National Transportation Safety Board

Washington, DC 20594

Safety Recommendation

Date: November 4, 2011

In reply refer to: M-11-13 through -16
M-09-4 (reiterated)
M-09-5 (superseded)

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Background

On Saturday, January 23, 2010, about 0935 central standard time, the 810-foot-long oil tankship *Eagle Otome* collided with the 597-foot-long general cargo vessel *Gull Arrow* at the Port of Port Arthur, Texas. A 297-foot-long barge, the *Kirby 30406*, which was being pushed by the towboat *Dixie Vengeance*, subsequently collided with the *Eagle Otome*. The tankship was inbound in the Sabine-Neches Canal with a load of crude oil en route to an ExxonMobil facility in Beaumont, Texas. Two pilots were on board, as called for by local waterway protocol. When the *Eagle Otome* approached the Port of Port Arthur, it experienced several unintended heading diversions culminating in the *Eagle Otome* striking the *Gull Arrow*, which was berthed at the port unloading cargo.

A short distance upriver from the collision site, the *Dixie Vengeance* was outbound with two barges. The towboat master saw the *Eagle Otome* move toward his side of the canal, and he put his engines full astern but could not avoid the subsequent collision. The *Kirby 30406*, which was the forward barge pushed by the *Dixie Vengeance*, collided with the *Eagle Otome* and breached the tankship's starboard ballast tank and the No. 1 center cargo tank a few feet above the waterline. As a result of the breach, 862,344 gallons of oil were released from the cargo tank, and an estimated 462,000 gallons of that amount spilled into the water. The three vessels remained together in the center of the canal while pollution response procedures were initiated. No crewmember on board any of the three vessels was injured.[1]

[1] For more information, see *Collision of Tankship* Eagle Otome *with Cargo Vessel* Gull Arrow *and Subsequent Collision with the* Dixie Vengeance *Tow, Sabine-Neches Canal, Port Arthur, Texas, January 23, 2010*. Marine Accident Report NTSB/MAR-11/04 (Washington, DC: National Transportation Safety Board, 2011), available at http://www.ntsb.gov.

The National Transportation Safety Board (NTSB) determines that the probable cause of the collision of tankship *Eagle Otome* with cargo vessel *Gull Arrow* and the subsequent collision with the *Dixie Vengeance* tow was the failure of the first pilot, who had navigational control of the *Eagle Otome,* to correct the sheering motions that began as a result of the late initiation of a turn at a mild bend in the waterway. Contributing to the accident was the first pilot's fatigue, caused by his untreated obstructive sleep apnea and his work schedule, which did not permit adequate sleep; his distraction from conducting a radio call, which the second pilot should have conducted in accordance with guidelines; and the lack of effective bridge resource management by both pilots. Also contributing was the lack of oversight by the Jefferson and Orange County Board of Pilot Commissioners.

Waterway Safety

The Sabine-Neches Waterway is a 64-mile-long waterway near the border between Texas and Louisiana. The midsection of the Sabine-Neches Waterway is the approximately 12-mile-long, 400- to 450-foot-wide Sabine-Neches Canal. The Sabine-Neches Canal shares this section of the waterway with the Gulf Intracoastal Waterway, which enters from the west at the Texas Island Intersection and exits the waterway to the east at the intersection with the Neches River.

In 2008, 2,538 tankships and 23,336 towing/tug vessels transited inbound and outbound in the Sabine-Neches Canal. Crude oil shipments accounted for the majority of tonnage through the waterway.[2]

Following the *Eagle Otome* accident, NTSB investigators examined channel dimensions to determine if the Sabine-Neches Canal is wide enough at Missouri Bend (the turn in the canal where the sheering problem began) for vessels the size of the *Eagle Otome*. Using the beam and length of the *Eagle Otome*, the calculations[3] showed that although the minimum turn radius at Missouri Bend is within preliminary guidelines provided by the U.S. Army Corps of Engineers (the Corps) for channel design,[4] the channel width at Missouri Bend is less than the Corps' suggested minimum for a vessel the size of the *Eagle Otome.* Using the Corps' preliminary guidelines, NTSB investigators calculated that the *Eagle Otome* ideally needs a canal width in the range of 414 to 463 feet at Missouri Bend, as opposed to the actual canal width of 400 feet.

NTSB investigators contacted the Corps about the channel dimensions at Missouri Bend. A Corps director responded that no strict Corps design criteria exist for navigation channel width. The director further stated that the Corps' preliminary guidelines are conservative, that the width guidance provided in the engineering manual can usually be reduced, and that many shipping

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[2] *Waterborne Commerce of the United States, Calendar Year 2008*, Report Number CEIWR-WCUS-08-2 (Washington DC: Department of the Army Corps of Engineers, 2010).

[3] The calculations are available in the NTSB public docket on this accident.

[4] The Corps published general channel design guidelines in an August 2004 engineering manual titled "Hydraulic Design of Deep-Draft Navigation Projects." The guidelines are not specific to the Sabine-Neches Waterway and provide only general design guidance. The engineering manual clarifies that final channel designs should be developed through ship navigation studies that incorporate simulation tests with local pilots.

channels in the United States are narrower than what the Corps' guidelines stipulate.[5] The Corps uses simulation studies to aid in determining final channel configuration. Although a simulation study was conducted in the Sabine-Neches Waterway in 2002, the Corps did not conduct such a study of Missouri Bend, and according to a Corps director, it is not clear what effect the results of a simulation study of Missouri Bend would have had on the channel width in that location. The circumstances of this accident suggest that the margin of safety in the Sabine-Neches Waterway—particularly in its narrow sections, such as the Sabine-Neches Canal where the accident occurred—may be insufficient, and the NTSB is concerned that the turn dimensions at Missouri Bend may be inadequate for large ships. Moreover, as indicated in an NTSB kinematics parameter extraction study,[6] the hydrodynamic forces in the area of Missouri Bend and the Port of Port Arthur can become excessive, and the channel dimensions leave little margin for operator error. Given the hazardous substances carried on board some of the vessels in the waterway, any increased risk of collision is of concern. Although large vessels have been transiting the waterway for years without incident, the NTSB nevertheless concluded that the dimensions of the Sabine-Neches Waterway may pose an unacceptable risk, given the size and number of vessels transiting the waterway. The NTSB therefore recommends that the Coast Guard conduct a ports and waterways safety assessment for the Sabine-Neches Waterway, determine from that whether the risk is unacceptable, and if so, develop risk mitigation strategies.

Mariner Fatigue

Also as a result of this investigation, NTSB determined that the first pilot, who had the conn of the *Eagle Otome* leading up to the accident, was fatigued because of his untreated obstructive sleep apnea and his work schedule which did not prevent extended hours of wakefulness and disruption to circadian rhythms. For at least 3 days during the week before the accident, the first pilot had maintained a day-awake, night-asleep work schedule. However, in the 1–2 days before the accident, he worked two consecutive piloting assignments that resulted in his being awake for at least 27 hours straight. He subsequently rested during daytime hours, which was contrary to the circadian rhythms that he had been maintaining.

The Sabine Pilots Association had a rest period policy in place; however, because it did not consider circadian rhythms nor prevent extended wakefulness, the policy was ineffective in preventing fatigue. Further, no regulatory body with pilot oversight authority had rules or regulations in place that could have precluded the adverse effects of fatigue-inducing scheduling practices from impairing the very cognitive skills that the pilots needed most to effectively navigate vessels through the Sabine-Neches Canal.

The circumstances of this accident illustrate the important role that hours of service rules play in preventing fatigue in transportation. The NTSB's concern about effective hours of service rules led it to issue Safety Recommendation M-99-1 to the Coast Guard calling for it to upgrade its hours of service rules to reflect advances in the science of sleep. The NTSB does not agree

[5] In the past decade, concern has been raised about the increasing size of ships in static-width waterways. See W. Gray and others, "Channel Design and Vessel Maneuverability – Next Steps: When Ships Get Too Big For Their Ditches," *Marine Technology*, Volume 40, Issue 2, April 2003, available at <http://www.usna.edu/naoe/channel/final.pdf>, accessed October 18, 2011.

[6] The study is available in the NTSB public docket on this accident.

with the Coast Guard's position that mariner education and medical oversight are sufficient to prevent mariner fatigue. The NTSB has been disappointed with the Coast Guard's response to M-99-1, particularly in light of the extensive research demonstrating the adverse effects of fatigue that has been gathered since the NTSB issued the recommendation.

Moreover, other Federal transportation regulators have made considerable progress toward preventing fatigue by establishing or initiating scientifically based hours of service rules. For example, in August 2011, the Federal Railroad Administration upgraded its hours of service rules to include provisions for the disruptive effect that working through nighttime hours has on circadian rhythms. The Federal Aviation Administration (FAA) recently initiated the process of upgrading its hours of service rules, contained in 14 *Code of Federal Regulations* (CFR) Parts 117 and 121. Among the provisions of the proposed upgrade is an accounting for circadian effects on (aviation) pilots' performance by requiring additional rest, or reduced hours of service, for flights beginning in what would be pilots' circadian low periods.

Further, the FAA proposed an alternative to hours of service rules—fatigue risk management systems (FRMS)—in which airlines work with the FAA to develop tailored scheduling rules according to the routes they operate and their particular needs. At this time, a sufficient amount of experience has been gained to provide regulators with knowledge about the benefits of FRMSs to prevent fatigue-inducing scheduling practices. A recent study provides several illustrations of the application of FRMSs to transportation settings.[7] The FAA has stated that this approach would meet the intent of its proposed rulemaking changes to implement effective, scientifically based hours of service programs to prevent schedule-induced fatigue, and the NTSB has supported this approach. Pilot commissions and the Coast Guard may consider this method as an acceptable means of implementing hours of service rules effective in preventing fatigue.

Pilot Oversight

In its investigation of the November 3, 2007, allision of containership M/V *Cosco Busan* with the San Francisco–Oakland Bay Bridge,[8] the NTSB concluded that regular communication among pilot oversight organizations about pilot-related performance data and best practices would enhance the ability of those organizations to effectively oversee pilots. As a result, the NTSB issued Safety Recommendation M-09-5 to the Coast Guard:

> Establish a mechanism through which representatives of pilot oversight organizations collect and regularly communicate pilot performance data and information regarding pilot oversight and best practices.

The Coast Guard did not concur with M-09-5, stating in a July 2009 response that "pilot oversight organizations have not expressed a desire or need to collect and regularly communicate pilot performance data." The Coast Guard further stated that the American Pilots' Association (APA)

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[7] P. Gander and others, "Fatigue Risk Management: Organizational Factors at the Regulatory and Industry/Company Level," *Accident Analysis and Prevention*, vol. 43 (2011), pp. 573–590.

[8] *Allision of Hong Kong-Registered Containership M/V* Cosco Busan *with the Delta Tower of the San Francisco–Oakland Bay Bridge, November 7, 2007*, Marine Accident Report NTSB/MAR-09/01 (Washington, DC: National Transportation Safety Board, 2009).

provided enough mechanisms for information exchange among various pilot organizations. Because of the Coast Guard's decision not to implement M-09-5, the NTSB classified the recommendation "Open—Unacceptable Response" in November 2009, pending further response from the Coast Guard.

The *Eagle Otome* accident indicates that a need exists for both regular communication and a readily accessible database of nationwide pilot incidents and accidents that could reveal to pilot oversight organizations particular hazards—for example, fatigue-inducing scheduling—that jeopardize the safety of the waterways they oversee and allow them to discuss with each other these safety hazards and methods to address them. Moreover, the APA, which the Coast Guard identified as best suited to carry out the intent of Safety Recommendation M-09-5, is not a pilot oversight organization and represents the interests of only one segment of U.S. marine operations, pilots on local waterways. The APA does not represent the interests of vessel operators, vessel owners, vessel flag states, classification societies, the International Maritime Organization (IMO), other waterway users, the waterway ecosystems, or the neighbors of the waterways. By contrast, the Coast Guard, as a U.S. government agency, oversees civilian marine operations to ensure the safety of our nation's waterways and to protect the marine environment. Therefore, the NTSB concluded that the Coast Guard is the organization with the resources, capabilities, and expertise best suited to (1) enhance communication among pilot oversight organizations and (2) establish an easy-to-use and readily available database of pilot incidents and accidents. Given the Coast Guard's response, the NTSB classifies Safety Recommendation M-09-5 "Closed—Unacceptable Action/Superseded." The NTSB recommends that the Coast Guard facilitate and promote regular meetings for representatives of pilot oversight organizations to communicate information regarding pilot oversight and piloting best practices. In addition, the NTSB recommends that the Coast Guard establish a database of publicly available pilot incidents and accidents and make the database easy to use and readily available to all pilot oversight organizations.

Bridge Control Ergonomics

About 2 minutes before the *Eagle Otome* collided with the *Gull Arrow*, the *Eagle Otome* master tried to increase the tankship's propulsion from 65 rpm to a total of 90 rpm, or from full ahead to navigational full ahead. His intent was to increase the water flow across the rudder and thereby enhance the rudder's effectiveness in an attempt to avoid striking the *Gull Arrow*. However, when the master attempted to press the button that would have enabled him to do this, he inadvertently pushed the "manual emergency stop" button, which was identically shaped and located immediately adjacent to the "program by-pass" button. As a result, instead of increasing the propulsive power, the opposite occurred: the engine stop order reduced rather than increased the engine rpm. NTSB investigators determined that the master's error did not contribute to the accident because, at the same time, the first pilot ordered the anchor dropped to try to stop the vessel anyway. Without the help of the anchor, the *Eagle Otome* would have needed about 2,625 feet to come to a stop (according to the vessel's maneuvering diagrams), and less than 500 feet separated the *Eagle Otome* and the *Gull Arrow* at that point.

Although the engine stop order did not lead to the accident, the master's error was a common one in which the operator intends to accomplish one action but instead causes another,

an error referred to as a "slip."[9] This type of error, which includes such common ones as typographical errors, is highly influenced by the design of the particular control. The NTSB has long been interested in control design in transportation and its relationship to operator errors that lead to accidents.[10] Although commonly accepted human factors guidelines for control design have been available for several decades to reduce the incidence of design-induced errors, and although such guidelines are required to be applied to aircraft control design, vessel designers continue to design critical component controls without employing these guidelines.

For example, one standard human factors reference[11] lists six different ways controls can differ: location, shape, size, color, labeling, and mode of operation. The greater the difference among controls in at least the first three of these factors, the less likely an operator in a stressful situation will be to inadvertently command the wrong action by activating the wrong control. The buttons on the *Eagle Otome*'s engine control console were not required to meet commonly accepted human factors design principles. In fact, they were located adjacent to each other and were the same size and shape, contrary to standard human factors design principles.

The IMO took action on this issue in 1998, when its Maritime Safety Committee issued MSC Circular 834, "Guidelines for Engine-Room Layout, Design and Arrangement." However, these guidelines were advisory only. Similarly, the vessel classification society American Bureau of Shipping has developed guidelines for the design of critical vessel controls and displays and has distributed these guidelines to its customers and the marine community. However, the American Bureau of Shipping does not mandate its guidelines in the vessels it surveys. The potential safety issue illustrated by the error made by the *Eagle Otome* master stems not from a dearth of information about the need for human factors guidance in control design or from a lack of such guidance itself. Rather, it stems from the absence of a requirement to apply such guidelines in the design and manufacturing of critical vessel controls. The NTSB therefore concluded that commonly accepted human factors principles were not applied to the design of the *Eagle Otome*'s engine control console, which increased the likelihood of error in the use of the controls. The NTSB therefore recommends that the Coast Guard work through the IMO to encourage the application of human factors design principles to the design and manufacture of critical vessel controls.

Changes in Mariner Medical Conditions

Also as a result of the *Cosco Busan* accident investigation, the NTSB concluded that the Coast Guard's system of medical oversight of mariners lacked a requirement for mariners to report changes in their medical status between medical evaluations (required annually for pilots and every 5 years for non-pilot mariners; the latter to become every 2 years). As a result of this finding, the NTSB issued Safety Recommendation M-09-4 to the Coast Guard:

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[9] D.A. Norman, *The Design of Everyday Things* (New York: Doubleday, 1988).

[10] See, for example, *Design Induced Landing Gear Retraction Accidents in Beechcraft Baron, Bonanza, and Other Light Aircraft*, Aviation Special Study NTSB/SR-80/01 (Washington, DC: National Transportation Safety Board, 1980).

[11] M. Helander, *A Guide to Human Factors and Ergonomics* (2nd edition) (Boca Raton, Florida: CRC Press, 2006).

> Require mariners to report to the Coast Guard, in a timely manner, any substantive changes in their medical status or medication use that occur between required medical evaluations.

The Coast Guard concurred with the intent of the recommendation but stated that to require all mariners to report changes in their medical condition would require a regulatory change, which the Coast Guard believed would be met with resistance. The Coast Guard stated that it was reviewing options to address the issue. In November 2009, the NTSB classified Safety Recommendation M-09-4 "Open—Acceptable Response."

The first pilot on board the *Eagle Otome* was diagnosed with obstructive sleep apnea (OSA) in the Spring of 2008. He did not report this diagnosis on his subsequent 719K form, dated February 2009, nor was he required to do so because the version of the form in effect at that time did not specifically ask about the diagnosis of sleep disorders. The Coast Guard's subsequent version of the 719K form, released in November 2009, does inquire about sleep disorders, and the first pilot disclosed his OSA diagnosis during his subsequent medical certification in February 2010.

However, had M-09-4 been implemented, the first pilot on the *Eagle Otome* would have been required to promptly notify the Coast Guard of his OSA diagnosis in 2008; as it was, he ultimately did not report it until nearly 2 years later, after the accident. Because of the loophole that currently exists in the Coast Guard's medical reporting system, and because other mariners who may be diagnosed with a serious health condition do not currently need to promptly report it to the Coast Guard, the NTSB reiterates M-09-4 in the *Eagle Otome* report.

As a result of this accident investigation, the National Transportation Safety Board makes the following safety recommendations to the U.S. Coast Guard:

> Conduct a ports and waterways safety assessment for the Sabine-Neches Waterway, determine from that whether the risk is unacceptable, and if so, develop risk mitigation strategies. (M-11-13)
>
> Work through the International Maritime Organization to encourage the application of human factors design principles to the design and manufacture of critical vessel controls. (M-11-14)
>
> Facilitate and promote regular meetings for representatives of pilot oversight organizations to communicate information regarding pilot oversight and piloting best practices. (M-11-15)
>
> Establish a database of publicly available pilot incidents and accidents and make the database easy to use and readily available to all pilot oversight organizations. (M-11-16)

Also as a result of this accident investigation, the National Transportation Safety Board reiterates a recommendation previously issued to the U.S. Coast Guard, as follows:

> Require mariners to report to the Coast Guard, in a timely manner, any substantive changes in their medical status or medication use that occur between required medical evaluations. (M-09-4)

Finally as a result of this accident investigation, the National Transportation Safety Board reclassifies a recommendation previously issued to the U.S. Coast Guard, as follows:

> Establish a mechanism through which representatives of pilot oversight organizations collect and regularly communicate pilot performance data and information regarding pilot oversight and best practices. (M-09-5)

Safety Recommendation M-09-5, previously classified "Open—Unacceptable Response" has been classified "Closed—Unacceptable Response/Superseded" by Safety Recommendations M-11-15 and M-11-16.

The NTSB also issued safety recommendations to the Sabine Pilots Association, the Jefferson and Orange County Board of Pilot Commissioners, the American Pilots' Association, and governors of states and territories in which state and local pilots operate.

In response to the recommendations in this letter, please refer to Safety Recommendations M-11-13 through -16 and M-09-4. If you would like to submit your response electronically rather than in hard copy, you may send it to the following e-mail address: correspondence@ntsb.gov. If your response includes attachments that exceed 5 megabytes, please e-mail us asking for instructions on how to use our Tumbleweed secure mailbox. To avoid confusion, please use only one method of submission (that is, do not submit both an electronic copy and a hard copy of the same response letter).

Chairman HERSMAN, Vice Chairman HART, and Members SUMWALT, ROSEKIND, and WEENER concurred in these recommendations.

[Original Signed]

By: Deborah A.P. Hersman
Chairman