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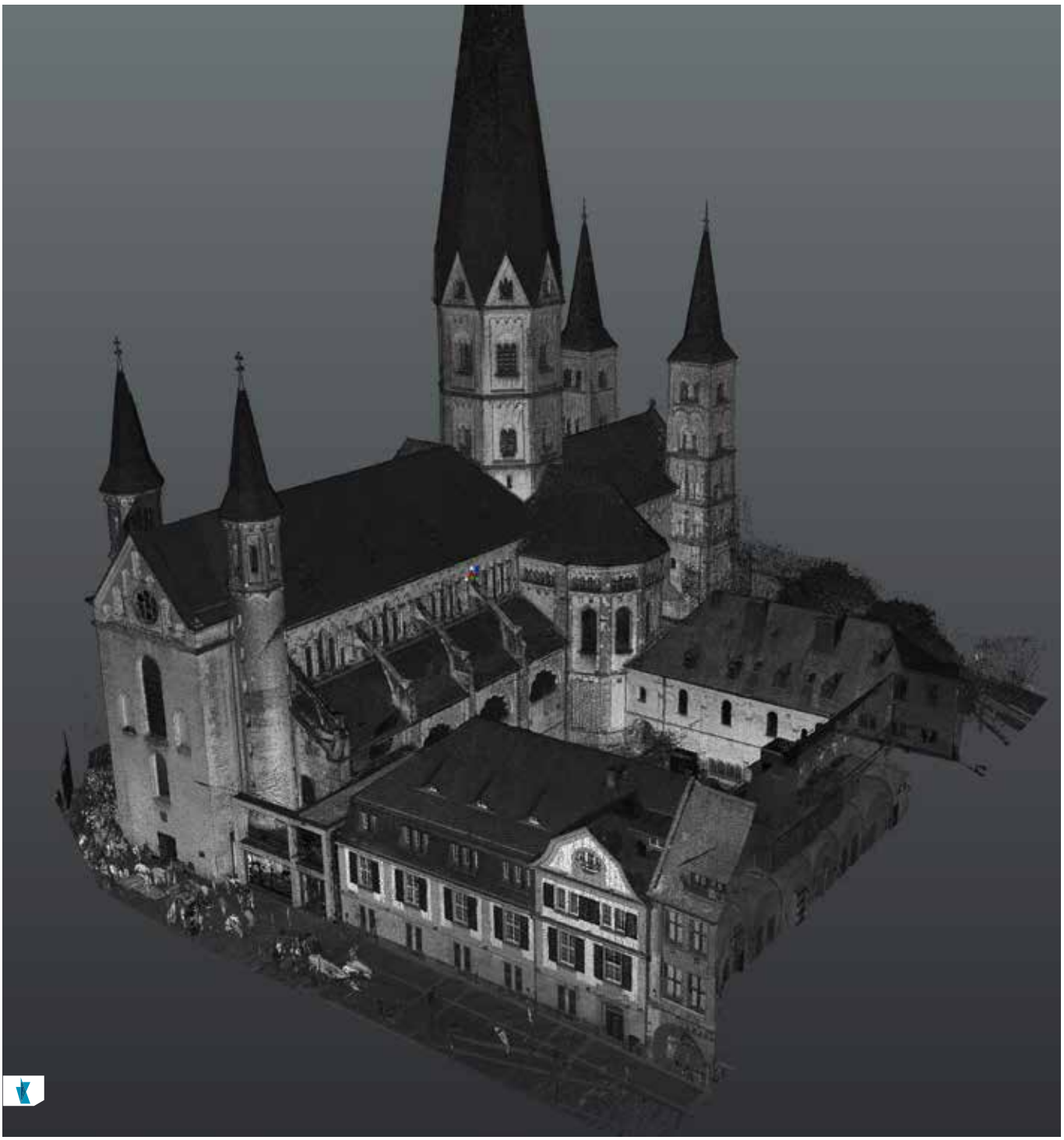

HEXAGON GEOSYSTEMS | Leica Geosystems

CONTENTS

22
Measuring the height of Earth from space

31
Game on with laser scanning


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39
Measuring for the gold

A Message from the President

At Hexagon Geosystems, we focus on creating digital realities so professionals can work within current and accurate environments to produce the best possible results. What is a digital reality? When Russian technicians are trained to face dangerous events, like fires caused by faulty electrical connections, in a video game made with the aid of laser scanning technology, he learns critical safety measures in a digital reality so he can apply them in the real world. When Swiss researchers capture precise imagery of snow properties from airborne sensors, they operate in a digital reality to discover new methods to improve avalanche warnings.

A digital reality must mirror the real world so results can be precisely imported back to improve the current situation. To build better rail tracks and keep workers safe, Dutch surveyors provided the reality capture of rail yards with the help of our mobile mapping solutions. Contractors on a new expressway project in New Zealand needed to have a clear understanding of the dimensions of the land so they could lay a smooth path, so they turned to our MS60 MultiStation and machine control guidance.

Digital realities not only recreate today's reality, but they also show us what can be. Space exploration from the United States with our new LiDAR technologies is helping scientists to comprehend global ice melt and better protect the Earth. Miners in Ghana now see where weak points are in the walls of a mine with our monitoring solutions, preventing catastrophic accidents. From above the earth to below the surface, digital realities are critical for safety and effective planning for the future.

Digital realities ensure we are shaping smart change in an rapidly evolving world. I'm proud our solutions are a part of this change. Enjoy your read.

Juergen Dold
President, Hexagon Geosystems

Written by Katherine Lehmuller

SAFELY AHEAD OF THE GAME WITH CUTTING EDGE TECHNOLOGY

The Waikato Expressway is a significant new four-lane highway being built on the North Island of New Zealand. When completed, it will be a vital strategic connection for the Waikato region, linking the busy urban centre of Auckland to the rapidly growing Bay of Plenty region. This has been designated by New Zealand as one of the seven Roads of National Significance (RoNS), a programme that invests in the future growth and safety of New Zealand. When finished, the four-lane expressway will not only improve travel time and contribute to the region's economic growth, more importantly, the thoroughfare will improve the safety of driving, significantly reducing serious accidents, traffic congestion and noise.

OVERCOMING CONSTRUCTION OBSTACLES WHILE LOOKING AFTER MOTHER NATURE

The Waikato Expressway has been split into seven different sections of construction and is being built by various contractors. All sections will be completed by early 2020. New Zealand's Transport Agency chose the Fulton Hogan HEB alliance to construct the 15.2 kilometre stretch, known as the Huntley section, and the two companies have already successfully worked together on other large construction projects, such as the recently opened Tauranga Eastern Link in the Bay of Plenty region.

The estimated NZ $458 million construction of the Huntly section, which commenced in October 2015, will entail building nine bridges, of which four will transport traffic over local roads, four over existing streams and one over a railway line.

There are 36 major culverts, or underground tunnels, ranging in length from 13 to 130 metres. These allow rivers with fish and other aquatic life to pass through. The Fulton Hogan HEB alliance takes special care to preserve the wildlife in and around these streams as many are on the endangered species list.

Certainly the most challenging aspect of the Huntly section is its diverse terrain. Bulk earthworks for this section involves moving more than 3 million cubic metres of material. One million cubic metres of rock needs to be removed from the Taupiri Pass and requires controlled blasting for the final 10 per cent of the road's construction.

A FULL ARRAY OF SOLUTIONS

Global Survey has become the preferred supplier to the Fulton Hogan HEB alliance and many of its solutions can be found on location. The equipment being used by the survey teams on-site includes the new Leica MS60 MultiStation with Leica Captivate software as well as numerous Leica TS16 robotic total stations, base stations and rovers.

Global Survey has also rolled out a large fleet of Leica Geosystems machine control systems on excavators, graders and dozers, which are being used extensively. The machine control systems allow the operator to visualise the design in 3D and then the automated machines control the blade precisely to design. Feedback from the operators and foreman on-site concerning the use of the systems has been very positive. By using the 3D machine control, the joint venture is able to meet tight construction tolerances required by the project and get significant gains in productivity whilst saving in survey and setout costs.

"By utilising the very latest Leica Geosystems survey technology, we have been able to create a high level of safety and increase productivity. Surveyors no longer need to work in dangerous trenches or around large heavy machinery in operation," said Ed Kelly, survey manager for the Waikato Expressway Huntly Section at Fulton Hogan HEB alliance.

SAFETY IS NOT ALWAYS IN NUMBERS ON CONSTRUCTION SITES

Due to the size and complexities of working on this site, safety was a large concern for the Fulton Hogan HEB alliance. Cutting through steep slopes, blasting away rock and using heavy machinery to move the 3.5 million cubes of earth could have been a very dangerous endeavour with so many surveyors and construction workers walking around on-site.

The safety risks associated with having survey field crews working close to machinery and on steep terrain are well understood by the joint venture. In addition to the clear productivity advantages of using the MS60 MultiStation, many of the potentially higher risk survey tasks are now carried out using the MS60 MultiStation.

© Fulton Hogan

"With pegs quite often being run over by machines, we have to recheck their positions. If surveyors are back in the office, it means waiting an hour for them to get to the construction site. That is a lot of downtime," said Kelly, "Now we don't have to wait to start moving earth. The MS60 MultiStation is great for production and for safety. And, after the initial surveying, the machine control systems take over so there's less people on-site."

ENDLESS POSSIBILITIES USING MS60 MULTISTATION AND CAPTIVATE SOFTWARE

Scanning with a MS60 MultiStation is new to the Fulton Hogan HEB alliance, and the firm is very pleased with the results. Fulton Hogan has used the MS60 MultiStation 3D scanner to create a wide range of scans with exceptional accuracy and results.

During the Huntly project, Fulton Hogan HEB alliance have applied the MS60 MultiStation for day-to-day construction tasks. However, in the future they would like to use the MS60 to its full advantage, by creating point clouds with overlaid measured points for realistic 3D models of the terrain before construction actually starts. Off-site and on-site work could be improved dramatically by adding visual control of actual construction. Scans of the construction could be done to confirm that construction is in accordance with the design during and after the project is completed.

On a project such as Huntly, with its hilly and steep terrain, the MS60 is put into use often. The MS60 increases productivity and makes applications such as volume calculations more accurate and faster. The MS60 MultiStation is the very latest cutting-edge technology and allows the alliance to demonstrate market leadership in technology.

MACHINE CONTROL – GREAT FOR PRODUCTION AND FOR SAFETY

Leica Geosystems 3D machine control systems, such as Leica iCON grade and excavate, are also used for safety and dramatically increase productivity and accuracy. Crews no longer have to move around large machines to stake out pegs.

Using this 3D machine control means less downtime and more productivity on-site. Machine operators and construction crews no longer needed to wait for surveyors to set out stakes and to check and recheck before working. Digital project plans are easily loaded into the iCON systems in industry standard data formats like DXF / DWG and LandXML, all of which decrease

© Fulton Hogan

office software investment costs and streamline getting data onto the machines quickly and efficiently. This is a significant benefit when managing design changes. Systems on the machines are all set up with Leica Telematics, which allows for 2-way data transfer to and from the machines and remote support through any web browser without the need for special software.

"We selected Leica Geosystems not only because of its quality, but also because the backup and support we receive from Global Survey is excellent. We could also bypass software we didn't need by transferring data directly out of AutoCAD (Civil 3D) to the machines. It saved us a lot of time and a lot of difficulties," said Kelly. Another advantage of using Leica Geosystems products is its application software. Survey hardware is often replaced every five years because of technical advances. Leica Geosystems is constantly improving its application software and frequently distributes updates that are made based directly on customer feedback.

Targeted to be completed by approximately the end of 2019, Fulton Hogan HEB alliance is ahead of schedule, in part due to the leading technology being used on-site from Leica Geosystems.


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FULTON HOGAN | HEB | JOINT VENTURE
WAIKATO EXPRESSWAY | HUNTLY SECTION

Written by Benjamin Federmann

OFF THE BOAT, INTO THE AIR

If you plan on driving from Kristiansand to Trondheim on the coastal highway E39 in Western Norway, strap in for an approximate 1,100-kilometre ride that can take up to 21 hours by car. Due to the seven fjords that must be crossed by ferry, the trip can be quite arduous.

With the installation of either suspension or floating bridges or submerged floating tunnels, the Norwegian Public Roads Administration or *Statens vegvesen* is looking to cut the trip to 10.5 hours. The nearly 23 billion Euro infrastructure project would produce the world's longest suspension bridge at a main span of 3,700 metres or the world's first submerged floating tunnel.

The project began in early 2015 to transform the current two-lane highway to four-lanes with an 11-kilometre tunnel along with other road construction works. The entire project is scheduled for completion by 2035.

To keep construction on schedule and provide contractor oversight, *Statens vegvesen* contracted Hawkeye AS, a surveying firm specialising in final documentation of 3D deliverables and a joint venture of Veseth AS and Rune Samnøy of Samnøy AS, to provide orthophotos and models of the project. To do so, the firm turned to the Aibotix Aibot X6 UAV to collect the needed imagery for tracking costs of mass movements, documenting progress and keeping stakeholders up to date.

A 360-DEGREE VIEW FROM ABOVE

Flying new missions every two weeks with fixed positions throughout the firm's five-year contract on the project from January 2015 to January 2020, Veseth AS has created its own online gallery of 360-degree images taken with the Aibot X6 and a special installation with a Nikon D800. Since November 2015, the gallery hosts more than 100 photos.

The photos, taken at centimetre accuracy, are used in all construction meetings, helping *Statens vegvesen* to plan each step of the project. Project management uses the photos for quality control purposes with contractors and other stakeholders. The online gallery is also a new form of communication with the public to show current project status and important steps. "Providing aerial imagery from a UAV is new for us, and the excellent resolution of the pictures of different construction areas is helping the overall project to flow smoothly," said Mads Solberg Eriksen, *Statens vegvesen* quality advisor.

"The 360-degree view possible with the Aibot X6 makes project documentation easier and faster."

SEEING THE WHOLE PICTURE

Hawkeye AS and Veseth AS are particularly known for their volume calculation of terrain both above and below water. A major challenge to the project has been the mass removal of non-native plants from the natural habitat during the construction of the 11-km tunnel. The firm has been combining several Leica Geosystems solutions for precise volume calculations and documentation. While the Aibot X6 provides a clear view from above for quality control, the firm uses a Leica C10 ScanStation and Leica Cyclone software to create detailed 3D models of the mass to be removed. The Leica TS16 total station and Leica GS 14 GNSS Smart Antenna provide accurate measurements for quantity surveys.

"With Leica Geosystems solutions, we are able to provide the client with the most up-to-date information faster than ever before," said Stian Veseth, CEO at Veseth AS and a part of the joint venture company Hawkeye AS. "We are able to rely on solutions that work every day like they should, and we have complete access to a network of experienced professionals that we use to stay ahead in business."

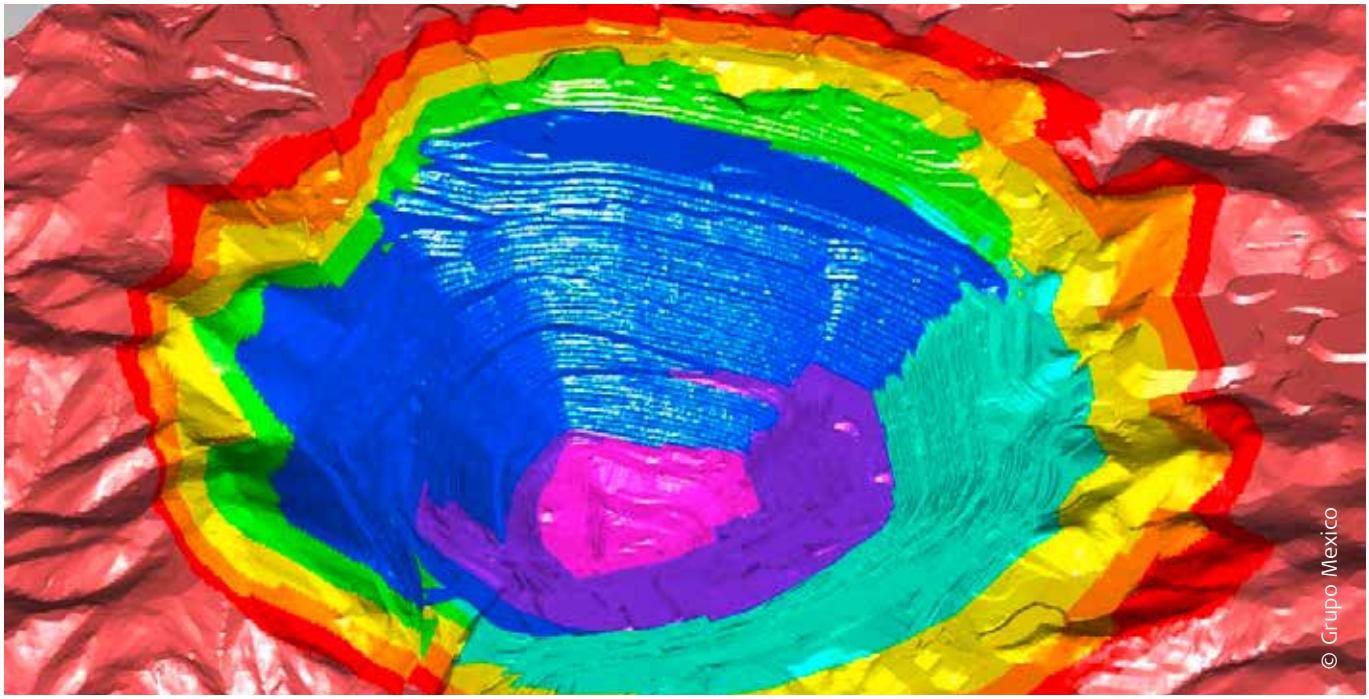
Combining the various solutions, the firm is consistently able to provide the client with a full picture of the worksite from above the ground and below the water of the fjords. One of the biggest infrastructure projects in Norway's history, the reconstruction of the E39 highways proves how UAVs compliment traditional surveying practices for an even bigger and clearer picture of what exactly is happening.

Editor's Note: Veseth AS' online imagery gallery of the project can be accessed at http://360aircamdrone.net/e39sr/

Written by Neville Judd

MINING INTEGRATION REACHES NEW HEIGHTS IN THE ANDES

Toquepala is more of a city than a mining camp. 'Home' to 2,000 people in the Peruvian Andes, the mine offers almost everything you might need, including an elementary school, a high school, hospital, supermarkets – even a golf course complete with 19th hole.



The mine run by Grupo Mexico is also setting new standards when it comes to integration and optimisation. Toquepala is the fifth largest copper mine in the world, measuring 2.5 kilometres across and descending more than 700 meters into the Earth. Last year, the mine won approval for a $1.2-billion expansion of the pit, which will double the mine's processing capacity.

STABILISING THE UNSTABLE WITH JIGSAW

To prepare for expansion amid tough economic times, Grupo Mexico decided to integrate Toquepala's operations and planning technologies. The company selected Hexagon Mining as a partner in this strategy, knowing that by aligning systems, it would be better positioned to weather volatile commodity prices.

We are constantly working to improve, integrate and optimise our processes for mining operations, utilising key technologies," said Enrique Sanchez, Grupo México senior technical adviser. "For many years we have relied on Hexagon Mining's Jigsaw system for fleet management with much satisfaction.

"Grupo Mexico has invested over US $2 million in modernising our processes and our operations and teams. For example, in the past we would transfer materials to the crusher via train or trucks, but today we leverage a system of conveyors and tunnels with more than 2 kilometres in distance, which sends materials directly to the crusher in this case."

"The purchase of equipment and technologies leveraging Jigsaw systems has been especially important in Toquepala, where in the past few months we have installed Jigsaw systems with much success."

Grupo Mexico is also a long-time user of MineSight, Hexagon Mining's mine planning software suite. Toquepala's mine planners use MineSight Economic Planner to determine economic pit limits, incremental pit shells, and preliminary pushback creation. They use MineSight Schedule Optimizer for short-term, mid-term and long-term planning.

"MineSight systems help us optimise our production for maximum gains that correspond to the overall value of the mine. Hexagon Mining's state-of-the-art technology is critical to our strategy. The idea is to have a single system for monitoring in standardisation of the automatic cycles, as well as the dynamic systems for increased optimisation of production.

"Hexagon's integrated mining solutions allow us to greatly improve our efficiency by shortening the gap between planning and execution."

HONOURING CHANGE

In June 2016, Grupo México was acknowledged as a Shaping Smart Change honouree at HxGN LIVE in Anaheim. Honourees are chosen for pushing the boundaries of innovation and implementing Hexagon technology to shape smart change around the world. Hexagon President Ola Rollén and Hexagon Mining President Hélio Samora were on hand to recognise Sanchez and Grupo México in a special ceremony.

In an interview at the event, Sanchez said the company is now pursuing Hexagon's safety technologies for further integration.


© Grupo Mexico

"We are in constant search for optimisation and key technologies," said Sanchez. "Upon installation of the Jigsaw system for our communications, we have also worked with Hexagon to add mobility and to be able to transmit HD-video quality with 100 per cent guarantee.

"We currently offer seven applications on the same platform such as radar control, pump systems, video systems, etc. All of this is integrated in a single platform, thanks to modern technology by Hexagon Mining. We are very happy with these systems."

Sanchez enjoyed HxGN LIVE and said he was impressed with the new technology offered by Hexagon Mining, such as the IDS Interferometric Mine Slope Radar.

"With one radar, we could achieve 360-degree coverage for monitoring the profile of the mine within one plan," said Sanchez. "Aside from the 360-degree view, the system is portable so we do not need to install electricity or additional construction for the equipment. In terms of maintenance and upkeep, the system's compact size is certainly a key factor to consider.

"This has impressed me greatly and I will be taking this information to share with the specialists at the mine. I believe it will be a good solution for them to consider."

"Grupo Mexico is committed to improving efficiency across the overall mining process."

© Grupo Mexico

Written by Katherine Lehmuller

GEOSCENTS – FUSING THE BEST OF BOTH WORLDS

On the Baltic island of Öland, just off Sweden's mainland, is a ring fort known as Sandby Borg. This fort is the location of a terrible event that took place roughly 1,500 years ago. Recently discovered archaeological treasures have awakened public interest in Sandby Borg, which until 2010 has remained virtually untouched. The site is a treasure trove full of information waiting to be discovered. With the help of the data collector Leica Zeno 20, ZenoCollector by Esri® app and Fabel, the world's first licensed archaeology dog, the mysteries of life and death in 500 AD begin to take shape. Limited time and costs of this archaeological dig have led researchers at Kalmar Läns Museum in Sweden to look for solutions. By combining a dog's incredibly acute sense of smell with an industry-leading data collector using GNSS accuracy, documenting and presenting history to the public have been changed for the better.

In the late 5th century the Roman Empire was in turmoil. Famine and violence lead many Germanic tribes to migrate to presumably safer places in Europe. The turbulence reached far beyond the Roman Empire and Europe. The inhabitants of the island of Öland built their villages inside circular stone walls, known as ring forts. These forts contained some of the highest standards of living in Scandinavia at that time.

The 5,000 m² walled area known as Sandby Borg is an immense challenge. Little of what happened there so long ago is known except that there was a surprise attack on inhabitants. They were struck down during their daily routines with only enough notice to hide their valuables. Highly unusual, the bodies were left unburied, lying where they fell – on the floors of their homes or over smouldering fire pits. All possessions, such as livestock and valuables, were left behind. Since then, the ring fort has not been disturbed. Presumably there could be the remains of hundreds of victims at the fort. The place is like a time capsule, offering a unique insight of how daily life might have looked like by the end of the 5th century AD and is just waiting to be discovered says Helena Victor, project manager of the Sandby Borg project.

SO LITTLE TIME, SO MUCH TO DO

Unmatched levels of cultural and historical finds remain below just centimetres of soil at Sandby Borg. When word got out about this invaluable find, plundering and looting became an issue. There was a possibility important historical information could be lost or destroyed forever. The Sandby Borg project began in 2010 with little idea of what lay below. A limited budget permitted only a short period of excavation in summer. Since its discovery, only 5 per cent of the site has been excavated. As yet, only two houses have been completely excavated, where unexpectedly researchers found 11 skeletons. These remains are complicated and time-consuming to remove. They bring important clues as to how people in this time lived and why they were attacked.

IMPROVE, SIMPLIFY AND COMMUNICATE

Three words: improve, simplify and communicate are goals Kalmar Läns Museum set to move forward. To accomplish these, a digital solution had to be found. This transformation would speed up workflows, get data back to the office to analyse quicker and enable the public faster access to information via websites and apps.

Previously, non-survey-grade mobile phones or tablets with the Esri® ArcGIS app had been used to collect data at the excavation site. After collecting this data, people back in the office had to combine it with survey-grade measurements because the phones and tablets were not accurate when collecting data. When the professional Zeno 20, running on Android, was released, the museum was immediately interested.

Finally the accuracy of a survey-grade data collector could be combined with the well-known Esri® mapping platform to connect field crews with the office. The solution was named ZenoCollector.

A DOG'S SENSE OF SMELL – DOING WHAT NO TECHNIQUE AS YET CAN DO

Fabel, the archaeology dog, is an expert at locating buried human bones. Archaeologist Sophie Vallulv is his trainer. In order to speed up the search, Fabel was brought to Sandby Borg to locate the buried remains before the excavation team arrived. Strapped to his back was a Zeno 20 using the Esri® ArcGIS.

The idea came about when archaeologists began thinking how they could record Fable's search pattern while still in the field. Previously Sophie had to remember where Fabel had searched and where he hadn't. When he discovered bones, Sophie would stick a white flag in wherever Fabel dug.

Because of Sandby Borg's size, it was extremely difficult to remember everywhere the dog went. Archaeologists, Nicholas Nilsson and Fredrik Gunnarsson at Kalmar Läns Museum, suggested building a harness for Fabel and putting the Zeno 20 in it.

"We tried it in the field and it works fantastic," says Sophie, "It's the perfect device for Fabel, thanks to its lightweight and accuracy."

"I thought about buying a regular hunting dog GPS device but the accuracy varied from 1 to 5 meters, which is extremely bad for documentation purposes. The Zeno 20 is capable of achieving 1 centimetre accuracy without an external antenna," explains Sophie.

A STORY STARTS TO TAKE SHAPE

Fable's searches are digitally tracked and recorded in real time. Communication with the team on the island as well as back on the mainland at the museum is instant. Collected data is immediately sent back to the office for analysis, maps can be made, data stored and updated. The general public can not only follow Fabel's progress, but also other finds of archaeologists on the project's website. And Sophie easily knows where to send Fabel on his next search.

To date, Fable has found the locations of 24 skeletal remains with Zeno 20 strapped to his back. This workflow brings an enormous time and cost savings to the Kalmar Läns Museum with still so many remains to locate. Archaeologists can plan their valuable excavation time far more efficiently, knowing where the bodies are located before they start with their next dig.

Both Fredrik Gunnarsson and Nicholas Nilsson at the Kalmar Läns Museum agree, "It simplifies and improves our workflows, and certainly brings us enormous time-savings. We recently visited the neighbouring Jönköpings Museum and discussed the advantage of using the Zeno device. They asked for a demo and were so impressed, they also bought a device."

Editor's Note: To follow Fabel, visit the Sandby Borg project website at *http://www.sandbyborg.se/en/home/*

Written by Katherine Lehmuller

KEEPING A VIGILANT EYE

© Nana Yaw Oppong-Quayson

Newmont's Ahafo South Mine lies within the Sefwi Volcanic Belt, one of Ghana's largest volcanic belts. These active regions contain a wealth of mineral deposits, such as gold, but are also cause for a great deal of concern amongst mining corporations and employees. A gold mine's steep walls are very fragile and in constant motion. Continuous, extensive monitoring by geotechnical engineers must be done in order to keep open pit miners safe from falling rocks or collapsing walls. One of the world's leading gold producers, Newmont Mining Corporation, selected the Leica GeoMoS monitoring solution due to the software's proven track record. The Ahafo mine is equipped with this industry-leading software to provide monitoring professionals with real time, actionable information and keep mining responsible and safe.

In business since 1921, Newmont operates mines in seven countries across seven continents. They acquired two mining properties in Ghana in the mid-1970s, Akyem and Ahafo, which quickly became major new gold mines for Newmont. With the Newmont Ghana mines, the company generated more than US $464 million in economic value for its stakeholders in 2015 alone.

The Ahafo Mine has been a challenge for Newmont over the few past years. The western part of the mine is characterised by a weaker rock material called graphite, which can cause stability issues when coupled with volcanic belt movement. Falling rock accidents were occurring and stability was becoming an issue.

In January 2016, a team of experts were employed to implement the GeoMoS monitoring solution at the Ahafo mine. This new solution makes necessary round-the-clock measurement observations of the mine pit walls in real time. Any fast movements occurring on the walls will be immediately detected and used to predict and prevent wall failures. This in turn saves the loss of equipment and, most importantly, protects the lives of Newmont employees on location in the pit.

10 YEARS – A WORLD OF DIFFERENCE

Commercial mining began at Ahafo back in 2006. Monitoring the stability of this 2100 x 450 x 120 metre pit was carried out manually by surveyors. Back then, they would periodically measure sets of prism targets installed on the mine's slopes, using manual Leica Geosystems total stations, such as the Leica TS11, and a software program located back in the office.

Deformation movement is determined by comparing sets of measurements. Ten years ago, data was collected manually once a day then brought to geotechnical engineers to analyse based on comparisons with subsequent measurement sets. The entire process was very time consuming. Surveyors could also only take measurements during the day, dividing them in shifts. With too few skilled personnel and not enough data, the incidents at the mine continued to occur. The company decided to increase the monitoring of the steep slopes to five times a day. This brought about the upgrade from manual to automated monitoring equipment, such as Leica Geosystems robotic total stations TS15, TCRP 1201 and TCRA 1203 that automatically monitored the 30 prisms installed throughout the mine.

"All of these instruments live up to their reputation for being extremely robust and precise. Newmont is convinced there's no better combination of accuracy and durability on the geodetic market," says Nana Yaw Oppong-Quayson, technical service engineer at PDSA Co. Ltd, authorised service and support partner of Leica Geosystems.

INVESTING IN THE BEST FOR MAXIMUM RETURN

Newmont opted for the new Leica MS60 MultiStation, which scans critical slope surfaces in 3D point clouds and is capable of collecting data without having to access targeted locations to install prisms. Such inaccessible or dangerous monitoring points are scattered throughout the pit and are now easily monitored. Maximum deformation volume results are now delivered in 3D point clouds, with each of the thousands of points within them being a highly precise measurement.

"Leica GeoMoS not only charted displacements out of 3D scans collected from the MS60 MultiStation, it also proved very helpful computing volumes of material moved from the pit," says Michael Muri, geotechnical engineer at the Newmont Ahafo Mine.

After considering several monitoring programs, the GeoMoS software was selected. It was the first automated monitoring system installed for a customer in Ghana by PDSA and Nana Yaw was part of the team who implemented it.

The solution consists of the Nova MS60 MultiStation, a digital terrain model (DTM) Meteo sensor for measuring atmospheric variations in temperature and air pressure, and a Netmodule Industrial WLAN Router for communicating between equipment and sending collected data. All of this is powered by a 12V solar panel power supply.

GeoMoS Monitor and GeoMoS Analyser software are used to monitor the mines.

All of this was set up in a shed close to the mine pit built specifically to protect the equipment. Once the instruments were configured, Nana Yaw and the team went back to the office, quickly installed GeoMoS and monitoring could begin.

WORTH ITS WEIGHT IN GOLD

Newmont uses the industry-leading GeoMoS monitoring solution at various other mine sites worldwide. Within the company, the software performance record is considered exceptional by monitoring professionals across the globe.

GeoMoS connects to the MS60 MultiStation, via a router, to collect data. It then stores and streams this data using a SQL database. The Meteo sensor, installed close to the monitoring station, measures any environmental changes, such as temperature and pressure, to correct the measured slope distances taken by the MS60 MultiStation.

The streamlined solution tracks the many movements of the gold mines. The MS60 MultiStation is able to scan critical, inaccessible sections of the mine safely, without placing people or expensive equipment at risk. Using the reflectorless mode of the electronic distance meter (EDM), the MS60 MultiStation is able to measure with the highest accuracy possible, locking onto natural targets to detect deformation movements in areas of the mine's surfaces where prisms have not yet been installed.

SIMPLER WORKFLOWS ENABLE FASTER, MORE INFORMED DECISIONS

All of this information is taken and processed by Monitor, which provides monitoring professionals with understandable information instantly. Rapid movement below the earth's surface can create unstable walls and dangerous developments immediately. Mining engineers and geologist use the results of this monitoring solution to understand the behaviour, condition and movement of a mine. If something moves, professionals using this software will know immediately. Detecting such movements around-the-clock also provides a continuous, long-term picture to form a better understanding of the pit's walls, which are continuously being chipped away at.

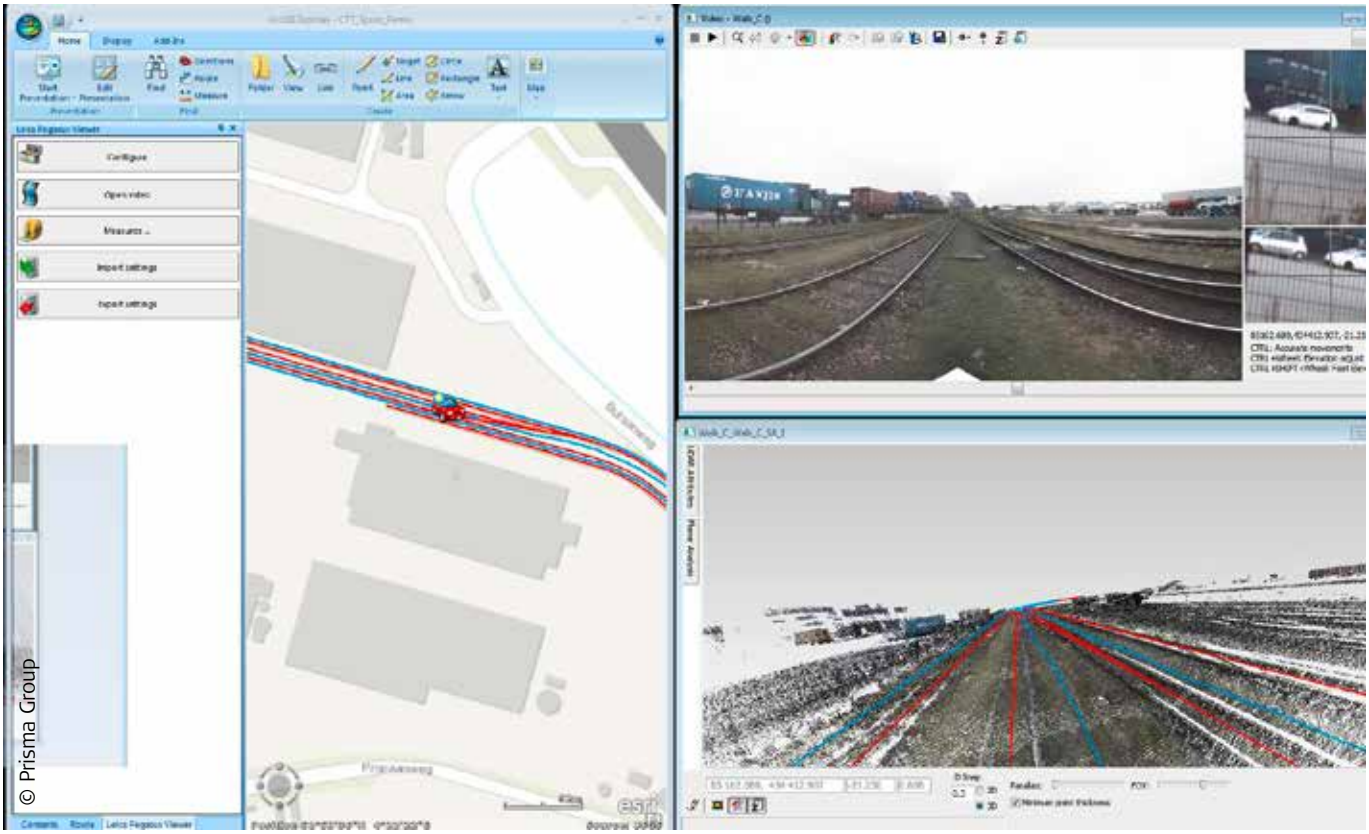
GeoMoS quickly processes and manages huge amounts of data collected by the total stations at the mine – reliably and around the clock. Because it is completely automated, human errors have been significantly decreased. Wireless communication between the mine and office enables accessibility to data in real time. The analysis is also much easier for monitoring professionals to understand. Clear customised layouts of massive amounts of data enables engineers to react faster and make decisions quicker. "For Newmont, being able to provide their expensive heavy equipment a safe haven certainly saves them big. But most importantly, a safer working environment means providing employees more protection and saving lives," concludes Nana Yaw.

Written by Natalie Binder

LASER SCANNING ON THE GO

As the world population grows and global changes in building and infrastructure construction become more rapid, our need to document this growth and change increases. Referred to as wearable reality capture sensor systems, this new concept is shaping how measurement professionals come to understand and shape the world among them.

The Leica Pegasus:Backpack was invented as part of this generation of new wearable reality capture sensor systems in response to the growing global changes. The Prisma Group was the first company to utilise the Pegasus:Backpack in its recent infrastructure project.



Based in the Netherlands, the Prisma Group consists of three companies: Prisma Meten, Prisma Geocensus and Prisma Van Steenis. The company has a variety of specialities including survey (rail, infrastructure, utility), industry (offshore and onshore), GIS, hydrography, geodetic measurements, 3D laser scanning, monitoring and mobile mapping.

The Prisma Group has always been a brand advocate of Leica Geosystems, relying on the quality products that generate quality services. One of the Prisma Group's goals is to develop the international market. With rapid progress in the field of 3D laser scanning, the Prisma Group was keen to work closely with Leica Geosystems to achieve its goal and to become No. 1 in the field of scanning.

CONCENTRATING ON SCANNING RAILS

Through a collaborative partnership, Prisma Van Steenis was the first 3D specialist in the Netherlands that produced a 3D scan with the Pegasus:Backpack at the rail tracks of Pernis Rotterdam, Netherlands. Leica Geosystems was approached by Prisma Van Steenis in November 2015 to help with this challenging project. The project came about as it was commissioned by the government for a rail contractor to firstly verify the principles of procurement and then to assess what materials, such as ballasts, sleepers and rails, were present. Prisma Van Steenis were commissioned to carry out the rail project.

The project scope entailed the scanning of the position and height of the rail tracks because the contractor was looking to renew his contract and was keen to impose the new alignment of the railway track. Before any measurements could be taken, there was an initial analysis of the project interfaces and overlaps, and the risks carried out with the scan data and the 360-degree shots. The area that was scanned was a yard with numerous tracks and switches, containing 1.5 kilometres of industrial freight, which was in full use by several carriers and companies. The complete 3D scan will be used for reverse engineering, to help with lay-plans, ballast volumes and profiles. The captured 3D data can be used to build a reliable design of a new railway track layout, delivered as a 3D model, and can also be used for BIM and quantity determination.

MOBILITY IN A DIFFICULT SPACE

There were many challenges working in a railway environment whilst trying to capture reality data during this project. From low-hanging electrical lines to constricted spaces around train cars, classical surveying methods can be extremely limited in this environment. Whilst working on the rail project, Prisma Van Steenis had to take the measurements whilst the yard was in use, and, therefore, there were real risks of collisions and a high risk to personal health and safety. By law, the risk area (the railway track) is not an accessible area for surveyors and

is normally prohibited for inspections. Prisma van Steenis needed a safe, quick and accurate solution to collect the point clouds and 360-degree pictures needed for this scanning project. The survey needed to be collected quickly to reduce cost and lead time.

The deployment of the Pegasus:Backpack provided numerous advantages over traditional methods for the Prisma Group. The surveyors were a lot safer on the tracks and ran much less risk to their health because they did not have to enter the risk area. In addition to this, the surveyors did not have to perform any measurements during nightfall, which is a hazard in itself with limited visibility causing many hazards. The Pegasus:Backpack was the perfect solution. Distances could be measured without entering dangerous areas with maximum effect. With one measurement from the Pegasus:Backpack, the surveyor was provided with the correct, current and complete information on the same day. The quality of the measurements from the Pegasus:Backpack is highly accurate and best in class.

The results of the project were compared with traditional terrestrial surveying (that took several days to complete) and the results from the Pegasus:Backpack were very impressive. The differences between the backpack's scan and the digital measurements are about 3 centimetres on an absolute level, and the relative results are even better (mm level). The captured 3D data can be used to build a reliable design of a new rail track layout. The newer technology also allowed the measurement professionals to conduct the entire survey in three hours, that would normally take five days. There was also a cost saving of nearly 50 percent for the contractor. The advantage of scanning is that you capture the entire situation, so any forgotten detail can be obtained from the point cloud at a later date if necessary.

"Using wearable reality capture enabled us to realise many benefits over traditional surveying techniques," said Prisma Director Klaas de Weerd. "With Leica Pegasus:Backpack, every spot in the rail yard was reachable. We also did not have to implement extra safety measures since there was no need for us to enter high-risks areas: we could simply capture the data from a safe distance. Finally, we saw great time savings due to error-free data acquisition in a baseline survey that will allow us to accurately monitor any changes to the design in the future."

A version of this story first appeared in GIM International.
http://www.gim-international.com/

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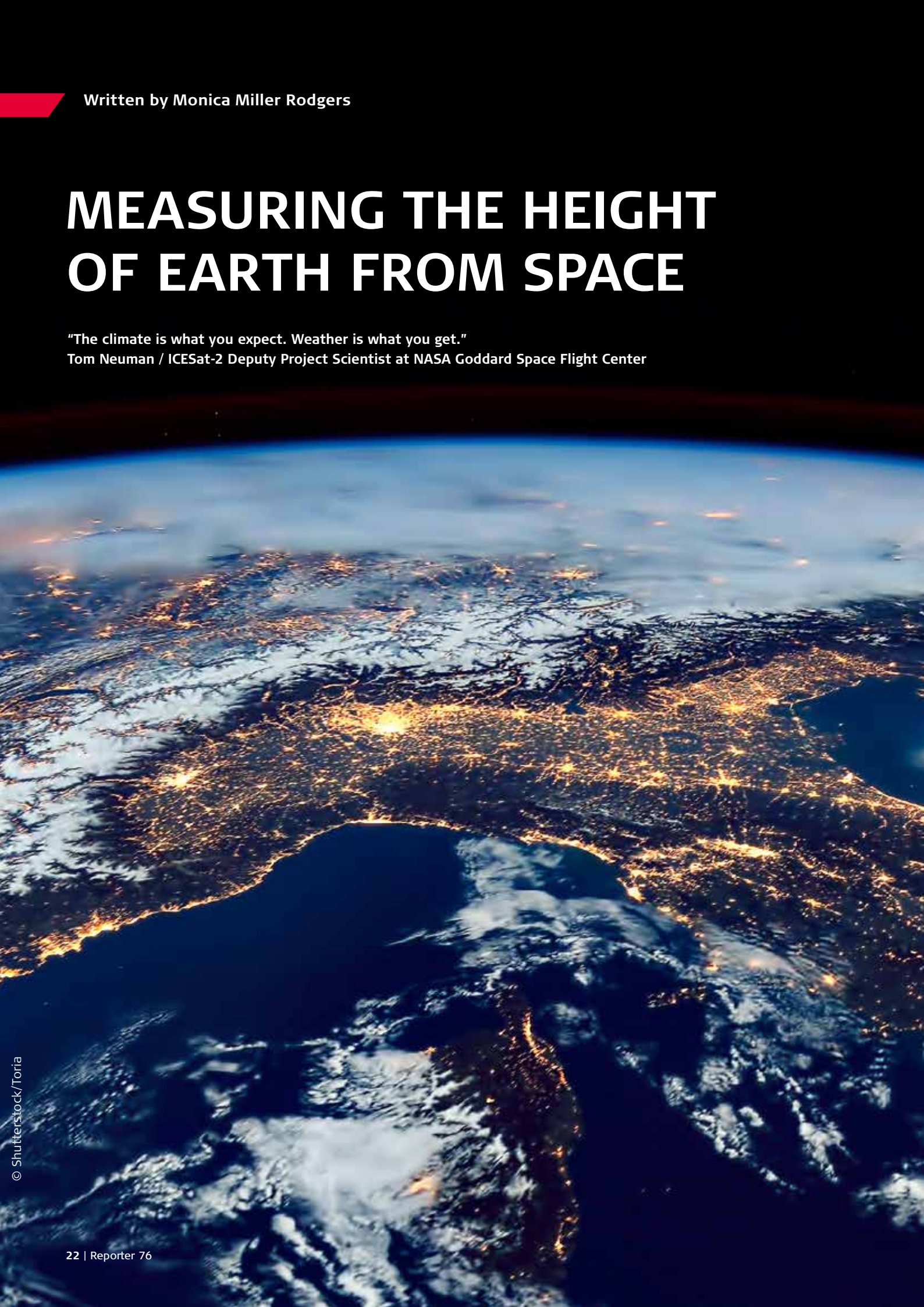
Written by Monica Miller Rodgers

MEASURING THE HEIGHT OF EARTH FROM SPACE

"The climate is what you expect. Weather is what you get."
Tom Neuman / ICESat-2 Deputy Project Scientist at NASA Goddard Space Flight Center



With a planet covered in more than 70 per cent water, with only 2.5-2.75 per cent fresh drinkable water, and 1.75-2 per cent of that only available in frozen form, climate change is a major concern for the National Aeronautics and Space Agency (NASA). Studying how this ice is protecting Earth from the sun's rays helps scientists better understand the overall effects of warming oceans and melting polar caps.

To conduct this vital research, NASA is set in 2017 to launch yet another satellite into orbit. This time, though, that satellite will accompany advanced measurement lasers and sensors.

LASER TECHNOLOGY BRINGS SCIENTISTS CLOSER TO ANSWERS

Using Earth's ice, either in the form of land ice sheets like glaciers and icebergs, or sea ice, NASA scientists are beaming lasers down from space to measure displacement to receive accurate elevation readings and melting statistics.

"We are measuring the elevation of the entire Earth," said Thorsten Markus, ICESat-2 project scientist at NASA Goddard Space Flight Center (GSFC) in Maryland, USA, in an educational video. "We are measuring the third dimension of our globe."

As polar caps melt, there is less and less ice to reflect the sun's rays. As more and more of that heat is absorbed, the world's oceans steadily rise in temperature. This not only impacts global climate but can also cause detrimental effects to the millions of species of animals and plants that make these waters their homes. Scientists study this effect on the environment to better understand why it's happening and how to find solutions to prevent and correct the situation.

"Both the ice and oceans in the polar regions drive global climate," said Charles Webb of the ICESat-2 Project Science Office in the video. "When the oceans heat up, that raises temperatures in the Arctic, in turn causing more melting of the ice."

The Ice, Cloud and land Elevation Satellite-2, better known as ICESat-2, will carry into space the Advanced Topographic Laser Altimeter System (ATLAS), an instrument that will transmit six precise laser beams to Earth and detect the photons that are reflected back to take accurate measurements. ATLAS determines Earth's elevation by measuring the time it takes light to travel to the surface of the ice and back. Displacement of the ice is calculated by taking the measurement of ice's thickness over time. ICESat-2 measures this thickness by recording the height of the sea ice surface and the height of the water beside it and taking that difference.

"As you measure the distance from the satellite down to the surface of the ice, we're able to tell how thick the ice is over time," said Aprille Ericsson, ICESat-2 project instrument manager, in the video. "We'll pass back over that path and we know if the ice has grown or if it has melted."

REPLICATING GEOSPATIAL DATA FROM SPACE

In order to provide the ATLAS science team with representative ICESat-2 ATLAS data in advance of the 2017 launch, Sigma Space designed and delivered the high-precision receiver and timing electronics and multiple opto-mechanical systems of the high-altitude, airborne Multiple Altimeter Beam Experimental LiDAR (MABEL) instrument to NASA GSFC. Sigma Space, recently acquired by Hexagon, is a provider of next generation remote sensing technology to rapidly deliver 3D maps of the earth.

MABEL serves as a demonstrator for the ICESat-2 ATLAS instrument, and the instrument has flown in several campaigns over ice, mountains, vegetation and water in locations such as the continental United States, Alaska and Greenland. These flights allowed the ATLAS science team to obtain and analyse data representative of what the ATLAS instrument will produce while in orbit. The MABEL instrument uses similar hardware to that used in Sigma Space's highly successful Single Photon LiDAR (SPL) instruments that produce 3D maps of Earth.

NASA GSFC selected Sigma Space to develop and design the Photon Counting Electronics (PCE) hardware for the ICESat-2 satellite's ATLAS instrument. The PCE hardware resides in the Main Electronics Box (MEB) of the ATLAS instrument. Comprised of three identical circuit boards, each responsible for 20 channels of the 60 channel system, the PCE will enable ATLAS to perform highly accurate three-dimensional measurements of Earth's surface and structures, using a low powered laser and single-photon sensitive detectors. Based on Sigma Space's SPL solutions, the PCE's novel timing electronics have been customised for the ATLAS instrument and for space flight using robust design techniques required for the space environment.

Sigma Space was involved in all aspects of the PCE development, from architectural definition, detailed chip and card-level design, performance characterisation and validation, testing, and integration. A small, focused team of Sigma Space engineers worked hand-in-hand with NASA flight software and algorithm development teams to ensure smooth hardware/software integration,

debug, and support throughout the program. Sigma Space delivered breadboard-level, engineering model, and space-flight model PCE hardware to NASA GSFC.

"The ATLAS PCE development has been a great success. Sigma Space was a key member of the ICESat-2 ATLAS team and worked seamlessly with NASA GSFC," said Ed Leventhal, Sigma Space director of Electrical Engineering. "We delivered very high performance hardware based on our SPL measurement technique. We are proud of Sigma's role in the ICESat-2 ATLAS program and look forward to a successful launch and mission."

MOVING INTO THE NEXT FRONTIER OF MEASUREMENT

With the acquisition of Sigma Space, Geosystems is moving into new airborne measurement capabilities through the use of SPL. Enabling 3D data collection at much higher speeds and resolution than conventional systems, this technology operates in night and day conditions and is able to penetrate semiporous targets such as vegetation, tree canopies, ground fog and clouds. Together with its speed of coverage (100 single beams at 6 million measurements per second), these features make it a superior choice for a wide range of industry applications, such as urban planning, aviation emergency services, disaster responses and Earth sciences.

"This is a very powerful technology that we see many uses for," said Marcos Sirota, Sigma Space CEO. "At six times the efficiency of any other LiDAR currently on the market, we can provide 3D measurements capturing terrain and features with equal or better spatial resolution than 2D imagery. Accurate absolute 3D LiDAR imagery has been unaffordable until SPL became available."

Elevation measurements are especially beneficial to organisations determining geological features of terrain, and this service is also an added benefit to the Hexagon Imagery Program (HxIP). With this new service component, Geosystems has now introduced the Hexagon Elevation Program (HxEP). Combined, the two programmes make up the new Hexagon Content Program (HxCP).

"Adding this elevation component to our already-existing imagery program doubles the benefit for users who can now access 15-centimetre accuracy terrain imagery plus next generation precise elevation information," said John Welter, HxCP director and Geosystems Geospatial Solutions Division president.

"With just starting at 6 million measurements per second with SPL, the possibilities ahead are very exciting. This is what it is all about – bringing up the point density while bringing down the cost per point."

While Sigma Space continues to support NASA`s many Earth science missions, the long term vision is also to support its planetary missions. Mapping elevations of Mars and beyond is certainly moving Geosystems into the next frontier of exploration and discovery.

Editor's Note: The educational video attributed to in the article, Our World: ***ICESat-2 Measures Ice Sheets****, can be viewed at https://youtu.be/5BdYLkxOpk4*

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HEXAGON
GEOSYSTEMS

Written by Walter and Martin Pilhatsch

FITTING TOGETHER PIECES OF A PUZZLE

The Bonner Münster (Bonn Minster) is one of the oldest churches in Germany. A major basilica in Bonn's old city centre, the existing structure of the church dates back to the 13th century. The ravages of time and poorly carried out restorations due to lack of proper structure documentation, have all left their scars on this historic building. Add to this the severe damage caused by an air raid in World War II, the Bonner Münster is in an alarming state and long overdue for extensive renovation. It was decided to call the engineering office of Walter and Martin Pilhatsch, located in Bonn, Germany, to collect and analyse data on the Bonner Münster church. Three generations of geodetic measuring experience combined with knowledge of 3D laser scanning, UAV aerial surveys and photo data analysis, made Pilhatsch surveying team the best choice for this complex job. Using the Leica ScanStation P40 and HDS7000, the team could complete a comprehensive 3D scan of the immense and complex building in the very heart of Bonn's city centre.

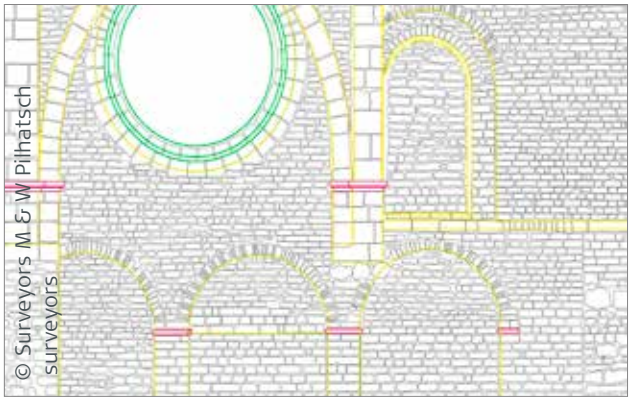
It was very important to understand the structural damage to the Bonner Münster in order to correctly restore the church. For this, a highly precise 3D scan of the exterior facade was needed. This data helped support planning with the historic preservation authorities and calculate restoration costs.

Detailed 3D laser scans were required to create the floor plan of six levels and 12 different building sections. To accomplish this data collected from the project's different sensors, such as Leica Geosystems' ScanStation P40, MS50 MultiStation, TS15 total station and an Unmanned Aerial Vehicle (UAV) needed to be efficiently linked.

Like a puzzle, the different data needed to fit together to build the model based on the geodetic network. Using precise TPS measurements from the TS15 and MS50, a basis for combining the scan data with the national coordinate system was created to become the foundation for this highly accurate geodetic network used to aid in the restoration of the church.

Height points were also connected to this network using the precision of a Leica DNA03 level. The actual surveying of the Bonner Münster was accomplished using a HDS7000 scanner and the latest ScanStation P40. The data of the façade's towers and high roofs was collected using a UAV with a Sony a6000 camera. These acquired images were then adjusted and geometrically rectified so that the image proportions were not distorted.

Many factors turned this surveying project into a real challenge. However, the swinging movement that occurred when walking on the roof trusses high above the ground made collecting precise data difficult. These measurements were also absolutely necessary to properly connect the roof area in the network. In order to keep the movement to a minimum, the Leica TS15 was positioned on the roof truss and the data was collected by remote control.



Detailed aerial images were collected using a UAV from areas where the scanners could not be positioned, such as for external roof or tower areas. This resulted in approximately 3,200 facade photos used for corrections and processing. Around 500 distinct points from the scanned point clouds were determined as the foundation points to link the images together.

With the help of Leica Geosystems products, the Pilhatsch surveyors were able to scan the Bonner Münster in the course of 13 days. In order not to disturb visitors at the church, public areas were scanned during four night sessions. Later, light exposure adjustments, or high definition range (HDR), optimised the panorama images. During the project, some 750 scanner standpoint setups were carried out. This resulted in a set of 15 billion data points, which were mapped onto the geodetic reference network to create the final resulting 3D pointcloud.

Handling such large amounts of data was easily possible thanks to Leica Cyclone. This software enabled the billions of points in the original scans to be seamlessly stitched together, regardless how large the volume of data was.

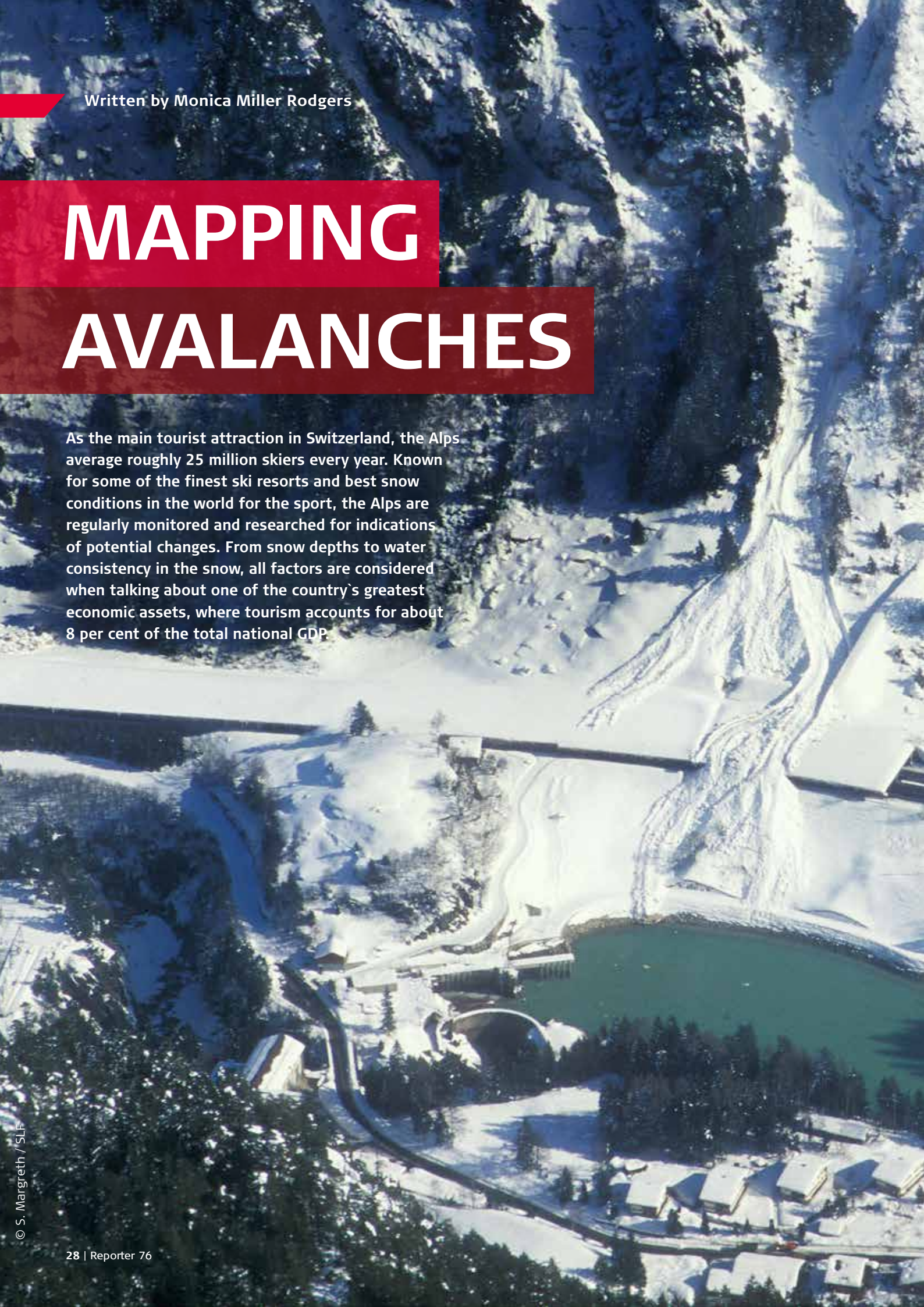
The point clouds provided the basis for further evaluation in CAD software using Leica CloudWorx software. Thanks to this powerful tool, creating levels and sections without any technical limitations whatsoever was easily possible.

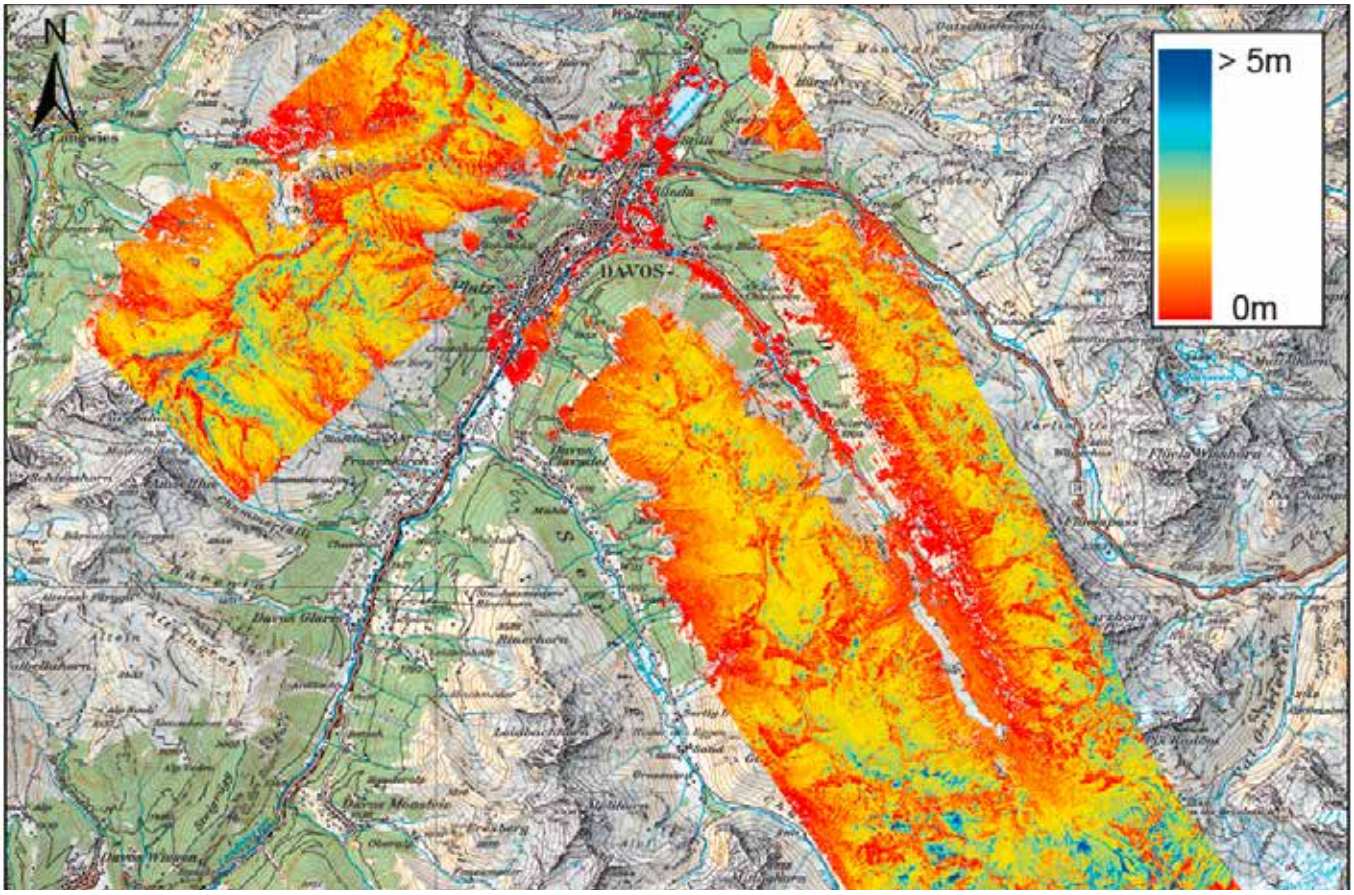
Highly efficient workflows helped save Pilhatsch surveyors a tremendous amount of time on this complex project. By using Leica Geosystems solutions, designed to seamlessly combine and integrate workflows, made the processing of such enormous volumes of data much easier. And for the Pilhatsch surveyors, this meant that the results of this big and technically exciting project could be delivered reliably on time.

Written by Monica Miller Rodgers

MAPPING AVALANCHES

As the main tourist attraction in Switzerland, the Alps average roughly 25 million skiers every year. Known for some of the finest ski resorts and best snow conditions in the world for the sport, the Alps are regularly monitored and researched for indications of potential changes. From snow depths to water consistency in the snow, all factors are considered when talking about one of the country`s greatest economic assets, where tourism accounts for about 8 per cent of the total national GDP.





© Y. Bühler / SLF

The Institute for Snow and Avalanche Research (SLF) in Davos, Switzerland is an interdisciplinary hub of research and services, The organisation is part of the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL). SLF carefully studies snow and its interactions with the atmosphere to provide valuable services, such as avalanche warnings, natural hazard warning systems and consultancy for avalanche protection measures. To produce this potentially life-saving information, SLF uses Leica Geosystems airborne sensor technology.

MAKING INFORMED DECISIONS FROM AIRBORNE IMAGERY

To classify the average risk of avalanches occurring in certain regions of Switzerland, scientists need to first account for and then understand the spatial distribution of snow and potential weak layers in the snow-pack. SLF researchers use the Leica ADS100 airborne sensor to capture highly detailed imagery of large fields of snow in the alpine areas. With this remote sensing data, the institute is able to visualise an entire alpine spatial terrain.

"In such remote areas, like these alpine ecosystems, it is difficult to get geodata," said Dr. Yves Buehler, a SLF scientist studying the dynamics and prevention techniques of snow avalanches. "With the data produced by the ADS100, we are able to accurately map these large areas of snow in such remote conditions, which is exactly what we need."

With the ability of the ADS100 to provide a full multispectral colour swath width of 20,000 pixels in RGBN, the SLF researchers create high accuracy digital surface models from the imagery to derive volumes of avalanches and map them to see what areas of the Alps may be most prone to these natural disasters. Making comparisons of avalanche warnings with detected avalanche events, researchers can validate and improve the warnings. Avalanche warnings are created to caution those who may be considering entering a certain area of the Alps on a scale of 1, low danger level, to 5, very high danger level.

"The near infrared bans produced by the ADS100, and its clear delineation of the red, blue and green bands, is very important in snow measurement," said Buehler. "These bands help us classify snow properties, which play a critical role in the development of avalanches. Depending on the snow type at the surface, dangerous formations of weak layers and slabs can arise if additional new snow is covering them. This can lead to higher avalanche danger."

MORE THAN JUST AVALANCHES

Another important product produced from the ADS100 data are snow depth maps. By subtracting the summer Digital Surface Model (DSM) from the winter DSM, the snow depth is derived. By comparing different snow depth maps, melt rates can be calculated. The two models must match perfectly for a correct snow depth map.

Used to understand hydrology and ecology aspects, SLF researchers can determine how much water is stored in the snow or how snow affects a certain terrain with these maps.

"In areas heavily dependent on acquiring water supply from mountain snow, such as the Rockies in the United States, or electricity producers that depend on hydropower, like here at Lake Davos, understanding how much water will be forthcoming from winter to spring is crucial," said Buehler.

Accurate snow depth measurements also help the researchers determine patterns of habitat for alpine area plant and animal life. Depending on how much snow stays from season to season can affect what types of animals will be present in the area and when the trees will begin pollination.

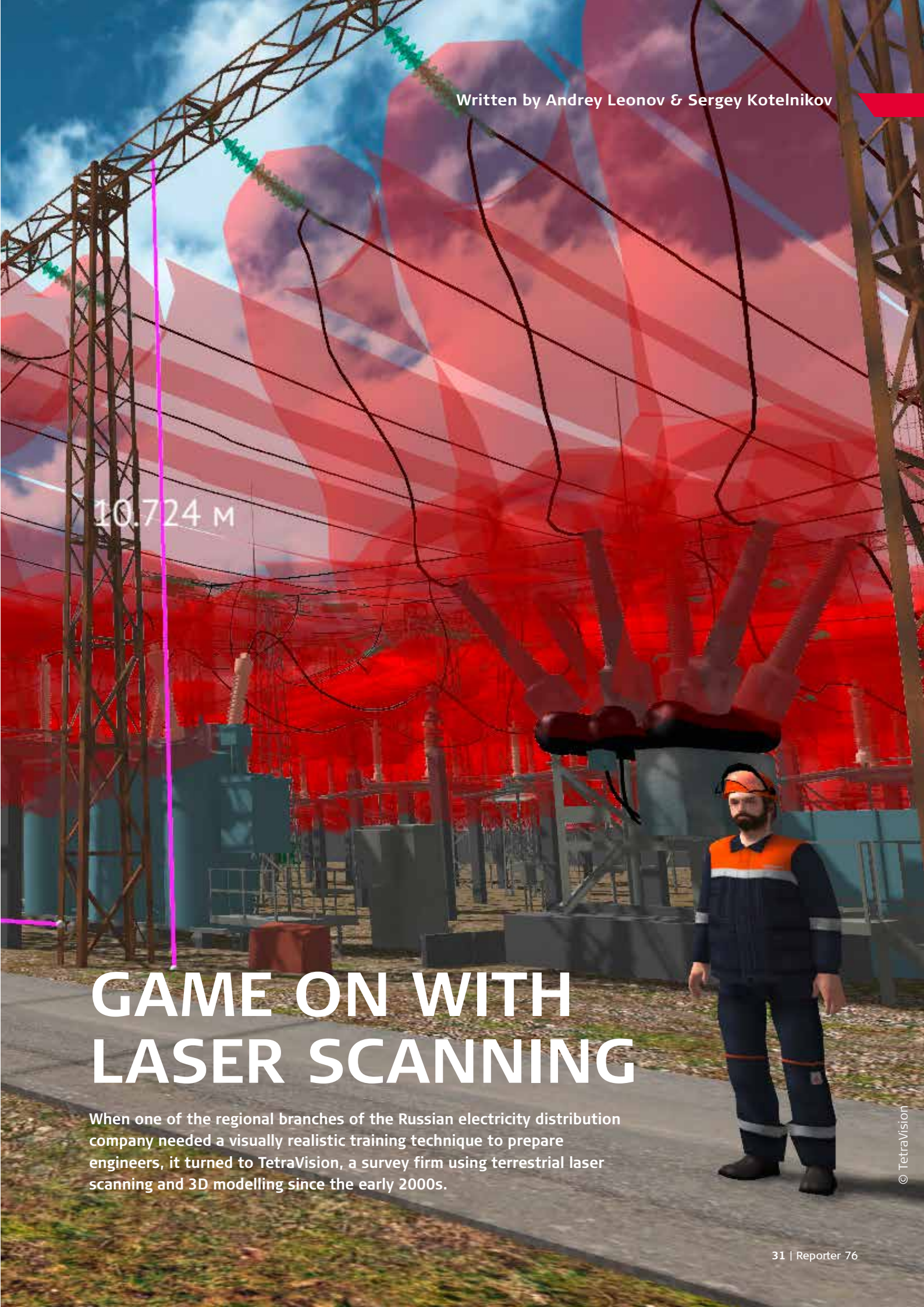
"Snow depth measurements in the mountains are really critical, and we must be able to get the right measurements to understand them," said Buehler. "In alpine areas, snow coverage varies greatly in time and spatial distribution. You have different ecosystems of vegetation and wildlife depending on how long the snow remains."

Though SLF doesn't currently have spatially continuous snow depth maps that go back far enough to determine long-term trends in snow distribution, the Institute is aiming to keep measuring long enough to accomplish this task. Currently, climate change is studied by using point measurements at stations, and the spatially continuous data allows for observation of snow depth distribution on a small scale.

As the backbone of its data collection programme, the accurate information provided by the ADS100 will certainly make larger scale study possible in the future for the region of Davos.

With a better understanding of climate change and other factors affecting snow, SLF continues to support the management of water resources and natural hazards in Switzerland and to develop sustainable solutions for mountain regions.

Written by Andrey Leonov & Sergey Kotelnikov



GAME ON WITH LASER SCANNING

When one of the regional branches of the Russian electricity distribution company needed a visually realistic training technique to prepare engineers, it turned to TetraVision, a survey firm using terrestrial laser scanning and 3D modelling since the early 2000s.

Developing a Game Based Learning (GBL) or Serious Game programme for support of maintenance and planning repair works as well as staff training and education, the firm produced a precise geometrical 3D model of industrial objects at an outdoor switchgear 110 kilovolts, a part of power substation 220 kV, with a total area of 2 hectares. As part of the project, the firm also created its own standalone software application with a required functionality and simple interface.

GAMING IN 3D

Using a Leica ScanStation P20, TetraVision collected hundreds of millions of points in more than 30 different scans of the 2 ha space. Combined with Leica Cyclone Register and Model software, the point clouds were registered and georeferenced to create an accurate 3D model of the area. Leica Cyclone Object Exchange (COE) was then used to transfer the data to Blender3D modelling applications. The game environment was created in TetraVision's own software application based on the Unity3D game engine to provide the functionality requested by the electricity distribution company.

"This was our first project where the customer wanted not only a CAD model for producing a set of 2D documentation, as was usually the case, but a realistic and interactive 3D model with a special game-like functionality," said Mikhail Anikushkin, TetraVision general director. "Though we scanned the area in the summer, the customer took into account future projects and requested a reliable laser scanning solution. As the ScanStation P-Series is capable of working in a wide range of temperatures from 20 °C to + 50 °C, it can handle the severe Siberian conditions in winter, too."

Based on the data received, TetraVision created a precise geometrical 3D model that was then optimised for real time interactive visualisation. Some 3D meshes were merged and others were simplified to decrease the total polygon count. The size of the final deliverable was only about 300 megabytes, and provided fast and smooth visualisation even on low-end computers.

Despite the simplification, the accuracy of the final geometry stayed high enough for all requested purposes. Global accuracy of the optimised 3D model was 2 centimetres across the substation, and local accuracy was less than 1 cm for a separate unit.

The "as built" geometry of the substation was complemented by 3D models of electrical danger zones according to current standards and regulations. All types of danger zones were modelled and visualised in the game as semi-transparent tubes around the conductors. Crossing over danger zone causes an alarm like screen flashing, tool tip and/or sound signals in the game.

Several 3D models of typical vehicles and workers were also added to the game. Players can move them arbitrarily across the substation to form any necessary configuration. With an avatar, players can conduct process steps to better understand how an activity should be performed. For example, in fire emergency scenarios, the player needs to perform special actions in the game to pass to the next level.

The game is also automatically updated to reflect the actual state of electrical switches. For example, a section of the substation can be switched off for repair, and the configuration of switches and danger zones will be changed in the 3D model appropriately. The actual state of electrical scheme can, therefore,

be visualised in real time in the 3D model, including visualisation of danger zones and current location of personnel. Such as the case for the execution of repair works and the safety of operations that can be controlled remotely in real time based on the telemetry data.

PROVING GBL FOR TRAINING

As a first of its kind in the regional market, the game has become a proving ground for power engineers for testing 3D gaming technologies and analysis of their potential for the staff training and preparation of maintenance and repair works. In the future, it can be also used for real-time visualisation of the substation`s actual state and staff location.

"Very much like a computer game and quite useful, this project will help power engineers better understand the potential for GBL," said Anikushkin. "Our customer now has no need to buy any expensive CAD-like software to use the model, which is an important advantage of the project. Visualised either in a standalone tool or in a browser, the game is simple and intuitive and field engineers have no need to learn complex CAD systems and graphics editors."

With the free movement across the 3D model of the substation in different modes, walk and fly through, overview with a fixed pivot and zoom support, the player can easily view and edit attributive information about the elements. This information can then be saved in a database. Screenshots in perspective view and in orthographic projection without perspective distortion (with the possibility of independent control of the front and back clipping planes) can also be saved. Finally, measuring the distance between any elements of the model, such as the automatic calculation and visualisation of the shortest distance between the movable object and the current-carrying wires, is also stored in a database for further use.

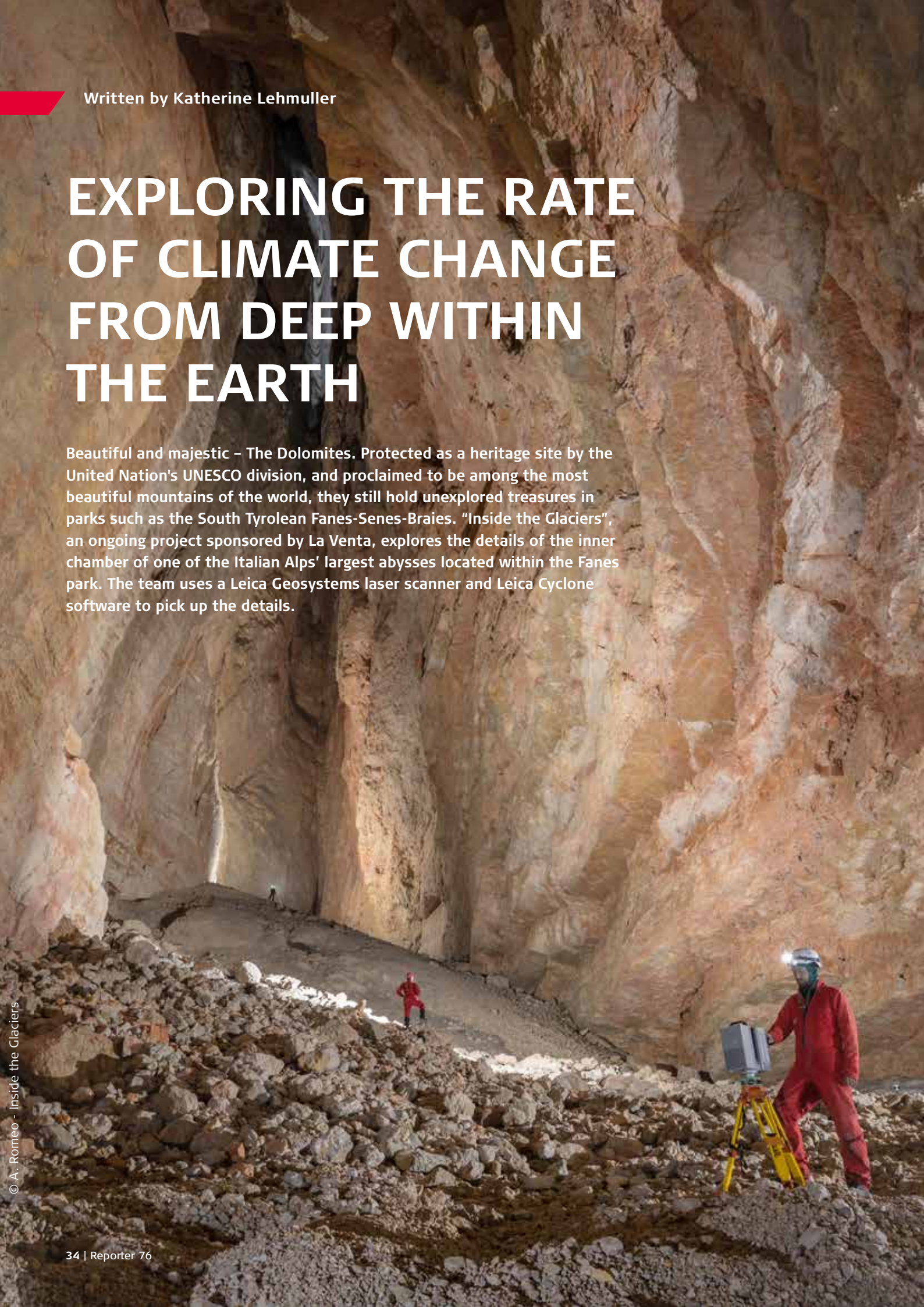
"The created model is intended primarily for supporting the safety of works," said Andrey Buynov, head of the Production Assets Management Department of the electrical distribution company branch. "The game simplifies the planning of repair works. In particular, it enables evaluating the possibility of safe activity and the planning of location and movement of personnel and machines, taking into account the danger zones. It also helps to train technical service engineers for the correct execution of the process steps."

As GBL and the 3D modelling of industrial objects becomes more popular in Russia and other parts of the world, more technical fields will turn to gaming for increased safety and efficiency on the worksite. With laser scanning, the game is on for providing detailed, accurate and realistic environments to support this training.

Written by Katherine Lehmuller

EXPLORING THE RATE OF CLIMATE CHANGE FROM DEEP WITHIN THE EARTH

Beautiful and majestic – The Dolomites. Protected as a heritage site by the United Nation's UNESCO division, and proclaimed to be among the most beautiful mountains of the world, they still hold unexplored treasures in parks such as the South Tyrolean Fanes-Senes-Braies. "Inside the Glaciers", an ongoing project sponsored by La Venta, explores the details of the inner chamber of one of the Italian Alps' largest abysses located within the Fanes park. The team uses a Leica Geosystems laser scanner and Leica Cyclone software to pick up the details.



© A. Romeo - Inside the Glaciers

There are scientific exploration teams and then there are the truly dedicated exploration teams. The latter is how one could describe the association La Venta Esplorazoni Geografiche based in Treviso, Italy. Lead by geologist Francesco Sauro, who was recently selected by TIME magazine as one of 10 Next Generation Leaders, the La Venta team organises and runs various geographical and environmental exploration projects, such as "Inside the Glaciers." The goal of La Venta is to create awareness of Earth's natural wonders, locally and globally, in order to conserve these unknown treasures.

Within the 25,000 hectare Fanes-Senes-Braies park lie the Conturines, a mountain located in the heart of the Dolomites. Deep within this mountain, high above sea level at 3,000 metres, is the Abyss of Cenote.

The entrance to the glacier abyss first presented itself after a sinkhole collapsed in the late 20th century. Never before touched by human activities, the discovery of this cave is one of major importance to researchers. Studying the morphological evolution of ice masses and microfossils found here will help researchers to better understand environmental changes happening to our world.

Because the cave's entrance lies at over 3,000 metres, weather conditions present difficulties and attempts to explore the abyss have failed. Finally, after two decades, the team, equipped with a Leica Geosystems laser scanner and Leica Cyclone software, could document the inner most chamber.

A first attempt in the 1990s was broken off at a depth of 70 metres, due to melting glacial ice water. The second attempt in 2010, was completed with difficulty, and the inner shaft was only partially documented.

Recently, Francesco Sauro and Alessio Romeo, geologist, speleology instructor and one of the two photographers at the cave, organised a team of geologists, equipped with Leica Geosystems products, to be lowered 284 metres into the abyss.

On October 15, 2015, despite 70 centimetres of fresh new snow and a two day wait, a helicopter brought 18 participants up the mountain to the abyss. A platform was installed within the cave and the scanner placed on it to ensure data of the highest precision. Because of Cyclone's ability to seamlessly stich together large amounts of data, the team was able to complete scanning the 2,700 m^2 area with over 200,000 m^3 volume in just a few days.

Tommaso Santagata, 3D technician, cave specialist and responsible for the La Venta project topographic survey and monitoring says, "Considering the size of this area, Leica Geosystems equipment and software helped us to obtain highly precise data incredibly fast." The team also used Hexagon's 3D Reshaper software to create surface models of the highly complex 3D geometric wall surfaces.

"The data obtained from the 3D laser scans enabled us to analyse the surface and ice layers of the walls in exact detail. 3D Reshaper enabled us to turn the pointcloud into a surface, giving us a detailed analysis of the surface. From this, we could calculate the volume of the chamber as well as make sections and contour lines," explains Tommaso.

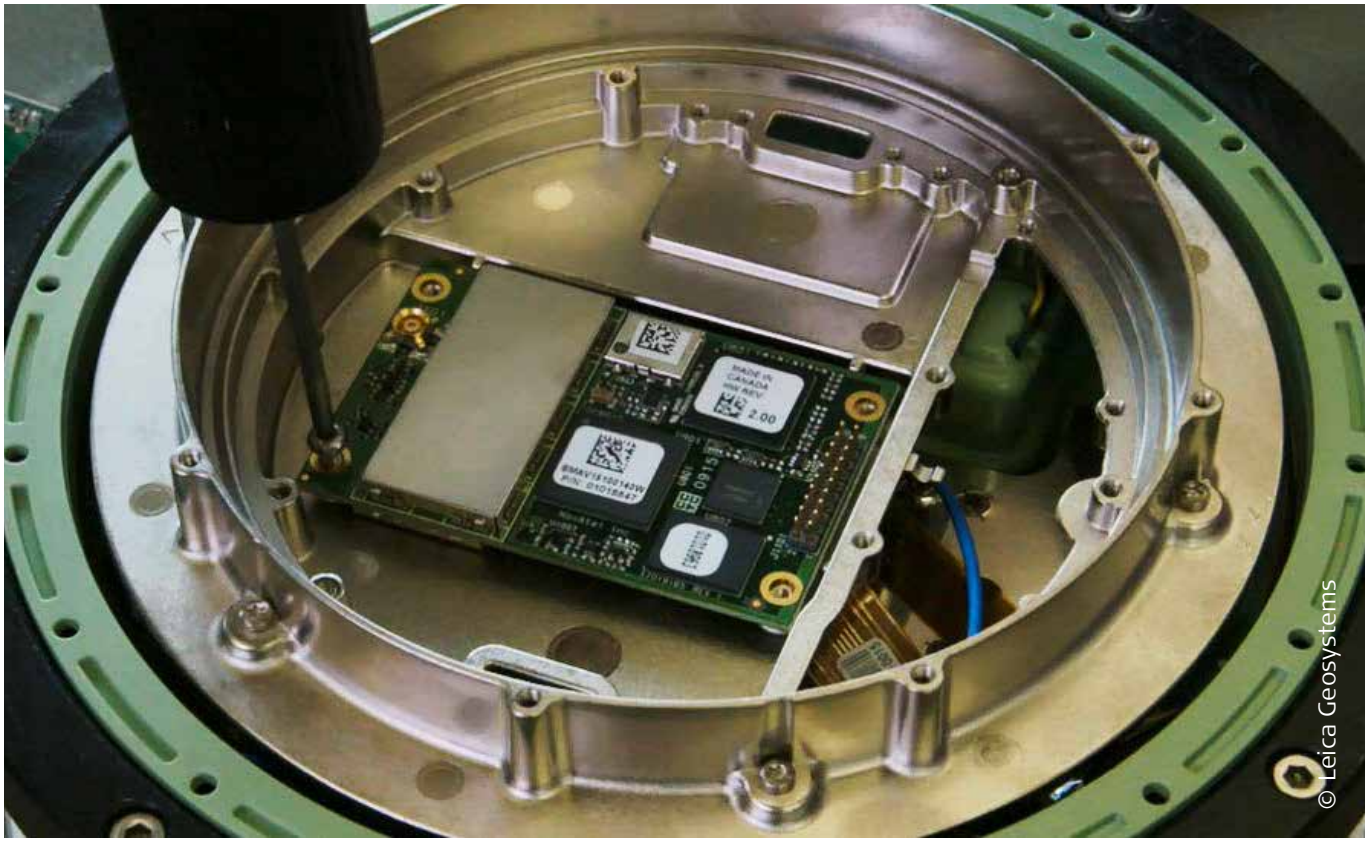
Both Earth Sciences departments at the University of Bologna and Innsbruck supplied very helpful advice. The data collected by the Leica Geosystems laser scanner and processed by Cyclone software will be analysed and compared with over 20 years of data acquired since the abyss was discovered. These scientific finds will be published when completed.

Tommaso concludes, "The scans acquired are the fundamental basis for future comparisons and studies. The floor of the huge final chamber is glacier rock and its surface is expected to evolve because of important climate changes in the coming years."

Written by Bernhard Richter

FUTURE-PROOFING WITH GNSS

In 2003, the European Union (EU) and the European Space Agency (ESA) agreed on the joint Galileo navigation programme. Back then, the EU comprised of 15 Member States, and this figure is not the only one to have almost doubled in the interim.



The ambitious target of having a functioning equivalent of the U.S. GPS by 2008 was deferred year after year for a number of reasons, primarily, albeit not only, due to difficulty in justifying its financing. The financial and banking crisis of 2007, triggered by the housing bubble, resulted in government debt crises and has delayed the programme ever since. Now, it seems, the conditions surrounding the Galileo programme have stabilised, which is clear to see in the nine Galileo satellites that are currently active.

At the annual meeting of manufacturers and the European GNSS Agency in November 2015, six new satellites were announced for 2016, along with eight further additions in the following two years. This rapid expansion means that users will soon have significant improvements in the availability of positions in difficult conditions. Galileo's full operational capability (FOC) of 30 satellites by 2020 appears to be safe, as it is unlikely that the assured budgets (2 billion Euros for deployment and 3 billion Euros for operation until 2020) will be withdrawn.

The Chinese BeiDou system has offered a navigation service since 2000, but the speed at which the system has been developed recently has surprised all the experts. As if that isn't enough, Ran Chengqi, Director of the Chinese Satellite Navigation Office, announced an accelerated expansion, with 35 satellites in total and 27 globally available satellites by 2017, rather than 2020 as planned. In many areas of the globe, BeiDou is well established for high-precision navigation and surveying.

Whether GNSS innovations will slow after the completion of Galileo and BeiDou can of course only be estimated and sketched out using GPS. The original, purely military GPS is in a different life cycle and shows how systems can be operated successfully. For years, only worn-out satellites have been replaced with newer generations. A pro-active approach, having sufficiently modern satellites with GPS L5 available as quickly as possible, falls victim to a cost-benefit approach. The lifespan of Block II satellites is also far exceeding expectations and further slowing the pace of the GPS modernisation.

NEW HIGH PRECISION RECEIVERS BRING OPPORTUNITIES

It is well established that GNSS modernisation is exclusively subject to military, political and economic interests. GNSS has never been developed as rapidly as it is today. By 2020, the completion of four fully-fledged global navigation services should be secured, which will significantly improve the performance of compatible and intelligent GNSS receivers.

It is very difficult for GNSS users to get an overview of the complex nature of GNSS modernisation. How can they be sure their GNSS receivers will still be functioning optimally in five years' time? The best case

scenario would be a GNSS receiver, which would provide maximal flexibility when signal structures change.

Legacy Leica Geosystems GNSS receivers, which support future-proof technology, will be used optimally up to and beyond 2020. Many of the models currently available are already supporting Galileo and BeiDou.

NEW LEICA VIVA GS16 GNSS SMART ANTENNAE FUTURE PROOFS BUSINESS

When developing the GS16 GNSS Smart Antennae, Leica Geosystems pursued the goal of being a technology leader in terms of future security. They continue to forge new paths, in regards to using current signals, and always provide users with a higher-performance GNSS measuring system. The 555 channels of the Leica GS16 are able to theoretically track up to 250 satellites and ensure compatibility with all currently recognised and planned signals.

However, it is not 100 percent certain that the proposed signal structures of future satellites will not change. Conceptually, the GS16 is unprecedented, with improved signal compatibility, sensitivity and quality. I am convinced that many GS16s, with their 555-channel GNSS receiver module, will still be being used in the field in 2030. The high degree of flexibility of the application-specific integrated circuit (ASIC) and the opportunity to make further developments available via software upgrades will ensure compatibility with new signals.

Asking "can my GS16 GNSS Smart Antennae track this signal or that signal simultaneously?" is unnecessary. The answer is simply 'yes.' In the unlikely event that the ASIC is unable to receive a signal due to an unforeseeable signal change, the aforementioned future-proof concept serves as a point of reference. The proven future-proof concept has enabled the simple, cost-effective replacement of receiver modules for almost 10 years, while still keeping the measuring instrument.

LESS CAN BE MORE

The more signals that can be simultaneously received and the higher the receiver sensitivity, the higher the level of measurement noise. The stated objective in creating the GS16 was to develop a dynamically and automatically adjusted receiver that selects the best signal and retrieves the best of multiple frequencies from all GNSS systems for the situation in real time.

For example, the large number of channels enables the simultaneous measurement of different modulations on the same carrier frequency. The simplest illustration of this is the simultaneous use of L2C and L2P on the L2 carrier frequency. Both signals are compared and an ad hoc decision is made about whether the more exact L2P, the stronger L2C or both signals should be used. Signals that are too weak can also have an adverse effect on the result – less can in fact, be more.

This intelligent technology, which enables the best signal to be selected according to application, is called RTKplus. Essentially, RTKplus consists of an improved GNSS antenna, a new GNSS measurement engine and a new RTK algorithm, which work in harmony and have only one objective: to determine the best position from a maximum number of observations.

INCREASING THE STABILITY OF RTK CORRECTION DATA

The optimal use of signals can sometimes not be enough to achieve the maximum availability of an exact position. The stability of receiving RTK correction data is a major focus here. Leica Geosystems is also forging new paths in this field with the help of SmartLink technology.

Interruptions in RTK correction data, mostly caused by a loss of mobile communications, can be bridged by geostationary satellites using extra-terrestrial correction signals. This can ensure a positional accuracy of around 3 centimetres (2D). The temporary or permanent bridging of RTK correction data loss is automatic and works in all overarching reference coordinate systems, like the ETRS89, ITRF2008 or NAD83.

These new RTKplus and SmartLink technologies are referred to as intelligent and self-learning. The new self-learning GS16 automatically adapts to different conditions. It calculates a robust and most accurate possible position from the best available signal combination and optimal RTK correction data. If the introduction of both the first civil GPS receiver, the WM101, and RTK systems are seen as milestones in the 30-year history of GNSS, then the self-learning Leica Viva GS16 Smart Antennae with RTKplus and SmartLink is a further forward-looking landmark in this still short history.

A version of this story first appeared in VDV Magazine at http://www.vdv-online.de/magazin.html.

Written by Monica Miller Rodgers

MEASURING FOR THE GOLD

The athlete paces, eyeing the track before him. He sees each step he'll take in his mind. He imagines reaching the white line and leaping, stretching his long legs out in front of him as far as possible. He can already feel the grainy sand spraying up around him as he lands. He takes the starting position and waits for the sound of the gun.

At the other end of the 400-metre track, a technician prepares to capture the results that will determine the placement of the athlete. Will he have jumped a far enough distance to be victorious? Or, will he have just missed the mark by mere millimetres? This winning or losing in track and field is determined using Leica Geosystems measurement technology.

A GLOBAL COMPETITION

For the past 42 years, world-class athletes from around the globe have gathered at the premiere European track and field event in the Voralberg region of Austria at Götzis to compete in more than 40 events. Athletes compete in the decathlon or heptathlon and collect points here to go toward their yearly total for the parent competition.

"Götzis is the best individual and most traditional meeting in the Combined Events Challenge of the IAAF (International Association of Athletics Federation). In the ranking of all Challenge Meetings, it can compare with the Olympic Games and world championships," said Walter Weber, Hypomeeting athletes manager. "Three world records and a uncountable number of national records were set in the last 42 years of this meeting."

Leica Geosystems total stations have historically been used at the meet to measure the distance in the long jump and the throwing events of the shot put, javelin and discus. Critical to the competition, the high accuracy of these total stations is depended upon to provide the results correctly and quickly.

"Before we started using the total stations, we had to hand measure each event with tape. This slowed down the events and always left too much room for error," said Hans Aberer, Hypomeeting technical director. "With Leica Geosystems total stations, we have been able to speed up results reporting to mere minutes, and we trust the good quality we are able to provide in those results."

JUDGING SPORTS EVENTS WORLDWIDE

From the Olympics to local clubs, Leica Geosystems measurement technology provides accurate results in precision efficiency. When judging sporting events, such as Hypomeeting, the speed and accuracy of measurements is crucial for keeping the event on schedule and providing correct results.

Leica Geosystems' Leonhard Koepf, senior product manager, and Gian-Philipp Patri, applications engineer,

© Juergen Margreitter

understand just how calculated these measurements need to be made. As members of the Measurement Team for the Hypomeeting, part of the Leica Geosystems community relations programme, the two spent the recent spring weekend taking anywhere between 500 to 600 measurements with the new Leica TS16 total stations for the meet. They kept constant track of the distances of jumps and throws for the 30 athletes in the competition using 360-degree mini prisms for faster calculations without the need for repeated aiming.

"The judges in these competitions are not necessarily measurement professionals, and making the process simpler for them is important so they can focus on determining the winner," said Koepf. "With the ability of the TS16 to stay locked onto the prism and the total stations automatically inputting results into the review system on the field, the judges can quickly make informed decisions."

Another important aspect of the measurement process is not getting in the way of the athlete's focus. From the zero line to where the athlete or the object he has thrown lands, the measurement technician must take extreme care not to interrupt the athlete's progression while keeping the line of sight clear of obstructions.

"These men and women come out here, and they are zoned in on what they have to accomplish. We can't be in their way, breaking their concentration with our measurements," said Patri. "With the GRZ101 360-degree mini prisms, we don't have to keep walking back to the pole and turning them. We stay out of the way and quickly provide the measurement without distracting the athlete or slowing the event down."

Canadians Damian Warner and Brianne Theisen Eaton took the tops scores for the decathlon and heptathlon, respectively, for Hypomeeting 2016.

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Written by Staff

OPENING THE WORLD'S LONGEST, DEEPEST RAIL TUNNEL WITH PRECISE MEASUREMENT

Surveying and monitoring systems made the construction of the Gotthard Base Tunnel in the Swiss Alps possible. The tunnel was inaugurated June 1, and the breakthrough on October 15, 2010 was due to highly precise surveillance and monitoring technology. The 57-kilometre long tunnel is the longest and deepest rail tunnel in the world.

Drilling a 57-kilometre long tunnel starting from both sides of the mountain and meeting in the middle with barely any deviation was a truly challenging task. Highly precise measuring instruments were needed to successfully accomplish the project.

MEASURING DOWN TO MILLIMETRE ACCURACY

At the tunnel site, the surveying consortium VI-GBT started measuring in 1996, when construction work began 20 years ago. The surveying engineers set up a basic network with 20 reference points. For this task, they used total stations, or optical measuring devices, and GPS, or satellite navigation solutions from Leica Geosystems, a global company with Swiss roots and a tradition of nearly 200 years.

The drilling began not only at the north portal at Erstfeld and at the

south portal at Bodio, but also at three intermediary points where side channels joined the main tunnel: Amsteg, Sedrun and Faido. In Sedrun (1,405 metres), a vertical tunnel 800 m long was drilled down to the main tunnel so construction workers could push north as well as south from that point.

During tunnel construction, surveying and measuring tasks had to be repeated every 400 metres. In order to make sure the tunnel was precisely on course, the surveyors had to check coordinates of the reference points. In addition, the exact height had to be measured with levelling devices – also from Leica Geosystems.

"When we broke through in the middle of the tunnel on October 15, 2010, the two tunnel sections met with a deviation of only 8 centimetres, whereas 25 centimetres would have been tolerated," said Ivo Schaetti, a surveying engineer at VI-GBT. He explains that surveying tunnels is very demanding due to temperature changes, humidity and dust.

"Thankfully, we could always rely on the accuracy of the surveying solutions from Leica Geosystems," Schaetti adds. "They are very precise. You can measure a distance of 400 metres with accuracy of less than a millimetre."

MONITORING THE DAMS ABOVE THE TUNNEL

During the entire construction period, the surroundings of three artificial lakes above the tunnel required monitoring: Curnera, Nalps and St. Maria. There was a slight probability that the construction of the tunnel – 1.4 kilometres underneath the lakes – would affect the stability of their dams. This monitoring was also done with instruments of Leica Geosystems. The fully automated devices monitored the dams throughout the entire tunnel construction from 2000 until 2015.

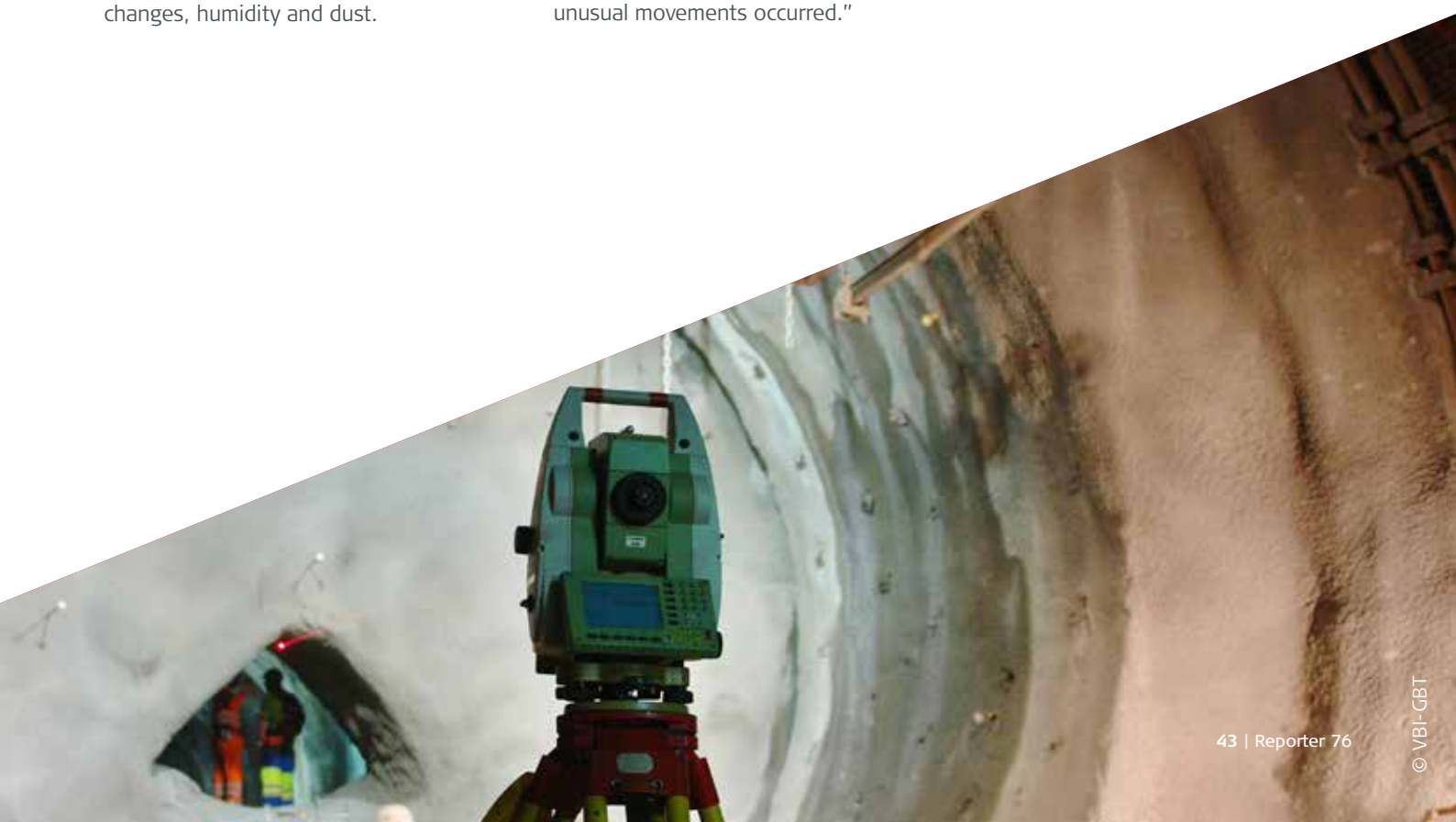
"Our total stations monitored the tiniest movement of the prisms that were mounted near the dams," says Falko Henning, Leica Geosystems product manager. "Happily, no unusual movements occurred."

There was no major delay during the construction, and the inauguration was held on schedule.

A SWISS TRADITION

Leica Geosystems has a rich history in Switzerland. From its origins with Kern & Company founded in 1819 in Aarau, today the industry leader in measurement technology operates globally serving customers in many segments, including engineering, construction and mining.

"Looking back on a tradition of nearly 200 years, we're honoured to once again take part in a significant milestone in Swiss history by providing the surveying and monitoring resources to successfully open the Gotthard Base Tunnel," said Juergen Dold, Hexagon Geosystems president and Leica Geosystems CEO. "With a commitment to Swiss quality and a global outlook, we will continue to innovate and support professionals around the world achieving feats of engineering like this tunnel."



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Written by Christine Grahl

SWEET SUCCESS IN PLANT DOCUMENTATION

With the capacity to slice 22,000 tons of beets a day and produce over 1 billion pounds of sugar annually, the Michigan Sugar Co. is the third largest sugar producer in the United States. Its factories, which were built between 1889 and 1902, dot the Michigan landscape, providing employment to many people. During peak processing season, more than 1,000 grower-owners and 1,600 workers support the company.

Over the decades, Michigan Sugar has installed an assortment of machinery updates and additions in its Croswell, Michigan, USA plant. The company has also augmented operations with auxiliary buildings that house new machinery. Each time project managers have carved out space for the equipment and related piping, the plant has become more congested and complex. Until recently, as is typical in many factories, plant documentation had not kept pace with the ever changing environment.

PLANNING FOR A TANK REPLACEMENT

When Michigan Sugar Co.'s management decided to replace an evaporation tank that spans three stories inside the factory, the project engineer, Chris Schanbeck, knew careful planning was in order. In the past, to design the new structure and guide a project plan, his team might have updated old drawings of the facility with hand measurements of the planned installations. He knew, however, that inaccuracies and omissions in the as-built data could lead to unexpected equipment clashes and misfitting parts. The result would likely be field rework, increased costs and project delays.

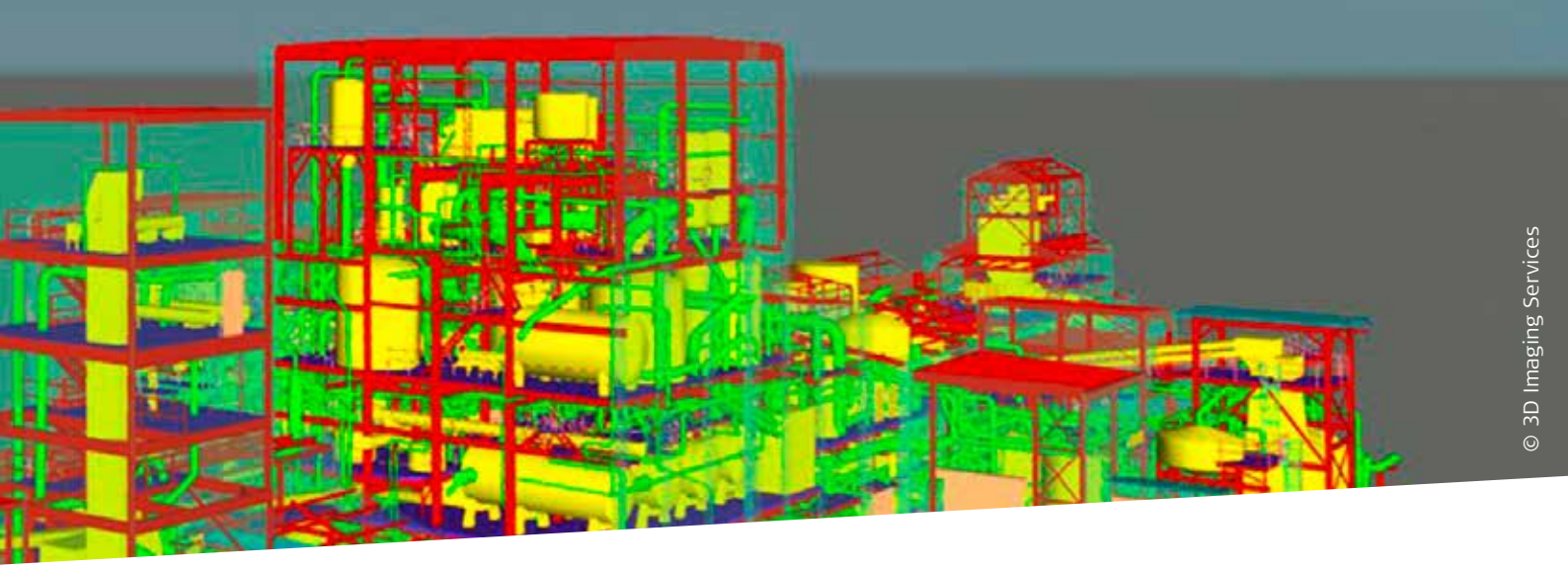
To ensure a sound design, Schanbeck needed a comprehensive, accurate, up-to-dat4e as-built model of the interior of the factory that would provide guidance for fabricating systems and components for the new tank and its structural steel support. A comprehensive model would also enable the team to plan how to move support equipment, such as pumps and piping, that was required to install the new tank. And it would allow designers to model how best to reroute and connect the labyrinth of piping after installing the new tank.

When Schanbeck researched his options for creating such a model, a colleague referred him to 3D Imaging Services in Flint, Michigan, USA. The company provides technology solutions that include 3D laser scanning and as-built modelling. Schanbeck believed the firm's 3D laser scanning capabilities would allow Michigan Sugar to produce the most precise, detailed model possible. Michael James, project manager at 3D Imaging Services, headed up the project. "The project was already in the planning phase and Michigan Sugar needed a way to capture existing conditions rapidly, so time was of the essence. Because of this, we chose the Leica ScanStation P40 to document the plant. It enabled us to reduce both field time and processing time," he says.

EFFICIENT, ACCURATE DATA CAPTURE

Schanbeck wanted to ensure the laser scanned model would provide the level of detail required and would be easy to manipulate. So 3D Imaging Services conducted a pilot project that involved laser scanning for a process equipment retrofit using the ScanStation P40 and creating an as-built model of it. This test application showed that laser scanning was the most efficient, accurate method of capturing the complex conditions of the sugar processing facility.

James explains the firm chose the ScanStation P40 because of the need to obtain accurate, comprehensive data and transform it into the required as-built model rapidly. By recording everything within



© 3D Imaging Services

its line of sight at a rate of up to 1 million points per second and producing a point cloud, this laser scanner empowered a crew of two to document the plant in one day. In that time, they were able to capture the data from 65 scan positions. James explains, "One person could have physically accomplished the job, but we used two to ensure safety."

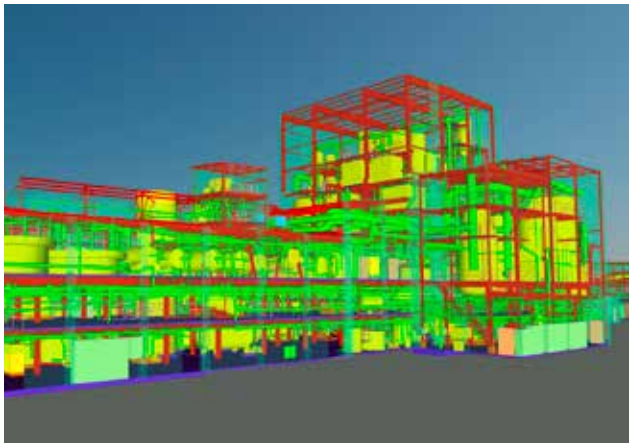
Also, the ability of the ScanStation P40 to put data into a coordinate system saved time and money because there was no need for a separate crew to carry survey control into the plant from the elevation reference point outside. After the team had established that reference and other reference points throughout the factory, it was easily able to tie the point cloud data to them. Finally, workflows from the scanner to Leica Cyclone software were seamless, enabling 3D Imaging Services to register the required elements of the model efficiently and accurately.

TIME AND COST SAVINGS, PLUS BETTER INFORMATION

Without laser scanning, Michigan Sugar would have had to take manual field measurements, and the documentation process would have required almost two weeks to complete. According to James, for the field documentation alone there was a cost savings of 68 per cent. Total savings, of course, go beyond that because manual measurements could have introduced human error, leading to construction clashes and rework. Industry-wide contingencies for rework on plant data gathered manually typically run from 12 to 30 per cent of total project costs, eating up time and money.

With the data from the laser scanner, all equipment and systems, not just a few chosen plant elements, were captured to within a millimetre of accuracy. Data processing was also fast and cost effective because the team paired the ScanStation P40 with Cyclone software, which work seamlessly in unison. This marriage of software and hardware made it easy for in-house engineers to extract, analyse the data and create a 3D model in AutoCAD® of all architectural, structural and mechanical systems. "Because we controlled all aspects of the project in one software package," explains James, "we did not have to import and export data from various software packages, saving us a lot of time."

The survey team also published Leica TruViews, dimensional photographs overlaid on top of the point cloud data, which people can view in Leica Geosystems' free TruView panoramic viewer. Even though they did not have in-depth knowledge of point cloud software, the professionals at Michigan Sugar were able to review the data and assess site conditions easily with the TruViews. Schanbeck has found the model so useful in helping engineering teams with their design work that he plans to use laser scanning to document the entire facility, facilitating future equipment modifications and additions.



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NEWS

WORLD'S FIRST HYBRID AIRBORNE SENSOR

Leica CityMapper, as part of the Leica RealCity airborne reality capture solution, enables professionals to collect and process imaging and LiDAR data with a single sensor and software. Combining CityMapper and Leica HxMap, the scalable post-processing workflow software, RealCity simplifies and streamlines the creation of all 2D and 3D geospatial information layers.

HEXAGON ACQUIRES IDS GEORADAR DIVISION

IDS GeoRadar Division provides mining and geospatial industries with innovative radar solutions for structural health monitoring and underground utility mapping. GeoRadar's structural health monitoring solutions enable engineers to remotely monitor movements and vibrations in real time. Underground utility detection solutions provide dimensional information.

UNCOVERING THREATS FOR INCREASED SAFETY

The Leica DS2000 utility detection radar identifies all potential threats, including plastic and all nonconductive pipes and fibre optics, increasing safety by lowering the risk of accidently hitting underground assets. Collecting twice the information in half the passes, data is collected with dual-frequency antennae that locate deep and shallow targets at the same time. With or without GPS, utility location can be accomplished on-site with no post processing needed.

HIGH PRECISION SAVES COSTS WITH SMART ONE-MAN OPERATION

Smart Targeting function enables automatic aligning of the vertical laser beam from the Leica Lino ML180 via the laser receiver in the remote control. Users no longer need to walk back and forth to continuously check alignment positions. Workflows are optimised, resulting in time and cost savings.

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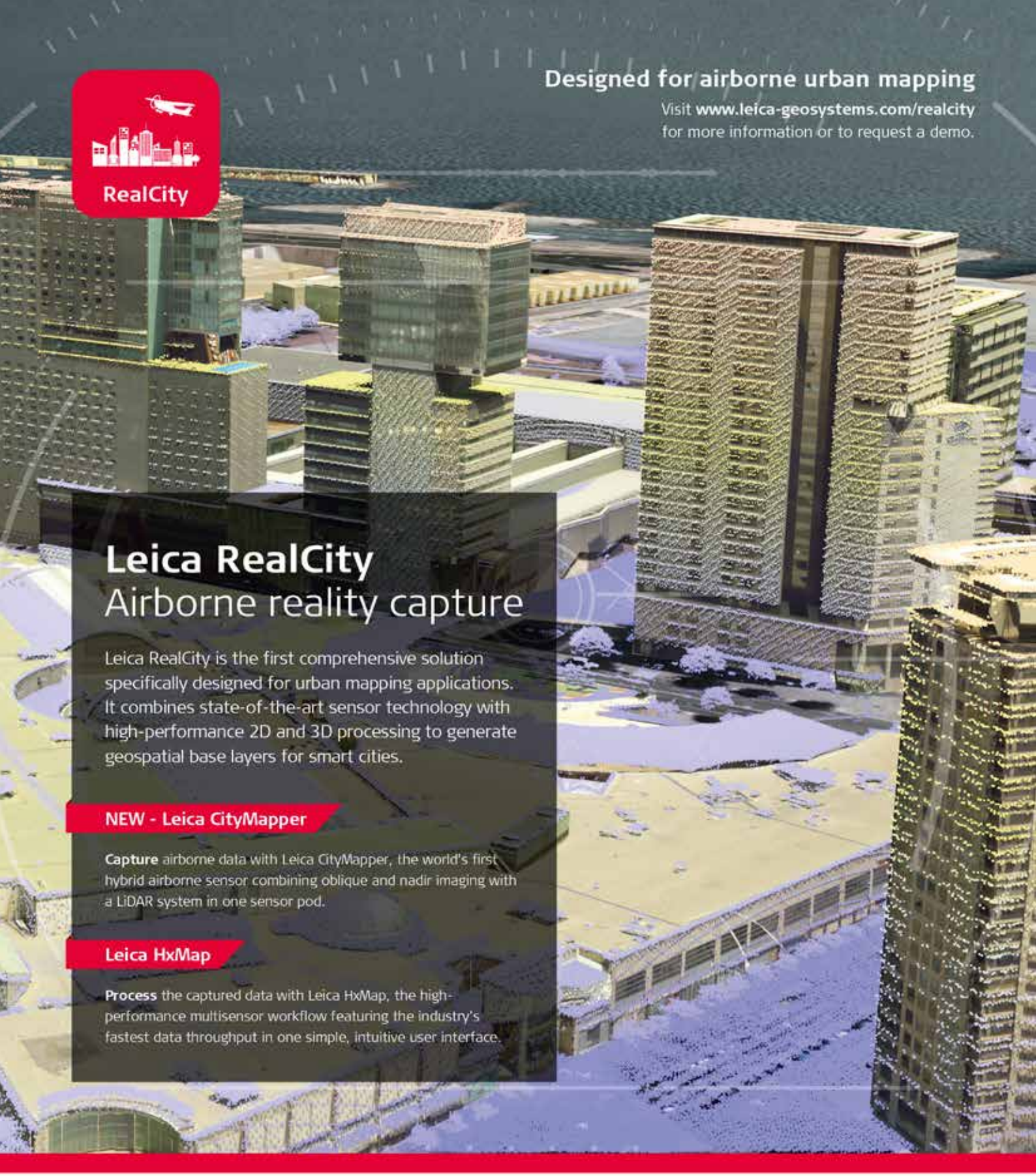

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