REPORTER

HEXAGON
GEOSYSTEMS

CONTENT

President's Message

When a business digitises, it becomes more efficient in how it produces, shares and evaluates information. When it digitalises, though, it undergoes a transformation to become a connected ecosystem. This transformation through digitalisation is the focus for this edition of *Reporter*.

The heavy construction industry is finding efficiencies and productivity through the use of the global GNSS correction service, HxGN SmartNet. Heavy machine operators in Denmark share how the digitalisation of the industry is increasing their bottom line and making their work easier.

The Rail Division of Atkins, the design, engineering and project management consultancy, is not only connecting its business through digitalisation but also bringing more efficient public transportation to London on a major upgrade project to the rail infrastructure leading into and around the capital city. Using a combination of Hexagon Geosystems measurement solutions, from GNSS to digital levelling, the company was able to provide quicker data visualisation and safer operations to the government entity responsible for the project.

The European gas infrastructure company providing the transport of natural and green gas in the Netherlands, Gasunie, found transformation through the integration of several Geosystems technologies. Creating a connected ecosystem of customers and subcontractors, Gasunie made laser scanning data available directly from the field to the stakeholders through laser scanning, immersive software and remote access platforms.

Transformation through digitalisation is how business and industries advance. Connecting is how we ensure we remain relevant and aren't left behind.

We're committed to bridging the gap from digitisation to a digitalisation transformation. We vow to keep innovating to move ourselves and the industries we support forward.

Enjoy your read.

Jürgen Dold

President, Hexagon Geosystems

© Gasunie

FROM THE LASER SCANNER TO OFFICE IN NEAR REAL TIME

Joost Assendelft

Case Study

Using 3D laser scanning to revise the gas transport network in the Netherlands

© Gasunie

To move gas safely and reliably to the end consumer, the Netherlands has a high-quality gas transportation network. For undisturbed gas delivery, it is important that the network is always in excellent condition. Therefore, Gasunie, a European transmission system operator that provides the transport of natural and green gas in the Netherlands and the northern part of Germany, performs daily management and maintenance work to the main gas transportation network and to the regional gas transportation network.

The network in the Netherlands includes:

- 12,500 kilometres of pipeline
- 3,000 valve schedules
- 80 measuring and control stations
- 1,000 gas receiving stations
- 13 compressor stations.

During the execution of maintenance and replacements, the delivery of gas to end customers continues. It is, therefore, a challenge to cause as little inconvenience as possible. For this reason, Gasunie first makes a detailed design of the pipes. Based on the design, the new components are prefabricated, so that the installation work in the field takes as little time as possible.

Combining multiple Leica Geosystems solutions that make laser scanning data available directly from the field to the customer and subcontractors, Gasunie can now save time and money with their re-designed Leica HDS workflows. Before integrating Leica Geosystems solutions, the time to deliver the as-built situation took quite long – now, a precise as-built model is ready within 24 hours.

THE MIX AND MATCH SOLUTION

To accelerate and improve the overall process, a pilot has been conducted in combination with Advin advisory and engineering firm using 3D laser scanning. The working process has been reviewed and innovative steps have been taken in the data processing by using Leica JetStream software for simplified point cloud access and ultra-high speed rendering.

After the design, prefabrication and transport of the parts, the new installation is assembled on site. This installation is checked using a Leica Viva GS16 GNSS Smart Antenna and a Leica Nova MS60 MultiStation linked to a CS35 tablet computer with Leica Captivate software. Inside the Captivate software, the Inspect Surface app looks at whether there are deviations between model and as-built situation and will determine whether the new situation meets the requirements of Gasunie.

The entire installation is mapped either with the MultiStation or with a Leica ScanStation P40.

This measurement is processed and checked in the field and uploaded directly to JetStream server via a mobile 4G connection on the CS35.

“The system Leica Geosystems has developed fits optimally to optimise our workflows. From the design to the final stage of a construction, this method of working reduces time and, therefore, saves money. In particular, the saved point cloud as asset information during the construction phase may become useful many years later. We are furthermore capable to scan brownfield assets and transform this to real 3D-asset information with new (future) functionality,” said Sijbrand Stratingh, senior pipeline engineer at Gasunie.

BENEFITING FROM THE INDUSTRY-LEADING POINT CLOUD PROJECT SERVER

The use of JetStream server has a number of important advantages. The data is centrally available in the cloud so engineers involved can directly access the data. Because the point cloud is available online, Gasunie can also access this data directly via TruView Global and/or JetStream viewer. The firm can then use the point cloud for discussions using digital reality, making better informed decisions if needed.

The smart point cloud technology in JetStream allows data to be viewed and used without delay via an online connection without missing any detail. There is only one version of the point cloud and, therefore, only one backup has to be made. Unnecessary copies belong to the past.

THE SELECTED CHOICE WHEN IT HAS TO BE RIGHT

Thanks to Leica Geosystems combined solutions, the 3D design generated with the point cloud can seamlessly be adapted to the as-built situation. Gasunie no longer has any need to create a completely new as-built drawing from scratch. An update of the 3D-model is sufficient.

“We always strive to work with state-of-the-art hardware and software that can provide the best solution to our customer. The choice for Leica Geosystems, a reliable supplier of high-end equipment, was a clear one. When we really have a problem, Leica Geosystems immediately

provides a solution," said Jeffrey den Ridder, surveyor at Advin. "After measuring the project, the excavated pit is replenished immediately with soil. The measurement must therefore be carried out as efficiently as possible and there is certainly no time for delays caused by defective equipment or technical failures."

After completing these first tests, Gasunie is very positive about the workflow through 3D laser scanning and instant online sharing of data through Jetstream in the cloud with Autodesk® AutoCAD® Plant 3D.

© Gasunie

MEASURING HIGH IN PORTS

Arno Kijzerwaard

Case Study

Tracking accurate measurements for crane operations around the world

© Langeveld Cranes

In a world where cargo transportation by means of intermodal containers keeps growing in volume, ship sizes show a steady increase as well. As a consequence, ports around the world have to invest in larger container cranes in order to handle these ships.

These container cranes are increasing in operating speed as well as in their level of automation. Trolley traveling speeds up to 240 or even 300 metres per minute are no exception anymore. On a track of 100 m, these trolleys easily travel more than 10,000 kilometres per year.

One of the key elements to crane maintenance at these high speeds is the wear, caused by the wheel-rail contact of the trolley. Effective prevention of this aggressive form of wear is realised by an accurate alignment of the trolley wheels. On a container crane with a girder height of more than 50 m, however, this alignment procedure puts extreme demands on measurement instruments.

STAYING ON TRACK

Though the alignment measurement of a set of steel wheels on steel rails seems a straight forward activity that could be performed by almost anyone in possession of a theodolite, this proves far less simple when located 50 m high on a moving steel structure in the wind. Not to forget one had to travel half the world to even get there.

The accurate alignment of trolley wheels on container cranes is such a specialty and niche market that the market area is simply formed by ports around world. Langeveld Cranes has almost a decade of development in this technique, bringing it to a whole new level. By now, their estimated amount of successful projects approximates 300 all over the world.

Langeveld has been using a Leica TS30 total station and recently added a Leica Nova TS60 total station to its equipment basket. The TS60 is used in combination with a Leica CS35 tablet computer and Langeveld's own specially developed wheel alignment software.

WORKING IN THE EXTREME

Tolerances for wheel alignment date back to the 1970s. Classic crane design standards all specify maximum allowable wheel angles of 0.4 mm/m. This is, however, not quite the same as describing good running behaviour. By approaching the alignment from the side of good running behaviour, a whole new accuracy level was achieved in the practical end result.

© Langeveld Cranes

This new accuracy level, though beneficial, puts higher demands on the accuracy and reproducibility of the measurements. The total stations have to measure up to the demands over and over again. The work of Langeveld's trolley wheel alignment is so much more accurate than ever specified in the history of crane standards. This in itself is one thing, but it's also significant that this result is always achieved on a height of more than 50 m from quay level on a moving crane in the wind.

Climate is another critical aspect to consider. The temperature working range of measurement equipment is usually one line in the data sheet. Hardly a difficult specification to meet when measuring close to Langeveld's home base in the Netherlands. This becomes a less theoretical value, however, when winter projects in Scandinavia are asked for, followed by tropical destinations around the equator.

After dozens of these projects, the TS30 total station has remained stable. Of course, the instrument is acclimatised prior to each working day. Still, extreme variations of ambient temperature are no longer theoretical values in this line of work.

"In every thinkable climate, all over the world, our Leica Geosystems total stations have travelled to ports on almost all continents, and passed through the hands of custom officials in many countries in Africa, the Middle East, Asia and South America," said Casper Langeveld, owner, Langeveld Project Management. "No matter the form of transport or the environmental conditions, these total stations continue to work and provide us with the measurements we need. We are able to trust the results and ensure quality deliverables for our clients."

NEW TRENDS, NEW NEEDS

Recent developments in crane automation have unexpectedly led to a complete new challenge. The classic crane driver was normally located almost directly above his load. Every move, shock and sound were immediately noticed and

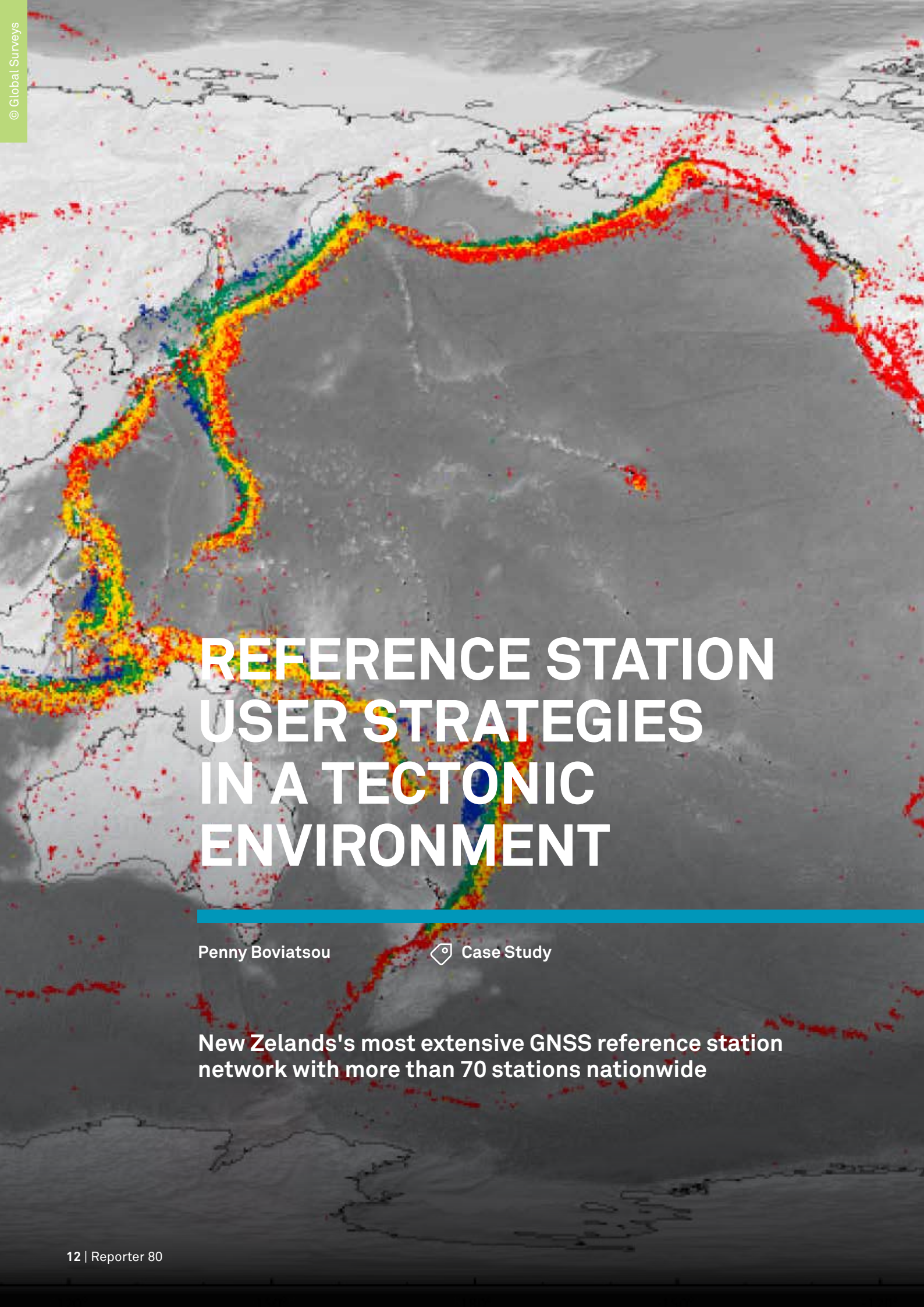
reacted upon. This could be anything between a radio call for a service engineer or, in a worst case, a full crane stop.

The recent trend of increased crane automation and remote control have effectively removed the driver from the crane. This means that there is no direct witness for unusual shocks or noises in the trolley behaviour anymore. Therefore, the trolley must run smoother than ever before, because any deviation in sound or shock will stay unnoticed for a far longer time.

Meeting the international demands and work volume, the TS60 was an easy choice for the firm as a natural successor to the TS30. With ATRplus, the TS60 total station's ability to remain locked on the target is maximised, ignoring other distractions in the field, which can be plentiful in a port.

As Langeveld's own software runs on the TS60, along with the possibility of also using Leica Captivate 3D field software, this is a crucial feature for the firm. This enables the internal communication to the total stations for a cohesive work environment.

"We trust Leica Geosystems' overall robust solutions for our business," said Langeveld. "We make a strong team together for the crane market."

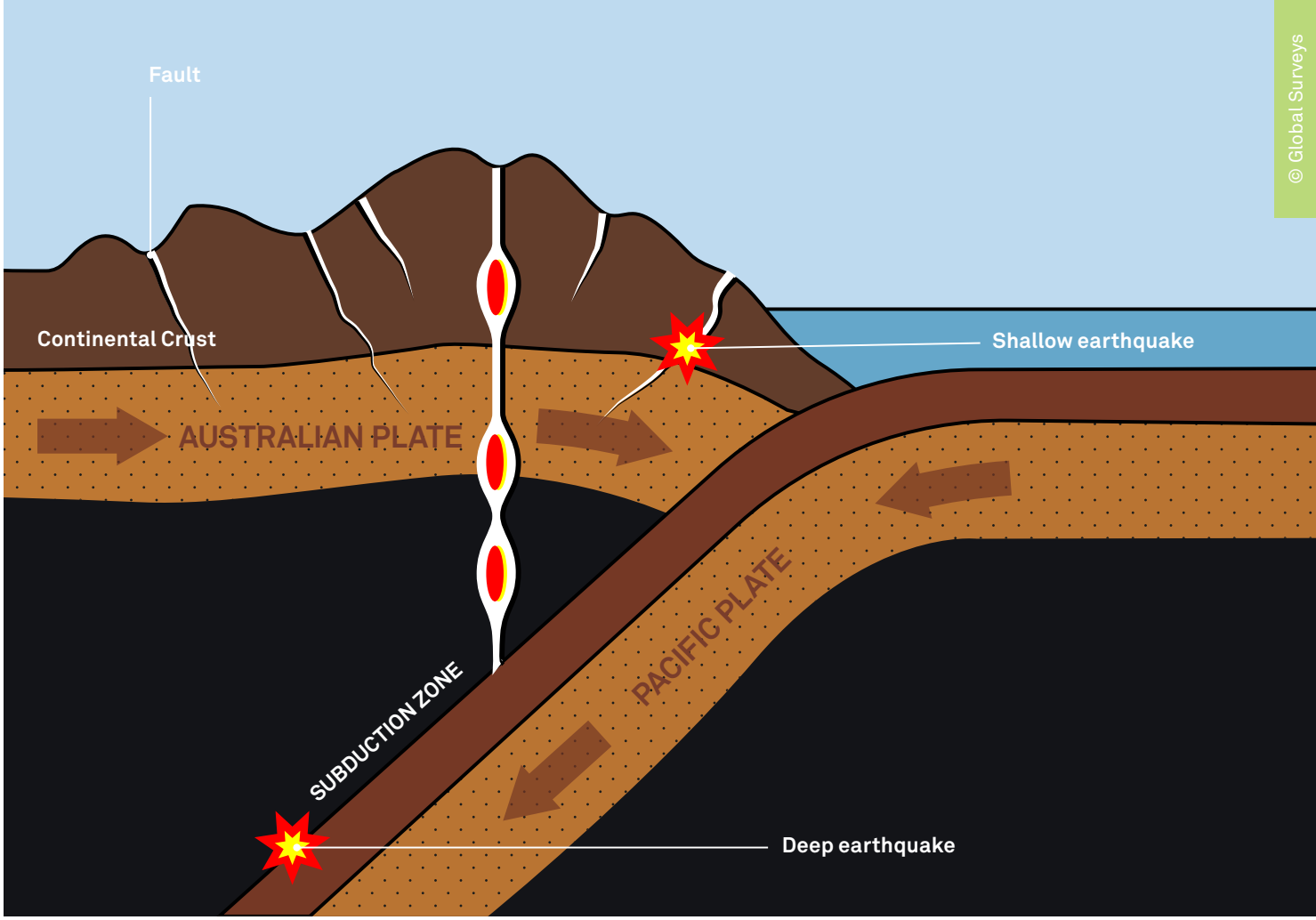


REFERENCE STATION USER STRATEGIES IN A TECTONIC ENVIRONMENT

Penny Boviatsou

Case Study

New Zelands's most extensive GNSS reference station network with more than 70 stations nationwide



Earthquakes are a response to the motion between tectonic plates. As two plates push together at a steady rate, the rocks along the plate boundary become more and more stressed until eventually something has to give — an earthquake occurs along a fault somewhere in the plate boundary zone.

New Zealand lies at the edge of both the Australian and Pacific tectonic plates. The Australian and Pacific plates push against each other along a curving boundary and generally don't move smoothly past each other. They move in a series of small rapid motions, each of which is accompanied by earthquakes.

SmartFix, based on the world's largest reference station network, HxGN SmartNet, is New Zealand's most extensive GNSS reference station network with more than 70 stations nationwide. SmartFix delivers centimetre-level, real-time kinematic corrections, post-processing solutions and sub-metre GIS corrections. HxGN SmartNet is an integrated 24/7 GNSS network RTK and correction service, built on the world's largest reference network, enabling GNSS-capable devices to quickly determine precise positions.

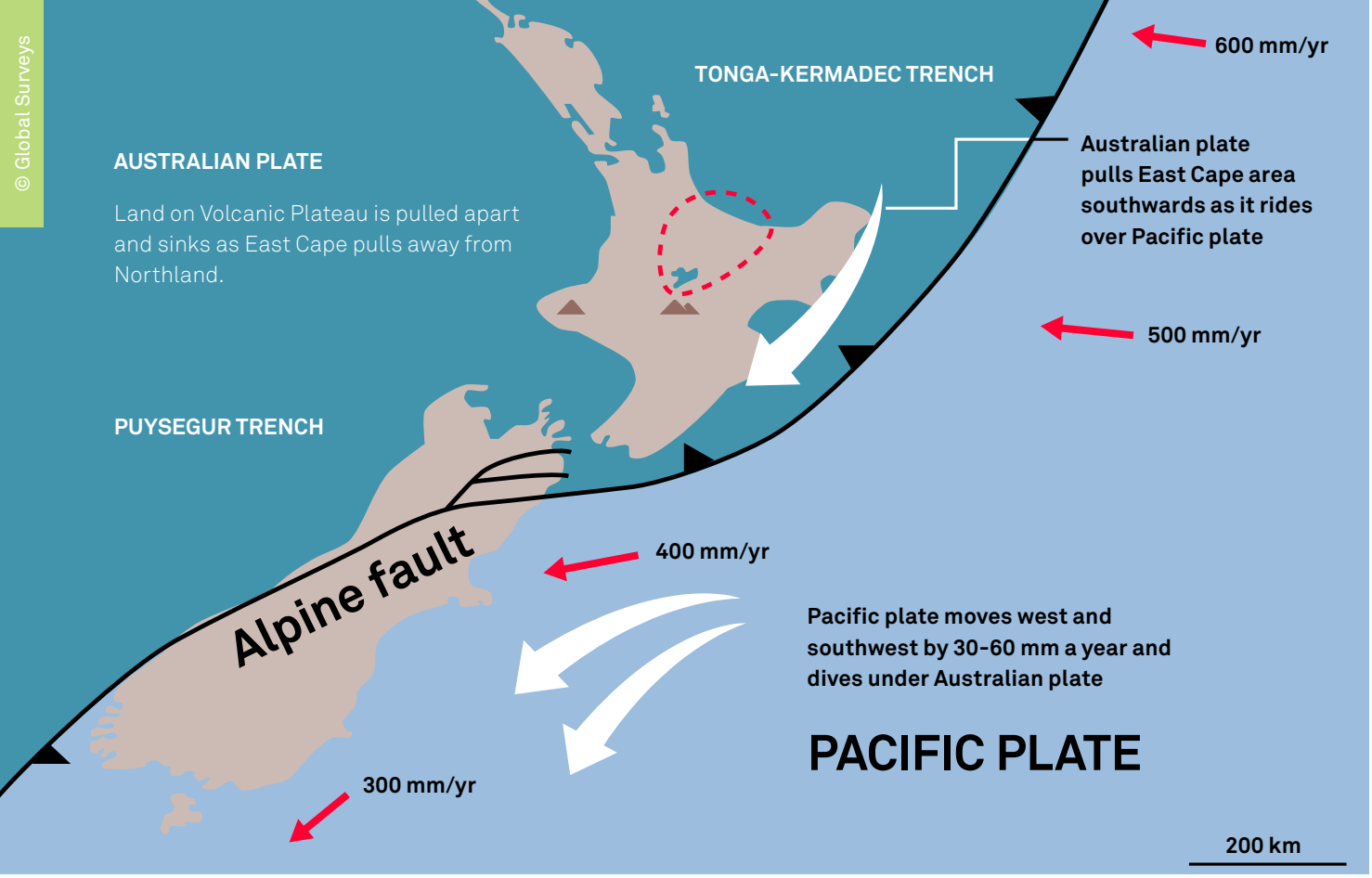
"Providing a real-time kinematic (RTK) correction service over the internet and RINEX files for post-processing, our customers can enjoy the benefits of SmartFix," said Bruce Robinson, director at Global Survey Limited. "If their GPS or GNSS receiver can connect to the internet, SmartFix can deliver the data they need."

EARTHQUAKES SHAKING UP NEW ZEALAND

New Zealand has two types of earthquakes. Deep earthquakes under North Island form a well-defined band (seismic zone) running northeast from Marlborough through White Island. Shallow earthquakes tend to occur to the southeast of this seismic zone, while the deeper ones occur towards the northwest.

The New Zealand GeoNet, a partnership between the Earthquake Commission (EQC), GNS Science, and Land Information New Zealand, monitors all geological hazards in the country, and locates between 50 and 80 earthquakes each day – about 20,000 a year. Earthquakes can occur anywhere at any time in New Zealand.

These earthquakes are continually altering the shape of New Zealand and while a lot of the



movement is small and unfelt, it is continual and the result is perceivable, measurable and locally variable. The measurable and variable part is what the reference station network SmartFix needs to deal with.

There are many examples of rapid movements that combine lateral and vertical movements. Such movements are clearly not uniformed; this variability creates challenges for those who need to establish reliable survey control or those who run reference station networks.

INVESTIGATING EARTHQUAKE ACTIVITY

Even though New Zealand is continuously moving and deforming under the influence of the Australian and Pacific tectonics plates, the country's datum is designed to provide constant unchanging coordinates for features.

Datums define how coordinates, longitudes and latitudes or heights, relate to physical locations. Projections are different ways of representing a position in a datum, for example as northings and eastings used on topographic maps. Together, they define New Zealand's coordinate systems.

To manage this deformation, the datum itself is moving and deforming along with the New Zealand land mass – it is a "plate-fixed" datum.

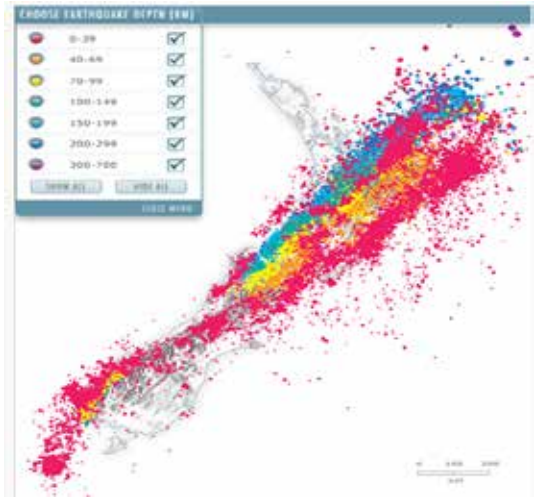
The New Zealand datum is known as NZGD2000, and this datum is based on International Terrestrial Reference Frame (ITRF) 1996 as at the position on the feature on January 1, 2000. Because the datum is deforming, NZGD2000 coordinates no longer reflect the true positions of points relative to one another.

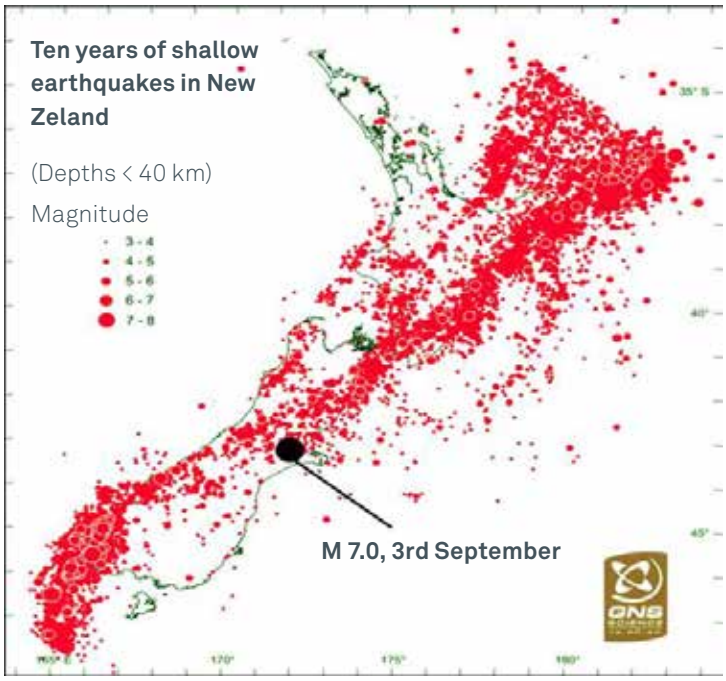
The local area distortion, however, is small, and for most applications, the deformation can be and is ignored. This allow for distances, bearings and areas to be calculated directly from NZGD2000 coordinates. This deformation, however, needs to be continually addressed and managed by the reference station administrators.

The error in ignoring the variation is no more than one millimetre in a kilometre for each year since 2000. A deformation model is periodically applied to account for deformation due to earthquakes, regarding calculating NZGD2000 coordinates, and as the measurement of the deformation model becomes more accurate.

CHALLENGES WHEN RUNNING A REFERENCE STATION IN NEW ZEALAND

The NZGD2000 datum was set on January 1, 2000 – the last time everything fit together nicely. Since 2000, New Zealand has had 17.5 years of differential movement, and while





the coordinates of the mark have not changed, the relative position has. A point surveyed today, from three different reference stations, will likely have three different NZGD2000 coordinates dependant on the reference station used.

"Education of clients is a major part of SmartFix administrator job here in New Zealand, as we are upskilling users to understand the geodetic implications of station selection," said Robinson.

The second challenge is obtaining and choosing the two coordinates for the reference stations that the Leica GNSS Spider reference station software requires. The two coordinates being the current epoch coordinates to ensure the reliability of the network and the NZGD2000 coordinate. The GNSS Spider solution is an integrated software suite for centrally controlling and operating GNSS reference stations and networks and helping to manage complex environments such as New Zealand.

A RELIABLE AND EFFICIENT SOLUTION

Using a network like HxGN SmartNet (SmartFix in New Zealand) saves field crews time as it precludes the setup of separate base stations, and it avoids the risk of having control fail due to a damaged or stolen base and removes the issues of radio interference. Surveyors have long used GNSS networks to save time and money as well as remove potential sources of error.

Instead of carrying around:

- GPS receivers
- batteries and cables
- two radios
- a tripod and a pole
- and setting up their own local base for each project,

network users simply carry a GPS or GNSS smart antenna (rover) with an internal modem or an external mobile phone and use that equipment to quickly access a network of permanent reference stations. The combined data from those permanent stations is used to generate RTK corrections and provide accurate positioning at much greater distances than traditional radio solutions.

"At Survey Global we are committed to the growth of the SmartFix (SmartNet) network," said Robinson. "It enables our customers to get reliable and repeatable NZGD2000 coordinates, despite the tectonic challenges, and for the user it makes them more efficient, allowing them to complete projects on time and on budget."

MODELLING FOR MONITORING – WHEN MILLIMETRES MATTER

Renata Barradas Gutiérrez

Case Study

Collecting point cloud measurements to monitor a hydroelectric plant in Lithuania

Hydroelectric plants harness the power of flowing water; the most extensively exploited renewable energy resource. Our daily activities and economies depend on a constant supply of electricity; hence, monitoring displacements and deformations to prevent problems related with structural failure, cracks or ageing material in hydroelectric plants is of vital importance.

Pumped storage hydroelectric plants are one of the various ways of extracting energy from water. The biggest hydropower energy sources in Lithuania are the Kaunas Hydropower Plant and the Kruonis Pumped Storage Hydroelectric Plant (KPSHP). The KPSHP is a pillar for the Lithuanian energy system that has been successfully supplying energy to homes and businesses for more than 20 years. Located close to the city of Kaunas, this state-of-the-art energy facility is the one of the biggest plants of its type in the Baltic region.

This 900 Megawatts hydroelectric plant is designed to generate electricity, balance consumption by regulating voltage, frequency and load fluctuations, and compensate energy deficiency in case of an emergency situation. According to Lietuvos Energijos Gamyba, the KPSHP covers 6 per cent of Lithuania's total electricity demand and is capable of ensuring 94 per cent of the total necessary energy reserves for Lithuania in case of emergency – a deformation in its structure can be fatal to Europe's Baltic state energy system.

GOING HIGH TECH FOR DAM MONITORING

To monitor KPSHP, UAB SmartOffice surveyed the hydroelectric plant using the Leica Nova MS60 MultiStation to collect measurements and a point cloud of the structure. The 3D data collected allowed UAB SmartOffice to analyse the surface and calculate the verticality of the hydroelectric plant. The model generated with the point cloud will also serve as a reference for future scanning that will monitor the current conditions and deformation of the dam.

"Scanning with Leica Nova MS60 MultiStation has brought more results than expected. Besides 3D scanning up to 1,000 metres, the main benefits were time saving, accuracy and simplicity," said Jonas Varnas, general manager at UAB SmartOffice. "Using the MS60 was as simple as a routine using a TPS but combining the precision of TPS measurements and 3D scanning into one system."

With the MS60 MultiStation, complex sites can be surveyed with overlaid measured points and 3D models in one view, allowing users to perform verticality and deformation checks to identify damage and defects in a more reliable, quicker and complete way. The 3D scan capability of the self-learning MultiStation helps users expand their portfolio of offered services, being able to be used for:

- construction monitoring
- quality inspection
- clash detection
- as-built Building Information Modelling (BIM).

© UAB SmartOffice

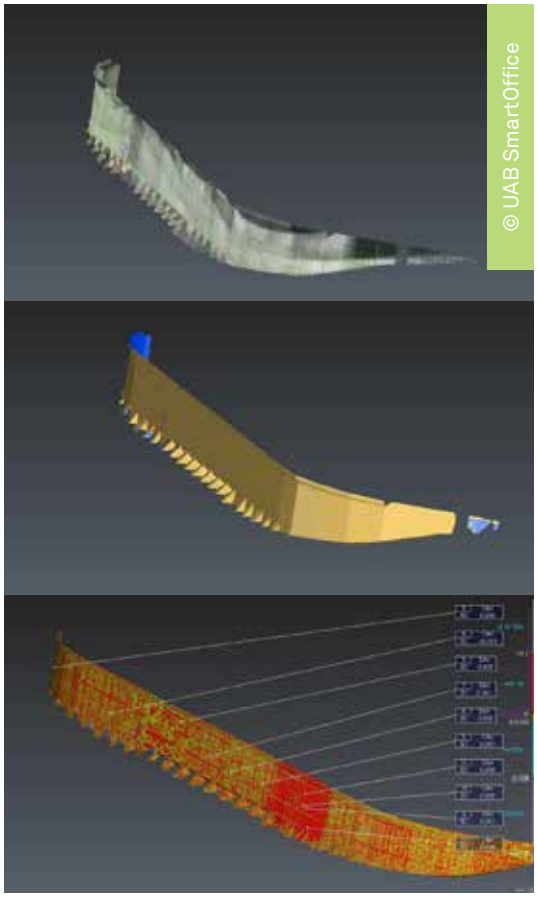
The KPSHP was monitored by geotechnical sensors, so no geodetic equipment was used. In comparison to other sensor technologies where deformation information is limited to few points, the MS60 MultiStation provides the ability to measure a dense amount of points and provide the measurement of displacements in relation to millions of points with overlaid TPS measurements.

INSPECTING AND COMPARING SURFACES

What makes the Kruonis plant special is its ability to operate in pump mode during periods of low demand or as a traditional hydroelectric plant to supply the normal energy demand during the day.

These water level changes in the upper reservoir of the dam can cause deformations. The KPSHP authorities, therefore, were interested in analysing the surface and verticality of the dam, identifying places with deformation and comparing the scanned model with the ideal model.

3D Reshaper, an essential software for surveyors working with point clouds, allowed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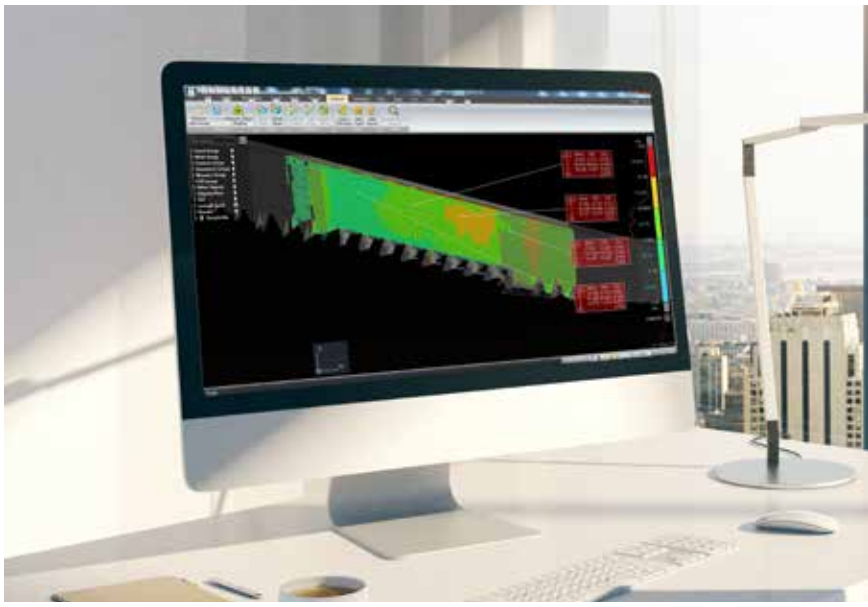
UAB SmartOffice to measure, inspect and compare surfaces displaying deviation information with millimetric accuracy. The modelled surface generated from the point cloud provided an accurate representation of reality to detect millimetric changes in shape for the entire structure.

“3D Reshaper allowed us to do the best shape export, analyse the surfaces with several integrated tools, and permitted our client to inspect surfaces in a very clear way – exactly what our customer was looking for,” said Varnas.



MONITORING MATTERS

In dam monitoring, millimetre precision is required. The consequences of structural deformations in these structures go beyond multimillion costs. Consequently, deformations should be discovered and monitored in a timely manner to ensure a safe operation and usage, and cost-effective construction and management.

IMPROVING THE RAILWAY INFRASTRUCTURE OF A CAPITAL CITY

Staff

Case Study

Measuring for new rail lines in the United Kingdom

With thousands of commuters into the capital city every day, additional trains into London are a plus to help with the heavy traffic congestion.

As part of the Brighton Mainline Upgrade Programme, an additional six trains per hour will be made available during the morning peak. Along with this, the programme would also see four additional services into London with a further two additional trains in 2043. Performance will also be improved through the segregation of flows and contribute toward additional train paths on the route.

Topographical surveys are required for this complex and extremely busy piece of London's railway infrastructure. The programme provides the ideal time to upgrade to newer, faster and more efficient solutions for data capture.

Network Rail, the government entity in charge of the programme, turned to Atkins to perform the surveys.

A MAJOR UPGRADE

Established in 1938, Atkins is one the world's most respected design, engineering and project management consultancies. Working closely with a wide range of clients from different sectors and regions across the public and private sectors and local and national governments, Atkins delivers long-term trusted partnerships to create a world where lives are enriched through the implementation of ideas.

Atkins Rail Division, based in Croydon, Surrey, United Kingdom, has been using Leica Geosystems surveying equipment for almost 20 years. The decision was made last year to replace the majority of the consultancy's trusted but aging fleet of Leica System 1100 and 1200 total stations and to add to the firm's existing GNSS, digital levelling and traversing equipment with the latest Leica Captivate solutions.

This major upgrade saw a broad spread of instruments:

- 1 Nova MS60 MultiStation
- 7 Viva TS16i Imaging total stations
- 4 Viva GS14 GNSS Smart Antenna
- 10 Captivate CS20 controllers
- 2 Captivate CS35 tablet computers
- 2 LS15 auto focus digital levels
- 8 full traverse kits

With the new portfolio, Atkins was ready to take on the important rail project.

SITE LIMITS AND CHALLENGES

To enable the additional programme paths toward London Victoria and London Bridge, there was a requirement to segregate flows at Windmill Bridge Junction. It would support performance improvement on the route through the segregation of key train flows, which currently transfer reactionary delays across the other adjacent lines and the wider South London network.

To achieve additional train stopping capacity at East Croydon, there was a requirement for additional platforms to be constructed. In addition to safely delivering a 12-car train operation between Selhurst and Gloucester Road Junction, infrastructure was required to accommodate a 12-car train on the Selhurst Spur.

As a result, feasibility options were developed to achieve these outputs. The options include:

- Grade separation of Windmill Bridge Junction
- Extension of the Selhurst Spur
- Additional track between Windmill Bridge Junction and East Croydon
- Two additional platforms at East Croydon.

It was identified that work would be required at East Croydon station to safely deliver the required passenger access to new platforms and provide sufficient increased passenger capacity on the concourse.

"As with all railway topographical surveys, the limitations of site access and the nature of railway infrastructure constrains the way we conducted the survey," said Matevz Groboljsek, Atkins Track Team project manager. "This was especially true on a project area of this scale and considering the complex junction and train routing available through the section of the infrastructure."

LEICA CAPTIVATE SOLUTIONS HELPING THE WORLD OF RAIL

With accuracy and reliability paramount in the rail environment, Atkins turned to Leica Geosystems' solutions and technology to avoid costly downtime during expensive and time restrictive track possession. The latest innovations available within the new Leica Captivate range proved invaluable in this situation.

The Leica Nova MS60 MultiStation, with its wide spread of functionality including the ability to scan up to 1,000 points per second, was used on the project. Combined with the imaging capability on all the total stations and the interoperability of these with both the Leica CS20 controller and CS35 tablet computer, this enabled Atkins to capture every necessary detail in the quickest and most effective way.

The same controllers and Captivate software were used with the GNSS Smart Antennae to establish control quickly and accurately using HxGN SmartNet correction service. Alongside the Captivate software, the latest Leica LS15 digital level with imaging and auto focus were used, allowing for a faster, more accurate staff reading in harsh conditions. The instruments were also used in conjunction with track trollies and alongside Leica Geosystems laser scanning solutions.

The provision of topographical survey data and selected point clouds for the project designers to use and develop created a rationalised railway infrastructure design that will increase capacity on an already packed section of South London's rail network. Ultimately this will declutter historical track alignments, making them suitable for rail expansion into 2020 and beyond.

The project and the data provided to it will lead to providing a better railway experience for the growing customer base and will be used to support economic growth of the surrounding areas.

PROVIDING TOPOGRAPHICAL SURVEYS TO LONDON'S RAILWAY INFRASTRUCTURE

For Atkins, Leica Geosystems solutions have brought many benefits to the project.

"By adopting Leica Captivate software technology, we can provide Network Rail with fast and accurate data realisation, avoid costly returns, and save them time and effort, whilst also reducing their risks," said Groboljsek. "By using a combination of Leica Geosystems solutions, data was collected safely, accurately, efficiently and, above all, within limited time during track access possessions. Reduction in time spent on the track reduced site-based risks and lessened risk of injury to Atkins personnel. Also, there was a reduced risk to Network Rail property and infrastructure."

Primary and secondary control was established using the fast and accurate Leica Viva GS14 GNSS Smart Antenna, using both post processed and live RTK data from HxGN SmartNet. The service was also used to increase efficiency by assuring the quality of 3D GNSS data directly in the field.

With intuitive and understandable software in the field and in the office, Captivate allowed instant 3D visualisation of the survey data collected on the railway site, providing a detailed understanding of the project requirements.

The Leica ScanStation P40 laser scanner also offered a fast scan rate with less noise and clearer scans along with streamlined workflows from the field to office and back via easy automated processing with Leica Cyclone laser scanning software. This was then all quickly and easily communicated to all staff and to the client using Leica TruView.

The Brighton Mainline Upgrade Programme upon completion is one of the first where the topographical survey was used much earlier in the project lifecycle. Combined with Leica Captivate solutions, the rail project is delivered smoothly allowing for the design team and surveyors to proactively manage and transmit decisions based on immediate feedback.

© Paolo de Girolamo

THE CHRONICLE OF AN ADVENTURE

Penny Boviatsou

Case Study

ECO40 boat trip research to provide ocean scientific information

On October 19, 2014 Matteo Miceli, a famous Italian oceanic sailor, left the Port of Riva di Traiano located close to Rome, Italy, with the Italian sailboat ECO40 for the Roma Ocean World Project. His goal was to sail around the world alone, without the help of any fossil fuel or additional supplies, other than what he brought with him for the entire 27,000 nautical miles (50,000 kilometres) journey.

ECO40 is a Class 40 oceanic vessel (Length overall of 12,0 metres) that was equipped with a data acquisition system for both the met-ocean parameters recorded on-board (i.e. apparent and real wind speed and wind direction, atmospheric pressure, current velocity, air and sea temperature, etc.) and the kinematic characteristics of the boat itself (i.e. speed and course over ground). A team of professors from the University of Rome and the Polytechnic Turin recorded the boat's movements by using three Leica GR25 GNSS reference receivers. With these they were able to:

- Calculate the height of waves along the ECO40 route by using the boat as a buoy and validate the numerical models of the United Kingdom - based Met (meteorology) office;
- Improve the structural design of the Class 40 sailboat by means of calculating the boat's dynamic stress and boat material durability during the trip;
- Record the wave characteristics taken from the ECO40's movements to produce a polar diagram of the boat's speed, which would be useful for future Class 40 racing boats.

Miceli transmitted the data via satellite for analysing to Professors Paolo De Girolamo and Mattia Crespi of the University of Roma La Sapienza and to Alessandro Pezzoli of the Polytechnic Turin.

On his way back to Italy, after rounding the three capes and sailing for 25,000 nautical miles, the ECO40 capsized at the Equator. Matteo was about 600 miles offshore the Brazilian coasts. He was saved by a cargo ship. When he came back to Italy, he organised a first expedition to try to recover ECO40, which was not successful. After a month, the expedition team tried again and found ECO40 300 miles offshore the Brazilian coasts. Now the vessel is back in Italy.

Fortunately, the data were saved together with the boat and the researchers were able to do the final analysis of the journey.

THE SAILOR'S JOURNEY

The planned route was the classic clipper route that runs from west to east through the Southern Ocean, taking advantage of the strong westerly winds. Namely the route consists in passing the Gibraltar Strait, then in descending the Atlantic Ocean and sailing around the Antarctic, at an average latitude of 50° S, from west to east rounding the most famous capes of the world: Cape of Good Hope, Cape Leeuwin and Cape Horn. Finally, sailing the Atlantic Ocean back to the Strait of Gibraltar and come back to the homeport.

"The data collected by the Leica GR25 GNSS receiver and the Leica AS10 antenna concerning the movement of the boat reported that ECO40 sailed wave heights of roughly 6 metres during the first storm with maximum waves reaching 10,0 m," said Miceli. "After the end of the trip, we are now able to calculate the exact measurements."


© Paolo de Girolamo

GATHERING THE DATA

A part of the measured data was sent to the land team on daily basis by satellite modem. These data, measured by the boat and transmitted almost in real time, helped significantly the team in charge of the safety of ECO40; the knowledge of the actual weather conditions the boat was really facing during the navigation could improve the route strategy and increase the boat safety.

"The measurements of the boat movements, obtained from the three GPS receivers, if properly analysed, can provide a measure of the waves that the ECO40 encountered during the navigation," said Miceli.

The three high precision Leica Geosystems GPS receivers were placed on the left and right side of the stern along the boat cross axis while the remaining one was placed close to the boat entrance along the boat's main longitudinal axis. The data were acquired by the system during the navigation of the ECO40 and stored on a flash-card by each receiver. The data analysis was carried out in post-processing after the recovery of the flash-cards.

Two different strategies were adopted in the post-processing:

1. The "Variometric Approach for Displacements Analysis Standalone Engine" (VADASE)
2. The moving base kinematic approach.

The two methods were used complementary in order to obtain the boat motion, and the boat motion has been applied to estimate the waves' properties faced by the sailboat during its navigation around the world.

Indeed, the first (i.e. variometric approach) was used to calculate the boat heave, surge and sway motions, while the second one (i.e. moving base kinematic approach) was used to calculate the roll, pitch and yaw motions. The wave characteristics (i.e. directional wave spectrum) were derived by using the heave, pitch and roll motions.

When fast movements have to be detected and their effects suddenly evaluated, Leica VADASE can help researchers make the most informed decisions immediately. The solution adds additional value to traditional GNSS monitoring, providing accurate velocity information based on a stand-alone GNSS receiver that is continually available in real time for precise and reliable analysis of fast movements.

The boat performance data (i.e. speed and course over ground) can allow, after a certain amount of time that is required, to obtain a statistically meaningful database, to estimate the real polar velocity curves of the boat. Indeed these curves were used for the prediction of the optimal route made by the land team by using a route optimisation software, which was sent daily to Miceli.

The actual polar velocity curves of the boat differ from the theoretical ones estimated by

the designer of the boat. This is due to several causes, among which plays an important role the ability of the crew to "push" the boat to the maximum of its performance and the presence of waves that normally is not taken into account when calculating the curves themselves.

These data are used mainly for two technical and scientific purposes:

1. The first purpose is the calibration and/or verification of the numerical models output that are commonly used for the wind and wave forecast and/or analysis into the oceans, and the calibration of the remote sensing data (e.g. satellite wind and wave measurements).
2. The second purpose is directly related to the vessel design. Indeed the knowledge of both the movements and the loads that this kind of vessel can deal with, together with the response of the materials to the fatigue stresses, can improve significantly the design methods.

ANALYSING THE MEASUREMENTS

This undertaking was the first time ever that a sailboat's movement was accurately measured by GNSS on a global journey and data were transmitted via satellite every few hours. In terms of the met-ocean conditions and in terms of the boat heeling, the first violent storm experienced by the ECO40 during its navigation occurred in the Gulf of Lion 21-22 October 2014. The heeling of the boat was estimated by using the GPS signals that were analysed by using a moving base kinematic approach. This analysis allowed to estimate the heeling angle **α** during the whole storm event.

"Concerning the met-ocean conditions, we analysed the storm on the basis of the wind data that were measured and transmitted almost in real time from the boat," said De Girolamo.

Wind data were measured on board of the ECO40 by means of an anemometer placed on the top of the mast. The first comparison was carried out with the European Centre for Medium-Range Weather Forecasts (ECMWF) and the second one was carried out by using the forecasted data, provided by the numerical model GFS (Global Forecast System).

© Paolo de Girolamo

This comparison, along with the results of the heeling analysis, showed that the wind measurement height plays an important role. The corrected measurements of the wind are comparable with the results obtained from the numerical models: a good agreement is noticeable within the first 60 hours. Nevertheless, a sensible discrepancy between the measured wind data and the numerical one is noticeable as the storm peak occurs.

The direct comparison between the forecast and the measured wind speed showed, in the present case, as expected, relevant discrepancies. These discrepancies are such to underestimate the forecast wind condition in the order of 50 per cent of the forecast wind for severe storm conditions.

The researchers and professors were able to put together a research paper based on the comparison between measured and numerical wind data.

"Still, despite the unexpected end of the journey, the data collected from the Leica GR25 GNSS receiver and the Leica AS10 antenna were enough to provide ocean scientific information for the development of new ocean knowledge and technologies for the benefit of society," said Frank Pache Senior Product Manager, GNSS Networks and Reference Stations at Leica Geosystems.

TRIPLE I: INNOVATION IN INDIA

Amit Kumar

Case Study

Highway surveying with mobile mapping in India

With increasing demand for readily available, consistent, accurate, complete and current geographic information, geospatial applications have indeed become the primary tool across the globe to access sophisticated geographic information. This transforms raw data into actionable, authoritative intelligence. The fields and sectors deploying these technologies are currently growing at a fast pace to unveil a smarter world. India is no exception.

Indian roads and buildings are ancient. Grand Trunk Road was built across India in 1857 to connect developing civilisations like Harappa and Mohenjo-daro. The public works department of the Maharashtra government wanted to develop, maintain and improve the road condition in India. The government and the consultants turned to Prashant Surveys, a professional land surveying and mapping firm based in Pune, India, specialising in 3D mobile LiDAR survey.

GOING MOBILE IN SURVEYING

Surveying is a vital part of the design and construction process. Carrying out topographic surveys for about 2,600 kilometres and delivering data in about two months is a very challenging task, which needs lots of efforts and is practically difficult. Prashant Surveys were able to conduct the surveys in one month using the Leica Pegasus:Two mobile mapping platform and deliver the data from the surveys in one more month. The same project would have taken more than one year to complete using traditional methods.

With Leica Geosystems Pegasus:Two mobile mapping platform, though, this objective was possible after some good training sessions and hands-on experience. Prashant Surveys made a substantial investment in the Pegasus:Two mobile mapping platform and reality capture solutions, becoming the first company in India to adopt this new technology. The firm was able to capture this vast length with a scan speed of 1 million points per second, maintaining survey grade accuracy of less than 2 centimetres.

“We see a huge technological jump for field data acquisition from the traditional total stations to the latest mobile mapping systems,” said Prashant Alatgi, head of Technical and Business Development of Prashant Surveys. “We could easily capture georeferenced, high density 3D point cloud data along with quality photographs, with the average output of about 100 km per day.”

OPENING NEW OPPORTUNITIES

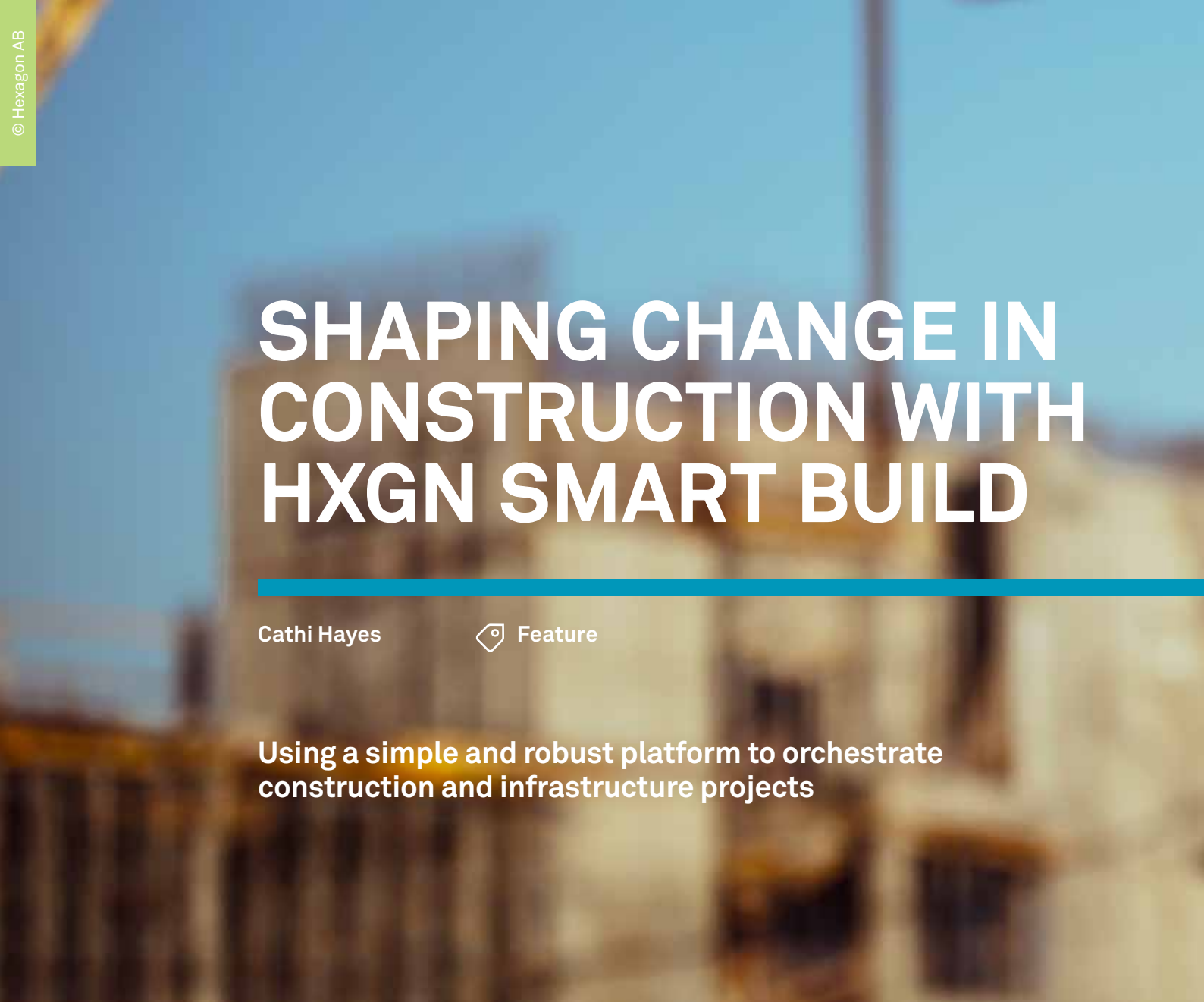
Prashant Surveys was tasked to conduct the highway surveys to:

- support the development of cadastral records for all road side features and build-up structures;
- widen existing state highways;
- align and improve the existing highways;
- create profiles of existing roads, L-sections and cross section of highway corridors.

Along with these standard surveying results, Prashant Surveys also sees further developments for the firm from mobile mapping technology. As the reality capture solution comes with several other features, there are varied mobile applications that apply. For example, the vehicle mounted mobile mapper and above-and-below ground reality capture enables urban and rail surveying for as-built detection, deformation monitoring and more. With trackable health monitoring features, environmental studies can be undertaken. Finally, with wearable reality capture in the Leica Pegasus:Backpack, Building Information Modelling (BIM) is also a possible application to enter.

"With the Pegasus:Two mobile mapping solution, not only are we seeing savings on the cost of manpower, management and all indirect costs associated, but there are also applications we can now enter we weren't able to before," said Prashant Alatgi. "The opportunities presented by the technology even further the ROI on our decision to pursue mobile mapping solutions and have been well justified."

© Prashant Surveys



SHAPING CHANGE IN CONSTRUCTION WITH HXGN SMART BUILD

Cathi Hayes

Feature

Using a simple and robust platform to orchestrate construction and infrastructure projects

Three major trends are disrupting construction today:

1. **Building Information Modelling (BIM)**
2. **Digitalisation with cloud**
3. **Mobile simplification**

The building construction industries are ripe for 'right-sized' technology solutions with simple and intuitive interfaces, yet very powerful technology behind the scenes. HxGN SMART Build is just that – a next-generation construction management SaaS technology that layers schedule and cost progress tracking over a 3D model for powerful 4D and 5D real-time progress and cost deviation tracking. The result is well-informed, fast decisions that ensure projects are delivered on budget and on time.

SMARTER DIGITAL LAYOUT

In addition, SMART Build ensures construction productivity and accuracy by synchronising 3D models and layout points to robotic total station software with its Digital Layout module. This lowers the BIM barrier for field teams and bridges the gap between office and field while meeting industry requirements of powerful, yet easy to use field solutions.

SMART Build enables intuitive model viewing in a connected cloud environment that eliminates the need for field teams to purchase and train on complicated desktop modelling software. Construction digital layout points can be added directly to any model object, such as concrete footings where points may be added to end points, mid points or centre points. A unique feature of the

solution is the construction layout points' ability to inherit intelligence from the model. So even if the model is not used in the field by layout teams, they still reap the benefit of model intelligence such as concrete type, floor level, rebar size, etc. The user selects the model attributes, as it is configurable.

Models and layout points are exported or synced with Leica Geosystems' robotic total station field software, such as Leica iCON build construction software or Leica Captivate, for fast and accurate layout. Robotic total station single-point quality control or as-built points can be round-tripped back into the SMART Build collaborative model environment for visual comparison. When as-designed versus as-built deviations are identified, issues can be logged in the SMART Build web client, with iOS or Android apps for fast and effective collaborative team resolution.

AN INTEGRATED APPROACH

The solution also extends beyond digital layout with the ability to plan and execute construction projects by combining models, cost and schedule in one integrated platform. Users can track actual time and cost in the field in real time and continuously compare to what was planned in the office.

Hexagon is shaping change in construction with HxGN SMART Build by leveraging contemporary cloud and mobile technologies to meet the needs of the evolving construction industry.

For additional information, please visit hxgnsmartbuild.com.

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FROM THE SKY TO THE GROUND – POSITIONING HEAVY CONSTRUCTION MACHINES WITH PRECISION

Karina Lumholt

Feature

Precise positioning for machine control with HxGN SmartNet in Denmark

Since the late 1990s, the heavy construction industry has increasingly benefitted from GPS technology to achieve highly accurate grade information to complete earth-moving jobs quickly and precisely.

Without a correction of the satellite signals from a reference station with a known position, a machine control solution's GPS system would have an accuracy only higher than a couple of metres similar to an in-car navigation system. This is not accurate enough for the construction industry that needs positioning precision down to a couple of centimetres.

The machine control solutions therefore need to receive corrected signals using a technique called Real Time Kinematics (RTK) from either a single RTK base station or an RTK network, which is a network of permanent GPS and/or GNSS receivers whose combined data is used to correct transmissions errors from the satellites.

HxGN SmartNet is a worldwide RTK network service based on Leica Geosystems' GNSS technology. With easy access to precise correction data, users experience the best availability, reliability and traceability using internationally recognised standards, together with flexible and affordable subscription options. Many professionals benefit from HxGN SmartNet to efficiently complete their daily tasks, such as:

- machine control
- surveying
- engineering
- construction
- agriculture
- utility surveys
- archaeology
- monitoring
- and many more.

SMARTNET IN DENMARK

With a total of 57 reference stations, controlled and approved by the Danish Geodata Agency, HxGN SmartNet has the most extensive RTK network and ensures the best coverage across the whole country. The 3D machine control solutions offered by Leica Geosystems Machine Control Division use a correction signal from a reference station or reference station network once every second.

Customers subscribed to HxGN SmartNet receive a SIM card for the earth moving machine's GNSS receiver that connects automatically via the telephone network to the closest reference stations. This allows the machine operator to receive centimetre-accurate coordinates from the satellites to his in-cabin panel.

"I depend 100 per cent on SmartNet in my daily work. I receive the project drawings and use the Rover CG60 from Leica Geosystems to mark out roads, wells, cables and so forth. I see instantly if there is something wrong, either with the satellite coverage or with the SmartNet signal, which, by the way, happens very rarely," said Jakob Lind, surveyor at Søren Kristiansen A/S.

A PRECISE POSITIONING NETWORK YOU CAN TRUST

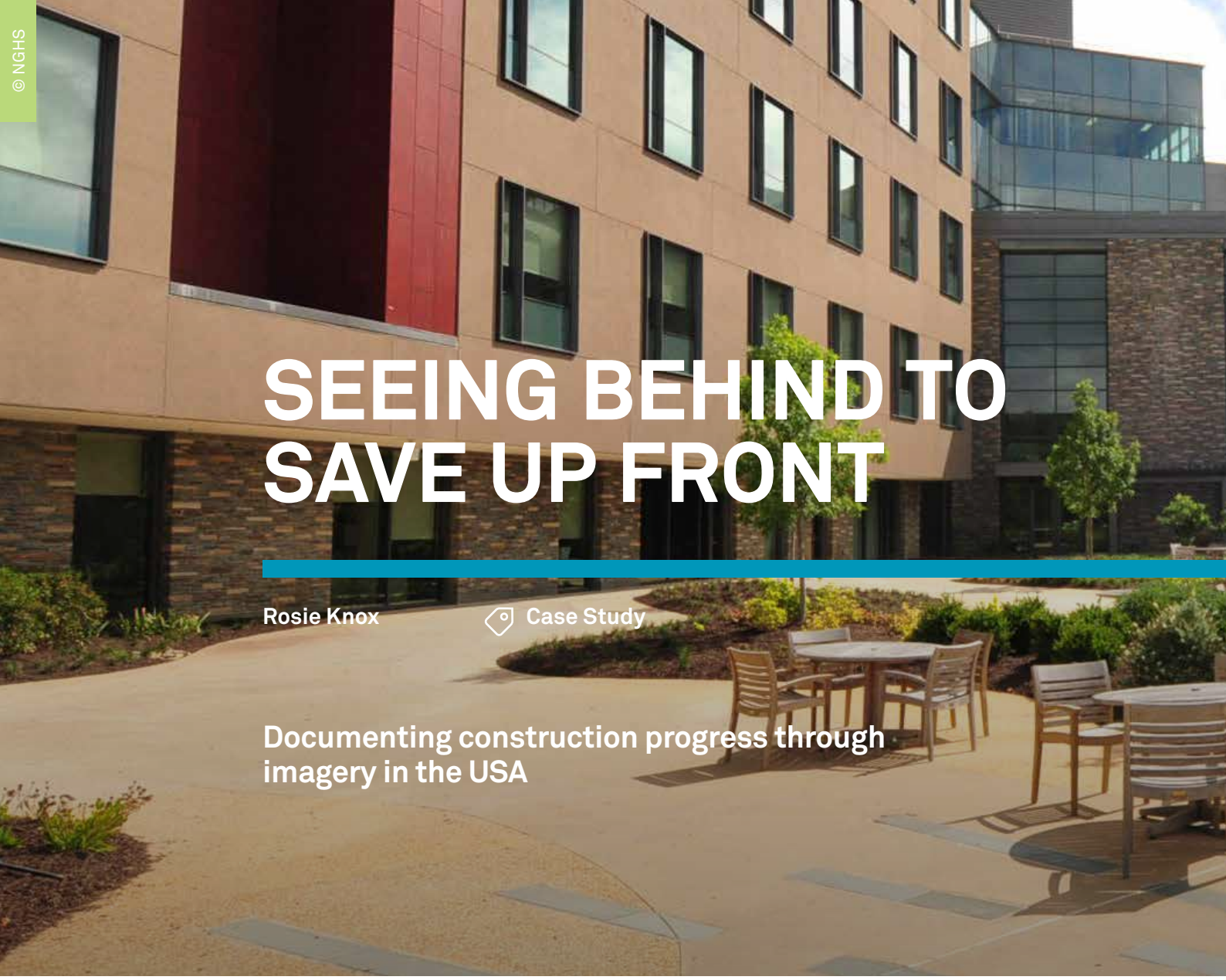
The automatic and precise positioning service integrated into machine control solutions only requires a mobile data connection and an acceptable internet connection. This 24/7 GNSS Network RTK and correction service, built on the world's largest reference network, goes unnoticed by its users while it quickly determines precise positions.

"I don't really notice the correction service because it normally works automatically and very well. If I temporarily loose internet connection, I receive a warning on the panel inside my machine," said Thomas Petersen from Fuglsanggård A/S.

This service continuously provides a highly-available infrastructure and even offers all customers a free text message service that reports if there is a problem with HxGN SmartNet and provides information about atmospheric errors. Built to provide high-precision and high-availability, signals affected by solar storms are restored in a couple of minutes and users can follow the information about solar flares and ionospheric errors on the website.

"Signals from the satellites can be affected by trees or tall buildings, and even the time of the day can have an effect on the satellite coverage. The 3D machine control solution gives users a warning on the panel if there is connection to less than the required four satellites or if the RTK signals are too slow," explains Christian Hansen, responsible for the HxGN SmartNet solution in Denmark. "In places with intensive data traffic, for example in the vicinity of large educational institutions, the correction signal can be delayed. If the caused inaccuracy is higher than 5 centimetres due to slow signals, the system will automatically shut down."

With several years' of experience as a machine operator Rune Lodall, sales consultant for Leica Geosystems Denmark recalled, "10 years ago the majority of construction companies used base stations on their job site, but today HxGN SmartNet offers such precise data that it is used for most projects, even for grading jobs that require maximum accuracy."



SEEING BEHIND TO SAVE UP FRONT

Rosie Knox

Case Study

Documenting construction progress through imagery in the USA

Healthcare facilities provide critical services while enhancing not only the economic benefits to communities but also the quality of life of citizens. Hospitals, emergency care centres and other medical establishments also present complex building challenges.

The Northeast Georgia Health System (NGHS), a not-for-profit community health system serving more than 1 million people in 18 counties across Northeast Georgia, USA, has undergone unprecedented growth in the last decade. In just one NGHS facility from 2015-2016 alone, more than:

- 30,000 patients received care in the Emergency Department
- 4,100 patients stayed in one of the hospital's inpatient units
- 3,200 surgical procedures were performed.

In 2015, NGHS generated more than:

- $1.5 billion in revenue for the local and state economy
- $45 million in uncompensated care
- 12,000 full-time jobs throughout the region and state.

With this much growth, several new facilities have been added to the System. Multivista construction documentation solutions have been used on five of these projects since 2008.

LOCATING THE INVISIBLE

In the most recent project, NGHS used Multivista's Interior Exact-Built, Exterior Exact-Built, MEP Exact-Built, and Interior Progression photo documentation services on its 119-acre Braselton medical campus.

Enabling the facility management team to see behind walls, ceilings, and even slabs eliminated many unforeseen conditions and costs.

"Multivista recently saved me approximately $100,000 by enabling me to locate several in-slab utilities," said Bill Clawson, NGHS vice-president of Facilities. "Multivista consistently helps our projects avoid cost overruns that typically come up with renovations. With every new renovation project, I ensure that Multivista is a budgeted component of each."

In another recent renovation project, Clawson and his team used Multivista MEP Exact-Built visual documentation to see behind the walls of patient rooms. The team was installing patient monitors in 556 rooms.

"With Multivista, we were able to ensure we were not hitting anything critical and installing the mounts in the safest and most cost effective locations," said Clawson. "With this project, Multivista also saved us upwards of $100,000."

Healthcare makes up a large percentage of Multivista's client base. The company has been contracted to visually document more than 550 hospitals and clinics throughout the 70 global markets served.

© NGHS

UNDERSTANDING THE SNOWMELT

Renata Barradas Gutiérrez

Case Study

Hydrologic research using Leica Geosystems GNSS solutions to measure the impacts of a changing climate in the Canadian Arctic

Regions of the Canadian Arctic are experiencing unprecedented warming as a result of the greenhouse gases emitted by human activity. The western Arctic specifically has experienced significant increases in near surface ground temperatures over the past few decades, almost twice that of the global average temperature increase. This warming trend has resulted in significant changes to the regional ecosystems and the physical processes operating across these environments.

To better understand how the Arctic tundra will respond under further climate change scenarios, members of the Marsh Lab Trail Valley Creek (TVC) research group from Wilfrid Laurier University in Canada led by Dr. Philip Marsh travelled more than 4,000 kilometres to study the changing hydrology of Canada's western Arctic using Leica Geosystems GNSS instruments. The research collects data on all components of the water cycle and aims to understand how further temperature increases will affect the local and regional freshwater systems by combining:

- detailed field observations
- remote sensing
- GNSS positioning and modelling.

SURVEY TIME

The annual input of water stored as snow is the most important aspect to the hydrological cycle and the largest freshwater contributor to Arctic stream and lake systems. At the end of winter, between April to mid-May, Marsh Lab TVC researchers conduct snow surveys measuring the snow depths and water storage across multiple basins of study. The group of researchers accurately measures the annual snowfall accumulated over the winter months to quantify the amount of liquid water storage, measured as Snow Water Equivalent, and to calculate the amount of water available to the hydrological system once the snow melts.

To better understand the heterogeneous nature of the tundra snow cover, Marsh Lab TVC researchers use many recent technological advances, including:

- Unmanned aerial vehicles (UAVs)
- aerial based snow depth data
- automated snow depth recording probes
- experimental cosmic ray neutron probe stations.

The team of researchers currently uses two Leica GS10 GNSS receivers and two CS20 field controllers to collect point type data for a wide variety of research projects. With Leica Captivate field software, the team collects and organises the data while Leica Infinity survey software is used to project and filter the collected field points, ensuring data is stored in the correct coordinate system. UAV post-processing software is also used.

"Our field work relies heavily on obtaining high accuracy spatial datasets and our Leica Geosystems GNSS system makes all of this work possible," said Branden Walker, Research Associate at Wilfrid Laurier University. "Previously using Leica Geosystems instruments at other research sites with excellent results, we chose to go with them again for this project."

The group of researchers also used the GS10 GNSS receivers and CS20 field controllers for regular surveying of ground control points, and surveying topographic changes for ground

validations and change detections of permafrost features.

"The majority of our ongoing research projects are centred on obtaining highly precise and accurate GPS data," said Walker. "Compared with other data sets, Leica Geosystems GNSS systems have proven to provide robust and reliable data."

COLLECTING DATA FORM ABOVE AND BELOW

One of the main methods for measuring the snow across larger areas is through the experimental use of UAVs. In order to validate, georeference and correct the GNSS data from the UAV, Marsh Lab TVC researchers need to measure the actual Snow and Ground Surface Elevation on the ground using a Leica Geosystems GNSS system for surveying ground control points with UAV mapping points with a high level of accuracy. These highly precise ground control points are then processed in Infinity survey software and a photogrammetry software to improve the accuracy of the UAV mapping points.

"The Leica Geosystems GNSS system we use allows us to create ground control points with a known position with sub-centimetre accuracy. This is very important for correcting our elevation products from the UAV, which may only differ from one flight to the next by a few centimetres," said Walker. "This data allows us to quantify snow depth and water storage with previously unobtainable spatial and temporal resolutions. The data from our UAV is post-processed and georeferenced using ground control points collected with our Leica RTK system to produce highly precise and accurate spatial datasets.

"Our Leica Geosystems instruments are the backbone of our research programme. The precision and accuracy provided by our GNSS instruments provides the spatial data required to map small scale variations in snow depth using the UAVs and helps us to save time in the field when setting up and collecting data points."

HELPING EARTH'S WATER MAPPING MISSION

The research conducted by Marsh Lab TVC researchers using Leica Geosystems GNSS systems will also be the main ground validation for Air Surface Water & Ocean Topography (AirSWOT) in North America, a component of NASA's Arctic Boreal Vulnerability Experiment (ABoVE). The AirSWOT validation mission measures the surface height of water on as many lakes as possible during flights. AirSWOT is part of SWOT mission to map Earth's water from space to know how much fresh water there is on Earth and to calculate river flow rates and monitor coastal ocean currents.

NASA's AirSWOT Phenomenology airborne radar flies across Northern Canada and Alaska measuring the Water Surface Elevation of tens of thousands of water bodies larger than

250 metres across. For the AirSWOT mission, the team has a small window to capture the measurements needed so they must have quick and reliable GNSS instruments that are capable of measuring from a long distance range from the base.

"The reliability of the rover to make quick and accurate measurements several kilometres from the base gives me confidence we will be able to validate NASA's AirSWOT data successfully," said Evan Wilcox, MSc Geography Candidate at Wilfrid Laurier University.

TRAINING FIELD RESEARCHERS

Marsh Lab TVC hosts research groups from North America and Europe who study Canada's arctic regions. Wilfrid Laurier researchers regularly help train student researchers on how to use Leica Geosystems products.

"Being part of a university led research group also results in a high student turn around, so the simplicity and intuitive design of Leica Geosystems products makes training the next round of field researchers and students much easier – again, saving our group time and money in the long run," added Walker.

Harsh Arctic conditions can, furthermore, push the limits of most equipment. Leica Geosystems GNSS receivers and CS20 field controllers are designed to perform in the most extreme conditions.

"The nature of our field work tests all instruments to their absolute breaking point and maximum," said Walker. "Our Leica GNSS systems have worked in a wide range of harsh arctic conditions, including temperatures of -20° Celsius."

CREDIBLE INFORMATION ON CLIMATE CHANGE

Backed up with the accuracy and precision of Leica Geosystems, the group of researchers are gaining a greater understanding on how the Arctic tundra systems have changed in response to increased air temperatures resulting from climate change. Accurate and reliable data is needed to better understand the complex relationship between snow depth, rain, lake levels, vegetation, permafrost and streamflow, and the physical processes at play to be able to predict future changes using mathematical models.

The data generated with this research is currently being used by a wide variety of research scientists and graduate students focussing on testing and validating new data collection techniques. The information obtained also contributes to a long standing research project that collects the historical dataset for the Arctic tundra. Understanding Arctic's hydrological processes will provide credible information on how climate change is chaining lake levels, stream flows and snow cover, and how this affects the lives of Canadians.

DIGITAL MONITORING OF MAJOR URBAN CONSTRUCTION SITES

Benjamin Federmann

Case Study

Capturing tunnel construction from above in Germany

The city of Karlsruhe plays a decisive role in transport planning in the southwest of Germany with more than:

- **300,000 inhabitants**
- **160,000 vehicles in the main part of the city**
- **190 million tram passengers every year.**

Not only does the highway A5 influence the planning scenarios in the greater Karlsruhe area, but also the inner-city use of the state street B10. This is the most important inner-city east-west connection for the region. The city of Karlsruhe as well as the federal state of Baden-Wuerttemberg react on the development of the traffic and the whole region by launching two exceptional tunnelling projects for the relief of overground traffic with the project The Combined Solution.

Projects like this come with concerns from citizens. Construction noise, disruption of daily life, costs, pollution and environmental restrictions are only a part of the potential issues that must be taken into account when working on this kind of large-scale urban projects.

The city government and the Karlsruhe Rail Infrastructure Society (KASIG) builders have set up a long-term and very early information campaign for this purpose. This takes place in the form of a project website, but also through public events and an information centre. The aim of the builders as well as of the participating construction companies and consortia was also to make the best use of the possibilities of digital solutions for construction site documentation. Leica Geosystems' solutions for surveying used by Karlsruhe Ingenieurbüro GEO GmbH are the decisive factors in this digital documentation.

HIGHEST ACCURACY FROM DAY ONE

The construction companies Ed. Züblin and Schleith are responsible for the construction of the Kriegsstraßentunnel next to Karlruhe's major area, Ettlinger Tor. Combined with a second tunnel in Kaiserstraße, both construction projects make up The Combined Solution for the city of Karlsruhe, which will help to significantly alter the traffic situation in the inner city from 2020 and 2021 respectively.

In the Kriegsstraße, this means that the vehicles are brought underground, while trams, pedestrians and all bicycles move above ground. On a path of 1,600 metres, the road tunnel dramatically changes the cityscape - as well as during the construction work. The construction planning and subsequent construction supervision is also given special importance for this reason.

The objective of the construction supervision cooperation, consisting of DB Engineering & Consulting, Emch+Berger and BUNG, is to obtain:

- highest accuracy in surveying
- preservation of evidence
- monitoring.

Before working on new construction sections, the task was the initial surveying of the construction area as well as an area of 50 m in all side streets. The expected accuracy of the data was 2 cm. This task was taken over by the team of IngenieurTeam GEO, using the Aibot X6 unmanned aerial vehicle (UAV). Equipped with the RTK and GNSS module, this technology allows airborne data to be collected parallel to the on-site operation, delivering highly accurate data by combining the Aibot HP GNSS 2 and the Sony Alpha 6000 with a 20 mm lens.

A SPECIAL CHALLENGE WHEN FLYING IN THE CITY CENTRE

Around the project, the Federal Court of Justice and the Karlsruhe State Theatre are critical buildings. As is customary in the case of a tunnelling construction site, it must be ensured that the construction does not lead to unplanned changes in the environment. Any reductions or unwanted volume changes must be excluded. This exclusion has to be documented and monitored. Conventional methods can only be used to a limited extent in parallel to construction measures for security and time reasons.

The use of an UAV was then recognised as an optimal solution for data capturing in the sense of an efficiency-oriented project process. The advantages of the 3D measurement and the monitoring compared to a purely point-based data acquisition using terrestrial methods lie in particular in the various usage scenarios of the generated data. They can not only answer questions from a surveying engineer's point of view, but they can also be used as a basis for the planning of the traffic routes during construction work. They can be used in pro- and retrospective construction planning and are a decisive factor in volume calculation almost in real time.

On one hand, you have the advantages of using UAV; on the other, you have challenges of flying in the city centre. Thus, the narrowness of the city has to be taken into account already in the planning of the automated flight, and, therefore, the flight route and altitude planning has to be defined specifically. Potential disturbances of the flight by cranes, vegetation and possible magnetic field disturbances due to the existing infrastructure and development play a role.

Benjamin Busse, an experienced expert in the field of the use of surveying drones at IngenieurTeam GEO, has therefore placed special emphasis on the involvement of all stakeholders during the planning phase.

“The new drone regulations in Germany do not allow flights over federal streets,” said Busse. “Thanks to a good relationship with all stakeholders, we got the special permission for the inner-city flights over the B10 with traffic, pedestrians and tram.”

DIGITAL RESULTS AND ECONOMIC BENEFITS

The deliverables for the project included:

- classical orthophotos
- high-resolution single images for documentation
- digital elevation models
- point clouds.

At the same time, the inspection of traffic route planning was mandated. This took place on the basis of existing plans, which were combined with the information from the orthophotos. As a result of the data from the flights and the high information quality, it is now planned to carry out quarterly monitoring, critical volume calculations as well as a supplement to the construction site diary through videos and photos from the bird's perspective with the help of UAV solutions.

Using conventional measurement and surveying methods, not only significantly less data could be collected, a team of five people would have needed six weeks to deliver the desired results. The team of two people for the UAV workflow only needed seven days.

Conventionally, Leica Geosystems total stations were used. The UAV team worked with a Aibot X6 Version 2, the Sony ILCE-6000, the Aibot HP GNSS 2 as well as a Leica Viva GS15 GNSS Smart Antenna for measuring the ground control points. The costs for the client using the conventional method would have been 180 per cent higher than working with the UAV solution. The monetary perspective is even more attractive from the UAV operator's point of view: the costs for IngenieurTeam GEO using the UAV solution were only a fifth of the costs of conventional methods.

"We see the UAV technology as part of our tool box," adds Martin Schwall, co-founder and managing director with IngenieurTeam GEO. "From a customer's point of view, UAVs allow fast and digital results with many advantages for additional information."

DIGITAL WORKFLOWS OFFER MANY ADVANTAGES

The use of the UAV solution from Leica Geosystems offers a multitude of advantages. The digitisation of the processes associated with construction projects always depends on a high data quality and density. For example, the information from the UAV flights can be used not only for planning and monitoring but also for machine control and project communication tasks. In a further development step, the data of the UAV will also be seamlessly integrated into the software solutions of Leica Geosystems.

The results are not only faster, but can be customised to meet individual requirements with little effort. While conventional methods generate selective data, they do not capture image data, and, therefore, do not allow digital visualisation. The use of a digital end-to-end solution based on UAV, corresponding sensor technology (here high-resolution RGB camera) and suitable software for postprocessing and data processing offer real benefits, such as:

- 3D measurement information
- option of a parallel inspection based on the image data
- data capturing parallel to the day-to-day business
- much higher safety for the locally working surveying engineers and UAV operators.

The generated data is the basis for answering existing and future questions and will help to archive all construction progresses from the first day.

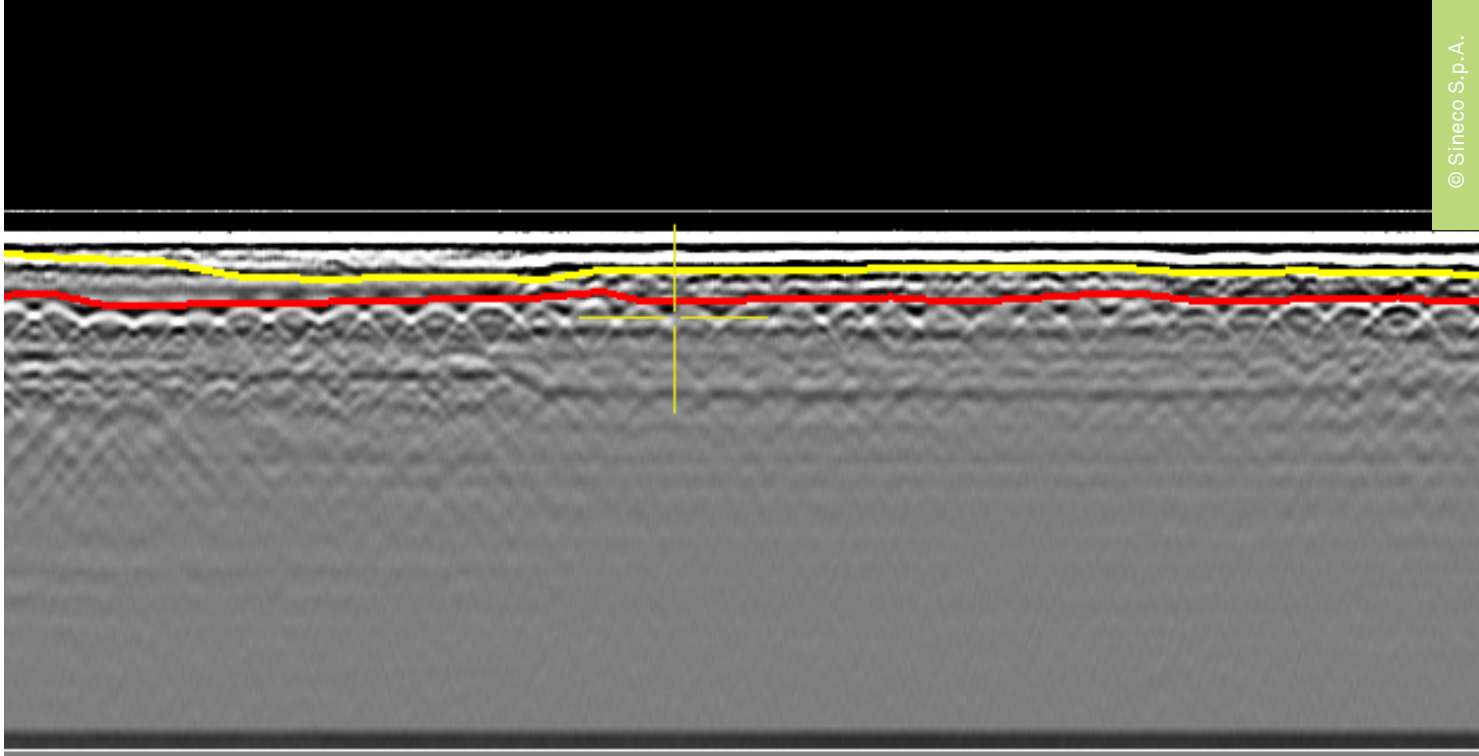
"As a next step, Leica Geosystems will fully integrate the UAV solutions in the software solutions for construction, monitoring and surveying," said Valentin Fuchs, product manager UAV, Geospatial Solutions Division, Leica Geosystems. "Helping our customers to visualise information and to use the collected UAV data to automate and speed-up processes is part of the bigger picture of future developments."

ENSURING SOUND INFRASTRUCTURE

Stefano Oppioni

Case Study

Multichannel ground penetrating radar for bridge deck assessment in Italy



Radargram and layer thickness tool displaying a section of the bridge. The yellow line indicates the asphalt layer thickness; The red line represents the position of the rebars.

Sineco S.p.A, an Italian engineering company, carried out a Non-Destructive Testing (NDT) bridge deck assessment at Rio Vizzana Viaduct on the Cisa Highway in Italy to assess the current infrastructure and early detect the bridge's damage. Using IDS GeoRadar's specific ground penetrating radar (GPR) solution for concrete bridge deterioration, RIS hi-BrigHT, Sineco S.p.A provided a rapid, non-destructive and accurate condition assessment and monitored the performance of bridge deck conditions, significantly reducing the necessary expenditure for the bridge renewal.

Sineco S.p.A operates in the engineering sector with special focus on the control and planning of maintenance interventions for large transport infrastructures. The company was established in 1987 by Società Iniziative Nazionali Autostradali (SINA) and other important motorway representative companies. Sineco S.p.A is also part of the Autostrada Torino Milano (ASTM) group, leader in transport infrastructures with a national motorway network of more than 1,200 kilometres.

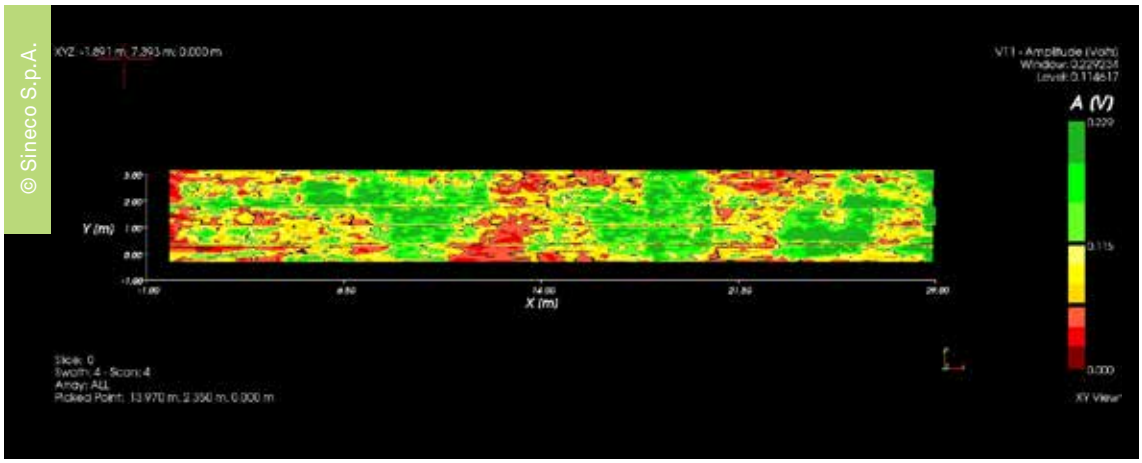
EARLY DETECTION OF BRIDGE DECK DAMAGE

To have a complete assessment of the corrosion, delamination and infiltration in the bridge deck at Rio Vizzana Viaduct, a survey using GPR was performed using the RIS Hi-BrigHT. This unique GPR solution enables users to interpret data easily using software specifically designed for bridge analysis.

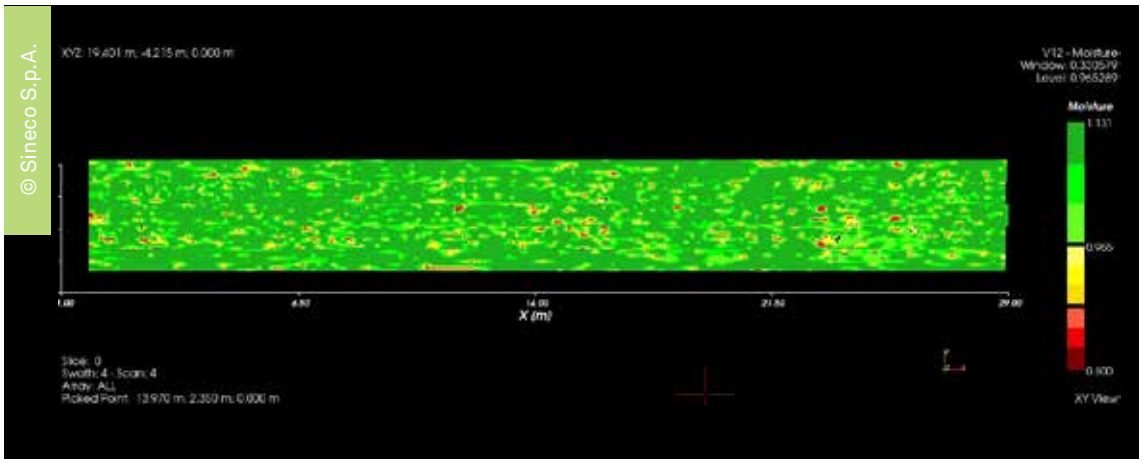
By processing the complete collected data set with automatic estimation algorithms, Sineco S.p.A could assess the bridge deck conditions by cross-correlating all the information extracted, such as:

- depth of the rebar layer
- concrete slab thickness
- power reflected by the rebars, and
- estimation of moisture presence by propagation velocity estimation.

Following the assessment of the deteriorated status of the concrete and rebar mesh, the bridge deck was completely removed and the data from RIS Hi-BrigHT was compared to the actual status of the bridge deck.



Map of Corrosion



Map of Moisture

The system is composed of a massive antenna array of sixteen 2Gigahertz channels with 10 centimetres spacing, mounted on a lightweight and highly manoeuvrable trolley and powered by a large, 24 ampere hour (Ah) 12 Volt battery. Compared to a single antenna GPR, RIS Hi-BrigHT is 1 metre wide and can scan a bridge with passes in a single direction. Thanks to the fast data collection of IDS Georadar's GPR system, authorities just needed to close the bridge during the survey for approximately 25 minutes for a total acquisition of 210 square metres.

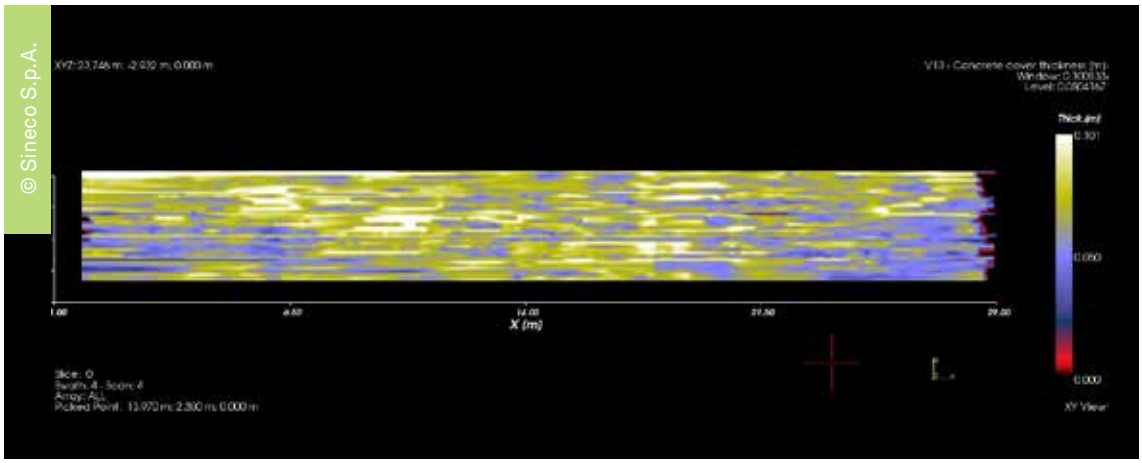
"Thanks to the double polarisation of the RIS Hi-BrigHT antennas, it is possible to obtain a complete and detailed detection along each scan line over the bridge deck, instead of losing time creating a net of orthogonal ones," said Marco Umberto Conti, geophysicist at Sineco S.p.A. "Acquisition experiences on bridge decks, demonstrated how easily and swiftly the job can be accomplished with RIS Hi-BrigHT, having benefits for both operator and customer."

POST-PROCESSING ANALYSIS AND DATA INTERPRETATION

In the post processing phase, Sineco S.p.A evaluated the:

- asphalt thickness
- depth of the rebar mesh and,
- visualised corrosion, concrete cover thickness and moisture in different maps.

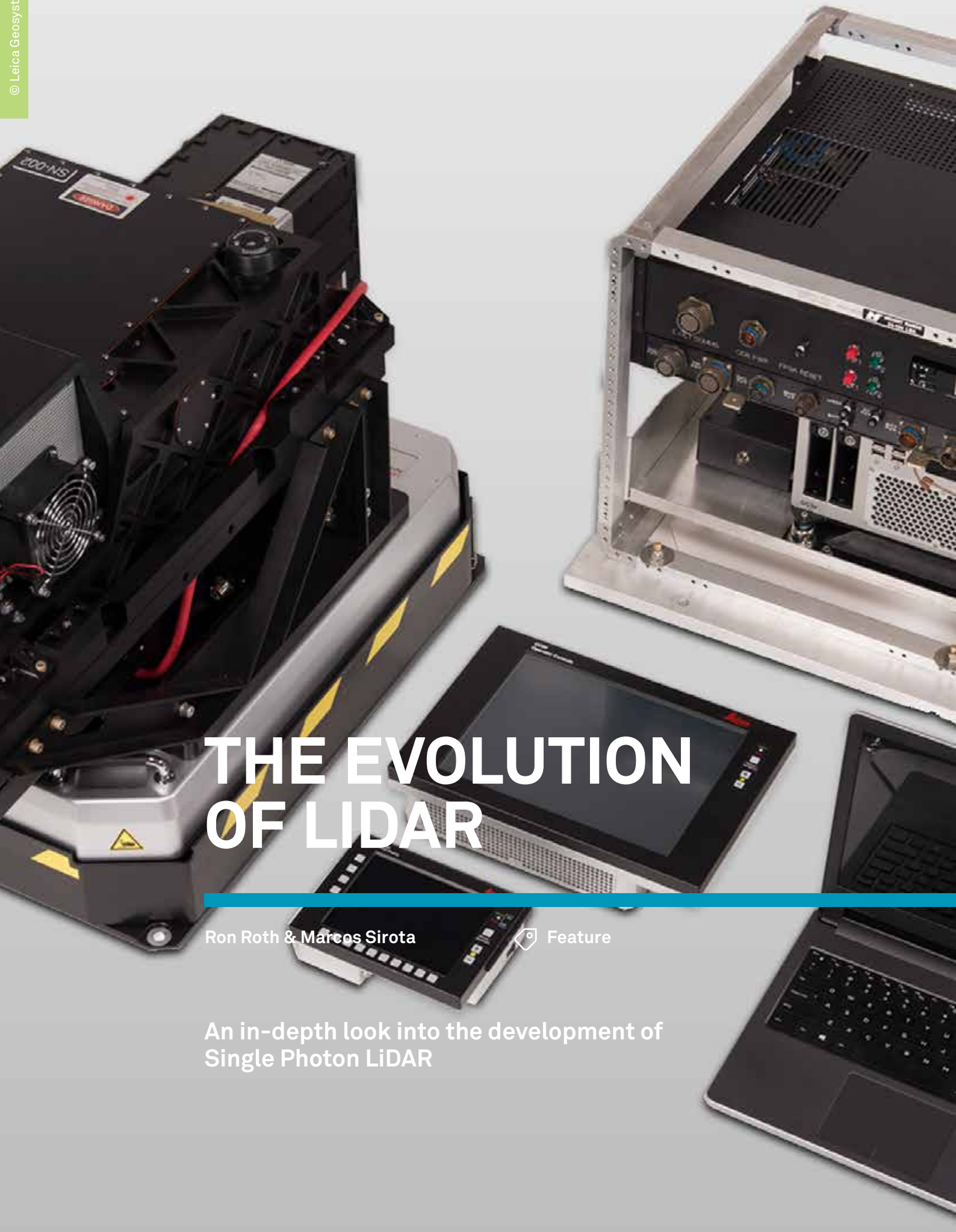
All this was done using IDS GeoRadar software GRED HD Bridge.



Map of Asphalt Thickness

Aside from reducing the duration of traffic interruption during field operations, the denser measurements provided by RIS Hi-BrigHT yield a more accurate characterisation of the condition of the bridge deck, a better prediction of the deterioration progression, and a better assessment of the rehabilitation needs. Such comprehensive and accurate assessments can also reduce the frequency of detailed follow-up inspections. In addition, data collected from the non-destructive tests of bridge decks can complement other information to better understand life-cycle costs, deterioration mechanisms, and the effectiveness of preservation techniques at various stages of the aging process.

"The advantage for the customer is clear: short time of single line or entire carriageway closure; less time waiting for the results of such detection; and a complete dataset for a restructuring planning," said Conti. "We have also seen through direct verification and scarifying of bridge concrete slabs that the Power Map exported using GRED HD Bridge is a very effective tool to identify areas potentially affected by the deterioration of reinforcing bars."



THE EVOLUTION OF LIDAR

Ron Roth & Marcos Sirota

Feature

An in-depth look into the development of Single Photon LiDAR

Current airborne linear-mode LiDAR systems, such as the Leica Geosystems ALS series, capture 1 million points per second. Increasing the pulse repetition rate is the best way to achieve dense point clouds at lower costs, as the flying speed can be increased. The pulse frequency, however, is constrained by parameters such as energy consumption and eye safety. Single Photon LiDAR (SPL) technology enables a much higher pulse rate to be achieved, since much less energy is needed per pulse.

LiDAR systems are typically constructed from a number of components:

- a range-finding system
- scanning optics to direct the laser pulses
- a position and orientation system to record the origination point of the laser pulse.

These systems use relatively high energy in each emitted laser pulse. Each pulse travels from the aircraft to the ground, from where it is reflected back to the scanner.

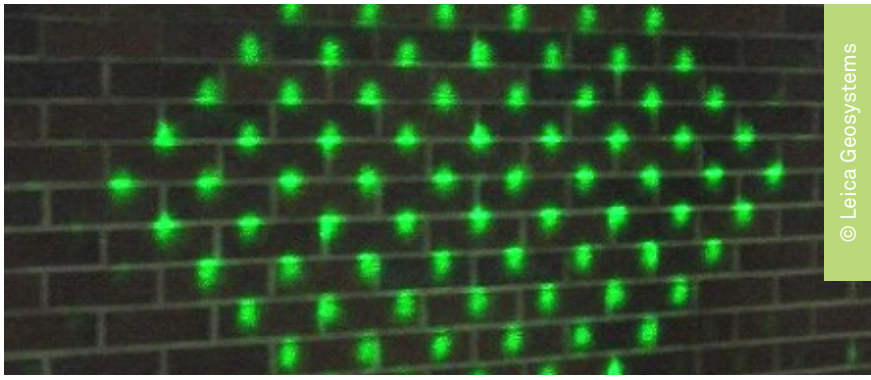
By using more energy per pulse, a stronger reflection can be recorded because more photons are reflected by the terrain below the aircraft. The output from linear-mode systems is impressive and these systems provide data with high spatial and radiometric precision. The technology does, however, impose some limitations on the maximum effective pulse rates that can be achieved.

HIGHER PULSE RATES

The pulse repetition rate is an important parameter to define the acceptable flying height and flying speed during data acquisition. A higher pulse repetition rate allows for faster flying while maintaining a similar point density.

As the pulse rate of linear-mode LiDAR systems increases, so, too, does the electrical power consumption. In addition, there will be greater heat generation by the lasers used.

The ability to generate increasingly higher average optical output, required for ever-higher pulse rates, is an engineering challenge. Besides accuracy and pulse repetition rate, the sensor design needs to consider not only total electrical power consumption and system cooling, but also size, weight and eye safety.



© Leica Geosystems

In order to take a next step in airborne LiDAR system development, the required energy per pulse must be reduced. This can be achieved by changing the nature and technology of the range-finding system. Next-generation LiDAR technologies, including SPL systems, rely on new range-finding techniques to achieve lower energy consumption and higher pulse rates.

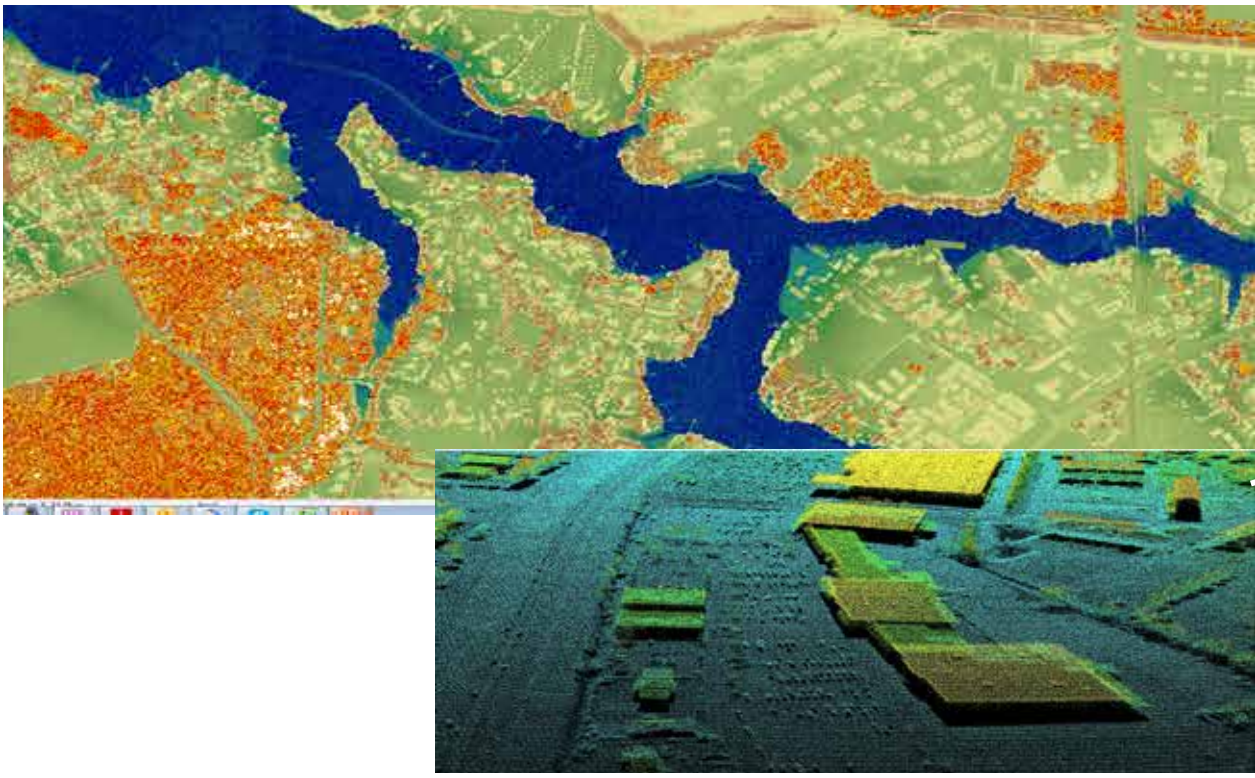
FROM SPACE TO EARTH

SPL technology was originally developed for Earth satellite ranging and has proven to generate accurate range measurements using a minimal amount of laser energy in each pulse. Compared to currently available linear-mode LiDAR systems, SPL systems contain a laser splitter, which splits each laser pulse into an array of 10x10 small laser beams (beamlets). For these 100 beamlets, the travel time of the photons to the ground and back is measured individually. The addition of highly-sensitive photon detectors deployed within the SPL system enable detection of a single returning photon with much less required energy.

The SPL system can generate 60,000 pulses per second. Since each pulse is split into 100 beamlets, this results in an effective pulse rate of 6.0 MHz – significantly higher than can be achieved with linear-mode LiDAR.

MULTIPLE RETURNS WITH INDIVIDUAL POINTS

Linear-mode LiDAR systems allow for the registration of peaks from various target reflections within the full return waveform, which can be processed to retrieve multiple returns. As SPL systems do not capture a continuous wave but count the individual photons instead, such a full waveform is not available. It is still possible, however, to retrieve



multiple returns thanks to the very short channel recovery times of 1.6 nanoseconds.

This means that the photon counter is reset every 1.6 nanoseconds to count if any new photons return from the beamlet. These are then regarded as a new return. The result is a true multi-return LiDAR system with short inter-return separations of 24 centimetres. As a result, SPL systems can acquire high density point clouds of 12 to 30 points per square metre with many returns underneath canopies.

The point density varies inversely with the flying height. If the flying height is doubled, the covered swath will double, but the point density will be cut in half. An SPL instrument flying at 200 knots at 4,000 metres above ground will produce a point density of roughly 20 points per square metre.

INTRODUCING THE LEICA SPL100

Linear-mode LiDAR remains the industry standard for airborne mapping, yet SPL technology is gaining acceptance for large projects. For instance, the U.S. Geological Service (USGS) 3D Elevation Program (3DEP), which aims to systematically collect enhanced elevation data in the form of high-quality LiDAR data, has explored SPL technology. The system has proven to meet the accuracy standard for USGS QL1 data, which corresponds to a height precision better than 10 cm for non-vegetated areas.

With this in mind, Leica Geosystems introduced its first commercially available SPL airborne systems in the Leica SPL100 earlier this year. The newest sensor in the company's airborne portfolio is the first to be released using Sigma Space technology since its acquisition by Hexagon in 2016.

The new SPL100 is one half of the new reality capture solution, RealTerrain. Combined with HxMap, the scalable post-processing workflow software, the new solution enables the efficient collection and rapid processing of large area LiDAR data sets. The efficiency gained by SPL100 acquisition and HxMap data processing

enable larger and more frequent LiDAR data acquisition for applications such as dense vegetation mapping and change detection.

"SPL technology brings up to 10 times the efficiency of prior offerings to our flying partners and customers. It is now possible to deliver extremely high point densities over large areas, enabling the digitisation of the world around us in detail previously not possible," said John Welter, Leica Geosystems Content and Engineering Services and Geospatial Solutions Division president. "Leica RealTerrain is the next evolution in providing high quality airborne information; both advancing the field and shaping the future of digital realities."

THE FUTURE OF LIDAR

SPL technology continues to advance over time in terms of accuracy and radiometric capabilities. This will result in an expansion in application areas for which SPL technology is suitable.

It is also expected that the effective pulse rate of SPL systems will continue to improve, just as the effective pulse rate for linear-mode systems has steadily improved over the past two decades. With current performance levels at 6 million points per second, SPL systems could potentially be capturing 1 billion points per second in less than a decade.

Bringing down the cost per point through higher effective pulse rates is the best way to address large-area, high-point-density projects in the future. As the use of SPL technology becomes appropriate in more and more applications, we will see positive changes throughout industries, such as increased efficiency in resource management, more effective infrastructure planning and better preparation for natural disasters.

GIM INTERNATIONAL

gim-international.com

A version of this story first appeared in GIM International.

INTEGRATION IS THE KEY TO SUCCESS IN MINING

Ernesto Vivas & Jose Portugal

Case Study

Mine planning with 3D visualisation in Mexico

© Peña Colorada

Map of the state of Colima

Hexagon Mining customer, Peña Colorada, is one of the largest iron ore operations in Mexico. Located in the state of Colima, Peña Colorada's operations consist of an open pit mine in Minatitlán and a pellet plant in the port city of Manzanillo.

Despite a production capacity of 4.1 million tonnes per annum of concentrate per year, Peña Colorada faces declining ore grades. In response, the company had to expand production even further. This expansion created challenges that were overcome by the adoption and application of new technology and improvements in geomodelling, mine planning, and mine operations.

The successful implementation of these technologies paid for itself many times over, and has led to significant improvements in production and performance, while lowering the operating costs and reducing the variance between planning and execution.

PUTTING GOOD IN TO GET GOOD OUT

The first step was to increase the confidence and reliability of the resource model. The Peña Colorada deposit comprises three main geologic structures affected by a moderate fault system. These three structures control the geology in terms of minable material characteristics.

The mineral resource model was constructed in two stages:

1. Construction of the geological model
2. Numerical modelling of attributes

Construction of the geological model involves three steps:

1. Processing of the drilling campaign
2. Accounting for the minimum scale of geological interpretation
3. Construction of surrounding solids.

The drilling campaign was processed through Hexagon Mining's mine planning suite, MineSight; specifically, its drillhole manager, MineSight Torque, and its 3D visualiser, MineSight 3D.

The geological envelopes were constructed as geometric solids using MineSight Implicit Modeler (MSIM) to accurately characterise the geological contacts. MSIM has since been replaced by Geologic, which leverages the power of implicit modelling by sequencing surfaces and solids to create an airtight geological model. The numerical modelling of attributes comprises the estimation of grades by localised ordinary kriging.

Once the block model was completed, new optimisation studies were evaluated with MineSight Economic Planner (MSEP) and new production schedules were completed with MineSight Schedule Optimizer (MSSO), which improved many aspects of the mine plan. For example, MSSO was used to evaluate and optimise the dump discharge plan.

FROM PLAN TO REALITY

The results of the optimisation generated a plan with less stripping required in the earlier periods and a combination of short and long dumps, which balanced the truck hours over the life of the schedule and reduced the number of trucks required. The estimated gains from this optimisation study amounted to approximately $35 million in project value.

Likewise, MSSO was used to evaluate the expansion project and the acquisition of bigger shovels (P&H 4100 XPC) and bigger trucks, (CAT 789C & 793F).

“Mine expansion projects cost millions, if not billions of dollars,” said Jose Villa, head of mine planning, Peña Colorada. “Investing in MSSO is easy to justify since it can guide important capital investment decisions and it costs less than the tires of an off-highway haul truck.”

Additionally, new geotechnical studies were prepared, which provided new guidelines for pit slope design. New technology was implemented to monitor ground movement and slope stability.

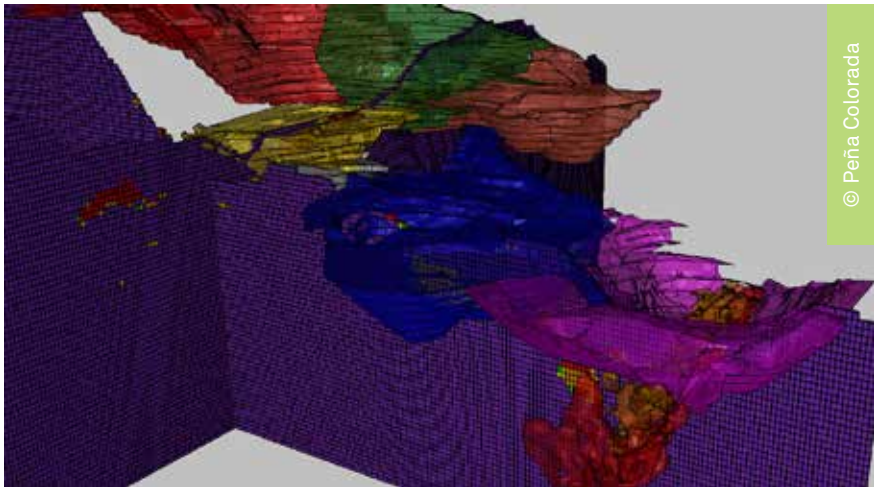
Peña Colorada implemented Hexagon Mining’s fleet management system (FMS) to monitor the operation and ensure plan execution and compliance. This enabled the company to capture in the field the value of the project as forecasted in the mine plan.

“However, there is always a variance between plan and reality,” said Villa. “This has been significantly reduced with the adoption of best-in-class mine planning software and fleet management system.”

Before the FMS implementation the designed blasthole collars for the production drills had to be staked out by surveyors. During the rainy season, however, the weather would delay the surveyors and consequently delay the drills,

which hurt production. After the implementation of the FMS, the planned/design blastholes are transferred digitally to the drill equipped with high-precision guidance for accurate blasthole location, so there is no need for the surveyors to stake out the collars in the field anymore. Now production stays on track.

“Hexagon Mining’s mine planning software and fleet management system has narrowed the gap between what is and what should be,” said Villa. “It has helped to unlock and realise significant project value.”



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SPEED IS THE NAME OF THE GAME

Monica Miller Rodgers

Expert Insights

Bernhard Richter, Leica Geosystems GNSS business director, explains new technology

© Leica Geosystems

Bernhard Richter
GNSS business director
at Leica Geosystems

With Leica Geosystems' commitment to self-learning instruments, the new Leica GS18 T GNSS RTK rover is the next evolution in the Leica Captivate Experience.

In this edition of *Expert Insights*, Bernhard Richter, Leica Geosystems GNSS business director, discusses the technology behind the industry's first tilt compensation solution that is immune to magnetic disturbances and is calibration free.

• What is the Leica GS18 T GNSS RTK rover?

The Leica GS18 T is the fastest and easiest to use GNSS RTK rover because the user does not need to hold the pole vertical anymore. This is thanks to the first tilt compensation solution that is entirely immune to magnetic disturbances and calibration free. Statistical analysis confirmed that on average users can save up to 20 per cent over conventional surveying practices with the GS18 T. With the fastest and easiest, self-learning GNSS Smart Antenna, the immersive experience of Leica Captivate is continued.

• What does this new technology do for the user experience?

Before defining the scope of any development, the utmost importance is to understand what pain is relieved. Pole levelling is a pain. On every point, a few seconds are needed to centre the bubble and hold the pole vertical. Some points are even not accessible with GNSS, such as corners, because the pole cannot be levelled. In addition, pole levelling requires a high level of concentration and distracts the user from safety relevant events, such as passing trucks. The GS18 T was designed with these user problems in mind.

• How does the GS18 T GNSS RTK rover work?

The antenna estimates a tilt compensated pole tip position by combining the GNSS position with altitude information derived from an integrated Inertial Measurement Unit (IMU). The technology is similar to solutions in the field of aviation, where heading, pitch and roll are important key parameters. Knowing pitch, roll, heading and the azimuth of the tilted pole allows calculating the pole tip position relative to the GNSS antenna.

We developed an affordable precise IMU that calibrates automatically and does not impose additional calibration procedures for the user. It was very important for us that when the user turns on the instrument, he will be ready to measure.

The GS18 T is optimised for the kinematic RTK use cases of a GNSS rover, where speed and ease of use are important for measuring and laying out points.

• For what applications can the new technology be used?

Put simply, this GNSS RTK rover can be used in any application. We did, however, focus on heavy construction, utilities, and surveying and engineering industries in the development and design stages. Especially useful in construction projects and maintenance of existing infrastructure, the GS18 T can measure anywhere on site since it is not affected by magnetic disturbances. The same goes for those working with electricity, gas, water and telecommunications in the utilities field. These professionals don't need to be surveying pros to be able to easily get the measurements they need for the job. Now, for our surveying and engineering professionals, they can trust they are getting the most accurate results at the fastest speed possible.

• If there are regulations requiring the pole to be levelled during the measurement, can users still benefit from the Leica GS18 T RTK rover?

Since the tilt values of the pole can now be stored for every measurement, such values can be shown in a report to prove the pole was levelled within the required tolerances.

• Why should users invest in the GS18 T GNSS RTK rover?

Without the need to level in the field any longer depending on the job, users will realise 20 per cent and more time savings. Field crews become more productive and can achieve more jobs in the same time. The field crews will be able

to pick up points they could not directly be measured before with GNSS such as corners of houses or partly obstructed points by cars.

- **Any sneak peeks into further Leica Geosystems GNSS innovations?**

We are dedicated to innovation at Leica Geosystems, and we continue to lead the industry in a new way of GNSS measurement with the GS18 T RTK rover. Though we feel our self-learning GNSS instruments will always adapt to the ever increasing satellite constellation demands, we will continue to explore opportunities to bring even more value to our customers.

FUSING PERCEPTION AND REALITY

Monica Miller Rodgers

Events

Hexagon Geosystems President Jürgen Dold presented *Perceptality* at HxGN LIVE in Las Vegas, USA

Hexagon Geosystems President Jürgen Dold presented *Perceptality* at Hexagon's annual international conference, HxGN LIVE, 14 June at the Venetian Ballroom in Las Vegas, Nevada, USA.

In his keynote address, Dold continued his focus on digital realities with an in-depth look at where they are going next. Pushing technology beyond its limits to make it simple and accessible for everyone, the keynote showcased projects from around the world and their innovative use of Geosystems reality capture solutions. Exploring how Hexagon customers are empowering themselves, Dold said the next level of digital realities is achieved with the inspiration and desire to pursue what is possible.

PERCEPTION + REALITY = PERCEPTALITY

To kick off the keynote, Dold elaborated on the need and power of both perception and reality.

Perception is our window to the world and is needed for the imagination of problem solving. However, it is subjective and hard to share and with that, somewhat limited. Reality is objective, based on facts, and measurable.

Alone, though, reality nor perception is enough. They need to augment one another for understanding.

"Perception and reality should not stay apart," concluded Dold. "Perception and reality should be fused."

This leads to perceptality – fusing perception and reality. Geosystems is in the business of augmenting perception with digital data to enable better decisions. This is the underlying of making the digital world real and providing a digital reality where users can "execute their brilliant visionary projects with higher quality and efficiency."

PERCEPTALITY POTENTIAL IN INDUSTRIES

Dold continued his keynote elaborating about the limitless potential of perceptality in several industries segments, such as managing the assets of utilities, cities and factories, the potential of perceptality for forensic investigators, and in the Architecture, Engineering and Construction (AEC) industry.

For utility companies managing power grids, perceptality allows to understand whether the assets are safe. To keep the lights on for thousands of customers who depend on them, these companies need to keep track of transmission lines. As vegetation grows near and threatens these lines, digital representations enable the professionals to make more informed decisions about the protection of the power lines.

With the recent release of the Leica SPL100 Single Photon LiDAR (SPL) airborne sensor, utility assets, such as transmission lines, can be captured and managed with factors of higher efficiencies. Dold used an example of power lines captured by the SPL100 at 2.5 kilometre height at 300 km per hour speed capturing 80 points per square mile. Traditional LiDAR under the same conditions only delivered 3 points per square mile. The details able to be seen in the SPL capture were easily recognisable.

Urban planners are empowered to augment their perception of developing smart cities with the reality to make better decisions. To create accurate 3D city models for ever-growing cities, the richer the data the better the understanding.

With the Leica CityMapper hybrid airborne sensor, oblique imaging and LiDAR data are combined to create detailed city models more efficiently and with higher quality. Especially through the new LiDAR embedded technology, customers are empowered to not only increase the speed of the 3D city modelling but also to map narrow urban canyons where traditional imaging based sensor technology are blind.

For plant managers, perceptality increases safety and decreases costs. In complex industrial facilities, billions are spent to keep track of assets. If even a small mistake is made at the beginning, the entire trajectory of the project can be off schedule, creating massive costs and significant time delays. Reality capture provides a means to avoid such costly mishaps.

With the new Leica Cyclone REGISTER 360, which was launched during the keynote, plant managers can now create digital representations of their intricate plants at much shorter times and with less labour involved.

Dold used the example of CESPA, the energy company in Spain that captured its facility with the Leica ScanStation P40. Combining the design with the richly-detailed point clouds enabled CESPA to see design conflicts on the site in the office without having to travel to the facility. On average, plant managers are realising 1-2 per cent cost savings on projects with real-world savings totalling millions of dollars.

“The design only shows what was designed and not what was added later,” said Dold. “To augment perception, you have to bring together the perfection of the design with the richness of the truth. Data has to be fused to reach perceptality.”

For public safety professionals, perceptality ensures justice by getting to the truth. Forensic investigations must capture a scene before it is compromised or changed. Crucial evidence has to be preserved to stand up at trial. With laser scanning, these scenes can be captured and preserved intact forever.

With Leica Geosystems’ Incident Mapping Suite (IMS), scenes are not compromised and evidence will be documented in court ready documents. Dold explained a particular case of a shooting where laser scanning was

able to provide a clear view of where shots were fired from and how. The captured point clouds allowed public safety professionals and court officials to digitally walk through the scene and analyse the path of the bullets, clearing conflicts between officer and witness testimonies.

For AEC professionals, perceptality brings greater efficiency. Renovations that are planned incorrectly can drive repair costs up and property values down. Augmenting building renovations with digital realities sees increased cost and time savings.

With the new Leica BLK360 imaging laser scanner, a technology that was typically not used by the AEC sector before has now become accessible. Dold explained the creative process behind the BLK360 as being driven by the desire to democratise laser scanning by focusing on the creation of a simple, vibrant, connected and portable device that functions with the simple push of a button.

"We are pushing the boundaries of technology to augment perception with reality," said Dold. "We want to move beyond just industries and bring perceptality to everyone – to anyone who can push a button."

WALKING THE BRIDGE

Dold concluded the keynote by exploring these boundaries of technology. He insisted Geosystems is moving beyond the limits to think of what has not been thought of before in a new way. He recognised barriers ahead of what has yet to be discovered while also acknowledging limitations in ourselves. He encouraged the audience to walk the bridge between perception and reality, developing visionary ideas while understanding the effects of the real world.

"At Hexagon Geosystems, we are building the bridge to transform the real world into the digital reality with unique reality capture solutions. We are providing interoperability through cloud-enabled techniques to bring perceptality to countless industries," said Dold. "We are all looking for better versions – better versions of technologies, of our companies, of ourselves. We at Geosystems are also working on these better versions, and we invite you to join us on this journey to a better version of your world."

HEXAGON GEOSYSTEMS FEATURES CUSTOMERS

AROUND THE WORLD. EVERY DAY. ANY APPLICATION.

Whether it is building the biggest tunnel road in Poland or working on an irrigation project in Mozambique, our users are working diligently to further not only the industry but global society.

At Hexagon Geosystems, we are honoured to be a part of this, supporting them with precise and accurate instruments, sophisticated software, and trusted services. We deliver value every day to those shaping the future of our world, and we thank them for all that they do continuously, tirelessly, decisively. Here, we feature a few of our users in the field doing what they do best - shaping smart change for a better world.

Share with us how you are solving complex daily challenges using Geosystems solutions. Send us your photos at reporter@leica-geosystems.com to be featured in our *Reporter* magazine.

Building project, Kuwait

Building project in Kuwait using Leica TPS 1200 by Jitesh Menon

Irrigation project, Mozambique

Irrigation project in Mozambique using Leica Viva GS14 by Danniely Zacarias Massingue

Road project, Iraq

Road project in Iraq using Leica FlexLine TPS by Haval M. Mustafa

Saudi Railway Organisation (SRO) tunnel project, Saudi Arabia

Saudi Railway Organisation (SRO) tunnel project in Jeddah, Saudi Arabia using Leica TCR 1203 by Rizwan Aziz Qureshi

Building the biggest road tunnel, Poland

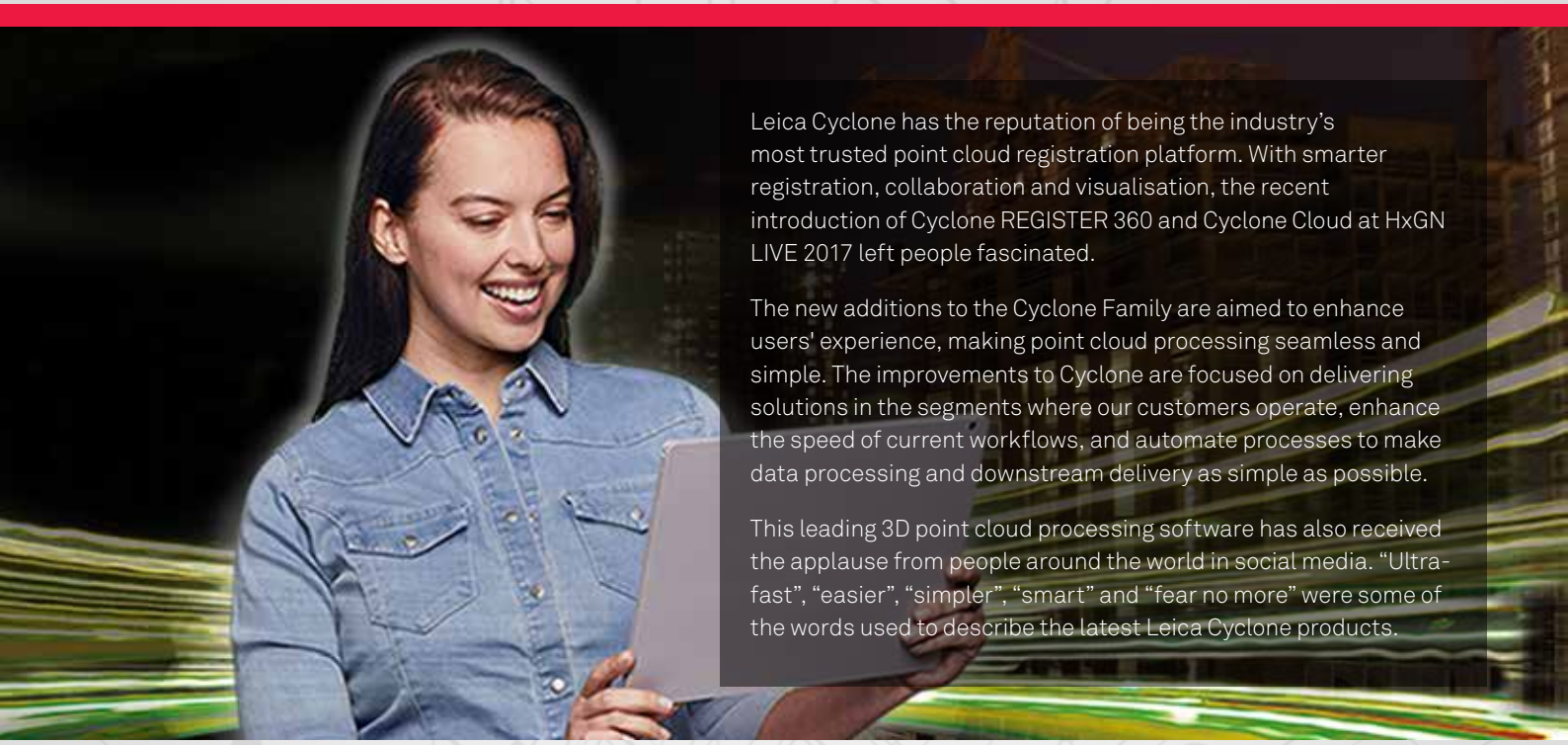
Building the biggest road tunnel in Poland using Leica FlexLine TS09 total station by Piotr Stanicki

Kho-rait archaeological zone project, Egypt

Kho-rait archaeological zone project in Egypt using Leica FlexLine TS02 total station by Abdel Halim Zakaria and Abdo Zakarya

LEICA CYCLONE REGISTER 360 LASER SCANNING SOFTWARE

IN YOUR WORDS



Leica Cyclone has the reputation of being the industry's most trusted point cloud registration platform. With smarter registration, collaboration and visualisation, the recent introduction of Cyclone REGISTER 360 and Cyclone Cloud at HxGN LIVE 2017 left people fascinated.

The new additions to the Cyclone Family are aimed to enhance users' experience, making point cloud processing seamless and simple. The improvements to Cyclone are focused on delivering solutions in the segments where our customers operate, enhance the speed of current workflows, and automate processes to make data processing and downstream delivery as simple as possible.

This leading 3D point cloud processing software has also received the applause from people around the world in social media. "Ultra-fast", "easier", "simpler", "smart" and "fear no more" were some of the words used to describe the latest Leica Cyclone products.

Jürgen Dold

Simpler look, smart, automated processing @HexagonAB @LeicaGeosystems

micrus

@LeicaGeoUS Cyclone Cloud! A new cloud system based on #docker containers announced at #hxgnlive #truview

SPAR 3D Editor

Leica Cyclone REGISTER 360: Ultra-Fast Registration to Complement the BLK360

Gary Kelly

For those who fear the process of registering point cloud data. Fear no more. Leica Cyclone REGISTER 360 - the power of Cyclone

Mark King

The new @LeicaGeosystems #laserscanning software: Cyclone REGISTER 360 takes point cloud data to the next level

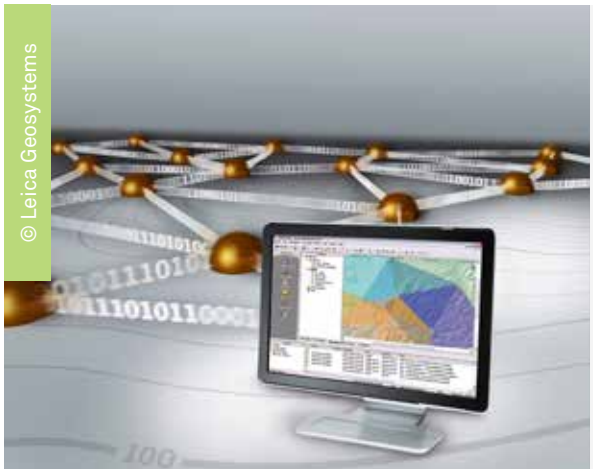
Bucky Lawley

It's here! Leica Cyclone REGISTER 360 - A new easier way to register your point cloud data

© Leica Geosystems

Leica Geosystems increases productivity with intelligent MSS400 Series Sensors

Ensuring speed, performance, precision and productivity, the new MSS400 Series Sensors incorporate SP Technology that allows faster digging without loss of precision at higher speeds for even more productivity from any excavator machine control solution. Inertial measurement technology incorporated in the sensors and combined with gyroscopes and accelerometers offers the most responsive sensor technology on the market to improve digging accuracy and increase the operator's overall speed in completing the work.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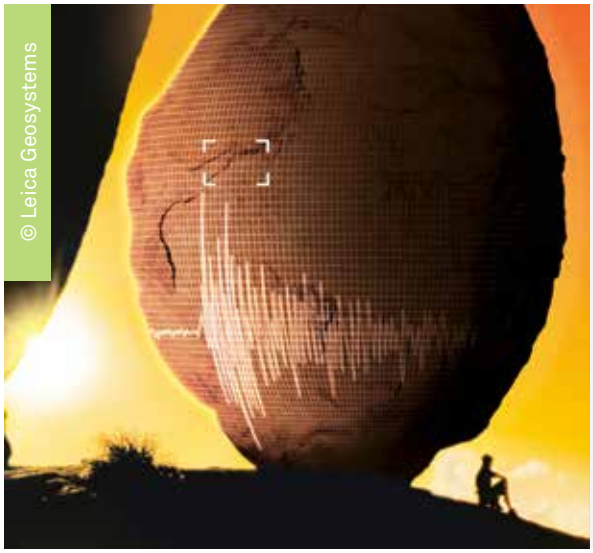
Leica Geosystems' GNSS networks now support Galileo, QZSS

Spider v7.0 now supports all known GNSS — GPS, GLONASS, BeiDou, Galileo and also QZSS. The all-in-one solution offers professionals from various industries, such as surveying, mapping, agriculture or GIS, improved positioning accuracy and correction service. Professionals can now increase productivity while they operate reliably in environments with obstructions or at high latitudes, due to the higher number of usable satellites from multiple GNSS constellations.


© Leica Geosystems

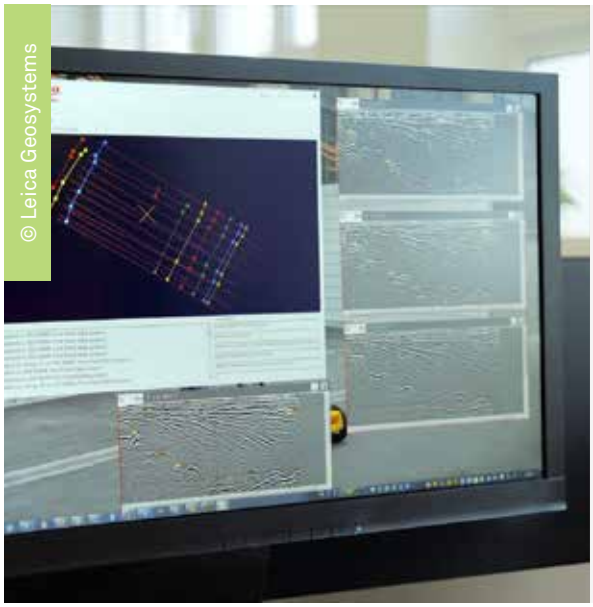
New Leica Zeno GG04 smart antenna increases access to GIS, enhances tracking performance

The new Leica Zeno GG04 smart antenna enables a flexible solution to improve mobile devices' GNSS accuracy with Real-Time Kinematic (RTK) and Precise Point Positioning (PPP). Paired with the Zeno GG04, any Zeno or third party mobile device with Android or Windows OS can now collect highly-precise positioning data with Leica Geosystems' GNSS technology and industry-leading 555-channel tracking performance. With PPP, users can collect data even in areas without cellular coverage. The bring-your-own-device (BYOD) functionality enables any smart device to collect survey-grade data, delivering centimetre results.



Leica Geosystems introduces imagery, live video stream to monitoring

With GeoMoS Imaging, an image based extension to the existing GeoMoS monitoring solution, users can continuously stay up-to-date on their monitoring project and make the best decision quickly and easily. The remote monitoring of a site can now become simpler; the live view enables users to observe and record areas of interest, and the joystick functionality allows direct access to the total station and remote operation from the convenience of the desk. Professionals can now increase their productivity and reduce their time in the field.



New utility post processing software delivers CAD drawings in less time with professional results

The new DX Office Vision utility post processing software is for mapping ground penetrating radar (GPR) data from the field into a CAD drawing in an easy and professional way with minimal training. DX Office Vision allows even non-experienced users to obtain professional 3D CAD drawings and visualise the detected underground utilities in a simple way. The intuitive interface enables users to filter, select, identify and make annotations of the located targets. With DX Office Vision, post processing for all ground penetrating data requires no add-on or third party software.

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IMPRINT:
Reporter: Leica Geosystems customer magazine, **Published by:** Leica Geosystems AG, CH-9435 Heerbrugg
Editorial office: Leica Geosystems AG, 9435, Heerbrugg, Switzerland, Phone +41 71 727 3131, reporter@leica-geosystems.com
Contents responsible: Monica Miller Rodgers, APR, Communications Director **Editors:** Monica Miller Rodgers, Renata Barradas Gutiérrez
Design: Stephanie Chau, Marino Plecas

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