Scanning Easter Island
India Land Records
Saving Wetlands
The Connected Site
Secrets of the Giants
Welcome to the latest edition of Technology&more!

Dear Readers,

If you've ever wondered how your peers worldwide are tackling real-world challenges using the latest tools, Technology&more is a great source for information. You'll find a variety of interesting applications and innovative product solutions that show how surveyors, construction workers, civil engineers, and mapping and GIS professionals are gaining maximum efficiency and productivity through innovative technology. This issue showcases projects using Trimble technology around the world from Easter Island, Germany, India, New Zealand, the U.K. and many other countries.

We take an in-depth look at how the survey, engineering and construction industries are poised for dramatic, positive change. These industries are turning to three key integrated technologies—positioning, wireless communication and information management—to improve productivity, minimize rework and eliminate waste. In the midst of this change, many surveyors are mastering these technologies and becoming even more central to infrastructure development by adding data management capabilities to their portfolio. Read about how these industries are moving into the future now—through Trimble's Connected Site.

For a look back at the past, we are celebrating a revolution that occurred in land surveying 60 years ago with the invention of the world's first light-based distance measurement system—the forerunner of today's optical total station. Developed by Dr. Erik Bergstrand in 1947, the invention is part of Trimble's lineage as the first measuring instrument from Geodimeter. To acknowledge the history and depth of innovation that comprises Trimble today, we will publish a "legacy" issue of Technology&more in 2008. If you have benefited from any of the instruments in Trimble's legacy—early Trimble, Geodimeter, Spectra Precision and Zeiss—let us know. We will choose the best applications that utilize the legacy products and publish them in this unique issue.

We hope you enjoy reading this issue of Technology&more.

Jürgen Kliem

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Trimble Engineering & Construction
5475 Kellenburger Rd.
Dayton, OH, 45424-1099
Phone: +1-937-233-8921
Fax: +1-937-245-5973
Email: T&M_info@trimble.com
www.trimble.com

Editor-in-Chief: Angie Vlasaty
Editorial Team: Lea Ann McNabb; Heather Silvestri; Eric Harris; Vivienne Edgar; Colleen Miller; Susanne Preiser; Stefan Schiepe; Emmanuelle Tarquis; Grainne Woods; Christiane Gagel; Lin Lin Ho; Bai Lu; Maribel Aguinaldo; Masako Hirayama; Stephanie Kirtland
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One of the United Kingdom’s largest civil engineering projects, the South Hook LNG (Liquefied Natural Gas) terminal is under construction at Milford Haven, Wales. Jointly, Besix (Belgium) and Kier Construction (U.K.) are refurbishing a 50-year-old oil jetty to receive the huge LNG tankers. The project includes heavy demolition of the old berthing and mooring facilities, repair and refurbishment of existing structures, and construction of new marine facilities.

Safety, weather and other environmental issues made a cost-effective, accurate survey a major challenge. Besix Head Survey Engineer Denis Meremans developed innovative solutions by integrating advanced survey equipment including robotic reflectorless total stations, Real Time Kinematic (RTK) Global Positioning System (GPS) systems and 3D scanning. The integrated approach increased safety, quality and productivity while reducing time, resources required and project cost.

The new jetty and berth piles are being built alongside the old piles that are cut off below the seabed; as the new piles are driven through, there is a risk of overlapping and clashing. An accurate existing pile layout was required from the outset to mitigate the potential risks and to assess the new construction structural engineering and design model.

Trimble RTK GPS solutions were used to set control and calibrate the site. RTK GPS was also used for ongoing positioning of the four self-elevating platforms (SEP) in the correct location onsite (within 500-km or 2-ft tolerance) to enable piles to be driven accurately. In total, 11 Trimble RTK GPS receivers are currently running non-stop to provide positioning information around the clock.

The piles were initially surveyed with a reflectorless total station—fine for visible and vertical piles—but Meremans soon became aware of its limitation. Obstructions such as handrails or scaffolding caused problems. And in some areas he was confronted by a jungle of piles, some hiding others and some impossible to recognize in the slab shadow.

Meremans decided to restart the entire pile survey using 3D scanning as an alternative survey method for inaccessible piles. He was able to acquire more and better quality data in one month using a Trimble 3D scanner than in six months using conventional methods; he also discovered 34 hidden piles that were previously undetected.

On a project this complex, different surveying tasks and applications require different approaches and techniques. The Besix-Kier survey team achieved optimum precision at the lowest cost by using a large range of survey equipment and advanced technologies—integrated survey engineering in action. See feature article in American Surveyor’s October issue: www.amerisurv.com
It’s not “Mount Doom” of *Lord of the Rings* fame—that mythical designation belongs to its neighbor Mount Ngauruhoe—but New Zealand’s Mount Ruapehu is today one of the world’s most active volcanoes. And in March of this year it gained international attention from the scientific community thanks to the spectacular river of mud, rock and debris—known as lahar—that poured from its peak.

Mount Ruapehu is 40 km (25 mi) southwest of Lake Taupo, within the Tongariro National Park. The North Island’s two major ski areas and eight glaciers are on its slopes. (Those slopes were also used to shoot some scenes for *Lord of the Rings.*)

At 2,792-m (9,160-ft) high, Ruapehu is the largest active volcano in New Zealand and is constantly monitored for activity. Between major eruptions, the deep, active crater fills with water. The 1996/97 eruptions formed a natural tephra dam (fragments of volcanic rock and lava from volcanic explosions), which prevented water from the crater lake from flowing down the volcano’s slopes.

Early this year Christchurch-based surveyor Reece Gardner was commissioned by GNS Science, New Zealand’s government-owned earth science research and consultancy organization, to monitor erosion rates of the tephra dam on Ruapehu’s Crater Lake.

Using a Trimble GX™ 3D Scanner, he created a detailed 3D model, containing more than 1.5 million points, of the entire dam in just a few hours. So when the dam burst on March 18, 2007, Gardner was able to provide “before and after” measurements of Ruapehu’s crater dam and its lahar; the dam was scanned three times before the lahar and once after.

"At the time of our first survey, New Zealand’s Department of Conservation (DOC) and GNS felt a lahar was
unlikely to occur in the near future, unless the lake level rose rapidly (due to high rainfall at the crater) or the dam was overtopped,” he said. “The heavy rainstorm on the mountain changed all that and the dam wall was breached on March 18, prompting a lahar to surge down the mountainside.”

After the lahar, Gardner’s final scan collected data on the dimensions of the breach and the volume of material removed from the tephra dam.

“Our first three surveys show the changes that were taking place before the dam broke,” Gardner said. “After the lahar I went back to do a final survey to see the impact of the dam failure.”

The 3D scanning surveys, combined with other scientific and video recordings, provided a unique snapshot that is now helping researchers around the world understand the way natural dams fail.

GNS geotechnical engineer Chris Massey is one of the scientists charged with handling the data collected on the Mount Ruapehu project. He commissioned the 3D scanning survey after using the same technology to measure landslides in the Kingdom of Bhutan in the Himalayan Mountains.

“We used the 3D scan data to characterize the amount of erosion on the downstream face of the dam prior to failure,” said Massey. “This allowed us to provide the DOC with accurate information regarding the area and rate of erosion.”

GNS combined information from the 3D scans with in-situ testing done on site to create a digital terrain model (DTM) of the different materials making up the dam in order to back analyze the failure.

Massey says the scans taken in January, February and March 2007 show that although there was significant erosion, the rate of erosion was slowing.

“The dam was made up of several different layers of material,” said Massey. “One particular layer of granular material appeared to be acting as a natural drain. It was seepage through this layer combined with an increase in the lake water level that eventually led to the breach. We have been able to demonstrate the rate of erosion due to the seepage from the granular layer between each of the scans.”

A detailed report will be released within the next few months.

Massey says the New Zealand data will be used by researchers around the world to test their own models of natural dam collapse and lahar processes. Detailed analysis of the observations made pre-failure and post-failure help scientists understand the processes that lead to the failure of other natural dams and therefore develop appropriate warning systems.

He also believes that 3D scanning is a powerful survey tool that has wide applications, from calculating the volume of material and subsidence in mining situations, to monitoring many different types of ground deformation associated with landslides or dam failures.
At one time North America had the greatest expanse of grasslands in the world, covering almost 2.6 million km² (1 million mi²). The majority of the continent’s waterfowl species depended on these grasslands for breeding, but in recent years much of the landscape has been drained or decimated, reducing the habitat available to waterfowl and other wildlife. DU was established in 1937 by conservation-minded sportsmen to reverse this loss and restore the waterfowl breeding grounds. Since then, DU has conserved more than 4.7 million hectares (11.6 million acres) of waterfowl habitat throughout North America including migration and wintering habitats. Today, DU has offices in Canada, the U.S. and Mexico.

Normally DU works with state or federal agencies as well as some private organizations and land owners that want to improve, enhance, or restore wetlands. The non-profit provides initial assessment, surveying and mapping, engineering design, and construction services to make land beneficial to wildlife. The owner then manages the land, with DU’s further involvement as necessary.

Working out of DU’s Great Plains Regional Office (GPRO) in Bismarck, North Dakota, construction manager Les Morgenstern’s job includes determining the best soil and sites for wetlands preservation and restoration. “For example, we’ll look at a 100-acre (40.5-hectare) cattail-choked dry marsh, which wouldn’t work as habitat for waterfowl,” he says.

“We survey the area with GPS to find out if there’s enough impoundable water to manage the cattails, open up the marsh and salvage the site. Clutches of hatching broods need some raised vegetation around the border so they can hide from predators.” Once hatched, the hen leads the ducklings to the wetlands, where they grow into adults. “If we determine the area is restorable for wildlife, we use the GPS data to design the site.”
DU's GPRO employs six surveyors over its eight-state region; crews use a variety of Trimble receivers, from Trimble 4400 GPS to Trimble R8 GPS receivers. GPRO uses the Trimble 5700 GPS receiver as base station with two Trimble R8 GPS rovers and Trimble TSC2™ controllers. On any job, DU crews will use the GPS to set control using UTM's or WGS84 data as the basis for its surveying and mapping operations, establish the vertical datum, provide topo and cadastral surveys for construction design, and even measure wetlands' depths. By calibrating the antenna to the water line and dropping a weighted sounding tape to the bottom, crews are able to determine water depth with GPS precision.

Due to the often untamed environments, DU surveyors try to work in crews; with GPS, each surveyor can accomplish in a day what used to take several surveyors a week, according to Morgenstern. "It used to take three field personnel using conventional tools and waders strapped on to walk through wetlands and collect 10 to 15 shots per acre of wetland," he says. "Now we can saturate an acre collecting 45 to 50 shots per surveyor. It has substantially increased our productivity and accuracy of the areas we are surveying."

And DU uses Trimble GPS in some creative ways: DU surveyors have calibrated antenna heights to the wheels of All Terrain Vehicles (ATV) and used GPS in continuous mode; strapped GPS receivers on their backs to use on snowmobiles and Jon boats equipped with Go Devils, special vehicles for navigating wetlands; and used GPS with Marshmasters, a track vehicle that can float and work through wetlands, bogs and marshes.

"What got us into GPS was its efficiency, ease-of-use and ability to collect a lot of data in a short time," says Greg Johnson, RPLS, and DU GPRO Chief Surveyor. "And our accuracy is within ±1/10 of a foot (±3 cm), which is the normal design specification we require of our contractors."

While DU usually surveys a particular site to determine if it can be improved and made waterfowl friendly, Johnson says there are often additional environmental benefits. "Our primary role is to help waterfowl but we can also work with the agency to improve water quality, which will build better fish populations and benefit people by filtering contaminants from ground water that ends up in municipal water supply aquifers," he says. "DU engineers determine whether it's best to restore the existing water control structures or to design a new water control system to benefit the wetland."

Another DU objective is collaborating with area ranchers on wetland rehabilitation so water is available for cattle. "By working closely with surrounding ranchers, we must verify we're on the same elevation datum (to prevent flooding on private lands) and better determine boundaries for the wetlands," Johnson says. "GPS allows us to help determine the legal boundaries of the land.
and then pinpoint what needs to be preserved or enhanced. These wetland systems are used for ducks until broods are established near the end of June, but then the ranchers have the water available for cattle, so it benefits everyone." DU also offers lease option programs to farmers and ranchers who are paid to keep the land as is and not drain the water; the site remains a natural habitat. GPS enables DU to accurately determine those lease boundaries.

Yet another GPS application is identifying the best location for earthen embankments, water control structures or stream channels. After surveying the area, the data is downloaded and converted from a digital format so DU engineers can analyze the results and determine restoration feasibility. They then calculate both the total acreage to impound and the amount of available water. Similarly, they may use GPS to survey and reconstruct a washed-out dam as a way to impound water and encourage beneficial vegetation growth that will make the wetland suitable for waterfowl.

After final construction, DU turns management over to the landowner. Owners then typically follow a wetland management plan that establishes a draining and flooding schedule to promote a healthy wetland system and encourage waterfowl use. “GPS enables us to provide them with the most accurate information to develop that management plan,” Morgenstern explains. “We can confidently convey where the water is and where structures should be so there’s minimal impact to land not designed to have water impounded.”

Morgenstern and Johnson admit that wetland conservation fieldwork can be hot and dirty. “But we’ll go back to a site from time to time and see the results of our efforts—and that’s rewarding,” Morgenstern says. “We’re still losing wetlands, but the accuracy and speed provided by Trimble GPS helps us minimize the loss. Having a good product and getting good service plays a big role in our success.”
Surveyors don’t receive a lot of public recognition. You see them by the road with their total stations and rovers, but the importance of their job—obtaining accurate positioning and precise calibration—is often overlooked. Only those who depend on them, such as urban planners, engineers, contractors and government agencies, know the surveyor’s critical role in helping give our world form and function.

Today, that is changing. With Google Earth, MapQuest and GPS navigation devices, location is making front page news. And so it’s fitting that a “monument of surveying” was recently installed in North America’s Pacific Northwest to spotlight a tool critical to a surveyor: a calibration baseline. The monument, called “Straight Shot,” will serve as public art—and as a teaching device about this important surveying tool.

Located in Seattle’s Warren G. Magnuson Park, Straight Shot is a procession of 12 standing ink jade limestone sculptures that run parallel to the Sand Point Calibration Baseline. Established in 1982 by the National Geodetic Survey (NGS), the working baseline had no permanent easement in the park. Straight Shot was initiated to protect the baseline for future park development. The accuracy of the Sand Point line is said to be within half a millimeter.

The sculptures are perfectly aligned along a 1-km (0.6-mi) course that runs north-by-northwest across the park. Two circular holes drilled through each stone invite visitors to peer through, creating a framed perspective of trees, grass, sky, water and surrounding park elements. The sight line offers a straight shot, thus the artwork’s title. Sighting through the stones, the viewer will have the experience of making a targeted observation in the landscape, adopting the stance of a surveyor calibrating his or her instruments.

“My goal as an artist is to draw attention to that which is often overlooked or unheard,” said Lynch. “For 13 years I have visited this park and never knew the baseline existed, though I have walked by it many times…I hope this work helps...provide a new perspective on a familiar scene.”

Trimble applauds the City of Seattle and the Land Surveyors Association of Washington for their initiation and support of Straight Shot and is proud to be the corporate sponsor for the project. Not only does Straight Shot bring attention to the significance of the baseline, it also highlights the value of surveyors and how they improve the world and our lives.

See artist’s blog on Straight Shot: http://sandpointbaseline.blogspot.com
Moving into the Future

The survey engineering and construction industries are poised for dramatic, positive change. To keep up with overwhelming demand for new infrastructure in the face of a limited workforce, construction firms are tasked with making major changes. To do so, the industry is turning to new technologies and benefiting from exponential productivity gain, minimized rework and the elimination of waste. In the midst of this change, many surveyors are mastering the new technologies and becoming even more central to infrastructure development.

This revolution is occurring through rapid innovation in three broad technological categories:

- Positioning technology—readily available RTK networks and Spatial Imaging—can swiftly acquire large amounts of high-quality, geolocated spatial data.
- Wireless communication—for example, cellular telephony—can move that data to all project stakeholders.
- Information management—such as visualization technologies and network-based project management—keeps the spatial data accurate, accessible and useful over long project life cycles.

These overlapping categories hold strong potential for tight integration among their components. In many cases, these technologies are seeing mainstream adoption or focused development by other industries. The real challenge for the architecture, engineering, and construction (AEC) industry is to integrate these advances into a total solution, capturing synergies that can transform project work.

Positioning Technology
Positioning technology breakthroughs are occurring wherever meter or millimeter precision is required. Global Navigation Satellite Systems (GNSS) developments are enhancing terrestrial positioning. And VRS systems are increasing globally, making centimeter-level RTK positioning available to all.

Non-satellite-based positioning is also advancing quickly. Traditional total station distance and angle measurement is becoming faster, more convenient and more accurate. In addition, with the increase in functionality and focus on ease-of-use, 3D scanning is becoming essential technology for acquiring spatial data. 3D scanners now enable surveyors and designers to utilize full 3D images in new ways and improve the collection of discrete points with x,y,z coordinates. Scanners are also making digitization in the field an everyday tool, closing the gap between office and field.

Wireless Communication
Wireless communication capabilities are exploding. In the last decade, several alternatives for data transfer have emerged—cellular standards like General Packet Radio Service (GPRS), robust point-to-point radio solutions, Bluetooth and satellite communications. These solutions range from simple and convenient—such as Bluetooth-enabled survey instruments that eliminate problematic cables—to highly significant—like the cellular standards that make RTK network correction delivery easy.
Information Management
Powerful processors, low-cost memory and fast, widespread Internet availability are enabling the development of information management solutions unthinkable a few years ago. One example is Spatial Imaging, which is becoming the new standard for design work. Scanning and digital imaging expedite model creation, which can replace 2D and 3D CAD drawings, making models accessible to all project stakeholders early in the project life cycle. Together with the accurate geolocation that network RTK enables, models are becoming the basis of 3D Geographic Information Systems (GIS); they will require expert management by surveyors and others who understand the complexities of spatial data maintenance.

Integrating Emerging Technologies
The construction industry has traditionally made productivity gains by relying on bigger and faster equipment—not by re-engineering basic processes. However, Trimble believes that focusing on the integration of innovative technologies into daily project workflows is the best way to serve the five key participants in infrastructure development: owners, government agencies, surveyors, AEC firms and contractors. Each group participates in a continuum of interrelated processes and works with a large number of providers. And each can benefit from integrated technological advances that connect participants more tightly.

Trimble has been working on the integration of these technologies—the Connected Site—for more than a decade. By employing technology advances to tie hardware to hardware, hardware to software, hardware and software to networks, and to tie all of these to project stakeholders, the Connected Site concept is poised to positively revolutionize work processes.

As part of Trimble’s commitment to building the Connected Site model for customers, the Company has established partnerships and alliances with industry firms to work on the concepts critical to the Connected Site approach. For example, in 2006 Trimble added the capabilities of visualization technology pioneer XYZ Solutions, Inc., and others to its portfolio. XYZ enables users to take fuller advantage of 3D models and the rich data sets they are built on, eventually enabling field digitization. Effective, rapid visualization is essential to a model-based workflow. Trimble has also added the capabilities of Meridian Systems to bring the business and lifecycle management software component to the Connected Site initiative, helping building owners, AEC firms and government agencies to facilitate the delivery of information throughout the entire plan, build and operate life cycle.

Transforming the Future Now
Traditional industry boundaries are blurring. The field and office are overlapping as data processing and engineering expertise move closer to projects. Surveyors are adding data management abilities to their skills portfolio. Engineering and spatial data are being tracked with project timeline and accounting data. Survey instruments are combining GNSS, optical and imaging capabilities. And grading machinery is being integrated with GPS to enable 3D machine control that puts design surfaces, grades and alignments in the cab, allowing automatic, accurate real-time blade positioning. Put simply, everything is coming together, integrating and connecting. Trimble’s Connected Site fosters a beneficial revolution in an industry that has a lot to gain.

See feature article in Civil Engineering News’ August issue: www.cenews.com
Views from the Field:  
Integration on the Job Site

“Today’s surveyor is a much more technically savvy individual than in years past. On our construction projects the surveyor is usually second only to the IT folks in terms of technical expertise,” says Sam Diaz, PLS, Chief Surveyor for Bechtel Corporation. Diaz agrees that technological advances are changing the face of the construction industry—and changing surveyors’ roles as well.

Innovations in positioning technology helped bring about that change. “Scanners, RTK GPS, reflectorless total stations and CAD—they’ve all changed what we do. Today we are becoming data managers.” Diaz also sees change in how surveyors perform calculations in the office and on site. “One difference is how we’re computing. Calculations are now more CAD-based than COGO-based.”

Looking ahead, Diaz believes that model-based design and construction is beginning to come into its own. “At Bechtel, we’ve crossed a threshold of sorts: on some projects, we have begun to digitally extract the stakeout data from the design models. And while I don’t think the industry is quite there yet, I think we’re getting to the point where many surveyors will be obtaining data digitally from the 3D model, and we’ll have the technology—survey equipment, machine control and communication—to work with that.”

Burns & McDonnell Engineering Company project manager Michael Folta, PE, also points to the ability of RTK networks to connect parties on construction projects. On a recent multi-million dollar transportation project in Chicago, the implementation of the local Trimble VRS™ network was the first task the consultants recommended to project owners: “We felt it would be worthwhile to validate all design control under one umbrella,” Folta says. “The network has been invaluable. It’s reduced the time to maintain control and we can drop in control very accurately for new contractors when they come on the project. From a coordination standpoint it was dollars well spent.”

Bruce Flora, PLS, owner of Flora Surveying Associates and Data Pro Ltd., has a different perspective from many surveyors due to his ten years of creating 3D models for machine control. “Having these tools [scanners and RTK GPS] is one thing,” he said. “Having the skills to run them is something else.”

Flora believes positioning technology requires trained, knowledgeable operators: “The magic of GPS is gone—today it’s everywhere. But using GPS to control machinery is the future of the construction industry. Yet this depends on building good models—machine control can build it wrong very accurately. We have powerful tools available now and surveyors are often the best skilled to run those tools.”

Construction technology is advancing, changing the workplace and creating new opportunities. In turn, surveyors are advancing as well to take advantage of those opportunities.
On April 29, 2007, a tanker truck crashed through a guardrail on northern California’s major interchange between I-580 and I-80—and exploded into flames. Intense fire melted the steel underbelly of the elevated roadway and caused it to collapse onto the roadway below. Reports warned that the mangled section of roadway—known as Oakland’s MacArthur Maze—would be unusable for six weeks to several months, a shortage of steel adding to the challenge of the massive reconstruction effort.

A mere 25 days later, however, the roadway was reopened. Thanks to the efforts of C.C. Myers (CCM), survey subcontractor Andregg Geomatics and the Trimble S6 Total Station, motorists were able to use the roadway a full month earlier than the California Department of Transportation’s (CalTrans) deadline.

The high-profile 50-m (165-ft) roadway reconstruction project required 153 m³ (200 yd³) of concrete road deck, 96 hours of curing time and 12 steel girders.

Within two hours of CCM’s call, Andregg’s survey team was providing as-built measurements of the remaining bridge using the Trimble S6 Total Station; they computed the lengths for fabricating new steel girders to 0.64 cm (0.25 in) tolerances. Crews also laid out for the concrete bent cap girder so workers could accurately position it on top of the existing columns. When the steel girders arrived, they had to fit in between the bent caps. Due to the bridge curve, the 12 girders required varying lengths. Andregg performed the field survey from noon to midnight on May 8, and then continued in the office until 5:00 A.M. to deliver the results, successfully meeting the girder manufacturer’s deadline at 6:00 A.M. May 9.

“We used a Trimble S6 because of its high accuracy and its ability to measure reflectorless on impossible-to-reach dark surfaces,” said Andregg’s Project Manager Tom Holmberg, PLS. “In addition, a good portion of the survey took place during the night and the built-in laser pointer was very useful in pinpointing where the shot was taken.

“The Trimble S6 was the main tool for this job and instrumental in getting the job done to the necessary accuracy. Due to the prefab, measurements couldn’t be off by any amount: there were no second chances. The Trimble S6 is phenomenally accurate.”
One of the most unique—and remote—areas on Earth, Easter Island was named for the day Dutch Admiral Roggeveen first discovered the island in 1722. How the island initially became inhabited remains speculative; legend claims that the first settlement began between 400–800 AD, while in a second phase Polynesian King Hoto Matua and others sailed double-hulled canoes to the island in the 14th century. The island’s huge volcanic rock statues—called Moai by the islanders—have also puzzled ethnographers, archaeologists and island visitors. On average standing 4 m (13 ft) high and weighing 14 tons (28,000 lbs), the Moai are believed to have been carved, transported and erected between 1400–1600 AD. Most archaeologists believe the Moai are standardized representations of powerful leaders on early Easter Island, or Rapa Nui, the name given their land by islanders. Today, the German Archaeological Mission is seeking to help document and conserve these historical artifacts. Using Trimble surveying equipment, the team is helping preserve the past for the future—today.

A triangle of volcanic rock, Easter Island lies about 3,800 km (2,361 mi) west of Chile in the Southeast Pacific Ocean. A Chilean province, the 163 km² (63 mi²) island has more than 800 Moai remaining, yet most are in poor condition. The statues were almost all erected singly or in a few groups along the coast on stone platforms known as Ahu. The Moai and Ahu are increasingly at risk of damage by exposure to wind and weather; most of the statues have been toppled over due to human activity or natural events—such as tsunamis—and lie face down on the ground. Since 1995, the Moai have been protected as UNESCO (United Nations Educational, Scientific and Cultural Organization) World Cultural Heritage monuments.
Risk of damage is one reason the German Archaeological Mission conducted four weeks of field studies on Rapa Nui in February 2007. The expedition, which will return to the island in February 2008, is a cooperative project between the German Archaeological Institute (DAI), Bonn; the Geomatics Department of HafenCity University, Hamburg (HCU); and the Bavarian State Department of Monuments and Sites, Munich. Work was closely coordinated with Chile’s Consejo de Monumentos Nacionales (Authority of Monuments of the Nation), Santiago, and local island authorities. The project’s objective is to further research the island’s history, its inhabitants and the still largely unknown Moai. In addition, the DAI will document and catalog the remaining Moai as well as assemble all relevant data into a GIS.

Prior to this project, the only available documentation had been in the form of pictures and drawings, combined with sketches of a few selected figures. To perform a comprehensive analysis of weathering and erosion for all the Moai, the team used a Trimble GX 3D Scanner to record the objects. The choice of a non-contact measurement method was very important as it is not permitted to walk on the Ahu or touch the Moai, which are sacred to the islanders. As local surroundings of some Moai were also to be scanned, it was necessary to use a scanner that had a wide range as well as high measurement precision. The goal was to produce exact models of selected Moai; the team would then do follow-up measurements to record the deterioration process with millimeter accuracy.

The Moai of Vaihu was the first figure scanned. The team used four scanner positions for surveying; the figure was then modeled using a high-resolution point cloud with a point grid of less than a centimeter. This technique allows signs of existing erosion to be clearly identified; more significantly, it will enable future measurements at set time intervals to quantify erosion processes and show the progress of conservation measures.

For many years, the conservation, protection and preservation of the Moai has been a bit controversial. Some efforts to restore and conserve the artifacts resulted in significant damage to the Moai. In addition, the island’s type of volcanic rock is not
easy to preserve. Because the Vaihu monolith stands in an open, isolated position without an Ahu, the figure is ideal to be used as a test object for updated conservation efforts. The Berlin conservation firm Denkmalpflege Maar GmbH will use it to demonstrate new conservation methods on Easter Island.

The stone figures of Ahu Akivi were scanned next. This group of seven Moai, about 4.5 m (15 ft) tall, are the only statues looking out to the ocean; all other statues face inland. The group was restored and set upright again in 1960 a few kilometers inland from the coast. The figures symbolize the seven scouts, which according to legend were sent across the ocean by Polynesian chief Hotu Matua to locate Rapa Nui.

To fully document the Moai, a total of 9.5 million points were recorded from twelve scanner locations. The Ahu, other old burial chamber remains behind the Moai, and the open space in front of the statues were also scanned. The eleven tie points (spheres) around the object were marked and determined by differential GPS (DGPS) so an identical coordinate system could be recreated when carrying out subsequent measurements. A detailed 3D model was first calculated with the point cloud of the figures by triangulation. This model will be used as the base dataset for future erosion studies. Scanning the surrounding area enabled both a site plan and a terrain model to be generated, providing the archaeologists with important baseline data for later excavation work.

The third object scanned was the single Moai Ko Te Riku of Ahu Tahai, located on the coast in Hanga Roa, the island’s only settlement. Due to its head covering (Pukao) of reddish volcanic rock on top of the figure, this Moai could not be completely scanned using four scanner positions just on the ground. In general, it is a problem to scan the top of the Moai from scanner positions on the ground.

During the scanning project, the scientists saw how important it was to be properly prepared for local weather conditions. Hot temperatures (27–33° C or 81–91° F) caused scanner operating temperatures of more than 40° C (104° F) at times. The scanner worked perfectly the entire time, but the island’s heat, wind and sudden showers added to the project’s challenge.

The scanned point clouds of the three objects are currently being processed at HCU. After registering and georeferencing the scans in Trimble RealWorks Survey™ software, a triangulated mesh of the point clouds is created and the Moai can be textured using the high-resolution images from the Nikon D70 digital reflex camera to enable interactive visualisation of the objects.

Further measurement campaigns with the DAI are planned for the future. The German archaeological expedition in February 2008 will provide comprehensive documentation of all the Moai as well as present a local deformation analysis of selected Moai.

Please contact Thomas.Kersten@hcu-hamburg.de or Maren.Lindstaedt@hcu-hamburg.de for more information on this project.
The Trans-Alaska Pipeline System (TAPS) is a 1,287-km (800-mi) engineering marvel. Passing through three mountain ranges, over three fault lines and crossing 500 rivers and streams to connect the northern oil fields with the seaport at Valdez, TAPS has transported more than 15 billion barrels of oil since its completion over 30 years ago. Alyeska Pipeline Service Company, headquartered in Anchorage, Alaska, was created in 1970 to design, construct and maintain TAPS. To ensure that the pipeline is stable and well-maintained, surveyors have regularly monitored TAPS since its construction.

Because normal geological activity could potentially damage the pipeline, Alyeska monitors slope stability at six key locations every year. In the past, the horizontal and vertical monitoring of these six sites took five crew members about 21 days using optical surveying methods. In 2005, Anchorage-based CMSI-Bell, J.V., began monitoring the pipeline using advanced GPS and 3D scanning technology to increase productivity and efficiency.

To check the pipeline and original control network, CMSI-Bell produced a single point monitoring system using Trimble R8 GPS rovers. They also used a Trimble 3D scanner to create a point cloud-based surface mesh-3D model monitoring system.

By setting parameters in a Trimble TSCe™ Controller, CMSI-Bell met accuracies of 1.5 cm (0.05 ft) horizontal and 2.13 cm (0.07 ft) vertical when measuring the intermediate control points with GPS.

Using a two-person field crew, they then scanned the ground at a 2.5 cm–6.3 cm (1 in–2½ in) grid and the support steel at a 0.6 cm–1.3 cm (¼ in–½ in) grid, scanning between 152 and 183 m (500 and 600 linear ft) of pipeline and associated monitor points per setup.

The scanned data was cross-referenced with historical data that had been collected with optical instrumentation and procedures. The scans were registered to the GPS control in Trimble RealWorks Survey software.

Using these methods, CMSI-Bell believes it has developed a precise, accurate annual monitoring service that requires fewer man hours while providing combined vertical and horizontal monitoring points as well as an annual ground monitoring comparison for enhanced quality control.

See feature article in POB’s December 2006 issue: www.pobonline.com
A rapidly growing community, Wheat Ridge, Colorado (CO), encompasses more than 15,000 households, extensive commercial development and light-industrial facilities. In spring 2007, the city secured funding to record its entire storm-drainage infrastructure and incorporate the data into its comprehensive GIS database. The project would include surveying a total of about 2,500 intakes, manholes and outflows in the city. An additional project requirement was to reference all data on both the local state plane modified coordinate system and Colorado state plane coordinate system.

Given the budget, the project would require extensive front-end planning, tight standardization of collected data and above all, a highly efficient workflow from start to finish. Luckily for Flatirons, Inc., the Boulder, CO, surveying, engineering and geomatics firm that won the project contract, a significant workflow advantage came in the form of on-demand corrections through Trimble VRS Now™ Service.

Flatirons had been testing Trimble VRS Now for a short period leading up to the project. Flatirons Geomatics Project Manager Chad McFadden immediately saw that the service could drastically improve field efficiencies. “We bid this job knowing that we had an advantage with Trimble VRS Now,” McFadden said. “With VRS Now, we are out the door in 5 minutes, saving an average of 1½ to 2 hours every day.”

**On Air and On Demand**

With corrections available on-demand throughout the network, Flatirons has eliminated the time needed to set-up and take-down field base stations throughout the project’s duration. The system also reduces the technical support needed by the field crews—a benefit that directly impacts the bottom-line.

Flatirons points to the unique radio broadcast option of Trimble VRS Now as a key to project success. Typically, network RTK systems use cellular communications be-
tween rover and network operations center. With the radio option, work is not interrupted due to loss of cell phone signal. Devin Kowbuz, another Flatirons Project Manager, puts the communications issue into perspective. “In the city, packet data takes a back seat to voice,” he said. “This can affect our ability to stay connected.” Using the Trimble RX35 radio receiver, the Flatirons team receives VRS Now corrections quickly and reliably. Trimble broadcasts VRS corrections throughout Denver’s Front Range (the Eastern slope of the Rocky Mountains).

GIS Detail with Survey Precision
For the Wheat Ridge project, Flatirons’ surveyors are simultaneously gathering detailed attribute information that goes well beyond the scope of a typical surveying job. “We’re not just dipping manholes,” McFadden said. “This project requires an extensive set of GIS information from each site we measure.” Additional information includes: the number of pipes leading to each manhole; direction of each pipe as it enters the manhole; condition and composition of each utility; and two photos shot from every data collection point (one directly into the target and another for frame of reference at the site). All this information, including photos, is seamlessly linked and accessible from the comprehensive Wheat Ridge GIS database.

All project data is documented in a field book and then entered into a standardized screen on the Trimble TSC2 Controller. While the “digital field book,” as McFadden puts it, is not likely to replace the surveyors’ written field documentation, capturing the information in this way ensures that Flatirons gets all relevant information into the system the first time and reduces repeat site trips. The many hours that Flatirons spent in standardizing the field documentation ensured a smooth process with few surprises back in the office.

Without a doubt, the Flatirons’ team developed an innovative and efficient approach to the Wheat Ridge storm sewer project, encompassing everything from field workflow and personnel to the one-stop approach to data collection. To achieve all this within budget required a breakthrough technology. A subscription to Trimble VRS Now with the broadcast radio delivery option provided Flatirons with the means to keep the team productive from start to finish. Built to be industrial-strength and easy to use, Trimble VRS Now Service is available in Germany, Great Britain, Ireland and the State of Colorado.

Trimble VRS Now Service — Broadcasting in Colorado
Surveyors in Colorado are augmenting their use of Trimble VRS Now services with a new communications system dedicated for network RTK corrections. Streaming over low-band radio waves, Trimble provides a key advantage to surveyors who need to stay productive in areas of limited cell phone access.

The radio broadcast provides additional assurance of field productivity and operational simplicity. Using the Trimble RX35—a radio receiver designed specifically for Trimble VRS Now—subscribers are able to initialize faster and maintain constant connectivity while on the job.

Trimble VRS Now broadcast streams are available throughout the network in Colorado.
The world’s seventh-largest country by geographical area and the second most populous, India is also one of the fastest-growing major economies today. In its drive towards modernization and economic development, India has been undertaking a major update of its land records management system.

The process of revising and updating land records in India is elaborate. Every 30 years, maps depicting land parcels are required to be updated through the process of survey and land parceling operations.

The 28 states in India are responsible for maintaining land records. Most Indian states had not done any survey or settlement operations since the nation’s independence in 1947. Consequently, record updates stagnated and no longer represented the realities relating to land ownership. India’s land records system is crucial: it forms the basis for assignment and land title settlement and must stand against legal scrutiny. It is also critical for land taxes, reforms and administration.

In fact, creation of an accurate, complete land information system is one of the key challenges for governance today. Although land records can cover a wide variety of information, the most important area involves geological data (land shape, size, forms, and soils); economic data related to crops, irrigation and land use; and information about legal rights, liabilities and taxation. In a 1988 conference attended by Revenue Secretaries of the States, the poor conditions of land records were formally recognized and immediate actions were recommended.
Doing it Differently

The Land Records Department in Maharashtra was one of the earliest to heed the call for land records reformation. India’s third largest state, Maharashtra is located in the northwest of Peninsular India, flanked by the Arabian Sea on the western coast. Its capital Mumbai (previously known as Bombay) is also India’s largest city.

One of the main responsibilities of Maharashtra’s Land Records Department is to carry out cadastral surveys and maintain updates of cadastral records and maps.

In the past, all land records and maps were maintained on paper; cadastral survey methodologies were by optical theodolites, chains and plane tables. An entirely manual process, completion of survey and mapping operations had taken decades at times; when maps and land registers were finally put to use, they were often already outdated. Maharashtra’s decision to digitize these records was made to help preserve them more accurately and securely, while making them more accessible for various stakeholders such as land and property owners, land revenue authorities and government bodies.

For the Land Records Digitization project, Maharastra’s Land Records Department is using 85 Trimble 3600 DR Series Total Stations and Trimble controllers. Land Records surveyors collect and store data in the field; the data is then seamlessly transferred from the field to office via USB memory stick or memory card, after which a detailed digital map is generated using AutoCAD software. These maps serve several useful functions: determining land acquisitions required for development projects; determining the corresponding compensation amounts for respective owners; and detecting any encroachments on landed properties.

In instances where property lines are disputed, Land Records surveyors have used the controller’s background map feature to instantly show results in the field and help resolve disputes more efficiently. They also easily load Land Records background maps onto the controller in the office; surveyors then use them for reference while carrying out actual field surveys.

To save the time involved in gaining permission to enter compounds, the surveyors use the system’s Direct Reflex (DR) measurement mode. “The non-prism mode is also useful in city surveys where there are tall buildings and heavier traffic flow.”

Land Records’ surveyors can also complete surveys faster than in the past. “Using our conventional method of a plane table survey, we could cover 10 hectares (24.7 acres) per day,” said Mr. Avinash Shinghane, a Land Records maintenance surveyor in the state’s Aurangabad district. “With Trimble total stations we are able to cover 20 hectares (49.4 acres) per day more accurately, efficiently and productively.”

Training and Education

Maharashtra Land Records emphasizes training and education for its surveyors. Since 2004, its training school in Aurangabad has conducted training courses on electronic total stations, field operations and data processing to more than 200 surveyors from various districts. Trimble distribution partner AIMIL Limited has provided intensive training support at the institute.

The success of the Land Records Digitization project in Maharashtra is showcased in the Museum of Land Records in Pune. The first museum of its kind to trace the evolution of cadastral survey and the history of land parceling in India, the Museum of Land Records has a special section that highlights Maharashtra’s achievements. A Trimble 3603 DR Total Station is also permanently exhibited at the museum.

“Computerization of Land Records was an important project of the state government,” said T. C. Benjamin, Settlement Commissioner and Director of Land Records for Maharashtra. “Maharashtra...has achieved the desired results in the computerization project. Rural land records, urban land records and the registration process all have been computerized.”
There are no cell phones and you can’t just fire off an email,” he says. “But the river is beautiful, clear and pristine. You see wildlife every day—rattlesnakes, wild turkey, elk and deer, mountain lions, mountain goats and big horn sheep. You see rock foundations where the old homesteaders lived; in some places their horse-drawn farm equipment is still visible. You see Indian petroglyphs everywhere, amazing things.”

Ruby is GNSS survey manager for J-U-B ENGINEERS, Inc., a comprehensive engineering firm with 14 offices in five states. J-U-B client, Idaho Power, contracted them to establish a control network along an 805-km (500-mi) stretch of Snake River. The network will facilitate ongoing bathymetric surveys as well as scientific and environmental studies. Using J-U-B’s network, Idaho Power’s engineers can monitor river and reservoir bathymetry as well as develop computer hydrodynamic models. The models represent river behavior under different flows; scientists use the models to assess how those flows affect fish and wildlife in the canyon, as well as sedimentation and erosion.

Because Idaho Power’s dams were built in the mid-1900s, their datum, based on NAD27, is no longer supported by the NGS, due in part to its incompatibility with GNSS. While the utility company has been doing its own hydrographic surveys for hydrodynamic modeling, research and GIS purposes for years, they saw the need to establish a consistent
datum based on the current NGS-supported NAD83. This would ensure that spatial information for river studies would be accurate and usable throughout the reach. It would also eliminate imprecise NAD27 data modeling.

“We want to collect the best data we can to make our spatial database highly useful,” said Shaun Parkinson, PE, PhD, leader of Idaho Power’s River Engineering Group. “We need to be able to do a myriad of different analyses using a variety of survey methods to determine how our projects affect different resources.”

And that includes water and sediment quality monitoring; mapping areas with significant cultural resources; shoreline erosion monitoring; and studying fish and wildlife, especially any threatened with extinction.

“We want to make sure we understand what conditions might be detrimental to these species and identify possible solutions to limit negative impacts,” said Parkinson.

Ruby has already tied in his control points from Buhl, Idaho, to the Hells Canyon Dam, a far more benign stretch than the one now facing him: a 193-km-long (120-mi) river gorge stretching from the Hells Canyon Dam down to Lewiston, Idaho. This is Hells Canyon, which plunges to a full 2.4 km (1.5 mi) below its western rim in Oregon and, to the east, peers upward from similar depths at Idaho’s snowcapped He Devil Peak in the Seven Devils Mountains.

Even in this age of GNSS technology, Hells Canyon “is a very challenging environment to work in,” Ruby says, “because it’s such a steep canyon. On the flats you might have nine satellites available, but down there you might have only a few.”

There are other challenges, too: the 46°C (115° F) summer heat, for one. This has never been an easy place to live. Not for the Native Americans of earlier times. Not for the homesteaders who tried to introduce cattle and sheep, beginning in the late 1800s. Back then, the U.S. Government provided pioneers with 65 hectares (160 acres) of land; if they made the land self-sustaining after three years they were given ownership. As one early resident said: “The government bet you 160 acres that you couldn’t live there three years without starving to death.”

No matter. Ruby will establish the network in three stages, each one with increasing densification—and each one beginning with that drive down the switchback road to Pittsburg Landing, the only boat launch on the canyon’s Idaho side.

Here Ruby meets up with an Idaho Power project team, including a project manager/engineer and a jet-boat pilot. The boat pilot grew up running the river, understands its most challenging stretches of whitewater, and even knows where some of the NGS benchmarks dating to 1945 are located.

But what might have been accomplished in a year by a 10-person crew back then can now be handled—and exceeded—in the space of a week or two by a three-person crew using GNSS technology.
In the spring, Ruby supervised the project’s reconnaissance phase, scoping out 14 NGS benchmarks along the 193-km (120-mi) stretch to establish his primary control points.

At each monument, Ruby and the Idaho Power crew set up a Trimble R8 GPS receiver to do static surveying for a full 24 hours, collecting data at 15-second intervals. The data is then downloaded into Ruby's laptop and a second 24-hour session starts.

NGS will then process the data and incorporate the points into their National Spatial Reference System.

This summer, Ruby began phase two: fast-static observations using the Trimble R8 GNSS System. The Trimble R8 GNSS supports all GPS signals, including the new L2C and the coming L5 GPS Modernization signals as well as all GLONASS signals, giving a big boost to the data volume. The fast-static data will then be post-processed using Trimble Business Center software.

In this phase, Ruby works with three receivers. He sets two as base stations on adjacent points established in the first phase. He then uses his rover to observe new points, especially additional NGS benchmarks, at 5-second intervals for 8 to 30 minutes, depending on satellite availability. Each point will be observed twice for redundancy and quality control purposes.

He repeats this fast-static process until the network is densified enough to facilitate RTK surveying along the entire river stretch. The project’s third phase will utilize RTK surveying to tie in the remaining 300 control points in that stretch. Each point will be tied with redundant three-minute observations.

As with any RTK observation, radio communication is the key component. Generally, an unobstructed radio signal will travel “about six miles (10 km),” Ruby says. “You start throwing big mountains in between the base and the rover, and a river that keeps turning like a snake—pardon the pun—and it can get difficult.

“But I’m confident that with a little effort, our Trimble technology will let us get the job done.”
Once again, the Technology&more photo contest has several winners. First place—and a Trimble jacket—goes to Kelvin Anderson, PE, of Idaho Power Company for his creative shot of surveying on the Snake River in Hells Canyon. You’ll see the photo on page 20 and the back cover.

This month’s Honorable Mention winners, who will each receive a Trimble watch, include:

**Have Butterfly, Will Survey**

Hendri Zarwandi, surveyor for PT. Surtech Utama Indonesia in Jakarta, was providing earthwork surveying for a large dam construction project in Sulawesi, Indonesia. Almost twice a day, a butterfly would fly near him and perch on his total station. Seems like the butterfly favored the Trimble 5600 Total Station, coincidentally the same surveying instrument favored by Zarwandi.

**River View**

Matthew Knott, a survey technician for Albert Geiger Geomatics in Paarl, South Africa, submitted this intriguing photo from a project in Guinea Bissau. The firm utilized two Trimble R6 GPS systems to perform various control surveys and staking out of a mine concession along the Rio Cacheu. Barnie Williers is the surveyor in the photo. The ferry on the left is used for transporting trucks and vehicles, but can’t be used during low tide because the water level drops by about 2 m (6.6 ft). It costs 4500CFA (about $9) to transport a vehicle to the other side and takes about 5 minutes. The dugout on the right is handmade from baobab trees and can fit about 26 people, bicycles and motorbikes in one, according to Knott. It costs 200CFA (about $0.40) to get to the other side.
Though the plant-eating sauropod dinosaur has been a favorite of children for generations, there are still many unanswered questions about these giant, primordial creatures. For instance, how did they reach such an enormous size and what did they eat? How did their organs function? Scientists believe that answering these questions would provide vital insight into the body size and function of other, more contemporary animals. But to obtain this information, accurate body measurements were needed. Today using Trimble Spatial Imaging, a German research team is seeking answers to those questions.

Sauropod dinosaurs lived 220 to 65 million years ago and were the largest and heaviest creatures ever to inhabit the Earth. They weighed as much as 100 tons (220,462 lbs)—the equivalent of ten elephants or 1,400 humans—and grew to 40 m (131 ft) in length. Their body structure was similar to an elephant’s, but with a long, giraffe-like neck supporting a small head and a long, whip-like tail. Sauropods held their neck and tail horizontally, so the spine formed a somewhat horizontal line as well.

The energy consumption of these animals was enormous. With a body surface of 140 m$^2$ (1,507 ft$^2$), they ate nearly a ton (2,240 lbs) of food per day, often spending 90 percent of their time eating. Their hearts alone weighed 380 kg (838 lbs) and pumped 3,600 liters of blood through their body; they inhaled and exhaled 1,500 liters of air per minute. So how was it that a body this size could function so much more efficiently than other animals?

"Body size is the most fundamental characteristic determining the ecology of an animal," says Dr. Martin Sander, a University of Bonn paleontologist who coordinates, “Biology of the Sauropod Dinosaurs: The Evolution of Gigantism,” a three-year-old research project covering interdisciplinary studies in paleontology, zoology, animal nutrition,
The project team includes higher education institutes from Berlin, Bochum, Flensburg, Munich and Tübingen in Germany as well as Lausanne, Switzerland and Vienna, Austria. The research group was set up in 2004 by the German Research Council. The Computer Vision & Remote Sensing unit of the Berlin University of Technology carried out work on 3D reconstructions of the dinosaurs.

Scientists had already used conventional photogrammetric methods to measure the skeleton of a sauropod *Brachiosaurus brancai* in the Natural History Museum at Berlin's Humboldt University. This is the world’s largest dinosaur skeleton in a museum. Obtained in the early 1990s, however, the data was not dense enough; the new team of scientists wanted additional data from dinosaur skeletons in Germany, China and Morocco. Reference data for live skeletal weights was obtained from an Indian elephant in the Zoological Museum Copenhagen and a preserved rhinoceros in the Zoological Museum Dresden.

The Berlin team used a Trimble 3D scanner to obtain the new productivity and level of detail for measuring the skeletons, which were up to 20 m (66 ft) in length and 12 m (39 ft) in height. “We chose this instrument because it can assure the required accuracy at both close and mid-range,” says Anke Bellmann, a survey engineer and team member at the Berlin University of Technology.

The work itself was fairly standard. Using the skeleton of a *Plateosaurus engelhardti* at Tübingen University, scientists spent three days measuring the dinosaur, which was 4.20 m (13.78 ft) by 1.60 m (5.25 ft) and 0.80 m (2.62 ft) high—with extended tail it was 5.35 m (17.55 ft) long. They used 10 scanner positions and 17 control points and recorded more than 3.2 million points. The team reported that scanner positions were accurate within 3 mm (0.12 in).

“Everyone was very impressed by our technology, particularly in China,” Bellmann says. “There is enormous interest in dinosaurs throughout the world. Using this more accurate data, the research group may be able to throw some light on the secrets of the giants.”
Saving Hundreds of Millions of Dollars

When Manuel Morales was hired as a senior transportation engineer and head of the culvert inspection program for Caltrans, he knew he would be responsible for bringing consistency to the state’s culvert maintenance program. What he didn’t know was that he was embarking on a 15-year project that would ultimately save the state hundreds of millions of dollars.

But that’s exactly what is happening. Morales and his team are six years and 24,000 culverts into a statewide mapping project that will ultimately provide a detailed overview of California’s culvert network.

It all started in the late 1990s when a San Diego culvert failed, closing part of an interstate highway. Culverts direct the water flow below the surface of U.S. highways and freeway lanes.

“Prior to the San Diego incident, each of Caltrans’ 12 districts had their own method of tracking the location and condition of culverts,” said Morales. “Some districts kept track of culvert data in an Excel spreadsheet, some took notes and kept them in a three-ring binder, and others stored the data in the heads of the guys who had worked there the longest. Collectively, we had no idea of the condition of the state’s culverts, or even where most of them were located.”

When culverts fail, as in the San Diego case, repairing sinkholes, washed-away roads and erosion can cost millions of dollars, in addition to the inconvenience and lost productivity of having major state highways closed for repair.

Because many of the state’s culverts were reaching the end of their 50-year lifespan, Caltrans officials then requested—and received—funding from the California legislature to implement a culvert management program. The program was designed to provide consistent reporting across all districts and to mitigate damage caused by culvert failure.

Initially, Caltrans officials implemented a two-year pilot program in four different districts to study what it would take to implement a statewide culvert inspection program. The pilot program team decided to incorporate the paperless procedure already in use by District 2, based in Redding. The Redding team was using a Trimble GPS receiver and handheld data logger with Trimble TerraSync™ and GPS Pathfinder® Office software to map and record culvert data.

Using GPS Pathfinder Office software, the team created a data dictionary, which provided consistent fields to be populated by field engineers. Once the data dictionary was complete, field teams would map the exact location of each culvert’s components using a lightweight, handheld Trimble GPS receiver.

In June 2001, the engineers used Trimble GPS receivers to begin mapping the location of all culvert features throughout the district, including all drainage inlets, manholes, discontinuations in the pipes, junctions and other attributes.
In addition to logging each culvert’s location, the inspectors used the data dictionary to record the culvert type, physical dimensions and material. An assessment of each culvert’s condition was also made by evaluating different culvert components, such as the deterioration of culvert material, joints, shape, alignment and waterway capacity.

Each day, the field team would download the information onto a desktop computer and differentially correct the field data for improved position accuracy. Using Trimble GPS Pathfinder Office software, engineers could create a visual representation of the day’s work.

“The pilot program was a huge success. For the first time, we were beginning to keep a spatially accurate record of all of our culvert features, as well as detailed information about each feature’s condition,” said Morales. “After a big rain, we knew exactly which culverts need to be re-checked, and we knew which held the highest priority for repair. Suddenly, we were able to monitor the condition of our culverts and repair those in need before roads were washed away.”

Following the pilot’s success, Morales and his team requested additional funding to implement the program statewide. In 2005, Caltrans received perpetual funding for a comprehensive, statewide culvert maintenance program.

Since then, Caltrans teams have begun using Trimble GeoXT™ GPS handheld receivers—integrated rugged GPS receivers and data collectors—to map their culvert networks statewide. Each district has received the technology, training and guidance necessary for the culvert mapping initiative. Engineering technicians are now developing a comprehensive database of the state’s culvert system.

“Each day, our engineers are inspecting the condition of our culverts across the state. So far, we have mapped more than 24,000 culverts; of those, we know that 70 percent are in great shape, and more than 10 percent are in need of major repair,” said Morales. “We already have teams of engineers working on the culverts most needing repair, and I’m sure we have already prevented some major culvert failures across the state.”

Today, all of the state’s culvert data is stored in one centralized GIS where Morales can access maps, drawings and reports about the condition of California’s culverts.

“Now, I can pull up a color-coded drawing that will show me exactly where our most troublesome culverts are throughout the state,” said Morales. “We can use that information to make important decisions about culvert repair and maintenance.”

Morales predicts it will take his team approximately 15 years to collect data about every culvert feature in the state.

“We’re already seeing a five-to-one return on investment and we’ve just scratched the surface of this project,” said Morales. “My goal is to prevent the state of California from ever having another catastrophic culvert failure.”
It was 1947.

Post-war Europe welcomed the news of the Marshall Plan. Independence had come to India and Pakistan. Post-war Japan re-opened its borders to western business. The sound barrier was broken. And the world’s first light-based distance measurement system for surveying was invented.

Developed by Dr. Erik Bergstrand from Sweden’s Geodetic Bureau of the Geographical Survey, the technology is the forerunner of today’s optical total stations.

As part of his work at the Geographical Survey, and with the assistance of the Swedish Nobel Institute for Physics, Dr. Bergstrand started researching the velocity of light in the late 1930s.

World War II intervened and it was 1947 before his invention was patented. In 1948 he approached Swedish firm AGA (Svenska Aktiebolaget Gasaccumulator Stockholm-Lidingö) for the financial and technical resources necessary to improve his device and establish its commercial value. His results were so promising that, in conjunction with the Geographical Survey, AGA paid for a sturdier, improved device—and so the development of Geodimeter (GEOdetic DIstance METER) instruments began.

The first completed instrument Geodimeter Model 0 was used during the winter of 1948/49. And in 1949 Bergstrand’s doctorate thesis, “A Determination of the Velocity of Light,” complemented his invention of the Geodimeter to bring him worldwide fame. The thesis was based on measurements taken using the first Geodimeter prototype on various known baselines of the Swedish triangulation network.

Today, electronic distance meters no longer stand alone but are integrated into such innovative instruments as the Trimble S6 Total Station and the Trimble VX™ Spatial Station.

Trimble acknowledges the importance of Dr. Bergstrand’s contribution to modern surveying techniques with a pictorial look at a few of the surveying systems that evolved from his invention.
The second largest economy in Southeast Asia today, Thailand enjoys a well-developed infrastructure, a free-enterprise economy and pro-investment policies. The country boasts strong exports, which rose nearly 17 percent in 2006. Export-oriented manufacturing and farm output are driving these gains. Substantial industries include electric appliances, components, computer parts and automobiles, while tourism contributes about five percent of the Thai economy’s GDP.

Thailand’s capital Bangkok is the political, commercial, cultural and transportation center of the country. A key point on global air routes, Bangkok also offers the only port able to accommodate oceangoing vessels; and most of Thailand’s railroads and major highways originate in Bangkok. With this in mind, Trimble is strengthening its commitment to the region by opening an office in Bangkok to better meet the needs of the Asia-Pacific region.

Trimble (Thailand) Company Limited, located 5 km (3 mi) north of the Central Business District in Bangkok’s Olympia Thai Tower, will be a primary base for sales and support of all survey solutions for the country as well as the Southeast Asian region.

The new Bangkok office follows the opening of Trimble’s office in Gurgaon, India.

Legacy Issue

To acknowledge the history and depth of innovation that comprises Trimble today, we will publish a “legacy” issue of Technology&more next year.

If you have benefited from any of the instruments in Trimble’s legacy—early Trimble, Geodimeter, Spectra Precision, Zeiss—let us know. We will choose the best applications that utilize legacy products and publish them in this unique issue. You provide the application and images, our team will write the article. If your story is chosen to use, you’ll win a prize from Trimble! Send your submission to survey_stories@trimble.com. We look forward to hearing from you.
Photo Contest
Enter Trimble's Technology&more Photo Contest!

The winners of the Trimble Photo Contest receive Trimble prizes and the photos are published in Technology&more. This issue's first place winner is Kelvin Anderson of Idaho Power for the Hells Canyon shot. Honorable mention winners are published on page 23. Send your photo at 300 dpi resolution (10 x 15 cm or 4 x 6 in) to Survey_Stories@trimble.com. Make sure you include your name, title and contact information.

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