Allision of Passenger Ferry *Andrew J. Barberi* With St. George Terminal Staten Island, New York May 8, 2010

Marine Accident Report

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National Transportation Safety Board

490 L'Enfant Plaza, SW
Washington, DC 20594

National Transportation Safety Board. 2012. ***Allision of Passenger Ferry* Andrew J. Barberi *With St. George Terminal, Staten Island, New York, May 8, 2010*, Marine Accident Report NTSB/MAR-12/01. Washington, DC.**

Abstract: This report discusses the May 8, 2010, allision of the *Andrew J. Barberi* with the St. George terminal at Staten Island. A total of 266 persons were on board the vessel. As a result of the accident, 50 people were injured, 3 of them seriously. Damages to the vessel and the terminal structure totaled $182,238.

Although this accident was not a “major marine casualty” as defined at 49 *Code of Federal Regulations* (CFR) Part 850 and 46 CFR Subpart 4.40, the National Transportation Safety Board chose to investigate it because the *Andrew J. Barberi* was also involved in an allision in 2003. Eleven people died and 70 people were injured in that accident.

Safety issues identified in this accident include undetected loss of propulsion control and lack of propeller pitch deviation alarms on vessels with controllable pitch or cycloidal propulsion, operational safety provided by safety management systems, and lack of voyage data recorders on U.S.-flag ferries. On the basis of its findings, the National Transportation Safety Board makes recommendations to the U.S. Coast Guard.

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Acronyms and Abbreviations

ABS	American Bureau of Shipping
AIS	automatic identification system
CCTV	closed-circuit television
DOT	Department of Transportation
ECR	engine control room
ECS	electronic chart system
EDT	eastern daylight time
FDNY	Fire Department of the City of New York
KV	Kill Van Kull (buoy near Staten Island)
IMO	International Maritime Organization
ISM	International Safety Management
MAIB	Marine Accident Investigations Branch (United Kingdom)
NTSB	National Transportation Safety Board
NYC	New York City
NYC DOT	New York City Department of Transportation
NYPD	New York City Police Department
SMS	safety management system
SOLAS	International Convention for the Safety of Life at Sea
S-VDR	simplified voyage data recorder
TSB	Transportation Safety Board of Canada
VDR	voyage data recorder

Executive Summary

On Saturday, May 8, 2010, at 0918 eastern daylight time, the passenger ferry *Andrew J. Barberi* allided with the terminal structure at slip No. 5 at the St. George terminal, Staten Island, New York, after a loss of propulsion control. Eighteen crewmembers, 2 New York City police officers, 2 concessionaires, and 244 passengers were on board. As a result of the allision, 3 passengers sustained serious injuries; 47 passengers, crew, and others reported minor injuries. The damage to the vessel and the terminal structure totaled $182,238.

The National Transportation Safety Board determines that the probable cause of the accident was a solenoid failure, which caused a loss of propulsion control of one of the vessel's two cycloidal propellers. Contributing to the accident was the propulsion system's lack of a propeller pitch deviation alarm, which was not required by regulation, but which would have alerted the pilothouse crew to the loss of propulsion control and permitted prompt action.

Safety issues identified in this accident include:

- **Undetected loss of propulsion control and lack of propeller pitch deviation alarms on vessels with controllable pitch or cycloidal propulsion.** The *Andrew J. Barberi* experienced a loss of propulsion control, in which the pitch of the propeller blades failed to respond to the pilothouse crew commands. Because no alarm alerted the crewmembers to the failure, they were unaware of the problem until very little time remained to correct it. Other accidents involving passenger injury and substantial property damage have also resulted from undetected loss of propulsion control. Pitch deviation alarms audibly and visually alert operators in the shortest possible time should the propeller not respond to a command. However, these alarms are not currently required by U.S. Coast Guard regulations.

- **Operational safety provided by safety management systems.** After a 2003 accident involving the *Andrew J. Barberi*, the New York City Department of Transportation Ferry Division voluntarily implemented a safety management system and trained its personnel in its procedures. This effort was evident in the 2010 accident, in which the personnel carried out their designated emergency response procedures in a timely and effective manner. International regulations require safety management systems for vessels in oceangoing service. The National Transportation Safety Board is concerned, however, that safety management systems are not currently required on U.S. passenger vessels in domestic service.

- **Lack of voyage data recorders on U.S.-flag ferries.** The *Andrew J. Barberi* was not equipped with a voyage data recorder, nor was it required to be. Although investigators obtained video footage from the vessel's closed-circuit television security system, which aided them in this accident investigation, the footage was nevertheless incomplete. It did not provide important detailed data, such as the exact moment the vessel's propulsion system failed to properly respond to the pilothouse commands. Although international regulations require all passenger ships and other vessels of 3,000 or more gross tons on international voyages to be fitted with voyage

data recorders, U.S.-flag ferries in domestic service are not currently bound by this requirement.

As a result of the *Andrew J. Barberi* investigation, three new recommendations are issued, two existing recommendations are reiterated, and one existing recommendation is reclassified in this report.

1. The Accident

1.1 The Accident Transit

About 0900[1] on May 8, 2010, the 310-foot-long passenger ferry *Andrew J. Barberi* (figure 1), operated by the New York City Department of Transportation (NYC DOT) Ferry Division, departed the Whitehall terminal in lower Manhattan, New York. The vessel was heading to the St. George terminal on Staten Island, New York, on its third roundtrip of the day (figure 2). On board were 18 crewmembers; 2 New York City Police Department (NYPD) officers, as was routinely the case; 2 concessionaires; and 244 passengers.

Figure 1. *Andrew J. Barberi.*

The *Andrew J. Barberi* was double-ended with identical pilothouses and propulsion units at each end. This allowed the vessel to approach and leave its slips without turning around. Its "New York-end" docked in Manhattan; the "Staten Island-end" docked in Staten Island. The pilothouse crewmembers repositioned themselves from one end to the other between transits.

[1] Unless otherwise noted, all times in this report are eastern daylight time (universal coordinated time –4 hours) and are based on the 24-hour clock.

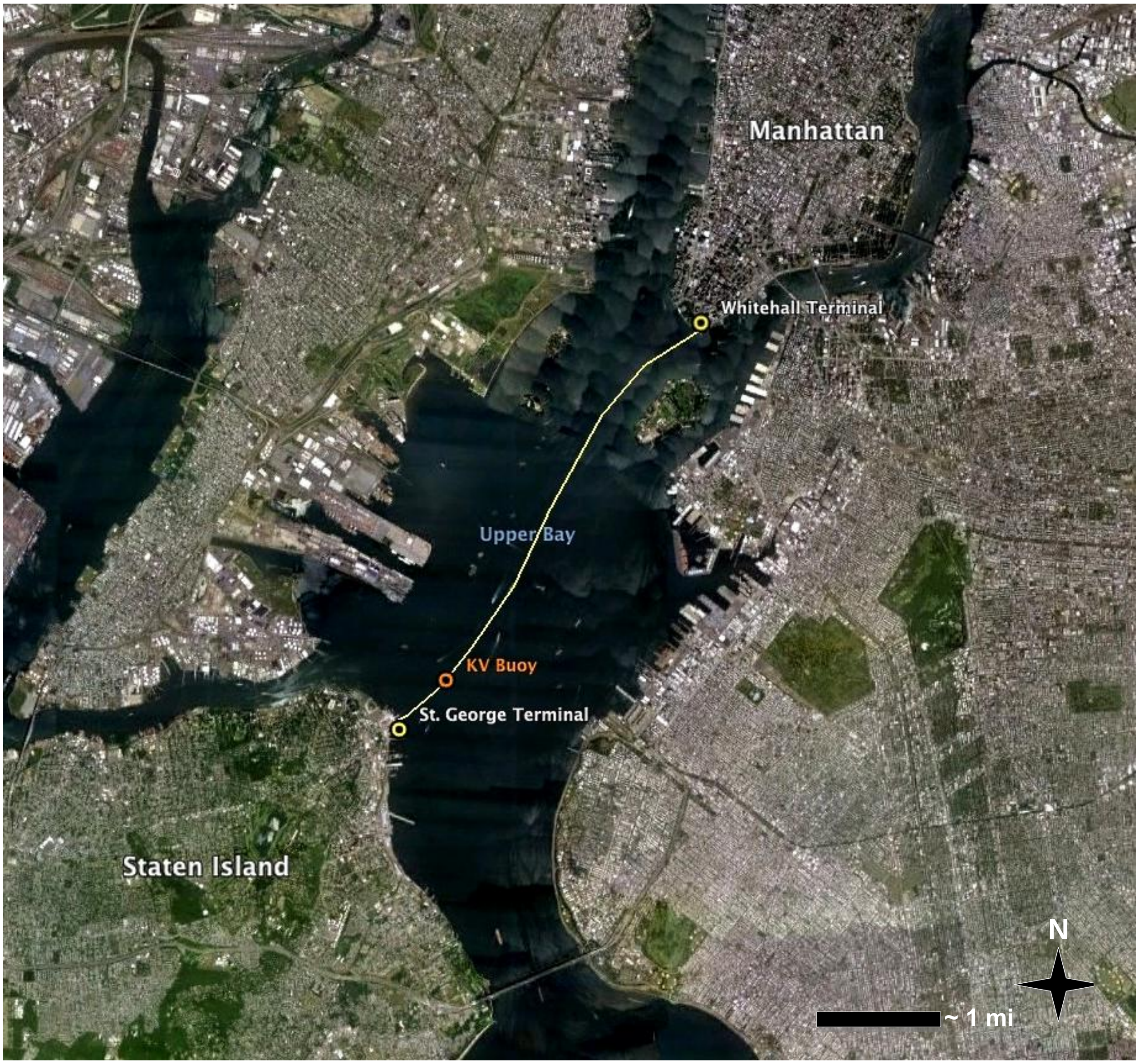

Figure 2. Aerial view of the vessel's route between Manhattan and Staten Island.

Each roundtrip began at the St. George terminal on Staten Island, which was also where the Ferry Division vessels were docked at night. The transit between Staten Island and Manhattan was about 5 miles long and took about 20 minutes, with the *Andrew J. Barberi* traveling near its full speed of 16 knots. On the day of the accident, the pilothouse crew consisted of the usual crew complement of a captain, an assistant captain, a mate, and a lookout. The vessel's engineering crew consisted of a chief engineer, a marine engineer, and three oilers. The day before, the engineering crew had performed a scheduled operational test of the vessel's two propulsion units—a routine measure that crews took on the first day of their 3- or 4-day duty shifts—and noted no deficiencies.

According to Ferry Division officials, captains typically operated the vessels during transits to Manhattan, and assistant captains operated them during the returns to Staten Island. The operator who brought the vessel to the dock (the captain or the assistant captain) maintained propulsion control in that pilothouse while passengers disembarked and embarked. On departure, that operator then transferred propulsion control to the operator who stationed himself in the departing pilothouse, and thereafter joined him there (also see section "1.7.2 Vessel Information; Propulsion System"). On the day of the accident, as was usually the case, the assistant captain was at the controls (figure 3) during the transit to Staten Island, and the captain was present as well to oversee the operation and assist, if required.

The first two roundtrips that day had been uneventful, with all systems performing normally. About 0916, near the end of its third return to Staten Island, the *Andrew J. Barberi* passed the Kill Van Kull (KV) buoy about 1,000 yards from the St. George terminal. This was the point where vessel crews customarily began preparing for arrival at Staten Island. Accordingly, the mate in the pilothouse made a routine radio call to the engineering crew in the engine control room (ECR) to stand by for docking. A video camera in the pilothouse—one of several onboard cameras in the vessel's closed-circuit television (CCTV) security system—was recording the pilothouse control station from a fixed vantage position. It recorded the assistant captain reducing engine rpm and pulling back on the levers that controlled propeller pitch to decrease speed in preparation for docking. (On vessels with cycloidal propulsion, like the *Andrew J. Barberi*, adjusting the pitch of the propeller blades changes the magnitude and direction of thrust. More detail is provided in section "1.7.2 Vessel Information; Propulsion System.")

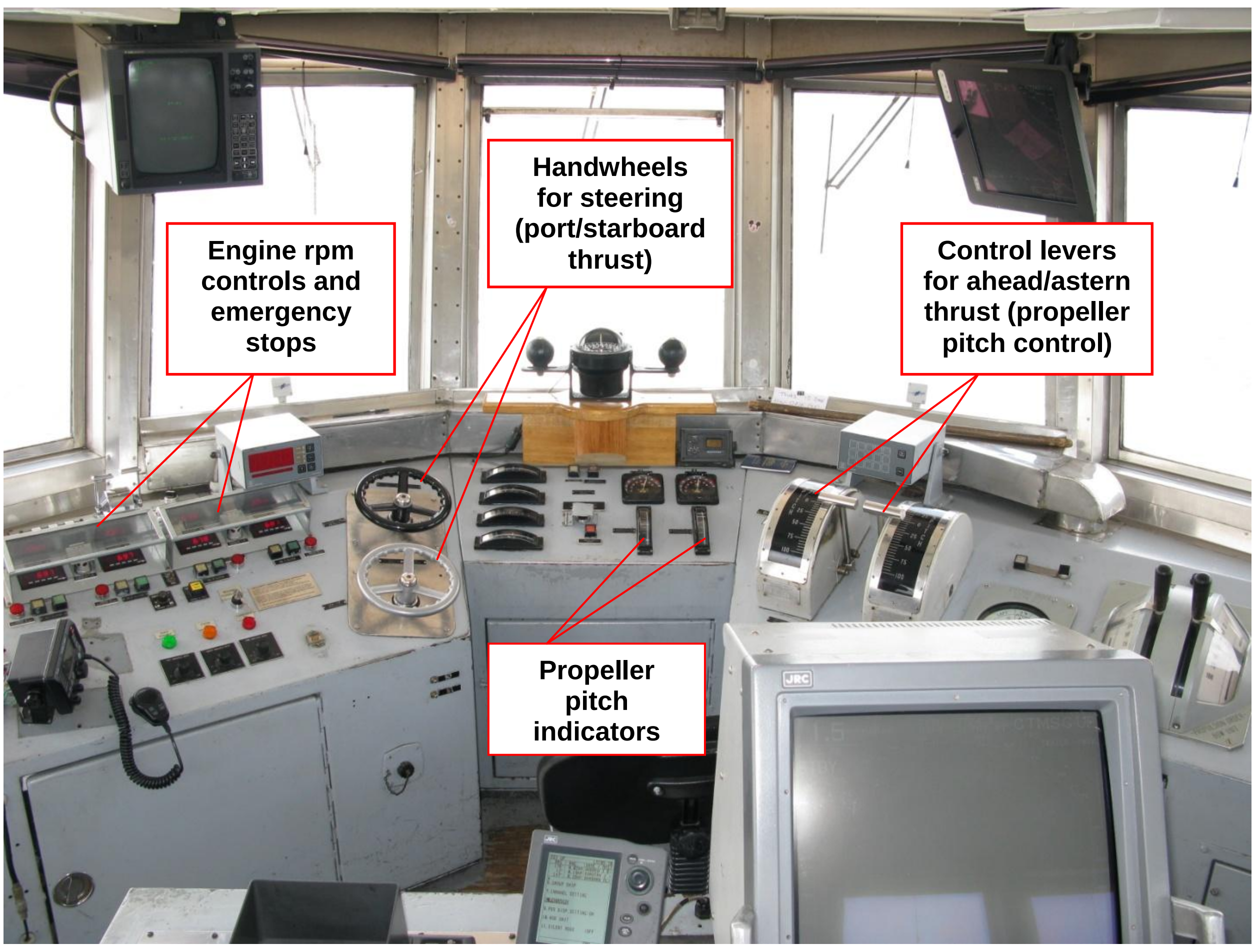

Figure 3. The control station in the Staten Island-end pilothouse.

The *Andrew J. Barberi* initially reduced speed as commanded, and, according to automatic identification system (AIS)[2] data, at 0917 the vessel's speed was 15 knots, down slightly from full transit speed.

The *Andrew J. Barberi* was not equipped with a voyage data recorder (VDR) or a simplified voyage data recorder (S-VDR),[3] nor was it required to be. Therefore, National Transportation Safety Board (NTSB) investigators could not determine the exact point at which the vessel's propulsion failed to properly respond to the assistant captain's input. However, the failure likely occurred as the *Andrew J. Barberi* began to reduce speed after passing the KV buoy.

The captain told investigators that, about halfway between the buoy and the slip, he thought that the vessel's speed was higher than he "would have liked to have seen it," but that individual operators approached the terminal at different speeds and that he had previously seen "plenty of [operators] come in faster or just as fast." Still, according to both men, the captain told the assistant captain to reduce speed about this time, to which the assistant captain responded affirmatively. The captain told investigators, "I did see him come down on the pitch. So I wasn't really nervous."

As the *Andrew J. Barberi* neared the slip, the CCTV showed that both men were standing, facing forward. According to the captain, he instructed the assistant captain to "back [the vessel] 100 percent," and the CCTV showed that the assistant captain input a full-astern thrust command to both propulsion units. The captain then increased engine rpm to maximum so that, as he explained to investigators, the vessel would react faster to the full-astern command. When the vessel failed to respond as expected, the CCTV showed that the assistant captain repeatedly and rapidly pushed the control levers downward to reiterate the full-astern command.

In the ECR, the chief engineer thought that, as the *Andrew J. Barberi* neared the slip, the approach "didn't sound normal" compared to the usual cadence and rhythm of the engines at that stage of the transit. One of the oilers alerted him to a CCTV screen, which allowed crew in the ECR to view the vessel's progress during the approach to the dock. The chief engineer told investigators that, in the brief time he had available to observe the CCTV, he saw that the vessel

[2] AIS is a maritime navigation safety communications system. At 2- to 12-second intervals on a moving vessel, the AIS automatically transmits vessel information, including the vessel's name, type, position, course, speed, navigational status, and other safety-related information to appropriately equipped shore stations, other vessels, and aircraft. The rate at which the AIS information is updated depends on vessel speed and whether the vessel is changing course. The AIS also automatically receives information from similarly equipped vessels. With regard to passenger vessels, under current domestic regulations at 33 *Code of Federal Regulations* (CFR) Part 164, AIS is required on board a) vessels over 150 gross tons, and b) vessels carrying more than 150 passengers and operating in areas covered by Coast Guard vessel traffic service, such as New York Harbor.

[3] VDRs maintain continuous, sequential records of data relating to a ship's equipment and its command and control, and capture bridge audio from certain areas in the pilothouse and on the bridge wings. Regulation 20 of the International Convention for the Safety of Life at Sea (SOLAS) Chapter V requires all passenger ships and all cargo ships of 3,000 or more gross tons (International Tonnage Convention), built on or after July 1, 2002, to carry VDRs when in international service. S-VDRs are not required to capture all of the parameters of a standard VDR but are permissible under a July 2006 amendment to SOLAS that applies to vessels built before July 1, 2002. (The *Andrew J. Barberi* was built in 1981; see section "1.7.1 Vessel Information; General.")

had already entered the slip and that he realized that they were "going to hit … and hit hard." He said that he told the engineering crewmembers to brace themselves.

In the pilothouse, the captain reached for the whistle and sounded the danger signal.[4] The mate announced "brace, brace, brace" on the public address system. After the assistant captain steered the vessel to avoid striking the outer point of the slip's portside rack, the vessel made lateral contact with the starboard-side rack (figure 4) about 9 seconds before the allision.

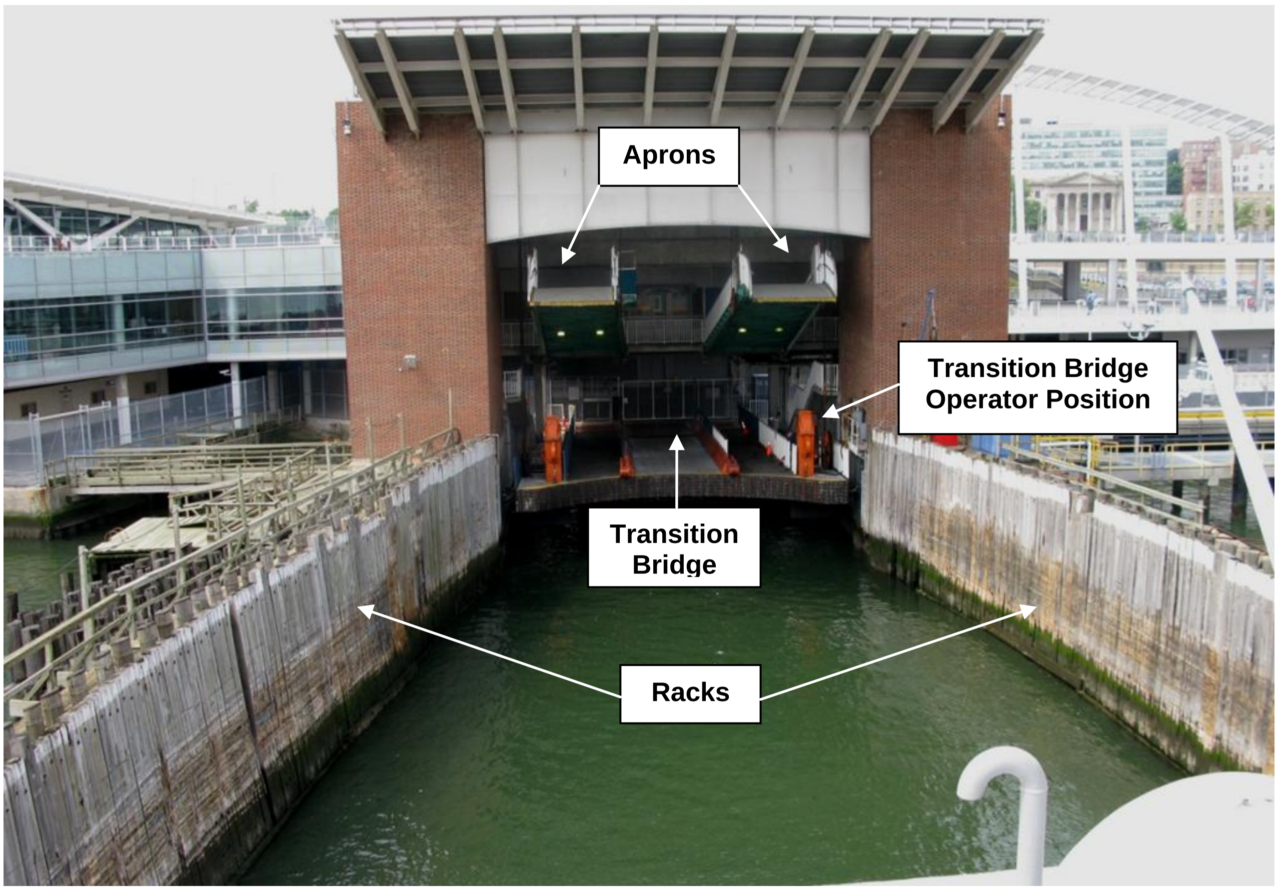

Figure 4. Slip at the St. George terminal on Staten Island. At the end of the slip, nearest to the terminal, is the adjustable height transition bridge, which abutted to the main deck of the ferry, and which passengers normally used to embark and disembark. The two retractable aprons, located above the transition bridge, were also normally used for embarkation and disembarkation.

The shoreside operator of the transition bridge told investigators that he, too, noticed that the *Andrew J. Barberi* entered the slip at a higher speed than usual. He was standing by as he normally did to connect the transition bridge to the vessel's main deck after docking, so that passengers could embark and disembark. Despite the *Andrew J. Barberi*'s bearing down on him, the operator remained at his station and positioned the transition bridge's face to align with the vessel's main deck, as he would do for normal dockings.

[4] Five short blasts of a vessel's horn.

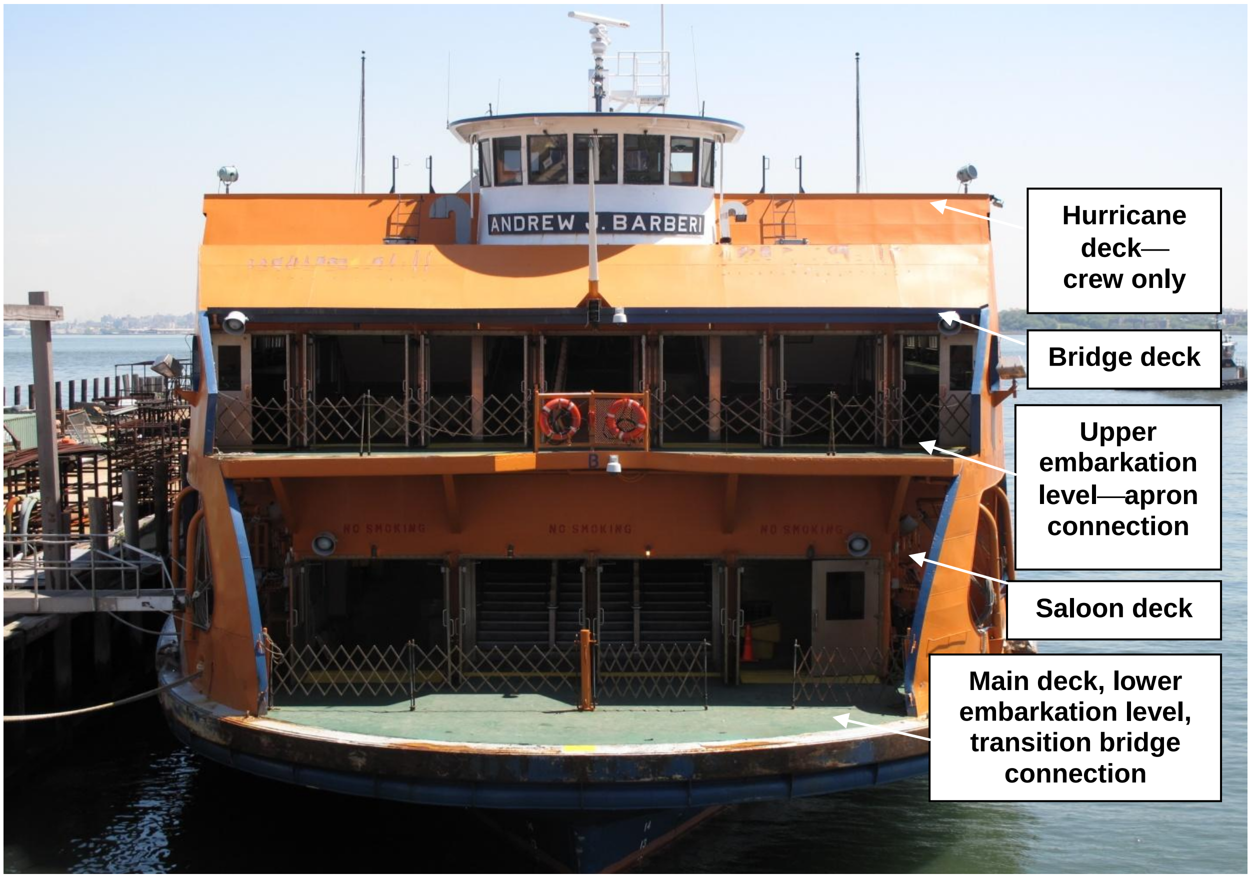

Figure 5. The decks and embarkation levels on the *Andrew J. Barberi*.

According to interviews with deckhands and passengers, even before the announcement to brace themselves, the crew and some passengers had already noticed the abnormal speed and surmised that the *Andrew J. Barberi* would make a hard landing. The vessel's CCTV showed that the deckhands began directing passengers away from the exterior embarkation areas, and that passengers prepared for impact. The pilothouse crew also braced for impact. The allision occurred at 0918:33, about 20 seconds after the *Andrew J. Barberi* entered the approximately 300-foot-long slip. Investigators estimated the speed at impact at less than 8 knots.[5] The CCTV from the vessel's passenger decks showed that people hurried away from the bow, and that most of the persons who did not sit down or brace themselves before the allision fell down onto the deck upon impact. The chief engineer told investigators that he felt two distinct impacts—the first was a lateral movement, and the second was a hard strike that knocked him off his feet. Security video footage from inside the terminal showed the vessel approaching head-on, and the dust and debris immediately following the impact (figure 6).

[5] Investigators surmised that the vessel's speed at impact was less than its average speed through the slip. Using the CCTV video footage, investigators calculated the average speed by measuring the distance that the vessel traveled from the moment its Staten Island-end pilothouse passed the outer point of the slip's starboard-side rack to the moment of impact.

Figure 6. Video images of the impact.

The video footage also showed that, as a result of the allision, the shoreside transition bridge—which was designed to absorb some impact by being unfixed and able to float—was lifted up and displaced several yards into a security-perimeter fence. The bridge came to rest about 5 feet above the *Andrew J. Barberi*'s main deck, overlapping it by about 3 feet. The two aprons were lifted up and landed on the vessel's hurricane deck, two decks above their normal connecting level.

Shortly after the allision, the assistant captain moved the propulsion control levers from full astern command and placed them in zero pitch, or neutral, position, calling for no ahead or astern thrust.

One of the two NYPD officers on board the *Andrew J. Barberi* told investigators that, immediately after impact, he used his police radio to call for ambulances. Police communications logged the officer's call for assistance at 0921. He and his partner, along with onboard mates and deckhands, then began walking the decks to assist any injured people. They administered first aid to one passenger, evaluated others, and told some passengers to remain where they were until shoreside emergency personnel arrived. Shortly after the officer's initial call, the commanding officer of the NYPD's Ferry Security Unit activated rapid mobilization of police resources. The NYPD notified the Coast Guard at 0922 and the Fire Department of the City of New York (FDNY) at 0923.

The FDNY arrived on scene about 0930 and set up a triage area on the pier near the *Andrew J. Barberi*. Along with the NYPD, the FDNY also checked the water to ascertain whether anyone had fallen overboard in the accident. The FDNY (including emergency medical services personnel) administered first aid and conducted searches for passengers. In total, 23 FDNY units responded to the scene.

The *Andrew J. Barberi* crew placed a gangway connecting the vessel's main deck to the displaced transition bridge. Using this gangway, passengers departed the vessel in single file. The FDNY supervised the disembarkation of passengers who could move on their own, and then evacuated others who needed assistance, including the injured.

The chief engineer began assessing the vessel for damage. In accordance with the company's safety management system (SMS; see section "2.2 SMS Recommendations from 2003 Accident Involving *Andrew J. Barberi*"), he tasked one of the three oilers to check the engineroom bilge levels, another to sound all tanks, and another to check for any breaches or water entry. The oilers also carried out other SMS-related duties. The only damage they reported was located in the Staten Island-end propulsion space; the hull and deck above the propulsion unit was breached. No hull breaches were found below the waterline. The onboard diesel-driven generator continued to supply electrical power to the vessel's lights and all onboard equipment throughout the accident sequence.

Within the hour, several Ferry Division managers arrived on board the vessel.

The engineering crew told investigators that, as a matter of course, they made rounds every 2 hours during transits. The marine engineer and one of the oilers reported that they had checked the propulsion units on both ends of the vessel minutes before the allision and had found no anomalies on either end.

1.2 Injuries

Fifty people were injured in the accident, three of them seriously. The injuries were primarily muscle injuries and pain to the jaw, neck, shoulder, back, hip, knee, or legs. Most of the injured persons walked off the vessel; some were removed on stretchers. The injured passengers were transferred to the Richmond University Medical Center on Staten Island; two of them were taken there by ambulance.

Table 1. Injuries sustained in *Andrew J. Barberi* allision.[6]

Type of Injury	Crew	Passengers	Other	Total
Fatal	0	0	0	0
Serious	0	3	0	3
Minor	6	38	3[7]	47
None	14	203	0	217

Title 49 CFR section 830.2 defines a fatal injury as any injury that results in death within 30 days of an accident. It defines serious injury as that which requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; results in a fracture of any bone (except simple fractures of fingers, toes, or nose); causes severe hemorrhages, nerve, muscle, or tendon damage; involves any internal organ; or involves second- or third- degree burns, or any burn affecting more than 5 percent of the body surface.

1.3 Toxicological Tests

Shortly after the accident, the *Andrew J. Barberi* crew submitted specimens to the Coast Guard for toxicological testing.[8] All results were negative for alcohol and the five classes of illicit drugs that the U.S. Department of Transportation screens for in postaccident testing (marijuana, cocaine, opiates, amphetamines, and phencyclidine).

1.4 Weather and Waterway Conditions

At the time of the accident, the tide was ebbing and the weather was partly cloudy with light variable winds and visibility ranging up to 10 miles. Newark Liberty International Airport in New Jersey, about 5 miles west of the accident site, reported light rain at the time of the accident. The air temperature was about 62 degrees F; the water temperature at Bergen Point West Reach, New Jersey, just over 3 miles away, was reported as 61 degrees F.

1.5 Damage

1.5.1 Vessel Damage

A representative of the American Bureau of Shipping (ABS), the *Andrew J. Barberi*'s classification society, surveyed the vessel on May 9, 2010, to ascertain damages and necessary repairs. All of the damage was located above the waterline and extended back about 52 feet from the vessel's Staten Island-end. The damage was generally symmetrical on the port and starboard

[6] The NTSB uses the injury criteria of the International Civil Aviation Organization in all accident reports regardless of transportation mode.

[7] "Other" includes the two New York police officers assigned to the *Andrew J. Barberi* and the shoreside transition bridge operator.

[8] In accordance with 46 CFR 4.06-3, postaccident alcohol testing must be conducted within 2 hours and drug testing within 32 hours of a serious marine accident, unless precluded by safety concerns directly related to the accident.

sides where the vessel impacted the rack pilings and concrete structure of the terminal (figures 7 and 8). On both sides, the hull was breached beneath the main deck, at the rub rail level,[9] in the space that contained the cycloidal propulsion unit. The damage included about 15 feet of tearing and deformation to the port and starboard main deck plating and bulwarks,[10] as well as tearing and deformation to the rub rails on both sides.

On the main deck, the portside mooring chock[11] was displaced. The watertight bulkhead separating the cycloidal propulsion space from the end-most ballast tank was buckled on both the port and starboard sides, and the immediate transverse web frames on each side of this watertight bulkhead were deformed. The survey also noted minor damage at the bridge deck, port and starboard of the pilothouse, resulting from the vessel striking the aprons.

Figure 7. Damage to the vessel's port side (Staten Island-end).

[9] Rub rail is a projecting strip that protects the vessel's body from damage through gliding contact.

[10] Bulwark is a vertical exterior bulkhead above the main deck.

[11] Mooring chock is a fitting on a vessel's deck through which mooring lines are led.

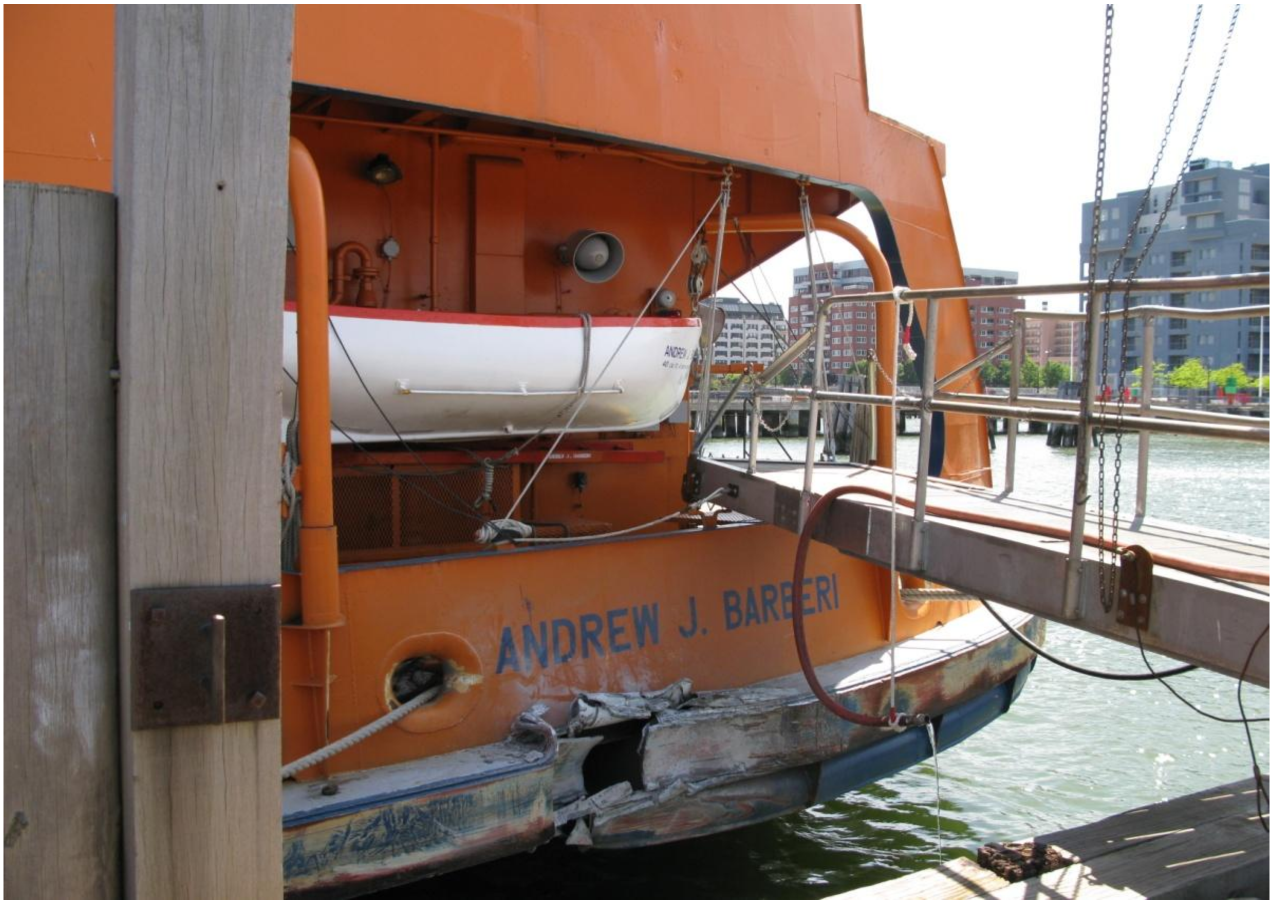

Figure 8. Damage to the vessel's starboard side (Staten Island-end).

The day after the allision, a local diving company surveyed the underwater hull and found no anomalies. Voith Turbo, the manufacturer of the vessel's propulsion system, video-examined the propeller blades and found no damage.

The cost to repair the *Andrew J. Barberi*'s allision damage was $168,625, according to Ferry Division officials.

1.5.2 Damage to Terminal

The No. 5 slip at St. George terminal sustained damage to its steel ladders and walkways. The transition bridge was pushed forward and displaced on impact. However, because this bridge was designed to absorb impact forces and be displaced in the event of an allision, it sustained no damage. In the days following the accident, the bridge was rigged back into place, and ladder and walkway steel damage was repaired. The cost to repair the slip was $13,613.

1.6 Personnel Information

1.6.1 Pilothouse Crew

The pilothouse crew consisted of four people: the captain, the assistant captain, the mate, and the lookout.

Captain. The captain, age 27, was a 2005 graduate of the State University of New York Maritime College, and had worked for the NYC DOT Ferry Division since graduating. He started as mate and was promoted to assistant captain in April 2009. He held a Coast Guard-issued inland master's license with first class pilot endorsement for the route. He told investigators that, while serving as assistant captain, he had made hundreds of transits on the *Andrew J. Barberi*. After completing 6 weeks of master qualification training, he was promoted to captain. The accident occurred on his second day as a fully qualified master.

On Wednesday, May 5, 2010, the captain worked the evening shift from 1330 to 2130, and went to sleep around midnight. On Thursday, May 6, he was off duty and awoke at about 0800. That evening, he went to sleep at 2100. On Friday, May 7, he awoke at 0400, started work at 0430 (he resided only minutes from work) and finished at 1530. After work that day, he went to the NYC DOT's ship simulator from 1600 to 1900 for familiarization training with the new electronic chart system (ECS),[12] and went to sleep at 2000. On Saturday, May 8, the day of the accident, he woke up at 0430 and reported to work at 0500.

Assistant Captain. The assistant captain, age 47, was a 1982 graduate of the Pakistan Maritime College. Following cadet service with the Pakistani National Shipping Company, he immigrated to the United States in 1998. The NYC DOT Ferry Division hired him in 2004. He started as deckhand and was subsequently promoted to mate and assistant captain. He held a Coast Guard-issued 100-ton master's license with first class pilot endorsement for the route. He told investigators that he had docked the *Andrew J. Barberi* many times.

On Wednesday, May 5, 2010, the assistant captain was off duty, and he reported awaking about 1100. He could not remember when he went to sleep, but stated that he had a good night's sleep. He also was off duty the following day, Thursday, May 6, and reported awaking about 1100 and relaxing at home. On Friday, May 7, he awoke at 0330, worked from 0600 to 1530, and went to sleep about 1930. On Saturday, May 8, the day of the accident, the assistant captain awoke about 0315 and started work at 0500.

Mate. The mate, age 23, graduated from the U.S. Merchant Marine Academy in Kings Point, New York, in 2008 and obtained a Coast Guard-issued third-mate license. NYC DOT Ferry Division hired him in January 2010. He started as a deckhand and was subsequently promoted to mate.

Lookout. The lookout, age 47, who was serving in the pilothouse at the time of the accident, was a deckhand. He had been a NYC DOT Ferry Division deckhand for nearly 20 years.

[12] ECS is a software system that displays electronic chart data on computer screens. It is intended to improve navigation safety and aid mariners in their day-to-day work.

1.6.2 Engineering Crew

The engineering crew consisted of five people: the chief engineer, the marine engineer, and three unlicensed oilers. The two engineers were Coast Guard-licensed. The *Andrew J. Barberi*'s certificate of inspection called for the engineering complement to be at a minimum one chief engineer, one other licensed engineer, and two oilers.

Chief engineer. The chief engineer, age 43, was a 1988 graduate of the U.S. Merchant Marine Academy. After graduating, he worked as an engineering officer on vessels for several companies and, from 1996 to 2006, in shoreside fleet management. He held a current Coast Guard license as a chief engineer of motor vessels (diesel), unlimited horsepower, with a restriction to near coastal waters (out to 200 miles). He also held a Coast Guard license as a first engineer of motor vessels, unlimited horsepower, and as a third engineer of steam vessels, unlimited horsepower.

The chief engineer began working for NYC DOT Ferry Division in February 2006. He had worked as engineer on board most of its vessels. At the time of the accident, he had been the *Andrew J. Barberi*'s chief engineer for about 3 months. He told investigators that he usually worked Friday through Monday. On Fridays and Sundays, his work hours were 0700–1500. On Saturdays, he worked from 0630 to 1430, and on Mondays, he worked from 1400 to 0200.

The chief engineer reported maintaining a regular schedule. He told investigators that he slept 5 hours the night between May 5 and 6, but that during each of the 2 subsequent nights, he slept 8 or more hours.

Marine engineer. The marine engineer, age 61, was the chief engineer's assistant and held a Coast Guard third assistant engineer's unlimited horsepower motor license. He had worked in the marine industry nearly his entire life. He began working for NYC DOT Ferry Division as an oiler in 1979 and became a vessel engineer in 1985. He told investigators that he had substantial experience with the Ferry Division's two Barberi-class ferries (the *Andrew J. Barberi* and the *Samuel I. Newhouse*), having worked on them since they were first built in 1981.

The marine engineer told investigators that he worked the same schedule as the chief engineer, Friday through Monday. He maintained a regular schedule and reported having received sufficient sleep during each of the 3 nights before the accident.

Oilers. The other three engineering crew were oilers who did not need licensing for work. Two of the oilers had worked for the Ferry Division since 2005, the third oiler since 2007.

1.7 Vessel Information

1.7.1 General

The *Andrew J. Barberi* was built in 1981 by Equitable Shipyards, Inc., in New Orleans, Louisiana. The vessel was of welded steel construction and had a gross register tonnage of 3,335. It could carry 5,992 passengers, with seating for 3,672. From its full speed of 16 knots, the vessel could come to a stop in about 40 seconds, within a distance of about 400 feet.

1.7.2 Propulsion System

The *Andrew J. Barberi* was equipped with two Voith Turbo cycloidal propulsion units, one at each end of the vessel (figure 9).

Figure 9. One of the two cycloidal propellers on the *Andrew J. Barberi*.

Cycloidal propulsion allows quick and precise control of a vessel's direction and speed. Cycloidal propulsion is similar to controllable pitch propulsion[13] in that the angle, or pitch, of the propeller blades can be changed to control the magnitude and direction of thrust. However, unlike a controllable pitch propeller, which can thrust only along its shaft axis, a cycloidal propeller can thrust in any direction, thereby allowing operators to both steer and propel the vessel. Further, a cycloidal propeller is mounted on a vertical, as opposed to horizontal, shaft.

Each of the *Andrew J. Barberi*'s propulsion units had five stainless steel propeller blades mounted vertically on a large circular plate below the hull. Each propulsion unit was driven by two General Motors diesel engines rated at 1,700 horsepower each (3,400 horsepower per propulsion unit). The two pilothouses on the *Andrew J. Barberi* could operate both propulsion units; so could the ECR (figure 10 shows the ECR propulsion control station).

[13] Unlike conventional fixed-pitch propellers, controllable pitch propulsion involves changing the angle of the propeller blades to control the magnitude and direction of thrust.

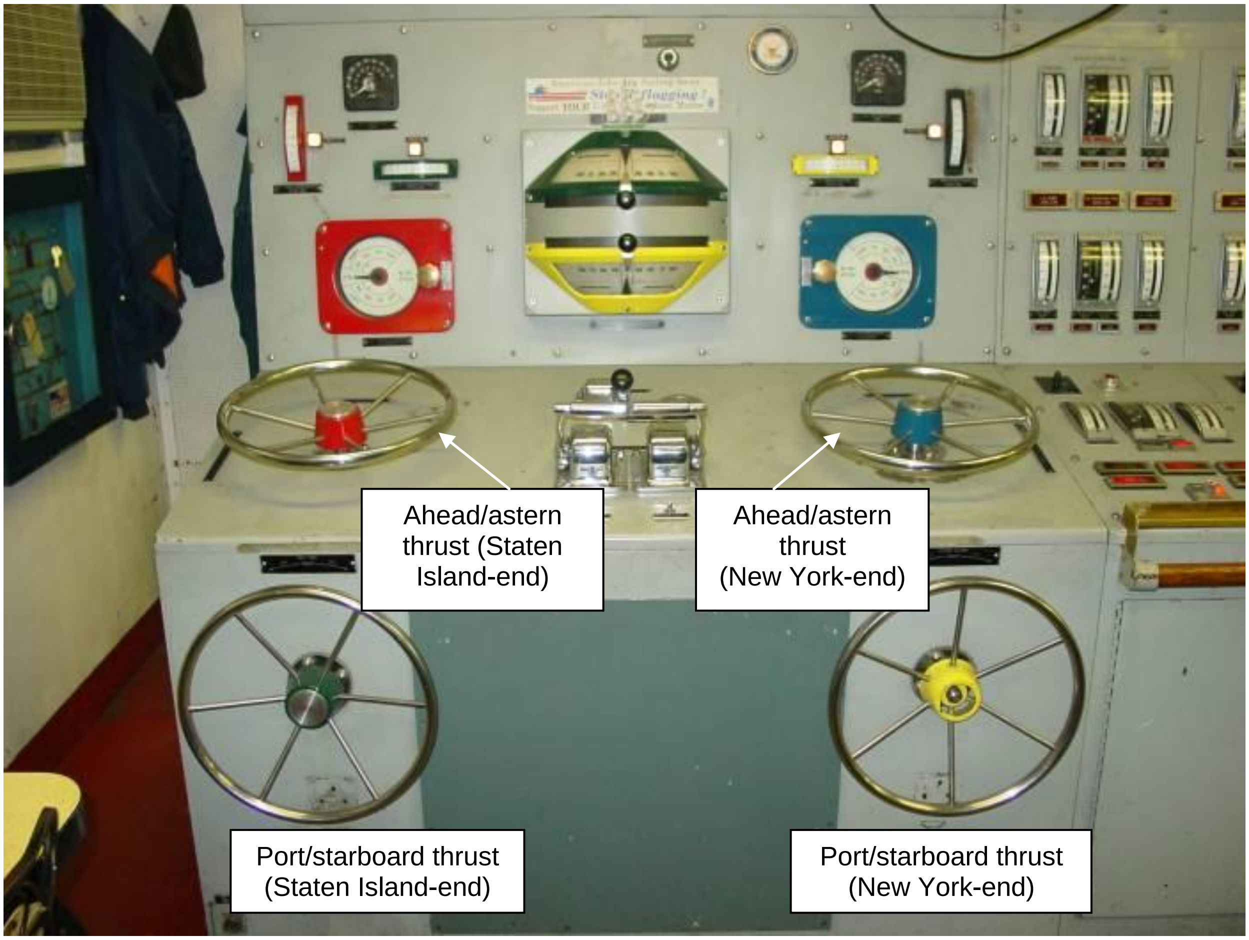

Figure 10. ECR propulsion control station.

The two pilothouses controlled the propulsion units through an electro-hydraulic system. To control the pitch of the propeller blades, the pilothouse crew would transmit an electrical signal from the pilothouse control levers and handwheels to solenoids[14] on the hydraulic control panels, located at the propulsion units (see figure 11 on page 18). The ECR controlled the propulsion units through an independent, direct linkage to hydraulic pumps located behind the control console. This method disabled the solenoids on the hydraulic control panels and allowed the crew to adjust the propeller pitch using the ECR control handwheels.

Only one of the three control stations had propulsion control at any given time. Crews would transfer the propulsion control between the ECR and the two pilothouses, with one person in the sending station and one person in the receiving station. When transferring control between the two pilothouses, the person in the sending station would press a "transfer" button and notify the individual in the receiving station. The person receiving control would press an "accept" button to complete the transfer. In an emergency, on receiving a signal from the pilothouse crew, the ECR crew could bypass the transfer process and take direct control of the propulsion units.

[14] A solenoid is a uniformly wound coil of wire in the form of a cylinder. Passage of direct electric current through the wire creates a magnetic field that draws a core or plunger, usually of iron, into the solenoid; the motion of the plunger is used to actuate switches, relays, or other devices.

2. Investigation and Analysis

2.1 Loss of Propulsion Control

2.1.1 Initial Discovery of Propulsion Problem

After the allision, the chief engineer went to the Staten Island-end pilothouse to check the ahead/astern control levers for both propulsion units. The control levers were still positioned in the zero pitch, or neutral, position, where the assistant captain had left them shortly after the allision, calling for no ahead or astern thrust. The chief engineer then looked at the propeller pitch indicators, which showed the actual thrust that the units were producing. He discovered that the New York-end indicator showed that propulsion unit was still thrusting ahead at 50 percent. To verify whether the indicator was reading correctly, the chief engineer looked over the vessel's stern at the New York-end. He confirmed that the propulsion unit was still thrusting ahead as evidenced by the water it was pushing behind the vessel. The chief engineer attempted to stop the ahead thrust from the pilothouse, but was unable to do so. With permission from the captain, the propulsion control was then transferred from the pilothouse to the ECR. Once the ECR had control, the crew successfully brought the thrust to zero.

After all the passengers had disembarked, the crew, under the supervision of Coast Guard inspectors, used ECR control of the New York-end propulsion unit to back the *Andrew J. Barberi* from slip 5. They then stopped the propulsion, and tugboats moved the vessel to a nearby maintenance slip. While controlled by the ECR, the New York-end propulsion unit performed and responded without problem. At the maintenance pier, the *Andrew J. Barberi* crew and Coast Guard inspectors conducted a dockside operational check of the propulsion units, confirming that the New York-end propulsion unit was not responding properly to pilothouse ahead/astern commands. The port/starboard thrust, or steering, responded normally.

2.1.2 Postaccident Testing of Propulsion System

On-site testing. On May 10, NTSB investigators—with assistance from Voith Turbo, the NYC DOT Ferry Division, the Coast Guard, and a technical service representative with Governor Control Systems, Inc., who was familiar with the configuration of the propulsion control system (the engineering group)—tested the two pilothouses' ability to control the pitch of the vessel's propeller blades. These tests were conducted without running the engines and without producing actual thrust. Instead, the engineering group used the propulsion units' electric standby oil pumps to drive the hydraulic controls and change the propeller pitch. From the Staten Island-end pilothouse, the engineering group commanded full forward pitch of both end propulsion units (which, if the engines were running, would create full ahead thrust). Both propulsion units responded properly by positioning the pitch of the propeller blades at 75 percent ahead thrust, the maximum attainable percentage while powering the system with the electric standby pumps. The engineering group verified the blade pitch on the propulsion units and then compared it to the pitch response shown on the propeller pitch indicators in the pilothouse; doing so confirmed that the propeller pitch indicators were accurate. The engineering group then commanded both propulsion units to return to zero pitch position (no ahead or astern thrust). The Staten Island-end unit responded properly; however, the New York-end unit remained stuck at

75 percent ahead thrust. The engineering group then transferred control of both propulsion units to the ECR, and when the command for zero pitch was given from there, the propeller blades on both of the propulsion units returned to zero pitch as commanded.

The engineering group was thus able to replicate and confirm the New York-end unit's "sticking" problem: After ahead thrust was applied and the control levers brought to zero, the New York-end propulsion unit failed to return to zero pitch. This same anomaly existed when tested from both the Staten Island- and New York-end pilothouses. When ahead/astern thrust was commanded from the ECR, the New York-end propulsion unit responded normally.

The engineering group then focused on the New York-end propulsion unit's control panel itself (figure 11) as the probable point of failure. The control panel transformed the electrical signal from the pilothouse to a hydraulic oil flow output, which controlled the pitch of the propeller blades and resultant thrust. The panel had two electro-hydraulic propulsion control valves (valves), one for controlling port/starboard thrust, the other for controlling ahead/astern thrust. Thrust control was achieved by using two electrically actuated solenoids, one located on each side of each valve, to mechanically move the valves between three positions (depending on the valve, either "ahead," "neutral," or "astern," or "port," "neutral," or "starboard").

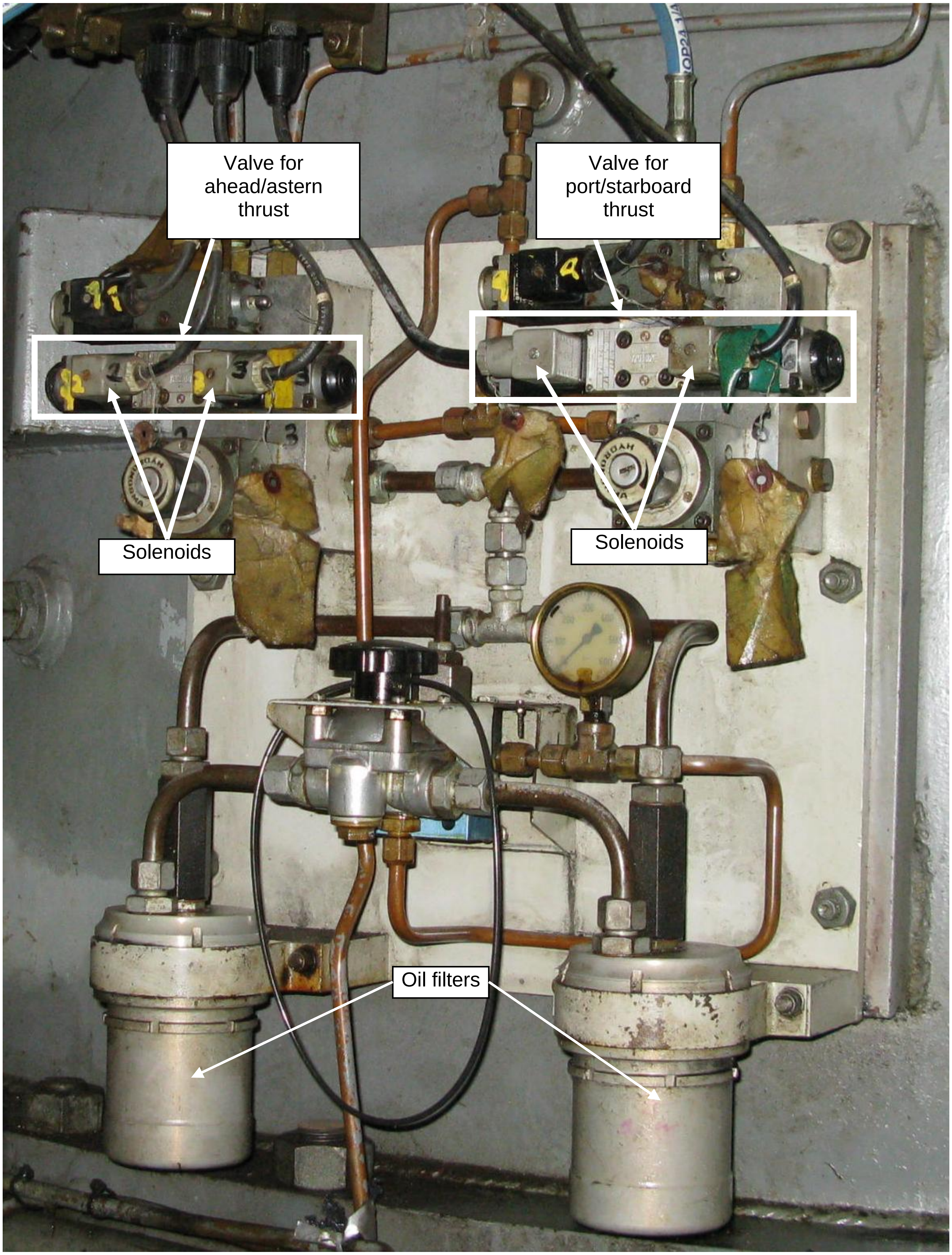

Figure 11. The hydraulic control panel located at the vessel's New York-end propulsion unit.

NTSB Laboratory Testing. Investigators brought the New York-end propulsion unit's hydraulic control panel to the NTSB materials laboratory, where they disassembled and examined the two valves, including their solenoids. Investigators discovered bronze ring fragments inside both of the solenoids that controlled ahead/astern thrust (figures 12 and 13).

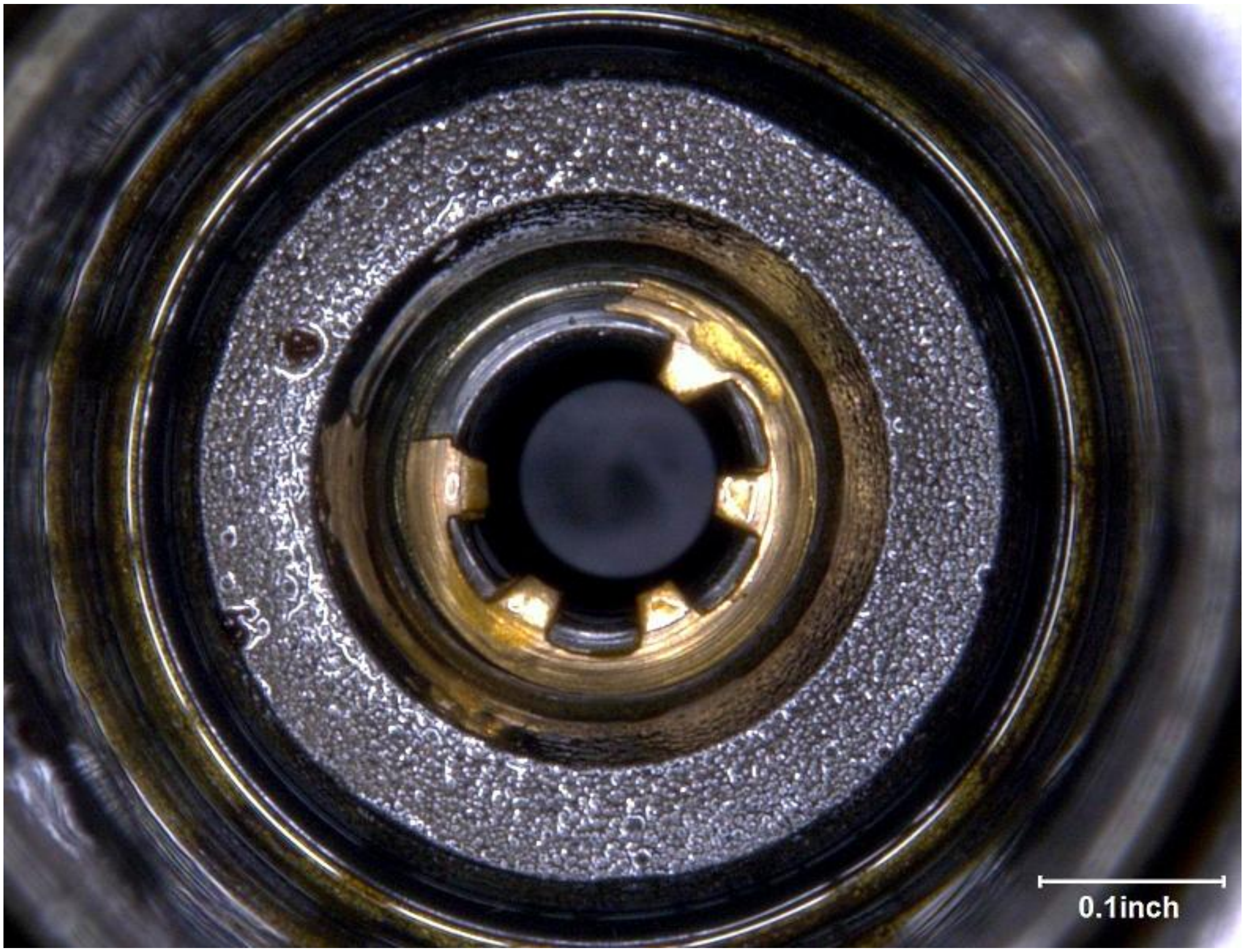

Figure 12. Fractured bronze ring in one of the two solenoids controlling ahead/astern thrust.

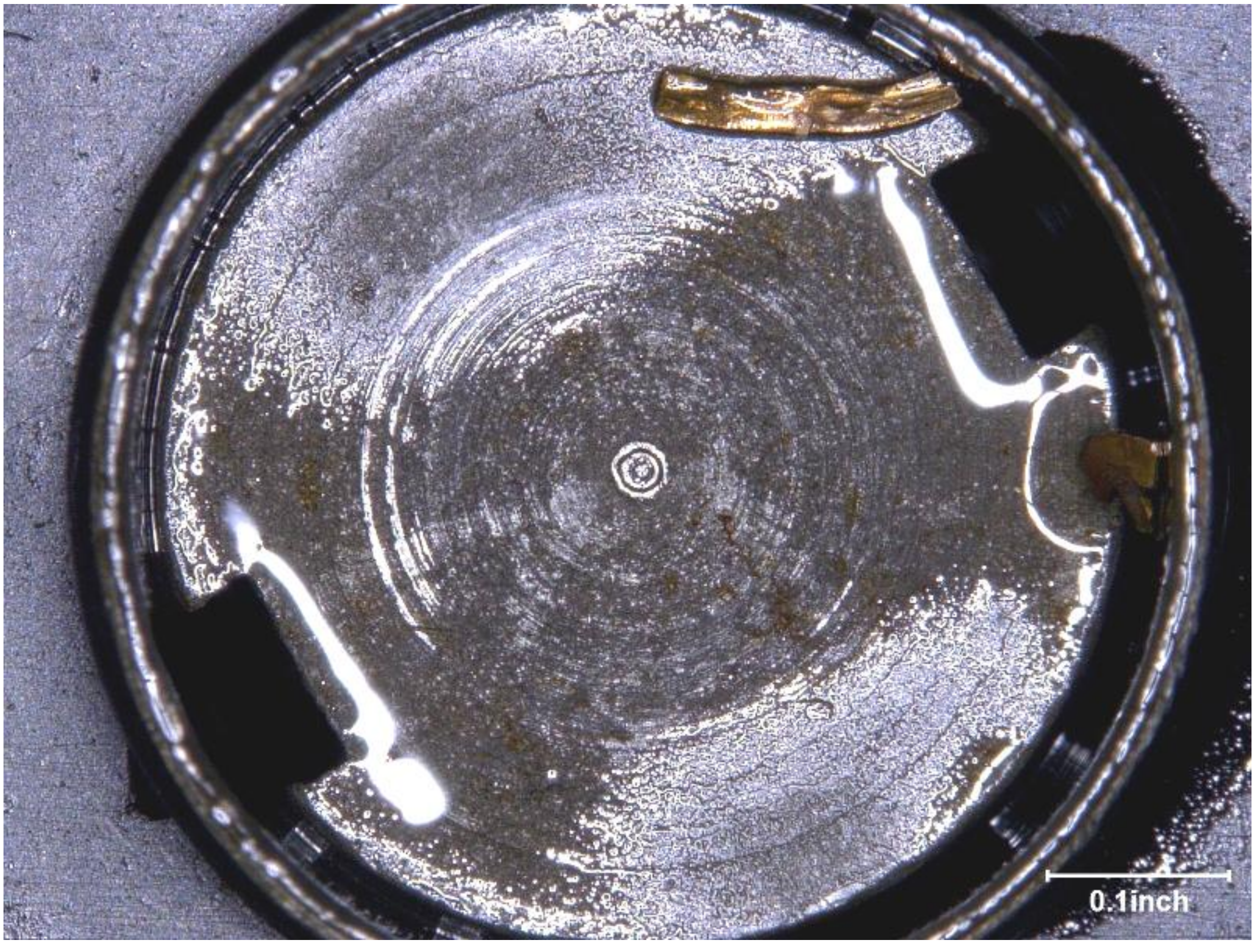

Figure 13. Bronze ring fragments in the second solenoid controlling ahead/astern thrust.

Investigators determined that the bronze rings in both of the solenoids controlling ahead/astern thrust had fractured, which allowed ring fragments to dislodge and interfere with the proper operation of the solenoids. The interference caused one of the solenoids to "stick" in a single position, which resulted in the inability of the New York-end propulsion unit to respond to pilothouse control. Investigators found no other anomalies.[15]

Although investigators examined the components to determine the mode of failure, damage to the fracture surfaces on the bronze ring fragments precluded investigators from determining the cause of the failure. Investigators noted that the rings in the ahead/astern-thrust solenoids—which had six tabs—were of a different design than the rings in the port/starboard-thrust solenoids, which had three tabs and were intact.[16]

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[15] The engineering group also took oil samples from various points in the New York-end propulsion unit to evaluate if contaminated oil might have contributed to the improper operation of the unit. The oil samples were submitted for independent lab testing, and the results were normal. The oil filters on the New York-end propulsion unit's control panel were found to be in good working order.

[16] The tabs of the fractured six-tab rings were 0.030 inches at their widest point. The tabs of the intact three-tab rings were 0.065 inches at their widest point. For further information, see the NTSB's Materials Laboratory Factual Report No. 11-063, available in the NTSB public docket on this accident.

NTSB investigators spoke with the solenoid manufacturer's product management specialist, who stated that this type of solenoid was used in many applications, but he could not find any evidence that the solenoid configuration with the six-tab ring was still being produced. Since its installation on the *Andrew J. Barberi* nearly 30 years ago, this solenoid model's internal design configuration underwent engineering revisions. New and comparable solenoids have different internal components.

When the accident occurred, the Ferry Division was already in the process of replacing the control panels on its Barberi-class ferries with new and similar hydraulic control panels. The Ferry Division's senior port engineer told NTSB investigators that the control panels were not being replaced because they were problematic, but rather to simply "upgrade the system." To confirm this, NTSB investigators examined the maintenance records, engine logbooks, and Coast Guard incident report forms, and nothing in these documents indicated that the control panel replacement resulted from maintenance issues or failures. The control panels on the other vessel in the Barberi class, the *Samuel I. Newhouse*, had already been replaced during its previous scheduled maintenance period in spring 2010. The *Andrew J. Barberi* was scheduled to have its control panels replaced later that year during its maintenance period. However, because the vessel was taken out of service as a result of the allision, the Ferry Division replaced the control panels in the week following the accident. On May 13, after the new control panels were in place, the engineering group tested both end propulsion units for pilothouse command response, and both ends performed satisfactorily. The *Andrew J. Barberi* returned to service on June 23, 2010, following completion of all repairs.

2.2 SMS Recommendations from 2003 Accident Involving the *Andrew J. Barberi*

SMS in the marine industry is a structured and documented system developed to enhance safe vessel operation, ensure compliance with regulatory requirements, prevent injury or loss of life, and avoid environmental pollution.[17] A proper SMS can and should be crafted to fit the operation's risks, such as vessel route, number of vessels operated, and number of passengers carried. SMS should result in ship owners and operators identifying safety-related issues before incidents happen. It also establishes a "designated person" shoreside to monitor the safety and pollution aspects of each vessel in a company's fleet, and to ensure that adequate resources and shore-based support are applied as needed. The designated person should have direct access to the highest level of the company's management. In addition, the company should clearly define and document the areas of responsibility for each vessel's master. The International Maritime Organization (IMO)[18] mandates SMS for vessels on international voyages, and U.S. vessels operating in international service are required to comply. However, the Coast Guard does not require SMS for U.S. vessels in domestic service.

[17] As established in 1994 by the International Safety Management (ISM) Code for the Safe Operation of Ships and for Pollution Prevention. By 2002, almost all of the international shipping community was required to comply with the ISM Code, which includes having an SMS.

[18] The IMO, headquartered in London, is a United Nations agency that promulgates international regulations directed toward the safety and security of shipping and the prevention of marine pollution caused by ships. The IMO exists to develop conventions, codes, and guidance to be used or implemented or to be overseen by maritime regulators or by its member states.

2.2.1 SMS Recommendation to NYC DOT; Subsequent Action

Because the NYC DOT Ferry Division operates only in domestic waters, the company was not required to have an SMS. Nonetheless, the Ferry Division instituted SMS on its vessels in response to Safety Recommendation M-05-2, one of three recommendations (M-05-1 through -3)[19] that the NTSB issued to the NYC DOT following the 2003 accident in which the *Andrew J. Barberi* allided with a pier at the St. George terminal (appendix B).[20] Safety Recommendation M-05-2 asked the NYC DOT to implement a comprehensive SMS.

The NTSB's report on the 2003 accident noted several deficiencies in the Ferry Division's operation, which contributed to the accident and led to Safety Recommendation M-05-2. For example, during the entire transit to Staten Island, the captain was absent from the pilothouse and appeared there only after the allision. He had not informed the other pilothouse crewmembers of his whereabouts or established communications with them to reach him immediately if needed; he failed to specify a watch in his absence and was unavailable to assist in preventing the allision or to mitigate its severity. Further, the assistant captain who was at the helm in the 2003 accident permitted the lookout to leave the pilothouse shortly before the docking at Staten Island. The lookout was the only other crewmember who would have been in a position to be aware of the impending allision. Further, according to several passengers and crewmembers, during the emergency response in 2003, the captain sounded no alarm, made no announcement over the public address system, gave crewmembers no directions over their walkie-talkies (which not all crewmembers had at the time), and did not keep passengers informed about the vessel's situation. As a result of its investigation of that accident, the NTSB determined that the NYC DOT Ferry Division's operational procedures at the time were "poorly understood, ineffectively disseminated, inconsistently applied, and inadequately overseen," with detrimental effects on the ferry system.

Subsequent to the 2003 accident and in response to Safety Recommendation M-05-2, the NYC DOT Ferry Division developed an SMS and sought to remedy the shortcomings that the NTSB had identified. Part of the SMS entailed identifying potential emergency shipboard situations and establishing ways to respond to them. In that regard, the SMS outlined 12 emergency scenarios, including loss of propulsion, collision and allision response, and postaccident crowd control and crisis management response, with specific step-by-step procedures.

For the Barberi-class ferries, the SMS stated, in part, that during loss of propulsion control, the pilothouse crew should transfer propulsion control to the ECR.

With respect to collision and allision response, the SMS required, in part, that the crew alert passengers and other crew of the impending accident; clear passengers from the projected point of impact; and direct passengers to a safe refuge and administer first aid as needed. Further, the SMS required that the engineering crew assess the damage at the impact point, take soundings, and report back to the chief engineer. Regarding crowd control, the SMS required

[19] The NTSB classified the three recommendations "Closed—Acceptable Action" in March 2006, following favorable action by the NYC DOT.

[20] *Allision of Staten Island Ferry* Andrew J. Barberi, *St. George, Staten Island, New York, October 15, 2003*, Marine Accident Report NTSB/MAR-05/01 (Washington, DC: National Transportation Safety Board, 2005).

that, in the event of an accident, crews remain visible to reassure passengers; provide passengers confident, clear, and concise direction and information updates; and keep passengers clear of the event location.

By 2010, the Ferry Division crewmembers and shoreside personnel had been trained in these procedures, and they carried out the majority of them on the day of the accident. If the assistant captain and the captain had had more time available from their discovery of the propulsion problem to the moment of impact, they could have implemented the SMS procedures related to loss of propulsion control. However, as it was, they correctly applied the collision and allision response procedures (also see section "3.3.2 Lack of SMS on U.S.-Flag Passenger Vessels").

In addition to developing and implementing the SMS, the NYC DOT Ferry Division also instituted other measures to improve its operational safety following the 2003 accident. It installed a passenger counting system to estimate more accurately the number of onboard persons in order to provide first responders with better information in the event of an emergency and to not exceed the vessel's maximum passenger allowance. In addition, as of the date of this report, the Ferry Division had nearly completed installing ECS with AIS capability on all its vessels to provide operators with real-time chart and navigation information. It also equipped both terminals with weather stations so that real-time wind speed and direction could be transmitted to ECS.

Finally, the Ferry Division constructed its own dedicated simulator facility at the Manhattan terminal to train and evaluate its personnel. This simulator was specifically designed to replicate the controls and response of Ferry Division vessels.

2.2.2 SMS Recommendation to the Coast Guard

Following the 2003 accident involving the *Andrew J. Barberi*, the NTSB also issued SMS-related Safety Recommendation M-05-6 to the Coast Guard:

> Seek legislative authority to require all U.S.-flag ferry operators to implement SMS, and once obtained, require all U.S.-flag ferry operators to do so. (M-05-6)

The Coast Guard proposed legislation in 2007 for authority to require U.S.-flag ferries carrying 399 or more passengers and operating on domestic voyages to implement SMS. The NTSB considered the Coast Guard proposal to limit applicability to 399 or more passengers arbitrary and did not accept it. In October 2010, through the enactment of the Coast Guard Authorization Act of 2010 as Public Law 111-281, Congress granted the Coast Guard legislative authority to require not only U.S.-flag ferry operators, but all U.S.-flag passenger vessel[21] operators, to implement SMS. However, the Coast Guard has yet to initiate rulemaking to implement SMS on passenger vessels. Nevertheless, because the Coast Guard obtained legislative authority and, thereby, satisfied part of Safety Recommendation M-05-6, the NTSB classified the recommendation "Open—Acceptable Response" in March 2011. The NTSB left

[21] "Passenger vessels" referred to in this report include passenger vessels inspected under 46 CFR Subchapter H, and small passenger vessels inspected under 46 CFR Subchapters K and T.

the recommendation open in anticipation of the Coast Guard subsequently requiring SMS implementation. (For further discussion on SMS, see section "3.3 Operational Safety Provided by SMS.")

2.3 Propulsion Control System Modernization

After the 2010 accident, the NYC DOT Ferry Division decided to modernize the propulsion control system from the existing electro-hydraulic type to a solely electric system. The Ferry Division scheduled both the *Andrew J. Barberi* and the *Samuel I. Newhouse* to have their systems replaced during their maintenance periods in 2012. The new electric control system will replace the original handwheel and lever operator propulsion controls with a joystick for each propulsion unit, allowing 360-degree directional and 0–100 percent thrust magnitude control. According to the Ferry Division, crew training on this system will be easier. The joysticks will be installed at all vessel control stations. The new system also incorporates redundant power supplies in the event that either of the online power supplies fails. The new system's control panels feature electric servomotor-driven jackscrews, eliminating the solenoids, filters, and hydraulic piping. Another important part of the modernization on the Barberi-class ferries is the inclusion of a propeller pitch deviation alarm that visually and audibly alerts operators in the shortest possible time should input to the propulsion unit not achieve the intended response (see section "3.2 Lack of Propeller Pitch Deviation Alarms").

3. Safety Issues

This section begins with a brief summary of factors that did not play a role in the accident, such as weather conditions and crew qualifications, and then discusses significant issues, such as undetected loss of propulsion control.

The weather conditions leading up to the accident did not impede navigation. Also, the individuals directly involved in the vessel's navigation—the captain and the assistant captain—held applicable licenses and were qualified for their positions. Postaccident toxicological tests were conducted on each of the crewmembers in accordance with Federal regulations, and the results were negative for the presence of alcohol or illegal drugs. Further, the *Andrew J. Barberi*'s pilothouse video captured footage of the crew during the transit from Manhattan to Staten Island. The footage did not show any crewmember using personal or portable electronic devices. The NTSB therefore concludes that weather, qualifications of the crew, illegal drug or alcohol use, and personal use of portable electronic devices were not factors in the accident.

The shoreside emergency response, including assets with the FDNY and the NYPD, arrived promptly and attended appropriately to injured persons. The NTSB concludes that the emergency response by the FDNY and the NYPD was timely and effective.

Investigators interviewed the licensed crewmembers on the *Andrew J. Barberi* about their work and sleep schedules leading up to the accident. Investigators also reviewed the pilothouse CCTV to evaluate the circumstances of the accident and the crew's response to the emergency. This combined information did not provide evidence that fatigue played a role in this accident.

3.1 Undetected Loss of Propulsion Control

3.1.1 The 2010 *Andrew J. Barberi* Accident

The circumstances of this accident indicated that a loss of propulsion control occurred, which the pilothouse crew did not immediately detect. Following the accident, investigators tested the *Andrew J. Barberi*'s two cycloidal propulsion units and determined that the loss of propulsion control was isolated to the vessel's New York-end only. Further examination revealed that bronze rings located inside the solenoids that controlled ahead/astern thrust on the New York-end propulsion unit had fractured. The cause of the rings' failure was unknown; however, the dislodged ring fragments interfered with the proper operation of the solenoids, causing one of them to stick in a single position. The NTSB therefore concludes that a solenoid failure in a propulsion control panel on board the *Andrew J. Barberi* rendered one of the vessel's two propellers unresponsive to propulsion commands from the pilothouse.

The pilothouse crewmembers' actions leading up to the accident, as captured by the vessel's CCTV, suggested that they were unaware of the improper propulsion response until seconds before the accident. As noted earlier, the propulsion unit likely failed after the vessel passed the KV buoy, less than 2 minutes before the allision. At this time, the assistant captain began giving commands to reduce the vessel's speed. For about the next minute and a half, he input routine, incremental reductions in ahead thrust to the propulsion units. Because he achieved a portion of the speed reduction that he commanded—the Staten Island-end propulsion unit, directly beneath him, responded normally—the incomplete response of the New York-end propulsion unit went undetected until the crew visually noted the vessel's excessive approach speed about half a minute before the allision. The pilothouse CCTV showed that, about 33 seconds before the allision, the assistant captain put both of the ahead/astern control levers astern. By this time, he had realized that the vessel was not slowing sufficiently and that the propulsion response was not commensurate with his input commands. The CCTV also showed the captain reacting about this time, and about 20 seconds before the allision, he maximized the engine rpm to increase the thrust of the assistant captain's astern command. This action indicates that the captain did not recognize the nature of the propulsion problem. The NTSB therefore concludes that the pilothouse crewmembers were unaware of the loss of propulsion control until seconds before the accident, and, as a result, they were unable to take effective action to avoid the allision.

3.1.2 Other Accidents Involving Undetected Loss of Propulsion Control

As part of investigating the *Andrew J. Barberi* accident, NTSB investigators requested that the Coast Guard and foreign marine accident investigative agencies provide data on other marine accidents that involved undetected loss of propulsion control on vessels with controllable pitch propulsion, including cycloidal propulsion. The Coast Guard queried its database and found 39 accidents in the past 10 years that met the "controllable pitch propulsion failure" criteria; 6 of those accidents pertained to passenger vessels. However, although these 6 accidents involved improper propulsion system response to input commands, the information was inconclusive as to whether the vessels had specifically experienced undetected loss of propulsion control.

The Transportation Safety Board of Canada (TSB) provided a few accidents as possible matches, including one on August 3, 2010, that clearly involved undetected loss of propulsion control. While approaching the dock on Mayne Island, British Columbia, Canada, the 426-foot-long twin-propeller passenger ferry *Queen of Nanaimo*, with 1,004 persons on board, experienced a control malfunction of its portside controllable pitch propeller.[22] Although the crew tried to slow the vessel, it instead sped up and struck the dock at a speed of 6 knots. Three passengers were injured and needed immediate shoreside medical assistance. The berth and the vessel's bow door sustained damage in the accident. TSB indicated that a mechanical failure caused the propeller to lock in the full-ahead position. Although the system had a wrong-way alarm,[23] that alarm was not designed to detect deviations between bridge control orders and actual pitch response. TSB also determined that the operator "did not immediately know that he did not have astern thrust available," nor that, through his attempt to increase astern thrust by increasing engine rpm, he inadvertently increased ahead thrust.

The United Kingdom's Marine Accident Investigations Branch (MAIB) reported 36 incidents between 2001 and 2010 related to controllable pitch propulsion failures on vessels over 500 gross tons. Investigators found one notable accident that occurred on April 27, 2000, and involved the 537-foot-long roll-on roll-off passenger ferry *Aquitaine*.[24] As the vessel entered the port at Calais, France, the bridge crew noticed that the speed was higher than normal and commanded both propellers astern, but only one propeller responded. MAIB's report on the accident stated that the loss of control of the other propeller had occurred about 13 minutes before impact, but the bridge crew was unaware of it. As a result, by the time the problem was discovered, the crew was unable to prevent the vessel from striking the berth at a speed of about 7 knots. Two hundred and nine of the 1,364 persons on board were injured, and the *Aquitaine*'s bulbous bow and bow apron were severely damaged. The MAIB determined that a pump in the unresponsive propeller had damaged rotor vanes, and as a result, the pump could not produce sufficient pressure to change the pitch of the propeller blades. Therefore, the pitch was locked in its last commanded position. Although the *Aquitaine* had several installed alarms for its controllable pitch propulsion system, none of them sounded because of the nature of the propeller pitch failure.

The NTSB recently investigated the March 23, 2008, sinking of the fish processing vessel *Alaska Ranger*, with a crew of 47, in the Bering Sea.[25] As the vessel was flooding, it experienced a loss of control of its controllable pitch propulsion system and began to thrust astern even though the operator had commanded ahead thrust. The master launched the liferafts, anticipating that they would come alongside the vessel as it moved forward. However, because of the apparently undetected astern motion, the crew had to jump overboard and swim to the liferafts,

[22] TSB Marine Safety Information Letter No. 08/10 regarding this accident is available in the NTSB docket.

[23] A wrong-way alarm compares the commanded vessel direction (ahead or astern) to the actual propeller pitch thrust direction. For example, the alarm would alert an operator should he input an astern-command, and the propeller pitch remains in the ahead-direction. The governing authorities of the St. Lawrence Seaway require wrong-way alarms; the Coast Guard does not.

[24] The *Aquitaine* report is available at <http://www.maib.gov.uk/cms_resources.cfm?file=/aquitaine.pdf>, accessed January 26, 2012.

[25] *Sinking of U.S. Fish Processing Vessel* Alaska Ranger, *Bering Sea, March 23, 2008*, Marine Accident Report NTSB/MAR-09/05 (Washington, DC: National Transportation Safety Board, 2009).

exposing them to the frigid water, as opposed to climbing down a ladder directly into the rafts. Five people died as a result of the *Alaska Ranger* accident.

These accidents illustrate that undetected loss of propulsion control does occur and can lead to or exacerbate accidents.

3.2 Lack of Propeller Pitch Deviation Alarms

Propulsion and steering are the primary mechanical systems responsible for vessel maneuvering; in fact, 46 CFR Part 62 states that both steering and propulsion are "vital systems"[26] on a vessel. Loss of control of a vital system may be mitigated if the operator is alerted to the problem immediately after it occurs. To that end, deviation-type alarms are important safeguards in vital systems because these alarms audibly and visually alert operators in the shortest possible time when equipment does not respond to a command.

Regulations at 46 CFR 113.43-3 require steering deviation alarms on inspected vessels greater than 1,600 gross tons with a propeller/rudder configuration to alert operators when the actual rudder position differs by more than 5 degrees from the command given. However, despite the fact that propulsion, like steering, is a vital system, regulation does not currently require propeller pitch deviation alarms on vessels with controllable pitch or cycloidal propulsion.

3.2.1 Previous NTSB Action on Steering Deviation Alarms

The NTSB has previously issued several recommendations on vessel steering systems, including recommending visual and audible alarms for loss of steering control, in order to allow operators more time to take corrective action. Following the February 27, 1977, loss of steering control on board sulfur carrier *Marine Floridian* near Hopewell, Virginia, and the subsequent allision with a highway bridge that then partially collapsed,[27] the NTSB issued several recommendations, including Safety Recommendation M-77-8 to the Coast Guard:

> Amend 46 CFR 111.80-70(F)(1) and (2) to require the installation of a pilot light and an audible alarm to indicate power interruption to steering gear motors in the wheelhouse independent of, and in addition to, those currently required to so indicate at the propulsion control station.

The Coast Guard subsequently proposed regulations to require visual and audible steering failure alarms. As a result, the NTSB classified Safety Recommendation M-77-8 "Closed—Acceptable Action" in May 1983.

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[26] According to 46 CFR 62.10-1, vital systems are "essential to the safety of the vessel, its passengers and crew." In addition to steering and propulsion, vital systems include—but are not limited to—fire detection and suppression, flooding safety systems, and emergency electrical generators.

[27] *U.S. Tankship SS* Marine Floridian *Collision with Benjamin Harrison Memorial Bridge, Hopewell, Virginia, February 24, 1977,* Marine Accident Report NTSB/MAR-78/01 (Washington, DC: National Transportation Safety Board, 1978).

Following the July 28, 1977, steering gear malfunction on board crude carrier *Sitala* and the subsequent collision with a fleet of moored vessels near New Orleans, Louisiana,[28] the NTSB recommended shortening the proposed steering deviation alarms' allowable response time:

> Amend the proposed steering standards for tankships to reduce the time allowed for alarms to alert the crew of a failure and to reduce the time allowed to restore steering control, and make these requirements applicable to all sea-going vessels entering U.S. navigable waters. (M-78-79)

Following the Coast Guard's favorable action, the NTSB classified Safety Recommendation M-78-79 "Closed—Acceptable Action" in May 1983.

3.2.2 Propeller Pitch Indicators v. Propeller Pitch Deviation Alarms

Although vessels with controllable pitch or cycloidal propulsion are required to have various alarms that alert operators to propulsion problems (such as low/high oil pressure and high oil temperature), no regulations currently mandate propeller pitch deviation alarms. Title 46 CFR 62.35-50 does require many vessels with controllable pitch or cycloidal propulsion to be equipped with indicators that display the actual pitch of the propeller blades. However, unlike alarms, indicators are only reference points for operators, and on the bridge of a vessel, there are indicators for many systems. As a result, unless operators continually check the propeller pitch indicators, they may not realize that the propulsion system is not responding properly.

Based on the *Andrew J. Barberi*'s CCTV footage and the assistant captain's interview, it is unclear whether he checked the propeller pitch indicators after the vessel passed the KV buoy. If the assistant captain did not check the indicators, this may have been because the vessel did partially respond to his inputs, and its speed did decrease somewhat. Neither he nor the captain had reason to suspect that anything was wrong at that point. Moreover, the assistant captain was also focusing on visual cues, looking forward, as would be expected in a critical phase of the operation, such as during approach to the terminal. This may explain why the assistant captain may not have checked the propeller pitch indicators after passing the KV buoy.

The crewmembers were trained in and familiar with the Ferry Division's SMS procedures for loss of propulsion control. However, the limited time that remained before the allision prevented the crewmembers from diagnosing the problem and fully implementing the SMS procedures. The NTSB therefore concludes that had the *Andrew J. Barberi* had an audible and visual alarm to alert the pilothouse crewmembers to the loss of propulsion control, they may have been able to avoid the allision by implementing emergency response procedures prescribed in the NYC DOT Ferry Division's SMS.

3.2.3 Installing/Retrofitting Propeller Pitch Deviation Alarms on Vessels

Current technology allows vessels to be fitted with propeller pitch deviation alarms either during initial vessel construction or, on most vessels, retroactively—as the NYC DOT Ferry

[28] *French Tankship SS* Sitala *Collision with Moored Vessels, New Orleans, Louisiana, July 28, 1977,* Marine Accident Report NTSB/MAR-78/10 (Washington, DC: National Transportation Safety Board, 1978).

Division elected to do with its Barberi-class ferries. The negative consequences of undetected loss of propulsion control are elevated for passenger vessels, because they carry more people on board, often transit in confined waterways, and generally dock frequently. A requirement that U.S.-flag passenger vessels with controllable pitch propulsion be fitted with such alarms would increase the likelihood of early detection of improper propulsion response to operator command, thereby allowing time to take effective corrective action. By having the audible and visual alarm in place, the operator is actively alerted to the situation, as opposed to having to monitor his control station gauges and detect the problem, which in a stressful scenario may be less likely to occur.

The NTSB also considers both steering and propulsion to be vital systems on a vessel, and, as such, should have an alarm that brings the operator's attention to the indicator in the event of critical failures. The same level of safety (that standards and requirements for steering deviation alarms provide) should also apply to propulsion deviations. And in the case of cycloidal propulsion, like on the *Andrew J. Barberi*, because the system combines both steering and propulsion, failures could result in loss of both steering and propulsion control. The NTSB therefore recommends that the Coast Guard require new-construction U.S.-flag passenger vessels with controllable pitch propulsion, including cycloidal propulsion, to be equipped with alarms that audibly and visually alert the operator to deviations between the operator's propulsion and steering commands and the actual propeller response. The NTSB further recommends that the Coast Guard, where technically feasible, require existing U.S.-flag passenger vessels with controllable pitch propulsion, including cycloidal propulsion, to be retrofitted with alarms that audibly and visually alert the operator to deviations between the operator's propulsion and steering commands and the actual propeller response.

3.3 Operational Safety Provided by SMS

3.3.1 The 2010 *Andrew J. Barberi* Accident

After the 2003 *Andrew J. Barberi* accident and three subsequent NTSB recommendations to NYC DOT, including M-05-2, which recommended SMS implementation, the NYC DOT Ferry Division improved its operational safety. It instituted an SMS, improved its passenger-counting system, and installed weather stations at both the Manhattan and Staten Island terminals. Further, the Ferry Division constructed a simulator facility at the Manhattan terminal to train and evaluate its personnel. Therefore, the NTSB concludes that, after the 2003 accident involving the *Andrew J. Barberi*, the NYC DOT Ferry Division took a number of steps that improved operational safety, including implementing an SMS.

A component of the SMS included developing emergency preparedness scenarios to train and prepare crews how to respond should emergencies occur. One of the scenarios that applied to this accident involved loss of propulsion control, and included steps to take in response. The other emergency scenarios that applied to this accident were collision and allision response, and crowd control and crisis management response. With regard to the SMS instructions for loss of propulsion control, because only seconds remained until impact once the pilothouse crewmembers realized that the ferry was not responding properly, they were unable to implement the procedures, such as signaling the ECR so that the chief engineer could take propulsion control. However, with regard to the SMS instructions for collision and allision response and for crowd control and crisis management response, there was time to carry out the procedures, and the crew did so effectively. The pilothouse crew warned passengers over the public address system and sounded the danger signal. The deckhands began directing passengers away from the Staten Island-end. The shoreside operator of the transition bridge remained at his position and, in accordance with his training, ensured that he aligned the bridge with the vessel's main deck. Had he not done so, and had the bridge protruded a few feet higher toward the oncoming vessel, the bridge could have severely injured any passengers who might have been waiting on the main deck to disembark the vessel, and who might have been unable to retreat.

Immediately after the impact, the deckhands, the mates, and the two onboard NYPD officers began moving around the decks to see if anyone was in need of first aid.

All of the Ferry Division personnel that NTSB investigators interviewed—from deckhands to company managers—displayed familiarity with the SMS procedures. Each of them knew how to apply the procedures to carry out their duties in this particular accident. Their action on behalf of the passengers' welfare demonstrated a commitment to safety and adherence to prescribed SMS procedures. Given the differences between crew actions in this accident and those in the 2003 *Andrew J. Barberi* accident, the NTSB concludes that the NYC DOT Ferry Division's SMS provided specific emergency procedures, which the crew and shoreside personnel performed in a timely and effective manner, and this benefited the passengers.

3.3.2 Lack of SMS on U.S.-Flag Passenger Vessels

Following the 2003 accident, the NTSB issued Safety Recommendation M-05-6 to the Coast Guard, asking it to seek legislative authority to require all U.S.-flag ferry operators to implement SMS, and once obtained, require all U.S.-flag operators to do so. In January 2011, the NTSB reiterated the recommendation following the investigation of the *Morro Bay*/*Block Island* accident.[29] The NTSB is pleased that the Coast Guard obtained authority through the enactment of Public Law 111-281 to require SMS not only on ferries, but on all passenger vessels based on the number of passengers who could be killed or injured. According to Coast Guard vessel data from fall 2011, limiting the SMS requirement to ferries alone would neglect safety improvement on 5,150 of 5,623 certificated U.S. passenger vessels (92 percent), because only 473 of these 5,623 vessels are designated as "ferries."[30] Although passenger vessels and their ferry subset are in different services, both are engaged in transporting passengers for hire. Accordingly, passengers should be afforded the same level of safety regardless of vessel service. Given that passenger vessels may also have large numbers of persons on board, the potential consequences of accidents are similar. Therefore, the NTSB supports the requirement that all U.S.-flag passenger vessels have an appropriate SMS, similar in concept to what international regulations require of vessels in oceangoing service. Although the Coast Guard is currently in the process of

[29] *Collision Between U.S. Passenger Ferry M/V* Block Island *and U.S. Coast Guard Cutter* Morro Bay, *Block Island Sound, Rhode Island, July 2, 2008*, Marine Accident Report NTSB/MAR-11/01 (Washington, DC: National Transportation Safety Board, 2010).

[30] According to Title 46 *United States Code*, section 2101, a "ferry" is a vessel that is used on a regular schedule to provide transportation only between places that are not more than 300 miles apart; and to transport passengers or vehicles, or railroad cars that are being used, or have been used, in transporting passengers or goods.

developing SMS requirements for towing vessels[31] following NTSB recommendations to do so, the Coast Guard has yet to exercise its authority to require SMS on passenger vessels. The NTSB therefore classifies Safety Recommendation M-05-6 "Closed—Superseded" in this report.

A proper SMS can and should be crafted to fit the operation's risk, such as vessel routes, number of vessels operated, and number of passengers carried. The NTSB concludes that implementing SMS on all U.S.-flag passenger vessels would further enhance operators' ability to achieve the higher standards of safety that the Coast Guard requires of U.S. oceangoing vessels in international service. The NTSB recommends that the Coast Guard require all operators of U.S.-flag passenger vessels to implement SMS, taking into account the characteristics, methods of operation, and nature of service of these vessels, and, with respect to ferries, the sizes of the ferry systems within which the vessels operate.

3.4 Lack of Voyage Data Recorders on U.S.-Flag Ferries[32]

For security reasons, video surveillance cameras are increasingly installed on board vessels in sensitive areas such as the navigation bridge. However, as on the *Andrew J. Barberi*, these cameras are meant to capture only general information, not specific operating data or pilothouse audio. The CCTV footage captured on board the vessel was important in this investigation and considerably aided the work of investigators. However, the CCTV footage was nevertheless incomplete and did not provide certain crucial information, such as the moment when the New York-end propulsion unit failed to properly respond (which a VDR would have provided; an S-VDR may not have). Moreover, NTSB investigators had to estimate the speed at which the vessel allided, whereas a VDR would have recorded the speed as determined by onboard equipment. Recordings of bridge conversations and radio transmissions are often very useful in marine accident investigations, but they were also not available in this accident. The NTSB therefore concludes that although the *Andrew J. Barberi*'s pilothouse CCTV captured certain accident-related information, it could not capture, record, and safeguard important detailed data from vessel navigation and control systems, as a VDR would have.

In a 2008 report to Congress,[33] the Coast Guard acknowledged the value of recorder information, and recommended that certain ferries be required to capture information similar to what a VDR would record. However, the Coast Guard still does not require VDRs on ferries.

Following its investigation of the *Morro Bay*/*Block Island* collision, the NTSB issued Safety Recommendations M-10-5 and -6 to the Coast Guard:

> Require installation of VDRs that meet the international performance standard on new ferry vessels. (M-10-5)

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[31] Coast Guard notice of proposed rulemaking, published at 76 *Federal Register* 49976, August 11, 2011.

[32] Unless otherwise specified, the terms "voyage data recorder(s)" and "VDR(s)" used in this section also include simplified voyage data recorders, or S-VDRs.

[33] *Report to Congress on Use of Voyage Data Recorders on Ferries* (Washington, DC: U.S. Department of Homeland Security, U.S. Coast Guard, March 26, 2008).

> Require installation of VDRs on ferry vessels built before the enactment of VDR carriage requirements that will record, at a minimum, the same video, audio, and parametric data specified in the IMO's performance standard for S-VDRs. (M-10-6)

The Coast Guard did not act on these recommendations, citing prohibitive cost and the 2008 report to Congress. Based on the Coast Guard's response, the NTSB classified Safety Recommendations M-10-5 and -6 "Open—Unacceptable Response" in July 2011.

Installing VDRs on older ferry vessels such as the *Andrew J. Barberi* can be technically challenging because it may not be feasible to capture the specified data on these vessels. The IMO anticipated this technical difficulty and developed an alternative standard (S-VDR) for older vessels. This standard allowed for exemptions from the requirement to record certain data if it could be shown that it would not be feasible to do so.

With regard to new-construction ferries, installing VDRs at the initial design stage poses little technical difficulty.

Moreover, VDRs can help vessel operators enhance their SMS—continual improvement is an important aspect of SMS. In addition to providing accident investigation benefits, VDRs can be valuable tools in a company's SMS, because they record many vessel, systems, and operational parameters. Operators can review crew and vessel performance through data obtained during actual operations. For example, the NYC DOT's dedicated simulator, coupled with data obtained from a VDR, could be used to study incidents, create new procedures, and train vessel operators. Therefore, the NTSB reiterates Safety Recommendation M-10-5 to the Coast Guard to require installation of VDRs that meet the international performance standard on new ferry vessels. The NTSB also reiterates Safety Recommendation M-10-6 to the Coast Guard to require installation of VDRs on ferry vessels built before the enactment of VDR carriage requirements that will record, at a minimum, the same video, audio, and parametric data specified in the IMO's performance standard for S-VDRs.

4. Conclusions

4.1 Findings

1. Weather, qualifications of the crew, illegal drug or alcohol use, and personal use of portable electronic devices were not factors in the accident.

2. The emergency response by the Fire Department of the City of New York and the New York City Police Department was timely and effective.

3. A solenoid failure in a propulsion control panel on board the *Andrew J. Barberi* rendered one of the vessel's two propellers unresponsive to propulsion commands from the pilothouse.

4. The pilothouse crewmembers were unaware of the loss of propulsion control until seconds before the accident, and, as a result, they were unable to take effective action to avoid the allision.

5. Had the *Andrew J. Barberi* had an audible and visual alarm to alert the pilothouse crewmembers to the loss of propulsion control, they may have been able to avoid the allision by implementing emergency response procedures prescribed in the New York City Department of Transportation Ferry Division's safety management system.

6. After the 2003 accident involving the *Andrew J. Barberi*, the New York City Department of Transportation Ferry Division took a number of steps that improved operational safety, including implementing a safety management system.

7. The New York City Department of Transportation Ferry Division's safety management system provided specific emergency procedures, which the crew and shoreside personnel performed in a timely and effective manner, and this benefited the passengers.

8. Implementing safety management systems on all U.S.-flag passenger vessels would further enhance operators' ability to achieve the higher standards of safety that the Coast Guard requires of U.S. oceangoing vessels in international service.

9. Although the *Andrew J. Barberi*'s pilothouse closed-circuit television captured certain accident-related information, it could not capture, record, and safeguard important detailed data from vessel navigation and control systems, as a voyage data recorder would have.

4.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the *Andrew J. Barberi*'s allision with St. George terminal was a solenoid failure, which caused a loss of propulsion control of one of the vessel's two cycloidal propellers. Contributing to the accident was the propulsion system's lack of a propeller pitch deviation alarm, which was not required by regulation, but which would have alerted the pilothouse crew to the loss of propulsion control and permitted prompt action.

5. Recommendations

5.1 New Recommendation

To the U.S. Coast Guard:

1. Require new-construction U.S.-flag passenger vessels with controllable pitch propulsion, including cycloidal propulsion, to be equipped with alarms that audibly and visually alert the operator to deviations between the operator's propulsion and steering commands and the actual propeller response. (M-12-1)

2. Where technically feasible, require existing U.S.-flag passenger vessels with controllable pitch propulsion, including cycloidal propulsion, to be retrofitted with alarms that audibly and visually alert the operator to deviations between the operator's propulsion and steering commands and the actual propeller response. (M-12-2)

3. Require all operators of U.S.-flag passenger vessels to implement safety management systems, taking into account the characteristics, methods of operation, and nature of service of these vessels, and, with respect to ferries, the sizes of the ferry systems within which the vessels operate. (M-12-3)

5.2 Previous Recommendations Reiterated in This Report

To the U.S. Coast Guard:

Require installation of voyage data recorders that meet the international performance standard on new ferry vessels. (M-10-5)

Require installation of voyage data recorders on ferry vessels built before the enactment of voyage data recorder carriage requirements that will record, at a minimum, the same video, audio, and parametric data specified in the International Maritime Organization's performance standard for simplified voyage data recorders. (M-10-6)

5.3 Previous Recommendations Reclassified in This Report

To the U.S. Coast Guard:

Seek legislative authority to require all U.S.-flag ferry operators to implement safety management systems, and once obtained, require all U.S.-flag ferry operators to do so. (M-05-6)

Safety Recommendation M-05-6 (previously classified "Open—Acceptable Response") is classified "Closed—Superseded" by M-12-3 in section "3.3.2 Lack of SMS on U.S.-Flag Passenger Vessels" in this report.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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Adopted: April 24, 2012

6. Appendixes

Appendix A

Investigation. The New York City Office of Emergency Management notified the NTSB's Office of Transportation Disaster Assistance about the accident shortly after it occurred. The NTSB launched a go-team consisting of Office of Marine Safety investigators, a public affairs representative, and a representative of the Office of Transportation Disaster Assistance. The NTSB Board Member on scene was Robert L. Sumwalt. The majority of the team arrived in Staten Island about 1800 that same evening.

Appendix B

2003 Accident Involving the *Andrew J. Barberi*. About 1520 on October 15, 2003, the *Andrew J. Barberi* was near the end of a regularly scheduled trip to Staten Island when it allided with a maintenance pier at the St. George terminal. Fifteen crewmembers and an estimated 1,500 passengers were on board. Ten passengers died in the accident and 70 were injured. An eleventh passenger died 2 months later as a result of injuries sustained in the accident. Damages totaled more than $8 million, with repair costs of $6.9 million for the *Andrew J. Barberi* and $1.4 million for the pier.

The NTSB determined that the probable cause of the 2003 accident was the assistant captain's unexplained incapacitation and the failure of the NYC DOT to implement and oversee safe, effective operating procedures for its ferries. Contributing to the cause of the accident was the failure of the captain to exercise his command responsibility over the vessel by ensuring the safety of its operations.

Safety issues in the 2003 accident included: actions of assistant captain and captain; NYC DOT oversight of ferry operations; medical oversight of mariners; SMS; and potential contribution of navigation technology to the safety of ferry operations.

As a result of the 2003 accident investigation, the NTSB made recommendations to the NYC DOT, the Coast Guard, the states that operate public ferries, and the Passenger Vessel Association.