January 16, 2025 MIR-25-02

Contact of Crane on Deck Barge *BMI 209* Towed by *Nickelena* with Mackinac Bridge

On May 7, 2023, about 0213 local time, the towing vessel *Nickelena* was transiting the Straits of Mackinac while towing deck barge *BMI 209*, transporting a crawler crane, when the crane boom struck the main span of the Mackinac Bridge (see figure 1 and figure 2).[1] The contact bent the crane boom backwards, causing the boom to eventually collapse onto the aft end of the barge. There were no injuries, and no pollution was reported. Damage to the Mackinac Bridge was estimated at $145,000; damage to the crane was estimated at $665,000.[2]

Figure 1. *Left to right*: The *Nickelena* on an unknown date before the contact, and the crane aboard the *BMI 209*, as seen from the *Nickelena* during the voyage and before the contact. (Sources: US Coast Guard and Basic Towing Inc.)

[1] In this report, all times are central daylight time, and all miles are statute miles.

[2] Visit ntsb.gov to find additional information in the public docket for this NTSB investigation (case no. DCA23FM032). Use the CAROL Query to search investigations.

Casualty Summary

Casualty type	Contact
Location	Straits of Mackinac, Mackinaw City, Michigan 45°49.05' N, 84°43.66' W
Date	May 7, 2023
Time	0213 central daylight time (coordinated universal time –5 hrs)
Persons on board	5
Injuries	None
Property damage	$145,000 (Mackinac Bridge) and $665,000 (crane) est.
Environmental damage	None
Weather	Visibility 10 mi, cloudy with rain, winds northeast 13 mph, air temperature 48°F, water temperature 44°F
Waterway information	Strait, width 3.5 mi, depth 254 ft

Figure 2. Location on the Mackinac Bridge that was struck by the crane aboard the *BMI 209*, as indicated by a circled *X*. (Background source: Google Maps)

1 Factual Information

1.1 Background

The 102.7-foot-long, steel-hulled towing vessel *Nickelena* was built in 1973 at Marinette Marine Corp in Marinette, Wisconsin. The vessel had been operated by several owners until 2010, when it was purchased by Basic Towing Inc (its current owner). The tugboat was used to move barges transporting construction equipment to sites around the Great Lakes. The deck barge *BMI 209* was built in 2012 at Basic Marine Inc in Escanaba, Michigan, for operations within the Great Lakes.

The *Nickelena* was to transport a Terex-American HC 275 crawler crane with a 160-foot-long boom and a 5-foot "rooster" sheave attachment on the deck barge from Escanaba to a construction project at Sault Ste. Marie, Michigan, where the barge and crane would remain until the project was completed. This transit required passing eastward beneath the Mackinac Bridge. The Mackinac Bridge, a four-lane vehicle suspension bridge spanning the Straits of Mackinac, connects Michigan's upper and lower peninsulas (see figure 3). The structure of the bridge was 26,372 feet long and 68.6 feet wide; the main span was 3,800 feet long, supported by two main suspension cables. The main suspension span consisted of a steel-framed stiffening truss, which was 38 feet deep. The stiffening truss supported the roadway deck above. According to the *US Coast Pilot 6* (Chapter 11), the vertical clearance (the distance from the water to the lowest point of the bridge) was 148 feet at the center of the main suspension span and 135 feet at the boundaries of the 3,000-foot-wide navigation channel. According to the Michigan Department of Transportation, the vertical clearance was 155 feet at the center of the main suspension span under normal conditions. Changes in vertical clearance depended on the amount of vehicle traffic crossing the bridge, lake water levels, and wind.

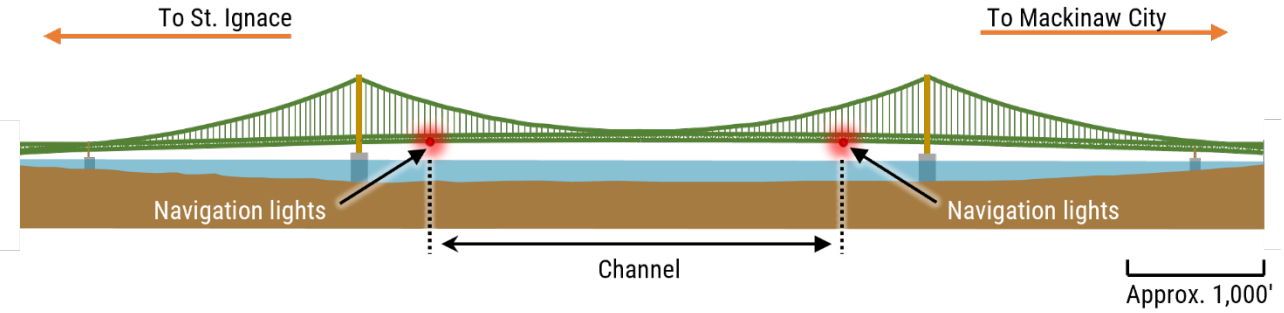

Figure 3. Diagram of the west elevation of the Mackinac Bridge.

At 0212, just before the contact, there was no traffic and minimal wind effect; however, the National Oceanic and Atmospheric Administration water levels for

Mackinaw City (south of the bridge) were higher than average. As a result, the vertical clearance was about 153 feet.

1.2 Event Sequence

The *Nickelena* captain and four crewmembers arrived on May 5 and 6, with the *Nickelena* and deck barge *BMI 209* scheduled to depart after the crane was loaded on May 6. Two managers from the tug and barge operating company positioned the crane on a 0.9-foot-thick crane mat (wooden timbers) to distribute its weight on the barge's deck and so that the barge would have proper trim for the trip. It was secured in place with four shackles (two on each side of the crane). The boom was secured to the forward deck of the barge via two steel wires.

After the crane was secured, the managers attempted to evaluate whether the crane boom was at a safe height to pass under the Mackinac Bridge. There were two methods to determine the angle and height of the crane boom: the Load Moment Indicator (LMI)—an electric measurement device that provided the angle setting and height of the boom on a computer screen—and the mechanical boom angle indicator (a dial located on the boom that displayed a degree value for the crane), which, in conjunction with the crane boom index chart in the crane's cabin, could be used to determine the boom height based on the crane's angle. One of the managers discovered that the LMI in the cabin of the crane was not working. They then tried, but were unable, to contact the crane owner for assistance in determining the boom angle.

The managers estimated, by visual evaluation, that the angle of the boom was between 50° and 60° and, since they believed that the boom was 140 feet long with a 5-foot "rooster" sheave attached for the construction project, they thought the boom was at a safe height for the transit. They decided against lowering the boom further to decrease the angle because they thought that by doing so it would reduce the stability of the barge for the tow. Before departing, one of the managers told the *Nickelena* captain, "everything's secured, ready to go."

Towing vessel regulations in Title 46 *Code of Federal Regulations* (*CFR*) Subchapter M require the operating company to have a towing safety management system (TSMS) or a towing vessel record. The vessel owners told the National Transportation Safety Board (NTSB) that they had a TSMS, as required, but they could not describe what it entailed, nor did the company respond to additional NTSB communications. Subchapter M also requires the officer in charge of a navigational watch to conduct a navigation assessment for the intended route and operations before getting under way, including consideration of "air draft relative to overhead obstructions for the intended route." According to the regulations, "The navigation

assessment must be recorded in the towing vessel record, official logbook, or in accordance with the towing safety management system applicable to the vessel."

There was no documentation that a navigation assessment was conducted before departure. Although the captain and the tug and barge operating company managers were aware that the planned route included passing beneath the Mackinac Bridge, none of them attempted to verify the bridge clearance.

On May 6, at 1400, the *Nickelena* departed Escanaba towing the deck barge *BMI 209* astern, heading east towards Sault Ste. Marie. Once the towing vessel and the barge were out of the harbor, the captain ordered the length of the tow line be increased to about 500 feet for the voyage (see figure 4). At 2300, the captain was relieved at the wheel by a crewmember and went below to rest in his stateroom; he planned to return to the pilothouse before the towing vessel and barge passed under the bridge.

Figure 4. Infrared footage of the *Nickelena* towing the deck barge *BMI 209* with the crane on board at 1226 the night of the contact. (Source: Enbridge Straits Maritime Operations Center)

On May 7, about 0200, the captain woke up and prepared to head to the pilothouse. At 0213, while he was still in his stateroom, the crewmember at the helm guided the vessel and barge under the Mackinac Bridge's suspension span at 8 knots within the marked channel.

At some point after passing under the bridge, both the engineer, who was out on deck, and the crewmember at the helm, looked aft and, with the help of the lights of the bridge, noticed that they couldn't see the crane's boom. The engineer went below and notified the captain.

After the captain arrived in the pilot house, he directed the crew to shine a spotlight aft on the crane and barge; the light showed that the boom had been bent completely backwards and had collapsed over the crane body and onto the aft part of the barge. The captain notified the company's office of the damage to the crane and of a possible contact with the bridge. The captain was directed to return to Escanaba. The company notified the Mackinac Bridge Authority about 8 hours after the casualty, which in turn notified the Coast Guard of the incident.

1.3 Additional Information

1.3.1 Damage

1.3.1.1 Bridge

The Mackinac Bridge Authority hired a consultant to survey the damage from the impact. The survey report, dated December 14, 2023, determined that the damaged area was on the west side of the span, 25 feet south of the center of the charted navigation channel. The survey identified damage on the stiffening truss bottom chord L96-L95 and upper diagonal U95-L96 truss members of the west truss (see figure 5).

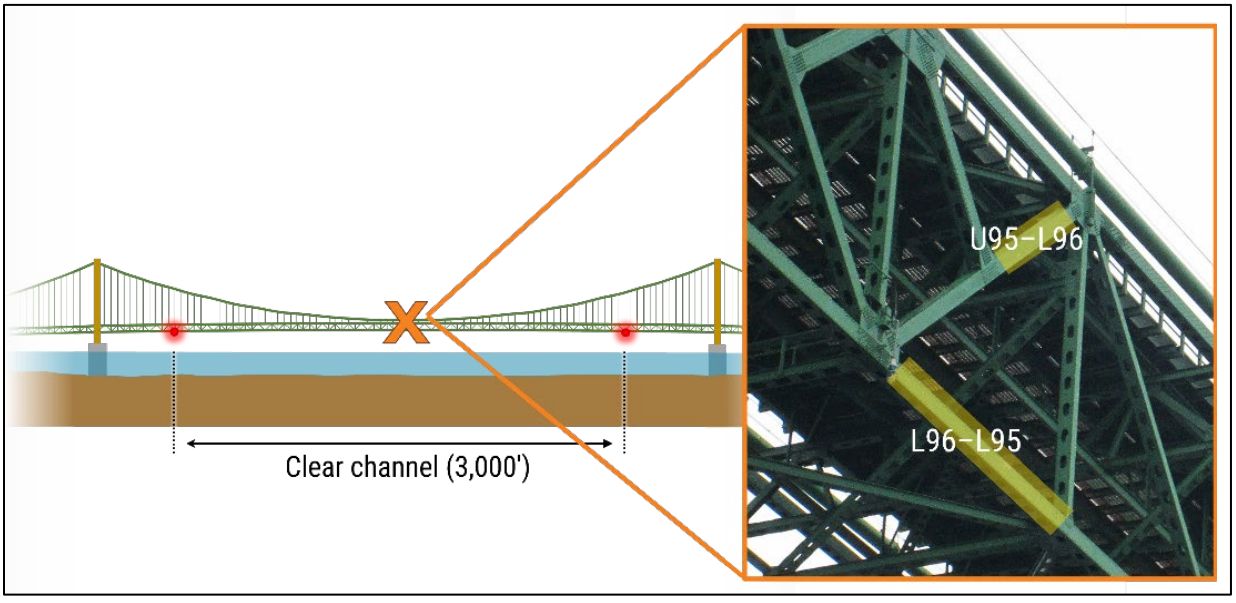

Figure 5. Area of west elevation of the Mackinac Bridge damaged by the contact with the crane boom aboard *BMI 209*, indicated by an *X*. Inset image at right indicates the location of the stiffening truss bottom chord (L96–L95) and upper diagonal truss (U95–L96). (Inset source: Mackinac Bridge Authority).

On the bottom chord L96–L95, the survey identified seven gouges and indentations within an impact area 6 feet and 2 inches in length along the west side of the structure. The gouges ranged from 1/8 of an inch to about 1/2 of an inch deep and were concentrated on the top edge of the bottom chord. The survey also found scratch marks consistent with the crane cables striking the westside surface of the bottom chord. In addition, 14 rivet heads on the chord were damaged, with either minor section loss to their tops or large gouges present.

On the upper diagonal member U95–L96, the survey identified several locations of impact, including three gouges to the bottom of the member. In addition, 11 rivet heads were damaged, with either minor section loss to their tops or large gouges present (see figure 6). The height of the highest damage was 183 feet above the water.

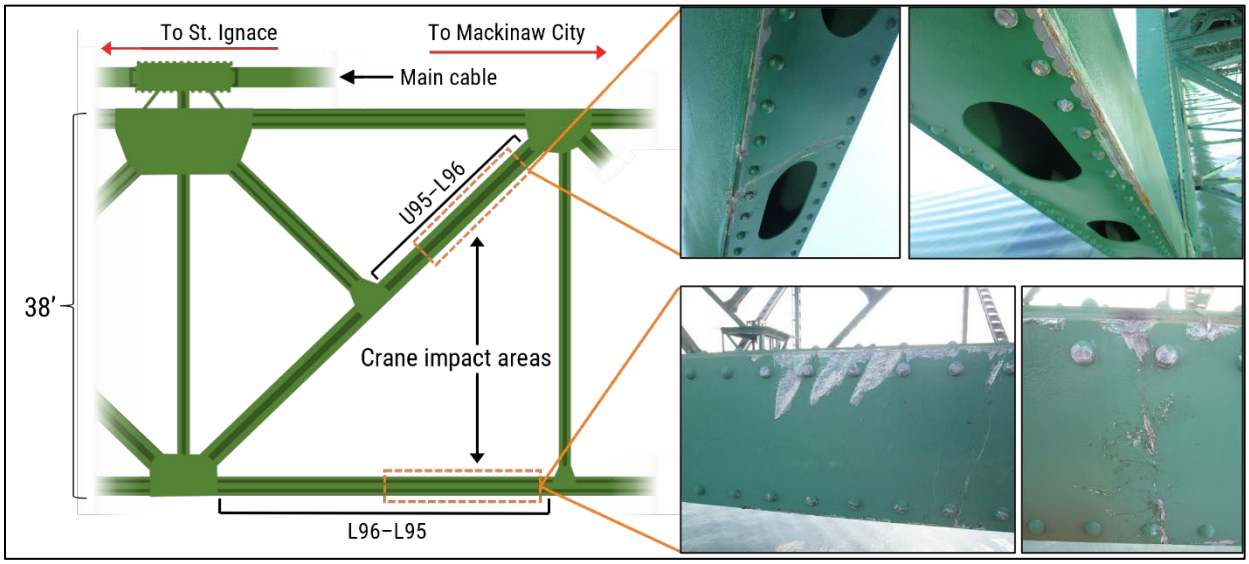

Figure 6. Areas damaged by the crane boom's contact with the bridge. (Inset source: Mackinac Bridge Authority)

1.3.1.2 Crane

Investigators examined the crane to determine the extent of its damage and found the crane boom (which was confirmed to be 160 feet in length with a 5-foot "rooster" sheave) to be completely folded back over the crane machinery body and resting on the crane body and the barge (see figure 7). The outer assembly of the boom was completely separated, while the inner assembly was still attached to the base of the crane. The top of the boom had impact-related damage and indications of boom-structure deformations below the rooster. The two cables that had been used to secure the boom to the barge parted, and the pully was damaged. In addition, scrape marks were found along the underside of the boom, below the pully.

Figure 7. The boom bent backwards over the cabin after striking the bridge. (Source: Coast Guard)

The crane's mechanical boom angle indicator was extensively damaged by the contact, so investigators could not determine whether it was operational before the bridge strike. Investigators evaluated the LMI and determined that the LMI display was showing a fail mode for the boom angle, the boom pitch and roll, and the wind indicator. The system had the capability to record data, but data downloaded and evaluated later only showed the dates and times of system startups and shutdowns.

1.3.2 Boom Height Evaluation

The NTSB conducted a study of the crane boom angle based on an infrared surveillance image of the crane from before the casualty (see figure 4) to estimate the height of boom at the time it contacted the Mackinac Bridge.[3] The study determined, based on a 3-D Terex American HC 275 crawler crane/deck barge simulation model, that the boom angle during the voyage and before contact with the bridge was 62 ± 1°, which equated to a height of 162.3 feet (see figure 8 and figure 9).

[3] "Crawler Cane Boom Elevation Study," December 15, 2024; NTSB Office of Research and Engineering (see docket).

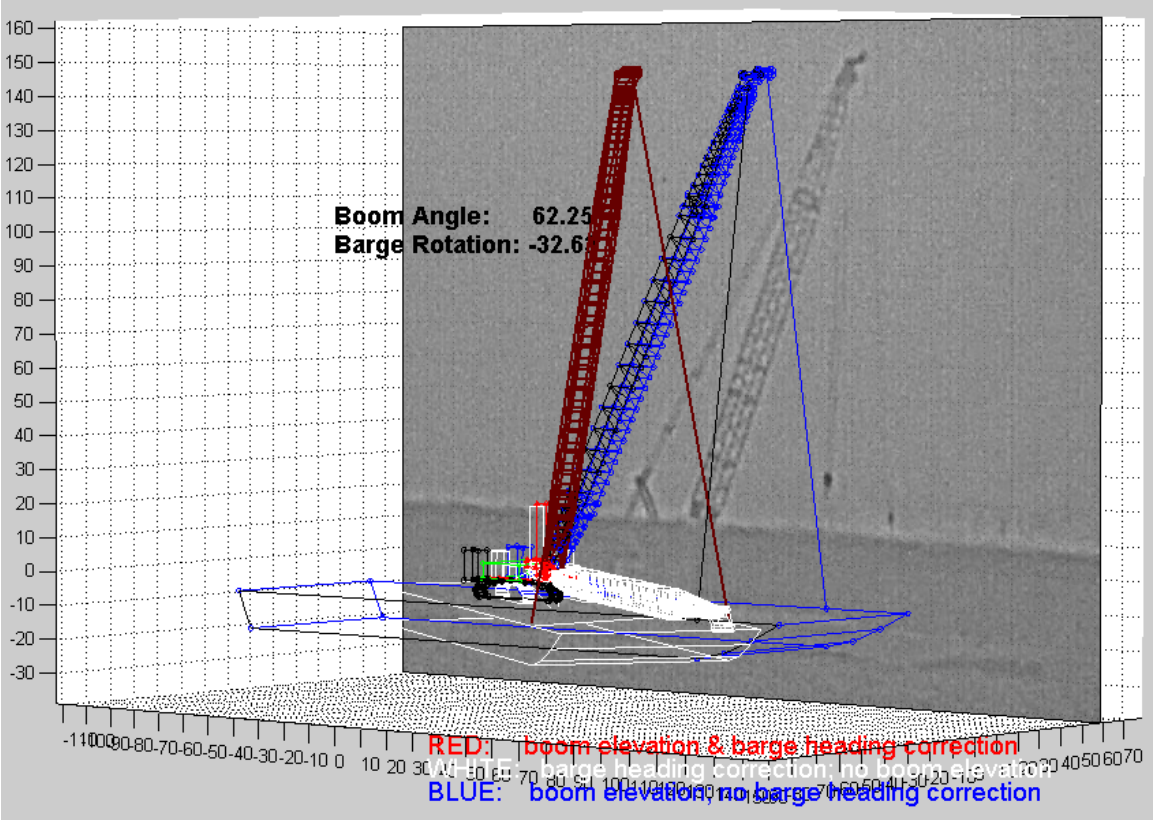

Figure 8. Infrared footage of the crane on board the deck barge *BMI 209* at 1226, with the NTSB simulation overlay of the boom angle at 62.2°. (Background source: Enbridge Straits Maritime Operations Center)

The NTSB study also determined that the maximum boom elevation angle for the Terex American HC 275 crawler crane (on deck barge *BMI 209*) to pass under the Mackinac Bridge near the center of the channel was about 55°.

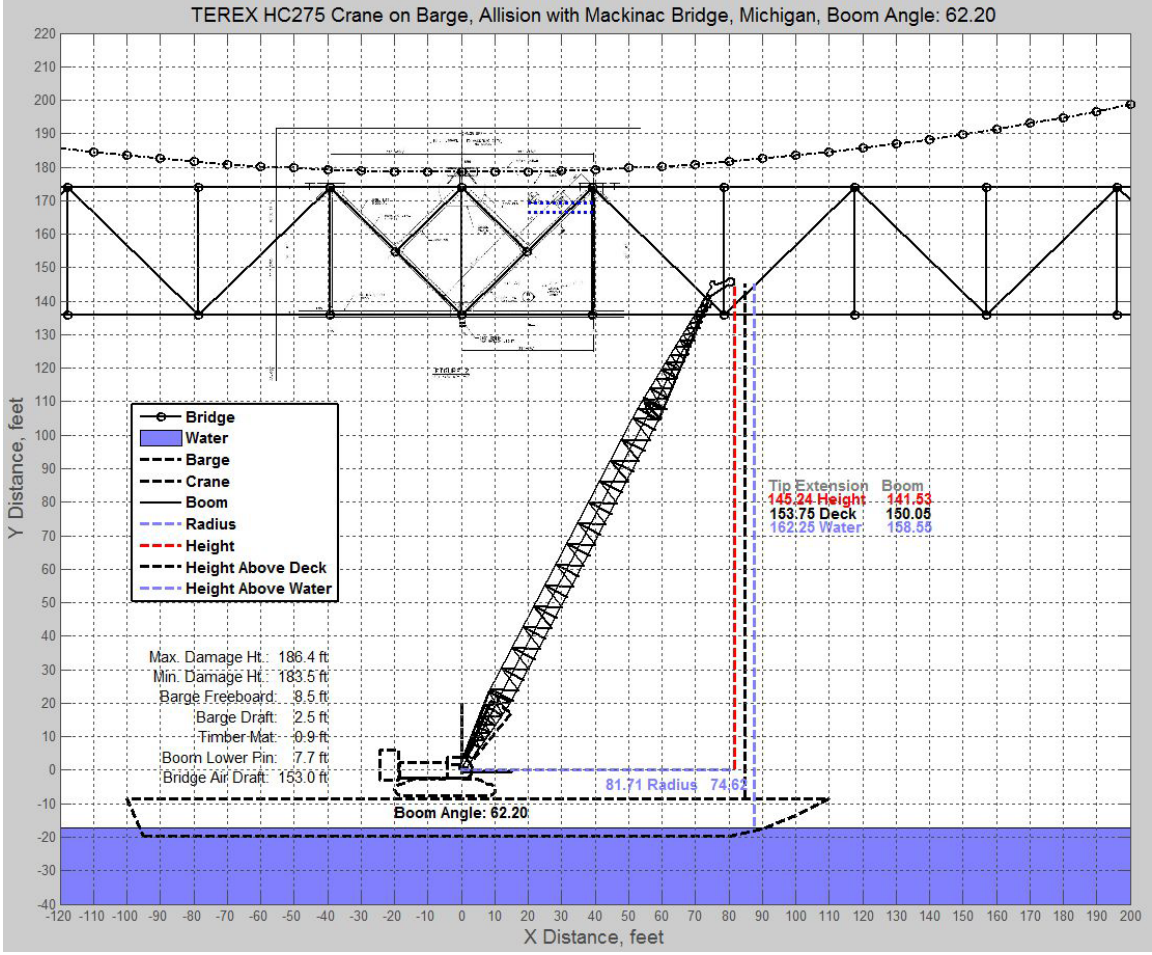

Figure 9. NTSB calculations showing that a 62.2° crane boom elevation angle yields upper boom contact with the bridge truss bottom chord for the reported *BMI 209* deck barge draft (2.5 feet) and bridge vertical clearance (153 feet). The calculated height of the tip extension from the water at this angle is 162.3 feet (blue text).

Coast Guard investigators conducted a boom height evaluation using an identical crane to estimate the height of the boom at different angles to assist in determining the combined height of the barge and crane before the casualty (see table 1). The freeboard and mat thickness measurements that were taken following the casualty were included in the estimation. The distance from waterline to the deck of the barge was 8.5 feet, and the timber mat was 0.9 feet thick. The Coast Guard used the crane's LMI and the mechanical boom angle indicator with the crane boom index to confirm the angle of the 160-foot boom before measuring the height from the top of the rooster on the boom to the ground.

Table 1. Coast Guard comparison of the boom angles and measured boom heights from the ground.

Angle	Measured Height	Total Estimated Height (including height of the crane to the barge waterline)
44.4°	127.0 feet	136.4 feet
55.0°	153.0 feet	162.4 feet
60.0°	156.0 feet	165.4 feet

2 Analysis

About 0200 on May 7, shortly after passing eastward under the main suspension span of the Mackinac Bridge, the crew of the commercial towing vessel *Nickelena* discovered that the crane they were towing 500 feet astern (aboard deck barge *BMI 209*) had struck the bridge and collapsed onto the barge.

Before departure, managers from the towing vessel operating company visually estimated the angle of the boom to be between 50° and 60° and believed that, with its 5-foot "rooster" sheave attached, the boom was 145 feet in length (the boom was 160 feet long). Using their visual estimation of the crane's boom angle and their boom length estimate, both of which were incorrect, they believed that the boom was at a safe height for the transit. The managers told the *Nickelena* captain "everything's secured, ready to go."

The damage to the Mackinac Bridge structure indicates that the first contact was to the stiffening truss below the roadway, at the top of the truss's bottom chord (about 155 feet above the water). Given the configuration of the crane, the wires securing the crane boom would have hit first, and then when they parted, the boom would have contacted the top of the chord. As the barge continued forward, the boom would have been pushed backwards and its angle and height above the water would have increased, leading to damage higher up on the bridge. At some point, the boom contacted the upper diagonal truss (U95–L96), about 183 feet above the water, before folding back and collapsing on the barge.

An NTSB study used video of the crane barge on the day of contact to determine that a boom elevation angle for the crawler crane over about 55° would contact the truss bottom cord of the bridge with the barge near the center of the channel. The study determined that the boom angle during the voyage and before contact with the bridge was about 62°, corresponding to a boom height of 162.3 feet above the water (see figure 9). Similarly, a postcasualty Coast Guard analysis determined that if the boom angle was 60 degrees (the high end of the towing company managers' estimate), the end of the 160-foot-long boom with an attached 5-foot rooster sheave would have been about 165 feet above the water level. Given the vertical clearance of 153 feet for the Mackinac Bridge at the time of the contact, the crane was about 10 feet too high to transit under the bridge (not including an additional safety margin).

Towing vessel operations are required to have a TSMS, which is a formal, documented system for owners and operators to ensure that rules and procedures related to safe operations are in place. A properly implemented TSMS is an effective tool for safety oversight; it is designed to reduce human error, create a culture of

safety at all organization levels, and reduce the risk of maritime casualties. Ensuring that the vessel and tow can safely pass any overhead obstructions on the route is a critical part of voyage planning. Procedures like voyage planning would have been included in a TSMS, and the TSMS would have required documentation of this planning once completed.

The vessel owners told investigators that they had a TSMS. However, there was no documentation that a navigation assessment was conducted before departure, and the captain took no additional actions to verify the tow was safe to transit the intended route after the towing company managers told him the tow was "ready to go." The captain, who was responsible for ensuring that the vessel was safe to transit the intended route, did not confirm the crane boom height before departure, nor did he attempt to verify the bridge's vertical clearance. Instead, he relied upon the erroneous estimates provided by his managers. The company managers, who should have been providing oversight and ensuring that effective voyage planning occurred, may have undermined this process by telling the captain that the crane on the deck barge was ready for the transit. A functional TSMS, when properly implemented with effective oversight, would have ensured both company managers and the captain collaborated to ensure effective voyage planning prior to departure. Therefore, the company did not implement the TSMS aboard the vessel to ensure effective voyage planning occurred before departure.

3 Conclusions

3.1 Probable Cause

The National Transportation Safety Board determines that the probable cause of the contact of the *Nickelena*'s towed crane on deck barge *BMI 209* with the Mackinac Bridge was the captain's and barge company managers' ineffective voyage planning, which did not identify the crane being towed was too high to pass safely under the bridge.

3.2 Lessons Learned

Verifying Navigation Risks when Voyage Planning

For vessels and tows with high air drafts, such as crane barges, bridges pose a risk of overhead contact. Operators should ensure they have the most accurate and objective data about the crane and bridge heights before getting underway. Appropriate navigational resources such as the *US Coast Pilot* or navigational charts should be consulted by owners and operators when developing voyage plans to assess navigation risks and hazards, including the air draft relative to bridge vertical clearances along the intended route.

Vessel Particulars

Vessel	*Nickelena*	*BMI 209*
Type	Towing/Barge(Tugboat)	Towing/Barge (Barge)
Owner/Operator	Basic Towing Inc. (Commercial)	Basic Towing Inc. (Commercial)
Flag	United States	United States
Port of registry	Escanaba, Michigan	Escanaba, Michigan
Year built	1973	2012
Official number (US)	1210059	1240283
IMO number	8654247	N/A
Classification society	American Bureau of Shipping	American Bureau of Shipping
Length (overall)	102.7 ft (31.3 m)	210.0 ft (64.0 m)
Breadth (max.)	44.0 ft (13.4 m)	58.6 ft (17.9 m)
Draft (casualty)	16.2 ft (4.9 m)	11.0 ft (3.4 m)
Tonnage	240 GT ITC	1,001 GT ITC
Engine power; manufacturer	1 × 2,000 hp (1491 kW) Fairbanks Morse diesel engine	N/A

NTSB investigators worked closely with our counterparts from **Coast Guard Sector Sault Sainte Marie** throughout this investigation.