This digest of the National Transportation Safety Board's (NTSB's) Marine Accident Report NTSB/MAR-17/01 contains a description of the accident and safety issues, and summarizes some of the safety recommendations intended to prevent such an accident from happening again. The full report and docket can be found at www.ntsb.gov.
The accident

September 29
On the evening of September 29, 2015, the US-flagged cargo ship El Faro cast off from Jacksonville, Florida, bound for San Juan, Puerto Rico, with crew of 33 and a cargo of vehicles and shipping containers. The vessel was operated by TOTE Services, Inc. (TOTE), which, until 2 weeks before the accident, was known as Sea Star Line, LLC. Hundreds of miles southeast, Tropical Storm Joaquin moved toward the Bahamas. At the time of the ship’s departure, El Faro’s captain was aware of the weather and planned to remain south of the storm. Before meeting the storm, the vessel’s speed was about 20 knots.

September 30
On September 30, 2015, at about 0600, the captain and chief mate discussed the storm’s route, referring to one of the ship’s onboard weather programs, Bon Voyage System (BVS).1 BVS files were sent to the captain’s e-mail address. However, tropical cyclone information in the BVS files (when sent) typically lagged what was found in other weather sources by 6 hours. In addition, there was another lag until the captain downloaded each file. Another source of weather information, Sat-C, delivered text broadcasts of National Hurricane Center (NHC) weather products to the vessel’s bridge.2 The captain favored BVS throughout the voyage, seemingly not considering the latency associated with the tropical cyclone information contained in the BVS files.3

At 0624, the captain shifted El Faro’s course slightly southward. At 0625, the Sat-C terminal received an urgent high seas forecast for Tropical Storm Joaquin of maximum sustained winds of 75 knots (hurricane strength) with gusts to 90 knots within 24 hours.

The captain and the chief mate discussed that any further course change would be drastic and wasn’t warranted “for a 40-knot wind.”4

At 0711, the captain was heard on the voyage data recorder (VDR) saying, “Needless to say, we’ll be watching the weather deteriorate today.” A few minutes later, he indicated his doubts that the ship’s anemometer5 was working properly.

At 0739, the NHC announced in an intermediate advisory that Joaquin had become a hurricane; however, intermediate advisories weren’t broadcast via Sat-C and were not available via e-mailed BVS files.

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1 El Faro’s voyage data recorder (VDR) captured both conversations and parametric data. However, only the voice of the person speaking on the bridge was captured in a two-way conversation with another person who was not on the bridge.
2 Sat-C is short for Inmarsat Satellite’s channel C. The Sat-C terminal provided timely weather information from the National Weather Service (NWS), including the National Hurricane Center (NHC).
3 The BVS vendor could also send e-mail updates, which provided current tropical cyclone information, if a user specifically requested them. During the accident voyage, however, El Faro’s captain did not request any.
4 The captain and crew expected to encounter winds of about this strength (later, they refer to “45-knot winds”) as a product of both the expected intensity of the storm and their expected position relative to it.
5 An anemometer provides wind speed and direction. Over 99 percent of the anemometer data samples captured on El Faro’s VDR during the accident voyage indicated a relative wind direction of between 180° and 193°.
Although the captain discussed alternate routes through the Northwest Providence Channel and the Old Bahama Channel (see The accident voyage, p. 8), he did not choose these routes. At 1943, the third mate arrived on the bridge for the watch change and said, “I just hope it’s not worse than what this [BVS] is saying because . . . Weather Underground . . . they’re saying it’s—more like 85—not 50 . . . wind.” At 2305, he made the first of two calls to the captain. On his second call, the third mate suggested diverting to the south, but the captain did not authorize a course change. Later, the third mate told the able seaman on watch that the captain thought they would be south of the storm. The second mate arrived for the 0000 watch at 2345.

Although he did not divert to the Old Bahama Channel, the captain did arrange with personnel ashore to make the return trip via the Old Bahama Channel.

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**El Faro’s weather data sources**

**BVS**

BVS presented processed tropical cyclone data in a graphical desktop program. Its advantage was that route and storm information could be plotted on screen. Its disadvantage was that the tropical cyclone information was typically 6 hours old when delivered. BVS files were sent only to the captain’s e-mail address on El Faro.

**NWS via Sat-C terminal**

When the NWS and associated entities (such as the NHC) made tropical cyclone information available, the information normally arrived on El Faro’s bridge via Sat-C terminal with limited delay. However, see Sources not used, at right.

**The Weather Channel**

One crewmember made repeated references to The Weather Channel. Although he consistently deferred to the captain, tropical cyclone information on The Weather Channel was more timely than the tropical cyclone information available via BVS.

**Satellite radio**

Satellite radio broadcasts heard on the bridge provided information about the position and increasing intensity of the hurricane. One broadcast said that Joaquin had increased in intensity from category 2 to category 3 just prior to the second mate’s call to the captain on October 1 at 0120.

**Broadcasts from USCG aircraft**

US Coast Guard aircraft broadcast hurricane watch and warning information, adding “mariners use extreme caution” on September 30. El Faro’s captain and second mate both responded, “Wow.” About 24 minutes later, USCG aircraft repeated the “extreme caution” message.

**El Yunque**

As El Faro sailed toward San Juan, a similar TOTE ship, El Yunque, was returning from San Juan to Jacksonville. The captains and chief mates talked by radio, and the captains exchanged e-mails, about the storm.

**Sources not used**

**NHC products**

El Faro did not receive intermediate advisories from the NHC because intermediate advisories were not broadcast via Sat-C. There is no evidence that El Faro’s crew procured these advisories on Hurricane Joaquin, even though they were likely readily available by e-mail via FTPmail.

**NAVTEX**

The NWS also provides weather information in Navigational Telex (NAVTEX) messages that print out on a ship’s dedicated receiver. The third mate reported trouble with the NAVTEX receiver, and there is no evidence that El Faro received NAVTEX weather messages.
October 1

At 0120 on October 1, after hearing satellite radio reports of the strengthening hurricane, the second mate also called the captain and suggested that they change to a more southerly route at 0200 instead of the earlier-planned east-southeast-erly route. Again, the captain did not authorize the change. Instead, he directed her to “run it,” which meant resume the earlier-planned route.

As the seas became higher and the winds intensified, El Faro’s speed slowly decreased. At 0340, the second mate adjusted course to steer further to the north to compensate for the wind pushing the ship to the south, and the second engineer began “blowing tubes.” The ship was heeling to starboard from the increasing wind on its port side, a condition called windheel. The vessel’s speed was about 16.8 knots at 0340. It dropped sharply thereafter.

When the chief mate’s watch began at 0345, the second mate told him that the engineers were blowing tubes. The chief mate adjusted course to nearly due east, further into the

7 Using high-pressure steam to remove soot from the boiler tubes. During this process, a steam-powered ship like El Faro would temporarily lose some propulsion power, and therefore a few knots.
wind. The vessel's speed was now about 13.8 knots. At 0409, the captain arrived on the bridge, shortly thereafter telling the chief mate that the only way to correct the starboard list was to transfer water to the port side ramp tank. At 0440, the captain called the captain over the electric phone. He said, "The chief engineer just called . . . something about the list and oil levels." He might have tried to gauge the list with a clinometer ("can't even see the [level/bubble]").

At 0443, the captain said to put the vessel into hand steering so it could be steered into the wind to try "to take the list off."

The captain turned the vessel northward to 65°. The captain took the conn and ordered a further change to 50° (farther into the wind). The vessel's speed dropped to 7.5 knots.

At 0445, the captain downloaded a BVS weather file that was available at 2304 the night before. Its position and forecast information for Joaquin was consistent with an NHC advisory delivered to the ship via Sat-C almost 12 hours before.

Less than 2 minutes later, El Faro's Sat-C terminal received an NHC advisory with up-to-date position, wind speed, and storm track information. At 0503, the captain, comparing

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8 The ramp tanks were intended to counter the effects of loading or unloading cargo in port. They could correct a list of about 3°.

9 On the VDR transcript, uncertain phrases, words, or partial words are placed inside parentheses. Here, parentheses within parentheses are rendered as brackets.

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Louvered openings in the hull allowed air to flow in and out of the cargo holds via ventilation ducts. These were required to be opened under way, but could have been shut in heavy weather. Pictured at left is the starboard side of El Faro, just above hold 3. Louvered vents are outlined in yellow and a large trailer opening is also visible.

Instead of each automobile being secured to the deck at each corner, they were secured to a long chain across the width of the ship (photo at left is from a similar lashing arrangement on board El Yunque). As the ship encountered heavy weather, vessel motion increased and lashings would have failed more easily as the deck became wet and the ship rolled (see How the water got in, p. 6).
the updated Sat-C weather information with his most recent download of BVS, said he was getting "conflicting reports as to where the center of the storm is." At that time, another BVS weather file became available, but the captain did not download it until an hour later (0609). Beginning at 0510, the captain and the riding gang supervisor—an off-duty chief engineer—discussed the extent of the starboard list, and the captain asked how the list was affecting "operations as far as lube oil(s)."

At 0514, shortly after the captain said their speed was maintaining at 11 knots, he turned the ship into the wind again. By 0518, the vessel's speed had dropped to 5.8 knots. It was now moving with a pronounced starboard list; in hurricane-force wind, rain, and waves; with zero visibility and an untrustworthy anemometer.

At 0543, the captain received a call from the chief engineer that there was a problem in cargo hold 3. He told the chief mate to go to the hold and start pumping. The crew continuously pumped the hold 3 bilges from this point onward.

At 0544, the captain was heard on the VDR saying "We got cars loose," likely referring to automobiles that had broken free of their lashings. The automobile-lashing arrangement did not meet the requirements of the vessel's approved cargo-securing manual, making automobiles more likely to shift in heavy weather.

The crew found that a scuttle (small watertight hatch) on the second deck, starboard side, was open and seawater on deck was flowing over it and down into cargo hold 3. The ship's list to starboard was causing seawater to pool near the scuttle located on the starboard side. The captain told an engineer to begin transferring ballast water from the starboard ramp tank to the port ramp tank.

Once the deck became wet in hold 3, automobiles were more likely to break free of their lashings. An automobile likely struck the intake piping leading to the emergency fire pump. Seawater piping to the emergency fire pump in cargo hold 3 was inadequately protected from such impact.

With a severe breach of the intake piping, water would have flowed into hold 3 under seawater head pressure. Bilge pumps could not keep up with flooding through the fire main.

As the ship's permanent angle to the sea (sustained list) increased past 15 degrees, the high seas would have allowed water to enter the hull through ventilation openings.

The accident (continued)

Second deck scuttle to hold 2A, similar to hold 3 scuttle

Photo: Herbert Engineering
**El Faro’s final maneuvers**

*El Faro’s* captain and crew turned the vessel’s bow into the wind several times. Then, at **0554**, the captain ordered a turn to port to get the wind on the ship’s starboard side, generating a port list. A few minutes later, *El Faro* lost propulsion (see Loss of lube oil suction, below).

At **0554**, the captain ordered a turn to port to put the wind on the ship’s starboard side, thereby generating a port list so the crew could better investigate the source of the flooding in cargo hold 3. This was also the most aggressive of several turns that followed the first conversation about oil levels at about **0440**.

Shortly after the turn to port, the chief mate reported that they had secured the scuttle on the starboard side of the second deck. The vessel was now listing to port and its speed was 2.8 knots.

At **0602**, the second mate said she heard alarms sound in the engine room. At **0609**, the captain downloaded the BVS weather file, which was sent at **0502**, whose information about the hurricane (position, forecast track, and intensity) was consistent with an NHC advisory the ship had received via SAT-C about 7 hours before. He ordered the engineers to transfer bilge water back to the starboard ramp tank, saying "I’m not liking this list."

Cargo hold 3 continued to take on water and the ship continued to lose speed, despite continuous bilge pumping efforts by the crew.

At **0613**, the captain said he thought that the vessel had lost propulsion.
The accident voyage

The captain’s plan was to remain south of Hurricane Joaquin. The captain and chief mate agreed that El Faro’s anemometer, which measures wind direction and speed, could not be trusted. Throughout the voyage, the captain relied primarily on e-mailed files for use in BVS, rather than other available weather data, which was more current. El Faro sailed close to the hurricane’s eye before losing propulsion and sinking.
On the accident voyage, he sought permission to use Old Bahama Channel on the return voyage to Cuba. One month earlier, the captain had sailed down the Florida coast and then through Old Providence Channel. El Faro’s course during Tropical Storm Erika was consistent with NHC Advisory #8, issued Sept. 29 at 1651. The captain made two changes to the original passage plan on the back side of the storm, meaning the less dangerous quadrant. In reality, the storm was east, not north, of El Faro.

At 0409 the captain returned to the bridge. He discussed the weather with the crew, apparently relying on the BVS file sent at 1700 the evening before. The captain thought they were on the “back side” of the storm, meaning the less dangerous quadrant. In reality, the storm was east, not north, of El Faro.
At 0616, the engine room called. Although the conversation from the engine room was not recorded on the VDR, the captain asked, “so . . . is there any chance of gettin' it back online?” It is likely that a suction pipe leading to the lube oil service pump had taken in air instead of oil (see Loss of lube oil suction, p. 7). The port list, coupled with the vessel’s motion, resulted in a loss of oil pressure that caused the main engine to shut down. Once propulsion was permanently lost, El Faro was pushed sideways by the wind and waves.

At 0631, the captain said he wanted “everybody up.” He had the second mate compose, but not send, a distress message.

By 0644, El Faro’s bow was pointed not into the wind, but perpendicular to it. Minutes later, the captain mentioned “significant” flooding in hold 3, but said that he did not intend to abandon ship, saying there was “no need to ring the general alarm yet.” At 0659 the captain called a designated person (DP) ashore and left a message. Seven minutes later, the captain was connected to the DP and reported a marine emergency. When the call ended at 0712, the captain had the second mate send the distress message.

The increasingly large induced list to port from wind and increasing flood water levels in hold 3, combined with the vessel’s rolling in the storm seas, likely caused seawater to enter cargo hold ventilation openings in the hull. It was possible to close these openings, but they were left open during the event; they were not considered downflooding points in any available guidance documents. Seawater poured into hold 3 and then into hold 2A and 2. At 0714, the chief mate told the captain that the chief engineer had said that, “something hit the fire main, got it ruptured, hard” (see How the water got in, p. 6).

One or more of the vehicles in hold 3 had likely struck the emergency fire pump, or “fire main” piping, at the starboard side of hold 3. The inlet piping to the fire main system was designed to supply seawater to the suction side of the emergency fire pump. With a severe breach, seawater would have flowed into hold 3 at a rate that would inevitably overwhelm the capabilities of El Faro’s bilge pumps. It is likely that the piping was breached earlier than 0714, based on the continued flooding of hold 3 after the scuttle was secured and the hold was being dewatered by bilge pumps. (Vehicles had likely been adrift at least as early as 0544, when the captain reported “cars loose.”)

Rather than mustering the entire crew, the captain and a few officers continued efforts to diagnose the problem, though they made no reference to consulting a damage control plan or booklet. Finally, at 0727, the captain ordered ringing of the general alarm. A minute later, the chief mate advised the captain over the radio that the crew was mustering on the starboard side, and at 0729, the captain ordered the crew to abandon ship. He ordered the liferafts thrown overboard at 0731 and told everyone to get into their rafts and stay together.

The recording ended at 0739.

10 A shutdown device stopped the main engine from running without lube oil, by design. However, the ship’s boilers and electrical generators continued to operate, and the ship had electrical power.
About 3 minutes after El Faro’s VDR stopped recording, a reconnaissance aircraft estimated a 10-second average surface wind speed of 117 knots about 21 nautical miles south of El Faro’s last known position. At 0800, Joaquin’s center was estimated to be about 22 nautical miles south-southeast of El Faro’s last known position, according to an NHC post-storm assessment.
Safety issues

The NTSB investigated many issues to find out what happened, why it happened, and what needs to be done to prevent it from happening again.

Captain’s actions

From early in the voyage, the captain made decisions that put his vessel and crew at risk, including making only minor course corrections to avoid Joaquin; relying on outdated weather sources; declining to change course or return to the bridge, even after receiving three calls from deck officers when he was not on the bridge; and introducing a port heel to shift water on the weather deck from starboard to port.

Use of noncurrent weather information

The captain continually referred to hours-old weather information from BVS. The watchstanders on the bridge were routinely getting more current information from the Sat-C terminal and from programs on satellite radio and The Weather Channel (see El Faro’s weather data sources, p. 3).

Late decision to muster the crew

After El Faro lost propulsion, the captain continued to voice his expectation that main propulsion would be restored. Although the captain did say he wanted “everybody up” at 0631, the general alarm didn’t ring until 0727, and the captain did not muster the crew until 0728.

Ineffective bridge resource management

Two members of the bridge team suggested or hinted that they disagreed with the captain’s decisions, but the captain disregarded their concerns. For their part, the bridge crew deferred to the captain’s authority and experience, rather than acting more assertively. Regardless, when the crew did voice concerns, the captain chose not to listen. The suggestions of not only one but two of his officers should have prompted him to at least return to the bridge and review the weather information.

Although bridge resource management (BRM) stresses assertiveness, traditional maritime culture emphasizes the captain’s authority onboard and responsibility for the vessel. TOTE had not effectively implemented BRM, which involves modernizing centuries-old roles and including the bridge team in discussions pertaining to the safe navigation of the vessel.

Inadequate company oversight

TOTE regarded captains as the primary nautical experts. According to one TOTE executive, “There is no one in the company that formally provides oversight for nautical.” Lack of training in BRM was one area in which company oversight failed. The company also failed to formally train crewmembers to use BVS, or on the damage-control module of a cargo-loading program called CargoMax. In addition, TOTE failed to track the vessel’s position relative to the storm and support the captain during the accident voyage.

Company’s safety management system

The company’s safety management system did not provide the officers and crew with the necessary procedures to ensure safe passage, watertight integrity, heavy-weather preparations, and emergency response during heavy-weather conditions.

Flooding in cargo holds

Water initially flooded into the cargo holds through an open scuttle. This lowered deck friction coefficients and likely contributed to loose vehicles in hold 3, which likely damaged the emergency fire pump piping in the hold, allowing seawater to flood the hold faster than the bilge pumps could remove it. The continued hold flooding and increasing list in heavy seas allowed seawater to downflood through the cargo hold ventilation system (see How the water got in, p. 6).

Loss of propulsion

The sequence of events leading to the ship’s loss of propulsion began with a sustained starboard list from beam winds and later flooding of a cargo hold. The captain acted to shift the starboard heel to a port heel. The port heel, in combination with momentary roll, likely allowed air into the lube oil system’s pump, which triggered a shutdown of the main propulsion engine (see Loss of lube oil suction, p. 7).

Downflooding through ventilation closures

El Faro’s certificate of inspection required that cargo hold ventilation closures be kept open at sea when the vessel was transporting vehicles with fuel tanks. In rough weather with a threat of downflooding, it was critical that crewmembers understood that such closures must be secured to prevent flooding (see How the water got in, p. 6).
Need for damage control plan

There is no evidence on the VDR that the captain or crew consulted a plan or procedure for damage control during the heeling, propulsion loss, and flooding sequence. Investigators determined that the vessel had no damage control plan or booklet.

Lack of suitable survival craft

_El Faro_ carried only open (not modern, enclosed) lifeboats. In addition, by the time the crew was abandoning ship, the severe weather, combined with _El Faro’s_ list, made it unlikely that the side-mounted lifeboats could be boarded or launched.

Recommendations

We issued 10 early safety recommendations, followed later by 53 more recommendations in our accident report. Some of the results that these recommendations are intended to bring about are summarized here. To read the full findings and recommendations, see the report (MAR-1701) at www.ntsb.gov.

- Better tropical cyclone forecasting, storm advisories, and weather dissemination systems to improve the accessibility and quality of forecasts and advisories for planners and mariners
- Engines and other critical machinery that work at greater angles of inclination (i.e., despite more listing)
- Lifeboats that can be launched at still greater angles of inclination, so that they can be launched even if engines or other machinery fail
- Enclosed, not open, lifeboats
- Protected seawater supply piping in cargo holds
- Remote open/close indicators for watertight doors and hatches
- Guidance that actions intended to correct a list can be dangerous with cargo adrift
- Class-approved damage-control plans/booklets onboard all vessels, regardless of build date
- Review of the inspection program and improved oversight for vessel inspections
- Lifesaving appliances updated at least every 20 years
- Personal locator beacons for crewmembers
- Better VDRs and VDR testing
- Weather reporting by ships to global authorities every 6 hours at fixed times, using the automatic identification system
- Appropriate and recurrent BRM and meteorology training for all deck officers
- Improved processes, procedures, documentation, training, and shoreside support at TOTE
- Enclosed, not open, lifeboats
- Protected seawater supply piping in cargo holds
- Remote open/close indicators for watertight doors and hatches
- External audit of TOTE’s safety management system
- Functioning weather instruments on TOTE ships
- Heavy-weather procedures on TOTE ships that address oil levels in critical machinery

Recipients

In many cases, we issued companion recommendations to more than one entity with a single result in mind. In other cases, such as recommendations to TOTE, the hoped-for results were narrower and could be achieved by a single recipient. The recommendation recipients are:

- US Coast Guard
- Federal Communications Commission
- National Oceanic and Atmospheric Administration
- International Association of Classification Societies
- American Bureau of Shipping
- Furuno Electric Company, Ltd.
- TOTE Services, Inc.
The search for *El Faro* and the VDR

Data recorders are among the most powerful tools investigators have for determining what happened in an accident and to prevent it from happening again. The search for the wreckage of *El Faro* and recovery of its voyage data recorder (VDR) took three voyages, and resources from several organizations.

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**First voyage**

**OCT 23 2015**  The Navy ship *Apache*, with three underwater assets, arrived at the site of the sinking

**Towed ping locator.** Investigators listened for the VDR acoustic beacon but heard nothing.

**Towed side-scan sonar (ORION).** ORION was launched on October 27, and, after 4 days of searching, located a large target of interest.

**Remotely operated vehicle (ROV) CURV-21.** Team members navigated the CURV-21 through the debris field, aided by a video feed.

NTSB investigators analyzed video footage of the hull and debris field and calculated object trajectories to identify where the mast and VDR might have come to rest. A second voyage was planned in consultation with SUPSALV, NSF, and WHOI (see Organizations Involved in the Search, next page).

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**Second voyage**

A vessel equipped with dynamic positioning was needed for the second voyage (dynamic positioning allows a vessel hosting underwater search vehicles to remain on station even during bad weather). The *Atlantis* (pictured above) became available in April 2016.

**APR 21 2016**  *Atlantis* arrived at the site of the sinking, equipped with the AUV (autonomous underwater vehicle) *Sentry* and an additional observation vehicle.

**Atlantis** surveyed site with multibeam sonar, verifying main hull wreck location and overall bottom bathymetry (depths and topography).

**Sentry,** programmed to search wide areas with different sonar frequencies or cameras, identified more than 200 targets of interest.

**Observation vehicle** obtained high-definition video and photos of *El Faro*’s hull, and interrogated the detected targets—one of which was the *El Faro*’s mast, with the VDR capsule attached.

The VDR is found directly at mast, and likely attached (remaining bolted) to the mast with obstructions, precluding a simple recovery.

A final recovery mission was launched in August 2016.

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### Sentry side-scan sonar survey of debris field

<table>
<thead>
<tr>
<th>Bridge</th>
<th>Stack</th>
<th>Mast/VDR</th>
<th>Hull</th>
</tr>
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<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td><strong>About 1722 ft (525 m)</strong></td>
<td><strong>About 3166 ft (965 m)</strong></td>
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Sinking of the US Cargo Vessel *El Faro*  14  National Transportation Safety Board
Third voyage

AUG 08 2016

The ROV CURV-21 arrived at the site of the sinking, again hosted on board the Navy ship Apache. At 1950, CURV-21 successfully freed the VDR capsule from the partly buried mast and brought it to the surface.

The documentation of wreckage, together with the data and audio downloaded from the vessel's VDR, provided invaluable information to determine the circumstances of the sinking.

Reviewing the VDR

The entire 26-hour recording was reviewed many times, with some statements reviewed more than 100 times by the VDR audio transcript group to ensure they understood what was being said in the recording.

About 10 hours of audio was determined to be relevant to the investigation and therefore transcribed by the VDR audio transcript group. The transcript required more than 1,100 work hours to complete. The transcript report is more than 500 pages and is the longest transcript ever produced by the NTSB.
Parties to the investigation

US Coast Guard
TOTE Services, Inc.
American Bureau of Shipping
National Weather Service
Harding Safety USA (Palfinger)
Herbert Engineering

The NTSB is an independent federal agency that investigates marine, rail, pipeline, highway, and aviation accidents, determines their probable causes, and makes recommendations to improve safety.

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