI Ex.073). Pre-departure and pre-arrival briefs were held aboard the *El Faro* to discuss the plan for docking and undocking as well as the weather. (Thompson, NTSB 12/06/15, p.50).

iv. **Heavy Weather Procedures**

The OMV contains guidance to masters and procedures for them to follow in regard to vessel stability, weather monitoring, and procedures for mitigating the risks and the consequences of adverse weather. (MBI Ex.198, pp.124, 206). The OMV also required the Master's standing orders to specify the vessel's safe and normal working parameters, beyond which the Master must be notified by the officer of the watch, including excessive weather conditions. (MBI Ex. 25, p.110).

v. **Training and Drills**

Vessel masters, individual mariners, and various shoreside personnel have individual responsibilities for overseeing, carrying out, and documenting various aspects of training. TOTE's training program, and the maintenance of training records, was managed and implemented according to the Training Addendum to the SMS. *See* TOTE Training Addendum (Attachment 1). In this regard, TOTE's training program for its mariners consisted of four parts: (1) indoctrination when the seaman comes aboard; (2) onboard Safety Training and Drills; (3) on board Tracked Training and Safety meetings; and (3) Certificated Training Ashore (STCW or license requirements). *See* TOTE Training Addendum, Sec. 2.0 at p. 1 of 3 (Attachment 1).

A comprehensive summary of training requirements, mandated for mariners who work aboard TSI's vessels, is included as a Training Matrix and discussed in Section 8 of the Training Addendum. *See* Training Matrix (Attachment 4). Additionally, various weekly safety training is conducted onboard TOTE's vessels, pursuant to Section 3.0 of the Training Addendum, and recorded on form TSI-V-SAF-005. Additional requirements for training, and recordkeeping for such training, are set forth in Sections 3 through 13 of the Training Addendum. Copies of these forms are submitted at the end of each quarter to the TSI Safety Department for review and retention.

vi. **Riding Crew / Contractor Indoctrination Procedures**

Under TSI's SMS, new crewmembers must receive indoctrination into various safety and operational procedures, as described in more detail in section 3.2.1.2 of the OMV, and the new crewmember must then sign the indoctrination log page for their department before being assigned to work. (MBI Ex.25, pp.51-52). As set forth in more detail in OMV section 3.4.1, TSI's SMS further requires embarked guests/riders, surveyors and contractors to receive sufficient indoctrination, training and instruction to enable them to safely carry out their functions and be able to respond to an emergency situation. Persons other than crew are not usually given duties in emergency situations and drills other than to muster in a set location. (MBI Ex.25, pp.51-52).

TSI routinely utilized and maintained indoctrination logs, demonstrating these procedures were regularly followed onboard the *El Faro* and other TSI-managed vessels. (MBI Ex.400).

In addition, the other evidence and testimony, with respect to the Polish riding crew in particular, is consistent with these procedures and, on the final voyage, any objective review of this evidence indicates that these procedures were likely followed. This evidence includes the following:

- Mr. Berrios testified that Captain Davidson made sure everyone participated in safety drills and was strict about providing proper indoctrination to riding crew. (Berrios, NTSB, 12/06/15, pp.47, 50, 65-67); (Berrios, MBI 02/19/16, p.133-134).
- Mr. Berrios further testified that the Polish riding crew would muster on the bridge during abandon ship drills. (Berrios, MBI 02/19/16, p.106). If individuals, including supernumeraries, did not report to their assigned muster station during drills, Captain Davidson "turned the drill into a real situation of missing person, missing crew member" and we would search for them until they were found. (Berrios, MBI 02/19/16, p.133-134.)
- According to Captain Stith, new crew members and non-crew members undertook a familiarization process of their duties and safety procedures. (Stith, NTSB 10/07/15, pp.58-60).
- According to Chief Engineer Robinson, the riding crew on the *El Faro* participated in the lifeboat drills. (Robinson, MBI 02/23/15, pp.31-32); (Stith, MBI 05/24/16, pp.32-33).
- According to Captain Hearn, ship riders that did not speak the English language were given an orientation to make sure they understood the basics of lifesaving equipment issued, and, typically, there was an interpreter or one person who was the primary contact to keep them together. They were also shown their muster location. (Hearn, MBI 05/17/16, pp.127-128).
- According to Mr. Baird, the Polish riding crew on the *El Faro* was given an indoctrination when they came onboard, and during fire and boat drills they would muster on the bridge. (Baird, NTSB, 12/06/15, p. 164).
- LT Beisner, the U.S. Coast Guard rider who embarked the *El Faro* for training purposes, testified that, as a rider on the *El Faro*, she received a three hour safety indoctrination and tour of the vessel, and she participated in a lifeboat drill that occurred during the two weeks she was onboard. (Beisner, MBI 02/25/2016, pp. 95, 102).
- The deck and engine cadets embarked on the *El Faro* similarly testified that they received a safety orientation and participated in drills, and the cowboys and Coast Guard riders onboard the vessel also participated in drills. (Deck Cadet NTSB, 11/03/15, pp 22-26, 42; Engine Cadet NTSB, 11/03/15, pp 52-53, 42-45, and 59).

The testimony from these mariners independently corroborates that riders (and others embarked on the vessel) were routinely given safety indoctrinations and participated in drills to the extent required by law and the SMS. Captain Davidson in particular made sure everyone participated in safety drills and was strict about providing proper indoctrination to riding crew. (Berrios, NTSB, 12/06/15, pp.47, 50, 65-67); (Berrios, MBI 02/19/16, p.133). The Polish riding crew would muster on the bridge during abandon ship drills. (Berrios, MBI 02/19/16, p.106).

Based on the totality of the evidence, it is more likely than not these procedures were followed on the final voyage.

b. Emergency Preparedness Manual (EPMV)

The Emergency Preparedness Manual (EPMV) contains procedures and guidelines for the vessel to independently address, among other emergencies, abandon ship, loss of propulsion, flooding, and severe weather. While there are no specific procedures for emergencies to be addressed in combination, such as a simultaneous loss of propulsion <u>and</u> flooding, these scenarios are independently addressed in the EPMV. When Captain Davidson contacted Captain Lawrence, he was implementing the emergency call procedures set forth in the EPMV. (MBI Ex.26, p.16 [EPMV]);(MBI Ex.198, p.231 [OMV, Rev. 20]).

c. Risk Assessment Model

TOTE had a risk assessment model in the SMS to assist vessel personnel in conceptually and subjectively assessing and managing risks. The risk assessment model included a subjective assessment of the severity versus frequency, to determine qualitatively whether there is an acceptable level of risk or not. This risk management model in section 4.2.2 of the EPMV was designed for use by vessel personnel, not shoreside staff, during vessel operations. (Lawrence MBI 02/13/17, p.1137; MBI Ex.26).

Since the loss of the *El Faro*, TSI has promulgated OPSMEMO #A-068 on 4/29/16, as a revision to the EPMV section 4.2.2. This section of the EPMV now provides a more systematic and quantitative approach to risk assessment onboard TSI managed vessels. The model offers a quantitative equation, “Risk = Likelihood of Occurrence X Consequence.” The revisions to the risk assessment model are intended to better operationalize the assessment and management of risk, by: (a) identifying specific hazardous activities; (b) assessing the risk associated with the activities; (c) identifying controls in place, and identifying additional controls, if needed to reduce risk to a tolerable level; (d) putting into place additional controls as needed; and (e) monitoring activities to ensure TOTE Services objectives are met. This new risk assessment model includes procedures for addressing various types of risks, including risks associated with heavy weather. See attached OPS MemoA-068 (Attachment 5).

d. ISM Audits

i. Internal Audits

The purpose of an internal audit is to conduct a review of the TSI’s SMS procedures and documentation requirements, set forth in the OMV and the EPMV. This type of audit is typically performed by the DP, a TSI employee, or another qualified auditor, such as an independent third party auditor, on an annual basis. The objective of the internal audit is to determine whether various elements within TSI’s SMS are implemented and effective in achieving stated objectives, and to take corrective actions as necessary when deficiencies are identified. Audits typically take a full day. They typically occur dockside, although one audit occurring during Captain Lawrence’s tenure as DP since 2014 did occur on one of TSI’s government ships while underway. The audits are intended to examine a sampling of the procedures implemented under the SMS. The subject areas to be audited are governed by guidelines contained in 2.2.4.1 of the OMV, but the subjects to be audited are additionally within the discretion of the auditor.

(Lawrence, MBI 02/20/16, pp. 28, 37-38, 47-48); (MBI Ex.25, p.32).

The audit may result in various findings, characterized as observations, corrective action requests, and non-conformities, with differing levels of urgency and action required on the part of shoreside and vessel personnel. (MBI Ex.25, p.34). Captain Lawrence testified that he is responsible for corrective action as a result of non-conformities found in those audits. In his own words: a major non-conformity is a "show-stopper", something to be addressed immediately, possibly before the vessel sails. A routine non-conformity is something to be addressed typically within a three-month period. An observation is something noted, and expected to be corrected before a subsequent visit to the ship. (Lawrence, MBI 02/20/16, p.26).

ISM internal audits were conducted on the *El Faro* in March 2014 and March 2015. Both audits resulted in various observations, and other follow-up items being identified, but no non-conformities were noted. (MBI Ex.311, pp. 3, 6).

ii. External Audits

ABS conducted a limited initial external audit on December 7, 2013, as the *El Faro* was being brought out of layup status. (MBI Ex.405, p.24). The audit found that, as the vessel was coming out of layup, the planned maintenance program was not fully operational and a corrective action request was issued to address this problem. ABS issued an interim Safety Management Certificate to the vessel, and required that the corrective action request be resolved by July 23, 2014. (MBI Ex.405, p.25).

On July 5, 2014, in San Juan, Puerto Rico, ABS conducted an all-day follow-up external audit, with two USCG inspectors attending the audit as observers. (MBI Ex.405, p.27). The corrective action request was noted as resolved, with the ABS auditors reporting that "onboard experience and Company shoreside support currently ensure[es] planned maintenance is conducted"… and that the preventive maintenance program "is up and running and those interviewed were familiar with its operation." (MBI Ex.405, p.25). In carrying out other aspects of this follow-up audit, the ABS auditors carried out the following activities and made the following observations:

- conducted an examination and assessment of the decks, accommodation spaces, and machinery spaces and the vessel was found to be well maintained considering its age; (MBI Ex.405, pp.27).
- officers were interviewed and found to have a good understanding of the SMS and their roles ensuring various safety and environmental policies, and the posting of the same; (MBI Ex.405, pp.28).
- vessel personnel were also interviewed concerning the vessel's Job Hazard Analysis program, lock-out/tag-out, confined space entry, and hot work permit procedures were reviewed. (MBI Ex.405, pp.27-28).
- the auditors further found that checklists, work instructions, and other documentation, including documentation pertaining to ballast water management, garbage management, stability calculations, loading/discharging plans and voyage planning were examined and

found to be in order. (MBI Ex.405, p.28).

- the auditors further noted that the Master's familiarity with the SMS was demonstrated throughout the audit, and the "Master's overriding authority was clearly delineated within the management system, and the Master was clearly familiar with its intended purpose and his responsibilities." (MBI Ex.405, p.29).
- finally, crew interviews conducted by ABS auditors revealed that most crewmembers identified Captain Lawrence as the DP, knew his contact information was readily available on the vessel, and understood his basic function under the SMS. (MBI Ex.405, p.29).

e. The Role of the Designated Person (DP)

i. Responsibilities and Job Description

The ISM Code states that the Designated Person should "provide a link between the Company and those on board…having direct access to the highest level of management. The 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 ensuring that adequate resources and shore-based support are applied, as required." (ISM Code, par.A.4). TSI DP served exactly this role.

TSI's SMS states that the DP:

> is intended to provide the shipboard crew an additional option to express a safety concern if he/she is of the opinion that an unsafe condition or practice is not being satisfactorily addressed within the shipboard chain of command in a timely manner. In order to implement and monitor the ISM program, to ensure the safe operation of TSI's fleet and to provide a link between the company and the vessel, TSI has designated the Manager, Safety & Operations [Captain Lawrence] as the ISM Designated Person. His/her responsibilities authority include monitoring of the safe operation and environmental protection aspects of the operation of TSI's fleet and that adequate resources and shore side support are applied. He/she has direct access to the President who represents the Executive Group. When performing as ISM Designated Person, he/she shall act independently from other assigned responsibilities. The name and telephone number of the ISM Designated Person shall be posted in a relevant location selected by the Master. The post up should include the statement found in this section. (MBI Ex.198, p.26).

Captain Lawrence's job description is consistent with the company's SMS. It states, the Manager of Safety and Operations "[a]ssists 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." (MBI Ex.006, p.18.) The job description further indicates that Captain Lawrence's responsibilities include the following:

- Prepares policy changes/additions for management review.

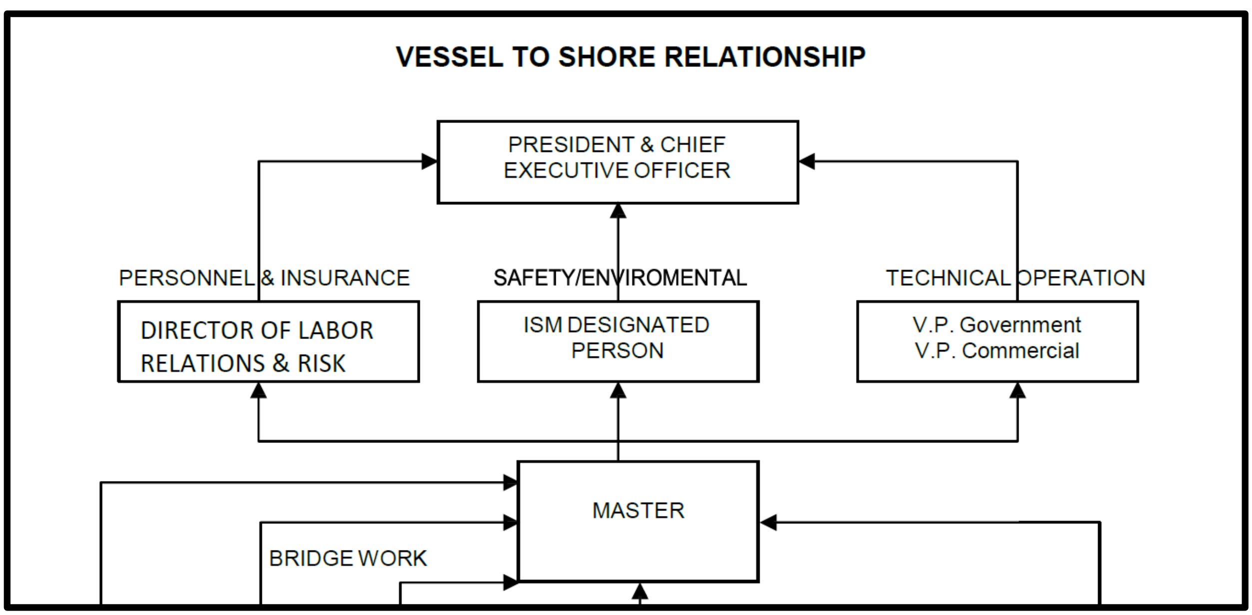
- Formulates general safety policies and procedures to be followed by company and vessel personnel in compliance with local, state, and federal Occupational Safety and Health Administration (OSHA) rules and regulations, and in the implementation of preventive safety measures and the development of the TSI Safety Program.
- Implements and administers the shipboard Quality System program. Conducts shipboard ISM training and internal audits. Recommends revisions to Quality System documentation pertaining to shipboard operations, as appropriate.
- Conducts shipboard security and safety assessments as necessary to meet SMS and regulatory obligations. Identifies risks to personnel, the environment and the ships and recommends corrective actions to senior management.
- Represents Company on various industry committees or safety groups and programs as required.

(MBI Ex.006, pp.18-19).

Captain Lawrence further described his role as the DP as follows: "…I oversee the safety management system. I support, I think is the key word I feel in my position is I support the operations groups and the entire company in fact as far as any safety issues or any safety advice." (Lawrence, MBI 02/20/2016, p.7, lines 17-20).

ii. **The DP's Role in Vessel Operations**

Under TOTE's SMS, there is shared responsibility among several shoreside departments to provide support to and oversight of vessel masters with respect to vessel operations. This operational relationship is depicted in TSI's SMS as follows:



(MBI Ex.25, p.29).

As noted above, the DP had direct access to the Masters of the vessels and direct access to the President of TSI. The flowchart shows three functional lines of authority and communication between the Master and the President of TSI: 1) Labor Relations; (2) DP; and (3) Technical Management. (MBI Ex.25, p.29).

As an operational and practical matter, TSI's oversight and support of the vessel is shared among these lines of authority, depending on the nature of the issue. For example, the Port Engineer is responsible for technical management of the vessel and communicates directly with the Master on issues surrounding the technical management and operation of the vessel. If there is a labor issue, the Director of Labor Relations may be the line of authority and communications ashore. If a matter involving the SMS is at issue, then the DP would be the line of authority and communications with shoreside personnel. In some cases, depending on the issue, the communications and line of authority for resolving a particular may well involve all three departments shown on the flowchart.

iii. **Support Staff Who Assisted the DP**

The DP was responsible for overseeing TSI's safety, environmental, and other regulatory compliance programs for its vessels under management. (Lawrence, MBI 02/6/17, at p.1223). In this regard, these responsibilities extended to 24 vessels and he was expected to be available 24 hours a day, 7 days a week, in emergency or other urgent situations. To accomplish this, the DP had two full time employees assisting him – the TSI Assistant Manager of Safety and Operations and TSI Ship Management Coordinator – and two other personnel who would assist with safety management system related duties on a part time basis. (MBI Ex.6, pp.2-4; attached job description for Ship Management coordinator (Attachment 6). In the summer of 2015, TSI had considered hiring an additional employee to assist the Manager of Safety and Operations/DP with his duties, but ultimately it was determined that a reallocation of duties was the best alternative at the time. The specific details of this reallocation of duties are described more fully in Capt. Lawrence Reallocation Memo, (Attachment 7).

In addition, of the 24 vessels under management, 14 were in active operation and 10 were inactive. The DP further testified that his span of control with this number of vessels is adequate, and that at his last company where he served as DP he had approximately 78 vessels under management." (Lawrence, MBI 02/17/2016, at p.37 lines 17-19; p.67, lines 21-23).

f. **Anonymous and Other Reporting Ashore**

i. **DP Posters - Phone Reporting and Email**

Designated Person posters are on every ship, notifying crew of the purpose and how to reach the Designated Person by phone and email. (Lawrence, MBI 02/20/16, pp.10-11). Outside, external audits revealed that the crew knew who the DP was and his basic role and function in the company. (MBI Ex.405, p.29).

ii. Saltchuk Speak-Up Hotline and Website (anonymous)

Similarly, in addition to the reporting mechanisms contained in the SMS, the parent company Saltchuk, had, at the time of the loss of the *El Faro* and continues to have, an anonymous reporting process for ethics, discrimination, illegality, irresponsibility, or safety issues. These reports to shore can be made by vessel personnel and other employees, anonymously if desired, by email or through a phone hotline. (MBI Ex.402, p.3). *See also* www.saltchuk/hotline.

g. Evidence of TOTE Safety Culture

In addition to the specific SMS procedures described and analyzed throughout the investigation, additional more qualitative evidence developed in the investigation overwhelmingly reveals that TSI's safety culture was a very healthy one, and that safety was never compromised in favor of commercial interests. One current master was asked to describe the company's safety culture, and responded as follows: "Obsessive…..[t]hey're very, very proactive on safety." (Loftfield, MBI 02/18/16, p.175).

A sampling of this additional evidence regarding the company's safety culture is as follows:

- When asked if he ever observed instances where he felt commercial pressure to maintain a schedule and influence the direction of the ship in any way, Third Mate Berrios testified "never." (Berrios, MBI 02/19/16, p.118, lines 1-4).
- According to Deck Cadet Ringlein, safety was more important to Captain Davidson than maintaining sailing schedule. (Deck Cadet, NTSB 11/03/15, pp.55, 85). According to the deck cadet, Captain Davidson would always say, with regard to the vessel's schedule, "we'll get there when we get there." *Id*. at 55.
- Captain Davidson did not make decisions that were risky and was adamant about everyone remaining safe. (Thompson, NTSB 12/06/15, p.105; Torres, NTSB 12/03/15, pp.8-9).
- When asked if there was pressure to make scheduled arrivals and departures, the off duty chief engineer of the *El Faro* testified no one was "pushing us to get there, it was get there when you can." (Robinson, MBI 02/23/16, p.17, lines 6-14). When asked about Captain Davidson's approach to safety culture, the off duty chief engineer testified "[s]afety was always strongly looked upon. You know all the safety meetings they were very explicit on if you need the equipment, if you don't think you have what you need step back, get it. You know safety was first. If the job had to wait to get completed then so be it." (Robinson, MBI 02/23/16, p.17).
- Captain Frudaker, the docking pilot on the *El Faro* upon its departure from Jacksonville on the accident voyage, testified he has served as pilot on the *El Yunque* and *El Faro*, over the last 15 years, dozens of times. (Frudaker, MBI 05/16/16, p.8, lines 17-23, p.9, lines 1-7). When questioned, Captain Bryson testified that he has never heard the officers on board *El Faro* or the *El Yunque* ever talk about the commercial pressure to meet the schedule. *Id.* at p.32.
- When asked about communications with shoreside management regarding keeping the

vessel's schedule, Captain Axelsson testified that he "never heard anything coming back to me regarding keeping a tight schedule. The way it was presented to me to – once we sailed let us know your ETA. And about what time you will be there. And if I was going to be an hour late there was no backlash, there was nothing about the why. I wasn't questioned. So I didn't see the ETA as a – as being pushed or forced." (Axelsson, MBI 05/16/16, pp.64-65).

- The lead Coast Guard inspector in San Juan, Puerto Rico, who conducted regular inspections concluded that (a) the SMS aboard the *El Faro* was working, (b) that the shipboard personnel had good relations with the company (shoreside) pertaining to safety management, and (c) that the *El Faro* was getting the necessary support from the company. (McMillan, MBI 05/25/16, p.38).
- The lead Coast Guard inspector in San Juan Puerto Rico, who conducted regular inspection of the *El Faro* and other vessels managed by TSI was asked about the company' safety culture and responded as follows: "Everything I've seen over the years they have a very good safety culture. It seems like they really take pride in it. If there would have been a problem, if they have any issues, they call us and let us know. Or they have scheduling of exams. They're always good about scheduling exams. We've never really had any issues with them in that regard. And if there's a problem with them, they let us know." (McMillan, NTSB 10/10/15, p.97).

There are countless other examples of witnesses current and former employees who overwhelmingly testified that the company's safety culture was and is a healthy one. For example:

- The safety culture onboard the *El Faro* and under Captain Davidson was strong. (Robinson, MBI 02/23/16, p.17); (Vagts, MBI 02/24/16, p.152).
- Captain Davidson always looked out for his crew; for him, it was always the crew first. (Vagts, NTSB 12/06/15, pp.65-66). He was very safety conscious, safety oriented, and always said "take your time and be safe." (Ringlein, NTSB 11/03/15, pp.79,96); (Baird, NTSB, 12/6/15, p.176); (Walker, NTSB 12/03/15, pp. 24-25).
- Safety was more important to Captain Davidson than maintaining sailing schedule. (Ringlein, NTSB 11/03/15, pp.55,85). He did not make decisions that were risky and was adamant about everyone remaining safe. (Thompson, NTSB 12/06/15, pp.105); (Torres, NTSB 12/03/15, pp.8-9); (Walker, MBI 02/23/16, p.121).
- Captain Davidson was very meticulous, organized, professional and well respected by the crew. (Baird, MBI 02/18/16, p.60); (Baird, NTSB 12/06/15 p.156); (Peterson, MBI 02/17/16, p.130); (Torres, NTSB 12/03/15, p.32); (Robinson, NTSB 10/08/15, p.70); (USCG Shiprider, NTSB 10/15/15, pp.50-51); (Berrios, NTSB 12/06/15, p.37); (Berrios, MBI 02/19/16, p.117); (Stith, NTSB 10/07/15, pp.76-77); (Stith, MBI 05/24/16, pp.58-59). He chaired safety meetings, printing out the report from the last safety meeting and reviewing it for the entire crew that was gathered. (Walker, MBI 02/23/16, p.135); (Stith, NTSB 10/07/15, p.77); (Stith, MBI 05/24/16, p.42). He made sure everyone participated in safety drills and was strict about providing proper indoctrination to riding crew. (Berrios, NTSB, 12/06/15, pp.47, 50, 65-67); (Berrios, MBI 02/19/16, p.62). During abandon ship drills, Captain Davidson made sure all safety equipment was brought to the lifeboats. (Berrios, MBI 02/19/16, p.49). He discussed the launching of lifeboats or rafts

in inclement weather. (Robinson, MBI 02/23/16, p.33).

- Captain Davidson admonished any crewmember who was not wearing appropriate PPE (personal protective equipment), and he thanked crew members for doing things safely. (Walker, NTSB, 12/03/15, pp.25-28); (Walker, MBI 02/23/16, pp.121-122).

Additionally, all crewmembers had ample opportunity to call or seek out company leadership, as they were in port two stops a week in the San Juan trade.

3. Bridge Equipment

As set forth in more detail below, the *El Faro* had a full complement of bridge electronics and other bridge equipment, in some cases in excess of what was required by applicable regulations. A detailed inventory of bridge electronics believed to be on the *El Faro* is set forth in MBI Exhibit 301. As a matter of procedure, TOTE's SMS required testing of all essential bridge equipment as a part of a pre-departure and pre-arrival checklist. (MBI Ex.73). All of the bridge equipment worked properly on 28 September when the *El Faro* arrived at Jacksonville. (Winegeart, NTSB 10/09/15, p.7). When the vessel departed on 29 September, all bridge equipment (navigational instruments, bridge electronics, radar, steering, helm, AIS,[7] etc.) was still working properly. (Bryson, MBI 05/16/16, p.43).

a. Navigation

El Faro was equipped with AIS, two gyrocompasses, an echo sounder, three radars, and three GPS devices. (MBI Ex.301; Baird, NTSB 12/6/15, pp.32-35). The *El Faro* exceeded regulatory requirements by being outfitted with two gyrocompasses (only one is required by regulation) and three radars (only two are required by regulation). SOLAS Chapter V, Regulation 19, par. 2.5 and 2.7.

b. Communication

El Faro had two separate satellite systems. The main Inmarsat system was the primary system for voice, fax, and email. (Stith, NTSB 10/07/15, p.31).

El Faro had medium and high-frequency calling radio, single side band, and VHF. It was equipped with Automatic Identification System, Long Range Identification and Tracking System, and a Narrow Band Direct Printing. (Stith, NTSB 10/07/15, pp.31-32) (Axelsson, NTSB 11/03/15, pp.71-74).

Through the Global Maritime Distress Safety and Signaling System (GMDSS), a separate SAT-C satellite communications system was available. This included an Electronic Position Indicating Radio Beacon. The Ship Security Alert System (SSAS) operated through this SAT-C system. (Stith, NTSB 10/07/15, p.31); (Loftfield, NTSB 10/09/15, pp.44-49). This equipment was tested on a regular basis by the vessel's crew. (Loftfield, NTSB 10/09/15, p.52).

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[7] The Automatic Identification System (AIS) is an automatic tracking system used on ships and by vessel traffic services for identifying and locating vessels by electronically exchanging data with other nearby ships, AIS base stations, and satellites.

c. Weather - Equipment - BVS / Sat C / NWS

The *El Faro* received SAT-C, high seas forecast, NAVTEX, and other weather information from the National Weather Service. (Axelsson, NTSB 11/03/15, p.121-123); (Axelsson, MBI 05/16/16, p.117, 158); (Hearn, MBI 05/17/16, pp.66-69); (Hearn NTSB 03/30/16, pp.433-443). Enhanced Group Calling (ECG) through SAT-C would also provide weather information to the *El Faro*. (Torres, NTSB 10/09/15, p.35).

During the voyage, the vessel was also receiving weather forecasts from Applied Weather Technologies (AWT). AWT provided the vessel with weather forecast information through Bon Voyage System 7.0 (BVS). (Hale-Brown, MBI 05/18/16, pp.8, 14). The Bon Voyage System - is a desktop application that provides subscribers such as the *El Faro* with weather-related information through email or broadband interfaces. Appendix D (Capt R. DiNapoli), p. 2 n. 2.

El Faro was equipped with SSAS, GMDSS, two 9 GHz search and rescue radar transponders (part of GMDSS), one 406 MHz Satellite EPIRB (part of GMDSS), and INMARSAT. (MBI Ex.46).

d. Voyage Data Recorder

The *El Faro* was equipped with a Simplified Voyage Data Recorder (S-VDR) installed in 2009. (Michel, MBI 02/24/16, pp.106-107). The S-VDR was enclosed inside a cradle that was bolted to an "I" beam on the flying bridge of the wheel house. There were bridge wing microphones in place. (Michel, MBI 02/24/16, p.103). Engine and rudder order responses were not connected to the S-VDR; SOLAS did not require this. (Michel, MBI 02/24/16, p.118). The S-VDR components included the capsule, data acquisition units, bridge alarm unit and the beacon. The data acquisition units included AIS, GPS tracking, the gyrocompass, speed log, wind anemometer, and depth. (Michel, MBI 02/24/16, p.101). The last performance test and certificate of compliance for the S-VDR was issued on December 2, 2014. (MBI Ex. 38; Michel, MBI 02/24/16, p.77).

e. Bridge Electronics Maintenance

El Faro had a shore-based maintenance agreement in place with Imtech. This allowed the ship to call Imtech (also known as Radio Holland) to meet the ship at the dock to service malfunctioning electronic equipment. (Brown, NTSB 10/13/2015, p.17). The *El Faro* maintained onboard the vessel a Bridge Equipment Service Records binder and a GMDSS records binder, similar to the records maintained on the *El Yunque.* (MBI Ex.43).

i. September 2014 Baseline Survey - Imtech -- Bridge Equipment Service Record

In September 2014, TOTE commenced an effort to increase attention to the maintenance of bridge electronics. See Jim Fisker-Andersen email dated Sept 12, 2014 (Attachment 8).

Radars, gyros, echosounder, VHF radios, antennae, NAVTEX, LRIT, and wind vanes were subsequently assessed, tested, and serviced as needed by Imtech. The overall condition of the bridge was assessed as very good, and various maintenance items were carried out. See 2014 Imtech Service Reports (Attachment 9).

ii. January 2015 - GMDSS Annual Survey and Testing

The *El Faro's* bridge electronic equipment was further surveyed and serviced on January 27, 2015 by Imtech, and the equipment was found to be working properly. (MBI Ex.46) The electronic equipment Imtech surveyed included the GMDSS, VHF, gyrocompass, radars, SSAS, AIS, SAT-C, MFHF DSC, EPIRB, and lifeboat radios. (Brown, NTSB 10/13/2015, pp.9-10).

The survey leads to, among other issuances, the issuance of a Cargo Ship Safety Radio Certificate, issued on behalf of the United States under applicable provisions SOLAS. (Brown, NTSB 10/13/2015, pp.10-11; MBI Ex.46, pp.3-5).

f. Anemometer and Operational Status

The anemometer onboard the *El Faro* was made by R.M. Young Co. (MBI Ex.301). There were wind vanes on both port and starboard sides of the radar mast. See 2014 Imtech Service Reports (Attachment 9). As discussed in further detail below, a review of the available evidence strongly suggests that the anemometer was operating, but with some degradation to the accuracy of the wind direction.

i. Imtech Survey

According to Sperry Marine, the equipment that feeds an input to the VDR, such as the anemometer, needs to be working properly during an Annual Performance Test of the VDR in order to certify it. (Michel, MBI 02/24/2016, p.102.) On December 3, 2013, the anemometer was checked and tested as part of the VDR Annual Performance Test, and found satisfactory. (MBI Ex.38, pp.1-2). During a service visit on September 16, 2014, Imtech assessed the port wind vane as operational and accurate. The starboard wind vane was missing and required installation of a new one. See 2014 Imtech Survey Reports (Attachment 9). On December 2, 2014, the operation and recording of the anemometer was checked, tested, and found satisfactory as part of the Annual Performance Test of the VDR. (MBI Ex.38, p.14).

ii. Testimony

The testimony of various witnesses, reviewed in the sequence in which they last served onboard the *El Faro*, further demonstrates that the anemometer on the *El Faro* was operational when the vessel left Jacksonville on September 29, 2015 and during the accident voyage, but with some degradation to the accuracy of the wind direction:

- According to Chief Mate Torres -- <u>who last served aboard the *El Faro* on July 28, 2015</u> (MBI Ex. 384) -- the anemometer worked on the *El Faro* when he left the vessel on July 28, 2015. (Torres, MBI 02/25/2016, p.88).

- Captain Axelsson -- who last served aboard the *El Faro* on August 4, 2015 (MBI Ex. 384) -- testified that when he served on board the *El Faro*, there were two anemometers, and the starboard anemometer worked, but the direction on the port anemometer direction was not accurate. (Axelsson, MBI 05/16/2016, p.125).
- Chief Mate Thompson -- who last served aboard the *El Faro* on August 11, 2015 (MBI Ex.384) -- served aboard the *El Faro* for approximately one year. He testified that when he was onboard there were two anemometers installed and at least one of them worked during his entire time onboard the vessel. Chief Mate Thompson (who was by then serving as Master) last departed the *El Faro* on August 11, 2015 and was relieved by Captain Davidson. (Thompson, NTSB 12/08/2015, pp.71-73).
- Captain Stith -- who last served aboard the *El Faro* on August 28, 2015 (MBI Ex. 384) -- testified that when he served on board the *El Faro*, the anemometer was operational. (Stith, MBI 05/24/16, pp.66-67).
- Chief Mate Brian Vagts -- who last served aboard the *El Faro* on September 18, 2015 (MBI Ex. 384) -- testified that he recalled there being two anemometers on the *El Faro*, but he could not recall if one or both anemometers worked. (Vagts, MBI 02/24/16, p.152).
- Second Mate Charlie Baird -- who last served aboard the *El Faro* on September 18, 2015 (MBI Ex.384) -- testified that there was one anemometer, and it was not working. (Baird, MBI 02/18/16, p.57).
- Third Mate Alejandro Berrios -- who last served aboard the *El Faro* on September 22, 2015 (MBI Ex.384) -- testified that there were two anemometers onboard and at least one worked when he was onboard, although the wind vane had a consistent offset to port of approximately 20 degrees. According to Third Mate Berrios, the anemometer was working when he left the vessel on September 22, 2015 -- one week before the *El Faro* departed on its final voyage. (Berrios, MBI 02/19/2016, pp.111-112, 124).

(a) **VDR Data - Dr. Dooley Analysis**

As discussed further below, meteorology expert Dr. Austin Dooley, Ph.D., concluded the true wind speed as calculated from the anemometer and the VDR adjusted route wind speed correlate, at least until *El Faro* enters the hurricane force wind field. Appendix C (Dr. A. Dooley), p.31 at Attachment 2. A chart of the comparison of the calculated true wind speed as calculated from the VDR data with what was found using his adjusted route model is shown below.

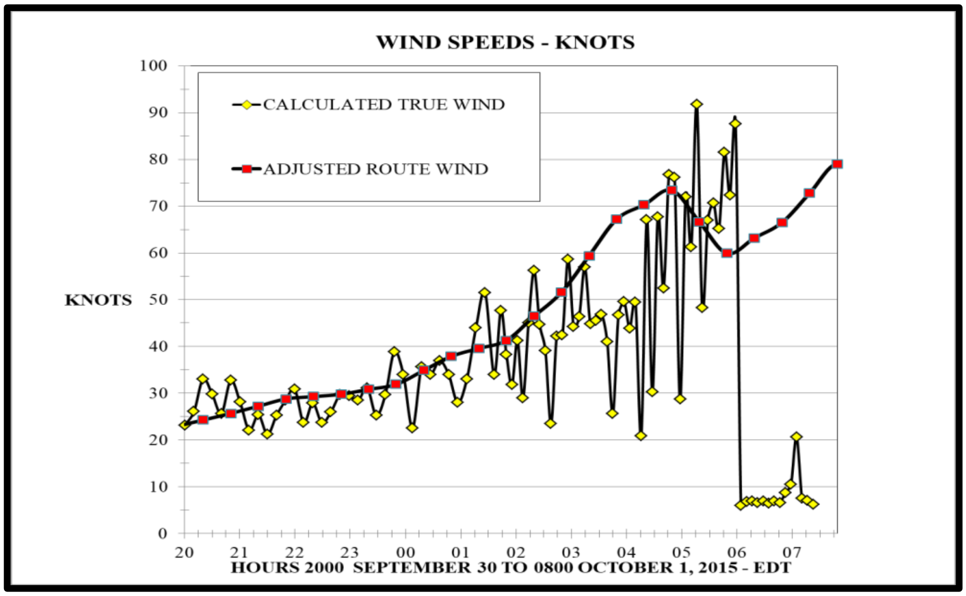

Figure A: Wind Speeds on Adjusted and VDR Route

This chart shows a correlation of calculated true wind and adjusted route wind speeds, though two windows exist where the winds do not correlate: from shortly after 3:00 a.m. to shortly after 4:00 a.m., and around 6:00 a.m. until *El Faro's* loss. *El Faro* had entered the hurricane force wind field at around 3:00 a.m. The disparity in the 3:00 a.m. to 4:00 a.m. window may be attributed to the intense rain noted on the VDR transcript, which may hinder the accurate functioning of the anemometer. See Appendix C (Dr. A. Dooley), Attachment 2, n. 17. The 6:00 a.m. to 7:45 a.m. window is when *El Faro* is in its final throes, and multiple failures are occurring. The disparate true wind readings are due to the sampling of the wind speeds extracted every 6-10 minutes from the approximately 400K lines of VDR data.

(b) **The weight of the evidence indicates the anemometer on the *El Faro* was operational and accurately displayed the wind speed, but one of the wind vane's directional indicators likely had an offset of 20 degrees**

The following conclusions are drawn from the evidence discussed above:

- An anemometer was not required to be installed by any law or regulation, even if the *El Faro* were built to today's regulatory standards;
- the *El Faro* had two anemometers on board;
- the VDR transcript indicates some crewmembers questioned the accuracy of the anemometer display, with the Master indicating he "didn't's trust it;"
- however, as Attachment 2 to Dr. Dooley's report demonstrates and concludes, and as corroborated by the witness testimony and service and survey records discussed above, the true wind speed as calculated from the anemometer and the VDR adjusted route wind speed correlate, at least until *El Faro* enters the hurricane force wind field; and

- the VDR data suggests the direction of wind, as measured from one of the anemometers wind vanes that was connected to the VDR, was not accurate.

These above findings are most consistent with the testimony of the witnesses, particularly the last two Chief Mates and Master to be aboard the vessel (Stith and Thompson), and Mr. Berrios, who was the last witness with knowledge to leave the vessel on September 18, 2015, who testified that the winds speed display for the anemometers was accurate and the wind vane for one of the anemometers was operational, but had a consistent offset to port of approximately 20 degrees. Further, in the period before the vessel's departure, there were no outstanding service issues regarding the anemometer that had been brought to the attention of shoreside personnel by the vessel.

4. Loading / Stability Approvals and Operations

a. Stability Approvals (USCG / ABS)

i. **Trim & Stability (T&S) Book**

The basic format of the *El Faro's* Trim and Stability Booklet dated back to the vessel's original construction date in the early 1970s which was approved by the U.S. Coast Guard's Third District. (Gruber, MBI 05/19/16, p.158). The *El Faro*'s Trim and Stability Booklet format and content was updated in 1993 and approved by ABS on behalf of the Coast Guard; it was also reviewed by the Coast Guard Marine Safety Center at that time, and no deficiencies or other problems were noted. (Gruber, MBI 05/19/16, pp.158-159).

The format and content of the *El Faro's* Trim and Stability Booklet were updated again in 2006/2007 and approved May 31, 2007 by ABS on behalf of the Coast Guard. (Gruber, MBI 05/19/16, pp.158-159); (Gruber, NTSB 01/29/16, p.62).

ii. **Cargo Max**

Since its inception, CargoMax has been installed and used on over four thousand vessels worldwide. Today, CargoMax is used aboard the MARAD fleet of vessels, and used by most U.S. operators of commercial cargo vessels. (Schilling-Newton, MBI 05/23/16, p.14). Masters of the *El Faro* specifically used CargoMax for calculating the vessel's stability. (Hearn, NTSB 03/30/16, p.338).

(a) Approval for Use

Herbert-ABS Software Solutions, Inc. developed the CargoMax program for the *El Faro* beginning in 2006, in conjunction with the stability work that HEC was performing. CargoMax was approved by ABS for use as a stability instrument on the *El Faro*. (MBI Ex.016 February 8, 2008 Approval Letter); (Cronin/Pisini, MBI 05/20/16, pp.116-117) (Gruber, MBI 02/09/17, p.634).

The program was approved by ABS in 2008 for use on the *El Faro* for: (1) stability calculations against the required GM curve in the approved Trim & Stability Booklet for various discrete cargo tier heights; and, alternatively, (2) performance of stability calculations against the Coast Guard wind heel criteria, based on the actual wind profile of the vessel in its as-loaded condition; this is what is referred to as the "auto wind heel" feature contained in CargoMax. Both features were approved for use. (Schilling-Newton, MBI 05/23/16, pp.134-135).

(b) Use by Shoreside

During the process of developing the stowage plan and during loading of the vessel, CargoMax was used by TMPR personnel to determine and confirm the following loading parameters: (a) GM margin, looking for minimum of 0.5 feet, (b) trim, looking for down by stern, (c) list, looking for actual list of zero, (d) available deadweight, looking for positive available deadweight, and (e) that maximum bending and shear force moments, stack weight limitation, and lashing margins are not exceeded. (Matthews, MBI 02/20/16, pp.188-192); (Rodriguez, MBI 02/20/16, p.146).

(c) Use for Assessing Stresses and Bending Moments

CargoMax could be used to calculate the amount of sag or hog of the vessel, for a particular loading condition, by using the observed drafts tool in CargoMax. (Schilling-Newton, MBI 05/23/16, p.132). It also determined the shear force and bending moments. CargoMax indicated if the vessel exceeded hogging stresses. (Torres, NTSB 10/09/15, pp.19-21).

iii. Cargo Hold Ventilation - Load Line Convention Approval by USCG and ABS

The exhaust and intake cargo ventilation trunks on the *El Faro* contained fire dampers, the configuration of which was approved by the U.S. Coast Guard and ABS when the vessel was constructed and thereafter. The nature of these closures, which were deemed by ABS to be at least weathertight, satisfied the Load Line Convention. (Gruber, MBI 05/19/16, pp.143-144). The ventilation arrangement and the approved drawing for *El Faro* are marked as MBI Exhibit 203.

Among other things, the Load Line Convention requires coaming height of hull openings to be at least 35.5 inches above the freeboard deck. In the case of the cargo ventilation trunks on the *El Faro*, the coaming height was approximately 7 to 8 feet above the freeboard deck (which was the height of the baffles). (Gruber, MBI 05/19/16, p.145); *see also* International Convention on Load Lines, 1966, Regulation 19. Accordingly, ABS, as the load line assigning authority, considered the vessel to meet the criteria under the Load Line Convention because the baffle arrangement for the cargo hold ventilation system far exceeded the required height of 35.5 inches above the freeboard deck. (Gruber, MBI 05/20/16, pp.37-38).

(a) Exhaust and Supply Dampers

The dampers that were located at the exhaust ventilation trunks were reviewed and accepted by the USCG and ABS when *El Faro* was constructed. (Gruber, MBI 02/09/17, (draft) pp.641-642). For the purposes of the Load Line Convention, the dampers are considered capable of being closed weathertight. (MBI Ex.322; Gruber, MBI 05/19/16, p.142, and 05/20/16, p.38.) Under the Load Line Convention, the dampers were never required to be watertight, but were only required to be capable of being closed weathertight. (Gruber, MBI 02/09/17, (draft) pp. 643-647.)

The drawings bearing ABS and USCG approvals in 1973, and the drawings relating to the lengthening of the vessel in 1993, designate the supply and exhaust trunks and the damper arrangement. (MBI Ex. 203) The drawing further indicates that the supply vents had a gasket arrangement where the fan was located on the intake or supply side, and the exhaust trunk vents were not fitted with a gasket. See ABS et al, *Joint Response to the U.S. Coast Guard Marine Safety Center's Technical Reports Concerning the SS El Faro Stability and Structures dated January 17, 2017, and March 22, 2017*, pp. 39-40, May 5, 2017.

(b) **Normal Operation - Dampers are required to be open by regulations**

There is no regulatory requirement requiring the dampers to be closed while the vessel is underway. (Gruber, MBI 05/19/16, p.166); (Gruber, MBI 05/20/16, p.45); (Loftfield, MBI 02/18/16, p.163). *El Faro's* Certificate of Inspection expressly provides, as a condition of carriage: "All cargo spaces are specially suitable for carriage of vehicles" (46 C.F.R. 90.10-38), maintain ventilation in accordance with blueprint 663-879-4 ALT 0 of Sun Shipbuilding and Dry Dock Company." The operational regulations for vessels inspected under 46 CFR Subchapter I require "continuous pressure-positive ventilation on each level on which vehicles are transported." (46 C.F.R. § 92.15-10).

b. **Role of Vessel Master / Mates In Stability / Cargo Loading**

i. **Regulatory Framework**

The 2003 ABS Supplement, applicable to the *El Faro*, states that the vessel must satisfy 46 CFR Subchapter S, or, as an equivalency, the IMO International Intact Stability Code. (MBI Ex.233, p.15.) The regulations in 46 CFR Subchapter S, which applied to the *El Faro*, state that the approved "stability book must contain sufficient information to enable the master to operate the vessel in compliance with applicable regulations…" (46 CFR §170.110(c)).

ii. **TSI SMS/Operational Responsibilities**

(a) **Stability Assessment and Verification**

TSI's SMS, applicable to the *El Faro's* operations, places responsibility for assessing and verifying the vessel's stability with the Master and Chief Mate. The Master is responsible for the ship's stability, and it is the duty of the Chief Mate to calculate the ship's stability and submit this information to the Master. The Master must review and approve of these calculations by affixing his/her signature prior to departure. The Chief Mate shall take corrective action to improve stability as needed. (MBI Ex.25, p.298). The details of how these responsibilities were carried out in practice on the *El Faro* are discussed further in section below.

(b) Supervise and Direct Cargo Securing

Under TSI's SMS, the Chief Mate is also responsible for proper lashing, bracing, and general securing of cargo. The Chief Mate is also required to coordinate with the stevedore to assure that the proper equipment for lashing and securing the cargo to be loaded is available in sufficient quantities. During cargo loading operations, the lashing arrangements are supervised by a deck officer. Cargo securing is inspected by the Chief Mate prior to departure from port, and the Chief Mate shall make an entry in the deck log book to verify that cargo is secure for sea. (MBI Ex.25, 298). The details of how these responsibilities were carried out in practice on the *El Faro* are discussed further below.

(c) Draft Readings and Water Density (salinity)

Under TOTE's SMS, the vessel's draft readings and water density (salinity) must be taken as part of the pre-departure checklist. (MBI Ex.25, p.185).

As a matter of operational practice, the Chief Mate typically met the Marine Operations Manager (or his stand-in) on the dock where they took drafts (forward, aft, mid-ships), and one of the Mates took the offshore mid-ships draft. Salinity was also obtained at this time. If they had an average observed mid-ships draft of greater than 30' 2-3/8", they used the immersion table (fresh water allowance table) to determine whether at the current salinity the *El Faro* was within its load limits. (Matthews, MBI 02/20/16, pp.178-179, 221); (Thompson, NTSB 12/06/15, p.33); (Baird, NTSB 12/06/15, pp.42-44).

The Third Mate or Second, whoever was on watch, obtained the salinity in Jacksonville, approximately an hour prior to departure. (Thompson, NTSB 12/06/15, p.26); (Baird, NTSB 12/06/15, pp.42-44). The Mate on watch typically used a hydrometer and a bucket of water to sample and determine the salinity/water density at the dock in Jacksonville; salinity would range from approximately 1.01 to a 1.025. (Vagts, MBI 02/24/16, p.140). The GM margin would decrease slightly with fuel burn. (Vagts, MBI 02/24/16, p.145).

Further, TOTE's SMS requires log entries for, among other things, departure drafts and salinity information. (MBI Ex.25, p.185).

c. Role of TMPR Personnel

The Terminal Manager and Marine Operations Manager for TMPR in Jacksonville oversaw the day-to-day terminal operations which included stevedoring operations when a vessel was in port. (Rodriguez, MBI 02/20/16, p.111). The Marine Operations Manager (or his stand in) was typically in constant contact with the Master and Chief Mate throughout cargo operations regarding the status of the loading operations and stability characteristics of the vessel. (Matthews, NTSB 12/02/15, p.63); (Stith, MBI 05/24/16, p.48). The procedures for loading and discharging cargo and TMPR's roles and responsibility with respect to cargo operations is discussed in more detail in section III.B.4.b.

d. Role of PORTUS

PORTUS Stevedoring LLC (PORTUS) performed the physical movement of the containers and other cargo loaded onto the vessels. TMPR's operations group coordinated with PORTUS throughout the cargo operations, and PORTUS prepared the preliminary and final stow plans. (Nolan, MBI 02/18/16, pp.136-137). A preliminary load case (CargoMax) was developed by TMPR shoreside personnel based on the cargo, fuel requirements, and other criteria. (Morrell, MBI 02/16/16, p.37); (Matthews, MBI 02/20/16, p.173). The CargoMax load case was continually updated by TMPR personnel until cargo operations were complete.

e. Spinnaker Shoreside

PORTUS utilized the computer program Spinnaker to prepare the stow plan for the Lo-Lo operations. (Rodriguez, MBI 02/20/16, p.115). For the Ro-Ro operations, PORTUS used a handwritten stow plan. Matthews, MBI 02/20/16, pp.175-176).

The Marine Operations Manager or his stand-in would print out Spinnaker on day 2 of loading operations, which would include the information from PORTUS, and continually update that through the day with input from the PORTUS stevedores. (Matthews, MBI 02/20/16, pp.174-175).

f. Lashing - Cargo Securing Manual

The *El Faro's* Cargo Securing Manual was reviewed and ultimately approved by ABS on January 20, 2006. (MBI Ex.40). However, the Cargo Securing Code (CSS), including the requirements pertaining to Cargo Securing Manuals (CSM), did not apply to the *El Faro*, because, as a legal matter, those standards were considered voluntary guidelines at the time of the loss of the vessel. It was not until May 9, 2016, after the loss of the vessel, that these requirements were implemented under U.S. law for vessels such as the *El Faro*. In fact, by May 9, 2016, compliance with the SOLAS cargo securing manual standards became mandatory for self-propelled vessels over 500 gross tons on international voyages that are subject to SOLAS. *See* 81 Fed. Reg. 27992, dated May 9, 2016, at 27994, an interim rule which amends 33 C.F.R. Parts 97 and 160. ("The SOLAS CSM requirements are included as an annex to a Coast Guard guidance document issued in 1997 [NVIC 10-97] but a vessel owner or operator's compliance with that guidance is only voluntary. This interim rule makes compliance with the SOLAS standards mandatory for self-propelled vessels over 500 gross tons on international voyages that are subject to SOLAS."). The regulations at 33 CFR Part 97, cited above, did not become effective until June 8, 2016. *See* 81 Fed. Reg. 27992, dated May 9, 2016, at 27993. Thus, as to the *El Faro*, Cargo Securing Manual guidelines were voluntary, advisory standards at the time of the loss.

Even though these standards were not legally required, TOTE's SMS nonetheless references the approved CSM and notes that the approved CSM "should be reviewed periodically" by the Chief Mate and "essential elements should be incorporated into the C/M's Standing Orders for cargo operations." (MBI Ex.25).

Despite not being legally required, as set forth in more detail in section III.B.4 below, the *El Faro* fully satisfied the voluntary guidelines and standards of the CSS Code and in the vessel's CSM.

5. Engineering/Propulsion

a. Engineering Plant Description and Overview

i. Boilers

The *El Faro* had steam propulsion boilers manufactured by Babcock & Wilcox (B&W). (Laakso, MBI 02/25/16, p.112). These boilers provided steam that powered low and high pressure turbines that, in turn powered the vessel's shaft. The boilers also provided power to two turbo generators that provided electrical power to the ship. The boilers were inspected by the Chief Engineer every three months, at which time a water wash would be done. This process was typically done on the northbound trip while the vessel steamed on one boiler. (Neeson, MBI 02/26/16, p.197).

ii. Electrical Power Turbogenerators and Emergency Generator

The turbo generators (either one or two) supplied electrical power to the main switchboard and to the emergency switchboard. (Appendix A (J.Daly), p.8). The emergency diesel generator started automatically upon sensing loss of power, and automatically came on line to supply electrical power to the emergency switchboard, only. This generally happened within fifteen seconds of a blackout. This switchboard powered certain critical equipment including the gyrocompass, a main engine lube oil pump, a turbo generator lube oil pump, the emergency fire pump and emergency lighting. *Id*.

b. Preventive Maintenance System / AMOS

The El *Faro* crew and shoreside managers used AMOS to track the vessel's maintenance, history, and ordering. The First Engineer would typically input work orders and then close them out as they were completed. (Robinson, MBI 02/23/16, p.13). Upon relief of the Chief Engineer, the outgoing Chief Engineer would draft relief notes for the incoming Chief Engineer with a copy to the Port Engineer, in order to keep track of ongoing scheduled and unscheduled maintenance items. (Robinson, MBI 02/23/16, p.18);(MBI Ex.414).

The vessel's propulsion equipment was properly maintained. Furthermore, based on a review of the available maintenance records from 2013 through September 2015, maintenance items on all critical engineering equipment were current, and no scheduled or unplanned maintenance items had been neglected, deferred or overlooked. (Appendix A (J.Daly), p.4).

c. Alaska conversion project - Description of Survey / Work of Riding Crew

The *El Faro* was scheduled to be relocated to the Pacific Northwest to act as a relief vessel when the company's Orca-class vessels went to dry dock for installation of new engines. Mr. Neeson served as the project manager for the *El Faro's* relocation and conversion work to the Alaska service. He coordinated with vendors, ordered supplies, and notified the Coast Guard and ABS of the company's plans and work status. (Neeson, MBI 02/26/16, p.142). Chief Engineer Jeff Mathias was hired to assist with the conversion to Alaska service. (Neeson, MBI 02/26/16, pp.200-201). During this period, the *El Faro* was undergoing various preliminary work to prepare the vessel for cold weather service, including the installation of a Butterworth heating system and for its return to a full roll-on-roll-off vessel in the Alaska trade. (Morrell, MBI 02/16/16, pp.24-25); (Neeson, MBI 02/26/2016, p.144). The Butterworth heating system served to assist with de-icing the decks and other areas of the vessel in cold climates. It was being reinstalled on the vessel; it had been previously removed after it last transitioned from the Alaska trade.

The Polish riding crew were assisting with this preliminary conversion work and were being supervised by Chief Engineer Jeff Mathias, who was satisfied with their work. (Neeson, MBI 02/26/16, pp.201-202). The riding crew was not tasked with any repairs or modifications or any work on any portion of the propulsion systems, including the boilers, main turbines, turbo generators, and reduction gear. (Neeson, NTSB 10/08/15, p.15).

Prior to arriving in Jacksonville on September 28, 2015, the *El Faro*'s Chief Engineer sent an email updating the Port Engineer and others that he intended to lower the Butterworth heater (with the assistance of the Polish riding crew) through the 2nd deck soft patch on Monday September 28, 2015 into the engine room; Mr. Mathias also used the Polish riding crew in prefabricating the stand upon which it was to rest. (Neeson, MBI 02/26/16, p. 144-146). The soft patch on the second deck was re-secured with bolts prior to the vessel departing Jacksonville on September 29, 2015. (Neeson, MBI 02/26/16, pp.164-165).

6. Survival / Life-Saving Equipment

a. SOLAS Safety Equipment Certificate

ABS issued *El Faro* a Safety Equipment Certificate in 2006, and updated it, reflecting new equipment in 2007 (for new 406 EPIRB), 2009 (for S-VDR and 10cm Radar), and 2010 (for LRIT). (MBI Ex.071).

b. Annual Safety Equipment Survey

At the time of the *El Faro's* 29 September sailing, Harding Safety USA had recently completed a safety equipment annual inspection. That process included surveying the davits on the *El Faro*, which passed as 100% functional. (Neeson, MBI 02/26/16, p.136-137,167). On 29

September, the *El Faro* had all lifesaving gear aboard and stowed. (Neeson, MBI 02/26/16, p.167).

When Harding Safety USA's representative, Mr. Wagner, departed the vessel prior to it getting under way on 29 September, the lifeboats and davits on both sides were in good working order. (Wagner, MBI 05/26/16, p.14); (MBI Ex.074). Mr. Wagner commented that had he been required to get underway with the vessel at that time, he "would've felt plenty safe with the guys and the ship and [his] equipment." (Wagner, MBI 05/26/16, p.30).

El Faro carried two extra 25-person life rafts as a precaution taken in light of davit corrosion previously identified on *El Yunque*, and the possibility that a similar situation might develop on *El Faro*. (Neeson, MBI 02/26/16, p.137).

c. Immersion Suits On Board

The *El Faro* was not required to have immersion suits on board due to the Caribbean route she was on. Specifically, SOLAS Chapter III, Regulation 7 Section 3 states: "If the ship is constantly engaged in warm climates where in the opinion of the Administration thermal protection is unnecessary, this protective clothing need not be carried." As set forth in 46 CFR §199.214, immersion suits are not required if the vessel the vessel operates between 32N and 32S.

Nonetheless, the *El Faro* was outfitted with 52 to 56 immersion suits. The AMOS maintenance system shows a purchase order for 52 immersion suits for required 2-year inspection and pressure testing on August 14, 2015, and a purchase order for 4 oversize adult immersion suits. (Survival Group Factual Report, NTSB 12/9/2016, p.53). Immersion suits were stored in a closet inside each crewmember's room. (Walker, MBI 02/23/16, p.130) If crew could not get to their room, there were immersion suits in the emergency gear locker located on the portside main deck. (Walker, NTSB 12/03/15, p.22); (Berrios, MBI 02/19/16, p.95). Per the Fire and Control Plan, immersion suits were also located at duty stations. (MBI Ex.134).
Additionally, *El Faro* had brand new (additional) immersion suits in the "oil skin" locker.

G. Meteorological Information Received On Board

The *El Faro* received weather information via three primary sources: NAVTEX, SAT-C, and BVS. (Baird, NTSB 12/06/15, p.104); (Berrios, NTSB 12/16/15, p.27); (Berrios, MBI 02/19/16, pp.102-111).

1. Inmarsat C - SafetyNet (SAT-C) - Marine Broadcast System

a. Source and Format

Inmarsat-C is a satellite-based system, used for the transmission of data only; voice communication is not possible with INMARSAT-C. Appendix D (Capt R. DiNapoli), p. 9. Regular transmissions via this medium include those of "Inmarsat-C SafetyNET," which is an internationally-adopted, automated satellite system for promulgating weather forecasts and warnings, marine navigational warnings, and other safety-related information to all types of vessels. It is part of the GMDSS system. U.S. National Weather Service SafetyNET broadcasts are distributed using the Inmarsat-C satellite system of geostationary satellites, and are delivered in text-based format similar to the text messages contained in High Seas Forecasts. *Id*.

b. Frequency and Delivery Schedule

The U.S. National Weather Service (NWS) prepares high seas forecasts and warnings for broadcast via SafetyNET for each of three different ocean areas four times daily. In the case of the *El Faro*'s accident voyage, these messages were typically received on the vessel via the Sat-C terminal at approximately 0500 EDT, 1100 EDT, 1700 EDT, and 2300 EDT. (MBI Ex.268, pp.92-95).

c. Currency of Information

The NWS takes approximately 3 hours to process weather observations and run its model before its forecast is made available to the public. For example, if a forecast is issued at 1100 local time, it was based on weather observations taken approximately 3 hours earlier. (Franklin, MBI 05/17/16, p.136).

In the case of the accident voyage, the SafetyNet SAT-C transmittals of Forecasts and Advisories generally occurred at or near the same time as the tropical cyclone-related products were publicly disseminated by the National Hurricane Center. (MBI Ex.268, pp.92-95).

2. Bon Voyage System Weather Service (Applied Weather Technologies)

a. Source and Format

Applied Weather Technologies (AWT) provided the vessel with weather forecast information through the Bon Voyage System 7.0 (BVS). (Hale-Brown, MBI 05/18/16, p.19). According to AWT's brochure for BVS version 7, BVS "is a graphical marine voyage optimization system that provides on-board and around-the-clock weather-routing information…Using [an] on-board computer, BVS 7 provides the most recent weather and ocean data to the ship by broadband or email communications in a highly compressed format…This data is then used to generate color-enhanced maps and graphics that allow the ship's captain to easily view and interpret potential problem areas in advance." The *El Faro* directly received those services by email. (MBI Ex.268, p.298.) Emails from AWT indicate *El Faro* had BVS version 7.0.0.78 installed on the Master's computer in March 2014, and the bridge computer in June 2015. (Hale-Brown, MBI 05/18/16, pp.14, 22).

b. Frequency and Delivery Schedule

BVS generally distributed its weather information to the *El Faro* by email every six hours, at approximately 0500, 1100 , 1700, and 2300 EDT. (MBI Ex.268, pp.108-109).

c. Currency of Information

As stated above, for its forecasts, the U.S. National Weather Service takes approximately

3 hours to process weather observations and run its model before its forecast is made available to the public. (Franklin, MBI, 5/17/16, p. 136). Once NWS issues its forecasts, AWT then processes the data and runs its own wave model -- this process takes approximately 1.5 hours. AWT then packages the model for distribution to its clients. This entire process from beginning to end results in a 9-hour processing time between when the weather observations are taken and when the weather information is transmitted to the ships. (Hale-Brown, MBI 05/18/16, pp.62-63).

3. NAVTEX

a. Source and Format

NAVTEX is short for "Navigational Telex," an automated medium frequency system for broadcasting text over radio. There are stations located worldwide and, in the United States, transmissions originate from Coast Guard radio stations along the Atlantic, Gulf, and Pacific coasts, as well as in Alaska and Hawaii.[8] The system operates at 518 KHz. NAVTEX forecasts are configured to limit coverage to within 200 miles of the United States' coasts.[9] It was developed to provide low cost, simple, and automated means of receiving information aboard ships at sea within approximately 200 miles of the shore. A dedicated shipboard NAVTEX receiver is connected to a printer that provides hard copies of the telex transmissions. Typical broadcasts include information such as navigational warnings, meteorological warnings, ice reports, search and rescue information, etc. Appendix D (Capt R. DiNapoli), p. 9.

[8] U.S. Coast Guard, *NAVTEX Maritime Safety Broadcasts*, Sep. 8, 2016, http://www.navcen.uscg.gov/?pageName=NAVTEX. Accessed Feb. 22, 2017.

[9] Internet Archive capture of National Weather Service Marine Forecasts, https://web.archive.org/web/20150922082332/http://www.nws.noaa.gov/om/marine/navprod.htm (visited Aug. 19, 2017).

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FZNT25 KNHC 292120
OFFN04

NAVTEX MARINE FORECAST
NWS NATIONAL HURRICANE CENTER MIAMI FL
520 PM EDT TUE SEP 29 2015

...PLEASE REFER TO COASTAL WATERS FORECASTS (CWF) AVAILABLE
THROUGH NOAA WEATHER RADIO AND OTHER MEANS FOR DETAILED
COASTAL WATERS FORECASTS...

SOUTHEAST GULF OF MEXICO

.SYNOPSIS...THE LOW PRES PREVIOUSLY LOCATED OVER THE NE GULF OF
MEXICO HAS MOVED INLAND THIS AFTERNOON. ANOTHER AREA OF LOW PRES
OVER THE NW GULF WILL WEAKEN TO A SURFACE TROUGH AND SHIFT INTO
THE CENTRAL GULF THROUGH MID WEEK...AHEAD OF A COLD FRONT MOVING
INTO THE NORTHERN GULF THU. THE FRONT WILL SHIFT SOUTH AND STALL
FROM SW FLORIDA TO S TEXAS FRI...THEN BECOME DIFFUSE SAT.

.TONIGHT...SW TO W WINDS 5 TO 10 KT...SHIFTING TO W 10 TO 15 KT
AFTER MIDNIGHT. SEAS 3 TO 4 FT. SCATTERED SHOWERS AND ISOLATED
TSTMS.
.WED...W TO NW WINDS 10 TO 15 KT...BECOMING NW 5 TO 10 KT IN THE
AFTERNOON. SEAS 2 FT OR LESS.
.WED NIGHT...NW WINDS 10 TO 15 KT. SEAS 2 FT OR LESS. SCATTERED
SHOWERS AND ISOLATED TSTMS.
.THU...NW WINDS 10 TO 15 KT. SEAS 2 FT OR LESS.
.THU NIGHT...NW TO N WINDS 10 TO 15 KT. SEAS 2 FT OR LESS.
.FRI...NW TO N WINDS 10 TO 15 KT...INCREASING TO 15 TO 20 KT IN
THE AFTERNOON. SEAS 2 FT OR LESS...BUILDING TO 3 FT IN THE
AFTERNOON.
.FRI NIGHT...NW TO N WINDS 15 TO 20 KT...DIMINISHING TO 10 TO
15 KT AFTER MIDNIGHT. SEAS 3 FT.
.SAT...N WINDS 10 TO 15 KT...DIMINISHING TO 5 TO 10 KT IN THE
AFTERNOON. SEAS 3 FT IN THE MORNING...SUBSIDING TO 2 FT OR LESS.
.SAT NIGHT...N TO NE WINDS 5 TO 10 KT. SEAS 2 FT OR LESS.
.SUN...N TO NE WINDS 5 TO 10 KT. SEAS 2 FT OR LESS.

WITHIN 200 NM EAST OF THE COAST OF FLORIDA

.SYNOPSIS...TROPICAL STORM JOAQUIN NEAR 26.0N 71.0W 999 MB AT
2100 UTC MOVING W-SW OR 240 DEG AT 4 KT. JOAQUIN WILL REACH
25.8N 71.6W TONIGHT...25.5N 72.5W WED AFTERNOON...25.1N 73.3W
WED NIGHT...24.8N 73.9W THU AFTERNOON. LARGE NE SWELL WILL
CONTINUE TO MOVE ACROSS N PORTIONS OF THE AREA AND SPREAD SW
THROUGH MID WEEK.

.TONIGHT...S OF 27N...NW WINDS 5 TO 10 KT...SHIFTING TO W TO NW
10 TO 15 KT AFTER MIDNIGHT. N OF 27N...NW WINDS 10 TO 15 KT.
SEAS 3 FT S OF 27N...AND 4 TO 7 FT N OF 27N. SCATTERED SHOWERS
AND ISOLATED TSTMS.
.WED...S OF 27N...W TO NW WINDS 10 TO 15 KT. N OF 27N...NW WINDS
10 TO 15 KT...INCREASING TO 15 TO 20 KT IN THE AFTERNOON. SEAS
3 FT S OF 27N...AND 4 TO 7 FT N OF 27N. SCATTERED SHOWERS AND
ISOLATED TSTMS.
.WED NIGHT...NW WINDS 10 TO 15 KT S OF 27N...AND NW TO N 15 TO
20 KT N OF 27N. SEAS 3 FT S OF 27N...AND 4 TO 9 FT N OF 27N.
SCATTERED SHOWERS AND ISOLATED TSTMS.
.THU...TROPICAL STORM CONDITIONS POSSIBLE. NW WINDS 10 TO 15 KT S
OF 27N...AND NW 15 TO 20 KT N OF 27N. SEAS 3 FT S OF 27N...AND
4 TO 10 FT N OF 27N. SCATTERED SHOWERS AND ISOLATED TSTMS.
.THU NIGHT...TROPICAL STORM CONDITIONS POSSIBLE. S OF 27N...W TO
NW WINDS 10 TO 15 KT...INCREASING TO 15 TO 20 KT AFTER MIDNIGHT.
N OF 27N...NW TO N WINDS 15 TO 20 KT...INCREASING TO 20 TO 25 KT
AFTER MIDNIGHT. SEAS 3 FT S OF 27N...AND 4 TO 10 FT N OF 27N.
SCATTERED SHOWERS AND ISOLATED TSTMS.
.FRI...TROPICAL STORM CONDITIONS POSSIBLE.
.FRI NIGHT...TROPICAL STORM CONDITIONS POSSIBLE.
.SAT...TROPICAL STORM CONDITIONS POSSIBLE.
.SAT NIGHT...S OF 27N...W TO NW WINDS 10 TO 15 KT. N OF 27N...W
TO NW WINDS 15 TO 20 KT...BECOMING W 10 TO 15 KT AFTER MIDNIGHT.
SEAS 3 FT S OF 27N...AND 3 TO 9 FT N OF 27N.
.SUN...W TO NW WINDS 10 TO 15 KT S OF 27N...AND W 15 TO 20 KT N
OF 27N. SEAS 3 TO 8 FT.
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Figure B: NAVTEX Transmission from 5:20 p.m. September 29, 2015

b. Frequency and Delivery Schedule

NAVTEX forecasts broadcast by the Coast Guard and received aboard the *EL Faro* would have normally been broadcast from Miami at 0000 EDT, 0800 EDT, 1200 EDT, and 2000 EDT each day. (MBI Ex.268, p.48). For the accident voyage, the last four transmissions of NAVTEX messages that would have been received onboard the *El Faro* occurred at 0811 EDT, 1211 EDT, and 2012 EDT on September 30, 2015, and at 0013 EDT on October 1, 2015. (MBI Ex.268, p.48).

In addition to those products discussed above, there are numerous other weather broadcasts distributed by the NHC that are not specifically distributed to vessels. These are described in the NTSB's Meteorological Group Factual Report. (MBI 273, pp.15-78).

c. HF Voice Broadcasts (VOBRA)

The US Coast Guard broadcasts NWS high seas voice forecasts and storm warnings from six high seas communication stations including two located in Chesapeake, Virginia and New Orleans, Louisiana. ("USCG HF Voice." *National Weather Service*, March 26, 2015, http://www.nws.noaa.gov/om/marine/hfvoice.htm)(accessed May 9, 2016).

These broadcasts occur in the Single Side Ban (SSB) voice mode at regular intervals on multiple HF frequencies so as to be receivable at any time of day and at any distance from the transmitting stations out to several thousand miles or more. Offshore Forecasts, to include hurricane information, was included in the schedule at 0115, 0530, 0715, 1130, 1315, 1730, 1915, 1915, and 2330 EDT (MBI Ex.268, pp.138-139). As the vessel's GMDSS console was required to include an HF SSB receiver, the ship was capable of receiving HF voice broadcasts of NWS information at the time of the subject incident. Notably, these broadcasts transmit much of the same information that is contained in the High Seas Forecasts and similar information received via the INMARSAT-C SafetyNet system, but they are in voice format instead of text format. (MBI Ex.268, p.138).

4. Satellite Radio

Satellite radio could be heard on the VDR recording on the bridge. At 0110 local on 10/01 the Weather Channel could be heard on the satellite radio, but only briefly about the storm's impact to the mid-Atlantic states. Similarly, at 0113 the Weather Channel could be heard on the satellite radio, but only briefly about its impact to the New York area. These are cut-away reports from the normal programming; the Weather Channel is not available on Sirius XM.

At various times in the VDR transcript, the second and third mate reference the "Weather Channel." (MBI Ex.266, pp.60, 131, 249, 265, 266, and 290). Nothing is discussed in depth, and it cannot be determined whether the "Weather Channel" reports referenced in the VDR transcript were watched on the television or heard on the satellite radio. The *El Faro* could receive television at sea for about a day out of Jacksonville. (Baird, MBI 02/18/16, p.54). This was another source of weather information available to the vessel. These discussions captured on the VDR occurred at the following times: 0744, 1419, 2022, 2241, 2242, and 2356 EDT on September 29, 2015, and 0108 EDT on October 1, 2015.

H. Master Decision-Making At Sea - Legal and Operational Framework

Throughout the investigation, several Coast Guard and NTSB investigators questioned the oversight role that TSI's shoreside management played with respect to weather monitoring and the Master's navigation decisions while at sea. The company's SMS provisions in this regard, and any assessment of them in the context of the investigation, should be done in light of the legal and operational framework under which deep draft commercial vessel Masters have historically operated worldwide. This legal and operational framework has longstanding precedent, and reflects the practical realities of commanding a vessel at sea that have existed, and continue to exist, since the advent of transnational shipping.

The company's SMS considers the Master to be in "supreme command of the vessel," and who "has the overriding responsibility for the safe operation of the vessel and the authority and discretion to take whatever action he/she considers appropriate in the best interest of the crew, vessel and marine environment." (MBI Ex.25, p.108). These provisions in the company's SMS, and the principles behind them, are established by law. ISM Code, Part A, Reg. 5.2 ("The Company should ensure that the SMS operating on board the ship contains a clear statement emphasizing the master's authority. The Company should establish in the SMS that the master has the <u>overriding authority</u> and the responsibility to make decisions with respect to safety and pollution prevention <u>and to request the Company's assistance as may be necessary</u>.") (Emphasis

Added.)

Not only are these provisions required by law, there are important safety reasons why the Master, not shoreside management, is exclusively vested with this authority.

As one authoritative treatise put it: "[p]ersons in offices ashore, no matter how experienced they are at sea, do not see what is happening immediately on the ship in the totality of the circumstances." International Law of the Shipmaster (2009), Cartner, Fiske and Leiter, 9.10.1, p. 158. In fact, history has "demonstrate[d] that decisions by those in the office ashore may sometimes be slow, improper, unsuitable or simply incompetent." *Id*., (citing U.S. Coast Guard Marine Board of Investigation in the Matter of the Loss by Grounding of the VLCC Amoco Cadiz). As a result of this history, it was "recognized that there is a need to reinforce the power of the person on the spot, who should have the authority to make proper decisions with regard to safety and environmental protection." *Id.* The provisions of the ISM Code and SOLAS discussed below were undoubtedly a result of, and a reflection of, this recognition. *Id.*

As set forth in more detail below, the U.S. Coast Guard and the relevant safety committees of the International Maritime Organization (IMO) have repeatedly reaffirmed this legal and operational framework in the interest of safety. TSI's SMS was entirely consistent with these longstanding principles.

1. SOLAS - Chapter V, Regulation 34 and 34-1

Chapter V of the SOLAS Convention, to which the U.S. is a party, addresses various aspects of the safety of navigation and voyage planning. Under SOLAS Regulation 34, the Master is vested with the legal authority and responsibility for preparing and carrying out the voyage plan, taking into account all known navigational hazards and adverse weather conditions. (SOLAS Chapter V, Regulation 34; MBI Ex.086).

Chapter V, Regulation 34-1 of the SOLAS Convention, entitled "Master's Discretion," states the owner or operator of a vessel "shall not prevent or restrict the master of the ship from taking or executing any decision which, in the master's professional judgment, is necessary for safety of life at sea and protection of the marine environment." (SOLAS Chapter V, Regulation 34-1).

Regulation 34-1 – which limits shoreside management's role in restricting the Master's decision-making in regard to safe navigation – was originally proposed to relevant bodies at the IMO, by the United States, in 2000. (See IMO Maritime Safety Committee, MSC Circular 72/10/3, dated February 18, 2000, Proposed Revisions to SOLAS Chapter V, submitted by the United States (Attachment 10).

2. International Safety Management Code

a. Implementation of U.S. Notice of Proposed Rulemaking and Final Rule

In 1997, the U.S. Coast Guard conducted a rulemaking, implementing the provisions of Chapter IX of the International Convention for the Safety of Life at Sea (SOLAS) 1974, as amended, commonly referred to as the ISM Code. See Notice of Proposed Rulemaking, 62 Fed. Reg. 23705 (May 1, 1997) and Final Rule, 62 Fed. Reg. 67492 (Dec. 24, 1997) (Attachment 11a-b). During the rulemaking process, comments were submitted to the Coast Guard suggesting that shoreside management, specifically the Designated Person under the ISM Code, should share responsibility for operation of the vessel. In rejecting this proposal, the U.S Coast Guard stated:

> "The Coast Guard disagrees … the designated person does not have a responsibility for operation of the vessel. The designated person's responsibility is to monitor the safety management system of the company and the vessel(s), as directed by the responsible person. If problems arise with the policies and procedures for the safe operations of the vessel which the Master does not believe he or she has the right tools to manage, those problems should be communicated to the vessel's owner. The Master can communicate through the safety management system, or directly to the vessel owner, or through the designated person to the vessel's owner." 62 Fed. Reg. at 67502.

Regarding the Master's overriding authority, and the autonomy that he/she needs to provide effective leadership at sea, the Coast Guard further stated:

> "the Master is the responsible person's representative on the vessel and all authorities that can be expected of the Master should be supported by the safety management system. The Master has overriding responsibility and authority to ensure that the vessel is operated safely, and consistently with all applicable laws. <u>When the Master is not specified, it is impossible to expect the individual employed as the Master to provide proper leadership or decision making clarity</u>. Where the Master follows international, national, coastal, or local regulations or directions, regarding management of a vessel, he/ she is making decisions on how to use these factors in the efficient and safe operation of the vessel taking into account the policies provided by the safety management system." 62 Fed. Reg. at 67497 (emphasis added).

From a communications perspective, the ISM Code contemplates that communications will be initiated <u>by</u> the Master <u>to</u> shoreside management for support as needed. In the very same sentence of the ISM Code that requires the Company's SMS to vest overriding authority in the Master, the Code also provides that the SMS must grant the Master the authority and means "<u>to request the Company's assistance as may be necessary.</u>" (ISM Code, Part A, Reg. 5.2.)

The company's SMS is entirely consistent with these principles.

b. U.S. Coast Guard Model SMS

The U.S. Coast Guard Headquarters Office of Operating and Environmental Standards (G-MSO-2) published a "Safety Management System Manual" (SMS Manual), which was designed to serve as a template or example for vessel operators to use in developing their own safety management systems. See attached Safety Management System Manual, (Attachment 12).

This document addresses navigation decision-making and the assessment of weather as follows:

> The vessel will be required to operate in constantly changing environments. It is important to constantly monitor the changing weather conditions and be aware how the weather can dramatically affect the vessel's behavior….[i]t is the ultimate responsibility of the master to constantly monitor and assess the weather conditions…"
>
> Safety Management System Manual, (Attachment 12), p.50.

The company's SMS is entirely consistent with the Model SMS Manual published by the Coast Guard.

3. TSI's SMS

TSI was issued a Document of Compliance by ABS on behalf of the USCG, pursuant to the SOLAS Convention, certifying that TSI's SMS was audited and complies with the ISM Code. See attached Document of Compliance, dated August 21, 2014 (Attachment 13). The *El Faro* was also issued a Safety Management Certificate, applicable to the vessel itself, by ABS on behalf of the USCG, pursuant to the SOLAS Convention. It certifies that that *El Faro*'s SMS was audited and complies with the ISM Code. See attached Safety Management Certificate for the *EL FARO*, dated October 8, 2014 (Attachment 3).

The heavy weather monitoring procedures, contained in TSI's SMS at the time of the accident voyage, were originally implemented in 1996, and modified and expanded over the years in 2002, 2008, and 2009. (MBI Ex.198, p.193). Under these procedures, the Master is responsible for the monitoring and analysis of the weather along the vessel's intended track, and to take whatever action is necessary to prevent damage to the vessel from heavy weather. Additionally, under the SMS, the Master is required to <u>advise</u> shoreside management of speed reductions and/or course changes due to adverse weather. (MBI Ex.198, p.206) (emphasis added). Under TOTE's SMS, vessel Masters also kept in contact with shoreside management through routine communications ashore, including the noon reports, arrival reports, and departure reports, and other communications involving the vessel and future operations. Updates were required if an ETA changed by more than 6 hours. (MBI Ex.198, p.226 (section 11.5.3.1)).

The Master is not required under TSI's SMS, or any applicable law, to seek permission to make course changes or take other action the Master deems necessary in the interest of safe navigation, and safety of the vessel and crew. The evidence indicates that, in practice, Masters who worked aboard the *El Faro* and other TSI-managed vessels were provided this autonomy and overriding authority, as required by the ISM Code.

The witnesses in the investigation testified consistent with these SMS provisions. (Masters operating TSI-managed vessels are in control of the vessel with the overriding authority for the safety of the vessel and its crew. (Greene, MBI 02/17/16, p. 52); (Lawrence, MBI 02/20/2016, pp.29, 30 and 58); (Cadorette-Young, NTSB 12/02/15, p.78); (Loftfield, MBI 02/18/16, p.12). The navigation and operation of the vessels are controlled by the Master. (Chancery, MBI 02/24/16, p.53). Masters and the bridge team make whatever adjustment they need for weather. (Cadorette-Young, NTSB 12/02/15, p.77). The Master must only notify the company where there is a course change or speed reduction due to adverse weather. (MBI Ex.198, OMV, section 10.8.2). He or she does not need permission to do so. (Morrell, MBI 02/16/16, p.51).)

Under TOTE's SMS, shoreside management is available 24 hours a day to provide whatever assistance, advice, or support the Master needs, in keeping with ISM Code, Reg. A5.2. (Stith, NTSB 10/07/15, p.39). The evidence indicates that TSI shoreside management, in fact, supported Masters and the vessels when they needed such support. (Loftfield, MBI 02/18/16, p.176).

a. Weather Monitoring

The SOLAS Convention and ISM Code, and its implementing regulations and policies discussed above, contemplate and require many things of shoreside management. But monitoring weather from ashore in relation to a vessel's track, and providing affirmative oversight and direction of the Master's navigation decisions at sea, is not among them. In fact, the ISM Code does not mention weather monitoring by shoreside management, or the subject of weather at all, in its text. In 1997, when the Coast Guard implemented the ISM Code into U.S. law through a rulemaking and public comment process as described above, the subject of weather monitoring, or any subject involving weather, was not mentioned or discussed in either the Noticed of Proposed Rulemaking, the public comments, or in the Final Rule itself. See Notice of Proposed Rulemaking, 62 Fed. Reg. 23705 (May 1, 1997) and Final Rule, 62 Fed. Reg. 67492 (Dec. 24, 1997) (Attachment 11a-11b). Nowhere in the Coast Guard's model SMS provisions for the assessment of weather, or anywhere else in the model SMS manual, does it mention or even suggest that shoreside management should be involved in monitoring the vessel's track in relation to the weather or advising the Master about the weather or what course to take.

4. Shoreside Communications: Regarding Tropical Weather Systems

Some investigators have examined the amount of email traffic generated between shoreside personnel and the *El Faro* for Hurricane Danny and Tropical Storm Erika, which occurred in August 2015, and compared it to the amount of such email communications which occurred in the case of Joaquin. The implication of some questions during the investigation was that Hurricane Danny and Tropical Storm Erika were handled differently under the company's

SMS than Joaquin was handled. This is a misconception that we feel, in fairness, must be addressed.

a. 2015 Safety Alert Was A Routine Reminder of the Upcoming Hurricane Season

Some investigators questioned why a "safety alert" was issued for Hurricane Danny, but not for Joaquin. Captain Lawrence issued Safety Alert 15-008 when Danny became the first hurricane of the 2015 season. He used the alert to advise TOTE Services Inc. "vessels, in all oceans, should review their general and vessel specific heavy weather procedures and be prepared for the unexpected occurrence." (MBI Ex.45) He testified that he issued the Safety Alert to notify the fleet that hurricane season was beginning for the year, and to remind them that they needed to take preventative measures and be ready for the season. (Lawrence, MBI 02/20/16, p.29). Given the purpose of the alert - to remind the fleet of the upcoming hurricane season - no similar safety alert was issued for Tropical Storm Erika or Hurricane Joaquin.

b. Email Traffic Varies by Storm Depending on Expected Storm Track

Some investigators questioned why the amount of email traffic between the *El Faro* and shoreside personnel for Hurricane Danny and Tropical Storm Erika was larger than the amount of email traffic occurring during Joaquin. A close examination of the vast majority of the communications involving Danny and Erika reveals that those communications were largely focused on the impact the storms would have on terminal operations (which in some cases prevented vessels from entering port, and thereby impacted the vessel's schedule). In addition, Danny and Erika were forecasted, long in advance, to impact TOTE's terminals and the vessels' routes. Joaquin, by contrast, was not forecasted far in advance, the predicted path was away from the vessel's anticipated trackline, and the storm was never predicted to impact the terminals.

The company's communications, in regard to these three storms, was best described by the Director of Ship Management:

> In reference to Erika and Danny, those were both bearing down on our ports of call. Erika was bearing down on San Juan and Danny was bearing down on San Juan. And then bearing down on Jacksonville. So those [storms] would have directly affected not only our port operations, but our ships if we had scheduled a ship to be in port those days. Those hurricanes were forecasted to be out as much of a week bearing down on our two ports. And so obviously they had a significant amount of attention in the ports, significant amount of attention in the news media, and obviously we had to pay close attention to what we were planning for bringing our ships in….[a]nd obviously what's going to be happening if there's a hurricane bearing down on that port. Because you have nowhere to run. A port is – you can't run from a hurricane. And in contrast, since we're talking about hurricanes, you know Joaquin was – as recently as several days before the incident a tropical depression heading to the North Atlantic.

(Fisker-Anderson, MBI 02/19/16, p.52)

The DP, Captain Lawrence, similarly testified. In discussing the differences between the communications about Joaquin, when compared to the number and nature of communications for Danny and Erika, the DP testified that Erika and Danny were storm systems that were headed directly towards Puerto Rico (as well as Jacksonville in the case of Erika), and were forecasted to do so many days in advance. (Lawrence, MBI 02/20/16, pp.67-68). These storms were also forecasted to track into the area where the vessels on the Puerto Rico run would normally transit. *Id.* By contrast, Joaquin was not forecasted to track towards Puerto Rico or Jacksonville, and its forecasted track looked nothing like the forecasts for Danny and Erika. *Id.*

The following graphic further illustrates the differences between these storms, their differing impacts to shoreside terminal operations, and the advance warning and predictability that occurred in the case of Erika and Danny (when compared to Joaquin).

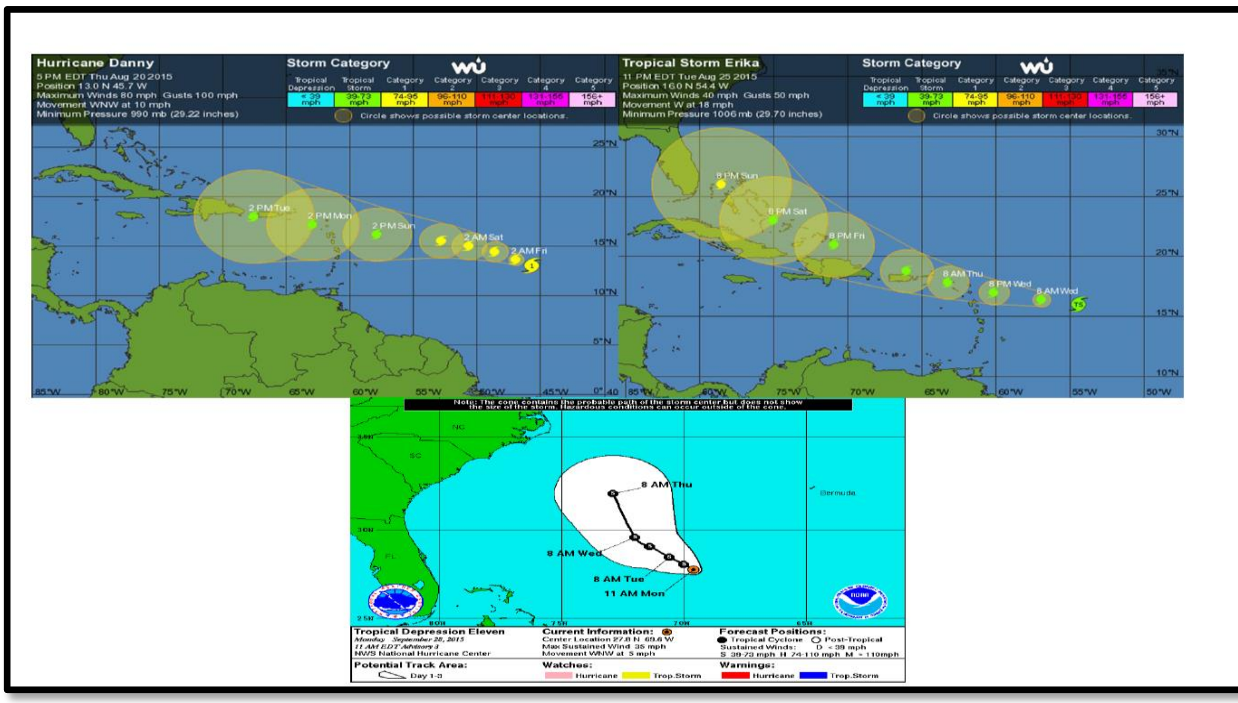


Figure C: Comparison of Danny (top left), Erika (top right), and Joaquin (bottom)

c. *El Faro*'s communications Regarding Erika and Joaquin followed the Company's SMS Protocol

Some investigators questioned why Captain Lawrence affirmatively sent an email to the Master of the *El Faro* in the case of Erika, requesting information about the voyage plan, but did not affirmatively do so in the case of Joaquin.

However, upon close examination of the email traffic between shoreside management and the Master of the *El Faro* reveals that, for **both** Erika and Joaquin, the Master of the vessel was the first to initiate contact with shoreside management, without any solicitation from them. In other words, the Master did exactly what was called for under the SMS in both cases.

In the case of Erika, a close examination of the email traffic reveals the following sequential communications took place between the Master of the *El Faro* and shoreside management:

- At approximately 1039 EDT on August 25, a TMPR employee at the Jacksonville terminal sent an email to 13 shoreside personnel in Jacksonville and San Juan (as well as 3 vessel masters), with the subject "Tropical Storm Erika update for SJU this week." The email provided information pertaining to actions the Coast Guard was taking to implement an indefinite port closure, due to tropical storm Erika. No information is requested from the vessels' masters, and the DP is not copied on this email. (MBI Ex.004, pp.42-43). This email has nothing to do with the Master's weather avoidance strategies, and provides no new weather forecast information that the vessels do not already have.
- At approximately 1046 EDT on August 25, the President of TMPR responds, stating: "Thanks for the update Don and lets make sure we stay in communication. Stay safe to everyone at sea!". The DP is not copied on this email. (MBI Ex.004, pp.41-42). This email, too, has nothing to do with the Master's voyage planning and weather avoidance strategies.
- At approximately 1210 EDT on August 25, Captain Davidson replies (not in response to any question), and advises (a) that he has reviewed the weather and plans to avoid the storm by taking the Old Bahama Channel; (b) that the new route will add approximately 160 miles to the voyage, but they it is a safer route that allows options if Erika's track changes; and (c) that they are making weather preparation plans, including plans to secure cargo. The DP is not copied on this email. (MBI Ex.004, pp.41-42).
- At approximately 1424 EDT on August 25, the Director of Ship Management responds to the Master of the *EL FARO*: "Thanks Capt Mike. Good plan. Stay safe." The DP is not copied on this email. (MBI Ex.004, p.41).
- At approximately 1526 EDT on August 25, the Vice President Commercial Marine Operations responds to the Master of the *EL FARO*: "Mike, Voyage plan noted and concur with your assessment. Please keep all update as the situation changes." The DP is not copied on this email. (MBI Ex.004, p.45).

The above communications, regarding weather avoidance and voyage planning, were entirely consistent with the company's SMS; the Master was advising shoreside management of course changes due to adverse weather as required by the SMS. Not having been copied on any of the previous email exchanges above, the DP participates in the following exchanges.

- At approximately 1706 EDT on August 26, more than 24 hours since the Master advised shoreside management about his voyage plan and course change, the DP (copying other shoreside staff) sent the following in email (a new email string) to Captain Davidson: "to ensure we are all on the 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." (MBI Ex.004, p.59). In his email, the DP made clear that he was generally being kept apprised by other shoreside managers, but nonetheless wished to be directly included in the discussions going forward.[10] *Id.*

- At approximately 1949 EDT on August 26, Captain Davidson responds to the DP, copying other shoreside staff, reiterating his plans to use the Old Bahama Channel to avoid Erika that he had stated the previous day, and the benefits to doing so; he also provides updated information on the vessel's speed and the Master's assessment and intentions in regard to the potential port closure in San Juan. (MBI Ex.004, pp.58-59). In other words, Captain Davidson provided the DP with essentially the same information that he previously provided to other shoreside managers, but slightly updated.
- At approximately 1225 EDT on August 27, Captain Davidson sent another email to company management that included the updated storm information and preparation plans for the vessel and crew. He also informed the DP that he would address a number of items with the crew at the safety meeting later in the day. (MBI Ex.004, p.81).
- At 1109 and 1306 EDT on August 28, Captain Davidson provided additional reports to the DP (and other shoreside management), updating the status of the weather reports they have received, the weather they are experiencing, the status of the port closure, information about pilots, and expected docking time in San Juan. (MBI Ex.004, pp.80-81).

Erika was consistently forecast, upwards of 5 to 7 days in advance of its impact, to impact the vessel's track. Accordingly, those communications between the *El Faro* and shoreside staff played out over several days. By contrast, Joaquin was initially predicted to track north, away from the *El Faro*¸ but the forecast quickly changed. Thus, the time between the forecast and the impact on the vessel was considerably less in the case Joaquin, and in the most critical period, developed during the overnight hours.

Specifically, in the case of Joaquin, the Master of the *El Faro* sent a report to shoreside staff (including the DP), regarding Joaquin, at 10:22 AM on September 30, approximately 12 hours after the vessel left Jacksonville. In this report, the Master of the *El Faro* provided details of the hurricane, including its location, projected wind speed, the direction the system was tracking, and his intended strategy to avoid the storm. This report is similar in nature to the report the Master of the *El Faro* provided in the case of Erika, on August 25 at 12:10. The report from the *El Faro*'s Master regarding Joaquin, on September 30, was acknowledged by Mr. Fisker-Andersen at approximately 3:45 PM. If daily email updates to shore were intended to be provided, as seems to be the case in regard to Erika, the next update by the Master would have been sent to shoreside management at approximately 10:22 AM on October 1, but the vessel was lost prior to that time.

Simply stated, communications for the two weather systems - in regard to the Master's voyage planning and weather avoidance strategies - followed essentially the same protocols as called for in the SMS. The one minor difference is, in the case of Erika, the DP was initially not included in the discussion regarding, and then later he asked to be brought into those email

[10] The DP's follow-up email directly to the Master of the *El Faro* was not required (or prohibited) under the SMS.

exchanges.

I. At-Sea & In-Port Watches & Daily Routine

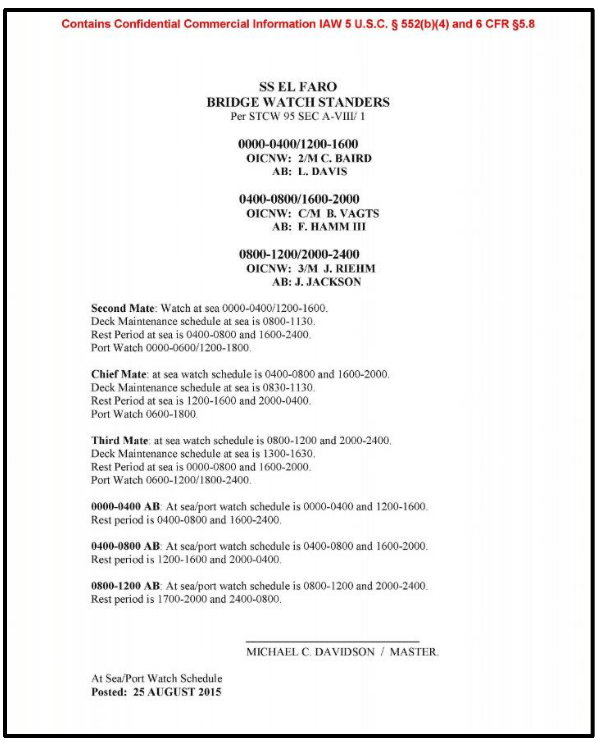
The company's SMS contains specific provisions addressing the conduct of watches, at-sea and in-port and also contains numerous checklists that pertain to those watches and various routines. (See MBI Ex.25 - OMV and MBI Ex.336 - OMV Forms Addendum.)

1. At Sea

a. Deck (licensed & unlicensed)

The provisions concerning at-sea bridge watches include those in OMV, Section 10.13. Some of the specific forms/checklists that are particularly relevant to at-sea bridge routines include: Form 16A-Pre-Arrival & Pre-Departure, Form 16B-Change of Bridge Watch, and Form 16C-Daily Underway Bridge Equipment. (See MBI Ex.336, p.14)Mariners testified regarding the use of these, including the checklist to assist in the watch turnover. (Berrios, MBI 02/10/17, p.850).

The *El Faro* followed a "4-on/8-off" bridge watch schedule, with the Second Mate standing the 0000-0400 and 1200-1600 watches, the Chief Mate standing the 0400-0800 and 1600-2000 watches, and the Third Mate standing the 0800-1200 and 2000-2400 watches. The *El Faro* Deck Watch Schedule (Bridge and Day work), posted on August 25, 2015, is included below in Figure D.



Contains Confidential Commercial Information IAW 5 U.S.C. § 552(b)(4) and 6 CFR §5.8

SS EL FARO
BRIDGE WATCH STANDERS
Per STCW 95 SEC A-VIII/ 1

0000-0400/1200-1600
OICNW: 2/M C. BAIRD
AB: L. DAVIS

0400-0800/1600-2000
OICNW: C/M B. VAGTS
AB: F. HAMM III

0800-1200/2000-2400
OICNW: 3/M J. RIEHM
AB: J. JACKSON

Second Mate: Watch at sea 0000-0400/1200-1600.
Deck Maintenance schedule at sea is 0800-1130.
Rest Period at sea is 0400-0800 and 1600-2400.
Port Watch 0000-0600/1200-1800.

Chief Mate: at sea watch schedule is 0400-0800 and 1600-2000.
Deck Maintenance schedule at sea is 0830-1130.
Rest Period at sea is 1200-1600 and 2000-0400.
Port Watch 0600-1800.

Third Mate: at sea watch schedule is 0800-1200 and 2000-2400.
Deck Maintenance schedule at sea is 1300-1630.
Rest Period at sea is 0000-0800 and 1600-2000.
Port Watch 0600-1200/1800-2400.

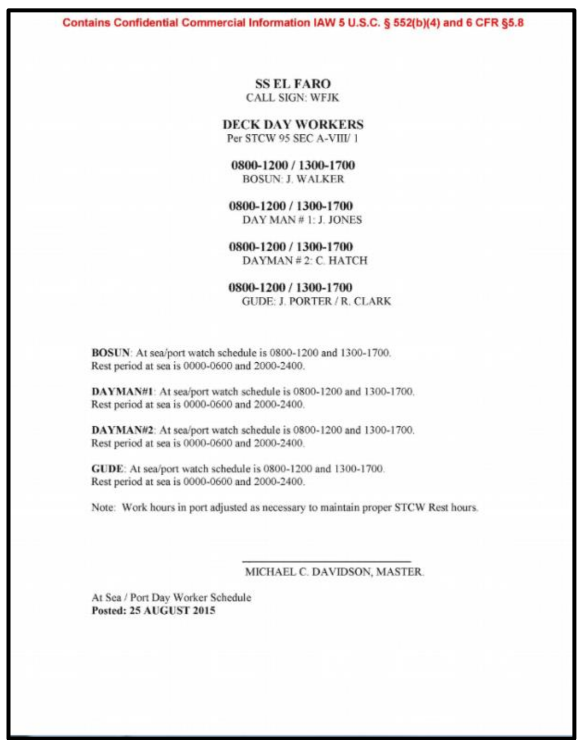
0000-0400 AB: At sea/port watch schedule is 0000-0400 and 1200-1600.
Rest period is 0400-0800 and 1600-2400.

0400-0800 AB: At sea/port watch schedule is 0400-0800 and 1600-2000.
Rest period is 1200-1600 and 2000-0400.

0800-1200 AB: At sea/port watch schedule is 0800-1200 and 2000-2400.
Rest period is 1700-2000 and 2400-0800.

MICHAEL C. DAVIDSON / MASTER.

At Sea/Port Watch Schedule
Posted: 25 AUGUST 2015



Contains Confidential Commercial Information IAW 5 U.S.C. § 552(b)(4) and 6 CFR §5.8

SS EL FARO
CALL SIGN: WFJK

DECK DAY WORKERS
Per STCW 95 SEC A-VIII/ 1

0800-1200 / 1300-1700
BOSUN: J. WALKER

0800-1200 / 1300-1700
DAY MAN # 1: J. JONES

0800-1200 / 1300-1700
DAYMAN # 2: C. HATCH

0800-1200 / 1300-1700
GUDE: J. PORTER / R. CLARK

BOSUN: At sea/port watch schedule is 0800-1200 and 1300-1700.
Rest period at sea is 0000-0600 and 2000-2400.

DAYMAN#1: At sea/port watch schedule is 0800-1200 and 1300-1700.
Rest period at sea is 0000-0600 and 2000-2400.

DAYMAN#2: At sea/port watch schedule is 0800-1200 and 1300-1700.
Rest period at sea is 0000-0600 and 2000-2400.

GUDE: At sea/port watch schedule is 0800-1200 and 1300-1700.
Rest period at sea is 0000-0600 and 2000-2400.

Note: Work hours in port adjusted as necessary to maintain proper STCW Rest hours.

MICHAEL C. DAVIDSON, MASTER.

At Sea / Port Day Worker Schedule
Posted: 25 AUGUST 2015

Figure D: *El Faro* Deck Watch Schedule

The at-sea watch (and work) schedule provided for the required 10 hours mandated rest, per STCW requirements. The work/rest hours were tracked on a record sheet and reviewed for compliance. (MBI Ex.283). Captain Davidson was cognizant of rest hours and would sometimes take over watches for a few hours and send his mates to rest to ensure they were rested. (Torres, NTSB 12/03/15, pp.52-53); (Ringlein NTSB 11/03/15, p.58); (Stith, NTSB 10/07/15, pp.92-93).

Various mariners provided testimony confirming that their experience was consistent with typical at sea routines as well as consistent with the OMV. Some examples of that testimony follow:

- A former Master testified that his at-sea duties included: being on the bridge when docking and undocking, arriving, and departing port; filing electronic notice of arrival; taking over the bridge watch at 0600 to relieve the Chief Mate early so he could work on other matters and assist with the Chief Mate staying within STCW hours requirements; handling daily email and correspondence; tracking the status of certificates and upcoming inspections; and payroll. He also had a habit of walking a certain target distance each day, so he spent a lot of time walking on deck to see what was being done, to ensure proper steel preservation techniques were being used. He had a couple days at sea during each voyage where his workday was only 8 hours long. (Loftfield, MBI 02/18/16, pp.153-156)

- The Chief Mate was in charge of checking lashings around deck. (Axelsson, NTSB 11/03/15, p.80); (Axelsson, MBI 05/16/16, p.154); (Vagts, NTSB 12/06/15, p.11); (Vagts, MBI 02/24/16, p.134). The Chief Mate made rounds of the holds every morning. (Axelsson, NTSB 11/03/15, p.82); (Stith, NTSB 10/07/15, pp.45-46); (Thompson, NTSB 12/06/15, p.61). Other Mates also checked lashings during their rounds. (Berrios, NTSB 12/06/15, p.12); (Berrios, MBI 02/19/16, pp.18-19); (Baird, NTSB 12/06/15, pp.57-58); (Baird, MBI 02/18/16, pp.45-46); (Torres, NTSB 10/09/15, p.38); (Torres, MBI 02/25/16, pp.50-51,70-71); (Walker, NTSB 12/03/15, p.48); (Walker, MBI 02/23/16, p.16); (Stith, MBI, 05/24/16, p.24).

- A former *El Faro* Second Mate testified that he was responsible for all navigation and voyage planning. He was generally responsible for the bridge and all equipment on the bridge. Outside his watch-standing duties, he would turn to other duties from 0800 to 1100, which included exercising the fire dampers, by opening and closing them. (Baird, MBI 02/18/16, p.91).

At sea, all spaces in *El Faro* had safety and security rounds done on them, with shipboard personnel physically visiting <u>each of the spaces</u>. (Loftfield, MBI 02/18/16, p.8). There were rounds done to check the lashings on all the cargo on a daily basis. (Baird, MBI 02/18/16, p.151). If the ship were to run into heavy weather, the crew would normally check all the lashings on the 2nd, 3rd, and 4th decks to make sure "everything was tight" and properly tied down and secured. (Baird, MBI 02/18/18, p.45). During heavy weather chains can loosen, so the crew would check them every day, sometimes twice a day. (Baird, MBI 02/18/16, p.84). However, if the weather was so severe that it would be unsafe to do a round, the round was not made. (Baird, MBI 02/18/16, p.151).

The balance of the deck department, when not on watch, had day work assigned regarding routine maintenance and repair. (Walker, MBI 02/23/16, pp.113-144).

The following excerpts from the VDR transcript indicate that the crew aboard the *El Faro* secured the vessel for heavy weather during the final voyage:

SEPTEMBER 29, 2015	
CAPT 07:18:56.6 07:19:01.1	so I guess when you address the men today let 'em know we got some weather.
CM 07:19:01.1 07:19:01.8	absolutely.
CAPT 07:19:02.0 07:19:04.5	we have diverted slightly.
CM 07:19:04.5 07:19:06.1	first order of business.
CAPT 07:19:06.6 07:19:17.2	and take a hard look at some of that cargo down there. delegate the men (to look at) the lashings as you deem necessary.
*******	*******
AB-2 13:03:51.1 13:03:52.7	pack (your) pipes (up) for *.
SUP-1 13:03:52.8 13:04:01.5	absolutely. * * bottles secured. pipes are uh– pipes are all lashed down (just/so) yeah that should be alright.
*******	*******
2M 15:47:26.4 15:47:42.8	well we're on– on the track right now. and uhhh one-three-eight. so the boatswain is * * the boatswain and his (merry) men (said that) he went down and uh tightened up the lashings on second deck.
CM 15:47:43.0 15:47:48.4	yeah they should have been workin' on the uh * * the midship trailer. you'll get good beam *.
2M 15:47:44.6 15:47:47.0	okay so he's still on...
2M 15:47:48.4 15:47:50.3	I did– I did main deck.
CM 15:47:49.9 15:47:50.9	yeah that's all I (did).
2M 15:47:50.4 15:47:52.4	oh okay. yeah. I know you did it.
CM 15:47:52.3 15:47:57.5	I told him do second deck you (do main/two “B”)– (once he gets back up) * * *.
2M 15:47:54.7 15:47:54.9	yeah.
2M 15:47:57.4 15:47:58.9	okay. perfect.
CM 15:47:58.7 15:48:05.7	(secure for/stay clear)– secure for sea then we'll log the hourly (weather) here and I got this. thanks.
*******	*******
AB-3 22:39:11.3 22:39:15.9	well @SA’s got that mess all secured– there's not even a napkin (layin'/hangin') out there.

3M 22:39:24.0 22:39:33.2	yeah– we're gunna be in for a rough night.– as luck would have it– it's gunna fall right during our rest period I think.
AB-3 22:39:32.9 22:39:33.4	yeah.
3M 22:39:33.5 22:39:40.1	during the worst of it. * * restless night. but again– maybe I'm just bein' a...
AB-3 22:39:40.2 22:39:55.6	I looked around– made sure anything that rolled around– (might) wake me up– I got it all wedged in. put in a drawer or something. (making) clunking noises- and irritations.

See, *El Faro* VDR Transcript, pp.54-55, 110, 145-146, 264.

b. Engine

The provisions concerning at-sea engine watches include those in OMV, Section 6.6. The specific form/checklist that is particularly relevant to in-port engine routines includes: Form 16D-Change Of Engine Watch. (MBI Ex.336, p.14).

One Third Engineer stood the 0000-0400 and 1200-1600 watches, the Second Engineer stood the 0400-0800 and 1600-2000 watches, and the other Third Engineer stood the 0800 to 1200 and 2000 to 2400 watches. Specific assignments included: a Third Assistant Engineer was generally responsible for water onboard, the Second Assistant Engineer was generally responsible for the boilers, and the other Third Assistant Engineer was generally responsible for lube oil. (Robinson, MBI 02/23/16, p.12).

An *El Faro* Chief Engineer testified in detail as to his daily routine. The day would start with a meeting in the engine room. The First Engineer would assign maintenance tasks and the daily schedule. The Chief Engineer would try to take care of paperwork before the day started, so he was available in the Engine Room. The First Engineer ran the day-to-day activities, but the Chief Engineer sought to be available whenever needed. (Robinson, MBI 02/23/16, p.12). The Chief Engineer also did a visual inspection of the machinery areas and checked the logs when he first entered the engine room in the morning. *Id.*

The Chief Engineer also monitored STCW rest hours. He did so by collecting the overtime sheets and monitoring engineers' hours. He noted they were trained on what they were allowed to do. (Robinson, MBI 02/23/16, p.12). When a new engineer came on, his or her watch was supplemented by more experienced watch engineers standing the watch, with the new engineer. The relieved watch engineer would work an extra two hours overtime after his or her watch, and the relieving watch engineer would work an extra two hours before his or her watch. This did not impact compliance with the STCW requirements. (Robinson, MBI 02/23/16, p.22).

The First Engineer monitored AMOS and assigned tasks as maintenance was scheduled. Similarly, he would close the items in AMOS when completed. (Robinson, MBI 02/23/16, p.13).

2. In-Port Watches

The provisions concerning in-port watches include those in OMV, Section 10.15. The specific form/checklist that is particularly relevant to in-port watch routines includes: Form 16BB-Change of Port Deck Watch. (MBI Ex.336, p.14).

Because the *El Faro* was on a steady run, the port routine was regimented and consistent. All hands knew what to expect each port visit.

The Master's duties in port included personnel and administrative matters as well as oversight of loading and stability issues. The Master's administrative workload varied depending on the number of persons getting on and off the vessel. He reviewed STCW hours of crew to ensure compliance with the work/rest requirements. He interacted with the Port Engineer and other port-side support. When preparing for departure from the port, the Master ensured all pre-departure gear testing was performed, interacted with the pilot, and confirmed final cargo loading. (Loftfield, MBI 02/18/16, p.17). One Master estimated his in-port workday was approximately 13-hours long. (Loftfield, MBI 02/18/16, p.154).

The Chief Mate would first meet with shoreside personnel, upon arrival, to discuss the plan for discharging and loading, including how much cargo they were to load, what the ballast would be, and anything specific or unique that needed to be discussed. On the actual departure day, the Chief Mate would basically do day work, and the Second and Third Mate would stand a 6-hours on / 6-hours off watch. The Chief Mate would supervise the cargo operations throughout the day, which would include ensuring every piece of cargo was stowed and lashed properly. Towards the end of the day, once the loading was nearly or actually completed, the Chief Mate would meet with shoreside personnel from TMPR to review and approved the stability documentation and related cargo information, take the drafts of the vessel, and then return to the vessel to further review and verify the stability information and related cargo documentation, as the vessel was being prepared for departure. (Torres, MBI 02/25/16, pp.7-8, 31).

The Third Mate stood in-port cargo watch from 0600-1200 and 1800-2400, and the Second Mate Stood in-port cargo watch from 0000-0600 and 1200-1800, as noted in Figure D above.

Port mates were often used during in-port cargo operations, when available. According to a former *El Faro* Chief Mate, the role of the port mate was to make the cargo operations more efficient and to allow greater opportunity for rest to the onboard mates (which would assist with STCW compliance). (Thompson, MBI 05/20/16 p.63); (Thompson, MBI 02/06/17, p.37). For example, this Chief Mate instructed the Port Mate to work with the Third Mate for a few hours, then relieve the Third Mate to allow him to rest, and then assume the watch until the Second Mate took over, in effect, to allow an early knock off of the earlier watch and later assumption of the later watch. In other words, the Port Mate was an extra body to assist with the cargo operations. (Thompson, MBI 02/06/17, p.39); (Berrios, 02/10/17 p.810). There is no regulation requiring ports mates and TSI's SMS does not require port mates in order to conduct cargo operations, but when requested and available, TSI had a practice of providing a port mate. No port mate was requested by the *El Faro* for the cargo operations conducted in Jacksonville on September 28-29, 2015.

In the engine room in port, manning and operations were as at sea, with the boilers operating and supplying ship's power through the SSTGs. Engineers stood their normal 4 and 8 hours rotation as well as their day work 4 hours. There was an increased level of activity with the ability to shut down some equipment and the regular attendance of shoreside contractors for maintenance and repairs.

3. STCW Rest/Work Hours

The pattern of work hours for TSI personnel on the *El Faro* was typical of maritime workers engaged in similar operations and trade, as these work hours are largely governed by union contract and STCW work and rest hour requirements.

Licensed personnel generally worked 10 weeks on, and then had 10 weeks of vacation. Unlicensed crewmembers worked various tour lengths ranging from 1 month to 6 months at a time, in accordance with their union shipping rules.

Under applicable agreement with the AMO (licensed union), licensed officers were expected to work up to 12 hours a day, and were paid overtime wages for all hours worked each day in excess of 12 hours (there is no overtime for weekends unless more than 12 hours are worked). Generally, under applicable agreement with the SIU (unlicensed union), unlicensed were expected to work 8 hours a day, and were entitled to overtime hours for (a) all hours in excess of their normal 8-hour workday during the week and (b) all hours worked on holidays and weekends.

In addition to the work hours restrictions under the respective union contracts noted above, TSI also imposed certain work rest requirements in order to comply with applicable STCW rest hour requirements, detailed further below.

a. TSI Rest and Work Hour Requirements and Tracking Responsibilities

As provided for in TSI's SMS, and in accordance with STCW 2010 (Manila) amendments, TSI licensed and unlicensed personnel who are assigned duty as officer in charge of a watch or as a rating forming part of a watch [to include non-watch (day workers)] and those whose duties involve designated safety, prevention of pollution and security duties shall be provided with a rest period of not less than 10 hours of rest during any 24-hour period and a minimum of 77 hours in any 7-day period. TSI's SMS and STCW specifies that the hours of rest may be divided into no more than two periods. One of these periods shall be a length of at least 6 hours and the intervals between consecutive periods of rest shall not be more than 14 hours. (MBI Ex.25, p.65).

Under STCW and the 2010 Manila exceptions, non-conformities or situations where the prescribed rest hours were not maintained due to unplanned events or operational considerations are permitted. However, as soon as practicable thereafter, the Master must ensure that TSI personnel who have performed work in these conditions are provided with an adequate rest period. (MBI Ex. 198, p. 65).

Under TSI's SMS, individuals were required to track their rest hours in accordance with the STCW. (MBI Ex.25, p.66). The SMS provides the ability of the Master to suspend these requirements, but only in very limited circumstances such as in emergency situations involving the immediate safety of the vessel. During non-emergency situations, if the Master is aware of a situation in which the rest hours of personnel will be exceeded, the Master shall contact the DP.

Generally, individuals were responsible for keeping track of their own work rest hours on the tracking form (discussed below), and Department Heads were responsible for reviewing the records of their personnel and managing those work hours to allow for adequate rest in accordance with the requirements set forth above. (MBI Ex.25, p.65).

b. STCW Tracking Documentation

The *El Faro* used a form to track STCW hours, Form TSI-V-ADM-009. (MBI Ex.283); (Thompson, MBI 02/06/17, pp.32-33). This form required daily tracking of work and rest hours, to allow for compliance with the work-rest hour requirements set forth above. The Master was ultimately responsible for checking the STCW sheets and ensuring the crewmembers got proper rest. (Thompson, MBI 02/06/17, pp. 34-35). The Chief Mate tracked his hours, and assisted the Mates with tracking their hours. (Thompson, MBI 02/06/17, pp.34-35).

A former *El Faro* Third Mate testified regarding completion of the STCW tracking record and described it as follows: he used the STCW tracking program on the bridge computer; it contains 24 boxes that represent the hours in the day; you input in each box whether you worked the full hour or a portion of the hour (half or a smaller portion). You can complete this in advance to predict whether you will have any problems with the expected work in coming days, and if a conflict was possible, you could talk to the Mate and revise your expected work schedule to ensure everybody is in compliance with the STCW program. (Berrios, MBI 02/10/17, p.811). TSI has recently implemented a new STCW tracking computer program, in place of the spreadsheet form (TSI-V-ADM-00). According to the Third Mate, the new STCW computer program is a helpful aid to ensure compliance with STCW mandated rest periods. (Berrios, MBI 02/10/17, p.810).

During the investigation, unsigned forms were provided to the NTSB and MBI, but cannot be fully verified because they are not signed. A review of those forms indicates that the crewmembers regularly kept track of their STCW rest hours and complied with the STCW work rest requirements set forth above. A former Chief Mate testified that the forms in the MBI's possession were not signed or commented upon because they were probably copies from the ship's computer. The normal process on board was for the sheets to be printed out, the crewmember would sign it, the Department Head would sign it, the Master would sign it, and the form would be filed on board. He believed the Chief Mate kept a binder of all STCW records, either in his office or on the bridge, though he was not 100% sure where they were kept. (Thompson, MBI 02/06/17, p.33). This same Chief Mate testified he believed the STCW records were subject to audit. (Thompson, MBI 02/06/17, p.36).

III. ANALYSIS

A. Analysis Overview

When it departed on voyage 185S on September 29, 2015, the *El Faro* was in its regularly scheduled service between the ports of Jacksonville, Florida and San Juan, Puerto Rico. Appendix D (Capt R. DiNapoli), p. 5, ¶ 7. As set forth in more detail below, the *El Faro* met all applicable regulatory and class requirements, was fully certificated, and found by the U.S. Coast Guard and ABS to be fit for its intended service. See Section III.B.1 below.

An objective analysis of the evidence further demonstrates that the vessel was seaworthy in all respects, when she departed Jacksonville on September 29, 2015. Specifically, the evidence demonstrates (a) the vessel's stability was calculated in accordance with TSI's SMS, and the Chief Mate verified that the vessel's stability calculations satisfied applicable requirements prior to departure (section III.B.3.a); (b) the vessel's hull and watertight fittings (scuttles, hatches, watertight doors) were well maintained in accordance with TSI's SMS, and the watertight integrity of the *El Faro* was not compromised (section IV.B.3.b); (c) the vessel's cargo was properly secured in accordance with applicable standards prior to departure (section III.B.3); (d) the few pending engineering maintenance items were routine in nature, raised no safety concerns, and played no role in the loss of the vessel (section III.B.4); and (e) the personnel on board the *El Faro* were well qualified and trained (section III.B.5).

While the *El Faro* was fully certificated and fit for its intended service, our analysis of the evidence also reveals a series of unfortunate challenges that the *El Faro* encountered, which led to its loss. An analysis of the conditions and challenges the crew of the *El Faro* were facing on the accident voyage are set forth in more detail in sections III (Forecasting Error), III.D (Navigation Decisions), III.E (Dynamic Stability Analysis of *El Faro* on the Accident Voyage), III.F (Loss of Propulsion), and III.G (Removal of Water From Hold 3 & 2A).

B. The *El Faro* Was Seaworthy in All Respects

1. Certifications & Inspections

a. Vessel Certificates

The *El Faro* was properly outfitted and fit for its intended service. It had been issued and maintained a current Coast Guard Certificate of Inspection, and had been subject to countless surveys and inspections by ABS and the Coast Guard, ensuring compliance with applicable class rules, international conventions, and federal regulations.

Specifically, at the time of the loss of the *El Faro,* Class and statutory certificates were up to date. (O'Donnell, MBI I, 02/26/2016, p.12) At the time of the casualty, the *El Faro* was classed by the American Bureau of Shipping and all of its required surveys were "in the green". (O'Donnell, MBI 02/26/16, p.179); (MBI Ex.077 – ABS Survey Manager). Significantly, there were no conditions of class in place at that time. All internal and external ISM audits were up to date. (MBI Ex. 311 and MBI Ex.78).

2. Results of Recent Surveys & Inspections

a. USCG Oversight Exam - March 6, 2015

On March 6, 2015, Jerry McMillan, a civilian inspector for the USCG, conducted an inspection of the *El Faro*. He was the lead inspector for the annual Alternate Compliance Program (ACP) oversight exam of the *El Faro*. (McMillan, MBI 05/25/16, p.25). McMillan personally conducted an examination of: (a) the container deck securing points, (b) lashing gear, (c) life rafts, (d) life jackets, (e) immersion suits, (f) anchor and mooring equipment, (g) Ro-Ro lashing gear (some of which was connected), (h) firefighting systems, (i) hatches going into the cargo holds, (j) large watertight doors in the cargo holds, (k) condition of the decks, (l) rum tanks, (m) the CO2 room, and (n) the rose boxes. (McMillan, MBI 05/25/16, pp.30-33).

With respect to the overall condition of the *El Faro*, including the watertight and weathertight fittings, McMillan's opinion was that the vessel was in good condition and looked as if everything was being maintained. (McMillan, MBI 05/25/16, p.33). He did not note any issues or problems regarding the vessel's cargo securing equipment, ground tackle, or mooring lines that would have made the vessel more vulnerable in a storm environment. (McMillan, MBI 05/25/16, p.33). As part of the annual ACP exam, McMillian observed the fire and abandon ship drills. In his opinion, the crew was very proficient and knew exactly what they were doing. (McMillan, MBI 05/25/16, pp.31,34).

McMillan concluded that the SMS aboard the *El Faro* was working. He further concluded that the shipboard personnel had good relations with the company (shoreside) pertaining to safety management and that the *El Faro* was getting the necessary support from the company. (McMillan, MBI 05/25/16, p.38).

Chief Warrant Officer Andrew Schock, of the U.S. Coast Guard Sector San Juan who assisted Mr. McMillan, did not observe anything that raised concerns regarding the vessel's watertight integrity during the *El Faro's* annual ACP exam. He did not have any concerns with regard to the vessel's SMS. (Schock, MBI 05/25/2016, p.179).

The annual ACP exam included a 6-hour examination of the *El Faro's* machinery. (Schock, MBI 05/25/16, p.165). This included inspection with satisfactory results and no deficiencies noted for the following systems: (a) Accommodation/Occupational Safety, (b) Communications, (c) Construction/Loadline, (d) Deck/Cargo, (e) Documentation, (f) Electrical, (g) Engineering, (h) Fire Fighting Inspected Lifesaving, (i) Navigation, (j) Operations/Management, (k) Personnel, (l) Pollution Prevention/Response, and (m) Stability. (MBI Ex.127, p.121).

The emergency generator, shaft seal, and steam pipe hangers (among many other items) were also inspected during the annual ACP exam and found satisfactory and in good condition. (Schock, MBI 05/25/16, pp.173,175,185-186).

b. ABS Machinery Survey - June 16, 2015

ABS Surveyor Mark Larose conducted the annual continuous machinery survey of the *El Faro* on June 16, 2015. (Larose, MBI 05/19/16, p.7). ABS notified the U.S. Coast Guard of the survey, but the Coast Guard was not in attendance. (Larose, MBI 05/19/16, pp.16-17). The survey took approximately five hours and included a review of the *El Faro* Chief Engineer's records and photographs of each opened piece of equipment. Larose matched each piece of equipment with the ship's records and physically ran the equipment, which included the ballast and bilge system, piping and pumps, freshwater system, steering gear, boiler feed water system, and he performed test shutdowns for the engines. Larose also found no deficiencies with any of the steam piping hangers. (Larose, MBI 05/19/16, pp.46-47,65-68).

3. Stability

a. Stability Calculations for Voyage 185S

As noted above, the *El Faro* had a Trim and Stability Booklet, approved by ABS on behalf of the USCG, and used CargoMax, an ABS-approved stability computer program. As described below, CargoMax was used by vessel personnel, with the assistance of TMPR shoreside personnel, to load the vessel within the applicable stability regulations. With respect to CargoMax, Mr. Rodriguez, the TMPR Terminal Manager, testified that TMPR's role is to assist the Chief Mates in keeping track of the cargo and entering the weights into CargoMax. (Rodriguez, NTSB 10/08/2015, pp.49-50).

The loading plans for the *El Faro*'s voyages, from Jacksonville to San Juan, were "very similar" each week. (Rodriguez, MBI 02/20/2016, p.173). For voyage 185S, the amount of Ro-Ro and Lo-Lo cargo to be loaded on the *El Faro* was very similar to the week before. (Rodriguez, NTSB 10/13/2015, p.12).

As discussed in more detail below, the Chief Mate and Master were provided the stability information with sufficient time to verify and perform stability calculations (up to an hour or more before departure), and the *El Faro* was properly loaded and sailed within applicable stability requirements for voyage 185S.

i. Preparation of loading plan for *El Faro*

The loading plan for the *El Faro*, for the voyage from Jacksonville to San Juan, was carried out in accordance with routine operations. It was developed and carried out through the following sequence of events:

- On September 27, 2015 (while the vessel was at sea on its way to Jacksonville from San Juan), the Chief Mate sent Mr. Rodriguez all of the tank loading information for the anticipated arrival condition of the vessel in Jacksonville on September 28, 2015. MBI Ex. 392. Mr. Rodriguez used this tank information from the Chief Mate in developing the preliminary and the final CargoMax load case file for voyage 185S. (Rodriguez, MBI 02/20/2016, pp.115-117).

- The *El Faro* arrived in Jacksonville at approximately 1230 on September 28, 2015. (MBI Ex.392 – Arrival-Departure Emails). Mr. Rodriguez went aboard the vessel on arrival to see the Chief Mate and the Master, to deliver mail, and discuss the upcoming cargo discharge and loading operations. (Rodriguez, MBI 02/20/2016, pp.113-114; Rodriguez, NTSB 10/08/2016, pp. 31-32).
- On September 28, 2015, at 1326, the Chief Mate sent Mr. Rodriguez the updated fuel tank loading condition on arrival. (MBI Ex.392). As a matter of standard procedure, Matthews (or Rodriguez when he stood in for Matthews as he did on 28-29 September) typically received anticipated ballast and departure fuel information from the vessel's Chief Mate and Chief Engineer as well as loading information regarding the fructose tanks. (Matthews, MBI 02/20/16, p.172); (Stith, NTSB 10/07/15, p.10).
- On September 28, 2015, at 1524, Mr. Rodriguez saved a CargoMax load case file, which contained loading information that was being developed for the *El Faro*'s 185S voyage. As a matter of standard procedure, Matthews (or his stand-in, here Rodriguez) used a prior load case to approximate the vessel's load condition at the scheduled port visit and then immediately updated the load condition with the actual ballast, fuel, and fructose information. With this information, he estimated required ballast at departure from Jacksonville so the vessel could plan accordingly. (Matthews, MBI 02/20/16, pp.172-173) (MBI Ex.57, p.1).
- For voyage 185S, the amount of Ro-Ro and Lo-Lo cargo to be loaded on the *El Faro* was very similar to the week before; this served as a basis for the pre-stow plan. (Rodriguez, NTSB 10/13/2015, p.12). Mr. Rodriguez told this to the Chief Mate, when he first came aboard the vessel. (Rodriguez, NTSB 10/13/2015, pp.12-13,15; Rodriguez, MBI 02/20/2016, pp.113-114).Mr. Rodriguez typically updated the CargoMax load case file continuously throughout cargo loading operations. During the course of loading, the normal procedure was that Matthews (or Rodriguez when standing in) updated the active CargoMax loadcase as he received updated stow plans from the PORTUS stevedores. (Matthews, MBI 02/20/16, p.175); (Rodriguez, MBI 02/20/16, pp.114-115)
- Stevedoring personnel were responsible for discharging, loading, and securing of cargo, as directed by the Chief Mate and other deck officers on the vessel. The stevedores load the vessel at the direction of the Master and mates, who ultimately have the operational authority and responsibility for loading the cargo. (MBI Ex. 198 - OMV 13.6). As Spinnaker was updated throughout the operation, the CargoMax load case file was also updated. (Rodriguez, NTSB 10/13/2015, pp.9-10, 12-13, 15). PORTUS utilized the computer program Spinnaker to prepare the stow plan for the Lo-Lo operations. (Rodriguez, MBI 02/20/16, p.115). For the Ro-Ro operations, PORTUS used a handwritten stow plan. (Rodriguez, MBI 02/20/16, p.115).
- Throughout the discharge and loading of cargo on September 28 and 29, Mr. Rodriguez kept in continuous communications by radio with the Chief Mate, regarding cargo operations, loading of the vessel, and the GM of the vessel. (Rodriguez, NTSB 10/13/2015, pp. 21-22; Rodriguez, MBI 02/20/2016, p.114). The purpose of the ongoing dialogue with the Chief Mate was to ensure there were no surprises for the Chief Mate and Master, when the final stability documents were delivered to the vessel at the conclusion of cargo operations. (MBI, Matthews, 2/20/2016, p.197).
- As cargo loading operations were nearing completion on September 29, 2015, Mr. Rodriguez saved the final CargoMax load case and printed it out. (MBI Ex.58, p.1).

- Ro-Ro cargo operations concluded at 1830 and Lo-Lo cargo operations concluded at 1854. (MBI Ex.004, p.93).

ii. **The Chief Mate Received the Final Loading Documentation in a Timely Manner**

As a matter of routine procedure, at the conclusion of cargo operations, Mr. Matthews (or Mr. Rodriguez in his absence) delivered a hard copy of the stow plans (Ro-Ro and Lo-Lo), the reefer manifest, the dangerous cargo manifest, a hard copy of the CargoMax summary printout, together with a flash drive containing the final CargoMax load case, to the vessel's Chief Mate. The general practice of all Mates was to receive the CargoMax data from Matthews (or Rodriguez), compare it with all numbers from visual draft readings, the inclinometer, and salinity reading and discuss with the Master prior to sailing. (Loftfield, MBI 02/18/16, pp.16-17); (Axelsson, NTSB 11/03/15, pp.90-91); (Axelsson, MBI 05/16/16, pp.85-86); (Thompson, NTSB 12/06/15, pp.24,26).

Mr. Rodriguez confirmed that he followed this procedure on September 29, 2015. (Rodriguez, MBI 02/20/2016, p.114). As noted above, cargo operations concluded at 6:54 PM.

Also as a matter of routine procedure, when the cargo and stability documentation described above are delivered to the vessel, the Chief Mate signs the original dangerous cargo manifest, and it is retained ashore. (MBI Ex.91); (CargoMax Program Documentation, (Attachment 14), pp.8-9. On September 29, 2015, at 1915, after the Chief Mate signed the dangerous cargo manifest, Mr. Rodriguez scanned it (along with other final cargo documents), emailed it to his email address, and at 1927, Mr. Rodriguez sent these documents to various cargo stakeholders. See Cindy Harvey email dated September 29, 2015, (Attachment 15). Accordingly, because the dangerous cargo manifest was acknowledged and signed before 1915, the cargo documentation (including the flash drive with the final CargoMax load case), must have been delivered to the Chief Mate prior to 1915.

The vessel departed (last line) at 2007. (MBI Ex.004, p.93).

iii. **The *El Faro* Complied With Applicable Stability Requirements On Voyage 185S**

The *El Faro*'s final CargoMax load case, which was delivered to the Chief Mate at the end of cargo operations, shows that the vessel had a GM of 4.455 feet (corrected for free surface), which satisfied the minimum GM requirement of 3.655 feet set by regulation. This showed a "GM margin" of 0.8 feet. (MBI Ex.58, p.1). During loading, the goal was to obtain a GM margin of at least 0.5 feet, a zero degree list (no list), and at least 100 tons of available deadweight. (Rodriguez, MBI 02/20/16, pp.122-123; Rodriguez, NTSB 12/04/15, p.45). The 0.5 feet GM margin is a company, self-imposed safety margin (over and above regulatory requirements) which accounted for fuel consumption and allowed for an adequate margin of stability throughout the voyage to San Juan (without any further movements/adjustments of fuel or ballast, which options were also available). (Appendix B (Prof. C. Munsch), p. 10-11); see also Matthews, MBI 02/20/16, p.177); (Stith, MBI 05/24/16, p.67). If there was insufficient GM margin, TMPR took cargo off the vessel. (Rodriguez, NTSB 10/13/15, p.22). The regulations require only that the vessel satisfy the minimum required GM, throughout the voyage. The regulations do not specify a required GM margin in addition to the minimum required GM. (Gruber, MBI 05/19/16, p.165).

The CargoMax printout also indicated 478 long tons of available deadweight - that is, the amount of cargo, ballast, fuel or other items that *El Faro* could have taken onboard and still been within required draft limits. A copy of the printout delivered to the Chief Mate is set forth in MBI Exhibit 58. The Master and Chief Mate of the *El Faro* could have, but did not, load additional cargo. The *El Faro* departed and left 36 containers behind, to be delivered on another vessel at a subsequent time. See Cindy Harvey email dated September 29, 2015 (Attachment 15). The corrected available deadweight of more than 600 long tons, would have given the Master the flexibility to take on additional ballast in various ballast tanks, if needed.

The vessel had no list upon departure from Jacksonville on September 29, 2015. (Rodriguez, MBI 02/20/16, p.132) (Frudaker, MBI 05/16/16, p.27). Note that when the *El Faro* was upright (zero list), CargoMax showed approximately 2.5 degrees of starboard list. This "constant" was regularly accounted for when the vessel was loaded. (Matthews, MBI 02/20/16, pp.200-201). TOTE's expert later determined this to be the result of the vessel having a transverse center of gravity slightly to starboard, due to the vessel's Ro-Ro configuration, and is explained further in Appendix B (Prof. C. Munsch), pp.5-6.

When Mr. Rodriguez delivered the cargo and stability documents to the vessel, the Chief Mate reviewed the CargoMax printout for 5 or 10 minutes, and he informed Mr. Rodriguez that he found a few errors in regard to the fuel and lube oil tank amounts, which would need to be corrected. (Rodriguez, MBI 02/20/2016, p.127). The CargoMax printout delivered to the vessel shows approximately 200 long tons more fuel than was onboard (100 Long Tons in each #3 Port and starboard double bottom tanks); the Chief Mate also identified an error in the lube oil storage tank amount, which should have been 11.5 long tons, but instead showed 1.5 long tons). (Rodriguez, MBI 02/20/2016, p.127; MBI Ex.58). Identification of these errors and their subsequent correction by the vessel, are further corroborated in the *El Faro*'s departure report (total bunkers on board), issued at 2144 on September 29, 2015. (MBI Ex.004, pp.92-93).

On October 1, 2015, Mr. Rodriguez corrected the CargoMax load case file. (MBI Ex.059, p.1). The corrected CargoMax load case shows that the vessel had a GM of 4.284 feet (corrected for free surface), which satisfied the minimum GM requirement of 3.644 feet. This showed a "GM margin" of 0.64 feet. (MBI Ex.59, p.1). The available deadweight, after correcting the CargoMax loadcase, was more than 600 long tons. Therefore, during the voyage, the Master could have, if desired, taken on additional ballast into several different tanks to improve stability, including the #1 deep tank and the No. 2 port and starboard (inner) double bottom tanks, among others. (MBI Ex.59, pp.2-3). Under TOTE's SMS, when heavy weather is forecasted along the vessel's track, the Master should consider taking on additional ballast. (MBI Ex.25, p.218). Based on the stability documentation, this option was available to the vessel, but it is unknown if the Master took on additional ballast after departing Jacksonville.

Based on the above, the Chief Mate and Master were provided the stability information with sufficient time to verify and perform stability calculations (up to an hour or more before departure), and the *El Faro* was properly loaded and sailed within applicable stability requirements for voyage 185S.

b. Watertight Integrity

The evidence developed in the investigation, discussed further below, demonstrates that the watertight doors and scuttles were inspected and maintained, and that, on the accident voyage, the crew of the *El Faro* had in place policies and procedures in the SMS that were well designed to ensure watertight integrity of the vessel prior to departure and throughout voyage 185S, and detect flooding of spaces within the vessel. Based on the evidence, the most likely cause of the initial ingress of water into Cargo Hold No. 3 was the scuttle on the second deck not being secured properly.

i. Scuttles and Watertight Doors

According to the general arrangement drawing for the *El Faro*, there were a series of watertight access scuttles on the second deck, which could be used to access cargo holds below the second deck. For cargo hold number 3, there was an access scuttle on the starboard side (at approximately frame 163) and on the port side (at approximately frame 138.5). (MBI Ex.107). The VDR transcript reveals that the scuttle on the second deck entering cargo hold number 3, on the starboard side, was the source of water that was detected in cargo hold number 3. (MBI Ex.266, p.434).

A series of large watertight cargo doors are located in watertight bulkheads, distributed on the second deck, third deck, and fourth deck (tanktop), at frames 87, 128, 134/27, and 169. The number 6 watertight door is the only large cargo door that provides access to the cargo hold number 3(through hold 2A). (MBI Ex.107).

ii. SMS Procedures for Securing of Scuttles and Watertight Doors were followed

Under TOTE's SMS, the Master has overall responsibility for ensuring that the vessel is, in all respects, safe for sea before departure. (MBI Ex.25, p.229). Watertight doors, hatches (scuttles), and external openings below the main deck are checked and secured as part of a pre-departure checklist. (MBI Ex.25, p.184). The Chief Mate is specifically responsible for ensuring that all watertight doors and hatches are secure. (MBI Ex.25, p.229). At sea, cargo holds are required to be inspected daily by the Chief Mate or his delegate. *Id*.

In addition to being routinely checked and used during cargo operations and as part of the pre-departure checklist, the cargo watertight doors were inspected on a monthly basis. (MBI Ex.25, p.185). The practice aboard the *El Faro* was to secure watertight doors when cargo was completed. (Berrios, NTSB 12/06/15, pp.12-13); (Axelsson, NTSB 11/03/15, p.83); (Axelsson, MBI 05/16/16, pp.121-122); (Torres, NTSB 10/09/15, pp.47-50); (Stith, NTSB 10/07/15, p.45); (Thompson, NTSB 12/06/15, p.58); (Hearn, MBI 05/17/16, p.44). To get ready for sea, scuttles on the second deck were also closed by either the Chief Mate or the bosun. (Berrios, NTSB 12/06/15, pp.14-15); (Berrios, MBI 02/19/16, p.115); (Baird, NTSB 12/06/15, pp.53-54,72);

(Walker, NTSB 12/03/15, p.10); (Walker, MBI 02/23/16, pp.112-113); (Thompson, NTSB 12/06/15, p.59). Scuttles remained closed while the vessel was underway unless they were being used by crew. (Berrios, NTSB 12/06/15, pp.58-59); (Vagts, NTSB 12/06/15, pp.63-64). The small watertight doors in the engine room that allowed personnel to enter the holds (at the third deck level) were normally kept closed while the vessel was at sea and always when foul weather was expected. (Baird, MBI 02/18/16, pp.70-87); (Robinson, NTSB 10/08/15, p.77). Watertight doors and scuttles were secured when heavy weather was expected. (Axelsson, NTSB 11/03/15, p.82); (Loftfield, MBI 02/18/16, p.161-162). A watertight door to enter the engine room was sometimes left open while underway but would be secured for heavy weather. (Berrios, MBI 02/19/16, pp.40-41); (Axelsson, NTSB 11/03/15, pp.85-86); (Robinson, NTSB 10/08/15, pp.70-71); (Robinson, MBI 02/23/16, pp.91-92).

The inspection results were tracked on a monthly report. (MBI Ex.132). The evidence and testimony in the case demonstrates that these procedures were, in fact, regularly followed by the crew of the *El Faro*.

iii. The Scuttles and Watertight Doors were properly maintained and in good conditions

On January 9, 2015, all watertight doors and scuttles were inspected and tested as part of the annual hull survey, performed by ABS. (MBI Ex.132, p.1; Hohenshelt, MBI 05/24/16, pp.106-108). As part of that survey, the operation of the watertight door hinges, the physical condition of the gaskets, and the condition of the hydraulic motor and pumps were checked for each watertight door, and an operational test was performed. At the time of the survey by ABS, similar tests and inspections were performed on the small watertight doors and scuttles. These scuttles, watertight doors, and other watertight closures were found to be operationally satisfactory and in good condition. (Hohenshelt, MBI 05/24/16, pp.106-108.) In addition, while onboard, the ABS surveyor observed evidence that the crew had performed a “chalk test” on the watertight doors to verify their watertight integrity, and that it appeared to the ABS surveyor that the test had been performed within a day of his attendance onboard the *El Faro*. (Hohenshelt, MBI 05/24/16, pp.130-131.)

The Coast Guard conducted an ACP oversight exam on March 6, 2015. One of the issues the lead inspector in San Juan pays particular attention to on such exams is the condition of the hull openings and their closure devices. (McMillan, MBI 05/25/16, p.30). During the last ACP oversight exam on March 6, 2015, the Coast Guard inspected the watertight doors, scuttles, and other watertight fittings, including the gaskets and closing mechanisms, and found them to be satisfactory condition. (McMillan, MBI 05/25/16, pp.51-53, 30-31; Schock, MBI 05/25/16, p.178). The lead Coast Guard inspector found that the ship was in good condition and that the ship was being maintained. (McMillan, MBI 05/25/16, pp.51-53, 30-31).

Consistent with the above inspections, surveys, and procedures, the evidence indicates that the crew of the *El Faro* routinely carried out preventive and corrective maintenance on the watertight doors, scuttles, and other fittings. Specifically, the monthly cargo gear inspection record for July 2015 documents specific maintenance and repairs previously performed on the *El Faro*’s cargo watertight doors on the *El Faro*. These monthly records were maintained onboard the vessel, and thus, the most current records were lost with the vessel. Other records, including the deck work log, demonstrate that the crew regularly performed preventive and corrective maintenance on the scuttles and watertight doors.

In this regard, Captain Axelsson, who last served on the *El Faro* in August 2015, testified that the chief mates perform chalk tests on the watertight doors, and they never had any problems with them. (Axelsson, NTSB 11/03/15, p.76). The Port Engineer testified that the crew would conduct visual inspections of the scuttles and watertight doors, and use a ladder if necessary on the large watertight doors; the crew would also perform chalk test to verify contact points of the watertight doors. (Neeson, MBI 02/13/17, p.1081). The deck work log indicates such repairs and maintenance to watertight doors and scuttles were carried out on 5/10/14, 12/18/14, 12/20/14, 12/21/14, 12/25/14, 12/27/14, 12/28/14, 1/3/15, 1/9/15, 1/10/15, 2/14/15, and 2/14/15. (MBI Ex. 335).

Finally, the most recent Chief Mate's turnover notes, dated September 18, 2015, state that "[a]ll Watertight doors are in good order." (MBI 131, p. 90). Approximately one month earlier, on August 11, 2015, the Chief Engineer's turnover notes stated that the bottom knife edge to watertight door number 2 is holed and leaking. (MBI Ex.131, pp.11-12). Watertight door number 2 is on the second deck, leading to cargo hold number 5. (MBI Ex.107). However, the evidence indicates that water initially entered cargo hold number 3 (and later hold 2A), and there is no evidence that cargo hold 5 flooded prior to the loss of the vessel. Therefore, there is no evidence that the knife edge to watertight door number 2, even if not repair, played any role is the loss of the vessel.

iv. Bilge Alarms were not required, but were installed and functioned properly

The *El Faro* was not required by law to have bilge alarms in the cargo holds. (McMillan, MBI 05/25/2015, p.54; see also Appendix B (C.Munsch), p.40). However, even though not required, TSI installed and maintained bilge alarms on board the *El Faro* in cargo holds 1, 2, 2A, 3, 4, and 5. (Robinson, MBI 02/23/15, p.136). As part of routine preventive maintenance, bilge alarms were tested once a month. (Axelsson, NTSB 10/01/15, pp.119-120); (Baird, MBI 02/18/16, p.73). The Third Mates assisted the Chief Mate on a monthly basis to inspect the bilge alarms, and during cargo operations they tested all the bilge alarms in the cargo holds. (Berrios, MBI 02/19/16, p.37).

The bilge alarm floats in cargo hold 3 were located in the vicinity of each bilge well, located in the very aft part of the cargo hold on the port and starboard sides of the hold. (Robinson MBI 5/23/15 pp.93, 101; MBI Ex.007). If sufficient water accumulated in the vicinity of the bilge well and float, the float would be raised, which would actuate the bilge alarm, audibly and visually, in the engine room. *Id.*

The bilge floats were estimated to be located 3 or 4 inches above the tank top level. (MBI Walker 05/23/16, p.120). In addition, in order to actuate the alarm, the bilge floats would need to be raised 2 or 3 inches, for a period of approximately 6 seconds. (Neeson, MBI 02/13/17, pp.1055, 1072). The bilge wells (and therefore the bilge floats) were located inboard from the side of the vessel by approximately 20 feet. (MBI Ex.007); Appendix B (Prof C. Munsch), p.43.

Because of this location approximately 20 feet inboard of the side of the vessel, if the vessel was experiencing a persistent heel, some amount of water would likely accumulate on that side of the hold (away from the bilge well), before actuation of the bilge alarm; this would, in effect, delay actuation of the alarm. (Neeson, MBI 02/13/17, pp.1093-1094); Appendix B (Prof C. Munsch), p.36. In other words, based on the location of the bilge well and alarm inboard from the side of the vessel, water could have been entering into cargo hold 3 for up to 2 hours/minutes if the vessel were heeled over without the bilge alarm actuating. *Id.* at 43.

There is no evidence produced in the investigation that suggests the bilge alarm did not function as designed and installed.

4. Cargo Stowage

The cargo was stowed and lashed in a manner that complied with all applicable requirements on the subject voyage, Voyage 185S. There is no evidence that any lashings prematurely failed or failed to perform as required. The lashing failures that were known to occur close to the time of the vessel's sinking, were the result of the developing event and were not a cause of the accident.

a. Pre-stow and general loading procedures

TMPR customers select a specific voyage when booking shipments. If any cargo is not loaded on the selected voyage, it will be placed on the next available vessel or barge. (Lisk MBI 05/27/16, pp.25-26). The cargo was assigned one of two categories: P1 or P2. The preference was to load P1 cargo on the vessel/voyage selected by the customer. P2 cargo generally could move to the next scheduled vessel (or barge), if necessary. (Wagstaff, MBI 05/18/16, pp.91-92); (Lisk, NTSB 12/02/15, p.25). TMPR had slack built into the round-trip weekly voyage schedules for the *El Faro* and the *El Yunque*, including its stevedoring operations. (Keller, MBI 05/26/16, pp.77-78); (Wagstaff, MBI 05/18/16, p.108). This would allow for delays in cargo operations, departures from and arrivals at ports, and diversions while underway without requiring any significant adjustments to the schedule, but adjustments could readily be made.

TMPR advised the terminal of the priority status (P1/P2) assigned to the cargo. The terminal then evaluated the weight of the cargo and input that information into CargoMax. TMPR's cargo service team received only anticipated weights from the customer. The terminal weighed the actual cargo upon arrival at the terminal. (Lisk, MBI 05/27/16, p.11). This was done on scales that are calibrated every month by a third-party vendor. (Rodriguez, MBI 02/20/16, pp.139,143). If a container was overweight, it was not even allowed into the terminal -- it was turned around at the gate. (Newkirk, NTSB 10/12/15, p.29).

Stevedore and longshore personnel were provided by PORTUS. PORTUS performed the physical movement of the containers and other cargo loaded onto the vessels. Stevedoring personnel were responsible for discharging, loading, and securing of cargo, as directed by the Chief Mate and other deck officers on the vessel. The stevedores load the vessel at the direction of the Master and mates, who ultimately have the operational authority and responsibility for loading the cargo. The OMV 13.6 describes this relationship: "The Chief Mate is responsible for proper lashing, bracing, and general securement of cargo. He shall coordinate with the stevedore to assure that the proper equipment for lashing and securing the cargo to be loaded is available in sufficient quantities. During cargo loading operations, the lashing arrangements shall be supervised by a deck officer. Cargo shall be properly secured and inspected by the Chief Mate prior to departure from port." (MBI Ex.198 - OMV 13.6).

TMPR's operations group worked in conjunction with PORTUS as they prepared the stow plan. (Nolan, MBI 02/18/16, pp.137-138). A preliminary stow plan was developed by TMPR shoreside personnel based on the cargo, fuel requirements, and other criteria. (Morrell, MBI 2/16/16, pp.37, 68).

PORTUS utilized the computer program Spinnaker to prepare the stow plan for the Lo-Lo operations. (Rodriguez, MBI 02/20/16, pp.114-115). For the Ro-Ro operations, PORTUS used a handwritten stow plan. (Rodriguez, MBI 02/20/16, p.115). For Ro-Ro stowage, a given hold was divided into three sections (port, center, and starboard), and the weights of different types of Ro-Ro cargo in each section were entered into CargoMax. (Rodriguez, MBI 02/20/16, pp.120); (Matthews, MBI 02/20/16, p.176). For the fructose tanks, the actual weight of the cargo and tanks was entered into CargoMax. (Rodriguez, MBI 02/20/16, pp.149). There were a total of six 53-foot fructose containers added in 2014 as removable tanks, purchased and intended to be transferred to the Marlin-class ships after delivery. (Morrell, MBI 02/16/16, pp.22). The ABS structures group approved the fructose tank installation aboard the *El Faro*. (Cronin/Pisini, MBI 05/20/16, pp.122-123). The fructose tanks were not included in the Cargo Securing Manual because they were mounted and semi-permanently welded atop container foundations, then to the deck. (Cronin/Pisini, MBI 05/20/16, pp.123-124). The fructose tank weights (and their cargo content) were accounted for by entering their weights into CargoMax. (Rodriguez, MBI 02/20/16, p.149).

As discussed in more detail in section III.B.4, Mr. Matthews (or Mr. Rodriguez when he stood in for Matthews as he did on 28-29 September) typically received tank information from the Chief Mate, and, as cargo loading proceeded, entered the weights of the Ro-Ro and Lo-Lo cargo into CargoMax for the Chief Mate, so that the Chief Mate could review and verify the vessel's stability in accordance with TSI's SMS.

b. A Cargo Securing Manual was not required, but the *El Faro* used an approved manual

As set forth in section III.B.4.b, while not required by applicable law, the *El Faro* had an approved Cargo Securing Manual (CSM) that complied with the IMO CSS Code. (MBI Ex.40). Specifically, *El Faro*'s Cargo Securing Manual fully complied with the requirements in MSC/Circ.745 dated 13 June 1996 – "Guidelines for the Preparation of the Cargo Securing Manual" – and was prepared in accordance with the International Convention for the Safety of Life at Sea, 1974 (SOLAS) Chapters VI, VII and the Code of Safe Practice for Cargo Stowage and Securing, IMO Resolution A.717 (17) and USCG NVIC 10-97 (Guidelines for Cargo Securing Manual approval). Appendix B (Prof. C. Munsch), p.17.

The company's SMS references the approved CSM and notes that the approved CSM "should be reviewed periodically" by the Chief Mate and "essential elements should be incorporated into the C/M's Standing Orders for cargo operations." (MBI Ex.25, p.301).

i. EL Class Minimum Lashing Guidance - Background

Standard, simplified guidance for enhanced lashings was created and employed on board the *El Faro,* which resulted in additional lashings routinely being used, beyond the minimum that would have been specified by the CSM. Specifically, since 2006, PORTUS used one standard vessel lashing scheme for the El Class vessels (also commonly known as the *Ponce Class* vessels) referred to as "hurricane lashing" (or "bad weather lashing" or "storm lashings"). (Callaway, MBI 02/19/16, pp. 156-157); (Loftfield, MBI 02/18/15, pp.28-29); (Stith, MBI 05/24/16, p.22). This standard, enhanced, lashing profile was contained in the EL Class Minimum Lashing Guidance document. (MBI Ex. 294, pp. 34-40 (Exhibit B))

The background and origin of the standard lashing guidance employed onboard the *El Faro* (and other *Ponce Class* vessels) is instructive. Prior to 2006, there would be occasions when PORTUS would lash in accordance with the normal or "good weather" lashing standard, and then at the end of cargo operations the Chief Mate would ask for additional "heavy weather" lashing to be applied, if weather "popped up." That tended to slow down operations. To avoid this, PORTUS approached the company and proposed to always apply "heavy weather" lashing in all cases, and the company agreed. (Callaway, MBI 02/19/16, p.157). As PORTUS put it:

> "[s]o we got tired of going behind and fixing everything [by applying hurricane lashing] and we just made it standard to hurricane lash going forward period. So the standard for hurricane lashing, quote unquote has been in place since I have been supervisor [2006]." *Id.*

Thus, to eliminate any confusion among lashing profiles, one standard "storm lashing" or "hurricane lashing" or "heavy weather lashing" profile was adopted on the *El Faro,* as of 2006.

ii. The El Class Minimum Lashing Guidance complied with the Cargo Securing Manual

Under the EL Class Minimum Lashing Guidance, containers on deck were secured with a twist-lock footing and lashing bars and turnbuckles. (Stith, NTSB 10/07/15, pp.15-16). For these Lo-Lo containers, this standard method of lashing involved lashing the outside two wing stacks with rods and turnbuckles to the bottom of the second tier. (Callaway, NTSB 10/12/15, p.10). In addition, if CargoMax revealed that a lashing margin on any tier had been exceeded, for example on an inside tier that was otherwise using only twistlocks, PORTUS would also lash that tier with rods. (Rodriguez, MBI 02/20/16, p.162); (MBI Ex.68); (Callaway, MBI 02/19/16, pp.175,177).

Similarly, this "hurricane" or "bad weather" lashing profile set forth in the EL Class Minimum Lashing Guidance was used on the Ro-Ro decks. (Rodriguez, MBI 02/20/16, pp.160-

161); (Thompson, NTSB 12/06/15, p.54). There were three lashing options for lashing of trailers: two chains, four chains, and six chains. For a Roloc box on the button, the basic lashing consisted of two chains on the rear end of the trailer. Most of the cargo stowed below decks on the *El Faro* was on a button, unless it was a vehicle that was not configured to go on a button. If it was not on a button, there were extra lashings put on the Roloc box. (Hearn, NTSB 03/30/16, p.19). Other types of cargo were secured with ratchet straps if they could not be secured with lashing chains. The ratchet straps would go to D-rings that were welded to the deck. (Stith, NTSB 10/07/15, pp.14-15). The *El Faro* had extra lashing points for the securing of cargo as a result of the D-rings that were added to *El Faro's* second deck. (Hearn, NTSB 03/30/16, p.20).

For every instance where a Roloc box was not stowed on the button, six chains (4 on front, 2 on back) were used regardless of location. For Roloc boxes on the button in certain locations (those at risk of higher forces), a total of four chains were used (2 on front in addition to the Roloc box and 2 on the back). Even if on a button, trailers received four chains throughout Hold 2A, in the outboard two stow positions from Holds 2B to 2D, and throughout Hold 2E. Decks 3 and 4 were the same. All items on ramps received six chains. (Callaway, MBI 02/19/16, p.159,163); (MBI Ex.294, at Ex.B, pp.35-40); (Kidd, MBI 05/23/16, pp.206-208); (Newkirk, NTSB 10/12/15, p.23); (Deberry, NTSB 10/12/15, pp.17-26).

Some investigators have questioned whether there was some confusion or disagreement regarding whether this "heavy weather lashing" scheme was used as a matter of routine on the Puerto Rico run. We believe there is no confusion or doubt the *El Faro* was using the EL Class Minimum Lashing Guidance. At one stage of the investigation, we believe some investigators mistakenly focused on testimony of two past masters who, because of their time of service onboard the vessel, would have had no reason to know that the EL Class Minimum Lashing Guidance was implemented as an enhanced scheme, considering it was implemented before their arrival on these vessels. from their own historical perspective, not having served on the Puerto Rico run prior to 2006, the EL Class Minimum Lashing Guidance (which was, prior to 2006, referred to be "storm lashings" or "heavy weather lashings") was merely standard procedure while these two masters served on these vessels in this service. These two masters, Captain Loftfield and Captain Hearn,[11] were merely asked whether they were aware of an optional or special heavy weather lashing scheme being used in different seasons, beyond the normal lashing, and their response was they were not aware of that. However, they were not shown the El Class Minimum Lashing Guidance and asked to confirm whether lashing was completed consistent with that Guidance -- had they been asked that question, confirmation would have been provided that this was the only lashing scheme used and that there were no changes in

[11] Captain Hearn's testimony is vague and unclear on this point, and he, too, was not shown the EL Class Minimum Lashing Guidance during the questioning. In addition, Captain Hearn did not enter the Puerto Rico trade until 2008. (NTSB, Hearn 03/30/2016, p.249). Thus, Captain Hearn, like Captain Loftfield, would not necessarily have been privy to the historical distinction betweenof selectively applying "heavy weather lashing" when needed, and the "new" procedure - of 2006 - of always applying "heavy weather lashing." A closer examination of Captain Hearn's testimony further demonstrates this point. When asked if there was a "heavy weather profile or difference in profile [based on the season]", Captain Hearn testified there was "No seasonal profile." The only thing clear from his testimony on this subject is that, from Captain Hearn's perspective, there was only one lashing profile all year long on the Puerto Rico run. Thus, Captain Hearn's testimony is actually consistent with other witnesses' statements that there was only one standard lashing profile in the Puerto Rico (The Minimum EL Class Lashing Guidance), but additional lashings could always be requested.

schemes by season.

In contrast, there was specific testimony from two masters who provided details regarding the lashing scheme. These masters, combined with the other evidence, including testimony of PORTUS and terminal personnel as well as the El Class Minimum Lashing Guidance document itself, confirm the blanket application of "heavy weather lashing." Specifically, Captain Stith testified that one "storm lashing" profile was adopted on the *El Faro* to eliminate any confusion among lashing profiles, and that "storm lashing" profile was, in his view "over lashed." As a result, he would not typically apply additional lashings in heavy weather. (Stith, MBI 05/24/16, p.22). Similarly, Captain Thompson, testified that "[t]hey used to, I believe, lash for heavy weather pretty much all the time anyway just in case. I think that was the way the port guys in Jacksonville were doing it." (Thompson, NTSB 12/08/2015, p.54.)

There is no doubt that the enhanced "heavy weather" lashing profile - reflected in the EL Class Minimum Lashing Guidance - was consistently applied when securing cargo onboard the *El Faro*, and was indeed applied on the accident voyage. This method of lashing was in full compliance with the CSM. Appendix B (Prof. C. Munsch) at p.18.

c. Stowage on the *El Faro* on Voyage 185S

i. Stowage and lashing complied with all requirements

Before the vessel arrived in Jacksonville on 28 September, Rodriguez received tank information in a spreadsheet from the Chief Mate via email -- he entered this information in long tons into CargoMax. (MBI Ex.59 – Corrected CargoMax 10/01/15 Summary; Rodriguez, MBI 02/20/16, pp.116-117). Rodriguez went to the vessel when it arrived, delivered the mail to the Master and Chief Mate, spoke with the Chief Mate, and discussed the vessel's loading. (Rodriguez, MBI 02/20/16, p.113-114). After discharging cargo on 28 September, loading of the *El Faro* began and was completed on 29 September. (Rodriguez, MBI 02/20/16, p.114). Throughout the day on 29 September, Rodriguez updated the Chief Mate on the status of loading operations via radio as the stevedores made updates to the stow plans. (Rodriguez, MBI 02/20/16, pp.114). Rodriguez spoke often with the Chief Mate and other Mates during cargo operations. (Rodriguez, MBI 02/20/16, p.136).

Everything was typical during loading and there were no problems whatsoever with the cargo lashing. (Callaway, MBI 02/19/16, p.172). On 29 September, Mr. Newkirk (PORTUS Vessel Superintendent/Vessel Planner) spoke with the Chief Mate in Mr. Rodriguez's presence, to ask if the Chief Mate was "good" with the loading and lashing; the Chief Mate responded that he was and told them "good job." (Newkirk, NTSB 10/12/15, p.19).

As detailed in Section III.B.3.ii, on 29 September, approximately one hour before the vessel departed, Mr. Rodriguez delivered the final loadcase, stow plan, dangerous cargo manifest, and reefer manifest to the Chief Mate. (Rodriguez, MBI 02/20/16, pp.178-179).

While at sea, it was part of the routine practice for lashings to be checked. While the *El Faro* was at sea, the crew performed rounds to check lashings, scuttles, and watertight doors.

(Thompson, NTSB 12/06/15, p.61). The Chief Mate was in charge of checking lashings around deck. (Axelsson, NTSB 11/03/15, p.80); (Axelsson, MBI 05/16/16, p.87); (Vagts, NTSB 12/06/15, p.11); (Vagts, MBI 02/24/16, p.134). The Chief Mate made rounds of the holds every morning. (Axelsson, NTSB 11/03/15, p.82); (Stith, NTSB 10/07/15, pp.45-46); (Thompson, NTSB 12/06/15, p.61). Other Mates on watch also checked lashings during their rounds. (Berrios, NTSB 12/06/15, p.12); (Berrios, MBI 02/19/16, pp.98-99); (Baird, NTSB 12/06/15, pp.57-58); (Baird, MBI 02/18/16, p.45); (Torres, NTSB 10/09/15, p.38); (Torres, MBI 02/25/16, pp.31, 46-47); (Walker, NTSB 12/03/15, p.48); (Walker, MBI 02/23/16, pp.116-117); (Stith, MBI, 05/24/16, p.24). There is no evidence to suggest that the crew of the *El Faro* deviated from these safety practices on voyage 185S.

ii. Comments regarding lashings while underway are not reliable

At one stage of the investigation, investigators inquired into quoted language from third mate Riehm and AB Jack Jackson, on the VDR transcript, that they "should have" asked the longshoremen for "storm lashes." Given the clear evidence that the vessel did employ the enhanced lashing profile, referred to as heavy weather, storm, or hurricane lashing, as prescribed in the EL Class Minimum Lashing Requirements, these individuals must have been referring to asking the longshoremen for additional storm lashes, beyond what is contained in the EL Class Minimum Lashing Requirements. In fact, this term, "additional storm lashes," was the exact term used by Captain Davidson when describing his at-sea preparations for tropical storm Erika. (MBI Ex.004, p.41). This suggests Captain Davidson was himself aware of this distinction that the vessel already had "storm lashings," when lashed according to the normal procedures set forth in the EL Class Minimum Lashing Guidance.

iii. Lashing quantities were sufficient

The *El Faro* had sufficient lashing gear available on hand. Captain Thompson testified that there were no problems with the lashings when he was on the *El Faro*. They were greased and maintained on a regular basis. They "had plenty of lashing on the ship usually. We had extra lashing actually." (Thompson, NTSB, 12/08/2015, p.57.) Mr. Matthews testified that, "based on the required amounts of lashing gear, the *El Faro* had in excessive [amount of lashing gear] of what was required for RORO, based on the last inventory…" (Matthews, MBI 02/17/17, p.1714).

According to the April 24, 2015 inventory (MBI Ex.19, p. 2), the vessel had onboard far more Ro-Ro securing gear items than the minimums suggested by the cargo securing manual (inventories of individual items exceeded minimums by between 20% and 200%). That inventory suggests that the vessel was short various twistlocks, lashing rods, and turnbuckles (lines 5-8 in the inventory). However, these items are used for the lashing of Lo-Lo cargo only. With respect to Lo-Lo cargo, once the vessel has completed loading, the Lo-Lo loading configuration is "locked" and there would not be any need to add or change the lashing gear, such as twistlocks, once underway. Therefore, there is no significance to the number of "spares" available for such items. Finally, there was additional lashing gear, to meet minimum inventory requirements, maintained shoreside in Jacksonville and, if needed, it was always available.

iv. Lashing gear was properly maintained

Lashing gear, including binders, turnbuckles, chains, lashing rods, D- Rings, and buttons were regularly inspected and maintained. (MBI Ex.132). Records of repair and maintenance of fixed lashing gear were routinely kept, as part of the monthly cargo gear inspection records. *Id.* In addition, regular records of repair and maintenance of fixed lashing gear were maintained as part of the deck work log, the most recent version of which was dated July 25, 2015. (MBI Ex.335, pp.10, 13-16, 25-27, 35-37). The records document the maintenance of the cargo securing devices as required by the cargo securing manual. [12]

d. Lashing sufficiency on final voyage and the NCB's Reports

The NTSB asked the National Cargo Bureau (NCB) to perform an analysis of certain lashing issues on the *El Faro*. According to the NCB (MBI Ex.290, section 2.0 Scope), it was asked to: review the vessel's Cargo Securing Manual, review the sufficiency of securing arrangements for the Main Deck (containers) and 2nd Deck (Ro-Ro cargo), review the sufficiency of securing arrangement for any "suspect loads" such as high, heavy, or athwartship stows, and calculate breaking or failing points. However, the NCB was not provided sufficient information to perform an accurate or helpful analysis. They were not provided important documents regarding stowage and lashing procedures used on the vessel, and they were not asked to review any transcripts of the numerous NTSB interviews, prior MBI testimony, or the VDR audio recordings.

The initial report developed by the NCB was not based on actual facts and contained, as a result, many errors. The NCB witnesses confirmed that they did not see how the vessel was actually secured on its final departure from Jacksonville; and that they did not review the VDR transcript; transcripts of any witnesses; testimony of the PORTUS personnel who actually lashed the vessel; testimony of mariners regarding how they checked and tightened lashings before departure, how they determined which lashings to apply, how they requested corrections and additions to lashings, how they did daily rounds to check the condition of the Lo-Lo and Ro-Ro lashings; testimony that there had not been any lashing failures or cargo claims as a result of lashing failures in the past on the vessel; or the actual sea and weather conditions the vessel encountered. (Anderson/Walker, MBI 02/09/17 draft, pp.732-733, 737).

TOTE provided a detailed set of comments in response to the NCB's original report. (MBI Ex.294). The NCB issued supplemental reports (MBI Ex.291-293) and later testified at

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[12] At one point in the investigation, investigators may have mistakenly believed that the "buttons" on the deck were subject to a periodic structural test. We believe this may have been a result of a misinterpretation of Captain Hearn's testimony. The "test" that Captain Hearn described was merely a wear and tear test and a test to ensure the button was the correct size, but it was not a test for strength. (Hearn, NTSB 03/30/16, pp.27-28)("test that pin to make sure that there was no wear on the inside of the button and that the button was the correct size for that pin") and (Hearn, MBI 05/17/16, p.109) ("There was a testing tool that we used to measure the clearances inside to make sure that there was no wear or tear or damage or obstructions inside the button so we knew they were in good operating condition.").

Phase III of the MBI. The net result of the supplements and testimony provided by the NCB was that NCB agreed with many (if not most) of the comments TOTE raised. Most importantly, NCB confirmed they could not determine whether (or at what point, if ever) any particular lashing item might have failed and whether any lashing failure was a contributing cause of the incident or a result of the incident. What follows is a discussion of certain aspects of the lashing on the *El Faro*. TOTE refers to its comments contained in MBI Exhibit 294 and to the February 8-9, 2017 MBI testimony of the NCB witnesses for more details on these points.

As described below, the lashing of cargo on the *El Faro* on its final voyage was proper. There is no evidence that any particular lashing was not proper or not in compliance with requirements. More important, there is no evidence (and the NCB confirmed it was not able to determine) that any lashing failures contributed to the incident. Instead, any failures of lashings were the result of the incident, as a natural consequence of the loads eventually imparted on the lashing systems exceeding their design limits.

i. Container stack weights were proper

The container stack weights on the final voyage of the *El Faro* were proper. Of the 148 container stacks on the *El Faro* (MBI Ex.69 - Final Stow Plan), there were 7 instances where there was a potential technical "exceedance" of the specified weight limit for a given stack (that is, where the strength margin reflected in Cargo Max for a specific stack was less than 0). The initial NCB report indicated there were 8 instances. However, as explained in TOTE's comments, one of those determinations was in error as the weight in Bay 15 - Stack 05 did not exceed the stack-specific limit. See MBI Ex.294, pp.3-4. See also Anderson/Walker, MBI 02/8/17, draft, p.592 ("I think we had seven or eight slightly overweight in our initial report.").

However, given the configuration of the structures for loading in each bay, it is incorrect to focus on a single stack. First, the possible exceedances were all less than 0.7 long tons. Given that the total weight of the containers in each bay is in the range of 250 to 625 long tons, such possible exceedances are inconsequential (and fall within the margins of error in weight measurement). More importantly, the presence of structural transverse beams used to distribute stack weights across the deck must be considered. Because of those beams, one needs to look at adjacent stacks (that is, all stacks that share a common transverse beam) to determine the total load being placed on the beams and therefore the deck. Stacks adjacent to the potential "overweight" stack were all below their stack-specific weight limit, meaning the beams would more than adequately compensate for isolated, inconsequential exceedances.

See MBI Ex.294, pp.3-5 for a more detailed discussion of this topic.

ii. Container stack lashing margins were not exceeded

Container lashings were properly applied on the final voyage of the *El Faro*. Lashings were applied consistent with the El Class Minimum Lashing Requirements document (MBI Ex. 294, Ex.B) as discussed above. However, when the NCB was asked to prepare its analysis, it had not even been given this document and it wasn't given the testimony of the many witnesses who testified to the manner in which lashing was performed. The application of lashings consistent with the El Class Minimum Lashing Requirements lashing profile included applying lashing rods to the outer two stacks, but also to certain interior container stacks depending on the content of the abutting stacks. With this lashing profile in use, there was only one container stack (Bay 17, Stack 08) that the NCB identified as potentially being under-lashed. (See MBI Ex.291, p.3; Anderson/Walker, MBI 02/8/17, draft, p.576.) However, the El Class Minimum Lashing requirements document reflects that when an inside stack has an abutting stack of a lesser height, that taller stack receives lashing rods. If that were the case, no lashing margin exceedances existed. (See general discussion at Anderson/Walker, MBI 02/9/17, draft, pp.763-767.) For this stack, even if it were not lashed, the potential exceedance was 0.9 LT. This minimal amount constituted 1.7 % of the weight of that stack (and .19% of the weight of that bay), and was clearly within margins of error for weight measurement. Further, given the safety factors built in, this potential exceedance is insignificant. Finally, the NCB witnesses agreed that there is "no evidence that any of those slightly overweight stacks failed in any way." (Anderson/Walker, MBI 02/9/17, draft, p.745).

See MBI Ex.294, pp.5-7 for a detailed discussion of this topic.

iii. Ro-Ro stowage - on and off button - was proper

Stowage of Ro-Ro trailers, whether on or off a button, was proper on the *El Faro*. The NCB focused on the stowage of trailers on the 2nd Deck. As confirmed by the NCB, there were no concerns with the Ro-Ro trailers stowed on a Roloc button on the second deck -- the cargo was "adequately secured." (MBI Ex.290, pp.9, 29, 31, and 33). The NCB focused on Ro-Ro trailers stowed off a button on 2nd Deck, but based its analysis on incomplete information and incorrect assumptions. Those "off-button" trailers were all properly stowed, as discussed below.

First, the vast majority of the Ro-Ro trailers are stowed on a button. In contrast, NCB was incorrectly told to assume that a large percentage of Ro-Ro trailers were stowed with a Roloc box off the button. This assumption was without any basis. The testimony upon which this was likely based was from an employee of PORTUS who stated in his testimony that he "[had] no recollection of the exact number" of cargo stowed off button and ignored the testimony of various mariners who testified to most cargo being stowed on a button. (MBI Ex.294, pp.7-8, 48).

A mariner, who had sailed extensively as Chief Mate and Master on the *El Faro* reviewed the final stow plan and determined that "it was likely that every trailer was stowed on a button at the time of the September 29, 2015 departure from Jacksonville, with the exception of … four trailers." (MBI Ex.411, p.2). Only one of those four was in Hold 2A, the hold the NCB focused on as being in the area of greatest accelerations. *Id*. As discussed below, calculations regarding the sufficiency of the lashing profile used on "off button" trailers (such as the one identified in Hold 2A) confirms that the lashing of that trailer was sufficient.

Calculations using various combinations of reasonable assumptions, that is, assumptions that closely reflect the actual facts, all confirm that the use of six chains on an off button trailer stow provides more than the minimum required restraint for such trailers. This is the case at the vessel's service speed of 19.5, for trailers in the stowage locations subject to the highest accelerations, and whether lashing angles were at 60 degrees (as incorrectly assumed by the NCB) or at 45 degrees (as contained in the *El Faro*'s Cargo Securing Manual). The NCB originally used a speed of 24.5 knots even though there were no facts to support the use of that speed. The NCB did not consider the September 30, 2015 noon report that showed a speed over the last 24 hours of 19.3 knots, the AIS data that reveals the vessel's speed started to slow down as of 0100 on October 1, or the VDR testimony that the speed as of 0215 that day was down to 16 knots. (Anderson/Walker, MBI 02/09/17 draft, p.740). In fact, TOTE's calculation using 19.5 knots was conservative given that the vessel was moving slower than 16 knots by the morning of October 1. These calculations are described in greater detail in TOTE's submission. (MBI Ex.294).

During the course of the investigation investigators inquired and commented regarding the stowage of non-standardized cargo on the *El Faro* and the requirement for advanced calculations under annex 13 of the CSS Code. However, for such cargo, those calculations are not required. Instead, for non-standardized cargo, there are two acceptable methods to secure non-standardized cargo set forth in the Cargo Securing Manual: (1) non-standardized cargo can be secured with lashing using the "Rule of Thumb Method" whereby the total of the MSL values of the securing devices on each side of a unit of cargo (port and starboard) shall equal the weight of the unit; or (2) lashings may be assessed and shown to be adequate through the performance of advanced calculations under Annex 13 of the CSS Code. (MBI Ex. 40, p.29) Relevant personnel have confirmed that the simplified Rule of Thumb method was typically employed for non-standardized Ro-Ro cargo, such as backhoes, bulldozers, and boat trailers. Finally, TOTE submits that, while it cannot provide specific details due to the passage of time, the Annex 13 calculations were likely performed in connection with the development of the standardized, conservative lashing profiles contained in the EL Class Minimum Lashing Guidance for Ro-Ro trailers stowed off the button.

See MBI Ex.294, pp.7-13 for a detailed discussion of this topic.

iv. Automobile lashings were proper

The Cargo Securing Manual described the manner in which automobiles were to be lashed, specifically stating "For all automobiles use four auto lashings, one at each corner." (MBI Ex.40, p.41). Those four lashings were secured to fixed securing devices -- D-rings, clover-leafs, or chains. The lashing of automobiles with the use of chains run transversely across the deck was proper. There was testimony regarding, and the NCB was asked to comment on, the practice of using chains running transversely across the deck as securing points for automobile lashings. When used, such chains ran across the width of the ship, were passed through D-rings along their length, and were secured to D-rings at either end. The use of chains for lashing cars in this manner is not in the Cargo Securing Manual, but is a common practice in the industry. In discussing this, the NCB stated: "As we have no experience of cars being secured in this manner, we are unable to comment on the efficacy of the lashing arrangement or likelihood of failure in adverse conditions." (MBI Ex.293, p.2). The NCB representative testified that, while he had never seen chain referred to as a securing point, he saw no reason why it could not be one. (Anderson/Walker, MBI 02/8/17, draft, p.584). He also testified that some Ro-Ro vessels have approved Cargo Securing Manuals that allow automobiles to be stowed with no lashing at all. (Anderson/Walker, MBI 02/9/2017, p.750). The example given in the testimony by the NCB was the MATSONIA, a vessel "similar in class to the *El Yunque* and *El Faro* in design". (Anderson/Walker, MBI 02/8/2017, p.586). Clearly if using no automobile lashings can be proper in an approved Cargo Securing Manual, then using chains and vehicle lashings provides more restraint and must be proper.

v. There is no evidence suggesting lashing failure contributed to the incident

The evidence, which NCB did not consider, provides no support (and indeed contradicts) any conclusion that there was any deficient lashing, or any sort of progressive failure that contributed to the incident. This includes the VDR testimony, NTSB interviews, MBI hearing testimony, and the visual evidence regarding the *El Faro* where she lies. None of this evidence supports any suggestion of insufficient lashing, failure of deck cargo supports or lashing points, or any other failure of lashing or failure to comply with the Cargo Securing Manual. The NCB made it clear that it could not make any conclusions as to any failure points and could not reach a conclusion as to whether any lashing failures contributed to the incident or were a result of the incident. These statements were very clear:

- "We were not able to determine precise points at which lashings would break or fail as this is subject to numerous variables such as cargo position, cargo securing points, lashing angles, material strength, wave properties and ship motions that we could not predict." (MBI Ex. 290, p.11).[13]
- "As far as failure points, we were not able to determine breaking or failure points." (Anderson/Walker, MBI 02/08/17 draft, p. 579).
- "So failure points, we could not determine. There's too many variables involved; not enough information regarding the precise manner in which lashings were attached and led and precise vessel motions." (Anderson/Walker, MBI 02/08/17, draft, p.580).
- "We cannot make [the] determination [of whether] cargo shift, if it occurred, may have contributed towards the incident or it may have occurred as a result of the incident." (Anderson/Walker, MBI 02/08/17, draft, p.580-581).
- There is "no evidence, whatsoever, that there was, in fact, a domino effect involving failure of lashings on the *El Faro*." (Anderson/Walker, MBI 02/09/17, draft, p.734).
- "[We] cannot say if a cargo shift actually occurred [and] if a cargo shift, in fact, occurred, [we] can't say whether it contributed towards the incident or was a result of the incident." (Anderson/Walker, MBI 02/09/17, draft, p.736).

e. Lashing Operational Limitations

Lashing standards set forth in the CSS Code and other lashing standards are designed to provide lashing profile that adequately secures cargo, within certain limits. Lashings are not designed to withstand *all* forces on the cargo, but those forces the cargo is reasonably likely to

[13] The NCB has stated it was not able to compute the failure point for lashings of the suspect cargoes, but stated we understand that NTSB would do so instead. Where the expert consultants who were hired to perform cargo lashing calculations said it was not possible to determine failure points, it is questionable whether the NTSB will be able to do so, unless, of course, numerous assumptions are made, each of which will be subject to question. In any event, TOTE has not seen NTSB's engineering calculations or scientific methodologies on this issue and requests the opportunity to review and comment on them.

encounter. (Appendix B (Prof C. Munsch), p.23). Professor Munsch's report at page 23 is instructive:

> All cargo lashing system are designed to withstand forces generated by vessel motions and the effects of wind, and apply a factor of safety. No cargo lashing system to my knowledge applies a lashing force requirement due to sloshing of water in an enclosed lower hold. Lashings are never designed for sloshing loads due to flooding water.
>
> It is important to note that lashings are designed to be able to withstand a certain amount of force; forces that the regulations assume are likely to be encountered under certain operating settings. Lashings are not designed to withstand unlimited forces under any circumstances. Therefore, when the design limitations are exceeded, lashings can and do fail, but that does not mean that such lashings were not proper or did not comply with the CSS code or other regulations and requirements. As this pertains to the *El Faro*, the lashings below deck are designed to withstand certain forces but are not designed to withstand additional forces exerted by forces of water in the hold. Such water, especially when moving as the vessel rolls, heaves, and pitches, can exert additional forces on cargo lashings that exceed their design limitations. If it were the case that cars in fact broke lose in Hold 3 (as a comment on the VDR might suggest), given the amount of water likely in hold 3 by 0545, the failure of those lashings was due to the forces exerted by the considerable amount of water in that hold, and not by any failure to follow proper and required lashing requirements. No conceivable lashing profile that would normally be used for lashing automobiles could withstand such forces associated rapid movement of that amount of water.
>
> (Appendix B (Prof C. Munsch), p.23).

5. Engineering Plant - Pending / Upcoming Maintenance

As set forth in sections V.B.1, the *El Faro* was subject to numerous surveys and inspections by ABS and the U.S. Coast Guard, and found to be in compliance with all applicable regulations and fit for its intended service. We briefly address the few engineering issues that were pending resolution, at the time of the loss of the *El Faro*. For each of the issues pending maintenance resolution, there is no evidence that any of this pending work played a role in the casualty.

Chief Engineer Jim Robinson prepared a set of Chief Engineer Turnover Notes when he was ending his tour on the *El Faro* on 08/18/2015. The Notes were addressed to Sean Holmes and Richard Pusatere. (MBI Ex.130, pp.10-16). These Notes reveal that there were no major items outstanding on the vessel -- all significant repairs and maintenance were up to date and a plan was in place for routine items and items that were to be addressed in the upcoming yard period. Certain items that received attention during the Marine Board of Investigation (MBI) are discussed below.

It is worth noting that as a matter of routine, repairs were not delayed unless they involved an issue that must be addressed in a shipyard. Normal day-to-day operational items "were done as needed, right away." (Neeson, MBI 02/13/17, p.1089). The Port Engineer was the supervisor of smaller budget items, and his superior, the Vice President of Marine Operations Commercial, was the supervisor of larger budget items -- "So big ticket items would be approved from up above, but [the Port Engineer] never had anything denied." (Neeson, MBI 02/13/17, p.1089).

a. The Boilers

i. Recent Maintenance and Inspections

The port boiler was opened and cleaned July 11, 2015. The front wall brickwork was noted as requiring work and that it will be addressed in the shipyard. The starboard boiler was opened and cleaned July 25, 2015. The front wall brickwork was noted as also requiring work and causing the water wall tubes to bow out. A problem with the starboard boiler feed water regulator was identified during operation, so the crew pulled the diaphragm for inspection, and, while the diaphragm was not in bad shape, the seal around the plunger for the manual hand crank was bad, so they installed a new diaphragm and put the regulator back online. (MBI Ex.130, p.15).

ii. Walashek Boiler Survey

A boiler inspector from Walashek Industrial and Marine, Inc. rode on the *El Faro* and inspected the starboard boiler during the September 11-14, 2015 voyage. The findings of the inspection, including a description of the condition of the boiler components, were documented in a report to TSI, as requested. (MBI Ex.12). The boiler inspector did not recommend a timeframe for the repairs, and testified that, in his professional opinion, the repairs could have lapsed a couple of months and that "wouldn't have been a big deal." (Laasko, MBI 02/25/16, p.125). The observations and recommendations described in the Walashek boiler inspection report addressed issues affecting boiler efficiency. (Laasko, MBI 02/25/16, p.134). These issues did not adversely affect boiler safety or reliability. Had they, the inspector would have discussed the issue with the Chief Engineer. (Laasko, MBI 02/25/16, pp.134-135). The Walashek boiler inspector also testified that the age of the boilers did not automatically raise concerns. He believed that the boilers needed some maintenance on the refractory and tubes, but he did not feel unsafe around the boilers. (Laasko, MBI 02/25/2016, pp.122-123).

The Walashek report confirmed the findings of the vessel's engineers from their observations of the boiler operation and their numerous documented fireside inspections. The boiler efficiency was suffering due to a reduction in quality of combustion in both boilers. A major cause of this poor combustion was the geometry and condition of the burner throats -- over time, burner throats tend to break down and lose the geometry required to achieve optimal combustion. When there is a degradation of the burner throats, combustion suffers and the end result is more soot deposits and unburned fuel falling to the boiler floor as slag deposits. Appendix A (J. Daly), pp. 4-5.

The burner throat repairs were being scheduled for the shipyard period planned by TSI for November 2015, along with the removal of slag from the boiler floors and the clearing of the boiler gas paths. (MBI Ex.106; MBI Ex.131). Other issues noted in the Walashek report were to be evaluated at that time and addressed, as needed, including when the vessel transferred to the West Coast. At the time of the loss of the *El Faro,* TSI was developing a budget for the work to be performed on the West Coast. (T.Neeson budget email dated September 17, 2015, (Attachment 16). None of these issues addressed in this survey report affected the reliability and safe operation of the *El Faro* boilers. Appendix A (J. Daly), p.5.

b. The Lube Oil Pumps

In his 8/18/15 Notes, Chief Engineer Robinson included comments regarding the lube oil pumps. (MBI Ex.130, p.15). He noted that the aft lube oil pump discharge pressure, after warm-up, was a few pounds (approximately 3 psi) lower than the forward oil pump. Robinson noted that he had included as a shipyard item that the aft pump should be rebuilt or replaced. He also noted that the forward pump was also due to have its mechanical seal replaced at the shipyard. (MBI Ex.130, p.15) Mr. John Daly, TOTE's Marine Engineering expert, stated in his opinion that one cannot determine, based on a small pressure differential alone, that a problem existed with the mechanical seal on the pumps. He further concluded that Mr. Robinson's decision to address the issue at the next shipyard period was a reasonable one, and one that he would expect. Appendix A (J. Daly), p.26.

c. Strut Lube Oil

In his 8/18/15 turnover notes, Chief Engineer Robinson reported that the lube oil analysis report on the strut had been coming back with high tin readings. To manage the situation, he had been flushing the system every couple weeks by draining 10-15 gallons of lube oil, and continued monitoring the condition more frequently. If necessary, the condition would be addressed in the upcoming shipyard visit. (MBI Ex.130, p.16). According to Mr. Daly, this approach was reasonable and in line with what would be expected; there is no evidence that elevated tin levels in the strut played any role in the loss of propulsion. Appendix A (J.Daly), p.6.

C. National Hurricane Center - Weather Forecasting Errors

1. NHC Forecasting Errors for Joaquin

The errors in Joaquin's forecasted track and intensity were much larger than historical errors. The Branch Chief of the Hurricane Specialist Unit with the National Hurricane Center testified at the MBI hearings regarding the extent of the errors in the forecasting of Joaquin. Errors were discussed in terms of the difference between the actual hurricane position and intensity as of approximately 0800 EDT on October 1, 2015 and what the position and intensity were forecast to be 1 day, 2 days, and 3 days earlier for that time. Specifically, Mr. Franklin described those errors as:

- the 3-day location forecast was 536 miles off, which was "really about 1 in 100 type of track error"
- the 3-day intensity error was 80 knots too low
- the 2-day location forecast was 180 miles off, which was "something like a 90 or 95th

percentile of error"

- the 2-day intensity error was 60 knots too low
- the 1-day location forecast was 62 miles off
- the 1-day intensity error was 30 knots too low
- the "track forecast and intensity errors were much larger than normal for us"
- "the initial forecast called for a relatively weak system to head off to the West and Northwest and this instead it moved West Southward and Southward and strengthened"

(Franklin, MBI, 05/17/16, p.178).

Additionally, the National Hurricane Center's Tropical Cyclone Report contains the results of its post storm analysis of Joaquin. Table 6a in that report confirms the errors were much larger than usual -- the error in the 120-hour OFCL forecast position was more than double the mean error for the previous 5-year period and that error in the 48-hour forecast was about 57% percent greater than the previous 5-year mean error value. (MBI Ex.147, p. 22).

2. Significance of the Forecast Errors to the Navigation of the *El Faro*

These errors were contained in the forecast information received by the *El Faro*, including in the Advisories and in the BVS products. Obviously, the fact that the predicted storm intensities were much lower than the actual intensities was significant with respect to the conditions actually encountered by the *El Faro*. Perhaps more important were the direction and size of the errors in the forecast position of Joaquin.

It was against the forecast positions that the Master and the bridge watch standers planned and adjusted the vessel's route. TOTE's meteorology expert, Dr. Austin Dooley, analyzed the errors for the forecast positions at 0200 EDT and 0800 EDT October 1 and compared those to the Best Track (actual) positions. Appendix C (Dr. A. Dooley), p.7. The following chart shows the results:

FORECAST ISSUED AT EDT	FORECAST VALID AT EDT	FORECAST DURATION IN HOURS	DISTANCE FROM FORECAST POSITION TO BEST TRACK POSITION	BEARING FROM FORECAST POSIT TO BEST TRACK
28 05:00 AM	01/0200	72	465	187
29 05:00 AM	01/0200	48	216	182
29 05:00 PM	01/0200	36	96	179
30 05:00 AM	01/0200	24	77	159
30 05:00 PM	01/0200	12	41	140
28 11:00 AM	01/0800	72	536	185
29 11:00 AM	01/0800	48	180	180
29 11:00 PM	01/0800	36	104	167
30 11:00 AM	01/0800	24	62	165
30 11:00 PM	01/0800	12	25	168

Figure E: Forecast Position to Best Track (Actual) Position For 0200 and 0800 on October 1, 2015

To illustrate the findings in the chart above by way of examples:

- The actual position of Joaquin at 0200 EDT on October 1, 2015, was approximately 96 miles away, further to the south, from the position predicted by the NHC forecast that issued at 5:00 p.m. on September 29, 2015.
- The actual position of Joaquin at 0200 EDT on October 1, 2015, was approximately 41 miles away, again further to the south, from the position predicted by the NHC forecast that issued at 5:00 p.m. on September 30, 2015.
- The actual position of Joaquin at 0800 EDT on October 1, 2015, was approximately 104 miles away, further to the south, from the position predicted by the NHC forecast that issued at 11:00 PM on September 29, 2015.
- The actual position of Joaquin at 0800 EDT on October 1, 2015, was approximately 25 miles away, further to the south, from the position predicted by the NHC forecast that issued at 11:00 p.m. on September 30, 2015.

The above findings by Dr. Dooley were largely confirmed by Dr. Franklin from the NHC during his MBI testimony. (Franklin, MBI, 05/17/16, p.178).

This confirms that the forecast errors consistently predicted that Joaquin would be farther north and west of the Best Track (storm's actual) position. At roughly 21 hours before the forecasted positions, the forecasts contained errors of 77 nautical miles (for the 0200 position) and 62 nautical miles (for the 0800 position). These equate to errors that were, respectively, about 71% and 37% greater than the 5-year average. Appendix C (Dr. A. Dooley), p.7.

In addition to the errors in position and intensity, this storm was not predicted to rapidly intensify as it did. Rapid intensification is defined as an increase in 30 knots in 24 hours. (Franklin, MBI, 05/17/16, p.176). Joaquin experienced rapid intensification of 45 mph between 0800 local (1200 UTC) on 30 September and 0800 local (1200 UTC) on 01 October. (MBI Ex.147, p.11). The quality of the forecast information did have an impact on the *El Faro*, and, as described below, was an important, and complicating, factor in the navigation of the vessel.

D. Navigation Decisions

1. General / Responsibility

The navigation and operation of the TSI-managed vessels are controlled by the Master. (Chancery, MBI 02/24/16, p.53). Masters and the bridge team make whatever adjustment they need for weather. (Cadorette-Young, NTSB 12/02/15, p.77). The Master must only notify the company where there is a course change or speed reduction due to adverse weather (as these may impact arrival times requiring notice to tugs, pilots, labor for cargo ops, etc.). (MBI Ex.198, OMV, section 10.8.2). The Master does not need permission to do so. (Morrell, MBI 02/16/16, p.51). The Master's voyage plan for a particular voyage are approved and carried out by the Master on the vessel. For the voyage at issue, he reviewed and approved the vessel's voyage plan prior to departure from Jacksonville on 29 September. (MBI Ex.004, p.93 – *El Faro* Departure Report 29 September 2015).

2. Decision to Depart Jacksonville on September 29, 2015

Captain Davidson was carefully monitoring Joaquin. (Lawrence, MBI 02/20/16, pp.91,94). At the time Captain Davidson decided to depart the Port of Jacksonville at 2015 EDT on the evening of September 29, 2015 Joaquin was a tropical depression and was not forecasted to become a hurricane until October 3, 2015. (NHC Advisory Number 8, prepared at 1700 EDT on September 29, 2015, National Hurricane Center, Hurricane Joaquin Adv. Archive, accessed at http://www.nhc.noaa.gov/archive/2015/JOAQUIN.shtml). Although forecast to strengthen into a hurricane, its forecast track included a pronounced re-curve to the north-northwest and away from *El Faro*'s intended track. *Id.* Moreover, given that they had not yet entered the open Atlantic Ocean, Captain Davidson had multiple route options available both north and south of the Bahamas chain with regard to the track the vessel would ultimately follow to San Juan. Given the forecast weather data and available vessel track options, the Master's decision to depart Jacksonville on the evening of September 29, 2015 was reasonable. Appendix D (Capt R. DiNapoli), pp.13-14, ¶ 18).

3. Evidence of Weather Monitoring On Voyage

The OMV, at section 10.8.1 (MBI Ex.25), specifically provides, "The Master should use all available means to determine the weather that the vessel may encounter on a given voyage." The testimony and evidence suggest he did use all available means. According to the conversations recorded on the VDR, it is clear that Captain Davidson and the bridge officers were receiving and reviewing various sources of weather information, including: Sat-C, NAVTEX, weather fax, satellite radio, BVS, as well as the barometer and visual observations. Overall, evidence developed in the investigation confirmed that Captain Davidson, as a matter of practice, routinely relied on many sources of weather other than BVS, consistent with TOTE's SMS which directs the use of "all available means to determine the weather that the vessel may encounter on a given voyage."

4. Early morning course change and emails ashore and with *El Yunque* on September 30, 2015

On September 30, 2015, the Master ordered two course changes to continue to provide for greater distance between the vessel's plotted course and the evolving path of Joaquin. The first was at approximately 0625 EDT, when Captain Davidson directed a course change from about 133° to about 141°. The second occurred at 1905 EDT and is discussed below (see Subsection 5 below).

In an email later in the morning of 30 September, in response to inquiries from Captain Stith, Master of the *El Yunque*, Captain Davidson wrote:

> I have been watching this system for the better part of a week. We did alter our direct route slightly more to the south, which will put Joaquin 65 nm to the north of us at its cpa [closest point of approach]. Fortunately we departed the dock in JAX on time last evening and making 20k [knots] doesn't hurt either. All

> departments have been duly notified, and we should be on the back side by 10/01/0800.

(MBI Ex.004, pp.95-96); (Stith, NTSB 10/07/15, p.85); (Stith, MBI 05/24/16, p.54). Captain Stith believed Captain Davidson had a solid plan that was well thought out. (Stith, MBI 05/24/16, p.57). At the time, Captain Stith was traveling northbound en route from San Juan to Jacksonville. (Stith, MBI 05/24/16, p.52). All the information received by the *El Yunque* showed that the storm was going to turn north or remain stationary and would not be an issue. (Stith, NTSB 10/07/15, p.86);(Stith, MBI 05/24/16, p.51).

During that day, by an email sent to TOTE shoreside operations personnel at 1322 EDT, the Master advised that he had been observing the erratic track of Joaquin for the better part of a week and that the storm now appeared to be tracking as forecast. He advised further that he had adjusted the normal direct track of the vessel to the south-southeast so as to pass approximately 65 miles to the south of the storm's track and be on the "back" side of Joaquin by the morning of October 1. (MBI Ex.004, p.101). The email was transmitted on 30 September 2015 at 1712 UTC (112 PM EDT). While the email appears to ask for agreement with Captain Davidson's proposed alternative route for the return trip, he did not have to ask for permission, and nobody can explain why he used that wording in the email. (Fisker-Anderson, MBI 02/19/16, pp.110-12);(Lawrence, MBI 02/20/16, p.30).

At the time he sent the email, the latest available forecast information was Advisory Number 11, released at 1100 EDT, which reflected a storm having hurricane force winds with a relatively small radius of only 35 miles from its center and still included the pronounced re-curve to the north-northwest by 0800 EDT on the morning of October 1, which would move it further away from the proposed vessel track.

The Master's decision to continue along the plotted course was reasonable because of two factors. First, the geographical dimensions of Joaquin were substantially smaller in area than is typical for hurricanes occurring in North Atlantic Ocean waters, and the planned track of the vessel would have been well outside the radius of hurricane force winds. Appendix D (Capt R. DiNapoli), p.18, ¶22. Second, the vessel's position and plotted track relative to the storm's track would have kept the vessel in the storm's navigable semi-circle. *Id*. at p.19, ¶23. At a distance of 65 miles from the storm's center, the vessel would have remained well outside the radius of hurricane force winds, and encountered only the predominantly following winds and seas of its navigable semi-circle.

In the northern hemisphere, the "half-circle" that lies to the <u>right</u> of the storm's track is referred to as the "dangerous semi-circle" and that which lies to the <u>left</u> of the storm's track is referred to as the "navigable semi-circle." This is so because the forward speed of the storm system is added to the wind velocities on one side of the storm (the "dangerous" side) and subtracted from the wind velocities on the other side (the "navigable" side). A vessel meeting such a storm in its dangerous semi-circle encounters strong headwinds and head seas that cause heavy pitching and rolling motions, with considerable pounding of the vessel's structure as it plows ahead into such conditions. Conversely, a vessel meeting a storm in its navigable semi-circle encounters less strong and predominantly "following" winds and seas that result in a gentler ride and minimal structural pounding. Appendix D (Capt R. DiNapoli), pp.18-19, ¶¶22-23).

On the basis of the forecast information and projected storm system track available to the vessel at the time, the Master's estimation that the vessel would pass "under" (south of) the storm's path, approximately 65 miles from its center, was accurate and manageable. Accordingly, the Master's decision to continue along the selected course during the day on September 30 was reasonable. *Id*. at p.19, ¶24.

5. Master and Mates' assessment of Weather at 1700 and the evening course change on September 29, 2015

At approximately 1715 EDT on September 30, 2015, the Chief Mate received NHC Advisory Number 12 via the Sat-C reception terminal of the vessel's GMDSS. Advisory Number 12 reported Joaquin was generating maximum sustained winds of 85 mph, the radius of hurricane force winds was still 35 miles outward from its center, with tropical storm force winds extending 125 miles from the center. A hurricane warning had been issued for the northwestern Bahama Islands, however, the southeastern Bahama Islands, including Acklins and Crooked Island, remained under a tropical storm warning only.

At 1747 EDT, the most recent available BVS file (containing Advisory Number 11 in graphic form) was downloaded by *El Faro*. Both Advisory Number 11 (received via BVS) and Advisory Number 12 (received via Sat-C) confirmed that the storm had tracked further to the south than previously forecast. The Chief Mate plotted the projected positions of both Joaquin and the vessel for 0200 EDT on October 1, and discussed the situation with the Master. This resulted in the decision to alter course further to the south, to pass inside of San Salvador Island and thus steer even further away from the storm's center based on the Chief Mate's recent plot of the storm's path. That second course change, from about 139° to about 150°, occurred at approximately 1905 EDT, with the goal of allowing *El Faro* to pass on the "back" side of the storm system, in its navigable semi-circle, while also remaining well outside the radius of hurricane force winds.

On the basis of the forecast information and projected storm system track available to the vessel at the time, the Master's plan to alter course further to the south so as to achieve even greater separation, while still remaining in the storm system's navigable semi-circle and well outside the radius of hurricane force winds was reasonable. Appendix D (Capt R. DiNapoli), p.23, ¶29).

6. Master and Mates' assessment of Weather at 2300 on September 29, 2015

During the 2000-0400 watches, the latest BVS file package onboard *El Faro* was the package downloaded at 1747 EDT, which included the content of Advisory Number 11. [1] The next BVS download on the *El Faro* did not occur until 0445 on October 1, which included the content of Advisory Number 12, followed by a download of BVS at 0609 which included the content of Advisory Number 13. At approximately 2305 EDT, the Third Mate on watch received

NHC's Advisory Number 13 via the vessel's Sat-C terminal and noted the latest storm position and forecast track. He recognized that the storm had intensified to a Category 3 system, that its center was further south than originally anticipated, and it was continuing to move in a southwesterly direction that would bring it closer than expected to the vessel's track after the intended course change back to the east was made upon passing San Salvador Island. Once past San Salvador, the plan was to return to an east-southeasterly heading (on a course of 116°) to start bringing the vessel back to its usual track for San Juan.

The Third Mate telephoned the Master in his stateroom and suggested he review the latest storm information that was just received. (*El Faro* VDR Transcript, p.268). The Third Mate then plotted the latest forecast track for Hurricane Joaquin against the projected vessel track, concluding that the vessel would now be 22 miles from the storm's center between 0400 and 0430 EDT on October 1. The Third Mate telephoned the Master again to advise him of this updated plot information. (*El Faro* VDR Transcript, p.269). From the Third Mate's comments to the Able Seaman on watch after that call to the Master, it appeared the Master had stated that "we'll be south of it [i.e., in the navigable semi-circle] by then – so the winds won't be an issue." *Id*.

The latest track forecast for Joaquin, as plotted out by the Third Mate, showed the storm crossing directly <u>ahead</u> of the vessel, at a distance of approximately 22 miles. Of additional concern would be the fact that the vessel would now be in the system's <u>dangerous</u> semi-circle, with its stronger winds and head seas. Based upon the VDR transcript, it does not appear Captain Davidson was made aware that the vessel was going to cross directly ahead of Joaquin and be in the dangerous semi-circle. The Master's perception of Joaquin's position at that time may have been impacted by the BVS information that he had previously reviewed with the Chief Mate around 1800 EDT. That information showed a predicted 0200 storm position over 40 miles further to the north of the position plotted by the Third Mate from NHC Advisory Number 13. Had this BVS information been accurate, the vessel would indeed have passed well to Joaquin's south side and in its navigable semi-circle. This is likely the reason why the Master did not come up to the vessel's bridge to review the 2305 EDT Sat-C information the Third Mate described to him over the telephone. Appendix D (Capt R. DiNapoli), p.26, ¶34).

7. Master and Mates' assessment of Weather during 0000-0400 Watch on October 1, 2015

At approximately 2345 EDT on September 30, 2015, the Second Mate relieved the Third Mate and assumed the bridge watch. At this time, the vessel had not yet passed San Salvador Island and had not yet made a planned course change to 116°. As part of the watch transfer process, the Second Mate reviewed the latest weather information and vessel/storm track plots. Both officers concluded that the current navigation plan had become less than optimal and an alternative plan would be to turn due south at 0200 EDT and travel through the Crooked Island Passage. The alternative plan was not without its risks. Crooked Island Passage does have hazards (shallows, rocks, etc.) to which the *El Faro* would have to be attentive (MBI Ex. 285), and the Master may have also been concerned about those when compared to a relatively unimpeded deep water route he had already planned. Appendix D (Capt R. DiNapoli), p.27, ¶35).

The Second Mate prepared the new route waypoints and plotted the alternate track through Crooked Island Passage commencing with a course change to the south at 0200 EDT. This was done with the anticipation that the Master would likely come up to the bridge by that time. The magenta line in the illustration below shows the alternate route planned by the Second Mate -- the intersection of the magenta line with the bottom of the illustration represents the position the vessel could have achieved by 0600 EDT. The light green line in the illustration depicts the vessel's actual track until it lost propulsion shortly after 0600 EDT on October 1. The blue and red lines show the forecast and actual paths of Joaquin through approximately 0600 EDT.

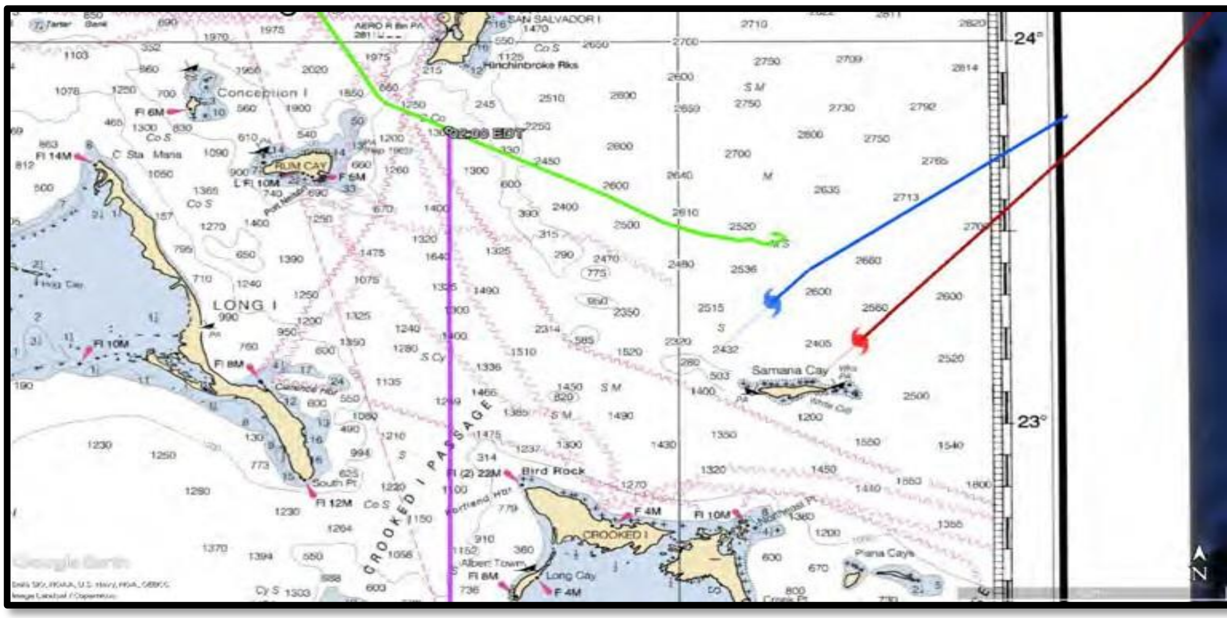

Figure <u>F</u>: Track Lines

As *El Faro* began to pass abeam of San Salvador Island, the Second Mate concluded the planned course change to 116°T was not the path the vessel should continue on. At 0120, the Second Mate called the Master, advised that their planned course change was not a good option, and proposed altering course to take the southerly route through Crooked Island Passage. The VDR transcript reveals that during the call she commented that they would be meeting the storm, Fox News reported it moved up a category, stated "it isn't lookin' good right now," and she proposed heading "– right now my uh– trackline I have zero-two hundred– alter course straight south and then (we'll) * go through all these * shallow areas . . . ." (*El Faro* VDR transcript, p.310). However, the Master's response was to stay with the original navigation plan and make the course change to 116°T. This position by the Master almost certainly was based on his belief, likely based on the content of the most recent BVS information he had reviewed, that on the planned course the *El Faro* would be south of the storm's center and in its navigable semi-circle. (Appendix D (Capt R. DiNapoli), p.28, ¶37). By approximately 0315 EDT, the Second Mate observed that wind speed had now increased to 50 knots and that "we're gettin' into it now." It was becoming increasingly difficult to steer the vessel and maintain the 116° course.

The progression of events and conditions impacting the vessel are discussed elsewhere in this submission.

8. Situational Awareness by the Master on October 1, 2015

In hindsight, the Master's situational awareness appeared compromised. There were many factors that may have contributed to the situation, including; (1) his reliance on BVS; (2) information contained in a given BVS weather package was not current; (3) the ship was not experiencing adverse weather and waves until after 0100; and (4) his experience in Alaska and confidence sailing in rough weather. In other words, when a given Advisory and BVS download were available on the vessel (which became available roughly at the same times each day -- approximately 0500, 1100, 1700, and 2300), the Advisory was the more current forecast and the BVS presentation was based on the Advisory from six hours earlier. It is not clear the Master fully comprehended this.

This becomes clear when the timeline of available information is assessed. The Master downloaded BVS at 1747 (which contained the information in Advisory 11). (NTSB Electronic Data Group Factual Report, table 1, at p.10). Advisory 12 was already available and on the bridge, via the INMARSAT-C SafetyNet system, by around 1715. *Id*. Advisory 13 was available and on the bridge, via the INMARSAT-C SafetyNet system, by approximately 2305. The next BVS was not downloaded by the Master until 0445 on October 1. *Id*. Therefore, from 1747 until 0445, the Master's most current BVS information was that contained in Advisory 11, which had been issued at roughly 1100 on September 30. It would be this BVS package (and any other information from the bridge that he chose to rely upon) that would have formed the basis for his navigational decisions, including the decision to not alter course at 0200 to turn south through Crooked Island Passage.

The significance of this is reflected by the difference in the storm forecast tracks contained in the BVS (Advisory 11) release (upon which the Master apparently relied) and in Advisory 13 (upon which the bridge watch standers were basing their recommendations for course changes). The diagram below reveals the difference in the positions of the forecast for Joaquin at 0800 EDT (1200Z) on October 1 for Advisory 11 (in BVS) and Advisory 13 (on the bridge) -- the Advisory 11 position is 43.4 miles to the north-northwest of the Advisory 13 position for the same forecast time.

Figure G: Difference in Forecast Positions

Even so, the Master had some awareness of the conflicting information he was receiving. He expressed some frustration with the conflicts at 0503 when he stated: "That– that's fine– but here's the thing– you got two G-P-Ss– you got five G-P-Ss– you gunna get five different positions. you got one weather program (and I use/and use) B-V-S and that's what I (sent) up here * we're gettin' conflicting reports as to where the center of the storm is." (*El Faro* VDR Transcript, p.394).

The apparent confusion of the Master helps explain why the Master believed the *El Faro* would be beyond the storm's center when she came out from under San Salvador, supporting his decision not to change course at 0200.

The Master also appeared to not have situational awareness of the barometric pressure, which had not started to rise as it would have, or the wind direction which would have changed, had they passed the center of the storm.

In retrospect, it appears from the evidence developed in the investigation that the Master had a mistaken perception of Joaquin's positions/track, as compared to actual circumstances. The impact of this mistaken belief was further compounded by the erratic nature of the storm and pervasive forecasting errors. It appears more likely than not that the vessel would have avoided the worst effects of Joaquin had it made the timely diversion to the south, as proposed by the Second Mate. (Appendix D (Capt R. DiNapoli), p.28, ¶39)(further describing the conditions that the vessel would have likely encountered along this alternate route).

E. Dynamic Stability Analysis of *El Faro* During Accident Voyage

1. Analysis Overview

TOTE retained an expert Naval Architect, Professor Charles J. Munsch from SUNY Maritime College at Fort Schuyler, to perform a stability assessment and analysis, to independently determine, among other things, whether the *El Faro's* stability and arrangement satisfied applicable stability requirements, load line regulations, and structural standards. After reviewing all applicable evidence in the case, Professor Munsch concluded that the *El Faro* was operated in accordance with all applicable rules, regulations, and guidelines. (Appendix B (Prof. C. Munsch), p.53). As set forth in more detail in Sections III.F.4 and III.B.2 of this submission, the *El Faro* satisfied all applicable stability and load line regulations when it departed Jacksonville on September 29, 2015.

In addition to performing an assessment of regulatory compliance, Professor Munsch also performed a dynamic stability analysis of the *El Faro* during voyage 185S. The purpose of this additional analysis was to better understand the conditions that the *El Faro* was experiencing during Joaquin, how the vessel handled in those conditions, and the facts and circumstances leading to the loss of the vessel. The vessel's general track line in the final hours of Voyage 185S is depicted below in Figure H. The vessel lost propulsion around 0600-0610, went beam to the sea, and was pushed to the southwest, as depicted below, until the vessel was lost sometime after 0739 EDT. Professor Munsch examined the vessel's motions in the hours leading up to, and after, the loss of propulsion.

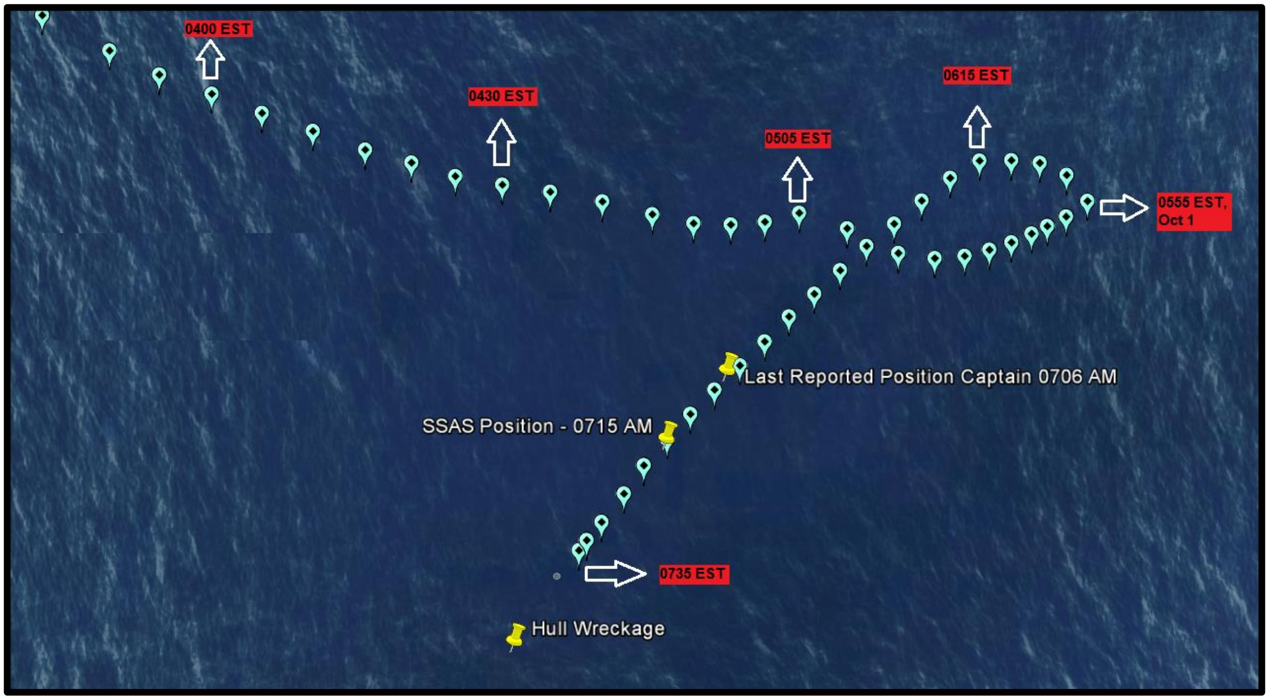

Figure H: Track Line Final Hours of Voyage 185S

As set forth in more detail below, based on Professor Munsch's calculations and analysis, it appears very likely that, shortly after 0600 on October 1, 2015, after the vessel lost propulsion, the vessel's cargo hold ventilation openings (at the top of the baffle plate) were periodically submerged at extreme rolls, heave, and pitching, resulting in large amounts of water entering cargo hold number 3. These ventilation openings progressively continued to be submerged with greater frequency over time, ultimately leading to flooding of cargo hold number 3 (and 2A) and loss of the vessel.

2. Methodology & Assumptions

Professor Munsch performed a dynamic stability assessment of the *El Faro* along voyage 185S using MAXSURF, a computer program he has used in the performance of his work for 25 years. (Appendix B (Prof. C. Munsch), p.26). Unlike many stability programs that calculate the vessel's stability in static and assumed calm conditions, MAXSURF is used to predict the dynamic motions of the vessel. *Id.*

In order to accurately calculate the dynamic ship motions of the *El Faro*, Professor Munsch first obtained assumed weather conditions from Dr. Austin Dooley, Ph.D. Dr. Dooley conducted a comprehensive analysis of the weather data, and developed predicted weather conditions along the *El Faro's* route on voyage 185S. See Section III.C. and (Appendix C (Dr. A. Dooley), p.17, Chart 8. The predicted weather conditions along the vessel's route are set forth below in Figure I. In addition, Professor Munsch also considered data retrieved by investigators from the vessel's VDR, which provided the vessel's speed and heading throughout the accident voyage.

All of the above information was necessary for Professor Munsch to perform his analysis using MAXSURF.

SS EL FARO AND HURRICANE JOAQUIN – SEPTEMBER AND OCTOBER 2015

TABLE OF ADJUSTED ROUTE CONDITIONS

EDT	WIND DIR	WIND KNOTS	COMB WAVE HT M	AVE DIR AT PEAK PERIOD	PEAK PER SEC	WIND WAVE DIR	WIND WAVE PER. SECS	WIND WAVE HEIGHT	SWELL DIR	SWELL HEIGHT	SWELL PER
30/2000	3	22.9	3.3	78	10.92	353	5.51	1.5	68	3.1	10.90
30/2030	8	24.3	3.6	78	11.09	18	7.71	2.4			
30/2100	13	25.7	3.8	77	11.25	43	9.90	3.2			
30/2130	12	27.3	4.0	80	11.50	51	10.83	3.7			
30/2200	10	28.8	4.2	82	11.75	59	11.75	4.2			
30/2230	2	29.3	4.3	78	11.52	43	10.69	3.9			
30/2300	354	29.8	4.4	73	11.29	27	9.62	3.6			
30/2330	352	30.9	4.6	70	11.18	46	8.38	3.1			
01/0000	350	31.9	4.7	67	11.07	349	7.13	2.7	62	3.9	11.10
01/0030	347	34.9	4.8	61	11.00	353	7.64	3.2			
01/0100	343	37.9	5.0	54	10.92	356	8.15	3.8	54	3.3	11.10
01/0130	343	39.6	5.0	41	10.57	354	8.37	4.1			
01/0200	343	41.3	5.0	28	10.21	352	8.59	4.3	65	2.4	12.10
01/0230	341	46.5	6.0	42	11.01	359	9.73	5.2			
01/0300	338	51.6	7.1	56	11.80	5	10.87	6.1	68	3.7	12.20
01/0330	341	59.4	7.9	46	11.56	11	11.10	7.4			
01/0400	344	67.2	8.8	35	11.32	16	11.32	8.8			
01/0430	352	70.3	8.9	36	11.12	18	11.12	8.9			
01/0500	360	73.4	9.0	37	10.92	20	10.92	9.0			
01/0530	19	66.7	8.9	55	10.91	39	10.91	8.9			
01/0600	38	59.9	8.7	72	10.89	58	10.89	8.7			
01/0630	46	63.2	8.9	70	10.98	59	10.98	8.9			
01/0700	54	66.5	9.2	68	11.07	60	11.07	9.2	263	0.3	10.20
01/0730	48	72.8	8.7	31	10.25	48	10.16	7.8			
01/0800	41	79.0	8.3	354	9.43	36	9.25	6.5	148	2.2	10.60
01/0830	44	73.9	8.7	32	9.97	47	9.88	7.8			
01/0900	46	68.8	9.1	69	10.50	58	10.50	9.1	274	0.8	11.20

DOOLEY SEAWEATHER ANALYSIS, INC.

Figure I: Table of Adjusted Route Conditions

3. Summary of Analysis and Finding

Based on the analysis, water appears to have entered cargo hold 3 from two likely sources. First, the effects of Joaquin resulted in progressively increasing amounts of water on the second deck, as the voyage proceeds through its final hours. If the scuttle into cargo hold number 3 was left open, Professor Munsch estimates that water could sufficiently accumulate in the area of the open scuttle, go over the scuttle coaming, and enter into the hold, beginning as early as 0300 EDT. Appendix B (Prof. C. Munsch), p.34. Second, at 0400, the cargo hold ventilation openings (top of the baffle plate), are estimated to be approximately 7.2 feet above the waterline at extreme rolls, heave, and heel angles. See Figure J below. The susceptibility of downflooding into the cargo hold ventilation openings increases significantly over time, particularly after the vessel changed its wind profile at approximately 0600 EDT.

Professor Munsch estimates that the rate of water entering through the cargo ventilation openings would occur at a rate roughly 10 times that of the open scuttle. (Appendix B (Prof. C. Munsch), p.45).

A table summarizing Professor Munsch's results is provided below in Figure J.

Time	winds (knots)	waves height feet	heel (due to wind) degrees	heel (water) degrees**	heel (cars) degrees	MAX heel total (degrees) NO roll		Roll RMS (Mean)	Roll Extreme	Extreme Roll (wind+water+cars)	RMS heave feet*	Distance from water to baffle RMS	Distance from water to baffle EXTREME	Pitch RMS (mean)/Extreme	Vessel Speed	Water In Hold (LT)
0200	41.3	16.37 ft	1.1	0	0	1.10	S	1.72	3.44	4.54	4.47	16.36	11.89	0.75/1.5		
0300	51.6	23.29	1.6	0		1.60	S	1.91	3.82	5.42	4.68	15.34	10.66	1.91/3.84		
0330	59.4	25.92	1.7	.11		1.81	S	1.6	3.2	5.01	5.43	14.97	9.54	1.84/3.68	17.2	7.5
0400	67.2	28.71	6.1	0.25		6.35	S	1.62	3.24	9.59	4.43	11.70	7.27	2.35/4.70	10.8	15
0430	70.3	29.2	6.0	0.65		6.65	S	0.82	1.64	8.29	2.53	14.82	12.29	2.8/5.6	9.4	35
0500	73.4	29.53	4.4	.75		5.15	S	0.59	1.58	6.73	2.78	16.03	13.25	2.83/5.66	6.6	46
0530	66.7	29.2	1.1	0.97		2.07	S	0.32	0.68	2.75	2.78	19.70	16.92	2.63/5.26	5.2	59
0600	59.9	28.54	1.4	1.01		2.41	P	1.52	3.54	5.95	9.79	9.74	0.05	2.25/4.5	8.9	65
0630	63.3	29.2	5.5	1.1	2.5	9.10	P	3.53	7.06	16.16	8.17	1.62	6.55	2.38/4.76		185
0700	66.5	30.18	5.5	4.98	3.20	13.68	P	4.47	8.94	22.62	7.19	4.06	11.25	1.89/3.78		305
0730	72.8	28.54	.6	8.35	3.5	12.45	P	4.48	8.96	21.41	6.59	2.17	8.76	1.82/3.64		545

red above baffle

* Heave at mean value extreme is higher
** does not include water in ER or 2 hold

Figure J: MAXSURF Motions Analysis Table

(Appendix B (Prof. C. Munsch), p.52).

The following is a summary of key events and observations from Professor Munsch's dynamic analysis regarding the final hours of voyage 185S.

0100: The vessel begins to experience tropical storm force winds (35 knots+) by 0100. Professor Munsch's analysis indicates water spray would enter second deck, but this water would easily drain through the side openings on the second deck. The vessel is riding out the weather well, with winds at the stern. (Appendix B (Prof. C. Munsch), p.52).

0200: By 0200, with 40+ knot winds off the port quarter, the vessel begins to heel approximately 1.1 degrees to starboard due to the wind. Wave heights are more than 16 feet. The dynamic analysis further indicates the vessel is experiencing a roll of approximately 3.4 degrees (at the extreme). There is also slightly less water spray on the second deck, as the relative wind shifts from aft towards the beam. (Appendix B (Prof. C. Munsch), p. 52).

0300: By 0300, the vessel is experiencing wind speeds in excess of 50 knots, slightly off the port quarter, causing a heel of approximately 1.6 degrees to starboard, and waves of approximately 23.3 feet. The vessel begins pitching more significantly fore and aft (1.9 degrees average and 3.8 degrees extreme). At the extreme angles of pitch, heel, and roll, the dynamic analysis indicates that green water begins to enter the second deck from the stern and starboard aft portion of the vessel. Green water that enters on the aft part of the vessel will flow forward due to the vessel's sheer and pitching action, and would accumulate and pocket near the scuttle going into cargo hold number 3. If the scuttle is open, the analysis indicates there is sufficient water on deck to flow over the coaming of the scuttle; a small amount of water begins periodically entering the scuttle during this period of time. (Appendix B (Prof. C. Munsch), p.34).

<u>0330</u>: By 0330, the vessel is experiencing wind speeds of approximately 59 knots, off the port quarter, causing a slight heel (1.7 degrees to starboard), and waves of approximately 25.9 feet. The vessel's extreme roll is approximately 3.2 degrees. The pitch of the vessel, fore and aft, continues (3.68 degrees extreme). Each time the vessel experiences an extreme roll, pitch, or heave motion, greater amounts of green water enter the second deck at the stern and aft portion of the starboard side. Green water on deck will tend to accumulate in the area of the scuttle. Professor Munsch estimates at this hour, sufficient water would likely accumulate in the area of the scuttle and enter the hold, at a rate of approximately 15 long tons per hour. The estimated amount of water in the hold is 7.5 long tons at 0330. Water entering the hold accumulates on the starboard side, thereby slightly increasing the vessel's heel (by 0.11 degrees). (Appendix B (Prof. C. Munsch), p.35).

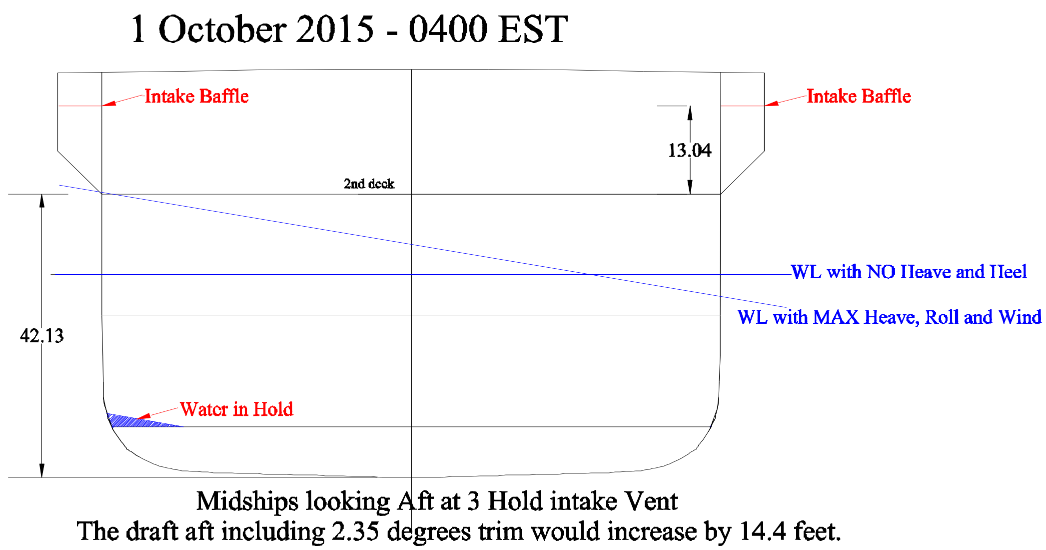

Figure <u>K</u>: Water in Hold Diagram at October 2015 – 0400 EST

<u>0430</u>: By 0430, the vessel is experiencing wind speeds of approximately 70 knots, off the port beam, resulting in a wind heel to starboard (to 6.0 degrees starboard). Wave heights have increased to approximately 29.2 feet. The vessel pitching, fore and aft, continues to increase (5.6 degrees extreme). Increasing amounts of water continue to enter the second deck as described above, and continue to enter cargo hold 3. By 0430, Professor Munsch estimates that approximately 35 long tons of water could have entered cargo hold 3. Due to the list of the vessel, and the location of the bilge alarms inboard of the side of the vessel by approximately 20 feet, the bilge float would not likely be raised for a sufficient period of time to actuate the bilge alarm. Water entering the hold accumulates on the starboard side, further increasing the vessel's heel (contributing to 0.65 degrees heel to starboard).

<u>0500</u>: By 0500, the vessel is experiencing wind speeds of approximately 73.4 knots, slightly off the port beam. The change in wind profile decreases the wind heel to 4.4 degree. Wave heights are approximately 29.5 feet. The vessel pitching, fore and aft, continues to increase (5.66 degrees extreme). Increasing amounts of water continue to enter the second deck as described above, and continues to enter cargo hold 3. By 0500, Professor Munsch estimates that approximately 46 long tons of water could have entered cargo hold 3. Water entering the hold accumulates on the starboard side, thereby slightly increasing the vessel's heel (contributing to 0.75 degrees heel to starboard). Due to the heel of the vessel, and the accumulation of water on the starboard side of the hold, the bilge alarm is not likely to actuate for the reasons described above.

A visual depiction of the midship section of the vessel at 0500, at extreme rolls, heave, and wind heel is provided in Figure L below. Figure L does not depict the effect of pitching fore and aft. The Cargo Hold ventilation opening (baffle plate) is further aft from amidships, and therefore the distance from the top of the baffle to the waterline would be less than depicted in the figure when the vessel pitches aft. Similarly, in the figure above, aft of amidships, when the vessel pitches aft, the second deck would routinely be awash on the starboard side of the vessel at extreme heave, roll and wind heel. The approximate distance between the waterline and the top of the baffle plate, for various points along the voyage, is depicted in Figure L below.

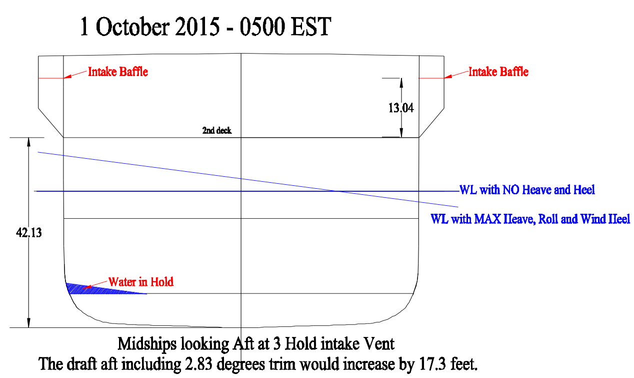

Figure <u>L</u>: Water in Hold Diagram at October 2015 – 0500 EST

<u>0530</u>: By 0530, the vessel is experiencing a slight decrease in wind speeds to approximately 66.4 knots, and the vessel is headed more directly into the wind. The change in wind profile decreases the wind heel to approximately 1.1 degrees. Wave heights are approximately 29.2 feet. The vessel pitching, fore and aft, continues (5.26 degrees extreme). Increasing amounts of water continue to enter the second deck as described above, and continue to enter cargo hold 3. By 0530, Professor Munsch estimates that approximately 59 long tons of water could have entered cargo hold 3. Water entering the hold accumulates on the starboard side of the hold, thereby increasing the vessel's heel (contributing to 0.97 degrees heel to starboard). Based on Professor Munsch's analysis, due in part to the reduction in heel of the vessel and continued accumulation of water, water in the hold is at or close to triggering the bilge alarm in the vicinity of the bilge well. (Appendix B (Prof. C. Munsch), pp.42, 52).

A visual depiction of the midship section of the vessel at 0530, at extreme rolls, heave, and wind heel is provided in Figure M below. Figure M does not depict the effect of pitching fore and aft. The Cargo Hold ventilation opening (baffle plate) is further aft from amidships, and therefore the distance from the top of the baffle to the waterline would be less than depicted in the figure when the vessel pitches aft. Similarly, in the figure above, aft of amidships, when the vessel pitches aft, the second deck would routinely be awash on the starboard side of the vessel at extreme heave, roll and wind heel. The approximate distance between the waterline and the top of the baffle plate, for various points along the voyage, is depicted in Figure M below.

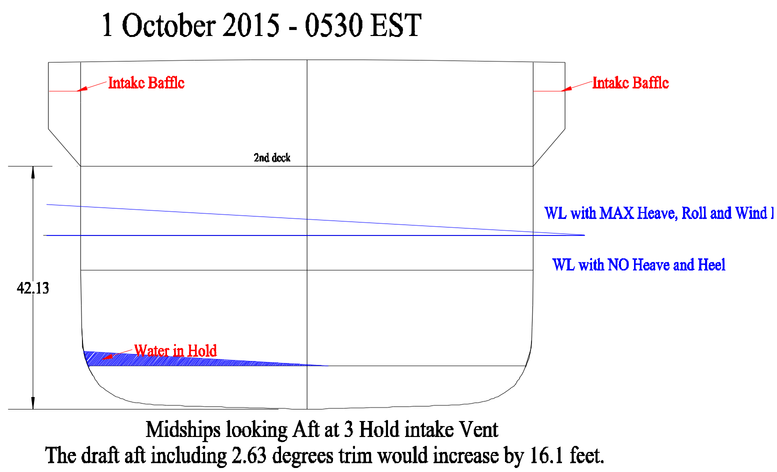

Figure M: Water in Hold Diagram at October 2015 – 0530 EST

0600: The Master turned to port at approximately 0554, in order to put the wind on the starboard side, to change the list from starboard to port list, and thereby expose the scuttle so it could be closed. (MBI Ex.266, p.421). By 0600, according to Professor Munsch's analysis, the vessel is experiencing a slight decrease in wind speed (approximately 59.9 knots), now off the starboard bow. The vessel's mean heave - that is, the vessel's average vertical up and down motion in the seaway - significantly increases to approximately 9.8 feet, and the vessel's heel changes from a starboard list to a port list. At this point in the voyage, at extreme roll, heave, and wind heel angles, the cargo hold ventilation openings (top of the baffle plate) are approximately at the waterline. Professor Munsch estimates that there was approximately 65 long tons of water in cargo hold before the scuttle was closed. In Professor Munsch's opinion, due to the amount of water likely in cargo hold 3 and the forces associated with the movement of that water, the vessel's car lashings likely failed when the vessel's list shifted from a starboard list to a port list at around 0600. (Appendix B (Prof. C. Munsch), p.23). The added effect of vehicle weight shifting in cargo hold number 3 is accounted for below in the dynamic assessment of the vessel at 0630.

0630: After the vessel loses propulsion, the winds (estimated at 63.3 knots) are on the starboard beam. The vessel also is experiencing beam waves, estimated to be approximately 29.2 feet. By 0630, the vessel's heel is estimated to be around 9.1 degrees to port. At this point in the voyage, at extreme roll, heave, and wind heel angles, the cargo hold ventilation openings (top of the baffle plate) periodically submerge by approximately 6.5 feet, and the cargo hold begins to rapidly downflood with water. Professor Munsch estimates that the potential flow rate of water through the ventilation openings is approximately 240 long tons per hour at 0630. Professor Munsch estimates that, by 0630, there is approximately 185 long tons of water in the hold. Of the 9.1 degrees heel to port, 5.5 degrees is attributable to wind heel, 1.1 degrees attributable to water in the hold, and 2.5 degrees is attributable to the shifting weight of the automobiles to the port side. (Appendix B (Prof. C. Munsch), pp.46-47, 52).

<u>0700</u>: At 0700, the vessel remains beam to the winds (estimated to be 66.5 knots) and waves (estimated to have increased to approximately 30.2 feet). By 0700, the vessel's heel is estimated by Professor Munsch to be around 13.7 degrees to port. At approximately 0711, the Master of the *El Faro* informs the DP that the vessel's list is approximately 15 degrees. (MBI Ex.266, p.478). By this point, as the vessel rolls an average 4.5 degrees per roll, the cargo hold ventilation openings (top of the baffle plate) submerge by approximately 4 feet on each roll. On extreme heave roll, heave, and wind heel, the baffle plates are submerged by approximately 11.25 feet. Professor Munsch estimates that, by 0700, there is up to 305 long tons of water in cargo hold 3.[14] Of the 13.7 degrees heel to port, 5.5 degrees is attributable to wind heel, 5.0 degrees attributable to water in the hold, and 3.2 degrees is attributable to the shifting weight of the automobiles to the port side. (Appendix B (Prof. C. Munsch), pp.50, 52).

A visual depiction of the midship section of the vessel at 0530, at extreme rolls, heave, and wind heel is provided in Figure N below.

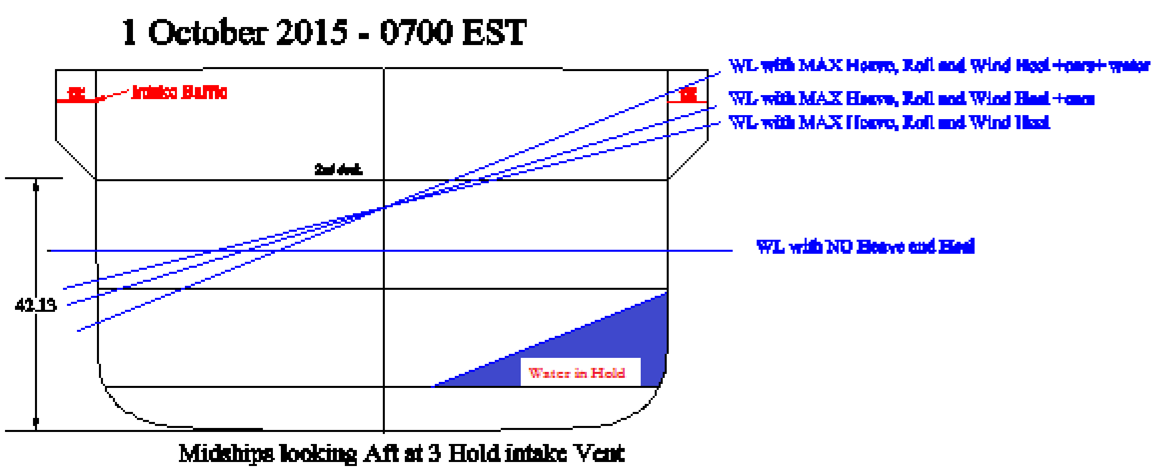

Figure <u>N</u>: Water in Hold Diagram at October 2015 – 0700 EST

0730: At 0730, the vessel remains beam to the winds (estimated to be 72.8 knots) and waves (estimated to have increased to approximately 28.5 feet). By 0730, the vessel's heel is estimated to be around 12.5 degrees to port. As the vessel rolls, water continues to rapidly downflood through the ventilation openings as described above. Professor Munsch estimates that, by 0730, there is up to 545 long tons of water in cargo hold 3, and cargo hold 2A is also progressively

[14] At approximately 0715, the bilge alarm in cargo hold 2A sounds. Professor Munsch estimates that cargo hold 2A began downflooding sometime between 0630 and 0715. Professor Munsch's analysis did not take this flooding into account in his calculations, but in his opinion, the additional flooding would have provided a loss of buoyant volume, further contributing to the loss of the vessel, beyond that described in his analysis. (Appendix B (Prof. C. Munsch), p.51).

flooding through the ventilation openings. The vessel is presumed lost shortly after 0730. (Appendix B (Prof. C. Munsch), pp.51, 52).

F. Loss of Propulsion - Main Propulsion Unit

As set forth in more detail below, the evidence indicates that while the *El Faro*'s main propulsion lube oil system was approved under applicable classification society rules, and the lube oil sump level was maintained at normal operating levels, the effect of water in hold 3, combined with the effects of Joaquin, subjected the vessel to environmental conditions that likely exceeded the applicable design standards. As a result, the vessel lost the main propulsion unit and the crew was unable to restore it.

Evidence on the VDR transcript indicates the vessel lost propulsion due to a loss of lube oil pressure, which likely occurred due to the vessel's heel and other extreme ship motions. (Appendix A (J.Daly), pp.13-24). The loss of propulsion is further analyzed and described below.

1. Main Engine Lube Oil System

The main engine lube oil system has a lube oil sump located below the main engine. The sump collects the oil that has lubricated the main engine, which is then pumped (recirculated) to the system so that the oil can once again to begin lubricating the main engine. (Appendix A (J.Daly), p.14). The operating level of the sump, among other things, will play a role in any loss of lube oil suction from the main sump.

a. Sump - Design & Normal Operating Level

The normal operating capacity of the lube oil sump is 1,426 gallons with low and high operating levels at 724 gallons and 2,020 gallons, respectively. (MBI Exhibit 320). The main engine lube oil soundings table (MBI Exhibit 350) indicates the above levels correspond to the following approximate soundings:

Level	Amount	Sounding
High	2020 Gallons	33 inches
Operating	1476 Gallons	26.9 inches
Low	724 Gallons	18 inches

According to the Machinery Operating Manual for the *El Faro*, the lube oil sump had a low level alarm set at 18 inches and the high level alarm was set at 33 inches. (MBI Ex. 320, p. 3).

The off duty Chief Engineer from the *El Faro*, who departed the vessel on August 11, 2015, began serving as Chief Engineer on the *El Faro* in 2006. (NTSB 10/8/2015, pp.5-6). The off duty Chief Engineer testified that the main engine lube oil system was normally run at a level of around 27 inches. (MBI, 2/23/16 at p.97). Another former Chief Engineer testified that he recalled the normal operating level to be 28 to 32 inches, but that operating level is inconsistent with other evidence, particularly the main engine's approved plans, operating instructions, and historical engine logs. (Appendix A (J.Daly), p.14).

The operating instructions for the main engine lube oil system on board the *El Faro* state as follows: "When necessary, add lube oil from the storage settling tank to the sump via purifier to maintain a normal level at 27 inches. Record the amount added in the logbook." (MBI Exhibit 384).

b. **Lube Oil Sump Level At Departure - Records**

The engine logs for the voyage 185S, which contain the sounding of the lube oil sump at the time of the loss, were on board and lost with the vessel.

The engine room log book entries for the year preceding indicated a lube oil sump level predominantly between 25 to 26 inches. Oil was added when the sump level reached approximately 23 inches. (Appendix A (J.Daly), p.14).

The last available engine log for the *El Faro* was for September 1, 2015, which shows a lube oil sump level of 26 inches. (MBI Ex.341). A former Chief Engineer of the *El Fa*ro testified that lube oil levels changed very little over time - approximately 1-2 inches per quarter. (MBI 02/08/17 (draft), p.474).

Information was presented during the MBI investigations using CargoMax to determine main engine sump levels. (MBI Ex.412, p.3). TOTE expert, Mr. John Daly, determined that this was not a reliable record to rely on for the purposes of defining the precise level of oil in the lube oil sump. The volumes of liquids in most engine room tanks, and changes to them, have an insignificant impact in calculating vessel stability, and, therefore, these records are generally not maintained with the same level of regularity as engine room logs. (Appendix A (J.Daly), pp.13-14). We believe the MBI's use of the assumed lube oil sump operating level of 24.6 inches is likely in error and, based on the available evidence, it is more likely that the engine log for the *El Faro* was for September 1, 2015 (26 inches) provides the most reliable figure. (MBI Ex. 341); (Appendix A (J.Daly), pp.14-15).

To illustrate this further with regard to the record relied on by the MBI, it appears that the specific gravity of the lube oil, listed in CargoMax, is apparently based on a default value which is not exactly consistent with the actual specific gravity of the lube oil in the tank. From a stability standpoint, this is of little overall consequence. However, when the correct specific gravity of the lube oil is used, the reported 4.2 long tons of lube oil in the sump equates to a sounding in the lube oil sump of approximately 25.5 inches. *Id.*

c. Effect of List & Trim on Lube Oil System Operation

i. Design Standard

The 1973 ABS Rules, specifically Rule 36.65 Lubricating-oil Systems, to which the vessel was built, states the following about lube oil systems:

> "*The lubricating systems are to be so arranged that they will function satisfactorily when the vessel is permanently inclined to an angle of 15 degrees athwartship and 5 degrees fore and aft*."

These design criteria for maintaining the satisfactory operation of lubricating systems assumes a static angle of list and trim, and does not account for dynamic effects of ship motion in a seaway. ABS confirmed, and TOTE's expert concurs, that the *El Faro's* lube oil system was properly approved and this design standard was satisfied. (Appendix A (J.Daly), p. 13).

ii. Effect of Lube Oil Suction Pipe Being Located Off Centerline and in Aft Part of the Main Engine Lube Oil Sump

The lube oil suction pipe does not draw suction from the centerline of the tank, but instead draws suction slightly off centerline; it is also located in the aft part of the lube oil sump. (Appendix A (J.Daly), p. 21). This location of the suction bell - being off center and in the aft part of the sump - made it more likely that lube oil suction would be lost when the vessel was heeling to port (as compared to starboard) and trimmed forward (when compared to being trimmed aft). (Appendix A (J.Daly), p. 22) This is further confirmed in MBI Exhibits 323 and 412.

d. Ship Motions - Effect On Machinery Operation on Voyage 185S

The first indication on the VDR transcript that the vessel's heel may be impacting machinery operation is at 0437 when the Chief Mate acknowledges in a conversation with the engine room "yeah we're heelin' over". At 0439 the Chief Mate receives another call from the engine room (from the Chief Engineer) and appears to receive a report about problems the engine room was having and responds "uh…we will get the captain...I understand." At 0440, the Chief Mate calls the Master and notes that the bridge received a call from the Chief Engineer, "something about the list and oil levels." (MBI Ex. 266, p.381). At 0443, the Master has a conversation with the engine room and thereafter states "wants to take the list off. So let's put it in hand steering", in an apparent attempt to correct the list by heading more directly into the wind. (MBI Ex. 266, pp. 380-383).

At 0443, the Master receives another phone call from the engine room, and confirms "you want us to take the list off a little bit?" (MBI Ex. 266, p.384). Thereafter the Master reports to the Chief Mate, "...just the list. The sumps are actin' up…to be expected".

At 0511, the supernumerary Chief Engineer is recorded on the VDR as saying, "I've never seen a list like this" and, "I've never seen it hang like this." The Master then asks how this affects engine room operations, to which the supernumerary Chief Engineer explains that the engine room may experience a low pressure alarm. The supernumerary Chief Engineer then responds that he has "never even seen it hang like this before." (MBI Ex. 266, p.299).

At 0515, the Master again receives a call from the engine room, and is apparently being asked about the list. The Master acknowledges that he is trying to take the list off but that the vessel has a lot of sail area. The Master then tells the engine room to call him back "in a little bit." (MBI Ex. 266, pp.401-402). At 0515, the Supernumerary Chief engineer asks the Master if the engine room is having a problem, and the Master responded "you know he's got a problem like you said a low level". (MBI Ex. 266, p.403).

There is only one main engine sump. During the conversation at 0443-0444 between the Chief Mate and the Master, the reference to "sumps" brings up the possibility that the lube oil problems they were having could possibly extend to equipment other than the main engine, such as the lube oil system in the generators. This is supported by the fact that a list to starboard should actually enhance the lube oil suction in the main engine, due to the off center nature of the lube oil suction pipe on the starboard side. (Appendix A (J.Daly), pp.19-21). On the other hand, there is evidence the vessel was experiencing significant pitching fore and aft,[15] which may have also impacted lube oil suction in the main engine and turbo generators.

e. Effort to Correct List/Expose Scuttle

i. Changing Wind Profile

At 0543, the bridge was informed that there was water leaking into Hold 3 through an open scuttle on second deck. Wind heel and water in Hold 3 were causing a starboard list, making it difficult and unsafe to attempt to close that open scuttle. To address this, at 0554, the Master ordered left twenty degrees rudder, resulting in a course change to port. This was an attempt to pass through the wind and reverse the list to port, in order to expose the scuttle as the vessel heeled over to port. In addition, the Master ordered ballast transferred from the starboard ramp tank to the port ramp tank.

At 0556, the Master reported to the Chief Mate that the list was now reversed from starboard to port. The Master stated at 0557 that, at that time, they had "a nice port list". (MBI Ex. 266, p. 424). The scuttle was reported closed at 0601.

ii. Shifting Ballast In Ramp Tanks – effects

At 0547, the Master ordered the transfer of ballast water from the starboard ramp tank to the port ramp tank in order to correct the starboard list, and at 0557 he requested the engine room to stop transferring ballast. A former *El Faro* Chief Engineer opined the ramp tanks would have limited affect on the vessel's list. The ramp tanks were used to correct the minor list that might

[15] See section III.E.

exist upon loading cargo, but not more. The affect of the ramp tanks depended on the load, but he inferred they would have limited effect. (Gay, MBI 02/08/17, pp. 542-543). In the opinion of Professor Munsch, the attempt to shift ballast from starboard to port between approximately 0547 and 0557, would have had a negligible impact on the vessel's list.

f. Likely Timing of Loss of Propulsion

As noted above, by 0557 the Master reported to the Chief Mate that they had "a nice port list". (MBI Ex. 266, p. 424). The scuttle was reported closed at 0601. At 0603, the Second Mate calls the engine room to report that the scuttle has been secured. When she gets off the phone, she states "hear an alarm going off (he/they) couldn't hear me" (MBI Ex. 266, p. 431). The alarm going off referred to by the Second Mate likely was the low lube oil alarm, which is audible in the engine room. At 0603, the Second Mate states "did we come down on the R-P-M or did they do that," to which the Master responds "they did". *Id.* At 0612, the Master states "I'm not liking this list" and "I think we just lost the plant." (MBI Ex. 266, p. 438). As set forth in Mr. Daly's report, there is no evidence that electrical power was lost,[16] and, therefore, Captain Davidson was more precisely stating that the main propulsion plant or system was lost. Therefore, shortly after 0600 and before 0612, the *El Faro* appears to have lost propulsion.

As noted above, when the vessel is heeled to port, or trimmed forward, the lube oil system is more prone to losing lube oil suction and losing propulsion. Thus the vessel's shift in list from starboard to port around 0600 is the likely cause of the loss of propulsion. (Appendix A (J.Daly), p. 19-23).

2. Response to Loss of Lube/Oil Propulsion

a. Low Pressure Trip

If air entered the lube oil suction line as is suspected, the pump discharge pressure would drop below the set point for the stand-by pump and the second main lube oil pump would have started. The second pump would similarly not have gained suction, due to the lube oil level in the sump. The main lube oil pump discharge pressure alarm on the engine room console would have sounded, audibly alerting the engineers. The flow of oil through the "bulls-eye" would also have stopped, confirming that there was no lube oil pump pressure and the lube oil gravity tank was now supplying lube oil to the main reduction gear and turbines. (Appendix A (J.Daly), p.23).

b. Securing the Main Propulsion System

Once lube oil pressure was lost, it would have been critical to stop the main engine and shaft from turning. The rotation of the reduction gear and turbines, without lubrication, would destroy their bearings and permanently disable the propulsion unit, leaving the vessel adrift. As described in Mr. Daly's report, to secure the system, the engineers would take several steps to stop the shaft from turning. This is likely what was occurring at 0603 on the VDR transcript, when the Second Mate and Master observed an apparent loss of RPM. The shaft had to be stopped before the lube oil supply in the gravity tank was exhausted. (Appendix A (J.Daly),

[16] (Appendix A (J.Daly), pp. 8-11).

p.123). There is sufficient oil in the gravity tank to continue to lubricate the bearings for approximately 8 to 10 minutes, while this process of securing the main propulsion unit is accomplished. (Appendix A (J.Daly), p.14).

c. Restoring Lube Oil Pressure

Once the shaft is secured, the jacking gear might be engaged at this point to lock the shaft to prevent rotation. Other engineering issues would likely be addressed by the engine crew during this time frame, including addressing the effects of a decrease in steam demand. (Appendix A (J.Daly), p.14).

The engineers also likely began immediately investigating the loss of lube oil pressure, troubleshooting the systems to ultimately rectify the situation and restore lube oil pressure. This likely would have including sounding the sump and determining whether oil should be added to the sump. This could be complicated by the fact that, by this time, most of the oil in the lube oil gravity tank would have likely drained into the sump. If oil was to be added to the system, according to TOTE's expert and corroborated by other witnesses, the lube oil purifier is the normal way to add such oil to the sump, but that is a relatively slow process. There is also a direct fill line to bypass the purifier. On the *El Yunque*, the direct fill line was a 1 inch line at the storage tank level. In Mr. Daly's experience, adding oil to an engine through a line this size could be a lengthy process. Once it was thought that there was a sufficient amount of lube oil in the system to compensate for the vessel's list and trim, a lube oil pump would have to be primed and started, thereby supplying lube oil pressure to the main engine and oil flow to replenish the lube oil gravity tank. Once the gravity tank was confirmed to be full, as indicated by flow through the overflow "bulls-eye", the main engine would be ready for operation. (Appendix A (J.Daly), p.14)

The vessel appears to have regained propulsion to some extent at approximately 0644. Mr. Daly's opinion is that depending on the complexity of the issues to troubleshoot, restoring propulsion following the procedures set forth above may take approximately 30 minutes. (Appendix A (J.Daly), p.14). The VDR transcript reveals that the vessel's shaft had turned at least momentarily, but it became more clear that by 0649 the vessel remained without propulsion.

There are a number of potential factors which may have prevented the *El Faro* from restoring propulsion, among them severe weather conditions and the resulting list, trim, and rolling motions that the vessel experienced. (Appendix A (J.Daly), p.14). At approximately 0700, the vessel was reportedly experiencing a 15 degree list to port, and based on the dynamic stability study performed by Professor Munsch, was likely rolling approximately an additional 9 degrees to port due to the wave and wind action in the seaway. (Appendix B (C.Munsch), p.52). Sustained rolls to one side of this magnitude likely resulted in the lube oil system being subject to an environment exceeding its design limitations.

G. Water in Hold 3 & 2A - Attempts to Pump Cargo Holds

As described in section III.E, water accumulated in cargo hold 3 through an unsecured scuttle on the second deck. Professor Munsch's dynamic stability analysis confirms that, as the *El Faro* encountered more severe weather, green water entered the second deck with increasing frequency as the vessel pitched and rolled, thereby resulting in increasing amounts of water entering through the unsecured scuttle. We assess below each of the potential sources of water that could have entered cargo hold 3.

1. Potential Sources of Water Ingress

a. Scuttle -- initial confirmed source

The unsecured scuttle was confirmed at several points in the VDR transcript as the initial source of water entering cargo hold 3. Professor Munsch estimates that water likely started entering through the scuttle as early as 0300. For the reasons stated in his report, and as outlined in section III.E.3, cargo hold 3 likely contained between 59 and 65 long tons of water, before the bilge alarm would have sounded. Once the scuttle was secured at around 0600, no additional water should have entered into the hold via this route. However, the evidence on the VDR transcript suggests that water continued to enter the hold from another source.

b. Water Likely Entered Hold 3 Through Cargo Ventilation Openings

The scuttle was secured around 0600, and around that time, the vessel also lost propulsion. The vessel then went beam-to the sea, and was pushed to the southwest, in the same general direction as Joaquin. Based on the dynamic stability analysis performed by Professor Munsch, between 0600 and 0630, at extreme roll, heave, and wind heel angles, the cargo hold ventilation openings would have likely been periodically submerged below the waterline as the vessel rolled and the cargo holds would have rapidly downflooded. Professor Munsch estimates that the rate of water ingress into the hold to be approximately 240 long tons per hour through the exhaust and intake vents, which is more than 10 times the flow through the open scuttle. See section III.E.3. Professor Munsch estimates that the rate of water ingress into the hold to be approximately 240 long tons per hour. *Id.*

c. Emergency Fire Pump Piping

There was reference on the VDR transcript that another possible source of water in Hold 3 was the Emergency Fire Pump suction line, leading to the skin of the ship at the tank top level. Specifically, in the VDR transcript, at 07:14:58.1, the Chief Mate stated: "* (at) first the chief said something hit the fire main. got it ruptured. hard." To which the Master asks, "there's no way to secure that?" The Chief Mate responds, "we don't know if they've (seen/still have) any pressure on the fire main or not. don't know where s'sea– between the sea suction and the hull or what uh but anything I say is a guess." Given the language "anything I say is a guess," we view this not as definitive evidence of a rupture, but reflective of a lack of full awareness of where the water was coming from, and speculation by those on board about potential sources of water.

However, when one examines the available evidence in regard to this configuration on board the *El Faro*, its routine operation and inspection, and the emergency fire overboard valve's normal position, it appears very unlikely this was the source of water entering cargo hold 3.

i. Emergency Fire Pump Configuration Description

The below photograph and figure shows *El Faro's* emergency fire pump. The pump is mounted vertically and painted red. There is an orange vertical pipe in the foreground, a vertical ladder to the left that leads to the platform above, and several pipes in the vicinity of the pump. The diagram to its right of the photo shows the location of the emergency fire pump in the starboard aft corner of Hold 3 on deck 4.

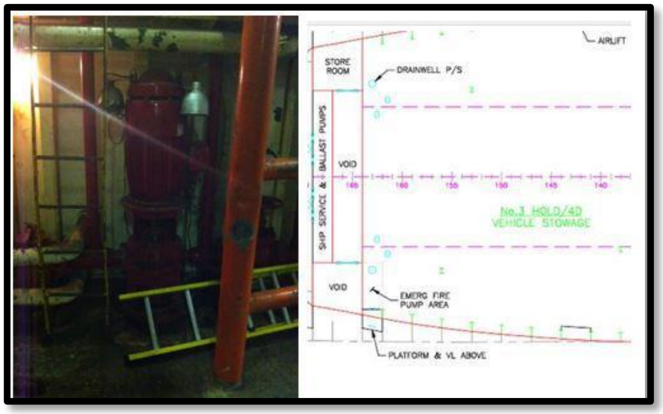

Figure <u>O</u>: *El Faro*'s Emergency Fire Pump and Motor

The *El Yunque*'s emergency fire pump configuration was similar to the *El Faro's,* but there were important differences. The emergency fire pump and piping on both vessels were in the starboard aft portion of cargo hold 3, and both vessels had bumpers around the pump to protect the system from damage. On the *El Faro*, but not the *El Yunque,* there was a steel framed platform above the vicinity of the emergency fire pump piping and overboard suction that was used when coming down the outboard cargo access scuttle. (Gay MBI, 2/8/17, pp 556-557). The steel framed platform above the firemain piping extended from the outboard sideshell of the vessel, inboard to the vicinity of the pump; the platform also extended, fore and aft, approximately 4 feet from the aft bulkhead. (Gay MBI, 2/8/17, pp 556-557). In addition, unlike the *El Yunque* which had a piping arrangement that went forward and then outboard to the skin of the ship, the *El Faro's* piping configuration likely went directly from the pump outboard to the skin of the ship without going forward. (Gay MBI, 2/8/17, pp 556-557).

When asked if there was any protection of the emergency fire pump suction lines from being damaged by potentially shifting cargo, a former chief engineer familiar with arrangement testified…"because in the cargo hold when the hull came down and met -- where it met the deck, a lot of that was up a little bit higher on that down slope. So if cargo was shifting, it would have probably stopped and hit that -- the end of the deck." (Gay MBI, 2/8/17, pp 556-557).

ii. Emergency Fire Pump Operation

The bilge and ballast pump and the emergency fire pump were surveyed and operated on June 16, 2015. (MBI Ex. 177, pp. 24-25; LaRose MBI, 5/19/2016, pp. 45, 55, 76). This pump was also routinely tested during most fire and boat drills. There is no evidence developed in the investigations to suggest it had any operational problems or that leaks existed within this equipment.

In addition, on the issue of whether the emergency fire pump piping was a likely source of water in hold 3, the witnesses' testimony reveals that the valve on the suction line, located near the side shell of the vessel, was normally left in the closed position. As a former chief engineer testified, due to the fact that the cargo hold 3 was not a manned space, and that suction valve was on the sea chest directly to the hull, that valve was, as a matter of standard operating procedure, closed. (Gay MBI, 2/8/17, pp 504-505). The valve can be opened, as needed, using a reach rod located on the second deck. *Id.* There is no evidence the crew of the *El Faro* deviated from the normal practice of leaving the valve closed. Accordingly, in order for seawater to enter the hold through the piping arrangement, the suction pipe would have to be sheared off or otherwise severely damaged, in the vicinity of the side shell plating. In other words, if the pump and/or piping is damaged in any location inboard of the reach rod and valve stem, no water will enter the hold because the valve would be closed. For justifiable reasons, the suction valve remained closed while at sea.

The chances of loose cargo striking the emergency fire main piping in this very precise location near the side shell, with sufficient force to cause catastrophic damage, appears unlikely.

2. Bilge/Ballast System Operation - Water Ingress Exceeds Pumping Capacity

There are several different factors which could hinder or complicate the crew's ability to pump the water from the cargo hold. (Appendix A (J.Daly), p.27). The ingress of water into cargo hold number 3 was estimated to be up to 240 Long Tons per hour between 0630 and 0700. (Cite Munsch Report.) The estimated bilge pumping capacity of the bilge and ballast system was estimated to be between 220 and 550 gallons per minute (which equates to 50 and 120 long tons per hour. (Appendix A (J.Daly), p.27). The opinion of our experts is that the amount of water entering into the hold far exceeded the design capabilities of the approved equipment onboard.

IV. PROPOSED FINDINGS

1. At the time of its departure from Jacksonville on September 29, 2015, the *El Faro*:
   a. was fully in Class (with the American Bureau of Shipping); and
   b. complied fully with all statutory and regulatory requirements, including compliance with: (i) its USCG "Certificate of Inspection" and its approved Trim and Stability Booklet; (ii) all of its certificates issued under applicable international conventions, including but not limited to its ISM Safety Management Certificate, SOLAS Certificates, and International Load Line Certificate; and (iii) the applicable ACP Supplement; and
   c. was fully and competently crewed.

2. Accordingly:
   a. the *El Faro* was seaworthy and fit for its intended voyage; and
   b. the *El Faro's* construction, structural modification history, maintenance and/or condition were not causative of and/or contributory to its loss.

3. An annual ACP exam of the *El Faro* was completed by the U.S. Coast Guard on March 6, 2015. The results of that exam were that no deficiencies were identified, and included a variety of findings: the vessel was in good condition and looked as if everything was being maintained; there were no noted issues or problems regarding the vessel's cargo securing equipment, ground tackle, or mooring lines that would have made the vessel more vulnerable in a storm environment; the crew was very proficient and knew exactly what they were doing in fire and abandon ship drills; the SMS aboard the *El Faro* was working; that shipboard personnel had good relations with the company (shoreside) pertaining to its safety management system; and that the *El Faro* was getting the necessary support from the company.

4. An ABS annual continuous machinery survey was conducted on the *El Faro* on June 16, 2015. This survey included a review of the Chief Engineer's records and photographs of opened pieces of equipment, the actual running of equipment, including the ballast and bilge system, piping and pumps, freshwater system, steering gear, boiler feed water system, and a test shutdown for the engines. No deficiencies were noted.

5. The *El Faro* was properly outfitted with all electronic data transmission equipment, including a full GMDSS suite, in compliance with applicable regulations.

6. At the time of the loss of *El Faro*, TSI managed 24 vessels, including *El Faro*.

7. TSI had a valid Document of Compliance. The company's SMS complied with the ISM Code.

8. Although not required by law, the company's SMS was also certified by ABS as complying with ISO Standards 90001 (for Quality) and 14001 (for Environmental Compliance).

9. TSI had (and has) a strong safety culture. The same strong safety culture carried over to the vessels in its management, including the *El Faro*.

10. Consistent with, and in full compliance with, applicable U.S. and international law, TSI confirmed and specified in its SMS that the Master has the overriding authority and responsibility for the safe operation of the vessel and the authority and discretion to take whatever action he/she considers appropriate in the best interest of the crew, vessel, and marine environment.

11. Through its SMS, the company fully published, implemented, and utilized a program to allow any crewmember (licensed and unlicensed) to make reports outside the shipboard chain of command, to the designated person ashore, if there was ever any safety, environmental, wellness, or other concern that was not being properly addressed on board.

12. The officers and crew were properly trained and qualified for *El Faro's* operational environment. They were highly experienced and familiar with the twice weekly route between Jacksonville and San Juan. The training provided the *El Faro* officers by the American Maritime Officers Union and crew by the Seafarers International Union, through respective license and credential requirements, and TOTE's training programs, was appropriate for the anticipated activities, and exceeded the minimum requirements imposed by the U.S. Coast Guard.

13. The record demonstrates that Captain Davidson was widely regarded as a qualified, competent, well-trained, safety-conscious, and meticulous master.

14. The evidence gathered during the investigation indicates the master, mates, and crew, understood that no operational commitments of the trade, such as the schedule, justified jeopardizing the safety of the crew, the vessel, or the cargo. To the contrary, there was consistent evidence and testimony that safety was of paramount importance.

15. The Polish riding crew on the *El Faro* was supervised by an off-rotation *El Faro* Chief Engineer and received vessel orientation from that Chief Engineer. Other riders similarly received an orientation upon boarding the *El Faro*.

16. The Polish riding crew was engaged in activity on the *El Faro* that did not contribute to its loss.

17. The minimum manning requirements for the *El Faro* required a total of 17 persons of various ratings (licensed and unlicensed). The staffing and personnel on board the *El Faro* greatly exceeded the minimum requirements as it had on board 27 persons assigned as permanent crew (compared to the 17 minimum required), the off-rotation Chief Engineer, and five Polish riders. In addition, several officers possessed credentials above the billet they were filling (for example: there were 2 credentialed Chief Engineers on board, 2 credentialed Masters).

18. The *El Faro* had a Trim and Stability Booklet that was approved by ABS on behalf of the USCG.

19. The *El Faro* used CargoMax, an ABS-approved stability computer program, to assist with assessing and confirming stability and trim of the vessel during loading and upon departure. The same program was used to assess the adequacy of container lashing and to assess hull stresses.

20. CargoMax is a stability program that is widely used in the shipping industry, and the manner in which the *El Faro's* masters and mates utilized CargoMax was consistent with industry norms.

21. The *El Faro* departed Jacksonville in compliance with its load line restrictions. The vessel could have loaded additional cargo, as it had approximately 600 long tons of available deadweight.

22. The *El Faro* also had more than the minimum required GM upon departure. The *El Faro* departed with a GM margin ("excess" GM) that was in compliance with company policy and that was sufficient to allow for expected fuel burn for the voyage plus additional "extra" days of steaming. The *El Faro* had the ability to take on ballast to increase GM underway.

23. While not required by regulation to have a Cargo Securing Manual, the *El Faro* did have one and, with few exceptions (that did not contribute to the loss of the vessel), all cargo was stowed in accordance with the Cargo Securing Manual.

24. To eliminate any confusion during loading and lashing that might otherwise occur if the lashing scheme were changed from voyage to voyage, the *El Faro* used a standard "heavy weather" lashing profile to secure its cargo on all voyages, as reflected in the El Class Minimum Lashing Requirements document. This generally resulted in cargo being "over-lashed," that is, being lashed in a manner that exceeded the minimum required lashing under the Cargo Securing Manual and IMO Cargo Securing Code (for example, lashing rods were used on certain containers that did not require any rods).

25. The lashings were thoroughly inspected prior to departure. The record reflects it was a routine practice to inspect lashings while at sea, and they were in fact checked on *El Faro's* final voyage. All Ro-Ro trailer cargo that used a Roloc box was stowed on a button, with the exception of four trailers that were stowed off-button. All Ro-Ro cargo was properly lashed.

26. Lashing gear (fixed and removable) was properly maintained and adequate lashing gear and spares were available on the *El Faro*. Additional stores of lashing gear were available on shore in Jacksonville.

27. There is no evidence that any lashings failed as a result of being inadequate or insufficient (that is, below what was required by regulation or the Cargo Securing

Manual). Any lashing failure that did occur was the result of forces being exerted that exceeded the gear's design and operational limits.

28. The watertight doors and scuttles were inspected and maintained properly. It is likely that, at some point during the final voyage, the scuttle on second deck above Hold 3 was inadvertently left unsecured. This scuttle was the most likely cause of the initial ingress of water into Hold 3.

29. The *El Faro* was not required by law to have any bilge alarms, but did have such alarms and tested and maintained them. Those alarms did detect water in the cargo holds.

30. The *El Faro* received a number of voice, text, and graphical weather products to allow its crew to assess the weather and to take appropriate action. These products were delivered in a variety of means, including HF/MF radio frequency band, Inmarsat-C (i.e., Sat-C), weather fax, satellite email (e.g., BVS), satellite radio, and via more common means when in range, such as television and the internet (accessed by cell phone or computer).

31. Given the forecast weather data and available vessel track options, the Master's decision to depart from the Port of Jacksonville at approximately 2015 EDT on September 29, 2015 was reasonable.

32. The forecasting of the projected development and movement of Joaquin was significantly in error throughout the entire course of events involving the loss of the *El Faro*. For example, the NHC confirmed that its early forecasts contained a "1 in a 100" rate of error. As examples, when compared to the storm's actual status as of the morning of October 1, 2015, the forecast for that time from 72 hours earlier was 536 miles off on position and 80 knots too low in intensity, and the forecast for that time from just 24 hours earlier was 62 miles off on position and 30 knots too low in intensity.

33. On the basis of the forecast information and projected storm track available to the *El Faro* as well as course change options available along the vessel's track, the Master's decisions to alter course, further to the south, twice on September 30, 2015 (once in the morning and once in the late evening), so as to achieve greater separation from the storm's predicted location, while still remaining in the storm system's navigable semi-circle and outside the radius of hurricane force winds, were reasonable.

34. Joaquin continued to track further south and west of its forecasted track, resulting in a situation that, with each successive forecast, it appeared that the vessel's current track and the storm's update forecast track would put the vessel closer to the storm than each prior forecast had predicted, despite the course changes made.

35. This situation and a course change option of heading south at 0200 on October 1 through the Crooked Island Passage were brought to the Master's attention by the Third Mate during the 2000-2400 (September 30) watch and the Second Mate during the 0000-0400 (October 1) watch.

36. The Master did not go to the bridge to review the new information and did not change course at 0200. The Master appears to have made his decision based on his assessment of the information he had available to him, which included prior forecasts and information from the BVS system.

37. The decision not to change course at or before 0200 reflected a loss of situational awareness by the Master regarding the position of the vessel in relation to the eye of the hurricane.

38. During the 0000-0400 watch on October 1, 2015, weather conditions worsened and the vessel began taking water on its Second Deck. As the voyage proceeded, water continued entering the second deck, likely from the stern and starboard aft portion of the vessel. Water would likely flow forward and tend to accumulate in the area of the scuttle into Hold 3, due to the vessel's sheer and pitching of the vessel fore and aft.

39. The *El Faro* was periodically subject to hurricane force beam winds and as a result had likely experienced a starboard list in the final hours of the voyage. The vessel also likely experienced significant pitching fore and aft. At 0440, the engine room reported having difficulty maintaining lube oil pressure due to the vessel's list.

40. At 0543, the bridge was informed that there was water leaking into Hold 3 through a scuttle on second deck that had inadvertently not been secured properly.

41. The Master's attempt to correct the list using the ramp tanks would have had a negligible effect on the vessel's heel (~ 1 degree).

42. Wind heel and water in Hold 3 caused a starboard list, making it difficult and unsafe to attempt to close that open scuttle. To address this, at 0554, the Master ordered a course change to port. This was an attempt to pass through the wind and "reverse" the list to port, placing the open scuttle on the "high" side allowing it to be safely accessed and closed. The scuttle was reported closed at 0601.

43. The vessel lost propulsion shortly after the *El Faro* changed course (and changed its list from starboard to port).

44. The *El Faro's* engineering plant was well maintained in accordance with all applicable rules, regulations, and company policies.

45. The pending maintenance items described in Walashek's September 2015 boiler survey were considered routine maintenance items that affected efficiency, and there is no evidence the conditions described in the survey report played any role in the loss of the vessel.

46. The *El Faro* did not lose electrical power at any point during the incident, as reflected on the VDR transcript and VDR extract data.

47. The lube oil system on *El Faro* met all applicable design requirements.

48. The *El Faro's* lube oil suction pipe for the main propulsion unit was located slightly off centerline and in the aft part of the main engine lube oil sump. This location made it more likely lube oil suction would be lost when the vessel was heeling to port (as compared to starboard) and trimmed forward (as compared to being trimmed aft). Although all design requirements and standards were satisfied, the location of the lube oil suction pipe likely played a role in the loss of propulsion.

49. The design criteria for the lube oil system were exceeded by the conditions encountered by the *El Faro* including conditions that resulted in sustained significant pitching fore and aft, and persistent list and rolls in excess of 15 degrees. With the design criteria exceeded, the vessel lost lube oil suction, resulting in a loss of propulsion. The ventilation system on the *El Faro* was approved by ABS and the U.S. Coast Guard, met all applicable regulatory requirements, and was operated in compliance with applicable regulations and the vessel's Certificate of Inspection.

50. Shortly after 0600 and the after the vessel lost propulsion, the vessel went beam to the seas and wind, until the vessel was lost.

51. Due to extreme heel and the other effects of Joaquin, shortly after the loss of propulsion, it is likely the cargo hold ventilation baffles were periodically submerged below the waterline, with greater frequency over time, and water entered into cargo Holds 3 and 2A through these openings.

52. After 0600, the rate of water ingress into Hold 3 from the ventilation openings far exceeded the pumping capacity of the bilge pumps for those spaces.

53. The baffle arrangement in the ventilation system was not able to prevent downflooding through the vents as a result of the excessive angle of heel and the sea conditions the vessel encountered. This resulted in progressive flooding of the holds.

54. With no propulsion, the vessel was at the mercy of the prevailing wind and sea conditions. Water continued to enter the holds, including through the vents. This progressive flooding resulted in the sinking of the vessel.

55. In light of the protection around the fire main on the *El Faro* in Hold 3, it is more likely that water entered the hold through cargo vents than through a potential rupture of the fire main as discussed on the VDR.

56. The lifeboats on the *El Faro* were in full compliance with the laws and regulations that applied to the vessel. The *El Faro* was not required to carry immersion suits but immersions suits were available on the vessel for all personnel.

57. The weather conditions (wind and sea) at the time of the sinking were so extreme that attempting to abandon the vessel on lifeboats or life rafts, with or without immersion suits, was not survivable.

V. SIGNIFICANT POST-ACCIDENT ACTIONS

TOTE Services, Inc. and TOTE Maritime Puerto Rico, Inc. follow a policy of consistent improvement. We take seriously our responsibility to continually review and improve the safety, quality, and environmental management programs based on content of management reviews, feedback from vessel personnel, audit results and recommendations, lessons learned from near miss and nonconformance reports, and industry best practices. Before and after the loss of the *El Faro*, various additions and changes were continuously made, consistent with the companies' respective safety, quality, and environmental management programs. Many of the additions and changes made after the loss were under consideration at the time of the loss. What follows is a list and description of various actions that have taken place after October 1, 2015. There should be no implication that these changes occurred as a direct result of the loss of the *El Faro*, or that any of the issues addressed by these changes were involved with the loss of the *El Faro*.

Radio Holland service contract. A new service contract has been entered into with Radio Holland to provide regular servicing and inspections of bridge equipment on the Marlin vessels. This new contract results in an increased number of attendances on the vessel, now approximately every two weeks, which will include operational tests, performing preventative maintenance, and addressing any known issues such as nuisance alarms or required repairs.

Fleet Broadband and VSAT Satellite Internet Access: We have added increased email and internet accessibility on the Marlin and Orca vessels, which includes full-time phone and high speed data connections. Email and internet are now available at all times for department heads (Master, Chief Engineer, Chief Mate, First Assistant Engineer, Steward) and on terminals in the bridge, engine room, and ship's office. At sea, the terminals in the ship's office and engine room can be used by anyone on board the vessel for email, giving all personnel 24/7 email access.

Weather Routing: We have made weather routing services from Jeppesen and AWT available. As discussed during the investigation, these services are primarily used for transoceanic voyages, but they have been made available to all vessels as a resource, even those on the short shuttle runs, including between Jacksonville and San Juan. There is no requirement that masters use or follow any weather routing guidance, as it is within the Masters' discretion to use these services as another resource.

Foss Maritime Center: A 24/7 call center was established as a replacement of a prior emergency call center to receive and process emergency communications. This initiative utilizes available joint services between the sister companies. This center also provides vessel tracking and weather monitoring support to TSI.

CargoMax: We have formalized the pre-existing CargoMax training program. Classes are held regularly and are instructed by Herbert Engineering with a vessel deck officer included. The classes are attended by the shoreside personnel who use CargoMax and the senior deck officers (Masters and Chief Mates) are also invited. In addition, we have added additional users for added coverage.

OPS MEMOS and SAFETY ALERTS: We have had a practice for many years of routinely issuing OPS MEMOS and SAFETY ALERTS, between formal updates to the safety management programs. That practice has continued after the loss of the *El Faro*. Since that event, many of these memos and alerts have been issued. Highlighted below are certain of those that may be of particular interest and relevance to this investigation:

- **A-68 Systematic Approach to Risk Assessment:** This Ops Memo introduces a revised approach to risk assessment that involves a more quantitative approach to risk assessment. This has been incorporated into the EPMV.
- **A-73 Heavy Weather Procedures:** At the beginning of hurricane season, as was done in 2015 (and in prior years), a reminder was sent to all vessels to review their heavy weather procedures. This also reiterates the Master's responsibilities to ensure actions taken aboard are appropriate with respect to vessel safety and provides for the convening of a Company Hurricane Advisory Team to advise vessels during cyclonic weather events.
- **A-88 Indoctrination for Contractors:** This memo was sent as a reminder to all vessels to ensure compliance with indoctrination requirements. There were no changes with this memo, just a reminder to enforce compliance.

Crew File & Status Tracking System Upgrade: The crewing system has been upgraded and TSI is working on enhancing the system to allow for greater visibility over crew documents, training, and training requirements. The system will allow for all training to be housed and visible in the system rather than having to keep all of the information in physical files. In addition, it will allow the vessels to see training that has been completed.

Vessel Familiarization for Crew, Contractors and Visitors: Videos have been developed and provided to the Marlin Class ships. One of the videos illustrates the general layout and features for new crew member and visitors joining the ship. Further, the video describes where the safety equipment is located, escape routes, and Emergency and Firefighting Equipment. The second video includes an introduction and welcome message from the president and a brief history, and then provides a narrated familiarization tour given by a chief mate for a new crew member. TSI plans to extend this to other vessels under management in the future.

Adopted Watchkeeper III Program for Tracking Crew Working Hours / Revised Travel Policy: This is an enhancement to the existing rest hour spreadsheet that was used to track rest hours. The crew uses this system as a planning tool to help them plan work/rest hours and to document compliance. Additionally, the system documents any non-compliance and subsequent corrective action taken to maintain compliance.

In addition, to allow for proper rest prior to taking on duties, officers are given the option to travel the day before they join the ship so they are not traveling on the same day they are scheduled to join the vessel and turnover. If a hotel is required, the Company will allow expenses for accommodations if the vessel is not in port and available to board.

Upgrade of SMS Program: TSI has been actively streamlining and transferring the SMS to an electronic system on the NS5 platform, a project that should be completed by the end of this year. The electronic platform for the SMS will enhance our ability to: maintain version history of all documents, record acknowledgement of documents by all recipients, and maintain an audit log of all changes to all documents. It will also allow us to organize documents in a hierarchical order making it easier to search documents in the repository. The platform is web based allowing access to its content from anywhere over the internet.

Secondary 406MHz EPIRB: A second EPIRB was added to each Marlin vessel. This EPIRB is float free and also records the VDR data. Only a single EPIRB is currently required.

Terminal Monitoring in San Juan and Jacksonville: TMPR installed a camera system to monitor and record activities on terminal for review and monitoring operations. Video terminals are available for monitoring activity in the TMPR stow room and in the TMPR terminal office. These videos are recorded and retained for a period of time for future access if necessary.

Lashing Gear: TMPR is in the process of formalizing and documenting a shoreside procedure for tracking the receipt of lashing gear inspection and maintenance records.

VI. ACRONYMS AND ABBREVIATIONS

ABS	American Bureau of Shipping
ACP	Alternate Compliance Program
AIS	Automatic Identification System
AWT	Applied Weather Technologies
BIMCO	Baltic and International Maritime Council (Standard Ship Management Agreement)
BVS	Bon Voyage System
CARS	Corrective Action Request
COI	Certificate of Inspection
CSM	Cargo Securing Manual
CSS	Cargo Securing Code
DP	Designated Person
EDT	Eastern Daylight Time
EGC	Enhanced Group Calling
EPMV	Emergency Procedures Manual - Vessel
GMDSS	Global Maritime Distress and Safety System
HF	High Frequency
IMO	International Maritime Organization
ISM	International Safety Management
LNG	Liquefied Natural Gas

MF	Medium Frequency
MF HF DSC	Medium Frequency High Frequency Digital Selective Calling
NHC	National Hurricane Center
NWS	National Weather Service
OMV	Operations Manual for Vessels
OSHA	Occupational Safety and Health Administration
SIU	Seafarers International Union
SMS	Safety Management System
SSAS	Ship Security Alert System
STCW	Standards of Training Certification and Watchkeeping
S-VDR	Simplified Voyage Data Recorder
TMPR	TOTE Maritime Puerto Rico, LLC
TSI	TOTE Services, Inc.
UTC	Coordinated Universal Time
VDR	Voice Data Recorder
VHF	Very High Frequency

VII. FIGURES

VIII. APPENDICES

Appendix A – J. Daly, Marine Engineering Expert Report, August 31, 2017

Appendix B – Professor C. Munsch, Naval Architecture Expert Report, August 31, 2017

Appendix C – Dr. A. Dooley, PhD, Meteorology Expert Report, August 31, 2017

Appendix D – Captain R. DiNapoli, Navigation Expert Report, August 31, 2017

IX. ADDITIONAL ATTACHMENTS IN SUPPORT OF SUBMISSION

Number	Document Title
1	Training Addendum, Section 2.0
2	Certifications
3	Safety Management Certificate and Document of Compliance
4	Training Matrix
5	OPS Memo A-068
6	Job Description Ship Management Coordinator
7	Captain John Lawrence Reallocation Memo
8	Jim Fisker-Andersen email dated September 12, 2014
9	2014 Imtech Service Reports
10	IMO Maritime Safety Committee, MSC Circular 72/10/3 dated February 18, 2000, Proposed Revisions to SOLAS Chapter V
11	(a) Notice of Proposed Rulemaking 62 Fed. Reg. 23705 (May 1, 1997) (b) Final Rule 62 Fed. Reg. 67492 (December 24, 1997)
12	Safety Management System Manual
13	Document of Compliance dated August 21, 2014
14	CargoMax Program Documentation
15	Cindy Harvey email dated September 29, 2015
16	T. Neeson budget email dated September 17, 2015