Blended scan data with photo

Crossing a Bridge at the Speed of Light

Laser scanning the I-95 Christina River Bridge in Wilmington, Delaware from the river

In the state of Delaware there is a push to maintain the current transportation network. As part of this reinvestment in infrastructure, the Delaware Department of Transportation has a robust multi-year rehabilitation program planned for one of its main northeast corridors, Interstate 95. In the fall of 2015, Pennoni a key sub-consultant to the prime designer Whitman, Requardt & Associates, LLP, was tasked to provide a 3D corridor survey. This was the first of its kind in Delaware and was a massive under-taking to scan and model various bridges, elevated highway and at-grade highway sections. As part of this endeavor, Pennoni made the recommendation to mobile scan six miles of the project corridor and to provide terrestrial scanning of the underside of the bridge locations that were inaccessible to the mobile scanner.

Picking the Right Tool

No two bridge scan jobs are ever the same, especially when working on

BY JONATHAN SEVER

multi-span bridges over water. Having the right tools and the confidence to use them, allowed the team to meet demanding project schedules. Selecting the right tool accessories to fulfill the project needs and to keep the project on the critical path, required thinking outside the box. With Pennoni having a variety of survey tools spanning Topcon total stations, Leica Robots, GPS and Scanners and FARO scanners it came down to selecting the most cost efficient tool, a few pieces of steel and a little ingenuity to get the job done. At the end of the day, the compact and lightweight FARO X330 won out with some home built jigs.

Leveling the scanner on the Jig


Installing the Jig on a pier

Field Operations

How do you survey the underside of a 558'-6" foot long span of I-95 over the Christina River? Factoring in that multiple pier structures are obstructing line of sight to critical features such as; bearing attachment points, top edge of the piers and the bottom face of all the steel beams that span a navigable water way, a unique solution was needed. One option discussed was to set up a conventional Topcon Total Station and locate all the features reflector-less. This would have required multiple setups on unstable muddy banks for clear sight lines, which would likely not produce the desired results. Additionally some of the setups would have required locating features from over 800' away so that the instrument person could have a clear line of sight. Since the features of the bridge needed to be subsequently modeled, sufficient existing conditions data could not be obtained in a timely manner with conventional survey methods so this option was crossed off the list. Another option was to use a Leica C10 Laser Scanner for the same role as the total station, collecting a larger data set of the structure. That too had its drawbacks as well. One being the weight of the unit and a tripod. At around 50 pounds, maintaining a stable set up to attain the accuracy needed would be challenging for the unit on soft soil.


Scanner running on the Jig

Close up of the Scanner on the Jig

Overview of the Project Site

View of the bridge in Bentley Pointools

Close up of the point cloud in Faro Scene 5.5 software

Another option that was discussed was to float a barge up the river and anchor it to the piers and scan the structure from the deck of the barge. The problem with the barge option was accounting for the constant change in the river elevations due to the tidal conditions and wave action. This was now the third option that had to be crossed off the list of possible methods.

Tool Development

The final option and ultimate solution was to use our FARO Laser Scanner for some close-in overlapping scans from multiple fixed locations. Stepping back from the project for a moment and looking outside the box of traditional survey setups and equipment, we visualized the piers of the bridge as fixed positions for setting up the FARO scanner and as a way to provide control reference points. With the relative lightweight of the scanner we conceptualized a stable jig that could support the 12 pound FARO and still have it be safely setup with minimal personnel and equipment. Also factoring in the design, we did not have to worry about the weight of our scanning equipment pulling our scanner technician over the rail of the boat when they would lift the instrument up to the Jig. Relying on some of my past mechanical engineering experience and welding experience, a lightweight prototype was fabricated. The Jig was made of 18 gage steel tubing and braced appropriately to support the scanner and prevent any flexing. Additionally a plate was welded and tapped to attach a tribrach for quick mounting and removal of the scanner and to accommodate a range of survey tools. At 15 pounds it was still maneuverable by a single person and using a tribrach, it allowed us to set the

View of the bridge in Bentley Pointools

jig in place, lock the scanner down and level the scanner in three easy steps. Additionally, 2000 pound ratcheting straps were welded to the jig to allow quick attachment to and removal from the piers, which did not require any permanent attachments to the bridge substructure. With the ratchet straps snugged up on the pier, final adjustment and strap tension was set with the two welded setscrews mounted on the top cross member. With the Jig having been conceptualized and a prototype fabricated, the question was—How do we set the Jig on the piers? In comes support from one of Pennoni's other unique resources: the Underwater Diving and Inspection group. Utilizing our 26' Dive boat allowed the surveying team to navigate safely within the River to place the Jig on each pier. Having the Jig setup to quickly deploy, allowed us to place the Jig and strap it to each pier in less than five minutes and have the scanner up in running in less than two minutes. Working around the tides, Pennoni was able to complete the underside scanning within six hours. On the following day we were able to complete the additional scanning of the bridge abutments and the scans of the sides of the bridge.

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The prototype Jig

Processing the cloud

Once all of the scans were completed and tied to conventional survey control, the data was processed in FARO Scene 5.5, using a mixture of traditional survey located targets and FARO Scene's Cloud to Cloud processing tools. Once all of the standard QA/QC checks were performed using Trimble Real Works 10, the data sets were exported into various formats suitable for modeling in various CAD programs. Much of the data processing was completed with Bentley products including Microstation, Descartes and Pointools. Additionally, Pennoni's mobile scanning consultant merged the static scan data into the overall project point cloud from the Mobile Lidar to produce a seamless data set for the surface model extraction using Microstation and TopoDOT. By selecting the right field and office tools, Pennoni was able to capture a 1.3 billion data point set of the Christina River Bridge (https://youtu.be/a6mqaOgFoX0) and have the ability to constantly harvest the data in the office instead of mobilizing convention survey crews for every new data request. At the end of the day Pennoni's HDLS survey team was able to scan, model and extract data in a matter of days verses weeks by "Bringing the field into the office".

Jonathan Sever is HDLS Project Manager for Pennoni. You can follow him on social Media:
Linkedin: Jonathan Sever;
Youtube: SEVER3DSCANNING;
Twitter: @SEVER3DSCANNING