Issued July 11, 2023 MIR-23-15

Collision between Tugboat *George M* and Containership *MSC Aquarius*

On April 14, 2022, about 0346 local time, the tugboat *George M* and containership *MSC Aquarius* collided while both vessels were transiting north in the Houston Ship Channel approaching Morgan's Point, Texas.[1] About 1,000 gallons of gear oil were released from the *George M*'s damaged port propulsion unit. No injuries were reported. Damage to the *George M* was estimated at $750,000; damage to the *MSC Aquarius* was $183,665.

Figure 1. Tugboat *George M* postcasualty. (Source: US Coast Guard)

[1] (a) In this report, all times are central daylight time, and all miles are nautical miles (1.15 statute miles). (b) Visit ntsb.gov to find additional information in the public docket for this NTSB investigation (case no. DCA22FM015). Use the CAROL Query to search investigations.

Casualty type	Collision
Location	Houston Ship Channel, Upper Galveston Bay, Texas 29°39.58′ N, 94°58.37 W
Date	April 14, 2022
Time	0346 central daylight time (coordinated universal time –5 hours)
Persons on board	4 (*George M*), 31 (*MSC Aquarius*)
Injuries	None
Property damage	$933,665 est.
Environmental damage	About 1,000 gallons of gear oil released from the *George M*
Weather	Visibility 10 nm, clear skies, winds north-northeast 11 kts, gusts 16 kts, negligible flood current, air temperature 63°F, water temperature 71°F, civil twilight 0631, sunrise 0655
Waterway information	Channel, depth 45 ft, width 530 ft in deepwater channel

Figure 2. Location of the *George M*/*MSC Aquarius* collision, as indicated by a red *X*. (Background source: Google Maps)

1. Factual Information

1.1 Background

The *George M,* owned by Bay-Houston Towing Co. and operated by G & H Towing Company, was a 98.5-foot-long, US-flagged inspected towing vessel built in 2021 by Gulf Island Shipyards in Jennings, Louisiana. The vessel was designated as a "30–80 class" tugboat by its designer, a class type derived from the boat's metric length (30 meters) and towing power (80-metric-tonnes bollard pull).[2] Two 3,386-hp Caterpillar diesel engines provided propulsion, each driving a Schottel azimuthing thruster, commonly referred to as an azimuthing stern drive (ASD) or "Z-drive." Each Z-drive was able to rotate 360° via integral hydraulic motors, eliminating the need for a rudder. This rotation, used in conjunction with the throttle inputs from the diesel engine driving the unit, allowed for variable thrust in all directions. The *George M* was capable of 13 knots at full speed. According to the vessel's captain, the tugboat's maximum speed in the astern direction was 11–12 knots.

The *George M* had four crew: the captain, a mate, an able seaman (AB), and an engineer (the engineer was also credentialed as an ordinary seaman). The captain stood watch from 0500–1200 and from 1900–2400, with the mate taking the opposite watches.

The *MSC Aquarius,* owned and operated by Genious Shipping S.A. and managed by Cyprus Sealines Co., was a 983.9-foot-long, Cyprus-flagged containership built in 2003 by Japan Marine United Corp. in Kure, Japan. A single 70,902-hp Sulzer slow-speed diesel engine driving a fixed-pitch propeller provided main propulsion. The vessel had a crew of 30. At the time of the casualty, a pilot from the Houston Pilots was also aboard the vessel.

Figure 3. The *MSC Aquarius*, September 2022. (Source: Osvaldo Traversaro)

[2] *Bollard pull* is a measure of the pulling capability of a vessel at zero speed and is typically required for ship-assist tugs. It is determined by connecting the tested vessel to a pier bollard with a line and calculating the force (measured in metric tons) developed using a load cell.

1.2 Event Sequence

About 0930 on April 13, the crew of the *George M* boarded the tugboat to relieve an off-going crew as part of a standard 7-days-on/7-days-off rotation. The oncoming captain was normally assigned as the vessel's mate, but he had been temporarily assigned as captain while the permanently assigned captain was on leave. To fill the vacant mate's position, the company reassigned a mate to the *George M* from another tugboat that was undergoing maintenance.

At 1045 that morning, the *George M* received tasking to assist a liquid propane gas carrier getting underway. In accordance with regulations, the tugboat's captain and mate completed a navigation assessment for the job using a company-supplied, hard-copy form. One question on the form asked whether all crewmembers were "qualified, familiar and knowledgeable with the towing vessel's particulars and equipment." The captain and mate responded "yes" but noted on the form, "mate new to this particular vessel."

Over the next couple of hours, the mate operated the tugboat under the supervision of the captain while the *George M* assisted in three vessel movements. Based on his observation of the mate and previous experience when both the captain and mate had worked the same harbor-assist jobs on separate tugboats, the captain assessed that the mate was capable of safely operating the tugboat.

About 0045 the next morning, the pilot boarded the *MSC Aquarius* near the entrance to Galveston Bay for an inbound transit of the Houston Ship Channel. The containership was destined for a berth at the Barbour's Cut Container Terminal at the north end of Upper Galveston Bay. After a master/pilot exchange, the pilot took the conn, and the vessel commenced its transit. As it proceeded up the lower Houston Ship Channel en route to its destination, the *MSC Aquarius*'s speed was between 11 and 12 knots.

At 0234, the *George M* and two other tugboats received tasking for a harbor-assist operation to dock the *MSC Aquarius* at the terminal. At that time, the *George M*'s mate was on watch and the captain was asleep. In preparation for the job, the mate conducted a navigation assessment, noting no anomalies with the tugboat or concerns with the crew.

After the *MSC Aquarius* pilot determined that two tugboats were sufficient in the weather conditions that morning, the G & H Towing dispatcher recalled one of the three tugboats assigned to the containership. The two remaining tugboats—the *George M* and the *Mazu*—met the *MSC Aquarius* in the Houston Ship Channel south of Morgan's Point, Texas, about 0330. The pilot told investigators that, about the time that the ship met the tugboats, he began to slow the vessel's speed. Automatic identification system data

showed that, between 0333 and 0341, the *MSC Aquarius*'s speed reduced from 12 knots to 10 knots.

The pilot's plan was to back the containership into Barbour's Cut, which ran roughly perpendicular to the Houston Ship Channel, and he intended to use the tugboats to assist in turning the vessel in the main channel before backing into the cut. Over VHF radio, the pilot assigned the *George M* to the "center lead forward" position on the bow of the containership and assigned the *Mazu* to the center lead aft position on the stern.

To make up the *George M*'s hawser to the bow of the *MSC Aquarius*, the tugboat had to maneuver into position ahead of the containership, bow-to-bow, and rig its hawser through the ship's forward, centerline chock (the "bullnose"), a maneuver referred to by the operators as a "stem job." To prepare for the job, the *George M* mate positioned the tugboat directly ahead of the *MSC Aquarius*, with its bow facing the containership's bow, moving in the astern direction, while the containership continued to transit north in the channel. The mate said that, once in position ahead of the *MSC Aquarius*, he "paced" the containership—transiting at the same course and speed—and concluded that he had enough reserve power to safely conduct the stem job maneuver. The speed of both vessels at the time was 9.7 knots.

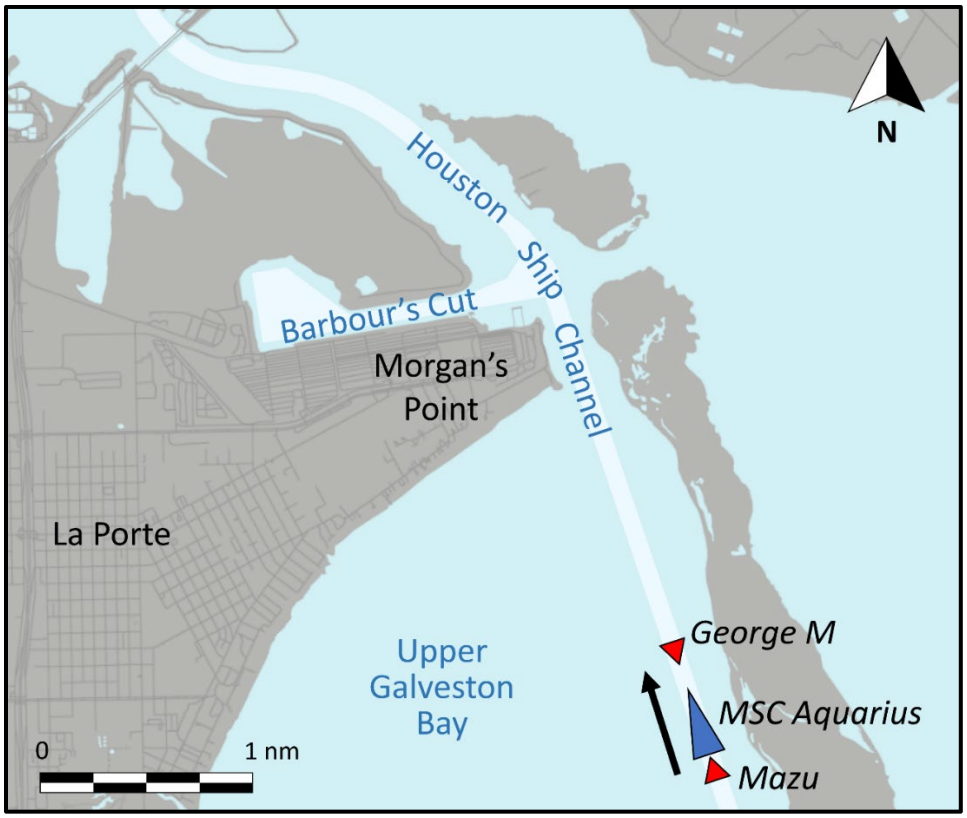

Figure 4. Positioning of the tugboats *George M* and *Mazu,* forward and astern of the *MSC Aquarius,* before the casualty (vessels not to scale).

The *George M* mate then slowed the tugboat's speed, closing the tugboat's bow with the bow of the *MSC Aquarius* in order to pass the tugboat's hawser up to the containership through the ship's bullnose. Once the *George M* was in position directly under the bow, the containership crew lowered a heaving line down to the tugboat. The *George M* AB tied the heaving line to a messenger line, which was attached to the tugboat's hawser. Then, the *MSC Aquarius* crew began hauling in the heaving line and messenger while the *George M* mate payed out the hawser via the tugboat's winch.

The mate said that, when the hawser was almost to the *MSC Aquarius*'s bullnose, the tugboat began to move off-centerline from the containership's bow to the starboard side of the ship's bow. In response, the mate increased engine speed on the *George M* and steered back toward the *MSC Aquarius*'s centerline.

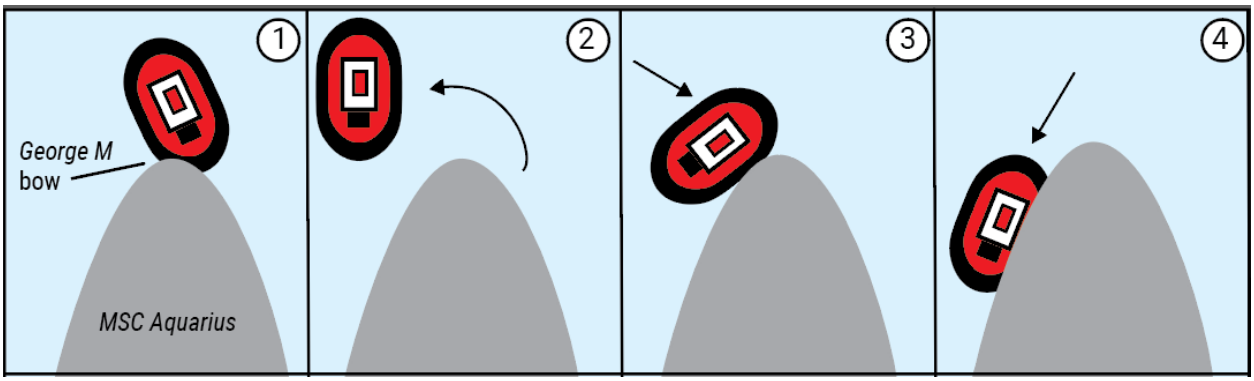

Figure 5. Sequence of events in *George M*/*MSC Aquarius* collision. 1) After moving to the starboard side of the *MSC Aquarius*, the *George M* moved back to port and the starboard bow of the tugboat collided with the bow of containership; 2) the *George M* accelerated and moved to a position to port and ahead of the *MSC Aquarius*; 3) the *George M* moved toward the centerline of the *MSC Aquarius*, the tugboat's speed decreased, and the vessels collided again; 4) the *George M* slid aft along *MSC Aquarius*'s port side until it became lodged in the flare of the containership's port bow. (Illustration not to scale.)

The mate said that the *George M* was "a little slower to get that [propulsion engine] power" than the tugboat he had previously been on, so he added more engine speed to regain position. He stated, "I kept powering it up and angling over, powering up and angling over, and it–I wasn't getting what I was… expecting out of it." He stated that he continued to add power until the propulsion power suddenly took effect. When that happened, the *George M* crossed the bow of the *MSC Aquarius*, and the tugboat's starboard bow struck the starboard bow of the containership.

After striking the bow of the *MSC Aquarius*, the *George M* continued over to the port side and ahead of the containership. The mate began working the *George M* back toward the centerline of the *MSC Aquarius*, but at the same time the tugboat's speed slowed, bringing the *George M* toward the bow of the *MSC Aquarius* again. According to the mate, he increased speed on the engines to full power and attempted to angle

the tug away from the ship, but the tug did not respond quickly. Consequently, the *George M* collided with the *MSC Aquarius* again. During the collision, the tugboat's port Z-drive struck the ship's bulbous bow, disabling the propulsion unit.

With the port Z-drive disabled, the *George M* slid aft along the port side of the *MSC Aquarius* until it became lodged in the flare of the containership's bow.

At some point during the attempted maneuvering, the mate had begun retrieving the hawser (he could not recall when he had done this). He stopped the winch and set the brake when he noticed that the messenger had wrapped around the winch drum several turns. The AB then detached the tugboat's messenger from the containership's heaving line.

The *George M* was not visible from the bridge of the *MSC Aquarius* because it was in a blind sector beneath the bow of the containership. The *MSC Aquarius*'s pilot stated that his first indication that something was wrong with the *George M* was the sound of a "frantic call" from the *MSC Aquarius*'s bow crew to the vessel's master over the ship's internal handheld radios. The crew was speaking in their native language (not English), so the pilot asked the vessel's master what was going on. The master responded, "we have [a] problem, this forward tug." The pilot ordered the *MSC Aquarius*'s engine speed to half ahead and radioed the tugboat, asking "*George*, you okay up there?" He received no response to the radio call, and subsequently he ordered slow ahead on the containership's engine.

After further communication with the bow crew, the master told the pilot that the *George M* was hung up on the containership's anchor. The pilot ordered *MSC Aquarius*'s engine to dead slow ahead and directed the *Mazu*, which had made up its hawser to the stern of the *MSC Aquarius*, to begin pulling on the containership's stern.

Meanwhile, the *George M* captain arrived in the tugboat's wheelhouse, having been awoken by the first collision with the *MSC Aquarius*. The captain surveyed the scene, determining that the mast and other equipment were not stuck in the containership's anchor (contrary to the reports from the *MSC Aquarius* bow to the ship's bridge). The captain then took the helm of the *George M* and radioed the *MSC Aquarius*, requesting that the containership slow. At 0350, the pilot on the containership ordered stop on the main propulsion engine. A minute later, the pilot ordered dead slow astern, then slow astern.

Once the *MSC Aquarius* had slowed sufficiently, the *George M* captain maneuvered the tugboat away from the containership. The *George M* proceeded to the tugboat company dock to assess the damage. The *Mazu* remained made up to the containership's stern, and another tugboat was dispatched to assist with the docking of the *MSC Aquarius*. The containership and the tugboats proceeded to Barbour's Cut without further incident.

1.3 Damage

The lower unit of the *George M*'s port Z-drive (the portion of the drive unit below the hull) separated from the upper unit when it struck the *MSC Aquarius*'s bulbous bow. The lower unit dropped until it became caught on the tugboat's hull, preventing it from being lost. The tugboat also sustained a collapsed mast, damaged railings, and indentation of the deck above the wheelhouse. The cost of repairs to the *George M* was estimated at $750,000.

The *MSC Aquarius* experienced a breach in its portside hull plating beginning 4.9 feet (1.5 meters) aft of the forward end of the bulbous bow, with inset plating in the surrounding area. The 5.6-foot (1.7-meter)-long breach was 1.6 feet (0.5 meters) wide forward, narrowing to 0.2 feet (0.1 meters) aft. The cost of repairs to the hull of the *MSC Aquarius* was $183,665.

1.4 Additional Information

1.4.1 Pilot-Tugboat Communications

The pilot stated that, in general, after assigning tugboats to assist positions on a vessel, it was up to the operator of the tugboat to determine when it was safe to approach and make up the hawser. If the tugboat operator requested that the assisted vessel slow down, the pilot would comply with the request unless speed was an operational necessity. In such cases, the pilot would work with the tugboat operator to delay making up the tug or to adjust the tugboat's position to a location where it was safe to make up at speed.

The *George M* captain and mate's descriptions of tugboat assignment and pilot communications were similar to the pilot's description. Both crewmembers stated that they had never had a pilot refuse to slow down a ship without providing an explanation or an alternate plan for the tugboat. When asked by investigators, the *George M* mate stated that he did not ask the pilot to slow the *MSC Aquarius* before the tugboat made its approach to the ship on the morning of the casualty.

1.4.2 *George M* Material Condition and Crew Experience

The *George M* was the newest tugboat in the G & H Towing fleet, having been delivered in January 2021. A master duty turnover checklist completed on April 13, as well as navigation assessments and engineering logs from April 13–14, contained no reported problems or concerns with the engines, Z-drives, or control systems before the casualty. The captain stated that the vessel's propulsion systems were working well before the collision occurred.

The captain of the *George M* held a valid Coast Guard-issued merchant mariner credential as a Master of Towing Vessels Upon the Great Lakes and Inland Waters. He had about 22 years' experience in the marine industry and had been operating harbor-assist tugboats with G & H Towing since 2015, primarily as a mate but occasionally filling in as a captain. The captain had been operating 30-80-class tugboats (the *George M* and the *Mazu*) for 10–11 months before the collision.

The mate held a valid merchant mariner credential as a Mate (Pilot) of Towing Vessels upon Oceans. He had 15 years' experience as a mariner on various types of vessels and had been a mate operating harbor-assist tugboats with G & H Towing since 2018.

In the 9 months before joining the *George M*, the mate had been assigned to "30–75" class tugboats. The 30–75-class tugboats were the same length (98.5 feet/30 meters) as the 30–80-class tugboats like the *George M*, but they were 3.3 feet (1 meter) narrower and were less powerful at 75-metric-tonnes bollard pull. The Z-drive controllers in the wheelhouses of the 30–75- and 30-80-class tugboats were similar, with a 360° trainable "combi-lever" for each Z-drive that allowed the operator to control azimuth (direction) and engine rpm independently. On the 30–75, the engine speed lever was on the side of the combi-lever, while on the 30–80 tugboat, the lever was on the top. According to the mate, the small differences in the controller required him to hold them differently, and, although he felt comfortable using the controllers on the *George M*, his hands were "extremely tired" after working the jobs on the day before the casualty. The G & H Towing Company director of operations and the *George M* captain and mate stated that the larger 30–80 tugboats reacted more slowly than the 30–75 tugboats to inputs from the operator.

In addition to Coast Guard credentialling, G & H Towing required captains and mates to complete a qualification process for each class of tugboat on which they were assigned. The process included performing various tasks and duties under the supervision of a qualified captain. The successful performance of these tasks was documented in a "Master/Mate Performance Assessment Record (MMPAR)." Once all tasks in the assessment record were completed and the full-time captain of the tugboat was satisfied with the new operator's performance, the full-time captain completed and signed a "Vessel Qualification Form" for the operator.

Line items in the MMPAR were divided into categories such as light tug maneuvers, basic tractor tug operations, judgment, and basic and advanced ship-assist maneuvers. The line items in the MMPAR for the 30–75- and 30–80-class tugboats were the same, but operators were required to complete a separate qualification process for each class of vessel.

The mate on the *George M* had completed the qualification process for the 30–75 tugboat in April 2021. However, at the time of the collision, he had not started the process for the 30–80 tugboat. The captain stated that he had intended to begin the mate's assessment on the day of the casualty. However, because he was not the full-time captain of the vessel, he would not have been authorized to sign the mate's final Vessel Qualification Form for the 30–80 tugboat.

According to the towing company's director of operations and the *George M* captain, the captain had the authority to allow a mate to operate a tugboat without supervision before completing the assessment if the mate was previously qualified on another Z-drive tugboat and the captain determined that the mate was capable of operating the vessel safely. In such cases, the tugboat was employable 24 hours a day. If the captain was not comfortable with the mate's abilities, he could limit the tugboat availability to 12 hours, and the captain was required to be in the wheelhouse at all times when the mate was operating the vessel.

The *George M* captain knew the mate was qualified on a Z-drive tugboat, having previously served on a 30–75 vessel, and he had observed the mate during operations on the day before the collision. The captain told Coast Guard investigators, "I was confident enough that [the mate] was fine doing the job and the procedures." The captain added that, although the 30–75 and 30–80 tugboats had differences, "fundamentals and the jobwise [they are] the same." At the time of the casualty, the *George M* was listed in the company's Operations Center Daily Status Report as available 24 hours per day.

1.4.3 Tugboat Operations in Center Lead Forward Position

When a ship is moving through the water in the forward direction, a high-pressure area forms around the bow. When a tugboat is in the center lead forward position (a stem job), it is subjected to the hydrodynamic forces created by the high-pressure area created by the ship it is assisting. The pressure increases with decreasing distance to the bow, and therefore the hydrodynamic forces are greatest when a tugboat is very close to the ship's bow while making up the hawser.[3] The *George M* captain explained, "As the ship is breaking through the water, it creates… a cushion. So, if you're… in line with the ship, in front of the ship, it tends to… throw you one way or another." The towing company's director of operations described a stem job as "one of the more advanced

[3] P.J. McArthur, *New Thinking in Ship Generated Hydrodynamic Fields: Introducing Concepts for Predicting Bank Suction and Rejection* (Northwest Interaction Ltd, 2011).

maneuvers." According to the *Pilot's Pocket Guide and Checklist*, "The position in front of the ship's (bulbous) bow is one of the most dangerous for the tug."[4]

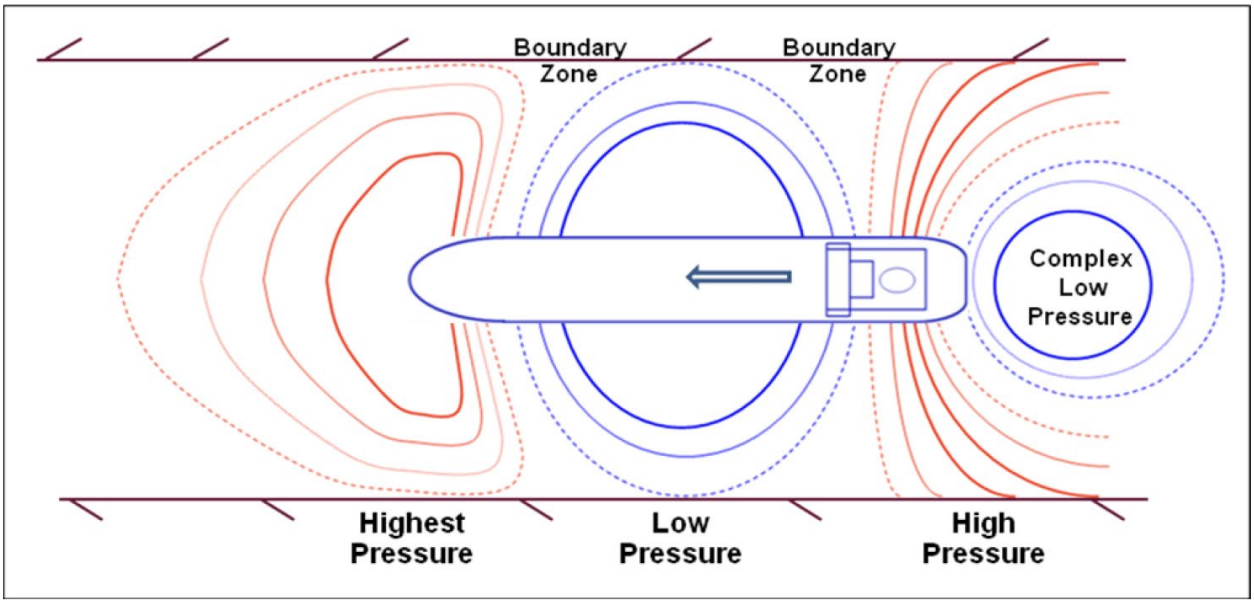

Figure 6. Ship-generated pressure fields for a vessel navigation in enclosed/confined water. (Source: P. J. McArthur)

In 2013, the Dutch Safety Board investigated a casualty resulting in the capsizing of a tugboat while it attempted to make up to the bow of a large ferry. In its report, the Dutch Safety Board determined high speed to be one of the main causes of the capsizing. Following the casualty, a working group comprised of members of the International Tug Masters Association and the Nautical Institute conducted surveys of pilots, tugboat captains, and ship masters from around the world to determine what were considered safe speeds and safe procedures for tugboat operations. A large majority of survey respondents reported that their maximum speed while making up a tugboat to the bow of a vessel was 6 knots.[5]

According to the textbook *Bow Tug Operations with Azimuth Stern Drive Tugs: Risks and Effectiveness*, "a good guideline is that ship's speed should not be higher than 60 percent of the tug's maximum speed ahead."[6] Although no specific speed limits were stated in the *George M* company's towing vessel safety management system, the tugboat operators had been instructed via semiannual master and mate seminars and

[4] UK Chamber of Shipping, *Pilot's Pocket Guide and Checklist: Working Safely with Harbour Tugs – Reducing the Risks in Port Towage*, Second Edition, 2021.

[5] Henk Hensen, Daan Merkelbach, and F. van Wijnen, *Report on Safe Tug Procedures Based on Pilot, Tug Master and Ship Captain Questionnaires*, April 20, 2013.

[6] Henk Hensen, *Bow Tug Operations with Azimuth Stern Drive Tugs: Risks and Effectiveness*, Third Edition (Rotterdam: STC Publishing, 2016).

other forums that the maximum speed for making up bow-to-bow in the center lead forward position was 7 knots. This limit was instituted in about 2016 as a precaution in case of an emergency loss of one engine or Z-drive; at 7 knots, a tugboat had sufficient power from one engine and Z-drive to escape from under the bow of the ship it was assisting.

The mate told investigators that he had performed between 25 and 50 stem jobs before the casualty. He stated that the speed of the *MSC Aquarius* at the time he attempted to perform the stem job on the containership, between 9.5 and 10 knots, was "on the high side," and that his preference was to conduct the maneuver at 5 knots.

1.4.4 Previous Casualty Involving Center Lead Forward Position

In January 2022, a similar casualty occurred involving the G & H Towing 30–80-class tugboat *Mercury*, which was performing a stem job on the tanker *Elandra Everest* in the port of Corpus Christi, Texas. The company's report into the casualty described that the tugboat's hawser had been made fast to the tanker, and while transiting together the tugboat began moving aft and to port from the center lead position on the ship. When the *Mercury* captain attempted to add power to bring the *Mercury* back to centerline on the ship, the tugboat did not respond sufficiently, and the two vessels collided.

Before making up the hawser, the tugboat captain informed the pilot on the tanker that the tanker's speed had to be less than 7 knots. The pilot acknowledged the requirement and told the captain that he would slow the tanker's speed to 6 knots. Navigation data from the tugboat showed that the tanker's speed over ground at the time of the collision was 7.4 knots, and it did not reach 6 knots until 6 minutes after the tugboat had made up to the ship.

A navigation assessment completed before the casualty transit predicted that the maximum current in the channel would be 2.8 knots ebb at 0836 that morning, about the same time that the collision occurred. The current was acting in the opposite direction of the tugboat and tanker's course over ground, and therefore the tugboat needed increased speed through the water (about 10 knots) to match the tanker's speed over ground. A company report of the casualty found that the captain of the *Mercury* "did not adequately plan for the strength of the predicted ebb current."

According to a company history report, the captain had only completed one other stem job on the *Mercury*, about 7 months before the collision.

1.5 Changes to Tugboat Qualification Process

In July 2022 (3 months after the *George M*/*MSC Aquarius* collision), G & H Towing issued a new Z-Drive Assessment Record (Z-DAR) to replace the Master/Mate Performance Assessment Record (MMPAR). The company developed the Z-DAR as a result of its postcasualty review of the *Mercury*/*Elandra Everest* and *George M*/*MSC Aquarius* collisions. The Z-DAR more clearly specified the tasks and duties to be demonstrated, with the total number of required tasks and duties increasing from 70 line items to 281 line items. Various ship-assist maneuvers and emergency procedures were required to be demonstrated five times, per the new Z-DAR, instead of one time, as required by the MMPAR, with two of the five maneuvers being completed at night. For maneuvering into bow-to-bow position, the Z-DAR required the operator to first demonstrate the ability to execute the maneuver offset from the bow of a vessel (five times), then execute the maneuver directly on the bow (five times). The line items for both the offset and direct bow-to-bow maneuvering noted that the tasks were to be completed at speeds of less than 7 knots.

2. Analysis

To make up the *George M* to the *MSC Aquarius* at the center lead forward position, the mate maneuvered the tugboat, in darkness, into position centerline on the bow of the *MSC Aquarius*, which was transiting at 9.7 knots. The tugboat's AB made up the heaving line to the hawser messenger, and the containership's crew began heaving in the line. While this was occurring, the *George M* moved out of centerline with the *MSC Aquarius*. The mate attempted to maneuver the tugboat back to centerline, but he was unable to regain position, and his attempt to do so resulted in two collisions between the vessels.

Hydrodynamic forces created by a ship increase exponentially with speed, and therefore an increase of even a few knots will have a significant effect on the forces acting on a tugboat in the center lead position.[7] The increased forces acting on a tugboat at higher speed require more reserve power, maneuverability, and operator skill to overcome. When the *George M* approached the *MSC Aquarius*, the speed of the containership was 2.7 knots above the towing-company-directed limit of 7 knots for the bow-to-bow maneuver and 3.7 knots above the 6-knot limit preferred by pilots, tugboat captains, and ship masters surveyed by an International Tug Masters Association/Nautical Institute working group. Hydrodynamic forces also increase with decreasing distance to the bow, and, consequently, the forces acting on the *George M*

[7] UK Chamber of Shipping, *Pilot's Pocket Guide and Checklist: Working Safely with Harbour Tugs – Reducing the Risks in Port Towage*, Second Edition, 2021.

were even greater as the tugboat approached the bow of the *MSC Aquarius* to make up the hawser.

In addition to producing significantly increased hydrodynamic forces, higher speed reduces the amount of reserve propulsion power available to the operator. If the tugboat moves out of position, the operator has less power to regain position as compared to the same maneuver at a lower ship's transit speed. In this casualty, the difference between the maximum astern speed of the *George M* and the speed of the *MSC Aquarius* was 2.3 knots. In other words, the containership's speed was 81% of the maximum astern speed of the tugboat, far greater than the 60% recommended in the *Bow Tug Operations with Azimuth Stern Drive Tugs* textbook. As an assisted ship's speed increases, the margin of error decreases to the point where regaining position may be impossible.

The January 2022 collision between the tugboat *Mercury* and the tanker *Elandra Everest* in Corpus Christi occurred under similar conditions to the *George M/MSC Aquarius* collision. The *Mercury* was in the center lead forward position, made up to the tanker, and transiting at 7.4 knots speed over ground. With an opposing ebb current, the vessels' speed through the water, about 10 knots, was nearly 3 knots higher than its speed over ground. The *Mercury* moved out of centerline and, when the captain attempted to regain position, the vessels collided.

According to the *George M* captain and mate, as well as the *MSC Aquarius* pilot, the mate could have requested that the *MSC Aquarius* slow, and the pilot would have slowed the containership if it was operationally feasible. If not operationally feasible, the tugboat mate could have worked with the pilot to delay making up the tugboat until it was safe to do so. However, neither of these actions happened. The *George M* mate did not communicate with the pilot after being assigned to the center lead forward position, and consequently, the pilot was not aware of the status of the tugboat or the need to slow.

The *George M* captain and mate held the requisite merchant mariner credentials for the positions they were filling on the vessel at the time of the casualty. Additionally, the mate was familiar with Z-drive tugboats and was fully qualified under company standards for 30–75-class vessels. However, the *George M* was a 30–80-class tugboat, and it was the mate's first rotation on board that class of vessel. The mate had not begun the company assessment and qualification process for the 30–80-class vessel before the casualty occurred. Although the 30–75- and 30–80-class tugboats were similar, small differences between platforms can impact operator performance, particularly during difficult maneuvers or emergencies where quick action is required. The company director of operations, the captain, and the mate all stated that the 30–80 tugboat was slower to react to operator inputs than the 30–75 vessel. When the *George M* became

offset from the *MSC Aquarius*, the tugboat did not respond to the mate's inputs as he expected based on his previous experience.

3. Conclusions

3.1 Probable Cause

The National Transportation Safety Board determines that the probable cause of the collision between the tugboat *George M* and the containership *MSC Aquarius* was the *George M* mate's attempt to make up bow to bow while the tugboat and containership were transiting at a speed that was excessive for the advanced harbor-assist maneuver. Contributing to the casualty was the *George M* mate's lack of experience operating the tugboat.

3.2 Lessons Learned

Speed During Bow-to-bow Harbor-assist Operations

The risk of a casualty during bow-to-bow harbor-assist operations with azimuthing stern drive (ASD) tugboats increases with increasing speed. Hydrodynamic forces around an assisted vessel's bow increase exponentially with speed, while the amount of reserve propulsion power available to the tugboat operator decreases. Therefore, owners and operators of ASD tugboats that perform bow-to-bow harbor-assist operations should set speed limits for these maneuvers. These limits may vary for different classes of tugboats based on design. Tugboat operators should communicate these pre-determined speed limits to ship masters or pilots in command of the vessels that they are assisting before engaging in these maneuvers.

Vessel	*George M*	*MSC Aquarius*
Type	Towing/Barge (Tugboat)	Cargo, General (Containership)
Owner/Operator	Bay-Houston Towing Co./G & H Towing Company (Commercial)	Genious Shipping S.A. (Commercial)
Flag	United States	Cyprus
Port of registry	Houston, Texas	Limassol, Cyprus
Year built	2021	2003
Official number (US)	1301303	N/A
IMO number	9905095	9262704
Classification society	American Bureau of Shipping	RINA
Length (overall)	98.5 ft (30.0 m)	983.9 ft (299.9 m)
Breadth (max.)	42.7 ft (13.0 m)	131.2 ft (40.0 m)
Draft (casualty)	20.0 ft (6.1 m)	39.0 ft (11.9 m)
Tonnage	411 GT ITC	75,484 GT ITC
Engine power; manufacturer	2 x 3,386 hp (2,525 kW); Caterpillar 3516E-HD Tier 4 diesel engines	1 x 70,902 hp (52,871 kW); Sulzer 12RTA96C diesel engine

NTSB investigators worked closely with our counterparts from **Coast Guard Sector Houston-Galveston** throughout this investigation.

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For more detailed background information on this report, visit the NTSB investigations website and search for NTSB accident ID DCA22FM015. Recent publications are available in their entirety on the NTSB website. Other information about available publications also may be obtained from the website or by contacting—

National Transportation Safety Board
Records Management Division, CIO-40
490 L'Enfant Plaza, SW
Washington, DC 20594
(800) 877-6799 or (202) 314-6551