



BENEFIT

BY SAMUEL GREENGARD

WITH

THE WAVES

THE CHALLENGES OF UNDERWATER ENGINEERING ARE REMARKABLE, BUT TECHNOLOGY IS DRIVING INNOVATION

Engineering has always revolved around the idea of expanding and extending the reach of humans. However, in the ongoing quest to build better transportation systems, more elaborate energy infrastructure and advanced telecommunications networks, it is easy to overlook a basic fact: Many projects involve underwater elements—and the scope of these projects is often complex and challenging.

“There is a great deal of innovation that goes into constructing, maintaining and repairing underwater structures and systems,” says Terry Browne, vice president of safety at Collins Engineers, Inc., a full-service civil engineering firm that specializes in underwater projects.

Underwater engineering is not for the faint of heart—or the short of breath. Dropping transoceanic cable at several thousand meters or sending divers to inspect bridges or deep-water oil platforms in near-zero underwater visibility is not only rife with difficulties, it can delve into the realm of dangerous and expensive. These projects require advanced know-how, sophisticated technology and a willingness to push the boundaries of conventional thinking—and engineering. Venturing beneath the surface of a river, lake, reservoir or ocean is far different than the engineering and construction that takes place on terra firma.

“Unseen situations equate to unknown conditions of critical infrastructure, along with unknown hazards,” says Browne.

How do firms specializing in underwater engineering accomplish seemingly impossible tasks? How do they put innovative concepts and leading-edge technologies to work?

Using an array of tools and expertise—from sophisticated dive suits and submersibles to sonar, acoustical imaging, LiDAR, electromagnetics and big data analysis—engineers navigate adverse pressures, poor visibility and strong currents in order to build and maintain the bridges, oil platforms, wind farms and pipelines that keep the world functioning.

“These projects involve complex and expensive infrastructure,” says Nicholas Welz, director of submarine cable systems for Tetra Tech, Inc., an engineering firm that specializes in major ocean and reservoir projects.

A DIFFERENT WORLD

Underwater engineering can encompass a diverse array of tasks, including:

- Design-stage data gathering
- Environmental permitting and archeological studies
- Subsurface construction monitoring and quality control
- Maritime threat assessments
- Rapid condition assessment following a seismic event, storm or accident
- Erosion detection and documentation
- Evaluating existing infrastructure

“Any work that is done above water may be accomplished below water with the proper planning, training, approach and understanding that there are additional obstacles that must be



Collins Engineers, Inc.'s underwater inspection team assesses both public and private waterfront facilities to ensure safety and long-term serviceability. Following the fieldwork, engineer-divers prepare repair design plans and provide construction observation services during contractor rehabilitation operations.

overcome,” says Shanon Chader, chief of the Coastal/Geotech Team and district dive coordinator for the U.S. Army Corps of Engineers (USACE) in Buffalo, New York.

Although the fundamentals of engineering remain the same on land or at sea, the way that underwater specialists approach projects can vary considerably. It is not unusual for teams to work in conditions where they cannot see components and equipment, where currents and pressure present extreme difficulties and dangers, and where forces and physics affect structures in entirely different ways.

Chader points out that limited visibility, water temperature, varying air temperature, wind, waves and other environmental factors can further ratchet up the challenges and risks. Teams may work in icy or polluted water and confront dangerous creatures.

“My dive team has had to deal with snakes, fire ants, dolphins, sharks and large alligators to name a few,” he says.

Of course, building and maintaining bridges, tunnels, dams, pipelines, oil and wind platforms, cables and other infrastructure also require specific technical acumen—and the right equipment.



“Today’s equipment and technology allow us to go deeper beneath the surface and obtain critical project information faster and better.”

MICHAEL J. GANAS
VICE PRESIDENT AND DIRECTOR OF UNDERWATER
AND MARINE ENGINEERING PROJECTS
BOSWELL ENGINEERING



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COLLINS ENGINEERS, INC.

“The technology and processes are often very different than projects taking place on the land,” says Michael J. Ganas, vice president and director of underwater and marine engineering projects at Boswell Engineering. The company performs underwater inspections and designs and manages or monitors underwater construction, inspections, maintenance and repairs of waterfront facilities such as dams, piers, bridges and other water-based structures. The firm has worked extensively with the New York State Department of Transportation, the Port Authority of New York and New Jersey and various other entities.

What makes the task more challenging is the fact that there is an “out of sight and out of mind” perception of these projects by marine facility owners, whereby information obtained by a servicing entity on the condition of a submerged structure must be accepted on good faith, though that information may essentially be erroneous. As such, underwater inspection is one of the most abused areas of civil engineering, according to Ganas. Underwater structures and equipment often deteriorate faster and more severely than comparable structures exposed to the atmosphere. This can lead to additional maintenance costs, damage, risks and

dangers. Additionally, building these highly specialized structures and spotting defects is only part of the challenge.

“Personnel must not only be proficient in commercial diving techniques to gain access to submerged structural elements, they must also possess a firsthand knowledge of a wide array of deterioration processes and their causes,” Ganas says.

WORKING UNDER PRESSURE

At the heart of underwater engineering is a basic fact: Advances in materials, methods and technology have radically changed the way firms approach projects. According to Welz, processes take place faster, more efficiently and within a safer framework than a decade or two ago.

“In the 1980s and 1990s, engineers used paper charts taped together and a wax pencil to plan transoceanic cable systems,” Welz says. “The planning process could take weeks or months to complete. Now you have GIS systems that can generate a contour map of the bottom and can model the way you are going to install the cable. The system can tell you exactly how much slack you are going to need to reach over bottom contours—and ensure that

Anatomy of an Underwater Project

The logistics, planning and coordination required for a major underwater engineering project are significant. For example, when Boswell Engineering landed a contract to install a scour monitoring system at the Indian River Inlet Bridge near Delaware Seashore State Park, a complex mix of tasks, technologies and processes was required.

Working under contract with the Delaware Department of Transportation, Boswell engineers used a sonar device to gauge the progression of developing scour holes that could potentially destabilize bridge piers located in the water. However, installation of the system

required three divers to work on the seaward side of the bridge, where water conditions are rough and hostile.

Knowing it would be impossible to mount the system to the pier stems when the swift and turbulent current was at its worst, Boswell Engineering divers had to utilize narrow slack tide windows when the flow was ebbing and reversing. Teams had to plan in advance by referencing Indian River Inlet tide tables.

The divers relied on surface-supplied commercial diver support equipment with diver-to-surface communication to perform the installation. Using a 68-foot crew boat to provide stability

in the powerful flow, the team used hydraulically powered hammer drills and welding gear to mount two prefabricated sensor support frames to the pier stems at fixed elevations underwater, one per water-based pier on the shoulder facing the seaward side.

Working in murky conditions, the team ultimately installed fendering frames to each pier stem above the sensor frames at elevations just above mean high water. These structures provide additional protection to the sensors against boats and floating debris. The project was completed in about three weeks. The system now provides an additional layer of safety for motorists who use the bridge.



“With all this data, it is possible to understand what challenges or problems exist and make an informed decision about a project.”

NICHOLAS WELZ
DIRECTOR OF SUBMARINE CABLE SYSTEMS
TETRA TECH

you have exactly the right amount of cable going over the stern as you lay the cable.”

These systems also depict underwater surfaces, including scour depressions, debris accumulation and exposed pier footings. As a result, engineers and other specialists, such as data scientists, must understand how to use sonar, LiDAR and other systems to develop reports and visualizations that aid in a project. The accuracy of data is crucial.

“There is a tremendous amount of liability associated with underwater operations, and firms should adequately risk-assess operations, constantly improve staff capabilities and embrace technological innovations,” says Browne.

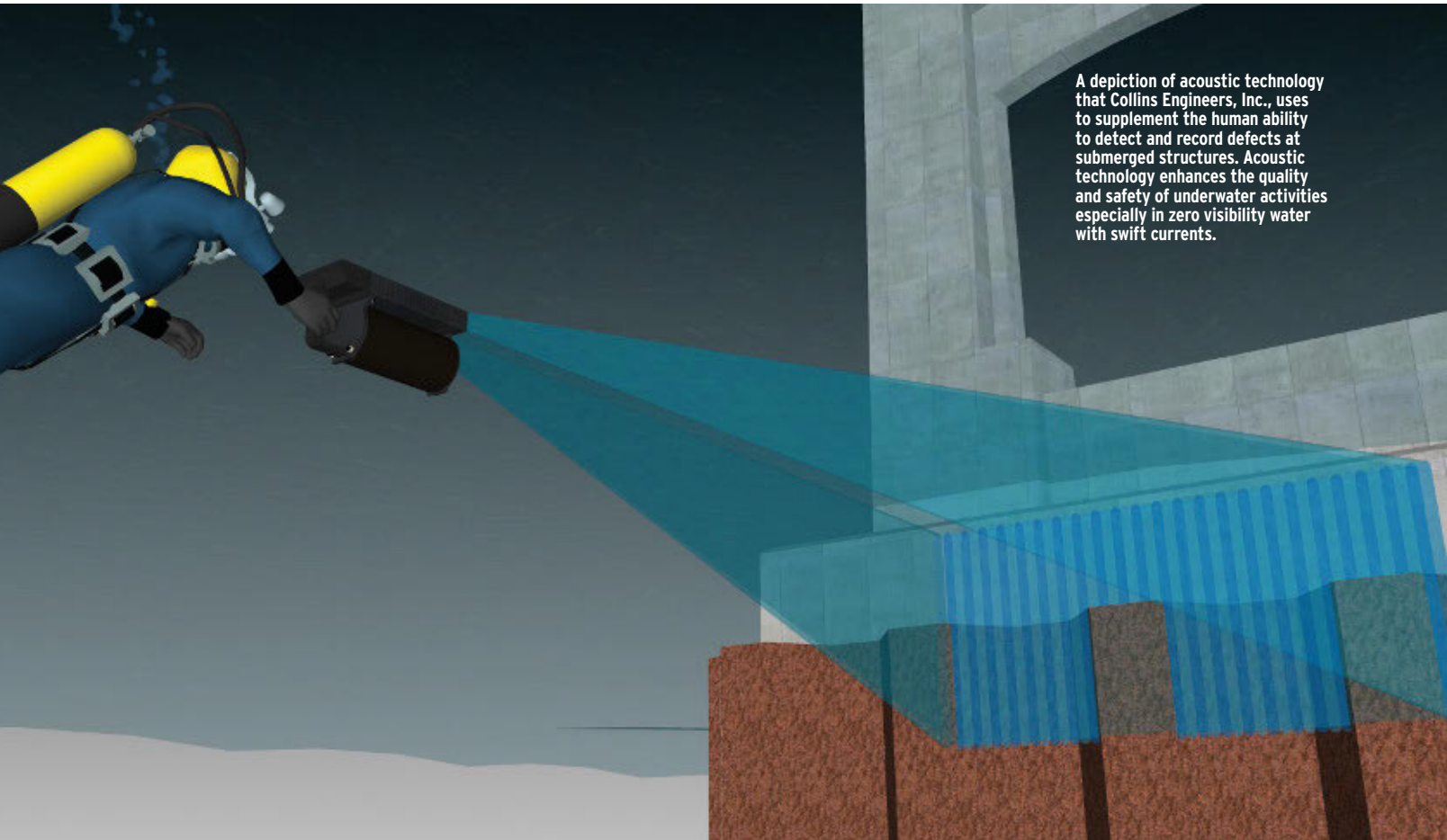
However, the technical, practical and logistical challenges do not stop there. Assembling all the equipment and systems required for a project can prove daunting. It is often necessary to transport specialized vessels—ranging from zodiacs to specially equipped

boats—to a site. This may mean transporting a boat across land or sea, or locating a suitable vessel near a job site. Once at the location, there is often a need to hire a local captain who is familiar with the waters and how to navigate through them smoothly and safely. In addition, it is sometimes necessary to transport high-tech equipment and engineering systems by airplane or helicopter.

“This may involve security and customs clearances,” says Browne. “Further complicating matters, different industries and countries have different requirements and regulations.”

Finally, at an underwater job site, an engineering firm may require advanced communications systems for both voice and data. There is often a need to share a display of geospatially submerged data points or underwater images in real time with clients and contractors located in a different city, country or continent. Setting up these systems requires specific expertise.

“No two sites are the same,” says Browne.



A depiction of acoustic technology that Collins Engineers, Inc., uses to supplement the human ability to detect and record defects at submerged structures. Acoustic technology enhances the quality and safety of underwater activities especially in zero visibility water with swift currents.



A Boswell Engineering diver prepares to perform an underwater inspection. In addition to being proficient in commercial diving techniques, a diver must also possess the knowledge of a wide array of deterioration processes and their causes.

BOSWELL ENGINEERING

A DEEP DIVE

Technology may be changing the way engineers approach underwater projects, yet the human element remains. It is often necessary to send divers into the water to inspect systems, install pipes, weld equipment, tighten bolts and replace components. Although most projects take place in water that is no deeper than 100 feet, divers sometimes travel to depths as great as 2,000 feet.

“In many cases, divers must work in murky conditions where they cannot see their hand in front of their face, and they must deal with surges and crosscurrents that make an installation or replacement of a system more difficult. It is often slow and tedious work,” says Ganas, who has worked on underwater projects over the course of three decades.

Make no mistake, venturing underwater to tackle complex engineering and construction tasks requires highly specialized skills—and gear. Divers require extensive training to handle a variety of underwater conditions and adhere to OSHA requirements for safety, but they must also learn specific engineering and construction methods. This includes understanding how to operate sophisticated devices and equipment used for underwater projects.

“We now use updated diving gear that includes remotely operated vehicles, Superlite helmets with lights, cameras, constant surface communications, advanced dry suits, hot water suits and fully outfitted dive trailers,” Chader says.

It is no small matter. “Being an effective engineer diver requires years of training, a special skill set, ability to effectively work with your dive team as well as individuals located at the dive site and a willingness to work in a variety of arduous above and below water conditions,” Chader says. USACE, for example, requires divers to pass an initial basic scuba course from a reputable agency, an advanced scuba course and obtain an initial three-week dive safety school certification. USACE also has a dive program that allows a diver to become comfortable with the gear and the team approach the agency uses.

“Many of our divers have additional above and underwater training in bridge inspection, diver survival, deep diving, dry suit

diving, rescue diving and search and recovery,” adds Chader.

Remotely controlled submersibles have also changed the way engineers approach underwater projects. In many cases, these vessels—sometimes as small as 10 feet long and as flat as a surfboard—can travel to greater depths than divers and eliminate the need for divers to undergo decompression, something that can take hours or even a few days. They can also serve as a second set of “eyes” to locate lost gear. For example, one model of submersible can tilt and turn while using cameras and various sensors. It can handle inspections, underwater mapping and 4D geospatial visualizations.

“With all this data, it is possible to understand what challenges or problems exist and make an informed decision about a project. You no longer have piecemeal data and different groups of engineers toggling between data sets. You have all the visualizations and data you need to make the right decision,” says Welz.

In the end, Ganas says that while marine technology and equipment have advanced remarkably—and powered dramatic improvements in design, engineering and construction—the basic objectives of underwater engineering have changed very little.

“Today’s equipment and technology allow us to go deeper beneath the surface and obtain critical project information faster and better,” he explains. “Yet, constructing a project and maintaining or repairing systems still requires the same basic engineering skills and expertise.” ■

Samuel Greengard is a technology writer based in West Linn, Oregon.

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