Reporter 72

The **Global Magazine** of Leica Geosystems

- when it has to be **right**

Leica Geosystems

PART OF HEXAGON

A Message from the President

Water, covering 71 percent of the Earth's surface, is central to all life on this planet. Whether consuming, cleaning, travelling or powering, water is the sustaining force that we all share in common.

In this edition of Reporter, you will read how our customers are keeping the water flowing, managing this precious natural resource so it can continue to nourish us all. Every day, professionals around the world are finding ways with geospatial data to lead conservation efforts.

The viability of water resources is a major focus for governments and companies around the globe. To ensure the wellbeing of a U.S. community, TruePoint Laser Scanning used the Leica ScanStation C10 in the renovation of a water treatment facility. The water of two lakes is being reused to produce electricity in Switzerland, where the UAV Aibot X6 has been deployed by Axpo to survey and document dam construction.

Global changes in climate are closely monitored to better understand our ever-evolving world. The Leica Nova MS50 MultiStation is contributing to environmental study as it is used by a team of specialists to measure movement of a glacier in Greenland. With 85 percent of the world population living in the driest half of the planet, water conservation is a critical concern. El Concorde Construction in Iraq has found a solution to water irrigation management with the Leica Zeno 10 GNSS/GIS handheld device and Leica Zeno Office software.

There is no denying the significant role water plays in all of our lives. I'm proud of our solutions and customers that are shaping this changing world.

Juergen Dold
President, Hexagon Geosystems

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The melting glacier, Eqip Sermia, in Greenland.
Read the article about the survey expedition on page 3.

© Farouk Kadded

Monitoring the changes of our lifetime

by Farouk Kadded and Luc Moreau

Greenland, rugged and wild, is covered by a massive ice sheet that represents roughly 80% of its surface. Glaciers break free of this ice sheet and become slow flowing rivers of ice that are constantly moving, being pushed by their own massive weight towards the sea. There are many reasons why researchers have recently taken an enormous interest in studying the secrets of Greenland's ice. One is that Greenland is especially vulnerable to climate change; the ice sheet is melting faster than any other body of ice in the world and the glaciers are moving ten times faster towards the sea than they did just five years ago. Another reason is that this country's ice represents roughly eight percent of all freshwater found on Earth. Should these glaciers melt, the meltwater would be enough to raise the sea level by over seven metres (20 feet), displacing millions of people on this planet. This will have serious consequences on our environment, making it extremely important to monitor these changes, which are occurring during our lifetime.

Luc Moreau, a glaciologist based in Chamonix, France, has been studying the impressive four kilometre (two and a half miles) wide Eqip Sermia glacier in West Greenland for over three years. Luc, along with, the SPELEICE association and the MONALISA production company, recently organised an expedition to collect data on the speed of this glacier's melt flow and to understand how this glacier's ice moulins (deep holes that transport meltwater through glaciers) affect the speed of its melting. Accompanying them was Farouk Kadded, product manager of Geomatics at Leica Geosystems France, and together they set out using the state-of-the art Leica Nova MS50 MultiStation and real-time GNSS positioning instruments Leica

The melting glacier, Eqip Sermia, in Greenland is moving alarmingly fast.

GS14 antenna and Leica GS10 receiver. The MultiStation was chosen because it was capable of making accurate, reflectorless 3D scans from a distance of 1 – 2 km (0.6 – 1.2 mi), was lightweight and compact enough to be carried in a backpack and was proven to be reliable and rugged. It was also the only scanner on the market that offered all four technologies needed: total station, scanning, GNSS and imaging.

Measuring the Eqip Sermia's movement flow

During his last expeditions, Luc set up a camera that took pictures daily over the last few years. He was able to identify the changes in the glacier size by piecing together a "timelapse" film from the images taken by this camera. This film, when accompanied by the collected topographic data of the Leica Geosystems equipment, could be used to calculate the length and speed of the flow of the Eqip Sermia glacier.

After Luc and Farouk found stable ground for the GS10 receiver to serve as a reference point, they started out looking for the ideal measuring positions on the glacier. This was a dangerous task on the quickly shifting glacier surface with its deep and deadly ice chasms. Carrying the MultiStation, a tripod, a reflector target, the rugged Leica GS14 antenna and a pole, they first set up the MultiStation on the stable left bank with the Leica GS14 GNSS antenna on top to get the exact coordinates for the MS50 to measure the selected points at a range of 1.3 kilometres (0.8 miles). After this, they perilously crossed the glacier to position a reflective target. For four consecutive days, they collected position data at the same time of day to calculate the glacier melt flow over a 24-hour period.

The glacier moved at a rate of up to 30 centimetres (12 inches) an hour, so the team had to work fast. Images were first taken by the MultiStation of several seracs, or ice towers, to help Luc and Farouk easily relocate the same points the next day.

The results proved that the glacier's movement was up to 7 metres (23 feet) a day. The last measurements taken in 2012, revealed the Eqip Sermia moved 3 metres (10 feet) daily. This flow, when compared with other glaciers around the world, moving roughly 30 centimetres (12 inches) a day, is alarmingly fast. The team also proved the glacier lost roughly 500 metres (1,640 feet) in just the previous month. Another goal the team had set out to accomplish, that of using the Leica MultiStation to make a 3D scan for posterity of the historic cabin that French polar explorer Paul-Émile Victor used as a base for his expeditions, was also successfully completed. Also, a large lake several kilometres inland on the Eqip

Sermia's surface was discovered. Should this water somehow find its way into a crack, it could cause a glacier meltdown. Finally results also proved that the glacier is melting 100 times faster below the surface of the ocean than above.

Measuring the inside the ice moulin

After making the same, day long trek on the path explorer Paul-Émile Victor took to reach the glacier's ice cap 60 years ago, the team set up camp and searched for a "moulin" to make the 3D scan. This scan would determine if the water inside a moulin did indeed reach the rock bed below the glacier. Why are these moulins so important to researching glaciers? With Greenland feeling global warming much more than the rest of the world, lakes of meltwater appear on the surfaces of the glaciers on very warm days. The excess lake water produces rivers that melt the ice at an alarmingly rate. If this water gets into a moulin, it will begin to swirl and erode the ice and find its way to the bottom of the glacier on Greenland's bedrock. This water builds up under the glacier and works like a lubricant. The glacier easily slides on this water surface and the forces of gravity push the massive weight of the ice even faster, towards the ocean.

The meltwater's journey

Luc and Farouk managed to set up the MultiStation on the tribach inside an ice moulin to scan the details of the ice crevasse. With some moulins reaching depths of up to 200 metres (650 feet) , it was truly exciting. Never before has such an accurate scan be done of how the water's flow formed nooks and crannies inside a glacier moulin, recording its progress to the bottom of the ice.

Working inside this hole is not without its dangers. Should the surface temperature fluctuate as much as 1-2°C (34-36°F), glacier water could start to melt and flow into the moulin, flooding everything. Scanning took an entire day, but they were able to scan the moulin in its entirety, measuring vertically, bit by bit, from the river that created it to its deepest part, collecting roughly 500,000 highly detailed points. Depth, circumference and width can all be provided by a 3D scan taken by the Leica MS50 MultiStation and the results were fascinating.

"The idea of measuring this way was to have all the dimensions of a moulin in order to appreciate its

© Luc Moreau

A bracket on the ice wall carries the MS50 to scan the moulin.

development over time and the deformation of the ice. The results proved very effective, the model visuals are excellent and the device well suited for this type of opening – provided you have good weather!" says Luc Moreau excitedly.

The 3D scan proved the Leica MS50 MultiStation's versatility and its robustness under extraordinary circumstances. Its new programs and features that work together, integrate new technologies, making measuring far more reliable, quicker and complete, enabling researchers to receive the information they require. Working together with companies that are at the forefront of their fields, can only help researchers to advance in their understanding the changing climate.

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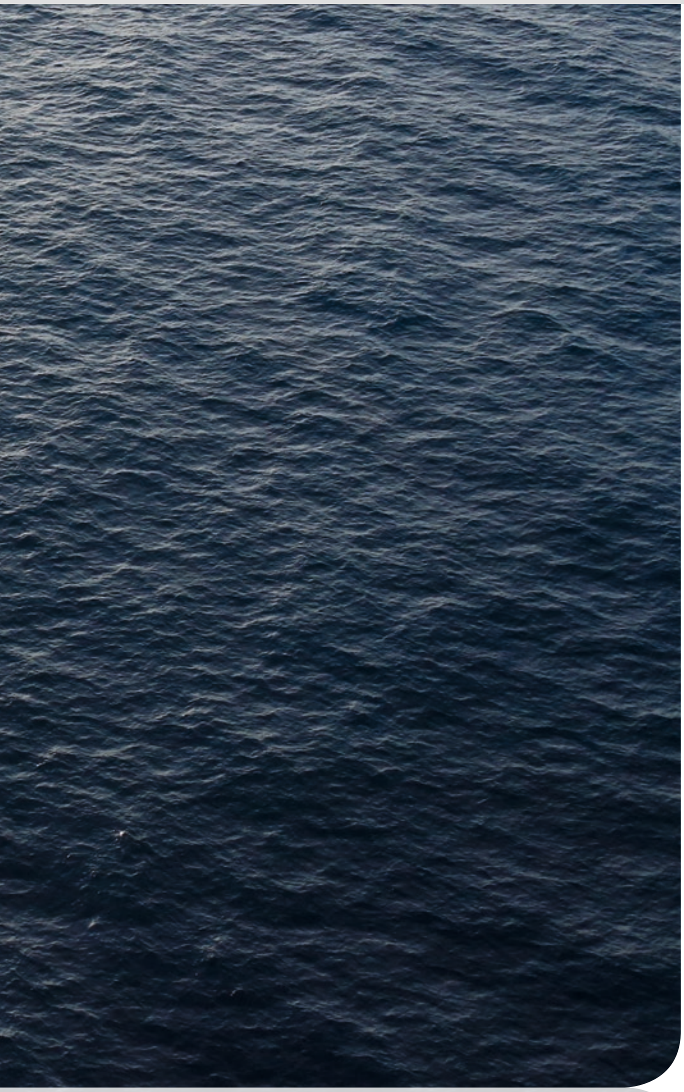
The sailor's journey

by Katherine Lehmuller and Marco Mozzon

On October 19, 2014, a brave sailor determinedly set out to sea. His goal was to sail around the world alone, without the help of any fossil fuel or additional supplies, other than what he brought with him for the entire 50,000 nautical mile journey. What would a sailor bring along in order to survive such an ordeal? This sailor, the Italian Matteo Miceli, decided on a fishing rod, two chickens, a plot of dirt to grow vegetables, a machine to desalinate drinking water and three Leica Geosystems' GNSS GR25 receivers and three Leica AS10 antennae.

To sail around the world self-sufficiently was Matteo's motivation for undertaking this journey, however he was just one member of a group working together on the project, "Rome Ocean World", and they had other goals as well, such as being the first sailboat to accurately record the water and boat's movement throughout the trip using GNSS technology. At the end of the journey, Professors Paolo di Girolamo and Mattia Crespi from the University of Rome and Allessandro Pezzoli from Polytechnic Turin, would analyse the data that would hopefully validate the UK-based MET (meteorology) numerical models by calculating wave heights on the Eco40 route; improve the structural design of the Class 40 boat by calculating the dynamic stress and durability of the vessel during the trip and finally, to produce a polar diagram of the boat's speed after recording wave characteristics, which will be especially useful for future Class 40 racing boats.

After setting sail from Rome's nearby Port di Traiano, Matteo had three beautiful days of weather, allowing him to check in with his team back in Rome, with which he was in daily contact. However, he was soon confronted with the first of many tests of seaworthiness when the remnants of Hurricane Gonzalo hit the Mediterranean with heavy rain and gale force winds. After several intense and expectant hours of lost contact, the Eco40 team received an automatic



data transmission on the boat's position, confirming it survived 80 km/h (50 mph) winds and six metre (20 feet) high waves, and that it was on its way towards Gilbratar.

This storm left the Eco40, the sailor and his chickens in bad shape. The garden was ruined, with its dirt full of salty water and vegetables dead. The chickens had been traumatised and wouldn't lay eggs for some time and the sea was still so stormy that fishing was out of the question.

For just such emergencies, the sailor kept 100 bags of freeze-dried food on the boat and for several days Matteo survived on 100 g (0.22 lbs) of carbohydrates, a handful of fried fruit and some salted fish he had managed to catch before the storm hit.

After the storm passed, Matteo had time to think. A professional sailor by trade, it was a challenge for him to stop and fix damaged boat parts. Matteo wanted to push the high-performance Eco40 to set record speeds but instead, he had to wait, either for the repairs to dry, or for wind. The sailor had time on his hands and was confronted with the commitment he had set for himself when agreeing to take part in this adventure. The lack of wind got to him, and even with the daily tasks of running a boat, data collecting or just plain day-to-day survival, he was sometimes lonely and often doubtful. Luckily the chickens, whom he nicknamed Blondie and Brunette, needed encouragement to lay eggs and they became fast companions. He also had daily support from his Facebook fans to cheer him.

Data was collected by the Leica GR25 GNSS receiver and the Leica AS10 antenna and sent via GEO stationary satellites without any problems. And the Eco40's hydro, wind and solar energies supplied as planned. The real problems of this journey were more mundane concerning human nature and the purpose of existence. For instance: The sailor could only get a few hours' sleep before being awakened by gusts of wind, which caused severe jolting of the boat; or the auto-pilot's voice waking him to tell him of some route change. If he could sleep more than 20 minutes at a stretch, he had to nevertheless keep his eye on the barometer since his life depended on knowing if a storm was approaching. Food was of course always a big concern – just to catch a fish or grow bean sprouts on a wet paper towel were major victories. Fish, sprouts or maybe an egg, this was Matteo's diet for months – if he was lucky – and he was happy to have it. The companionship of Blondie and Brunette helped to distract Matteo from loneliness and it was a sad day for the sailor when, for no apparent reason, Blondie passed away. Sometimes he was lucky enough to be accompanied by birds or dolphins, however he was alone on this journey and for him, it was the little things in life that mattered most.

Unpredictable weather patterns were also a major concern. One night, a sudden wind change caused the boat to do a death roll. Matteo woke to an almost capsized boat, halfway under water. Alone, in the dark and with water rushing into the cabin, the sailor had to think fast. It's a situation many of us wouldn't want to be in. Sometimes the boat sat in fog for days on end. Another time, a massive wave hit the boat while the sailor slept, causing a very bad head injury and severe anxiety. Nonetheless, Matteo had to go on tending the boat in order to survive.

The Eco40 sailing boat

This was no ordinary boat. It was a professional racing class sailboat known as the Class 40, customised and equipped to sail self-sufficiently around the world. Equipped with tread-proof solar panels, two wind generators and two hydro-turbines, the boat was appropriately named Eco40. Generating three kinds of renewable energy, the sailor hoped to have a continuous supply of electricity throughout his journey, and provide enough for the boat's electrical equipment, oven, microwave and hot water kettle as well as supply light for the onboard vegetable garden, for desalinating seawater and for a tiny freezer to store fish the sailor hoped to catch.

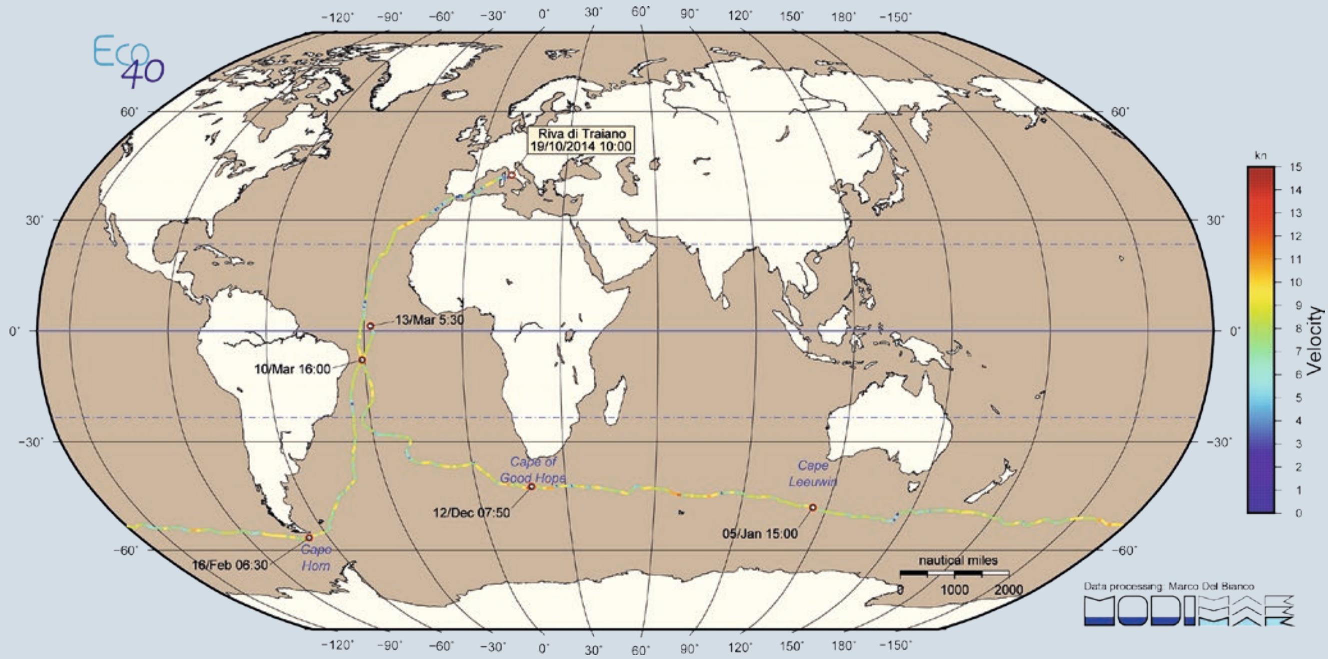
He journeyed through cold polar air and icy waters of the Sub Antarctic, with the unseen dangers of icebergs looming ahead. Severe waters for a boat to be in and it was during this part of the trip that the Eco40 lost its auto-pilot. It was damaged along with much of his electrical equipment after being struck by lightning. Luckily, his team (Cecilia Angelelli, Valerio Brinati, Allesandro Farina with Leica Geosystems' technical support Pierpaolo Pecoraro) "walked" him through this part of the journey, restoring his PC software, the boat's instruments and helping with battery problems via satellite calls. This damage needed to be rectified as quickly as possible, even if only temporarily.

With icy rain and freezing temperatures, Matteo remained strong. But stress took its toll on the sailor. At this point, he had been sailing alone for over 100 days. Lack of sleep, too little food and constant cold had its effect. He endured near-fatal storms and heavily damaged electrical equipment – and was very worried. This was certainly a bleak part of his journey – and it was somewhat noticeable in his communications. He started eating chicken feed to survive and had to pull out his own tooth. Yet, he did what he had to – to survive.

In early March, Matteo discovered the Eco40's rudder under 300 litres (80 gallons) of water. These bushings holding the rudder and almost caused the journey's end however Matteo had managed to repair them. This time bolts holding the boat's keel in place caused Matteo to lose the keel in March, on Friday the 13th, and wind capsized the Eco40. Alarm systems warned Matteo and alerted the Italian Coast Guard, who then sent word to the nearby merchant ship, Aramon, to pick up the sailor, who patiently waited in an inflatable raft he managed to fish out of the Eco40 before it sank.
The sailor also tried to rescue Brunette but sadly, he was too late.

Yet Matteo was lucky. The area where the boat capsized was known for its calm waters and he had, eight hours earlier, closed the double-crossing of the equator. He accomplished what he had set out to do. He rounded the Cape of Good Hope, Cape Leeuwin and Cape Horn; crossed the equator twice and crossed all the meridians he planned to. The Eco40 travelled, from start to its tragic finish, roughly 25,000 nautical miles (approx. 46,000 km/28,600 mi) and at the time of its capsizing, was approximately 965 kilometres (600 miles) from the Brazilian Coast.

Matteo also succeeded in accomplishing his goal to sail non-stop, all alone, around the world, from point of departure to point of arrival and maneuvered the Eco40 several times across oceans for 112.4 days at an average speed of 7.4 knots.



■ **The green line displays the global route Matteo sailed on the Eco40.**

After being rescued by the Aramon, Matteo was pampered by its crew. He had lost more than 30 kilograms (66 pounds) and spent his time relaxing, eating and making use of the ship's gym.

Matteo Miceli arrived back in Italy on March 19th at Rome's Fiumicino Airport. Upon seeing the professors for the first time since he left Rome, the sailor presented them with the all the SD cards containing the data that the receivers collected during the trip with the exception of the very last cards that were still in the GR25 receivers as the ship went down. These cards were last exchanged on February 28, when the Eco40 was off the Argentinian Coast.

Almost immediately, the professors and the sailor began planning how to recovery the boat. A satellite tracker was still sending out signals from the boat, which was drifting with underwater currents. The tracker's batteries would soon be empty so with little time to spare, the team flew back to Brazil and organised a boat for the rescue, while also planning the stabilisation, and transport of the Eco40 once it resurfaced. Unfortunately some 30 hours before reaching the recovery area, the tracker stopped sending a signal. The area was too large to search and on April 4th, the search was suspended and the team went home.

However, the journey is not over yet. Just seven days ago, word reached the professors that a Spanish fishing vessel spotted what was thought to be the Eco40 floating off the coast of Brazil, 350 nautical miles from where the team expected to find the boat. A photo was taken and posted on Twitter.

Unfortunately since then, no one kept track of its position, but according to the professors' calculations, it was headed out to sea ...

What next? The journey continues. Stay tuned ... ■

Good winds to all!

You can read the entire 10-part series of The Sailor's Journey at: http://www.leica-geosystems.com/sailor

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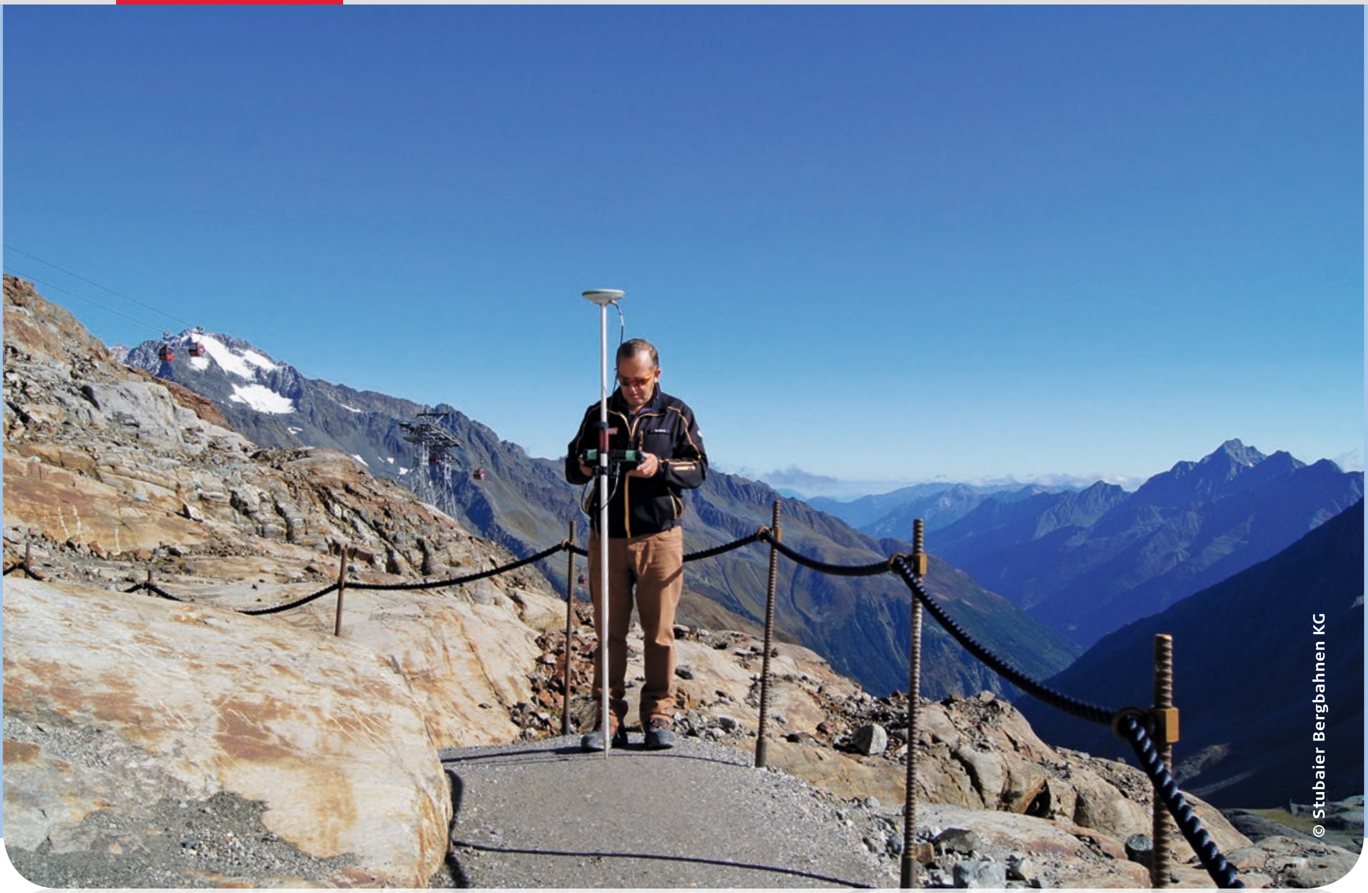
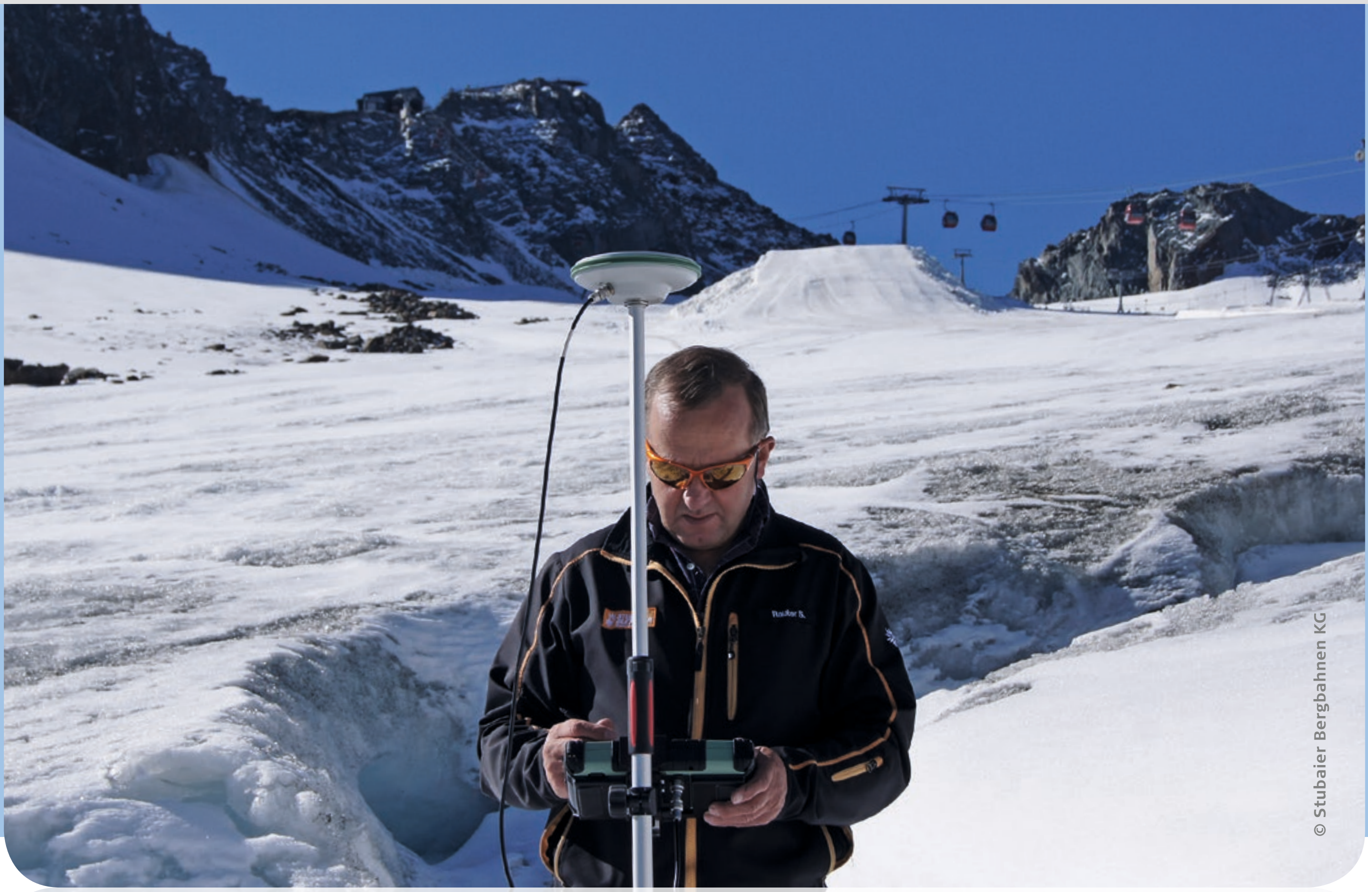


Managing ski areas with precise GIS data

by Monika Rech

With an overall size of 1,450 hectares (3,580 acres) and a total of roughly 200 hectares (500 acres) of prepared ski slopes, the ski area of Stubaier Bergbahnen KG is the largest glacier ski area in Austria. 26 cable car and ski lift installations transport close to 36,000 people uphill every hour. Around 104 kilometres (65 miles) of red, blue and black ski slopes wind their way down to the valley below the 3,333 metre (10,900 feet) high "Schaufelspitze" peak. The ski season is long, beginning in mid-September and serving ski and snow enthusiasts all the way to June. Around 300 employees of Stubaier Bergbahnen KG and a number of additional seasonal workers ensure that skiers are able to ski safely and enjoy their stay. The foundation for this is laid by Sepp Rauter, operations manager of Stubaier Bergbahnen KG, together with his team. Day in and day out, he keeps an eye on the slopes and glaciers with his rugged field companion: The CS25 GNSS Tablet PC from Leica Geosystems using Leica Zeno GIS Field software.

In 2004, Rauter had had enough. Time and again, excavation work on the slopes of Stubaier Bergbahnen KG resulted in costly damage to underground cables, lines and shafts. The operations manager explored the market to find technology with which Austria's largest glacier ski area operator could avoid these expenses. He decided on the handheld GIS data collector Leica GS20 GPS. In April of 2014, the company acquired the rugged and even more precise Leica CS25 GNSS Tablet with the external Leica AS10 antenna. Today, each and every pipe for drinking water, waste water and snow-making systems, as well as all the cables and ducts, are surveyed



Sepp Rauter carrying out precise measurement on the mountain using the Leica CS25 Tablet.

with precision, displayed cartographically and can be called up at any time in the Esri ArcGIS linked directly to it. As a result, costly damage has been avoided ever since.

Since then, Rauter has also precisely surveyed the ski slope surfaces, because as the operator and owner of the Stubaier Bergbahnen KG cable car lines, Rauter has to pay leasing fees to the Austrian Federal Forestry Office. "Today, this technology makes precisely calculated billing possible," said Rauter. Excavated dirt from site work has to be invoiced as well, which is why Stubaier Bergbahnen AG relies on precise volume measurement here as well.

Thanks to his newly acquired GNSS Tablet, Sepp Rauter always has his tract of glacier region in view. Professor Dr.-Ing. Wolf-Ulrich Böttinger, former member of the surveying, informatics and mathematics faculty at Stuttgart University of Applied Sciences (HFT) in Stuttgart, Germany, recently developed software which enables Rauter to measure the ice thickness of Stubai Glacier with the Leica CS25 tablet. This is possible with the Windows 7 operating system and Zeno Connect, which enable software solutions from third-party companies with high precision GNSS positions. Glacier movement is particularly important to Rauter, as the foundations of some of the cable cars and T-bar lifts are secured in ice. In other words, they move along with the glacier. "The location of the supports changes continuously, with some of them moving up to three metres a year," said the operations manager.

The people responsible for this monitoring at Stubaier Bergbahnen AG need to know the precise positions of the pillars so that they can respond to these movements. Thanks to technology from Leica Geosystems, Rauter is now able to manage his many tasks more easily. He finds measurement with the Leica CS25 tablet to be very convenient, as the device can be operated like any conventional tablet. While carrying out surveying work, Rauter can communicate via e-mail and forward the data directly on-site. Position determination with centimetre precision is possible with the Leica CS25 GNSS and Zeno Field or Zeno Connect software. While still in the field, Rauter is able to forward the data to the ArcGIS software in the office, leaving him enough time to thoroughly test the freshly groomed slopes.

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Renovating complex structures with 3D laser scanning

by Bruce Bowditch

The project engineer at a wastewater treatment plant in Tampa/Florida was faced with a challenging renovation – demolishing one of their pump houses and replacing the piping in the plant's digesters. While existing two-dimensional drawings documented the pipes, they did not include the level of detail necessary to plan the reconstruction in a way that guaranteed the new installations would not clash with existing structures.

The project engineer and his team required a thorough understanding of the labyrinth of pipes that wound around each other, changed elevations, and wove in and out of assorted plant structures. To assess the water tank's capacity, they needed measurements inside the tank that included a representation of the fill line to the highest part of the tank, as well as the point where water exits the tower. Finally, they wanted an overall site plan showing building footprints and their relationship to each other. This documentation would help them to understand the dynamics of the water flow, determine digester capacity, establish their connection points in the water tower and make informed decisions regarding the plant's restoration.

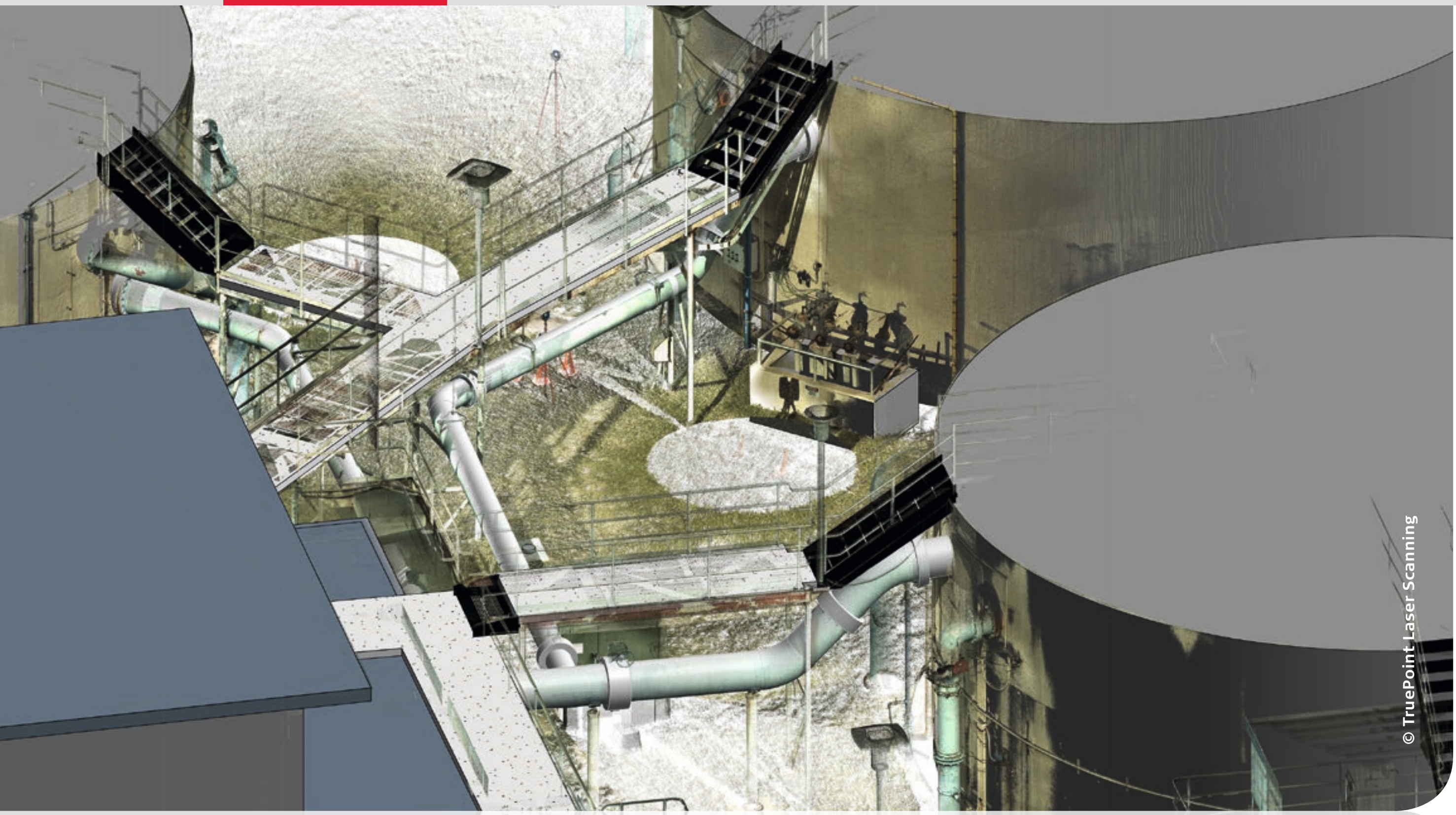
Point clouds, 3D visualisations and models provide valuable insight on a complex network of pipes and valves.

To complete the documentation manually would not only be complex, but it could also be dangerous. First, because the water tower was 53 metres (175 feet) tall, it was difficult to access. In addition, there was the ever-present risk of falling and drowning when taking manual measurements of wastewater digesters, open vats that are used to stabilise the solids removed from the wastewater during treatment.

Manual documentation would also be time consuming due to the complexity as well as the logistics of manoeuvring around the plant and, for example, negotiating catwalks that narrow to about 41 cm (16 in) wide in some places. It probably would have taken a team of four engineers around two weeks to take measurements, and they still would have only been able to gather a bare minimum of data.

From difficult and dangerous to simple and safe with laser scanning

The project engineer realised that laser scanning could be the solution to their problem. After searching for service providers, he contacted Ryan Hacker, president of TruePoint Laser Scanning. Because laser scanners methodically and quickly capture data points that represent all objects within their range, they could easily capture the complex piping and plant layout. In addition, since the TruePoint Laser Scanning team chose to use the Leica ScanStation C10, they were able to document buildings and structures accurately within a 300 metre (980 feet) range while capturing thousands of data points in a second. This long-range capability meant the technicians could safely scan the interior walls of digesters from the catwalks and record the water



A colourised point cloud of the water treatment plant with modelled tanks and building footprint.

tower from the ground, eliminating the need for man lifts and repelling equipment.

Two TruePoint technicians determined that they needed to take scans in thirty-six locations. Laser scanning captures everything in line of sight. To assure thorough documentation, however, they took scans from multiple angles. Each scan represented a fragment of the puzzle that TruePoint associates would later piece together. While the project engineer had originally planned a multi-phased project in order to continue operations while replacing specific pipes and valves, TruePoint was able to complete the data collection in a day. The quick process also saved money by reducing the need for several documentation projects. In addition, because all the data was available immediately, engineers could make a full plan that reduced the need for future change orders. The scans produced a series of point clouds, three-dimensional data sets that represent the scanned objects at the facility. Back at TruePoint's headquarters, the workflow fell into an easy rhythm as the team imported the multiple point clouds into Leica Cyclone software. Then, to gain a complete view of the plant they assembled the puzzle, registering the point clouds and joining them into a single data set. They sent the 3D representation to the engineers at the water treatment plant who also use Leica Cyclone software. The engineers imported the point clouds into their Autodesk AutoCAD software to create a model. In addition, TruePoint provided Leica TruViews that give a panoramic 3D view of the scanned area. The TruViews are intuitive for people to use; they can easily zoom in to see points of interest and look at them from all angles.

Taking measurements and analysing the data in the office

The engineers were able to scrutinise the data from the comfort of their offices and calculate factors such as the necessary rise over run for the pipes, water flow, and specific measurements. Having all the data at their fingertips enabled them to give a fabricator the exact size and shape of the new pipes they needed. Once they received the pipes, all they had to do on the site was to assemble them; thus, they saved money on manual labour time. As a result, the engineers at the water treatment plant were able to plan their renovations more accurately and comprehensively, increase safety, reduce costs and achieve their goals more quickly. Due to the success of this project, the project manager has now incorporated laser scanning into additional projects.

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Taking out the guesswork

by Gerard Lamarre

Canada's new Rt. Hon. Herb Gray Parkway isn't a typical transportation project. The six-lane, seven-mile curvaceous expressway on Canada's busiest land border crossing will eventually connect to a bridge in Detroit, serving as a primary entrance and trade corridor between the U.S. and Canada. The total cost for the project is an estimated 1.4 billion CAD (1.07 billion Euro). The project has a lot of layers, from excavation to open graded drainage, asphalt and concrete. Getting the dimensions, grading and paving right on the first try is imperative. Dominic Amicone, president of Amico Affiliates, the civil contracting firm leading the parkway's construction, was looking for something exceptional – a machine control system to take them through the construction process that provided the flexibility they needed to be accurate and efficient. After evaluating several industry leading providers, they chose Leica Geosystems as their strategic technology partner and began using the Leica Nova MS50 MultiStation and SmartNet RTK correction network to continuously check grades and refine information in real-time.

"The parkway itself is curvilinear in virtually every direction. There are really no straight lines and [there are] a number of tunnels and bridges with a road that meanders through," said Dominic Amicone. "Grade stakes and traditional layouts are pretty much archa-

GNSS correction data by SmartNet, helped Amico to easily and accurately carry out grading tasks.

ic in this environment." "This real-time ability, combined with the entire machine control operation, allows us to provide operators with real-time information that they can implement and use to get tolerances of 1 to 2 millimetres (0.04 to 0.08 inches), which would be unheard of without using these controls," said Amicone.

No more guesswork

Using traditional surveying methods, a project of this size would typically require grade stakes marked for elevation and a painstaking, manual process of checking grades against the markers. Crews would have to follow behind the paver, for example, constantly checking the grade and letting the operator know about upcoming high and low spots.

When there was a drastic change in grade – like a manhole lid or pothole – and the "checker" wasn't fast enough to catch it, work would have to stop and the paver would have to go back and fix the mistake.

Today using the Leica Nova MultiStation and SmartNet as pavers move forward, operators have a sonic sensor that lets them know immediately if they need to go higher or lower based on the pre-programmed model. The machine's blades are controlled automatically, adjusting the thickness of the material.

"The thing I like most about it is being able to predict the surface. Operators have a surface display on their tablet that lets them see exactly what they are getting into, which makes the whole process easier," said Brian Laramie, Amico's head surveyor. "Before, our process was reactive and required surveyors to perform grade checks every 20 metres (66 feet). It was slow and tedious, and we were constantly chasing grade. Now we're setting grade."

This automated process is more efficient and eliminates the number of crew members involved, which saves money and improves safety. But perhaps most impressive is the technology's speed and accuracy.

"We are seeing an incredible level of accuracy between similar points on two set-ups and the actual scanning process is very, very fast," said Laramie. "We are shooting granular surfaces, so you would think there would be at least an inch of discrepancy between the two scans, but we haven't come across that."

With the Herb Gray Parkway project, which is expected to be complete in the summer of 2015, Amico's work won't end with the design and initial construction. As part of the deal, the firm will maintain the structure for the next 30 years. This level of commitment requires the highest standard of quality and productivity, which encouraged Amico to seek out innovative equipment and technology not readily used in the marketplace.

"Here on the parkway, one of the biggest challenges we had was the frequency of changes," said Amicone. "Having a total GPS network system in place allowed us to change cross-sections, lines and grade on a regular basis, virtually daily. And with 14 crews on the jobsite at the same time, it allowed us to really control the material we were moving and the pavements we were placing."

Why Leica Geosystems?

"When it came time to select a GPS-controlled system, it was evident that Leica Geosystems not only had state-of-the-art technology and equipment, but they were willing to reach out of the box and come up with solutions for our unique project," said Amicone. "It was an interactive partnership from the very beginning."

Amico was particularly impressed with the innovative Leica Nova MS50 MultiStation and its ability to capture high-definition point clouds and provide crews with averages.

"It has allowed our crews to control grade and correct for sub-grade errors on the go," said Amicone. "The ability to correct that has not only minimised the oversight needed on a job, but it has also allowed us to hit production levels that would have otherwise been impossible to accomplish."

Using the Leica MultiStation and SmartNet process in the field enables surveyors to program the machines with operators on a daily basis. Changes can be easily accepted and modified, and operators have visibility into how machines are coordinated across the jobsite.

Though some crew members were apprehensive and sceptical at first of the new technology and control systems – even checking and double-checking grades to make sure they were accurate – they have now come to fully trust the numbers and are very confident with the new equipment and process.

"It is pretty impressive when you go onto one of our project sites and don't see a single grade stake," said Amicone. "This experience has definitely inspired us to keep pushing boundaries and strengthen our commitment to emerging technologies." ■

More information on Rt. Hon. Herb Gray Parkway can be found on the dedicated project website at: http://www.hgparkway.ca/

Watch the video at:
www.leica-geosystems.com/amico_parkway_canada

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The new industry standard

Though implementing innovation is often difficult, Amicone credits the company's accepting culture and the open-mindedness of his crews for their ability to embrace the new technology so quickly.

"The actual transition and implementation of the machine controls has been virtually seamless. Our people have accepted it because it's an extension of the way they think," he said. "The younger people that come into this industry now use computers as an extension of their right arms. They were really keen on adapting this new technology and using it on the jobsite. It really defines and integrates the entire team."

Are MultiStations, laser scanning, GPS and machine controlled solutions on their way to becoming the new industry standard? To the next generation of surveyors at Amico, it certainly looks that way.

"With this modern technology, construction is a completely different process now," said Laramie. "I drive through construction sites now and see batter boards and stakes popping up everywhere and everything looks like a smashed-up puzzle. I've been blessed with this technology. I don't even have to set up base stations – I just turn on the machine and go. All of my information is at my fingertips and loaded on to my data collector. I think back and can't imagine how crews did it without this."

Advances in Brazilian water management

by Ruth Badley and Ricardo Serrato

Field teams from DMAE (Municipal Department of Water and Sewer) for the Brazilian city of Porto Alegre, are using Leica Zeno 10 GNSS/GIS solutions to improve the quality and accuracy of asset data collection. The investment in advanced technology supports the city's plan for sustainable growth and a commitment to improve services for consumers.

Porto Alegre, the capital of the Brazilian state of Rio Grande do Sul, is home to approximately 1.5 million residents. DMAE is responsible for the management, supply, treatment and distribution of water and the collection and treatment of sanitary sewage.

With the responsibility to oversee and maintain the existing services whilst also steadily seeking to expand and improve the network capability, it was important for DMAE to be able to capture, collect and record asset and attribute information to a new and precise level of accuracy.

Working from a reliable and definitive database would make the management and administration of water and sewer assets more technically efficient, whilst also reducing costs, increasing profitability and ultimately providing a better service to more users.

New workflow

Using 13 Leica Zeno 10 handheld data collectors, together with a Leica GR25 reference station, field teams no longer rely on the time consuming and less accurate cadastral survey method for asset data collection. The old workflow involved taking measurements with a tape, collecting the position data with a GPS navigation tool and then sketching all the information on paper. The data collected on site had to be rewritten in the office and was only accurate to 1 metre (39 inches), unlike the new workflow, which results in measurements accurate to 40 centimetre (16 inches).

Using Leica Zeno 10 with the GR25 give on-site users real-time postioning data for fast actions.

All data can be transferred to the GIS database direct from the field, using Leica Zeno's 'EasyIn' transfer routine and then processed in Zeno Office. The data can also be exported back to the field, when required, using the 'EasyOut' tool.

Using the reference station allows all the data loggers to receive real-time positioning corrections via NTRIP (Networked Transport of RTCM via Internet Protocol). If communication between the reference station and data logger is not available, the collected combined data can be post-processed in the office DMAE engineer, Fernando André Neuwald commented, "With Leica Geosystems' tools the geo-referencing of network assets takes less time, yet achieves greater precision. We are building a high quality Geographic Information System so future decisions affecting assets and consumers can be made from a fully informed perspective."

Accurate data with rugged tools

Porto Alegre's subtropical climate means field work is often carried out in conditions of high humidity and significant rainfall. Summer temperatures often rise above 32°C (90°F) in summer and can drop to below zero in the colder months but precipitation can occur year round. The rugged and durable nature of Leica Geosystems devices are particularly suited to such environments as they carry an IP67 dust and waterproof rating and are fully operational at temperatures ranging from – 30°C to +60°C (– 22°F to +140°F). Sun readable touch screens make the data loggers particularly easy to use.

Fernando André Neuwald added, "It is essential for us to know the existing structures, and to be able to include in the database condition details that will assist teams to carry out preventative maintenance and improvements. In emergency situations, having the right information gives us the means to take fast, corrective action."

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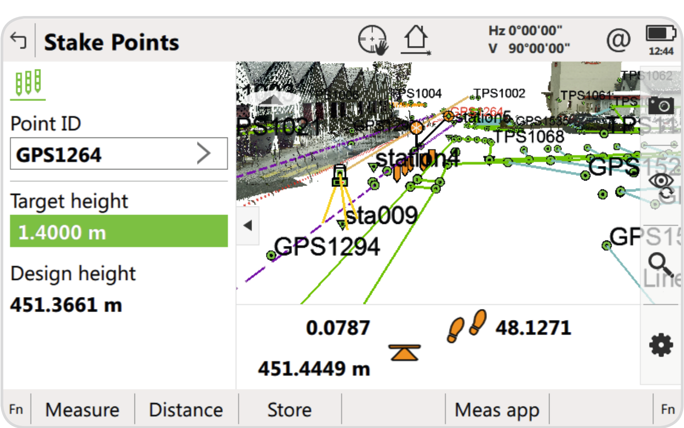
Be Captivated: Creating the Leica Captivate Experience

People think focus means saying 'yes' to the thing you've got to focus on. But that's not what it means at all. It means saying 'no' to the hundred other good ideas that there are. You have to pick carefully. Innovation is saying 'no' to 1,000 things. – Steve Jobs

Catching up with David Dixon and Alastair Green, developers of the Leica Captivate Experience, they shared just how they purposely ignored 1,000 good features they could have included and focused on what was most needed and valued for the user.

What is the Leica Captivate Experience?

Green: To put it simply, it's an enjoyable and fully-immersive customer experience in using Leica Geosystems' latest developments in measurement technology. When we were researching this new solution, we identified three areas that were the most important for customers:



■ **Leica Captivate produces realistic workable 3D models.**

1) Create a unique user experience

From basic skill level to experts who need to perform highly-technical tasks, the user interface of the new software was made for enjoyment. For example, we wanted a unique and exciting way to select the job and app to be used. With the thumbnail images in the job and app carousel we achieved this, or at least, so far, we have received very positive feedback.

2) Place 3D at the heart of the concept

Following the *3D Everything, 3D Everywhere* vision, where *everything* is all information in all the projects and *everywhere* is throughout the entire software in any application, data is simply and completely turned into realistic, workable 3D models. With the ability to merge the overlay of measured points, 3D models and point clouds into a single view, users can now manipulate onscreen displays to exactly create and check any worksite.

3) Improve the basics

Truly listening to our customers,we simplified usability with familiar touch technology and easy-to-use apps. Our customers often work all day on similar tasks, such as feature coding, linework, and staking points and lines. Keeping these fundamental elements of their jobs easy and enjoyable is very important for a positive customer experience. So intuitive is this experience, the customer already knows how to use the software before ever having to formally learn it.

What makes up the Leica Captivate Experience?

Dixon: We begin with the software, which is at the centre of our users' experience with our solution. Leica Captivate was developed with immersive tech-

■ **Leica Captivate provides familiar touch technology and easy-to-use apps.**

nology to bring about a new experience. The new field software requires a new generation of field controllers and tablets. That is why we developed the Leica CS20 and Leica CS35. With their large displays and high performance, they provide the perfect platform for Leica Captivate. We also thought about the user experience on the total station. We needed to develop a completely new generation of total stations and MultiStation. The Leica Nova MS60, the Nova TS60 and the Viva TS16 are the world's first self-learning MultiStation and total stations, which, thanks to ATRplus, automatically learn the environment around them and adjust accordingly to provide dominant performance. Our focus on the customer experience also runs to our GNSS offering. Thanks to Leica Captivate and the new range of field controllers and field tablets, we have a completely new GNSS offering combining unlimited performance with an enjoyable experience.

Green: The Leica Captivate Experience goes even beyond the core elements of engaging software, precise hardware and trusted services. This concept is putting the customer experience in the centre and building out from there. We first developed this revolutionary software for the customer and that drove the hardware activities, but the whole Leica Captivate Experience is the impression the customer forms from working with us from the initial contact with a sales representative all the way through to maintaining the equipment in the field – it's everything. With this launch, we're re-focusing our efforts to ensure the customer has an overall enjoyable experience with our entire company, not just the products.

How did you identify the need for the Leica Captivate Experience?

Dixon: For a long time in the geomatics industry, we have solely focused on just solving the problems of the customer. With the Leica Captivate Experience, we wanted to do more. Our goal is to deliver maximum customer satisfaction while meeting the need for accurate and precise measurements. We live in the mobile, digital era where our lives are completely integrated with technology. Wherever you look today, smartphones and tablets with easy-to-use apps are in constant use. Our customers use these devices in their personal lives, and now they expect this technology to be available when it comes to their professional instruments. With this in mind, we know the time is right for the Leica Captivate Experience. ■

David Dixon is a business director within the Leica Geosystems Geomatics Division where he oversees the product management of the total station portfolio. He has been with the company since 2001 and holds a Bachelor of Applied Science (Surveying) from RMIT and a MBA from ESSEC and University of Mannheim.

Alastair Green is a business director within the Leica Geosystems Geomatics Division where he oversees the product management of field software and field controllers. He has been with the company since 1997 and holds a Master of Geodesy and Engineering Surveying from the University of Nottingham.

Surveying and inspecting safely from the air

by Friederike Nielsen and Robert Lautenschlager

UAVs – Unmanned Aerial Vehicles – are now employed in many areas of surveying. This is not restricted to land surveys, but also includes open-cast mines, landfill sites and roads or buildings. In addition, these versatile little aircraft open up entirely new possibilities for the more efficient management of major construction sites. Before building work has even started, they can deliver a fast, low-cost aerial overview of local conditions and generate accurate and meaningful data for calculation and quotation purposes. Once building work has started, aerial photographs taken by UAVs provide regular documentary records of interim steps. Besides making it much easier to monitor construction progress, it also facilitates the control of internal processes. Once construction work has been completed, it is no problem for a UAV to carry out an inspection of the building and provide evidence that the work has been carried out as agreed and expedite final acceptance.

The Swiss power company Axpo is using the UAV Aibot X6 to survey and document the major construction project "Linthal 2015" in the Glarus Alps region. In an initial step, the entire Linthal valley was surveyed from the air and a point cloud with an accuracy of up to one centimetre (0.4 inch) was generated. This data will now form the basis for planning subsequent steps of the construction process.

The Swiss power company Axpo is building a new, underground pumped storage plant – the largest in the country – in the Canton of Glarus. In future, the plant will guarantee the future electricity supply to northeastern and central Switzerland. The plan is for the plant to pump water from Lake Limmernsee back up to Lake Muttsee – an altitude difference of

630 metres (2,070 feet) – where it can be used again to generate electricity when required. This large-scale project, which involves investment costs of around 1.85 billion USD (1.7 billion EUR) and is expected to take the best part of five years to complete, will employ up to 500 people at various construction sites. The plant should start to deliver electricity at the beginning of 2016.

Fast, flexible data collection

Hundreds of thousands of cubic metres of soil and rock will have to be removed to build the tunnels and caverns for the pumped storage plant. Most of this spoil will be transported to the Muttenalp mountain by cable car and used to build the dam, which will be more than a kilometre long and rise to a maximum height of 36 metres (118 feet). The rest of the material will be deposited in front of the existing Limmern dam. In October 2014, Axpo used the Aibot X6 for the first time to survey this area, which is known as the Limmerntobel Inert Matter Disposal Site. Because the surrounding mountains blocked satellite signal reception, the aircraft was flown manually without GPS navigation. Photographs of the terrain were taken at a vertical angle during the flight to create high-resolution images of the disposal site with a 60% to 90% overlap. Before the flight, 14 ground control points were plotted evenly in a distance of approximately 50 to 80 meters (160 to 260 feet) in seven corners of the surveyed area for subsequent geo-referencing of the images. "This was the first time the Aibot X6 had been deployed at an altitude of 2,000 metres (6,562 feet), but the rarefied atmosphere had no adverse effects on its flight characteristics," explains pilot Robert Lautenschlager.

The 50,000 square metres (12.5 acres) of land was surveyed in two flights lasting ten minutes each. Agisoft photogrammetry software was used to process the data collected and a precise point cloud with an accuracy of up to one centimetre (0.4 inch) was generated. The whole evaluation processed lasted about 120 minutes. The point cloud was then integrated in the local coordinate system of the construction site, enabling Axpo's surveyors to calculate the volume of the deposited material.

Periodic photographic records of the disposal site had previously been created using an external filming system suspended from a helicopter. Not only can high-precision geographical data be recorded within a short space of time using the Aibot X6, but it is also possible to create complete and seamless documentation of the current status of construction work. At any given moment, the UAV can give contractors an immediate overview of how building work is progressing, thus helping them to plan and control processes better.

Combination of surveying and inspection

The use of UAVs means that surveying and inspecting tasks can now be combined more and more frequently. The Axpo example is a perfect illustration of this: in future, the company intends to use the Aibot X6 not only for the creation of digital models of terrain for planning and building power plants, but also for vital inspection tasks. It will be possible to fly over existing dams and take photographs that will allow the condition of the concrete surfaces on the airside and waterside of the dam to be assessed in detail. In this case, the hexacopter will again be fitted with a digital camera and flown to locations where it will take high-resolution pictures of all critical areas, thus enabling even the smallest cracks and other anomalies to be detected.

The Aibot X6 can also be used to inspect electricity pylons. The hexacopter offers a number of advantages here, such as flexibility of deployment and availability at short notice in the event of a malfunction or defect. As the inspection is performed by a remote-control, unmanned aircraft, it is also safer and much cheaper than an inspection by helicopter or steeplejack, since it is not even necessary to switch off the current beforehand. In future, Axpo will also rely on unmanned airborne help in the environmental sector, where UAVs will be used to take pictures of mountain streams as part of residual water experiments.

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Generated point cloud of the area with an accuracy of up to one centimetre (0.4 inch).

Protecting cornerstones of our existence

by Robert Meier and Hildegard Holenstein

Swiss have a long tradition of fostering and preserving the country's biodiversity and understand it is the cornerstone of our existence on Earth. The Swiss agriculture policy supports biotopes, or biological communities, and has proactively set agreements to protect and manage biotopes such as raised bogs, fenlands and dry grasslands, and land owners who carry out these set agreements receive compensation. New agricultural policy, taking effect from 2014 to 2017, has made direct payments to land owners managing biotopes possible. In order to assess the possible landscape quality effects of these supported biotopes, the Canton of Glarus's Department Construction and Environment commissioned ARNAL, Büro für Natur und Landschaft AG, to conduct a study covering all areas in need of protection in Canton Glarus.

Robert Meier, CEO at ARNAL and project manager of this study, spent two weeks in the summer of 2014 with his intern Elias in the Glarus Alps. During this time, they measured land areas and collected other relevant information concerning the biotopes, and also finalised agreements with the local land managers. A Leica CS25 GNSS tablet PC was brought along to digitally collect data from the surface areas that needed to submit assessments.

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About ARNAL

The ARNAL company, with its five employees, is involved in numerous projects fostering harmony between humans and nature, and their shared landscapes, and have been offering solutions for a variety of complex and challenging issues for more than 15 years.

From their headquarters in Herisau, the company manages projects in the greater eastern Switzerland area and throughout the rest of the country. Large nature and landscape projects in the state of Salzburg are also managed from the branch location in Salzburg, Austria. *(www.arnal.ch)*

Location

- Around 20 mountains in the Glarus Canton
- Field hikes up to an altitude of 2,000 metres (6,562 feet) above sea level

Hardware and software

- Leica CS25 GNSS with Helix antenna
- Leica Zeno Field
- QGIS office software

Benefits

- Easy, faster and more precise data acquisition
- Leica Zeno data can be transferred directly into the QGIS software
- More efficient workflow, as several steps are no longer necessary
- Easier orientation in the field

As a company with extensive environmental experience that works closely with its customers, ARNAL has always supported the envirnoment, taking the landscape needs into consideration first. In the summer of 2014, ARNAL were commissioned to make new land management agreements and update existing ones in order to protect the fragile biotopes found in the Glarus Alps. For this purpose, land area sizes needed to be assessed and agreements negotiated with the land managers locally.

Checking and expanding biotopes

During this project, intern Elias gained first-hand experience of what it meant to be an ecologist. While on their field hikes, Robert Meier explained to Elias the riches and diversity to be found in each of the biotopes and demonstrated to Elias how to use the Leica Zeno GIS tablet. In just a short period of time, Elias was familiar with the device and ready to start collecting data.

Under the supervision of Robert Meier, Elias was able to verify existing biotope sizes on location by using the tablet's integrated GPS and the Leica Zeno field application. Any area sizes which needed to be changed were carried out directly in the field using precise positional data. As Robert Meier explained, "Using the Leica Zeno Field, we were able not only to record and correct geometric surfaces but we could also enter valuable information on managing the corresponding areas for later assessment directly in the field."

Back at the office, the data was imported directly into the QGIS GIS system, a free and open source program for creating, analysing and publishing geospatial information. Thanks to the work carried out with the Leica Zeno Field, it was no longer necessary to manually draw the areas in a field map and digitise them later in the office.

Ideal orientation in the field – even with poor weather conditions

It's well known that weather can change very quickly in the mountains, and the summer of 2014 was no exception. This made having an orientation aid all the more helpful in misty conditions with poor visibility. "We used to use paper maps for this, which had to be

Intern Elias collecting data of the biotopes in the Glarus Alps in Switzerland.

protected from the rain. Thanks to the water-proof Leica CS25 tablet, we can leave the umbrella behind and pinpoint our exact position in the area through localisation. It's also possible to 'pilot' the navigation function to the desired location," said Meier.

Making invisible boundary lines visible

The Leica CS25 tablet offered the team other advantages as well, such as the ability to display boundary lines, which often can't be seen or found. "Property boundary lines, for example, play a crucial role when it comes to direct payments. Using the Leica CS25, we were able to show land managers the boundary lines in the field. Land usage boundaries, such as the boundaries of forests, also play a role regarding payments. We could show these boundaries to them on the tablet as well, and made use of them as a basis for discussion," explained Meier.

"Our experiences with the Leica CS25 GNSS in this project were very positive, as some work steps could be consolidated and others, such as sketching, weren't needed at all. The data was recorded quickly and precisely with the GPS, meaning that we could reduce the amount of time spent on location by a considerable degree," concluded Robert Meier.

Believe it or not, this can have its downsides, too. Intern Elias would have gladly spent more time in the Glarus Alps: "I had a lot of fun out there. We were outside every day, and when the day was done, we knew that we had done something positive for the environment."

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Easing the ravages of time

by Rikard Evertsson and Mattias Bornholm

In the 17th century, vessels were not built from plans or drawings but from "rule of thumb", based on a shipwright's instincts and his sea experience. The builder of the warship Vasa poorly estimated its proportions. The underwater section of the vessel was far too small for the visible part above the waterline, making the ship completely unstable. On the day of its maiden voyage in 1628, the Vasa was loaded to full capacity. 64 bronze cannons were proudly displayed with all gun port windows open. As the Vasa left the harbour and its sails filled with wind, the boat rolled dangerously to one side and was swiftly filled with water coming in from all the open gun port windows.

Although the ship sat in less than 40 metres (131 feet) of water, it remained to a large degree unscathed in Stockholm's sheltered harbour until 1961. Now 333 years after sinking, the Vasa is an almost untouched piece of 17th century Swedish history that has returned to the surface.

Before being moved to the museum where it now rests, the Vasa was stored in a harbour shipyard with little protection to elements. It was coated with PEG, a chemical compound that replaced the water in the wood, and helped to prevent shrinkage and cracking of the 300 year old timber. The first visible signs of change were seen in the 1990's when white spots appeared on the surface of the wood caused by sulphur and iron used to build the ship.

These visible signs ultimately led researchers to focus on changes taking place below the surface and the first monitoring of the ship began in 2000. At that time, it was decided the best device to monitor the vessel was the Leica TDA5005. The data collected proved that even with PEG treatments, the structure of the ship was seriously altered by gravity. The 300 year old wooden structure of the ship had already lost over 40% (in certain parts, even up to 80%) of its mechanical strength. It was absolutely necessary to collect precise data in order to decide how to stop deformation and best conserve this historic vessel.

The correct support for the structure

Today the Vasa sits on standard storage blocks in a museum that was specifically built for the ship. These common storage blocks date back to the 1960's and do not provide proper support for the boat. Research shows a new storage system desperately needs to be built in order to properly support this fragile historic ship. However, in order for carpenters to build the correct support structure, huge amounts of accurate data need to be collected and analysed to determine exactly how the wood and the ship's structure have chemically and mechanically changed over the course of time. A Leica Nova TS50 using Leica SmartWorx Viva software was chosen to collect the data to make a prototype, which can be designed, tested and put to use.

Monitoring

Monitoring the Vasa takes place twice a year. Each surveying epoch takes roughly ten working days to accomplish, depending on the how many visitors are at the museum. Measurements are made by museum staff and the Department of Geodesy and Satellite Positioning at Kungliga Tekniska Högskolan.

In order to collect data from the Vasa with absolute precision, no less than twenty-nine prism points are attached to the museum's static walls. These serve as reference points to get the exact position of the Leica Nova TS50. Once these are calculated, the operator measures thirty-three prisms that have been attached to the inside of the ship's pliable hull and about 330 customised reflector tapes on the outside of the Vasa to collect information regarding deformation of the ship's structure. To ensure that data collection has been carried out correctly, a second measuring procedure is carried out from different setup position. This process is done over several years, again and again, in order to determine just how fast the deformation is occurring.

After each epoch, the data is processed and compared to earlier monitoring epochs done on the ship. The results prove that the ship has been tilted and pulled down by gravity over the course of time.

As a result of the last 15 years of monitoring, a new support system for Vasa will be developed. Over six million Swedish Krona (690,000 USD / 650,000 EUR) has been appropriated for research use and will include a study of how the quality of the wood and the structure of the ship have changed over the course of time. Research will last until 2016, after which a basis for designing a new working structure will be in place and the actual construction of the ship's storage block can begin.

Aside from helping with the design of a new supporting storage block for Vasa, the measurement data collected using the Leica Nova TS50 will certainly help determine the extend and speed of the ravages of time on the Swedish vessel and will enable researchers to better predict future changes in the wood, which is of great importance to the future of the Vasa. ■

About the authors:
Rikard Evertsson has worked for Leica Geosystems in Sales since September 2007 and Mattias Bornholm since September 2010. They are now responsible for sales in the Stockholm region. Before working in sales, Evertsson worked as a surveyor starting in 1995 and Bornholm in 1994.
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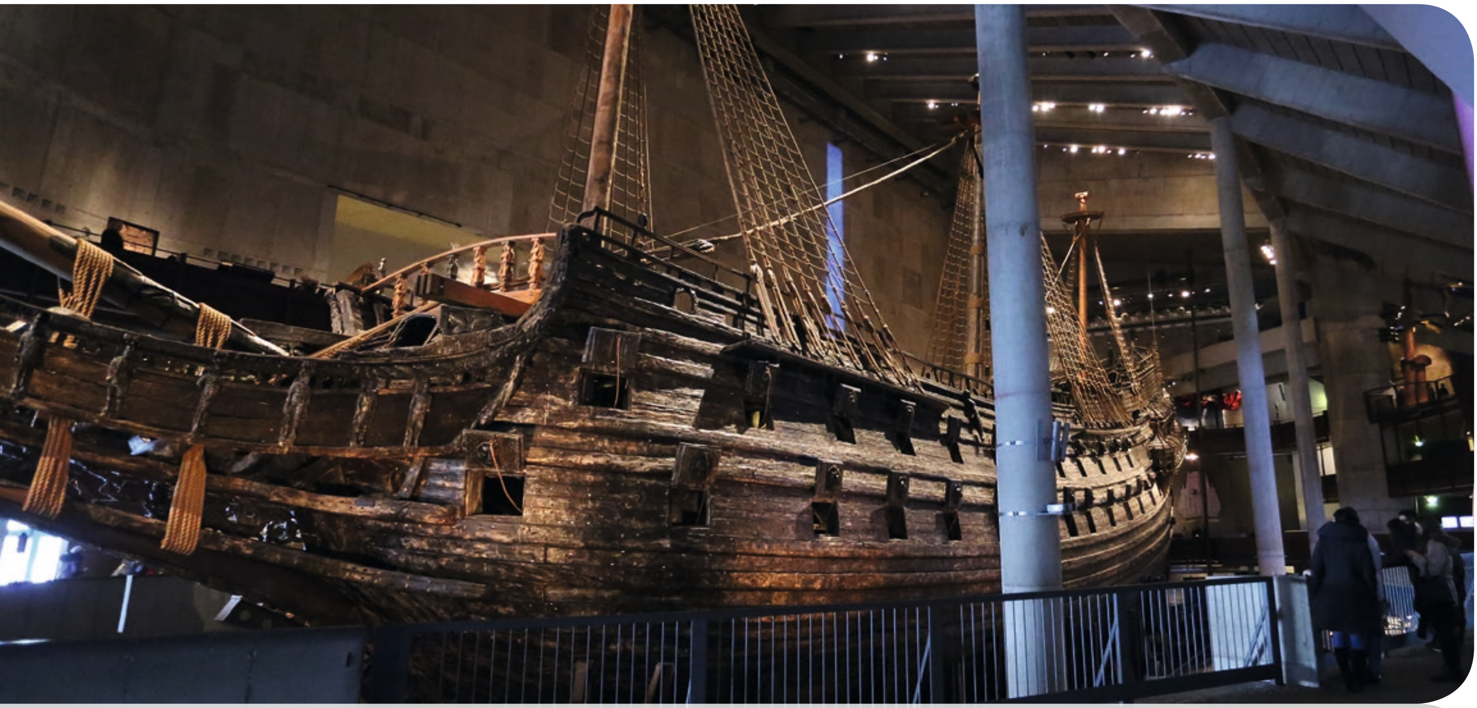

■ **A perfect support structure for the historic Vasa ship is needed to avoid further tilting.**

Efficiently managing irrigation networks

by Nabil Abdelkader

Water is becoming a scarce resource and it is of growing importance to efficiently use it in agriculture, particularly in arid climates, where recent droughts have brought an urgency to develop techniques for monitoring water irrigation and crop productivity. Increasing irrigation potential in the command areas requires considerable efforts, both in terms of time and money. Advances in remote sensing and GIS have offered water resource researchers and managers a new and fresh way for obtaining accurate spatial data on actual water use, water demand, allocation and distribution of water, and crop yield. For these tasks, the Leica Geosystems Zeno 10 GNSS/GIS handheld device with Zeno Office software provides the ideal solution. It is easy-to-use for non-GIS professionals, customisable and upgradable, allowing enhanced performance and increased profitability in the field of asset collection & management. By simplifying data integration from field to office, rich geospatial data of assets is easily captured and managed with one simple workflow.

El Concorde Construction is an organisation specialising in the design, engineering, management and construction of projects. The company has been contracted to define an integrated meticulous strategic plan for developing and managing water resources throughout Iraq in order to ensure sustainable management and development of the country's water and land resources. Long-term project phases are seen for the future in 2015, 2020, 2025, and 2035.

This project, which has been developed for several areas, in particular for the locations along the Tigris and Euphrates Rivers and their main water courses, for a total area of 12,000 square kilometres (4,630 square miles).

Project planning and requirements

All the survey features for the irrigation system and also their locations, need to be incorporated into an improved database to facilitate their planning. Every asset needs to be surveyed, feature by feature. Due to the nature of the data and the required accuracy, as well as the difficulty to access certain locations, it was decided that a physical survey would prove more cost effective than a vehicle-based one.

Collecting data with Leica Zeno 10

For such a large survey area, with high volumes of data and with work taking place regardless of weather, the right choice of the right survey equipment was essential. El Concorde selected the Leica Zeno 10 GNSS/GIS handheld using Leica Zeno Field software due to its compatibility with the existing Esri based GIS, its excellent mobility and its screen performance. In addition, the Leica Zeno GIS solution offers reliable technical support and this is essential when adopting new equipment into a business or project. A key element of ensuring rich asset detail was captured at the point of survey, making sure all data could be captured in a single visit. The integrated camera on the Zeno 10, which helped to document features with images, was invaluable for internal quality processes and assessments, and enabled the staff in the office to easily understand documentation, making it easier for them to work together and ensure the right data was captured at the time. This way, revisits were eliminated, thus minimising costs and delivering datasets without delay.

A simple workflow chain

The Leica Zeno GIS solution ensures efficient workflows by reducing trips from the field to the office

■ **Increasing crop yields on dry land: aerial map of the irrigation network.**

because it offers the ability to monitor data captured in the field, enabling direct integration in the office.

The data of the irrigation network that was captured with the Zeno 10 can easily be imported with just one click using the 'EasyIn' workflow from Zeno Office. The latest data is transferred directly to Esri ArcMap. This automated process is very easy to maintain and manage and ArcMap generates the final map that contains QC and processed data.

For further map updates that require new survey operations for the irrigation network, El Concorde Construction export features from ArcMap to Zeno Field using the equally simple 'EasyOut' wizard. Once the surveyors go out, they take the updated data set into the field.

Mohammed Al-Eswid, Project and Geomatics Engineer at El Concorde Construction states, "Leica Zeno could be easily carried to survey sites. Users can collect information by simply taking a picture with the handheld and entering the data which has been measured on-site and updated by Esri ArcGIS. The best thing is, you don't need to go back to the office for days."

Efficient workflow

A single spatial database for each project was designed and Leica Zeno Office software was used to create and manage a database containing all mandatory attribute fields requested, as well as other information, such as site photographs. It also contains drop down lists to improve data quality and speed of collection. The entire projects were surveyed by a specialist team of surveyors who collected 40,000 features.

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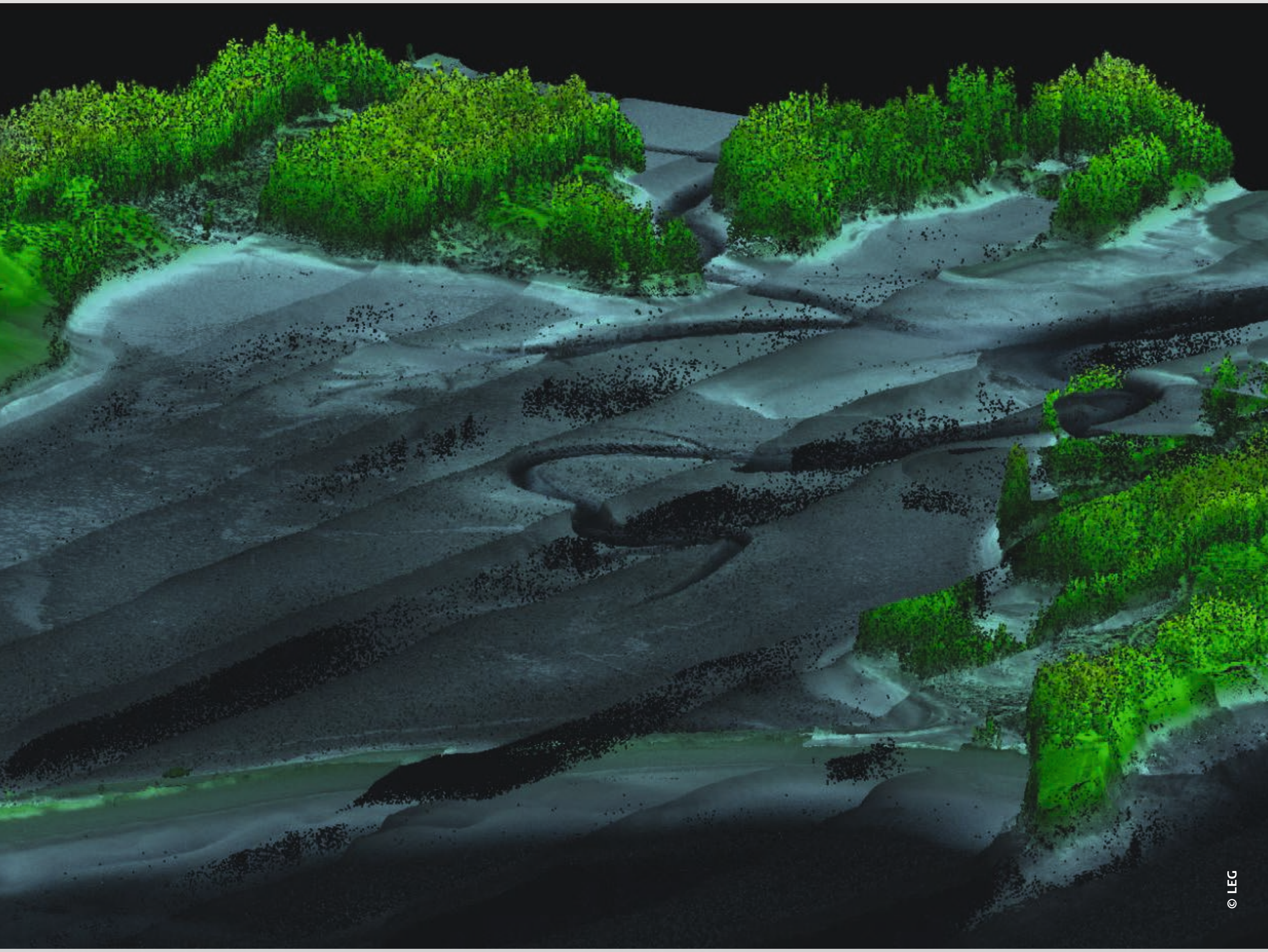
The Leica Zeno 10 was used to collect information needed to manage the irrigation network.

Exploring the surface below water

by Wayne Richardson

In September 2014, Leading Edge Geomatics (LEG) working together with staff from the Nova Scotia Community College (NSCC) and the Applied Geomatics Research Group (AGRG), installed the Airborne Hydrography AB (AHAB) Chiroptera II system, used for near shore environmental monitoring, into the Beechcraft King Air 90C aircraft. This was needed to perform the team's first ever point clouds using a topobathymetric system. A leading topographic LIDAR and aerial photo collection company with projects throughout North America, LEG decided to put its extensive operational and data processing expertise into using this new LIDAR scanning system, anticipating new markets and research in shallow water environments. It is hoped that this new sensor will lead the way in this area.

Anyone who has ever attempted to fly aerial surveys in the Atlantic Region of Canada will realise that it is extremely rare to find two consecutive days of cloud-free conditions. Even given the low altitudes that the system is meant to acquire data at 400 metres (1,300 feet), we were not expecting to move this initial project along as quickly as we did. Fortunately, the initial flights were launched during an unusual back-to-back series of sunny, clear days, with some of the best flying weather any of us could remember. With the exception of a few areas that had to be recollected due to muddy sediment in water columns, we were able to collect all of our priority projects in less than one week. Because the Leica Chiroptera II system is so user-friendly and easy-to-learn, the team was able to run several operators through training while capturing the data, and all of them reported an intuitive, easy-to-operate interface. The system allows operators to analyse wave-



forms sampled during flight collections to determine if the submerged ground was being recorded. This enables operators to quickly make decisions that save not only precious flight time and expenses but also guarantees the success of many flight missions.

This processing software provided by AHAB, known as LIDAR Survey Studio (LSS), enables viewing scanning results while still in the aircraft. Having used several other competitions' LIDAR data processing applications, the team found LSS capable of easily configuring, processing, and outputing the final data. The software combines the flight path, processed with any SPAN (Sychronised Postion Attitude Navigation) with the raw waveform, and presents it in an intuitive and well laid-out interface. Processing parameters are set via configuration files for system settings, processing settings (classification method), and calibration (sensor misalignment). The results of the software processing provide positioned and fully classified data. The user then examines the processed data of the bottom hits in relation to the water surface to determine if the classification was successful. If some modifications are required, changes are made and the data is run through the software again until the classification represents the data properly. Producing calibrated, correctly positioned and classified datasets is a very straight forward process.

The full 3D view displays the points quickly and smoothly, allowing the user to examine the processed results easily and work on the data to represent it as needed. The tools for display provide countless ways to represent the results. Selecting an individual return, or point from the data, displays the corresponding waveform data and image. These views aid in determining the accuracy of the data classification. The only limitation is the lack of manual classification tools. It would be useful to be able to change the classification of points based on the wealth of data contained in the full waveform and the rapidly available QC images (images that analyse the quality of the data). In practice, this may make it easier to understand if a return is in fact a bottom hit or submerged vegetation, instead of doing the classification clean-up in a third party application without access to the waveform information.

The Chiroptera II is a well-built, solid solution for shallow water collection. Our team was able to achieve excellent penetration results, but as expected, the system is heavily dependent on good water clarity. Areas such as the St John River would immediately block return data when another stream of water enters the river. This is not unexpected and murky water will remain an obstacle to this system. However, in areas where the water clarity is acceptable, the system performs superbly. The inlets on the New Brunswick Northumberland shore yielded excellent results with almost all of the sea bottom mapped.

The Sable Island data showed surprising clarity at depth penetration to 15 metres (49 feet). The topographic scanner (sold separately as the Leica AHAB DragonEye) was tested on Sable Island in isolation from the bathymetric scanner. This scanner performed well at 1,400 metres (4,600 feet) and provided ground sampling at better than one point per metre. The multiple look angle of the system ensures minimal LIDAR shadows in the data, which could possibly eliminate the need for multiple passes. Overall, the Chiroptera II is an extremely capable, flexible and well-designed Topo-Bathymetric system. ■

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The Leica Chiroptera II

The state-of-the-art Leica Chiroptera II system combines a 500 KHz topographic scanner and a 35 KHz hydrographic scanner with a 60 MP Leica RCD30 photogrammetric camera. The purpose of this system is to collect the littoral, or water shore, boundry and shallow water, where it is difficult and expensive to capture with traditional side scan or multi-beam systems, due to the navigation difficulties in shallow waters and harbours. This system also has the potential to provide a wealth of data for inland waterways, where currently only physical measurements of the bottom of lakes and rivers are possible. The Chiroptera II is designed to penetrate to depths of up to 1.5 x Secchi depth. Depending on water clarity, it should be reasonable to expect that this system can penetrate to 15 metres (49 feet).

Safely renovating ship locks

by Heiner Gillessen and Uwe Sowa

The Kiel Canal is the most travelled artificial waterway in the world. In 2014, an average of 89 ships per day passed through the canal. It is almost 100 kilometres (62 miles) long, from Brunsbüttel to Kiel-Holtenau, and links the North Sea to the Baltic, enabling ships to save a distance of some 250 nautical miles (or roughly 450 kilometres) to bypass the northernmost tip of Denmark at Skagen. Though nautical strategic factors may have been crucial at the time of its construction, the canal is currently used exclusively for the exchange of goods between countries in the Baltic region and the rest of the world. The Kiel Canal opened after eight years of construction on 21st June, 1895 and after an additional eight years, it was necessary to widen the canal due to the amount of traffic passing through. Each end of the Kiel Canal is closed off from the fluctuating water levels of the Elbe River and Baltic Sea by four locks: one double lock from 1895 (the small locks) and those built in 1914 (the large locks).

During a regular structural inspection, water from the 220 metre (722 feet) long by 10 metre (33 feet) deep south chamber from one of the small locks was pumped out in March 2013, with the chamber remaining dry for two and a half months. Since the water in the north chamber presses against the lock wall of the south chamber, the south chamber was monitored geodetically for safety reasons using a Leica TCRP 1201 total station and other sensors. The data collected from this monitoring provided information on the behaviour of the structure and protected inspectors and workers during the renovation.

■ **A Leica Geosystems total station takes measurements to observe possible movements of the chamber wall.**

Surveying required a measuring program to be prepared in advance for specifying the type and scope of the required measurements. Based on this program, the small locks of Kiel-Holtenau were set up to monitor the south chamber during the pumping out period and the dry phase. An immediate response to any emergencies which might have arisen was made possible by the ability to send out information on the change in the structural behaviour at any time during renovation work.

Monitoring with a total station

The Leica TCRP1201 total station, connected to the Leica GeoMoS monitoring software for data collecting and processing, was installed on top of the lock's control station, located on the partition wall of the two lock chambers. Since the location of the sensor was in an area subject to possible movement, the monitoring method known as free stationing was undertaken. This meant measuring six different stabilised reference points attached to surrounding buildings in the area that were not subject to movement in order for the hourly program-controlled data measurements to be possible. The measurement points on the lock were then determined in 3D. In this way, the ten measuring points from which the chamber width can be derived, served as "virtual sensors". These hourly measurements of the north and south sides of the chamber walls, as well as the control of the fjord and chamber water levels, was carried out using the highly customisable Leica GeoMoS family software programs. In addition, the coordinates of the six head-base points, the three chamber-base points and the two points on the inspection covers were also recorded. The values of each of the six groundwater measuring points on the north side and the south side, as well as the level of the fjord and chamber water level, were recorded hourly and transferred to the GeoMoS software.

Integrating geotechnical sensors into the Leica GeoMoS portfolio

A crack on the chamber wall of the southern side corridor was monitored using tilt sensors and fissurometers, and these also sent data to the Leica GeoMoS program. Any changes in the length and cross directions were displayed and analysed in easy-to-understand graphics by Leica GeoMoS Analyzer. The

■ **Ready for safe renovation: The empty ship lock gets inspected while the structure is being monitoring.**

standard deviation tolerance of the points measure was ± 2.2 milimetres (± 0.09 inches) and controlled by Leica GeoMoS Monitor.

"A special challenge was to integrate the geotechnical sensors into the monitoring system, which ended up working flawlessly. Even under extreme weather conditions like snow, freezing rain and storms, the system worked perfectly. This ensured a high degree of reliability regarding the information on the structural behaviour during the dry period," explained Heiner Gillessen, Technical Product Manager for monitoring at Leica Geosystems.

Dipl. Ing. Uwe Sowa of the Kiel-Holtenau Water and Shipping Authority assessed the movements which occurred during the renovation and the results after successful usage: "Each sensor has its own recorded data limit levels specified in the processing software that resemble the colours of a traffic light. Should a value exceed the defined tolerance it would appear in the red range, resulting in immediate notification via text message and email and ensuring that safety measures could be implemented. Except for a few exceptions in the yellow range requiring more in-depth analysis, all of the target values were always in the green range."

Meanwhile the lock has since been flooded, and the north chamber pumped out, renovated and monitored also using the same procedure. The level and movement behaviours of the locks will still be checked using digital tilt sensors and position sensors, and the data from these sensors sent to and evaluated by the GeoMoS software programs. ■

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Second to none

by Katherine Lehmuller and Marco Mozzon

K2, the second tallest mountain on Earth after Mount Everest, is in many aspects, second to none. It is without a doubt the most dangerous and difficult mountain to climb of the fourteen peaks reaching over 8,000 metres (26,250 feet). Consistently steep with exposed sides dropping sharply off in all directions, the K2 closely resembles a dangerously jagged pyramid and is prone to frequent and severe storms of merciless duration. The Italian Duke of Abruzzi was the first mountaineer to unsuccessfully attempt climbing K2's southeast ridge route, and from this time forward, the route was known as the Abruzzi Spur. How very appropriate then that the first to successfully reach the top of K2 in 1954 was an Italian team led by Ardito Desio and succeeded by climbing the Abruzzi Spur. This devoted explorer, geologist and climber inspired many generations of Italian mountaineers and founded the non-profit Italian association EvK2CNR, known widely today for promoting scientific and technological research in mountain areas.

"K2, 60 Years Later", named in honour of the first successful ascent of the K2 and for the strong mountaineer history between Italians and Pakistanis, set out to measure the K2 sixty years after Desio's team reached the top. Supported by the Pakistani Gilgit-Baltistan regional government and EvK2CNR, the Pakasti-Italian team decided that working in such an extreme environment meant that only a device designed and proven to exceed the most rugged industrial standards could be chosen. The team decided on using Leica Geosystems instruments.

Leica Geosystems offered the expedition the use of their latest GPS receiver, the Leica Viva GS14, made for the most demanding environments. This was an opportunity for Leica Geosystems to further prove the endurance of the Leica Viva GS14 in extreme temperatures and weather conditions and also to test the device's compact and lightweight portability. Three Italians from the EvK2CNR association, the world renown climber, Marcello Alborghetti, Maurizio Gallo, responsible for the project's technical matters and Giorgio Poretti, responsible for the expedition's scientific support and coordination, were first presented with the Leica Geosystems antennae and GX1230+ receiver in Italy before bringing it to Pakistan. Giorgio Poretti, professor at the University of Trieste, organised the part of the expedition dealing with GNSS measurements, directed the progress of the Leica Viva GS14, together with Pakistani researchers Aamir Asghar from University of Azad Jammu and Kashmir and Hameed Fahad from the University of Poonch (Rawalkot).

Carrying the receiver up the mountain and performing measurements at each of the five different K2 campsites and on the K2 summit, was accomplished by Pakistan's Rehmat Ullah Baigh and Italy's Michele Cucchi, who would set up the receiver at each stop, allowing it to remain for approximately 20 minutes to collect the latitude, longitude and altitude of each point from the available satellites.

One Leica GX1230+ reference receivers were permanently positioned by Maurizio Gallo at the Gilkey Puchot Memorial, a kind of shrine dedicated to climbers who died on K2, located close to the K2 Base Camp, and a second GX1230+ in Skardu, a final destination city for climbers to stop at before heading up the mountains. Here computer informatics expert, Fida Hassain from Central Karakorum National Park, helped install and process the transmitted data along with colleagues Asghar and Poretti. This coordinated network of two permanent GNSS stations allowed data from the summit to be processed with excellent precision and is still in operation today.

After returning the instruments to Italy and Leica Geosystems, the data was downloaded from the receivers and analysed. The results showed that after using GNSS technology, the height of the K2 was reduced from its previous altitude of 8,610.34 metre (28,248.03 feet) to 8,609.02 metre (28,244.75 feet), making the K2 1.5 metres (3,3 feet) shorter than previously believed.

Yet the biggest surprise was at K2's Camp Four on the Abruzzi Spur, where expeditions on this route begin their final ascent to the summit. Previous measurements stated that the route began at 7,900 metre (25,920 feet). Now data collected by the Leica GS14 proves that the route starts at 7,747.029 metre (25,416.667 feet), making the climb 150 metre (492 feet) longer than previously recorded. This is a huge and challenging difference for climbers of the K2, who at this point are struggling for weeks with the weakening effects of altitude sickness and the stress of staying focused.

The team has plans to climb Mount Everest in the near future, where a Leica Geosystems reference station is located, very close to the EVK2CNR's Pyramid International Laboratory at the Nepali side of Mount Evert and hope for another successful and challenging collaboration between EvK2CNR and Leica Geosystems. ■

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K2, 60 Years Later

The Italians have a long climbing history together with Pakistan, especially between the Italian EvK2CNR association and the regional Pakistani government of Gilgit-Baltistan. Dating back sixty years, the two have enjoyed worked together many times, most importantly on three historic expeditions: for the first successful ascent of the K2 led by Ardito Desio in 1954; fifty years later in 2004, to measure the K2 (a expedition's efforts to bring the GNSS receiver to the top failed when a climber fell) and finally, sixty years later, in 2014 with the expedition "K2, 60 Years Later", collected the most accurate measurements ever made of the K2 by using GNSS technology.

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