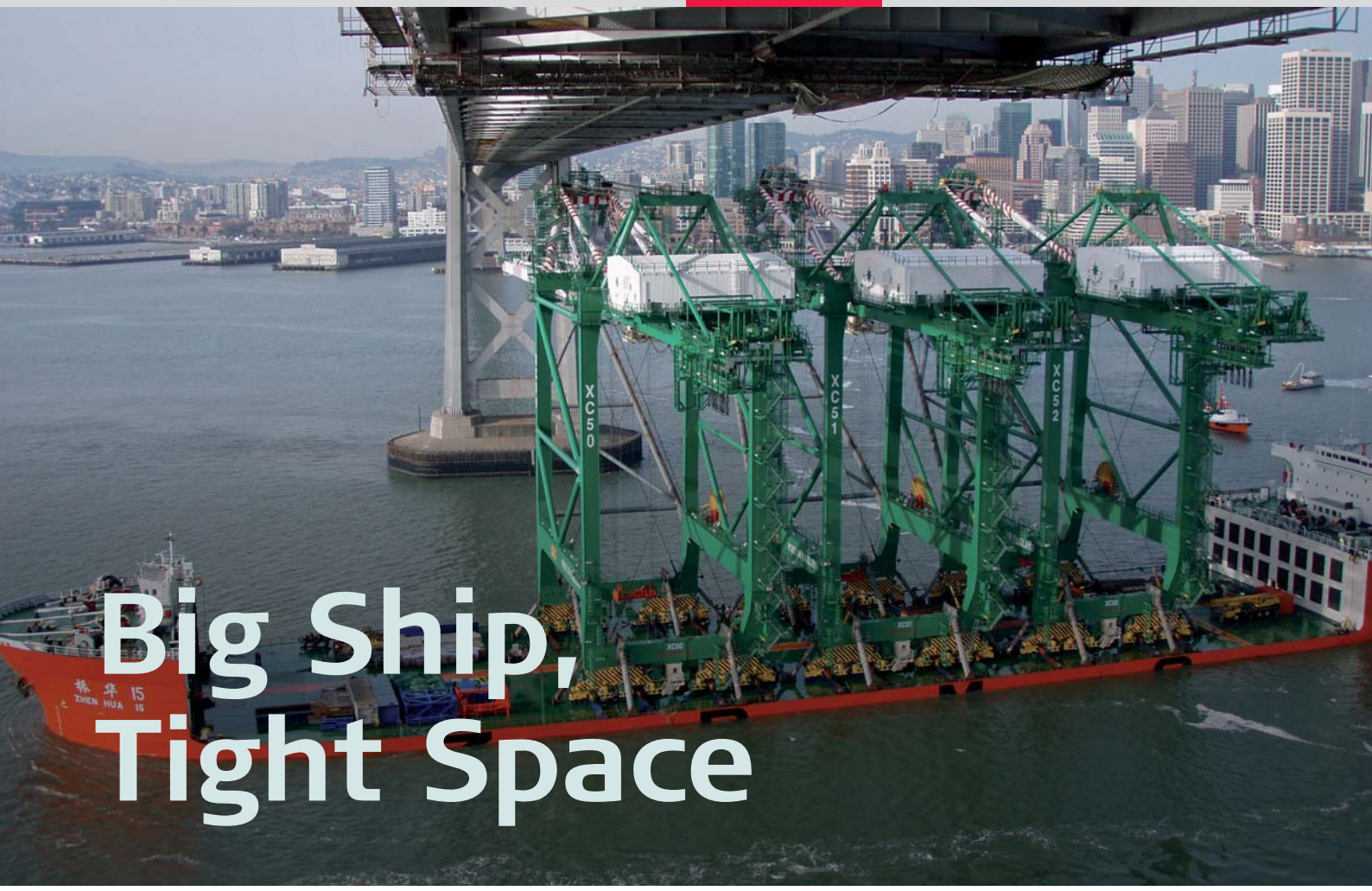

Big Ship, Tight Space

by Brad Longstreet and Dave Murtha

With a clearance of about 226 feet (69 m) between Mean Lower Low Water (MLLW) and the span underside of the San Francisco Bay Bridge, there's usually plenty of room for the world's biggest ships to pass through on their way to the Port of Oakland. But when one of those ships is loaded with three of the world's tallest container cranes, maybe there's not enough room ... or maybe there is. The job of deciding fell to Dave Murtha, the Port's chief surveyor.

The cranes in question are "Super-PostPanamax" and they're monsters – PostPanamax ships are too big for the Panama Canal, and as more are built, ports around the world are installing cranes that can accommodate them. In this case, the cranes being delivered are wide enough to reach across vessels carrying up to 22 Sea-Land style cargo containers side by side. Of more concern to Murtha was their height: 253 feet (77 m). When loaded on a ship big enough to carry them, this would easily exceed the Bay Bridge's clearance.

The crane's designers knew this, and planned to cut and fold the cranes shortly before passage was attempted. But this still left plenty of uncertainty. To be sure he was making the right call, Murtha would have to precisely equate tidal elevation values and NAVD 88 (North American Vertical Datum of 1988), determine the absolute Bay Bridge clearance, and verify the total height of ship and cranes. And just to complicate matters, he would have to do it all in real-time; the San Francisco Bar Pilots who oversee large vessel operations in the Bay wanted verification of sufficient clearance as the cranes approached the Bay Bridge. The Bay Bridge, incidentally, is known to have several feet less clearance than the Golden Gate Bridge, so Murtha's work would automatically confirm that the cranes could pass under the Golden Gate.

Murtha had an idea that made use of his extensive experience with leading edge survey techniques: "Since RTK GPS methods are now being used to measure elevation profiles of airport runways, it didn't seem like a big stretch to adapt RTK methods to verify load clearance. I told people in my organiza-

tion that I could measure the height of the cranes as they approached the bridge. Eventually my claim got passed on to the San Francisco Bar Pilots, and they were very interested in having me provide that information." Airport runway profiles can be post-processed and re-measured if necessary ... but given the inertia of giant cargo vessels, there would be no second chances to re-measure as the cranes approached the bridge.

Laying the Groundwork

Providing real-time information for this project required painstaking preparation for several reasons. For example, Murtha knew he needed a backup plan. "Redundancy was a very important part of the survey plan," he says, "Two different RTK rovers would be used at the top of the load of cranes, one using cellular modem communication equipment, and the other using a spread-spectrum radio modem."

The cellular modem could access a Leica GRX1200 Pro permanently installed at the Port's headquarters. This receiver is part of RTKMAX, a subscription real-time network operated by Haselbach Surveying Instruments (Leica Geosystems' authorized dealer for Northern California). But for reliable radio link RTK, he would need a base station with line-of-sight from both the Golden Gate and Bay Bridges. "The levee on the west side of Treasure Island was the perfect location," says Murtha.

Work was already underway to verify the Port's reference station and relate it to tide station values. Murtha says: "I included the Port's reference station in a GPS control survey which I am submitting to the National Geodetic Survey (NGS). The control survey was mostly conducted in June 2009 using Leica ATX1230GG antennas. Additional vectors focusing on height differences were measured in August 2009. This control survey consists of more than 100 vectors and also includes several miles of leveling conducted in June 2009 with a Leica DNA03 digital level and a calibrated pair of Wild GPCL3 Invar rods. Four different tidal bench marks were part of this control survey."

To supplement the work for the crane height survey, Murtha planned a static control survey with two objectives: establish the needed base station location and elevation on Treasure Island, and relate local tide datums to NAVD 88. He included six stations in the final network. With control firmly established; tide related to available benchmarks and NAVD 88; and the Treasure Island station set, Murtha could move on to additional tasks in this challenging project: verifying Bay Bridge clearance and crane height above the deck of the transport vessel.

Tricky Measurements on the High Seas

In 2000, when a shipment of Post-Panamax container cranes was delivered to the Port of Oakland at the Navy's former Fleet Industrial Supply Center (FISCO) in Oakland, Port personnel measured the Bay Bridge's mid-span clearance by trigonometric leveling methods. This time, Murtha used RTK to establish a spot elevation on the upper deck of the bridge,

then used a Leica TCRP 1201 total station to transfer elevation from that point to a magnetically mounted prism target that was visible from the upper deck and from the base of the nearest suspension tower pier.

Then, in what must have been a fun day in the field, Murtha took a boat to the pier and set up his total station. Two CalTrans (California Department of Transportation) employees, certified to climb on the bridge, used safety harnesses and belaying equipment to set another prism directly on the bridge's bottom chord. Murtha was able to confirm a clearance of 226 feet (69m) above MLLW.

The three cranes, standing their full 253 feet (77m) tall, arrived at Drake's Bay, north of San Francisco, on March 12, 2010, loaded on the Zhen Hua 15, a tanker with a specially modified low deck. While anchored at Drake's Bay, the crew of the Zhen Hua 15 spent three days folding over the crane apexes. Two days later, Murtha traveled by boat to the vessel to verify the final crane height, and to set GPS antenna mounts at the top of the middle crane. It turned out to be another exciting day in the field: "The crew of the Zhen Hua hoisted our equipment up to the boom level of the crane, which is about 180 feet (55m) above the deck of the vessel. Since the apex had been folded over more than 70 degrees, the stairs to reach the boom of the cranes were much more difficult to climb – think of a jungle gym 200 feet in the air slowly rocking back and forth with the waves. Once we got to the top we set ourselves to the task of setting up the GPS antenna mounts. I had modified two old tripods by removing the metal points and replacing them with three inch (7.6cm) diameter disk magnets attached to the tripod legs by metal hinges. Since tripods are excellent for setting up over non-level surfaces, I figured these modified tripods would be the best way to setup the antenna mounts."

With antenna mounts in place, Murtha and his crew returned to the deck to take total station measurements. Since the rolling of the deck ruled out the use of the vertical compensator – "I could see the bull's eye bubble moving back and forth" – Murtha turned it off and took a series of measurements intended to define the deck plane and crane height above deck. Back in the office, he "performed a classic seven-parameter, three-dimensional coordinate transformation," which confirmed what the crew's engineers had told him – the cranes had been lowered even more than planned, and should clear the bridge with about 10 feet (3m) to spare.

The Big Day

The transit was set for March 16th. The Port of Oakland employees once again climbed to the boom level, donned safety harnesses, and climbed to the top of the center crane. Even with all the checking and rechecking, it was still a tense moment; "We got there just a few moments before the Zhen Hua reached the Golden Gate Bridge," says Murtha, "and we were happy to see it pass under with what looked like 15 feet (4.5m) of clearance."

Murtha put his equipment into stakeout mode and started gathering data: "We hadn't yet reached Alcatraz, so we were still more than three miles away from the Bay Bridge, and I was able to tell the pilot that we had 9 feet (2.7m) of clearance. I called him again when we were between Alcatraz and Treasure Island, and he called me once more when we were much closer to the Bay Bridge to confirm the clearance values. Shortly after that I realized I could see the bottom of the bridge, so I called him on the radio one more time and said, 'I can see the bottom of the bridge. We're definitely going to clear it!'" ■

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