

Collision of the Tankship *Elka Apollon*
With the Containership *MSC Nederland*
Houston Ship Channel, Upper Galveston Bay, Texas
October 29, 2011



Accident Report

NTSB/MAR-12/02
PB2012-916402



**National
Transportation
Safety Board**

Marine Accident Report

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490 L'Enfant Plaza, SW
Washington, DC 20594

National Transportation Safety Board. 2012. *Collision of Tankship Elka Apollon with Containership MSC Nederland, Houston Ship Channel, Upper Galveston Bay, Texas, October 29, 2011. Marine Accident Report NTSB/MAR-12/02. Washington, D.C.*

Abstract: This report discusses the October 29, 2011, collision of the tankship *Elka Apollon* with the containership *MSC Nederland* on the Houston Ship Channel in Upper Galveston Bay, Texas. No one was injured. Damage was estimated at \$1.5 million for the *Elka Apollon* and \$1.3 million for the *MSC Nederland*.

Safety issues identified in the report include piloting challenges on the Houston Ship Channel, vessel separation, and lack of identification of U.S. Coast Guard precautionary areas on nautical charts for the Houston Ship Channel and vicinity. The National Transportation Safety Board makes recommendations to the Coast Guard regarding precautionary areas.

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Acronyms and Abbreviations

72 COLREGS	Collision Regulations (International Regulations for Prevention of Collisions at Sea, 1972)
AIS	automatic identification system
CFR	<i>Code of Federal Regulations</i>
ITC	International Tonnage Convention
MSC	Mediterranean Shipping Company (USA) Inc.
nm	nautical mile
NOAA	National Oceanic and Atmospheric Administration
PAWSS	Ports and Waterways Safety System
PPU	portable piloting unit
TEU	twenty-foot equivalent unit
VDR	voyage data recorder
VHF	very high frequency
VTS	vessel traffic service

Executive Summary

The *Elka Apollon*, a Greek-flag tankship, was outbound on the Houston Ship Channel for Freeport, Texas, on the morning of October 29, 2011. The *MSC Nederland*, a Panamanian-flag containership, was inbound on the same waterway to offload cargo at the Bayport Container Terminal at the western end of the Bayport Ship Channel. The pilots on the two deep-draft, oceangoing vessels agreed by radio that their ships would meet and pass one another just south of the intersection of these two shipping channels.

The pilot on the inbound *MSC Nederland* planned to let the *Elka Apollon* pass before turning to port into the Bayport channel. The pilot conning the *Elka Apollon* ordered a series of rudder commands as the vessel transited the intersection of the two channels and approached the *MSC Nederland*. A towboat, the *Mr. Earl*, under way in the vicinity and pushing an empty barge, was exiting the Bayport channel as the *Elka Apollon* was passing. As the distance between the *Elka Apollon* and the *MSC Nederland* closed, the *Elka Apollon* crossed the centerline of the Houston Ship Channel and subsequently struck the port side of the *MSC Nederland*.

No injuries resulted from the collision. The impact caused structural damage to both vessels, and three damaged containers from the *MSC Nederland* fell onto the deck of the *Elka Apollon*. The collision also tore off the *MSC Nederland*'s rescue boat and set it adrift in the waterway. Damage was estimated at \$1.5 million for the *Elka Apollon* and \$1.3 million for the *MSC Nederland*.

The National Transportation Safety Board (NTSB) determines that the probable cause of the collision between the *Elka Apollon* and the *MSC Nederland* was the failure of the pilot conning the *Elka Apollon* to appropriately respond to changes in bank effect forces as the vessel transited the Bayport flare, causing the vessel to sheer across the channel and collide with the *MSC Nederland*. Contributing to the accident was the combination of the narrow waterway, bank effects at the Bayport flare, and traffic density at the time, which increased the challenges in a waterway with a limited margin for error.

Safety issues identified in this accident include the following:

- **Piloting challenges in the Houston Ship Channel.** Pilots in this waterway face a variety of significant challenges particular to the Houston Ship Channel. These include the many large vessels and tows that transit the relatively narrow channel, limited vessel maneuvering room, and variations in the waterway's configuration that result in changing hydrodynamic forces these vessels encounter in the vicinity of its intersections. Mariners also must set optimal vessel speeds that allow for timely transit while maintaining safe passage given the channel's limited margin for error.
- **Vessel separation.** Insufficient distance between vessels when they turn, pass, and overtake one another near intersections can create unsafe situations. In these areas, waterway management measures such as required separation between vessels can help to minimize marine casualties. In addition, communication between vessels approaching one another—and with any

authority responsible for managing vessel traffic separation—is essential to safe passage. Such communication is particularly important when vessels will pass closely or meet in a busy or complex area.

- **Lack of identification of U.S. Coast Guard precautionary areas.** The Coast Guard designated 14 precautionary areas along the Houston Ship Channel and vicinity in which vessels are required to navigate with particular care. These areas are defined and described geographically in the U.S. Code of Federal Regulations and the *U.S. Coast Pilot*. One of these, the Bayport Channel Precautionary Area, was the site of the collision between the *Elka Apollon* and the *MSC Nederland*. The NTSB investigated another accident in 2011 which occurred in the Bolivar Roads Precautionary Area, also located very near the Houston Ship Channel. However, none of these 14 precautionary areas is identified on Houston Ship Channel navigation charts, and mariners may not be aware that these areas exist.

As a result of this investigation, the NTSB issues two new recommendations to the Coast Guard regarding precautionary areas.

1. Factual Information

1.1 Accident Overview

The 799-foot Greek-flag chemical tankship *Elka Apollon* departed Houston, Texas, for Freeport, Texas, about 0700 central daylight time (CDT)¹ on Saturday, October 29, 2011, carrying about 342,000 barrels of naphtha² (figure 1). The tanker, with two Houston pilots aboard, was outbound in the Houston Ship Channel, which runs east from the city of Houston and then southeast through Galveston Bay to the open waters of the Gulf of Mexico for a total length of about 50 miles (figure 2).



Figure 1. *Elka Apollon*. (Photo www.worldmaritimeneews.com, October 31, 2011.)

¹ All times in this report are given using the 24-hour clock in CDT (Universal Time Coordinated – 5 hours).

² A barrel contains 42 U.S. gallons; therefore, the *Elka Apollon* was carrying 14,364,000 gallons of naphtha. Naphtha is any of several highly volatile, flammable liquid mixtures of hydrocarbons distilled from petroleum, coal tar, and natural gas and is used as fuel, as a solvent, and in making various chemicals.

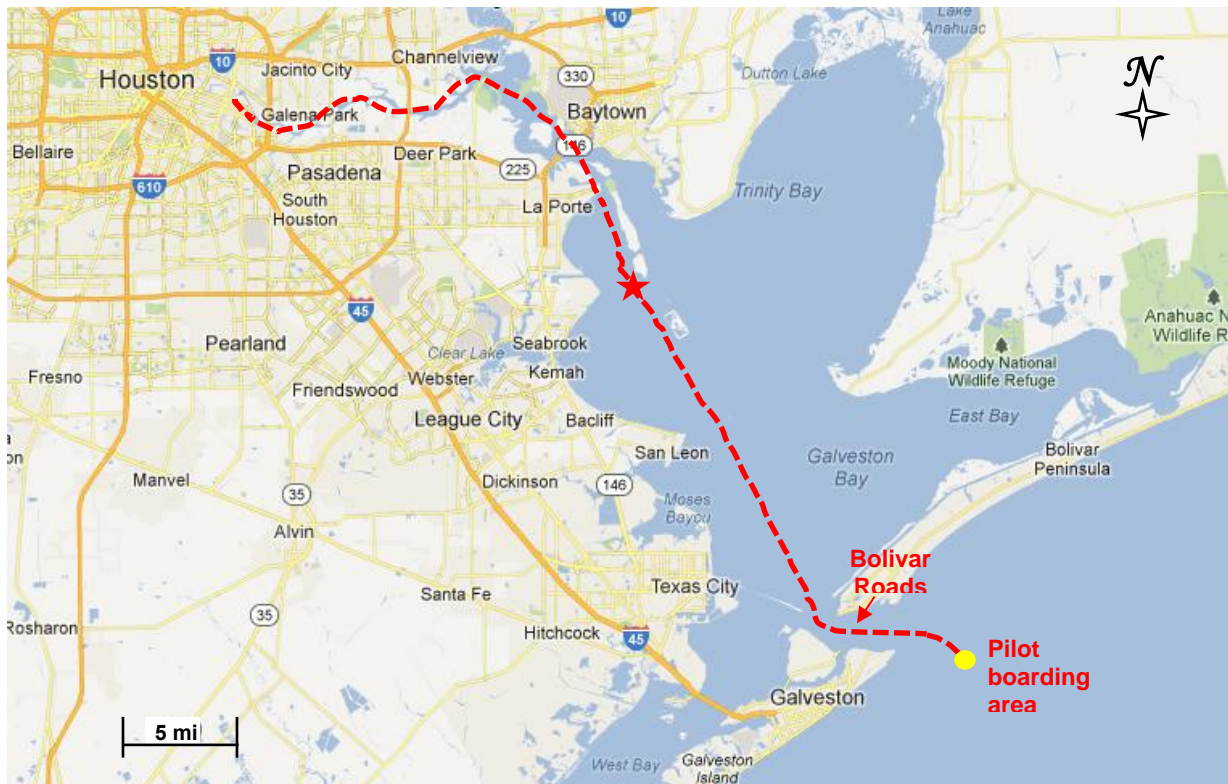


Figure 2. Houston Ship Channel, running from the port of Houston (upper left) southeast to Galveston, Bolivar Roads, and the entrance channel, shown by the dashed red line. The red star indicates the accident site, and the yellow circle is the pilot boarding area.

The same morning, the *MSC Nederland* (figure 3), a 777-foot Panamanian-flag containership, boarded a Houston pilot at 0648 at the beginning of the Galveston Bay Entrance Channel and proceeded to the Houston Ship Channel entrance near Bolivar Roads and the city of Galveston (figure 2). The *MSC Nederland* was inbound on the Houston Ship Channel to deliver cargo to the Bayport Container Terminal located on the Bayport Ship Channel, which runs west from the Houston channel.

The Houston pilot conning³ the *Elka Apollon* agreed to a port-to-port meeting via radio with the pilot on board the inbound *MSC Nederland*. The pilot on the *MSC Nederland* maintained his course and slowed the vessel in preparation for allowing the *Elka Apollon* and one additional deep-draft vessel to pass and clear before making a port turn into the Bayport Ship Channel. The intersection of the Houston and Bayport Ship Channels is known as the Bayport flare. The pilots anticipated that their ships would meet just south of this area. As the pilot on the *Elka Apollon* transited the Bayport flare and prepared to pass the *MSC Nederland*, he issued a starboard rudder order to move the *Elka Apollon* further to the right in the flare.

³ To have the conn is to direct the steering and propulsion of a vessel. A conning pilot has navigational control.



Figure 3. *MSC Nederland*. (Photograph by Wayne A'Court, www.marinetraffic.com)

About the same time, the towboat *Mr. Earl*, 70 feet long and pushing an empty barge 298 feet long and 54 feet wide, was exiting the Bayport Ship Channel and joining the Houston Ship Channel's barge lane ahead and to starboard of the *Elka Apollon*. The *Mr. Earl's* entrance into the channel at that moment resulted in a close-quarters situation between the two vessels.⁴ According to the pilot on the *Elka Apollon*, he issued port rudder commands⁵ to avoid the towboat and barge. The *Elka Apollon's* bow began to swing to port and toward the *MSC Nederland*.

The pilot on the *Elka Apollon's* said he attempted to check the bow's swing to port by employing counter steering commands to starboard but was unable to stop the tankship from moving toward the channel centerline. He radioed the pilot on the *MSC Nederland* to ask him to increase his speed. The *MSC Nederland* pilot ordered hard to port and emergency full ahead in an effort to swing his vessel's stern away from the approaching bow of the *Elka Apollon*. The efforts of the pilots on both ships were not sufficient to prevent the collision of the two vessels. At 0905:26, the *Elka Apollon's* port bow struck the *MSC Nederland's* port side at the main deck in the area of its superstructure. The impact damaged and dislodged several of the *MSC Nederland's* containers, three of which fell onto the *Elka Apollon's* forward deck.

Figure 4 provides an aerial view of the accident area near the intersection of the Houston and Bayport Ship Channels and Five Mile Cut, a channel extending east from the Houston Ship

⁴ While the term "close quarters" originally referred to combat aboard ships, modern usage implies uncomfortable closeness in a small area. Close quarters is used in a nautical sense to describe vessels that are close enough to risk collision.

⁵ A rudder command changes the angle of the rudder, an underwater blade located at the stern of a ship and controlled by the helm. When turned, the rudder causes the vessel's bow to turn in the same direction.

Channel. Also shown are the locations of the *Elka Apollon*, the *MSC Nederland*, and the *Mr. Earl* and their tracklines leading up to the collision. Characteristics of the Houston Ship Channel are described in greater detail in section 1.9, including a specific discussion of Houston pilotage requirements and oversight in section 1.9.3.

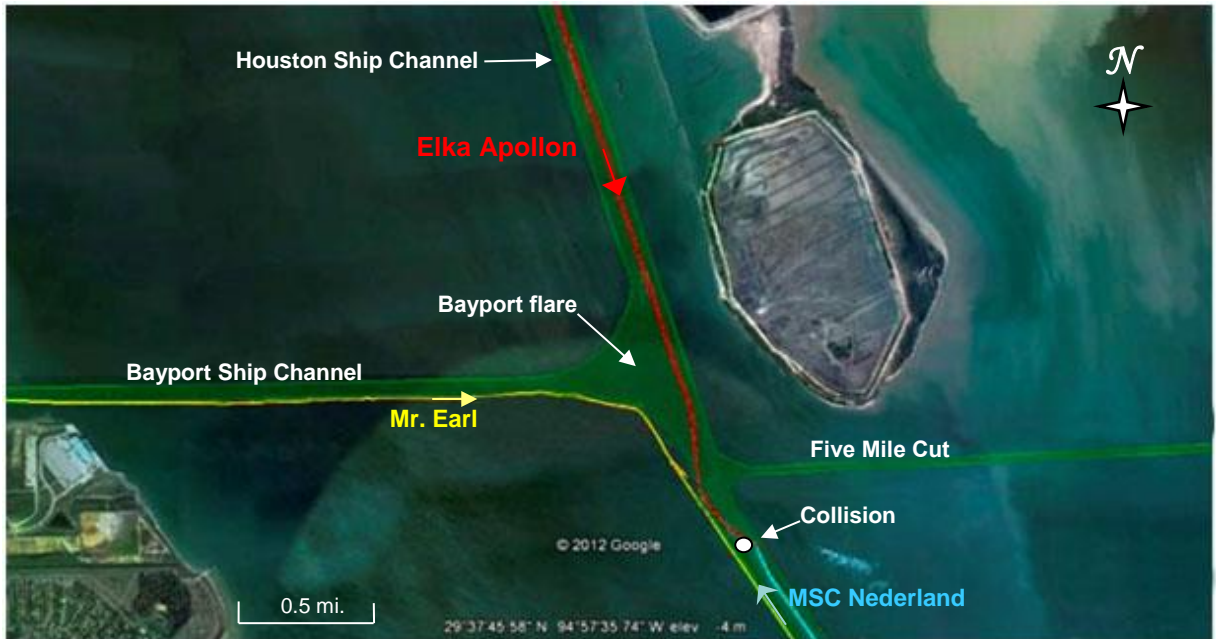


Figure 4. Aerial view of the accident area indicating the vessels' movements up to and following the collision. The *Elka Apollon's* trackline is labeled in red, the *MSC Nederland* is in light blue, and the *Mr. Earl's* is in yellow. (Image created by overlaying electronically captured position data on Google Earth image.)

1.2 Vessel Information

Vessel	<i>Elka Apollon</i>	<i>MSC Nederland</i>
Flag	Greece	Panama
Port of registry	Piraeus	Panama City
Owner/operator	Lydia Investments Co./ European Product Carriers Ltd.	Mediterranean Shipping Co. Ltd./ MSC Ship Management Ltd.
Type	Chemical tankship	Containership
Builder, date	Brodosplit Brodogradiliste, Split, Croatia Delivered March 2005	Bremer Vulkan AG, Bremerhaven, Germany Delivered November 1992
Classification society	American Bureau of Shipping	Germanischer Lloyd
Official number	11391	29517-04-B
IMO number	9299111	8918954
Call sign	SYEK	HPMR
Construction	Steel	Steel
Depth (ft)	68.88	61.68
Length (ft)	799	777.6
Width (ft)	137.9	105.6
Gross registered tons (ITC) ^a	59,486	37,071
Deadweight	84,999 metric tons (83,657 long tons)	47,120 metric tons (46,376 long tons)
Engine type and power	Single slow-speed MAN B&W, 13,530 kW (18,137 hp), diesel	Single slow-speed MAN B&W, 21,700 kW (29,510 hp), diesel

On the day of the accident:

Draft (ft)	31.8	28.9
Cargo	342,000 barrels of naphtha	1,207 TEUs ^b
Persons on board	24 crew 2 pilots	23 crew 1 pilot

^a Size measured according to International Tonnage Convention.

^b A TEU, or 20-foot equivalent unit, is a measure for describing a container ship's cargo carrying capacity. The *MSC Nederland*'s full capacity is 3,007 TEUs.

1.3 Damage to Vessels

1.3.1 *Elka Apollon*

All damage to the *Elka Apollon* was above the vessel's waterline, primarily to the port hull side plating and bow bulwark⁶ from 5 feet below the main deck upward to the top of the bulwark (figure 5) and extending about 40 feet. The bulwark in this area was severely bent with

⁶ A bulwark is vertical plating rising from the side of a ship, usually to protect the deck from sea and spray.

an open tear approximately 3 feet high and about 20 feet long. The structural support in the area of the tear was also distorted.



Figure 5. Damage to *Elka Apollon* port bow and partial view of containers that fell to its deck from the *MSC Nederland*.

Upon impact, three containers fell from the *MSC Nederland* onto the portside foredeck of the *Elka Apollon*. Two containers held three agricultural tractors each, and one contained stoves. None of the *Elka Apollon*'s cargo piping was damaged, but the fallen containers damaged the vessel's cargo tank fittings to the no. 1 port cargo tank on the main deck immediately above the cargo tank.

The total cost of repairs to the *Elka Apollon* was approximately \$1.5 million.⁷

1.3.2 *MSC Nederland*

The *Elka Apollon*'s port bow struck the port side of the *MSC Nederland* about 98 feet forward of the vessel's superstructure and scraped along the side of the ship above its main deck for about 148 feet. (Partial damage to the port side is shown in figure 6.) The main deck was punctured in one location. The puncture was approximately 18 inches long and several inches high and led into the longitudinal passageway outboard on the deck below the main deck. Damage to the *MSC Nederland* extended vertically from the main deck about 12 feet up the port side.

⁷ K. Tsartsaris, European Product Carriers Ltd., e-mail ("Information regarding Elka Apollon-*MSC Nederland* collision-10/29/2011") to B. Curtis, NTSB, April 20, 2012.



Figure 6. *MSC Nederland* damage, looking forward from superstructure at main deck.

According to the Marine Field Survey Report,⁸ six containers stowed on the port side just forward of the superstructure also were damaged. The *Elka Apollon's* port bow crushed the outermost 40-foot container stowed just over the *MSC Nederland* main deck in bay 40 and tore three similar containers stacked on top of it from the vessel. These three containers fell to the foredeck of the *Elka Apollon*. (Damage to containers is shown in figure 7.)

⁸ 3D Marine USA Inc., Field Survey Report, M/V *MSC Nederland*, October 30, 2011.

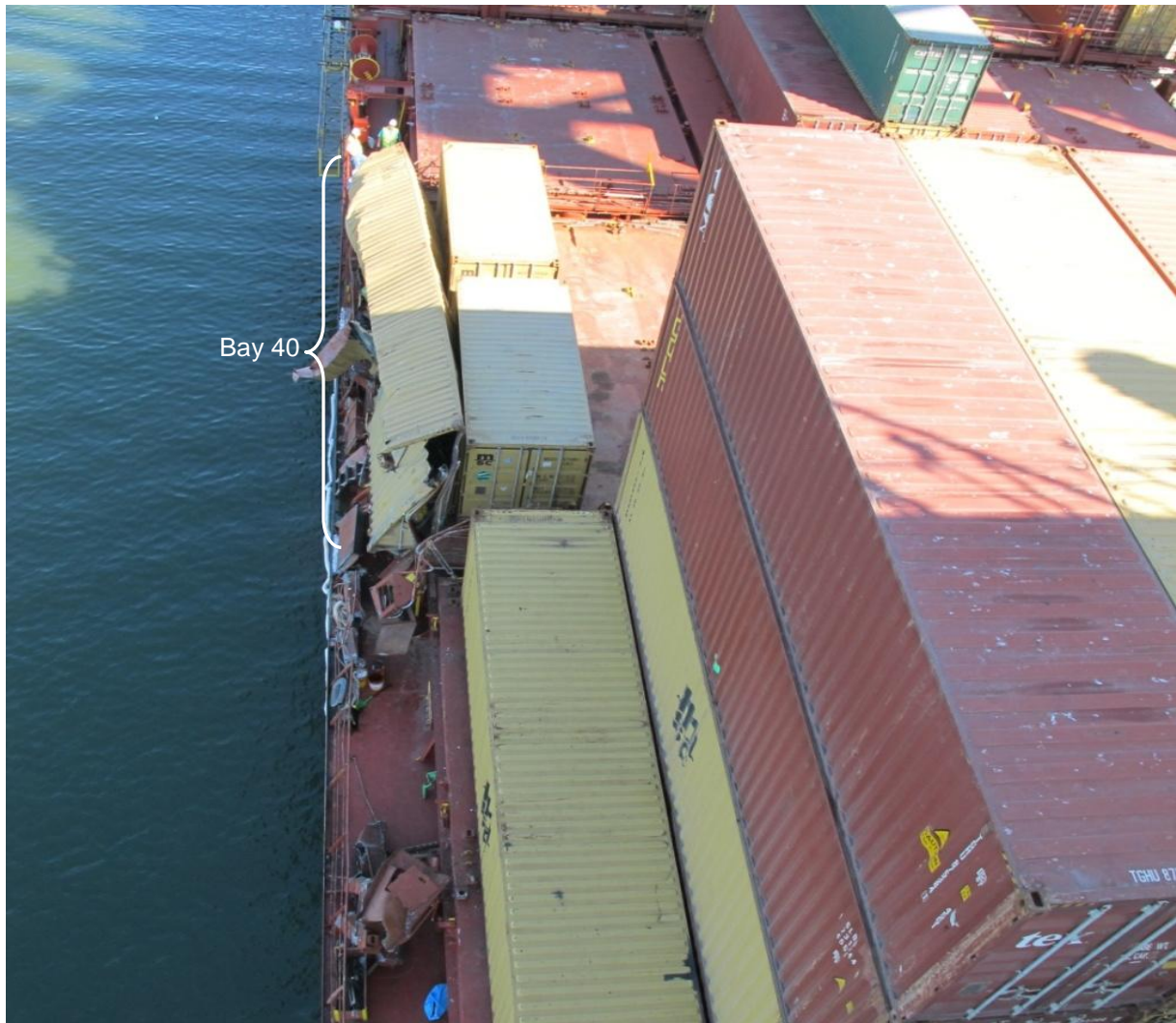


Figure 7. Damaged containers on *MSC Nederland*, photographed forward from bridge wing.

The *MSC Nederland*'s rescue boat, two life rafts, and their cradles were all damaged. The rescue boat was torn off and set adrift during the accident and later retrieved.

Following the accident, the vessel continued its transit into Bayport and moored at the Bayport Container Terminal. A representative of the Germanischer Lloyd classification society surveyed the vessel the next day to ascertain damages and necessary repairs.⁹ The total cost of repairs to the *MSC Nederland* was estimated to be \$1.3 million.¹⁰

⁹ Germanischer Lloyd, Survey Statement: Attachment to the Certificate of Class, Statement No. 50, *MSC Nederland* damage sustained at Houston, October 30, 2011.

¹⁰ A. Volta, MSC Mediterranean Shipping Company S.A., e-mail ("Information regarding Elka Apollon-*MSC Nederland* collision-10/29/2011"), June 19, 2012.

1.4 Injuries

No injuries resulted from this accident.

1.5 Environmental and Waterway Conditions

At the time of the accident, skies were clear, visibility was 10 miles, the temperature was 59° F, and winds were out of the north at 10 knots.

In the Houston Ship Channel at the accident site, the current was ebbing and according to ship pilots was less than 1 knot. (The Houston channel is discussed in greater detail in section 1.9, “Houston Ship Channel and Neighboring Waterways.”)

1.6 Toxicological Tests

Watchstanding crewmembers from both vessels and the three Houston pilots (two aboard the *Elka Apollon*, one on the *MSC Nederland*) underwent toxicological testing. These tests were conducted within the prescribed time frame for alcohol and the five classes of illicit drugs for which the U.S. Coast Guard requires postaccident testing (marijuana, cocaine, opiates, amphetamines, and phencyclidine).¹¹ All results were negative.

The vessel traffic service (VTS), which is operated by the Coast Guard to monitor and communicate with marine traffic in a primarily advisory capacity and to respond to traffic situations, was notified of this accident by the vessel operators. (VTS is discussed in more detail in section 1.9.2, “Vessel Traffic Service Houston–Galveston.”) The Coast Guard captain of the port of Houston determined that the Coast Guard civilian VTS watch supervisor and three Coast Guard active duty controllers should be tested for drugs. All four VTS personnel underwent drug testing that evening, and all results were negative. None was tested for alcohol.

1.7 Personnel Information

1.7.1 Ships’ Officers

Elka Apollon. The master of the *Elka Apollon*, age 47, attended a maritime academy in Greece and graduated with an officer’s license. He had 21 years of sea experience on tankers and had been licensed as a master for the last 6 years. He served 3 months as master of the *Elka Apollon* and said he had transited the Houston Ship Channel on at least one previous occasion.

¹¹ The three pilots were tested according to Federal regulations at 46 *Code of Federal Regulations* (CFR) 4.06, which require postaccident drug and alcohol testing for “each individual engaged or employed on board the vessel who is directly involved in” a serious marine incident. Alcohol testing must be conducted within 2 hours of a serious marine incident (unless safety concerns related to the incident preclude it, in which case no testing is required beyond 8 hours), and drug-test specimens must be collected within 32 hours.

MSC Nederland. The master of the *MSC Nederland*, age 61, said he had been at sea for over 40 years following graduation from a Russian marine college. He earned his master's license in 1997, joined the crew of the *MSC Nederland* as chief officer that same year, and served as master for the past 6 years. He estimated that he had called at the port of Houston on five occasions during his career, three of those times in 2011.

Mr. Earl. The captain operating the *Mr. Earl*, age 24, had about 5 years of maritime experience. He previously worked as a mate on towing vessels and as a tankerman and deckhand. He received his master of towing vessels license in May 2011 and since then worked as captain on the *Mr. Earl*.

1.7.2 Houston Pilots

Elka Apollon. On the day of the accident, the *Elka Apollon* boarded two pilots for its departure from the port of Houston to begin its voyage outbound on the Houston Ship Channel.

1.7.2.1 Conning pilot. The conning pilot, age 59, started working as a deckhand when he was 13 years old and obtained a tugboat operator's license when he was about 19 after driving inland river and seagoing tugboats, dredge tenders, and crew boats, among other vessels. In 1990, he began a 2-year ship's pilot training program with the Houston Pilots Association, working as a deputy pilot on progressively larger ships with deeper drafts. After completing the training, he was accepted into the pilots association and worked as a pilot for about 22 years, making an estimated 10,000 transits. Medical records indicate the pilot was in good health, took no medications, and underwent annual physical exams with the Coast Guard. No service-limiting conditions were noted at the time of his last physical. Coast Guard documentation supported an overall finding of good health.

About 0430 on the morning of the accident, the conning pilot received the telephone call to report to the *Elka Apollon*, scheduled to depart at 0630. He left home about 0530, arrived at the ship about 0600, and met the other pilot and the ship's captain on board. In an interview with investigators several days after the accident, the conning pilot said he could not recall when he had slept and when he had been awake during the preceding days. When off duty, he said his routine was to sleep at night between 2230 and 0430, but his on-duty schedule varied:

When I'm working . . . I'm up and down all different hours, night and day, so I don't—really never think about all that. I sleep when I'm tired and I work when they call me.

The pilot provided investigators a written schedule of the times he worked piloting jobs in the 4 days preceding the accident. During the times he was working, he said he was on board a vessel but may have been resting in a vessel cabin. The schedule he provided did not indicate at what times he was notified to report to a vessel or when he awoke to prepare for serving as a pilot. His work schedule indicated the following:

Date	Start work	End work
Saturday, October 29	0430	Time of accident (0905)
Friday, October 28	0300	0730
Thursday, October 27	1800	2330
Wednesday, October 26	2100	2330
Tuesday–Wednesday, October 25–26	2300	0500

The pilot told investigators, “There are times when I have been fatigued in the job, but this was not [one of those times],” referring to the day of the accident. The pilot also offered his opinion regarding why the Houston Pilots Association required two pilots on board large vessels, such as the *Elka Apollon*, when transiting the Houston Ship Channel:

Because you need the rest periods, and there’s the factor—the stress factor. . . . Not exhaustion but, you know, you get tired. You get tired, and it’s good to be a little swapped [with the other] . . . pilot. That’s all you really need to handle one of those large ships I think, and I think it’s a great guideline.

1.7.2.2 Nonconning pilot. The pilot not at the conn at the time of the accident, age 47, conducted the master-pilot exchange¹² and handled the initial leg of the trip from the dock in Houston along the Houston Ship Channel to Morgan’s Point, about 4.5 miles north of the accident site. He also had piloted and docked the inbound *Elka Apollon* when it arrived in Houston a few days earlier.

After graduating from Texas A&M University in Galveston, he worked for Sabine Transportation Company for 14.5 years, first as an ordinary seaman and working his way up to master, all on tank vessels. He received his unlimited master’s license in 1993. He then passed qualifying tests for pilots, was admitted to the Houston Pilots Association in November 2000, and began working in the association’s 3-year deputy pilot program in February 2001. He estimated he worked on 2,600 ships since he began piloting.

MSC Nederland. The pilot conning the *MSC Nederland*, age 38, qualified for and obtained his Merchant Mariner Document from the Coast Guard in 1997 while still a student at Texas A&M University in Galveston and received his third mate license in 2001. He also worked as a longshoreman in Houston while a student and after graduation. He was later credentialed as a second mate, as chief mate, and as a 1,600 ton master. He entered the Houston Pilots Association’s 3-year deputy pilot program in 2008. The apprenticeship included about 1,000 transits with vessels of various sizes and classes under the oversight of an experienced pilot, with his continuing progress monitored by a master pilot. In August 2011, he became a fully qualified pilot, and he estimated he had conducted 45 to 50 inbound or outbound transits in the Houston Ship Channel since then.

On the day of the accident, the pilot boarded the *MSC Nederland* at 0648. Before boarding, he said he had been taking a nap after completing an outbound transit beginning about

¹² According to the International Maritime Organization, pilotage assignments should begin with a conference between pilot and master to share relevant information about navigation procedures, local conditions, and the ship’s characteristics. The master-pilot exchange should also establish an appropriate working relationship between pilot and master.

0030 that night and lasting about 4 hours. The previous evening, he said, he rested starting about 1800 before that night's job. Prior to that trip, he said he had a 26-hour rest period. Pilots typically are on duty for 14 days with mandatory rest periods; he was on the tenth day of his 2-week duty period when he was assigned to pilot the *MSC Nederland*.

Once aboard, he conducted a master-pilot exchange and checked in with the Houston–Galveston VTS. He connected his monitoring and communications equipment, judged the vessel to be seaworthy, and assumed navigational control, making adjustments for outbound traffic and meeting situations.

1.8 Postaccident Actions

After the collision, the master of the *MSC Nederland* ordered the chief mate to check for damage to the port side of the ship, the deck, and the ballast tanks, and he called the ship's operator, Mediterranean Shipping Company (USA) Inc. (MSC), to report the accident. The pilot on the *MSC Nederland* said he asked the master to determine the contents of the containers that had fallen onto the deck of the *Elka Apollon* to make sure they did not hold hazardous materials and no substance was spilling into the waterway. The pilot on the *MSC Nederland* continued the short distance to a berth at the Bayport Container Terminal and then radioed VTS Houston–Galveston about 0915 to report the collision. He said he also contacted the pilot on the *Elka Apollon* to make sure no one on board was injured.

On the *Elka Apollon*, the crew immediately assessed vessel damage and sought to identify the contents of the containers that fell onto the deck from the *MSC Nederland*. The pilot on the *Elka Apollon* continued outbound on the Houston Ship Channel to the Bolivar Roads Anchorage near the entrance to Galveston Bay. At 0929, the pilot on the *Elka Apollon* called the VTS watch supervisor regarding the accident. The watch supervisor allowed the vessel to continue to the Bolivar Roads Anchorage as proposed by the pilot.

The VTS controller who received the first call from the pilot on the *MSC Nederland* reported the incident to his watch supervisor. At 0927, the supervisor reported the initial accident account to the Coast Guard Sector Houston–Galveston Command Center. A few minutes later he added that damaged containers had fallen to the deck of the *Elka Apollon* and a small leak, possibly oil or fuel, had been contained with no substance entering the water.

The Sector Houston–Galveston situation controller notified the duty investigating officer at 0938 and the duty port state control officer at 0955, sent a command notification text message,¹³ opened a case in the Marine Information for Safety and Law Enforcement database, and telephoned the District 8 Command Center to report the collision as required by the Coast Guard.¹⁴

¹³ Key leaders at Sector Houston–Galveston and duty personnel with a duty cell phone received command text notifications.

¹⁴ Coast Guard District 8, headquartered in New Orleans, covers all or part of 26 states throughout the central United States to the Gulf Coast, including Houston and New Orleans, two of the country's busiest ports.

The situation controller dispatched Coast Guard Station Houston and Station Galveston small boats and a port state control officer to the vessels. VTS briefly closed the Houston Ship Channel between lights 76 and 78 before determining that the containers had fallen onto the deck of the *Elka Apollon* and not into the channel. A Coast Guard Station Houston small boat was launched to retrieve the *MSC Nederland*'s rescue boat and two life rafts that were reported dislodged and released by the impact. The rescue boat was retrieved and returned to the *MSC Nederland*. A Coast Guard Station Galveston small boat was diverted to confirm that the *Elka Apollon* was not seriously damaged or leaking oil or hazardous materials into the waterway. Coast Guard Sector Houston–Galveston required both vessels to remain in port until their classification societies evaluated the damage and recommended repairs.

1.9 Houston Ship Channel and Neighboring Waterways

Houston is consistently ranked among the busiest ports in terms of cargo tonnage in the United States and internationally.¹⁵ In 2011, the Coast Guard reported that average daily traffic along the Houston Ship Channel included over 60 ships, 340 barge movements, and several hundred tow operations completing a total of more than 700 transits a day with dozens of ships in port. According to these data, total transits increased more than 25 percent from 1997 to 2011, and daily deep-draft vessel movements rose from 200 in 2010 to 287 in 2011.¹⁶ On the day of the accident, traffic in the Houston Ship Channel was heavier than usual—“extremely high” according to the Coast Guard¹⁷—due to high winds the day before. The next morning the wind had abated, and about 90 vessels were under way in the channel at the time of the collision.

The U.S. Army Corps of Engineers completed a major widening of the channel in 2005, and the collision occurred in an area included in this project. The widening project added dedicated barge lanes for towing vessels and deepened as well as widened the channel. The main Houston Ship Channel in the area of the accident is 530 feet wide with a depth of 45 feet. The barge lanes located along both sides of the main channel are 235 feet wide and 12 feet deep (see figure 8).¹⁸ With specified barge lanes alongside a major shipping channel—together with the high volume of marine traffic, relatively narrow main channel, and designation of 14 Coast Guard precautionary areas along the length of the channel—the Houston Ship Channel is a unique waterway in the United States.

¹⁵ Statistics and rankings are compiled by organizations including port authorities, local and national governments, marine industry groups, and business and economic analysts.

¹⁶ *State of the Waterway—2012* (Washington, DC: U.S. Coast Guard, 2012), <http://www.uscg.mil/vtshouston/docs/sww2012.pdf>, accessed June 1, 2012.

¹⁷ The Coast Guard conducted an internal review of the facts and circumstances of this collision. The Coast Guard identifies the memorandum documenting the review (INFORMAL INCIDENT REPORT – HG113_11/UE011_11) as containing deliberative opinions, advice, and recommendations, and it may be exempt from disclosure under the Freedom of Information Act. While the Coast Guard provided a redacted report to the NTSB, it was with the understanding the NTSB would not disclose it without Coast Guard consent. Therefore, the report has not been published by the NTSB, and it is not included in the public docket.

¹⁸ “Navigating the Houston Ship Channel: A reference for commercial users” (Houston, TX: Houston/Galveston Navigation Safety Advisory Committee, with sponsor support, June 2006).

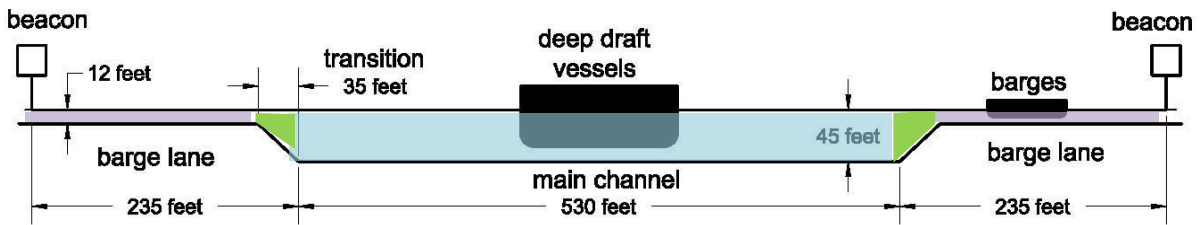


Figure 8. Dimensions of the main Houston Ship Channel, barge lanes, and transition zones following U.S. Army Corps of Engineers deepening and widening project.

In the vicinity where the accident occurred, the Houston channel makes a 15-degree bend, changing from a course of 161 degrees to 146 degrees (see figure 9). This turn is located at navigation beacons 75 and 76, slightly south of Five Mile Cut. Five Mile Cut allows smaller vessels with a draft of 6 feet or less to transit between the Houston Ship Channel and the shallower portion of Galveston Bay located to the east.

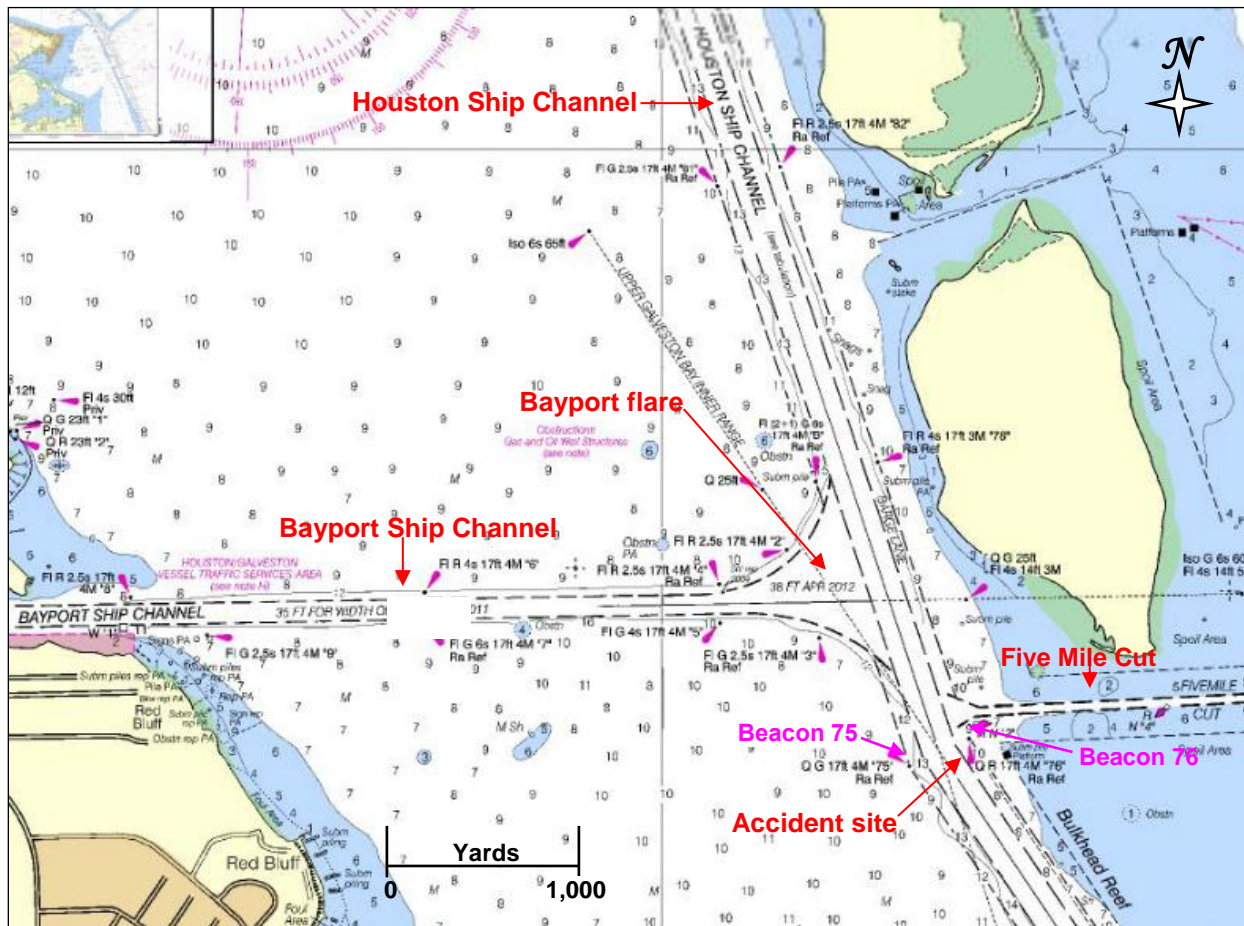


Figure 9. Houston Ship Channel and Bayport flare, as shown in an excerpt from National Oceanic and Atmospheric Administration (NOAA) nautical chart 11327. Along each side of the main Houston channel are the barge lanes, indicated by dashed lines.

The Bayport Ship Channel meets the Houston Ship Channel about 0.3 nautical mile¹⁹ (nm) northwest of Five Mile Cut and the 15-degree turn in the Houston channel. The Bayport channel runs east and west and can accommodate deep-draft vessels along with tug and tow traffic. The channel is 300 feet wide and 35 feet deep, according to the latest edition of NOAA chart 11327. The Bayport flare, near the accident location, is at the junction of the Bayport and Houston channels where the Bayport channel widens to the north and south to smooth the turn for vessels entering and exiting the waterway.

The director of VTS Houston–Galveston said in an interview with National Transportation Safety Board (NTSB) investigators that the intersection of the Bayport and Houston Ship Channels, the location of the current accident, was an area where “we had a history of problems” and “amply deserved to be codified in the CFR as a precautionary area. . . . It’s one of those areas that we watch closely.” Coast Guard regulations in 33 CFR 161.2 state that in a precautionary area “vessels must navigate with particular caution.”

Nautical charts for the Houston Ship Channel do not graphically depict precautionary areas²⁰ on inland waterways, nor are they required to do so. U.S. nautical charts are published by NOAA, based in part on information provided by the Coast Guard, the U.S. Army Corps of Engineers, and other federal, state, and local government agencies. Precautionary areas, however, are designated only by the Coast Guard.

1.9.1 Previous NTSB Investigation

The NTSB investigated another incident in 2011 in the area of the Houston Ship Channel, on this occasion in the Bolivar Roads Precautionary Area, which includes a section of the Houston channel, some 20 miles south of the current accident site. (Bayport Ship Channel and Bolivar Roads are identified in figure 2 above.) The *Coast Pilot*²¹ describes Bolivar Roads as a large, deepwater intersection of several channels connecting Galveston, the Texas City Channel,²² and the Houston Ship Channel with the Gulf Intracoastal Waterway (GIWW)²³ passing through it. The Texas City Channel extends from Bolivar Roads through the lower end of Galveston Bay to the Texas City turning basin. The waterway is 400 feet wide, 45 feet deep, and about 6.8 miles long.²⁴

¹⁹ 1 nautical mile = 6,076 feet.

²⁰ VTS Houston–Galveston Precautionary Areas are listed in 33 CFR 161.35(b) and in the *U.S. Coast Pilot* (see next footnote).

²¹ National Oceanic and Atmospheric Administration, *U.S. Coast Pilot*, volume 5, chapter 10, 38th edition, 2010. The *Coast Pilot*, published in nine volumes, provides information supplementary to NOAA’s nautical charts, including channel descriptions, anchorages, currents, tide and water levels, prominent features, pilotage, towage, weather, dangers, routes, traffic separation schemes, and Federal navigation regulations.

²² The Texas City Channel is a deep-draft navigation project serving the port of Texas City in Galveston County, Texas, maintained by the U.S. Army Corps of Engineers at a depth of 45 feet and a width of 400 feet.

²³ The GIWW, an inland navigable waterway maintained by the U.S. Army Corps of Engineers, runs approximately 1,050 miles from Brownsville, Texas, to Carrabelle, Florida, and is maintained at a depth of 12 feet.

²⁴ *Galveston Bay Entrance, Galveston and Texas City Harbors*, chart 11324, Coast Survey, edition 37 (Washington, DC: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, 2011).

The tankship *Naticina* was outbound for sea, transiting southeasterly in the Texas City Channel with two Galveston–Texas City pilots on board. The towing vessel *Alliance*, pushing two tank barges with a total length of 666 feet, was transiting northeasterly in the GIWW. The pilot on the *Naticina* and the captain of the *Alliance* agreed to meet at the intersection of the Texas City Channel and the GIWW, where, according to the pilot on the *Naticina*, the *Alliance* would slow and let the *Naticina* pass before the *Alliance* continued across the Texas City Channel. As the vessels neared one another, the second pilot assumed conning the *Naticina*. He determined that a risk of collision existed and directed the helmsman to begin altering the *Naticina*'s course to port, but the vessel was unable to leave the channel without running aground. The bow of the lead barge pushed by the *Alliance* struck the *Naticina* and punctured the no. 5 starboard ballast tank of the *Naticina*'s hull.

The NTSB determined that the probable cause of the collision was the encroachment by the master of the *Alliance* and its two barges into the Texas City Channel and into the path of the *Naticina* despite the crossing agreement.²⁵

1.9.2 Vessel Traffic Service Houston–Galveston

VTS provides mariners with information including position, identity, and intentions of vessels operating in the VTS area; meteorological information; status of aids to navigation; traffic congestion; and waterway restrictions. VTS controllers monitor this information using automatic identification system (AIS)²⁶ tracking, radar, very high frequency (VHF) radio, and in some cases closed-circuit television. VTS also offers navigational assistance, at the request of a vessel operator, by providing information about the operator's own vessel, such as course and speed; position in the waterway relative to the channel axis; landmarks and aids to navigation; and the positions, intentions, and identities of surrounding vessel traffic. VTS services to mariners are primarily advisory, but controllers are authorized to issue outcome-based directions.

The section of the waterway where the accident occurred was monitored by VTS Houston–Galveston, co-located with Coast Guard Sector Houston–Galveston in the city of Houston. Certain vessels transiting the waterway are required to check in with VTS before entering the VTS area and at designated reporting points in the waterway, and the pilots on both the *Elka Apollon* and *MSC Nederland* did so.²⁷

²⁵ *Collision of Tugboat/Barge Alliance/MMI 3024 with Tankship Naticina, Texas City Channel and Gulf Intracoastal Waterway*, Marine Accident Brief NTSB/MAB-12/01 (Washington, DC: National Transportation Safety Board, 2012).

²⁶ AIS is a maritime navigation safety communications system. At 2- to 10-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.

²⁷ VTSs utilize a regulatory Vessel Movement Reporting System to monitor and manage vessel movements. Per regulations governing VTS operations in the United States, VTS waterway users must provide a sailing plan report, position report, sailing plan deviation/amplification report, and final report to the VTS (33 CFR 161).

After the collision, Coast Guard VTS Houston–Galveston conducted an internal review of the accident in which it evaluated factors including the role of VTS. The study’s recommendations included suggesting that VTS expand its role in Houston Ship Channel operations to enhance safety. The report proposed VTS Houston–Galveston determine safe traffic levels given conditions in the waterway and develop ways to “become more proactive” in managing traffic as conditions warrant.²⁸

1.9.3 Houston Ship Channel Piloting

The Houston Pilots Licensing and Regulatory Act, incorporated into the Texas Transportation Code in 1995 (partially amended in 1997), established the Board of Pilot Commissioners for the Ports of Harris County, Texas, and authorized it to oversee the operation of the Houston Ship Channel; develop guidelines for piloting and pilot application, certification, licensing, and appointment; and maintain pilot standards of performance. The Texas code states, “To be eligible for a license as a branch pilot, a person must . . . be licensed under federal law to act as a pilot on vessels that navigate water on which the applicant will furnish pilot services.” Additional statutory requirements call for the pilot to be between 25 and 68 years of age and to have served at least 3 years as an apprentice, or deputy branch pilot. Pilots also are subject to medical oversight by the Coast Guard because they hold a Federal pilot’s license and/or endorsement.

The Board of Pilot Commissioners, or Pilot Board, establishes the number of pilots required for each port; considers pilot license applications; determines operating guidelines such as pilotage rates, location of pilot stations, and other logistics; and holds investigations or hearings regarding possible violations.

The Pilot Board also oversees the Houston Pilots Association, which represents nautical pilots licensed by the state of Texas and the Coast Guard who serve on vessels transiting the Houston Ship Channel. The Houston Pilots Association website includes detailed criteria for pilot qualification and application materials; guidance for mariners in the Houston Ship Channel and neighboring waterways, including communications, distances and clearances, anchorage information, and safety practices; and specific navigation safety guidelines for all areas of the Houston Ship Channel.²⁹

The *Elka Apollon* was designated a two-pilot ship according to the Houston Pilots Working Rules.³⁰ Two-pilot transits require only that both pilots be on board the vessel and be able to relieve each other throughout the transit. They are not required to be on the bridge at the same time or to follow any procedure for separating or designating duties necessary for piloting the vessel. According to a representative of the Houston Pilots Association, two pilots are required on larger vessels and/or transits of extended duration to allow one pilot at a time to rest. The off-duty pilot is to respond if and when called upon by the conning pilot to assist. Any widebody vessel, defined as having a beam of 120 feet or more, transiting above buoy 18

²⁸ See footnote 17 regarding the Coast Guard internal review.

²⁹ Houston Pilots Association website, <http://www.houston-pilots.com>, accessed May 17, 2012.

³⁰ “Houston Pilots Working Rules, Updated October 19, 2011,” unpublished document, Houston Pilots Association.

requires two pilots at all times. Buoy 18 is located at the southern end of the inbound Houston Ship Channel. The *Elka Apollon* had a 137.9-foot beam and was outbound from the port of Houston in the northern portion of the Houston Ship Channel. The *MSC Nederland*, with a beam of 105.6 feet, was required to carry only one pilot.

2. Investigation and Analysis

2.1 Sequence of Events

The following account of events leading up to, including, and immediately following the collision is derived from several sources:

- Radio communications among the pilots on the *Elka Apollon* and the *MSC Nederland* and crewmembers of other vessels in the vicinity at the time;
- Information recorded through the Coast Guard Ports and Waterways Safety System (PAWSS)³¹ such as radio transmissions, closed-circuit television surveillance, AIS data, reports received directly from vessels, and meteorological and hydrographic information;
- Transcripts from the *Elka Apollon* and the *MSC Nederland* voyage data recorders; and
- Interviews conducted with personnel involved in or contributing information about the collision.

The first pilot at the conn during the *Elka Apollon*'s outbound transit navigated the tanker along the Houston Ship Channel for about 12 miles. During this time, the second pilot retired below. At Morgan's Point, the first pilot was relieved by the second pilot, who remained at the conn for the rest of the transit up to and including the time of the accident. The second pilot is hereafter referred to as the conning pilot. The first pilot, now referred to as the nonconning pilot, remained on the bridge after he was relieved although he did not actively participate in navigating the vessel.

Both pilots said the *Elka Apollon* had no handling problems and the bridge crew effectively carried out any tasks asked of them by the pilots. The conning pilot said the *Elka Apollon* responded to his orders and prior to the accident he did not recall using a rudder angle of more than 20 degrees. He said the vessel's steering was "great. I didn't have any problem with her." He recalled that in the vicinity of the accident he had the vessel under way at about the typical speed for that area and it was handling well. NTSB investigators researched vessel speeds in this location and estimated the average speed to be approximately 9 to 11 knots.

The conning pilot returned to the bridge about 0825, and assumed the conn of the *Elka Apollon* in the vicinity of Morgan's Point, about 4.5 miles north of the accident site. He called VTS and received traffic information. The vessel was on a course of 162 degrees through the channel with minor heading alterations to maintain a steady course.

At 0854, the *Mr. Earl* towboat captain broadcast his vessel's progress and intentions over VHF radio as he prepared to exit the Bayport Ship Channel and turn outbound (south) on the

³¹ PAWSS was established to meet the goals of the Ports and Waterways Safety Act of 1972 (PWSA). As part of VTS, it provides automated processes to assist in monitoring vessel traffic and enhance mariners' navigation, situational awareness, and ability to avoid risks.

Houston Ship Channel. No communication took place between the pilot on the *Elka Apollon* and the *Mr. Earl*'s crew at or prior to that time. The conning pilot on the *Elka Apollon* told investigators that he later identified the outbound towboat *Mr. Earl* visually and on a portable piloting unit (PPU), which provides electronic charting to assist in navigating and identifying other vessels.³² The conning pilot said that, based on PPU information, the *Mr. Earl*'s presence "was a non-issue. He wasn't going to be in the channel with me. He was going to be following me out by a couple of minutes I think." The pilot also stated that once he saw the towboat would not affect his transit, he "clicked off" the *Mr. Earl*, that is, he chose not to display the *Mr. Earl*'s information on his screen "because it clutters up your view of everything."

At 0855, the conning pilot on the *Elka Apollon* contacted the pilot on the inbound *MSC Nederland* to determine a suitable meeting arrangement. Both realized they would most likely meet near the bend in the channel south of the Bayport flare, and the pilot on the *MSC Nederland* assured the pilot on the *Elka Apollon*, "We'll keep well out of your way on that one." The pilot on the *Elka Apollon* replied, "If it looks different just holler, we'll do something else."

The pilot on the *MSC Nederland* explained to the master that he planned to slow down and wait for two outbound deep-draft vessels, the *Elka Apollon* followed by the *Voge Dignity*,³³ to pass before altering course to turn west into the Bayport channel. The pilot on the *MSC Nederland* recalled that his ship was traveling 5 to 5.5 knots, and he felt no concern prior to the accident about the situation involving the *Elka Apollon* or other vessels. When the *Elka Apollon* later began to head toward the *MSC Nederland*, the *MSC Nederland* master said he felt his pilot's actions and maneuvers were correct for his ship given the situation. He added that he thought the damages could have been more serious if the pilot had not reacted as he did.

As the outbound *Elka Apollon* approached the northern portion of the Bayport flare, the helmsman maintained the 161-degree heading ordered by the conning pilot by applying predominantly port rudder as necessary for about 10 minutes. During this time, from 0851:25 through about 0902, the conning and nonconning pilots on board the *Elka Apollon* engaged in intermittent conversation nonpertinent to vessel navigation interspersed with radio communications and ship-related comments. At 0902:10, once in the Bayport flare, the pilot ordered the rudder to starboard 20 and 15 seconds later ordered midship, or zero angle position. These rudder commands, which maneuvered the vessel to the right of the main channel and deeper into the opening flare of the Bayport Ship Channel, initiated the accident sequence. The pilot who was conning the *Elka Apollon* stated in his interview that in meeting the *MSC Nederland* he "wasn't going to actually do the Texas chicken."³⁴ I was going to . . . go

³² A PPU consists of a laptop computer configured to display an electronic charting system used by marine pilots and mariners to navigate vessels and to identify other vessels in a waterway, including their course, speed, headings, distance, and calculated intercept time in relation to the user's own vessel.

³³ The *Voge Dignity* was a deep-draft, Liberian-flag oil and chemical tanker traveling about 1.5 miles behind the *Elka Apollon*.

³⁴ The "Texas chicken" maneuver is known to mariners who regularly navigate large vessels on the Houston Ship Channel. As two vessels approach from opposite directions, both normally turn to starboard to allow water displaced by their bows to move the ships away from each other and from the channel's centerline. After they pass, the suction of the displaced water flowing in behind the ships naturally pulls them back toward the center of the waterway.

down deep in the bend and follow along the curve, the edge of the channel in the turn and go under [the *MSC Nederland*] and give him more room.”

Less than a minute later, at 0902:37, the conning pilot ordered port 20, 9 seconds later he ordered hard to port, followed 8 seconds later by port 20.³⁵ At the time of this last port 20 rudder command, the *Elka Apollon* was toward the southern end of the Bayport flare on a heading of 171 degrees at a speed of 10.5 knots. At the same time, the outbound tow *Mr. Earl*, pushing its barge in the Bayport Ship Channel, was about 600 feet off the starboard bow of the *Elka Apollon*.

With the rudder still at port 20, at 0903:14, the conning pilot on the *Elka Apollon* communicated on VHF radio with two towboats pushing barges ahead in the channel and south of his position. These towboats were traveling in the channel’s barge lanes, outside the main channel. The conning pilot asked for a two-whistle³⁶ passing arrangement with both tows. This radio call from the pilot on the *Elka Apollon* to the tows lasted about 17 seconds. At the same time, the *MSC Nederland* was proceeding dead slow ahead at about 5.9 knots about 0.4 nm south of the bend in the channel at beacons 75 and 76 (figure 9 in section 1.9 indicates the location of beacons 75 and 76). The two tows on the radio call from the pilot on the *Elka Apollon* were in the outbound barge lane outside the main channel and between the two deep-draft ships (see figure 10).

³⁵ Throughout this report, rudder commands are given as “port” or “starboard” followed by the degrees of rudder angle. Therefore, a “port 20” command indicates the rudder is set 20 degrees to port.

³⁶ “Two-whistle” in this case means the *Elka Apollon* intended to overtake the two towboats on their port sides.



Figure 10. Portion of VTS AIS display at 0902 on October 29, 2011, showing the *Elka Apollon* outbound and the *MSC Nederland* inbound (green squares near center and bottom right of screen, respectively) as they approach each other near the slight bend in the Houston Ship Channel and Five Mile Cut. The *Mr. Earl* is indicated by the uppermost yellow circle. The two other tows in the barge lane are labeled *Paddy* (yellow circle) and *Uncle Nu* (orange circle). Below the vessel name is its speed in knots. The dark blue areas near the vessel locations are radar images. (Original AIS vessel labels have been simplified for readability.)

Ten seconds after the conning pilot on the *Elka Apollon* completed his call to the tows, and with the rudder still at port 20, he called over VHF radio at 0903:41, “*Mr. Earl* don’t squeeze over here. I’m getting ready to—my stern’s getting ready to come your direction.” This was the first communication between the *Elka Apollon*’s pilot and the *Mr. Earl*’s crew and the first time the *Mr. Earl* was mentioned on the bridge of the *Elka Apollon* as captured by the ship’s voyage data recorder (VDR).³⁷ The master on the *Mr. Earl* responded, “Right yeah squeezing over.” The pilot maintained in interviews that the presence of the *Mr. Earl* caused him to use port rudder—“I wasn’t going to use any left wheel . . . [*Mr. Earl*] caused me to swing to port early and then I lost control.” However, bridge recordings do not support this assertion as the pilot on the *Elka Apollon* is heard giving the port rudder commands at least 1 minute before he first audibly acknowledged the proximity of the *Mr. Earl*. Given the timing of these events, the pilot more likely issued these rudder commands to adjust his position in the channel rather than to avoid the *Mr. Earl*.

³⁷ A VDR maintains continuous, sequential records of data relating to a ship’s equipment and its command and control and captures bridge audio from areas in the pilothouse and on the bridge wings. All passenger ships and all cargo ships of 3,000 or more gross tons (International Tonnage Convention) built on or after July 1, 2002, are required to carry VDRs when in international service.

The pilot next ordered the rudder to midship at 0903:54 and followed up with orders of starboard 20 at 0904:02 and hard starboard at 0904:06. During this time, at 0904:04, the nonconning pilot can be heard on the *Elka Apollon*'s VDR saying, "I don't know what he's thinking." In his interview he said he was referring to the captain of the tow *Mr. Earl*.

At 0904:43, the pilot on the *MSC Nederland* ordered the engine full ahead after receiving a radio call from the conning pilot on the *Elka Apollon*, 12 seconds later ordered rudder hard to port and "full ahead emergency sea speed," and then ordered the ship's collision alarm sounded.

At this same time the pilot on the *Elka Apollon* ordered hard starboard and emergency full ahead. The rudder and engine orders slowed the *Elka Apollon*'s rate of turn to port, but according to recorded electronic data, at impact the tanker was still turning to port at about 15 degrees per minute with a vessel speed of about 8 knots.

At 0904:59, the pilot on the *Elka Apollon* ordered the starboard anchor dropped and the master relayed the order via his handheld radio, but the anchor was never deployed. Dropping anchor at the *Elka Apollon*'s speed of 8 to 9 knots likely would have been ineffectual in mitigating the collision. The *Elka Apollon* continued across the channel and struck the *MSC Nederland* at 0905:26.

2.2 Hydrodynamic Forces and the *Elka Apollon*

As described in the previous section, the pilot on the *Elka Apollon* ordered a series of rudder commands as the tanker transited the Bayport flare. As illustrated in figure 11, the ship responded by turning to starboard, toward the right bank of the Houston Ship Channel south of the flare, and then turning toward the left side of the channel and colliding with the *MSC Nederland*. To determine the cause of this motion and assess the role of channel hydrodynamic bank effects,³⁸ the NTSB conducted a study to examine the forces and moments³⁹ on the *Elka Apollon* extracted from the ship's recorded motion.⁴⁰

³⁸ Bank effects include bow cushion and stern suction. When a ship operates in an area with a shoal or shallow water near the channel edge, a positive (high) pressure area builds up off the bow near the shallow water and pushes the bow away from the shallow water or bank. This effect is known as bow cushion. As the water flow moves down the vessel's side, a negative (low) pressure area builds up at the vessel's stern and moves the stern toward the shallow water or bank. This effect is known as stern suction. Stern suction is stronger than bow cushion and requires constant corrective rudder and increased power to overcome. See R. W. Rowe, *The Shiphandler's Guide*, 2nd edition (London: The Nautical Institute, 2007).

³⁹ In this context, "moment" refers to the product of quantity (as a force) and the distance to a particular axis or point.

⁴⁰ This report, *Elka Apollon* Kinematics Parameter Extraction Study, is included in the public docket for this accident at <http://www.nts.gov/investigations/dms.html>.



Figure 11. Trackline of the *Elka Apollon* (blue) and positions of the *MSC Nederland* (red) and the *Mr. Earl* (brown) at 0904:29, about 1 minute before the accident.

As the *Elka Apollon* progressed through the channel north of the Bayport flare, it was exposed to bank effects from both sides, which largely balanced each other out. However, because the vessel was slightly to the left of the channel centerline, the forces affecting its left side, trying to turn the vessel to starboard, dominated. As a result, the helmsman was applying primarily port rudder, averaging an angle of about 4 degrees, to maintain a steady course of 161 degrees over the last 2 minutes of that course order. When the vessel entered the relatively open waters of the Bayport flare, the forces acting on the vessel's right side diminished and no longer counteracted those of the left bank that had been causing and continued to cause a starboard yawing moment on the vessel.⁴¹

Figure 12 depicts rudder positions, the ship's position relative to the channel banks, and the yawing moment for the ship's motion just prior to the accident. As indicated by the green line, starboard yawing moment began to develop at 0901:50. As mentioned, the helmsman had been countering this starboard yaw with port rudder when, at 0902:10, near the center of the flare, the pilot ordered starboard 20. This starboard 20 order compounded the existing starboard yawing moment due to the influence of the left bank, accelerating the vessel sheer to starboard.⁴² The pilot's

⁴¹ Yawing moment is a turning force or torque about a ship's vertical axis that changes its heading.

⁴² In this context, vessel sheer is a deviation from its intended course.

subsequent increasing rudder orders to port reduced the vessel's starboard sideslip⁴³ and at 0903:10 began to turn the vessel away from the right bank.⁴⁴

Although the *Elka Apollon* had begun to turn to port, additional time elapsed before the movement to the right bank was arrested. According to depth readings, recorded by a sensor located forward of the bow thruster, about 0904 the depth under keel decreased to about 12 feet, substantially less than the 20-foot average shown when the *Elka Apollon* was in the center of the channel. This indicates that about this time the bow was very close to the right bank; given the depth sensor's location on the vessel and the heading of the tanker, the stern was even closer to the bank.

Upon approaching the right bank, the *Elka Apollon* began to experience further strong bank effect from bow cushion pushing the bow to port and stern suction pulling the stern toward the bank. This is evidenced by the lack of starboard yawing moment in response to the hard starboard order at 0904:06. The yawing moment from the hard starboard rudder was overwhelmed by the port yawing moment from the bank effects. Thus these commands could not check the vessel's course already set in motion across the channel's centerline and toward the *MSC Nederland*. Therefore, the pilot's initial starboard 20 command at 0902:10 set in motion a dynamic sequence from which he failed to recover.

⁴³ Sideslip is the angle between the bow and the direction the ship is moving. It results in a side force on the hull that turns the ship. Sideslip is not shown in figure 11 of this report but is plotted in figure 11 of the NTSB *Elka Apollon* Kinematics Parameter Extraction Study, which is available in the NTSB public docket for this accident at <http://dms.nts.gov/pubdms/search/hitlist.cfm?docketID=51957&CFID=30427&CFTOKEN=87956464>.

⁴⁴ This time was derived from the NTSB kinematics study cited in footnote 40.

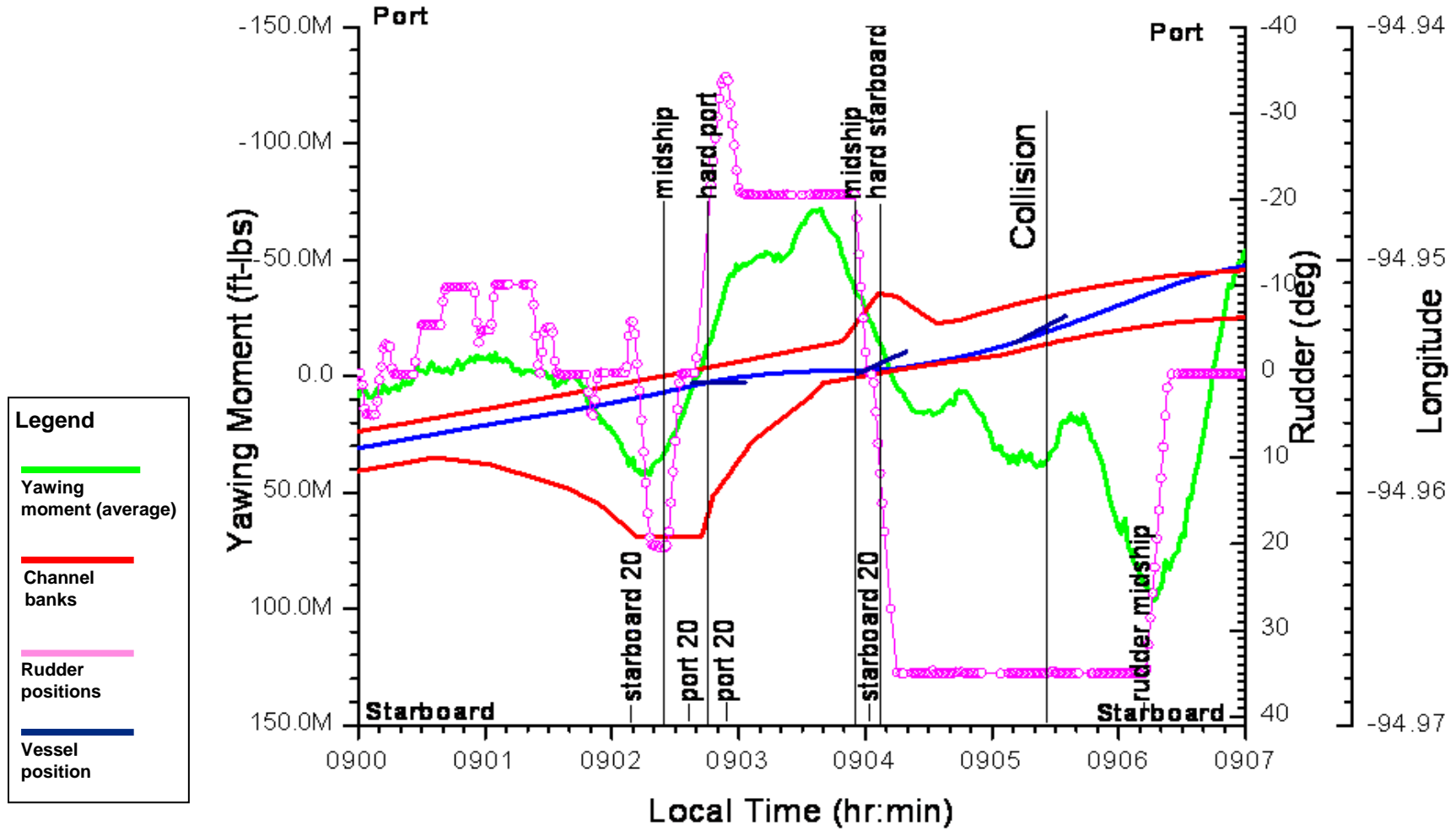


Figure 12. Rudder positions, average yawing moment, and position of the *Elka Apollon* over time as the vessel traveled south (from left to right on the plot) through the Bayport flare in the minutes prior to and just after the collision.

2.3 Inland Navigation Rules of the Road

The Inland Navigational Rules Act of 1980 set forth unified and updated inland navigation rules for vessels transiting the waterways of the United States.⁴⁵ Several of these “rules of the road” can be applied to the vessels involved in this collision, particularly the close-quarters situation that developed between the *Elka Apollon* and the towboat *Mr. Earl*.

Inland Navigation Rule 7, Risk of Collision, states that every vessel shall use all available means appropriate to determine if risk of collision exists and, if any doubt arises, consider that such a risk does exist. Further, assumptions are not to be made on the basis of “scanty information.”⁴⁶ After the pilot of the *Elka Apollon* said he initially determined the speed of the towboat with his PPU to be about 2.7 knots, he did not check again to confirm its speed had not changed. The pilot told investigators that he expected to pass ahead of the *Mr. Earl*. By not subsequently verifying the speed of the *Mr. Earl*, he failed to recognize that the *Mr. Earl*'s speed had increased and, therefore, a close-quarters situation could develop.

Inland Navigation Rule 8, Action to Avoid Collision, states that a vessel required not to impede the passage of another vessel shall “take early action to allow sufficient sea room for the safe passage of the other vessel.” The *Mr. Earl*'s captain likely believed that his vessel would not impede the outbound *Elka Apollon* because he intended to stay within the barge lane. The pilot on the *Elka Apollon* stated in his interview that he did not contact the *Mr. Earl* by radio as he approached the Bayport flare because he had determined earlier that the towboat would not exit the channel until after the *Elka Apollon* passed.

Inland Navigation Rule 9, Narrow Channels, provides instructions to vessels transiting confined waterways. As the *Elka Apollon* proceeded through the Houston Ship Channel, it could only navigate safely within the main channel boundaries or it would run aground. Rule 9(d) specifies that “a vessel shall not cross a narrow channel or fairway if such crossing impedes the passage of a vessel which can safely navigate only within that channel or fairway.” However, because the intersection of the Bayport Ship Channel with the Houston Ship Channel was a “T,” and the *Mr. Earl* captain had announced his intention to proceed southbound, the tow would only enter and proceed to the right.

Inland Navigation Rule 2, commonly referred to as the rule of good seamanship or special circumstance, governs responsibility on the part of all vessels and is always in effect:

- (a) *Exoneration.* Nothing in these Rules shall exonerate any vessel, or the owner, master, or crew thereof, from the consequences of any neglect to comply with these Rules or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.

⁴⁵ *Navigation Rules: International—Inland*, Revised and Corrected through Notice to Mariners 48 (29 November 2003), COMDTINST M16672.2D (Annapolis, MD: U.S. Department of Homeland Security, U.S. Coast Guard). The manual contains International Regulations for Prevention of Collisions at Sea, 1972 (72 COLREGS) and Inland Navigation Rules Act of 1980 (Public Law 96-591).

⁴⁶ Navigation rules 7, 8, 9, and 2 are codified at 33 CFR 83.07, 83.08, 83.09, and 83.02, respectively.

- (b) *Departure from rules when necessary to avoid immediate danger.* In construing and complying with these Rules due regard shall be had to all dangers of navigation and collision and to any special circumstances, including the limitations of the vessels involved, which may make a departure from these Rules necessary to avoid immediate danger.

The configuration of a barge lane alongside a main shipping channel, particularly at a busy intersection such as the Bayport and Houston Ship Channels, is a unique waterway arrangement, and the vessels were not in a standard meeting, crossing, or overtaking situation. By meeting at the junction of the Bayport and Houston Ship Channels, the vessel operators unnecessarily placed their vessels at risk.

3. Safety Issues

NTSB investigators examined weather and waterway conditions, the experience and health of the ships' personnel, actions taken by vessel pilots and crew and VTS personnel, VDR recordings, data from the pilots' PPUs, and VTS communications. NTSB staff also examined engineering and hydrodynamic aspects of the vessels' transits. Based on this information, investigators excluded several factors and identified safety issues that warrant consideration of measures to mitigate or prevent the circumstances that resulted in the collision of the *Elka Apollon* and the *MSC Nederland*.

On the morning of the accident, visibility on the waterway was unlimited, and a light wind was from the north. Houston Ship Channel aids to navigation were found to be in place and functioning properly. Examination of the vessels and discussion with crewmembers revealed no propulsion, steering, or other mechanical problems. All crewmembers directly involved in the accident were tested for alcohol and illegal drugs, and all results were negative. The NTSB therefore concludes that the following were not factors in this accident: weather and environmental conditions, visibility, aids to navigation, vessel propulsion and steering systems, and use of alcohol or illegal drugs.

The pilot on the *Elka Apollon* radioed the pilot on the *MSC Nederland* about a minute before the collision to ask him to speed up. After hearing the *Elka Apollon*'s radio call, the pilot on the *MSC Nederland* ordered the rudder hard to port, then the engine full ahead and emergency sea speed in an effort to maneuver out of the path of the *Elka Apollon* or to minimize the force of the impact. He then ordered the ship's collision alarm sounded. Therefore, the NTSB concludes that the actions of the pilot navigating the *MSC Nederland* were appropriate and effective in reducing the amount of damage sustained by both vessels.

Upon learning of the accident, VTS controllers and the watch supervisor reacted quickly. The VTS watch supervisor and the Coast Guard Sector Houston–Galveston situation controller took action to report and record necessary information, learn the condition of the vessels and their crews, and ensure the ships were relocated out of the waterway to safe and unobstructive positions. They determined the nature of the damage, particularly the contents and condition of the cargo containers, to prevent any potential environmental impact. They promptly dispatched vessels to investigate the area and attempt to retrieve the missing rescue boat and life rafts from the *MSC Nederland*. The NTSB concludes that the response to the accident by U.S. Coast Guard Sector Houston–Galveston, including the Vessel Traffic Service, was timely and appropriate.

3.1 Piloting Challenges and the Waterway

The challenges inherent in navigating the Houston Ship Channel are significant, particularly at the helm of a deep-draft vessel. In analyzing the accident circumstances, investigators recognized several factors that could have contributed to the collision.

Like many inland ship channels, the Houston Ship Channel is a relatively narrow waterway. When two large vessels meet in a narrow waterway, the margin for error is greatly

reduced. The main Houston Ship Channel in which deep-draft vessels transit is 530 feet wide. The *Elka Apollon*'s beam was 138 feet, and the *MSC Nederland*'s beam was 106 feet, leaving less than 300 feet total for clearance between the two vessels and between each vessel and the edge of the main channel. In addition, just north of the accident site, bank effect diminishes and hydrodynamic forces become more variable because the waterway becomes wider as it intersects the Bayport flare. As the channel constricts again upon passing the flare, bank effects again increase. Pilots must remain particularly vigilant as these changing forces act on the vessels they are conning.

Another significant factor pilots must address is vessel speed, as they are well aware of the challenges of maintaining a speed appropriate to ensure vessel control without adversely affecting neighboring interests sharing the waterway. At the same time, the vessel's speed must satisfy the need for timely transit and allow continual movement of commerce within the port. Interview comments and observations by NTSB investigators suggest that the speed of the *Elka Apollon* was a commonly accepted rate through the accident vicinity. However, speed is crucial in the creation of bank effect forces because the magnitude of the forces varies with the square of the ship's speed or water flow.⁴⁷ In this accident, bank effect played a significant part in the pilot's loss of control of the *Elka Apollon*. Statements by all three pilots involved and a review of AIS historical data indicate that the *Elka Apollon*'s speed was not excessive. Nonetheless, any mistake, misjudgment, mechanical failure, or other complication will be exacerbated and therefore more difficult to overcome with higher vessel speed in an area with little margin for error.

In addition, on the day of the accident, traffic volume was high due to an influx of towing vessels into the channel after dissipation of the previous day's high winds. Three towing vessels were in the vicinity of the accident—the *Mr. Earl*, which was departing the Bayport Ship Channel, and two other tows which were farther south of the Bayport flare in the outbound barge lane. The latter two vessels were close enough to the *Elka Apollon* to prompt a radio call from the conning pilot regarding passing arrangements as the pilot on the *Elka Apollon* expected to overtake them shortly. Also at this time, the conning pilot was actively issuing rudder commands to the helmsman to maneuver the *Elka Apollon* into position to meet the inbound *MSC Nederland*. Prior to the accident, none of the pilots involved in the accident believed the proposed traffic scenario was an unsafe situation or could not be executed normally. However, the increased number of tasks due to traffic in the waterway raised the cognitive workload of the pilot conning the *Elka Apollon*.

The NTSB therefore concludes that the combination of the narrow waterway, bank effects at the Bayport flare, traffic density, and vessel speed increased the challenges for the pilot on the *Elka Apollon* in a waterway with a limited margin for error.

In addition, the trim of a vessel affects its handling characteristics. The *Elka Apollon* was partially loaded and evenly trimmed when it left the dock in Houston the day of the accident; that is, the ship had the same draft forward and aft. Had the *Elka Apollon* been trimmed by the stern, as opposed to the even keel trim existing at the time of the accident, its handling characteristics would have been improved. According to a widely used shiphandling text, "The steering

⁴⁷ R. W. Rowe, p. 65.

characteristics of a ship on an even keel vary depending on the ship's hull form. A ship with a large block coefficient^[48] steers poorly, tending to be directionally unstable.^[49] This condition is amplified if the ship trims by the head as she enters shallow water."⁵⁰ As a tanker, the *Elka Apollon* had a "full" hull form with a large block coefficient, and the vessel was transiting a relatively shallow channel. Further, evenly trimmed, full vessels tend to trim by the head (go down by the bow) proportionally with increased speed, meaning the draft forward will increase while the draft aft will decrease.

Maintaining a deeper draft aft than at the bow, known as stern trim, is important because as a ship's stern trim increases, it becomes more directionally stable and "from a shiphandler's point of view ... a ship steers better" as a result; a less stable ship requires "more rudder for a longer period of time [to check its swing] than is required to start that swing."⁵¹

In a previous accident,⁵² a loaded tanker of similar size also was evenly trimmed while transiting a channel and was involved in a sheering incident that led to a collision. As a result, the ship's operating company conducted a maneuvering study⁵³ of the accident tanker. Based on the study results, the company took steps to mitigate possible future occurrences by ordering all its vessels operating in that waterway to transit the area with a stern trim of at least 1 foot to provide increased vessel maneuverability.

When the *Elka Apollon* departed with an even trim, it still had at least 10 feet of clearance under the keel and could easily have accommodated a trim by the stern. Although both pilots stated they did not experience problems handling the *Elka Apollon*, trim by the stern would have improved vessel handling characteristics.

The dangers inherent in large vessels transiting narrow waterways were examined during a 2001 workshop that brought together channel designers, pilots and ship operators, and naval architects.⁵⁴ The resulting report noted that, in addition to limiting the size of ships that may transit a given waterway, safe use of U.S. waterways requires a "means of determining when special measures must be imposed on harder to handle ships. . . ." Recommendations also acknowledged "the importance (and difficulty) of the passing maneuver in restricted waters. While greater speed means greater control, it also means much bigger forces to overcome." Further, the report pointed out that economies of scale lead to larger vessels with greater capacities and that vessel beam is more likely to increase before other dimensions. This results in

⁴⁸ Block coefficient is the ratio of the volume of a ship's displacement to the volume of a rectangular box around the submerged portion of a ship's hull.

⁴⁹ The *ABS Guide for Vessel Maneuverability* states, "An important aspect of maneuverability is the ability of a vessel to stay on course." Directional stability is the tendency of a ship to maintain a straight-line course with the rudder angle at zero, or amidships.

⁵⁰ D. H. MacElrevey, *Shiphandling for the Mariner*, 2nd ed. (Cambridge, MD: Cornell Maritime Press, 1988). pp. 49-52.

⁵¹ *Shiphandling for the Mariner*, pp. 49-52.

⁵² *Collision of Tankship Eagle Otome with Cargo Vessel Gull Arrow and Subsequent Collision with the Dixie Vengeance Tow, Sabine-Neches Canal, January 23, 2010*, Marine Accident Report NTSB/MAR-11/04 (Washington, DC: National Transportation Safety Board, 2011).

⁵³ ABS Consulting, *Vessel Maneuvering Study, Eagle Otome*, PID 2464289, 3/1/2011.

⁵⁴ International Workshop on Channel Design and Vessel Maneuverability, Society of Naval Architects and Marine Engineers, New York Metropolitan Section, Norfolk, Virginia, May 3-4, 2001.

wider vessels transiting existing waterways without waiting for lengthy channel widening projects to be completed.⁵⁵ In short, the challenges faced in this accident not only are already well known but also are likely to intensify.

3.2 Close Quarters between the *Elka Apollon* and the *Mr. Earl*

In his interviews with investigators, the Houston pilot conning the *Elka Apollon* referred to a developing close-quarters situation with the *Mr. Earl* as a cause for the collision with the *MSC Nederland*. He indicated that he issued several rudder orders to port to avoid the tow as it exited the Bayport channel to enter the outbound Houston Ship Channel barge lane. However, NTSB investigators do not consider this close-quarters situation a factor in the *Elka Apollon*'s collision with the *MSC Nederland*. Nevertheless, at the time the near miss occurred, the proximity of the vessels compromised the margin of safety between the *Elka Apollon* and the *Mr. Earl*, and the captain of the *Mr. Earl* and the pilot of the *Elka Apollon* could have done more to prevent such an encounter.

If either or both operators had contacted the other, noted the circumstances, and initiated early and substantial action to avoid the close quarters, the situation could have been avoided. Given the speeds of both vessels and the equipment on board, the operators could have anticipated that they would likely be passing close by one another. The captain of the towboat *Mr. Earl* acknowledged during his interview that he could have held up had the pilot on the *Elka Apollon* asked him to do so. However, the NTSB notes he also could have taken action on his own to prevent the close passing.

The pilot on the *Elka Apollon* knew the *Mr. Earl* was outbound due to the VTS traffic report he received before taking the conn. He said he also identified the vessel visually and acquired its speed and position with the PPU shared by the two Houston pilots. He said that, when he checked, the *Mr. Earl* was moving at about 2.7 knots, and he determined that the *Elka Apollon* would pass the *Mr. Earl* before the tow came out of the Bayport channel. Further, he considered the normal routine would have been for the tow emerging from Bayport to call any deep-draft vessels on the Houston Ship Channel. He said he was taught during his time on tugboats "to stay out of the way of a ship."

During interviews, the conning pilot of the *Elka Apollon* stated he had no intention of using left rudder as he shaped up the tanker for the next course to meet and pass the *MSC Nederland*. He planned to bring his vessel close to the right bank south of the Bayport flare and let the bank cushion push him off. He stated that he only ordered left rudder after being alerted to the *Mr. Earl*'s presence by the nonconning pilot. However, VDR transcripts show that the conning pilot was communicating by radio with the captain of the *Mr. Earl*, warning him "don't squeeze over here" and alerting him to the *Elka Apollon*'s stern swinging towards him after the port rudder orders were already given. The alert from the nonconning pilot came 1 minute 4 seconds after the first of a sequence of port rudder commands were given.

⁵⁵ W. O. Gray and others, "Channel Design and Vessel Maneuverability – Next Steps: "When Ships Get Too Big for Their Ditches," report of the International Workshop on Channel Design and Vessel Maneuverability (Norfolk, VA: Society of Naval Architects and Marine Engineers, 2002).

Further, port rudder commands at this time were prudent, if not necessary, to attempt to counter the starboard sheering motion that had developed. Without them, given the speed and angle at which the vessel was approaching the right bank near the southern end of the Bayport flare, the vessel could have run aground. Stopping port rudder earlier would have minimized the subsequent swing to port and across the channel; however, as mentioned above, the *Elka Apollon* did reach the right bank of the channel, indicating the potential for a grounding.

While the conning pilot ordered the rudder to hard port and then eased to port 20, he was calling and discussing overtaking arrangements with two tows in the barge lane ahead of the *Mr. Earl*. When the conning pilot contacted the *Mr. Earl* he spoke calmly, with no apparent indication of imminent concern. The position and course over ground of the *Elka Apollon* at that time showed the vessel closing in on the right bank and the outside limit of the main channel. As noted in the discussion of hydrodynamics, the conning pilot's rudder commands were not sufficiently effective because of the hydrodynamic forces acting on the *Elka Apollon* due to its position along the bank.

Several navigation rules were relevant to the meeting of the *Elka Apollon* and the *Mr. Earl*, and the accident suggests that both the pilot and the towboat captain should have practiced more responsible seamanship. For example, although the towboat master believed that entering the barge lane while a deep-draft vessel was transiting was routine, this movement created unnecessary and inherently unsafe proximity with the much larger vessel. The pilot on the *Elka Apollon* faced a greater challenge in maneuvering his ship than did the towboat captain. The *Elka Apollon* was more difficult to handle, slower to respond, and restricted to the depths of the center channel. The pilot therefore bore a greater share of the responsibility to ensure communication with the outbound towboat planning to enter the Houston Ship Channel to verify the towboat captain's intentions and agree to a more appropriate meeting and passing arrangement.

Both operators believed they were maneuvering correctly and were sufficiently skilled to keep to their prescribed lanes and out of each other's way, but they did not take all available measures to avoid passing too closely. The NTSB concludes that the pilot on the *Elka Apollon* and the captain of the *Mr. Earl* should have exercised prudent seamanship by communicating with each other about their intentions and taking early and sufficient action to avoid their subsequent close-quarters situation. The NTSB concludes that, given the presence of the *Elka Apollon*, a deep-draft tanker, the captain of the towboat *Mr. Earl* should not have turned into the Houston Ship Channel barge lane as the *Elka Apollon* was passing. However, the NTSB further concludes that, given that the *Elka Apollon* conning pilot's rudder commands preceded his awareness of the *Mr. Earl*'s position and because hydrodynamic forces were already affecting the *Elka Apollon*'s course, the close-quarters situation that developed with the *Mr. Earl* was not a factor in the collision with the *MSC Nederland*.

3.3 Pilot Actions

Investigators considered the background and extensive experience of the pilot conning the *Elka Apollon* in guiding vessels of all sizes through the Houston Ship Channel in relation to his actions leading up to the collision. During more than 20 years of experience as a Houston

pilot, he stated he made at least 10,000 transits in the channel. His experience included piloting large vessels through the Bayport flare in varying weather and a range of various traffic conditions. Given this extensive experience, NTSB investigators ruled out a lack of familiarity with the hydrodynamic forces a large vessel would encounter while traversing the Bayport flare in close proximity to other vessels as an explanation for his actions.

Investigators also considered medical factors. The pilot was 59 years old at the time of the accident and was in excellent health according to his Coast Guard medical evaluation form. He was taking no medications and had no vision or hearing limitations. Therefore, medical factors were ruled out as a possible cause of his error.

The pilot told investigators he could not recall the times he went to sleep and the times he woke up in the days immediately preceding the accident. However, he worked alternate day and night schedules, rising early to work a morning schedule the day before and the day of the accident after working the previous two nights. He said he was not fatigued at the time of the accident, but considerable evidence discounts the accuracy of a person's judgment regarding his or her performance decrement from fatigue.⁵⁶ Without his actual sleep schedule, the evidence is insufficient to determine whether he was fatigued.

NTSB examined the VDR transcript to assess the pilot's precise activities when he was entering and traversing the Bayport flare to determine whether he was distracted. The VDR transcript reveals that for about 10 minutes before entering the Bayport flare, he was engaged in intermittent conversations with the nonconning pilot that were not pertinent to operating the vessel. In the minute before the starboard 20 rudder command, however, no recorded conversation was attributed to the conning pilot. NTSB investigators determined the conning pilot's conversation would not have prevented him from appropriately responding to the hydrodynamic forces on the *Elka Apollon*.

As noted in section 2.2, "Hydrodynamic Forces and the *Elka Apollon*," the helmsman was intermittently applying varying degrees of port rudder to keep the tanker on a steady course prior to the pilot's starboard 20 command in the Bayport flare. To neutralize the bank effect of bow cushion working on the port bow of the vessel, the helmsman had to steer against this force. The conning pilot's starboard 20 order started the vessel on a path toward the southern bank of the Bayport flare. The pilot gave this starboard rudder order to initiate the port-to-port meeting with the inbound *MSC Nederland*. This starboard rudder command was either too much or was maintained for too long or a combination of the two because the vessel's movement to the right continued beyond what was intended. His subsequent port rudder commands were likewise either not large enough, not applied soon enough, or a combination of both to check the starboard movement of the tanker (this is depicted in figures 11 and 12). These port rudder commands, while appropriate for attempting to keep the vessel off the bank, were applied for too long and acted in concert with the hydrodynamic forces (bow cushion) from the channel's west bank, sending the *Elka Apollon* across the channel and into the *MSC Nederland*. The conning pilot's starboard rudder commands, ordered in an attempt to turn away from the *MSC Nederland*, were

⁵⁶ See, for example, T. J. Balkina and others, "The challenges and opportunities of technological approaches to fatigue management," *Accident Analysis and Prevention*, vol. 43 (2011), pp. 565–572, and T. Roehrs and others, "Ethanol and Sleep Loss: A 'Dose' Comparison of Impairing Effects," *Sleep*, vol. 26 (2003), pp. 981–985.

negated due to the tanker's proximity with the west bank and the hydrodynamic forces (stern suction) that neutralized the effectiveness of the rudder.

The NTSB therefore concludes that the conning pilot on the *Elka Apollon* did not appropriately respond to the varying hydrodynamic forces affecting the vessel during its transit of the Bayport flare, resulting in the pilot's inability to alter the *Elka Apollon's* course sufficiently to avoid the collision with the *MSC Nederland*.

3.4 Traffic Management in the Houston Ship Channel

Recognizing that the Houston Ship Channel presents particular challenges—high traffic volume, areas of converging traffic, and channel width and depth limits among them—the Coast Guard designated 14 precautionary areas in the Houston Ship Channel vicinity. The current accident occurred in the Bayport Channel Precautionary Area, which is centered at the intersection of the Bayport Ship Channel and the Houston Ship Channel.

In investigating a previous accident in August 2011 involving a collision at the intersection of the Texas City Channel and the Gulf Intracoastal Waterway, the NTSB determined that the towing vessel *Alliance*, pushing two barges, encroached into the path of the tanker *Naticina* despite a passing arrangement agreed to by personnel on both vessels. Due to the encroachment, the lead barge of the *Alliance* struck the *Naticina*. As in the current accident, vessels transiting designated precautionary areas were in close proximity. These locations—the Bayport Channel and Bolivar Roads Precautionary Areas—were in VTS areas of operation. Both accident areas were being monitored by VTS personnel. In the *Naticina–Alliance* accident, not only was the conversation recorded, but VTS watchstanding personnel heard the passing agreement exchanged between the vessel operators.

Given the occurrence of these accidents in VTS areas of operation, the NTSB examined how VTS could have enhanced safety on the waterway. VTS relies primarily on AIS data from vessels and returns from radar stations (if equipped) located along waterways. Vessel position data are updated on VTS controller displays every 2 to 10 seconds for underway vessels, depending on their speed. These displays may not consistently show both types of data, as radar or AIS data may not be consistently obtained. Further, the geographic areas of the waterways VTS monitors are often extensive. These factors make it difficult for VTS controllers to intercede with operators who have access to more accurate, real-time positional information regarding their vessels and the situation around them, especially when the vessels are in close proximity. Moreover, technological advances such as AIS, which was developed after VTS systems were implemented, provide previously unavailable navigation information to mariners regarding nearby vessels. Therefore, the primary means of collision avoidance in narrow waterways has been, and for the near future will likely continue to be, the actions and decisions of operators on the bridges of vessels traversing the waterways.

Nonetheless, the circumstances of this accident demonstrate that VTS enabled the Coast Guard to enhance safety in the Houston Ship Channel because following the accident, the Coast Guard, through its VTS, stopped vessel traffic in the channel until it was assured that the waterway was clear for safe passage. However, the Coast Guard lacks a viable means to take similar

action in a waterway before an accident. As in the *Alliance–Naticina* accident, the *Elka Apollon* and *Mr. Earl*'s close-quarters situation demonstrated the need for sufficient vessel separation to mitigate the risk of collision in these areas. The VTS Houston–Galveston informal review of the *Elka Apollon* accident proposed a similar strategy to improve the safety of Houston Ship Channel operations by suggesting that VTS “become more proactive”⁵⁷ in managing traffic. VTS is the mechanism through which the Coast Guard could mitigate traffic congestion in waterways, such as precautionary areas, where congestion can adversely affect safety.

The circumstances of this accident—the high volume of traffic following the cessation of adverse weather, converging traffic in a precautionary area, and the unique characteristics of the Houston Ship Channel—suggest the need for the Coast Guard to mitigate potentially dangerous traffic situations in the channel. Therefore, the NTSB concludes that a U.S. Coast Guard policy to mitigate traffic congestion in precautionary areas of the Houston Ship Channel would enhance safety. The NTSB recommends that the U.S. Coast Guard develop and implement a policy to ensure adequate separation between vessels operating in the Bayport Channel and Bolivar Roads Precautionary Areas and any other similarly configured precautionary areas in the Houston Ship Channel.

Federal regulations define the precautionary areas in the Houston Ship Channel and require the vessel operator to “navigate with particular caution” in such areas. Nautical charts for the Houston Ship Channel do not graphically identify precautionary areas or note them in any form, nor are they required to do so. The pilots on the *Elka Apollon* and *MSC Nederland* and the captain of the *Mr. Earl*, however, had considerable experience in this area and thus were fully aware of the need for caution when transiting the area of the Bayport flare, regardless of whether the precautionary area was designated on the nautical chart. Mariners not familiar with the waterway, on the other hand, would gain by noting those areas specifically depicted on the chart. These mariners unfamiliar with the channel might otherwise be unaware of the location of these precautionary areas. Mariners are accustomed to looking for and finding precautionary areas on nautical charts, specifically when approaching major harbors and areas of the inland waters of some U.S. ports. Such areas historically have been graphically depicted on U.S. nautical charts. Therefore, the NTSB concludes that, because precautionary areas are not currently identified on Houston Ship Channel navigation charts, mariners may be unaware of the existence and location of these areas. The NTSB therefore recommends that the U.S. Coast Guard graphically delineate precautionary areas on appropriate Houston Ship Channel nautical charts so they are readily identifiable to mariners.

⁵⁷ See footnote 17 regarding the Coast Guard’s internal review of this collision.

4. Conclusions

4.1 Findings

1. The following were not factors in this accident: weather and environmental conditions, visibility, aids to navigation, vessel propulsion and steering systems, and use of alcohol or illegal drugs.
2. The combination of the narrow waterway, bank effects at the Bayport flare, traffic density, and vessel speed increased the challenges for the pilot on the *Elka Apollon* in a waterway with a limited margin for error.
3. The pilot on the *Elka Apollon* and the captain of the *Mr. Earl* should have exercised prudent seamanship by communicating with each other about their intentions and taking early and sufficient action to avoid their subsequent close-quarters situation.
4. The conning pilot on the *Elka Apollon* did not appropriately respond to the varying hydrodynamic forces affecting the vessel during its transit of the Bayport flare, resulting in the pilot's inability to alter the *Elka Apollon*'s course sufficiently to avoid the collision with the *MSC Nederland*.
5. Given the presence of the *Elka Apollon*, a deep-draft tanker, the captain of the towboat *Mr. Earl* should not have turned into the Houston Ship Channel barge lane as the *Elka Apollon* was passing.
6. The timing of the rudder commands by the pilot of the *Elka Apollon* suggest that the close-quarters situation that later developed with the *Mr. Earl* was not a factor in the collision with the *MSC Nederland*.
7. The actions of the pilot navigating the *MSC Nederland* were appropriate and effective in reducing the amount of damage sustained by both vessels.
8. The response to the accident by U.S. Coast Guard Sector Houston–Galveston, including the Vessel Traffic Service, was timely and appropriate.
9. A U.S. Coast Guard policy to mitigate traffic congestion in precautionary areas of the Houston Ship Channel would enhance safety.
10. Because precautionary areas are not currently identified on Houston Ship Channel navigation charts, mariners may be unaware of the existence and location of these areas.

4.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the collision between the *Elka Apollon* and the *MSC Nederland* was the failure of the pilot conning the *Elka Apollon* to appropriately respond to changes in bank effect forces as the vessel transited the Bayport flare, causing the vessel to sheer across the channel and into the *MSC Nederland*. Contributing to the accident was the combination of the narrow waterway, bank effects at the Bayport flare, and traffic density at the time, which increased the challenges in a waterway with a limited margin for error.

5. Recommendations

As a result of this investigation, the National Transportation Safety Board makes the following recommendations:

To the U.S. Coast Guard:

Develop and implement a policy to ensure adequate separation between vessels operating in the Bayport Channel and Bolivar Roads Precautionary Areas and any other similarly configured precautionary areas in the Houston Ship Channel.

(M-12-6)

Graphically delineate precautionary areas on appropriate Houston Ship Channel nautical charts so they are readily identifiable to mariners. (M-12-7)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

DEBORAH A.P. HERSMAN
Chairman

ROBERT L. SUMWALT
Member

CHRISTOPHER A. HART
Vice Chairman

MARK R. ROSEKIND
Member

EARL F. WEENER
Member

Adopted: September 25, 2012

Chairman Hersman and Members Rosekind and Weener filed the following statements.

6. Chairman and Board Member Statements

Chairman Deborah A. P. Hersman, concurring in part, dissenting in part:

First, I support the adoption of the final report because it identifies and addresses many important issues. In particular, I appreciate how far the Coast Guard and the NTSB have come by recognizing the potential for VTS to be more proactive. I look forward to seeing process improvements that will enhance safety and prevent accidents.

Regarding this accident, we see an experienced pilot who has traveled the ship channel thousands of times—safely and uneventfully. But on this voyage he didn't anticipate what was required to safely manage the vessel he was piloting as it approached other vessels in this section of the channel. Why? Many would say that he just didn't perform well that day and sometimes people just make mistakes.

At the NTSB we have long seen the value of properly assessing risks, thinking and planning ahead, and communicating clearly. In our investigations we have seen airline pilots line up aircraft on the wrong runway, conductors forget to re-line a switch for the main track, and distractions in all modes of transportation result in tragic events. None of us is perfect. In our daily lives we all have momentary lapses in which we incorrectly prioritize our tasks (the toast gets burned), respond inappropriately to information or input (it takes us a couple of tries to parallel park), or commit errors of omission or commission (we forget to retrieve a document from the printer). Mistakes can and do happen. However, in transportation, there is an extremely low tolerance for error.

A possible explanation for the collision in this case was the failure of the conning pilot of the *Elka Apollon* to prioritize his tasks and allow nonpertinent conversations with the nonconning pilot to distract him from his primary responsibilities. For example, he did not communicate with the tug, *Mr. Earl*, or with two other tugs in the channel (*Paddy Cenac* and *Uncle Nu*) until he was in a very high workload period and moments before the near-collision with the *Mr. Earl* and the collision with the *MSC Nederland*.

The following timeline highlights key decision points and pilot actions captured by the VDR:

0851:35 through 0901:11 — in the minutes leading up to the accident the conning and nonconning pilots of the *Elka Apollon* engage in substantial nonpertinent conversations unrelated to the vessel's navigation. (These conversations are interspersed with radio communications and ship-related comments.)

0853:59 — the pilot of the tug, *Mr. Earl*, broadcasts over the VHF radio his progress and intentions to exit the Bayport Ship Channel and turn outbound. The conning pilot of the *Elka Apollon* did not, at this time or during the next 9 minutes, contact the *Mr. Earl*.

0854:58 — the conning pilot of the *Elka Apollon* contacts the *MSC Nederland* regarding a suitable meeting arrangement.

0902:10 through 0902:54 — the conning pilot issues a series of rudder commands:

0902:10 — starboard twenty.

0902:25 — midship.

0902:37 — port twenty.

0902:46 — hard port.

0902:54 — port twenty.

0903:14, 0903:23, 0903:41 — following the “port twenty” command, rather than continue to guide and direct the vessel, the conning pilot engages in radio communications with the three tugboats, calling the *Paddy Cenac* (0903:14) and *Uncle Nu* (0903:23) to arrange meeting points and then communicating for the first time with the *Mr. Earl* (0903:41): “*Mr. Earl* don’t squeeze over here. I’m getting ready to — my stern’s getting ready to come your direction.” The towboat master on the *Mr. Earl* responds back, “Right, yeah, squeezing over.”

0903:54 — midship.

0904:02 — starboard twenty.

0904:04 — the nonconning pilot of the *Elka Apollon* stated, “I don’t know what he’s [pilot on the *Mr. Earl*] thinking.”

0904:06 — hard starboard.

0904:16 — “#getting ready to hit us.”

0904:28 — the conning pilot of the *Elka Apollon* calls the pilot of the *MSC Nederland*, asking him to speed up because he is getting ready to come his way.

But by then it was too late.

0905:26 — the *Elka Apollon* continues across the channel, and strikes the *MSC Nederland*.

During this high workload period, the conning pilot essentially got behind in navigating the vessel (his primary responsibility) as he focused on lesser priorities. The close-quarters situation between the *Elka Apollon* and the *Mr. Earl* could have been avoided if the vessels had communicated with each other earlier and developed a plan to avoid the close-quarters situation.

The NTSB has addressed issues related to nonpertinent conversation in previous accident investigations. For example, in the August 26, 2006, accident in which Comair flight 5191 lined up on the wrong runway and crashed during takeoff in Lexington, Kentucky, we concluded that a contributing factor to the accident was the flight crew's nonpertinent conversation during the taxi, which resulted in a loss of positional awareness.⁵⁸

Similarly, in the American Airlines in-flight engine fire in St. Louis on September 28, 2007, we concluded that the casual atmosphere in the cockpit before takeoff eroded the margins of safety provided by the standard operating procedures and checklists and that the pilots failed to properly allocate tasks, including checklist execution and radio communications, and did not effectively manage their workload; this adversely affected their ability to conduct essential cockpit tasks.⁵⁹

Yes, these situations identify pilots who made mistakes, and perhaps we could leave it at that. However, understanding what caused an otherwise good pilot to make a mistake is why the NTSB has human factors experts and listens closely to the dialogue on the VDR. Therefore, I believe that it would have been helpful to highlight in the accident report why we believe there was this lapse of vigilance of the conning pilot of the *Elka Apollon*, by adding the following additional contributing factor to the accident:

The conning pilot was distracted from his primary task of safely guiding the vessel by nonpertinent conversations with the nonconning pilot and failed to prioritize his tasks resulting in late radio calls with the three barges and his close-quarters situation with the *Mr. Earl*.

Guiding vessels through the Houston Ship Channel is a tremendous challenge—my hat is off to the pilots who do this successfully every day. However, because it requires such intense concentration and engagement, pilots would benefit from further consideration of when and how they communicate with those both on and off the bridge.

Members Sumwalt and Rosekind concurred with this statement.

⁵⁸ For more information, see *Attempted Takeoff From Wrong Runway, Comair Flight 5191, Bombardier CL-600-2B19, N431CA, Lexington, Kentucky, August 27, 2006*, Aircraft Accident Report NTSB/AAR-07/05 (Washington: National Transportation Safety Board, 2007) at <http://www.nts.gov/doclib/reports/2007/AAR0705.pdf>.

⁵⁹ For more information, see *In-Flight Left Engine Fire, American Airlines Flight 1400, McDonnell Douglas DC-9-82, N454AA, St. Louis, Missouri, September 28, 2007*, Aircraft Accident Report NTSB/AAR-09/03 (Washington, DC: National Transportation Safety Board, 2009) at <http://www.nts.gov/doclib/reports/2009/AAR0903.pdf>.

Member Mark R. Rosekind, concurring in part, dissenting in part:

Overall, I support the final report and commend the staff for their efforts. In particular, the VTS recommendation addresses an area where existing resources can provide a greater margin of safety in this marine environment. At the board meeting, however, the discussion identified several areas that would further improve this accident investigation report, and these deserve attention.

First, there is an inconsistency in how the interactions between the *Elka Apollon* and *Mr. Earl* are addressed in the report. Findings 3, 5, and 6 highlight the lack of communication between the two vessels. While the conning pilot of the *Elka Apollon* did not communicate well with the *Mr. Earl* or use all available resources to maintain situational awareness, the captain of the *Mr. Earl* could have increased communication with the *Elka Apollon* and not turned into the barge lane as the *Elka Apollon* was passing. Yet in spite of these findings, the *Mr. Earl's* actions and inactions are excluded from having played a role in the accident. The findings are inconsistent given the other contributing factors subsequently added to the probable cause.

Second, one of the strengths of the report also reveals a weakness. It emphasizes the need for proper planning and attention to mission-critical tasks and therefore highlights an area that should be addressed further—*distraction*. If there is anything we can conclude from scores of NTSB investigations across all modes it is that a distraction is a distraction irrespective of whether it arises from a noncritical work-related source or non-work-related peripheral matter—for example, cell phone use. If any distraction in some way interferes with the safety of transportation operations, then it deserves to be highlighted in the report.

In this case, certain distractions that caught the attention of the conning pilot of the *Elka Apollon* were characterized as “noncritical interactions” and de-emphasized in the queue of events leading to the collision. For example, immediately following one of the conning pilot’s rudder commands, he communicated with tugboats in the channel, calling the *Paddy Cenac* and *Uncle Nu* to arrange meeting points. While these interactions may have been work-related, they were non-critical and distracted the conning pilot from critical steps necessary for operating safely in the channel. These work-related distractions can be viewed just as seriously as talking on a cell phone while driving a car. Highlighting these for what they are—even though part of the workload—are important to getting a complete picture of the events contributing to the accident and understanding more of the conning pilot’s actions and environment leading up to the collision.

Third, at the board meeting, contributing factors related to navigating this challenging area—“the narrow waterway, bank effects at the Bayport flare, and traffic density”—were added to the report. The distractions, however, caused by nonpriority communications such as the tugboats and *Mr. Earl's* location (lack of communication and movement into the barge lane) are not identified for their role as contributing factors in this accident.

Lastly, it is important to note that it was only at the board meeting—when the conning pilot’s “lapse of vigilance” was first described—that the possibility of fatigue emerged as an area warranting further consideration. It is not represented this way anywhere in the report. As the

long list of exclusions related to experience, weather, etc., was repeated and discussion began to focus on why this error occurred in this particular circumstance, this vigilance lapse becomes critical. From a behavioral standpoint, however, there are several potential performance decrements that could have been fatigue related: the *Elka Apollon's* very experienced pilot's preoccupation with secondary details and distractions, lack of timely engagement in essential operational tasks, and diminished performance in a waterway requiring a high level of vigilance and alertness. All of these performance issues raise concerns about the presence of fatigue. This is particularly relevant in light of the pilot's 4:30 a.m. wake time that day when he was summoned to work after being roused from sleep. It seems that there may be evidence suggesting that fatigue should have been investigated in greater detail.

This point once again emphasizes the importance of fatigue considerations in accident investigations, applied consistently across all modes. There may be information that could have been examined further and potentially connected in this report, from behavioral patterns to physiological conditions that might have provided a more complete explanation as to why the conning pilot of the *Elka Apollon*, who was seasoned in many Houston Ship Channel transits, failed to execute this particular voyage safely.

Chairman Hersman and Member Sumwalt concurred with this statement.

Member Earl F. Weener, concurring:

The mission of the National Transportation Safety Board, by statute, is to investigate and establish the facts, circumstances, and cause or probable cause of transportation accidents. By design, the NTSB is to conduct its mission in an objective manner, as established by its status as an independent agency of the federal government. Its organizational structure further supports this goal, with a board composed of five independent members, each bringing their unique talents, expertise, and experience to their positions. As well, the process for considering and approving accident investigation results is structured to enable each member to consider the facts and circumstances, individually, and independently determine their position on the cause or probable cause of an accident. Finally, to ensure the integrity of the process, members must conduct deliberations concerning investigation results in a public manner and are afforded an opportunity to record varying opinions through concurring or dissenting statements as it is highly improbable all five members agree uniformly on matters. So it is within this context I submit a concurring statement concerning this accident report.

I support the underlying investigation and analysis of this report, believing the facts and circumstances were well documented and explained. Additionally, I support the findings and voted in favor of the final probable cause statement. However, I am concerned about the basis for the revisions to the probable cause statement made at the meeting and the idea of establishing precedent for future statements. It is the sole prerogative of the board, comprised of five independent views, to determine the probable cause of an accident. Further, no two accidents, or cause scenarios for that matter, are alike. It would be imprudent and diminish the independent, objective nature of the board to attempt to dictate what should or should not be included in every probable cause statement or how a probable cause statement should be viewed.

The board should not be concerned with philosophical views of its work; it is charged with the responsibility of determining accident causes for the sole purpose of enhancing transportation safety. In carrying out this responsibility, the board must ensure the elements of a probable cause statement are fully supported by the facts and circumstances from the underlying accident investigation. Further, the board should be cognizant of the pitfalls associated with determining contributing factors and assigning weight to these factors. If taken to the extreme, any number of factors could be considered as contributing to an accident cause; however, inclusion of every factor possible leads to speculation, particularly if it concerns exploring the mindset of persons involved in the accident. As well, the value of the probable cause statement, and the resulting recommendations, is undermined or lost if the statement is too broad or vague. Alternatively, relying on the facts and evidence adduced from an investigation to determine the specific factors directly involved in the accident cause, even in cases where not every question can be answered, is a sound, responsible approach. If such factors cannot be supported by the underlying facts or are so general in nature as to detract from the underlying cause, it serves no benefit.

In this case, the facts and evidence from the accident investigation support a determination the probable cause of the collision between the *Elka Apollon* and the *MSC Nederland* was the failure of the conning pilot on the *Elka Apollon* to appropriately respond to changes in the bank effect forces as the vessel transited the Bayport flare. The contributing factors cited in the final probable cause statement, although factual, are well-known issues every

local pilot must contend with in this channel and successfully navigate on a regular basis. In fact, these factors are precisely the reason piloting requirements were established for this waterway. I see no basis for identifying these factors as uniquely contributing to the probable cause determination in this accident. Candidly, the conning pilot, a seasoned pilot well versed in the waterway complexities, experienced with heavy traffic density, and accustomed to managing bank effects, failed to respond properly in this instance.

Member Rosekind concurred with this statement.

7. Appendix: Accident Notification and Response

The U.S. Coast Guard National Command Center notified the National Transportation Safety Board (NTSB) Communications Center of the accident by e-mail at 1904 on October 29, 2011. The NTSB Communications Center forwarded the notification to the NTSB Office of Marine Safety at 1914 that same day. The NTSB launched a team of investigators from the Office of Marine Safety and a VDR specialist, all of whom arrived in Houston on the afternoon of October 30, 2011. The team's analysis focused on deck operations, engineering factors, human performance, accident response, vessel data recorder analysis, and hydrodynamics. The initial on-scene portion of the investigation was completed on November 8, 2011.

Parties to the investigation were the U.S. Coast Guard; the Houston Pilots Association; European Products Carriers Ltd., operator of the *Elka Apollon*; the Mediterranean Shipping Company (USA), operator of the *MSC Nederland*; and Cheryl K LLC, owner/operator of the *Mr. Earl*.

Investigators retrieved and reviewed the voyage data recorders from both vessels involved in the accident, the three pilots' personal electronic charting display units, and recorded data from the Houston–Galveston Vessel Traffic Service (VTS) and Coast Guard Sector Houston–Galveston Command Center. Data from the electronic charting system on the towboat *Mr. Earl* were also obtained. While on scene, investigators interviewed crewmembers from both ships, the crew of the towboat, VTS and Coast Guard Command Center controllers and watch supervisor, and the three Houston pilots aboard the ships at the time of the collision.