Reporter 67

The **Global Magazine** of Leica Geosystems

- when it has to be **right**

Leica Geosystems

Editorial

Dear Readers,

Europe's tallest building was officially opened in London this spring. "The Shard" is 310 m (1,017 ft) tall and named for its striking façade. Britain's capital city is but one of many places around the world currently humming with the activity of challenging engineering projects. Tall buildings like The Shard, or infrastructure projects such as the tunneling of the Kaiser-Wilhelm-Tunnel in Germany with minimum cover must all be geodetically monitored every second of every day to minimize possible risks to the infrastructure and life around it.

Man-made projects, however, are not our only challenge; Mother Nature also has challenges in store for us. Sadly, they do not always end as well as in the Swiss canton of Ticino earlier this summer, where, thanks to Leica Geosystems' GeoMoS monitoring solutions, factory workers were safely evacuated before a rock fall. News like this and successes in challenging construction projects are what make us proud that our customers trust Leica Geosystems' products and solutions.

Like every year at this time Intergeo is coming up and we will be presenting a number of innovations from the 9 to the 11 October in Hanover, Germany. For example, the new Leica ScanStation P20 which can measure up to 1 million points/second at a very high range and the Leica Viva GS08plus which is the smallest, cable-free precision GNSS solution available. These and many more innovations will be on display at Leica Geosystems booth in hall 7, stand E.30. The Leica Geosystems sales team and I look forward to seeing you there!

Juergen Dold
CEO Leica Geosystems

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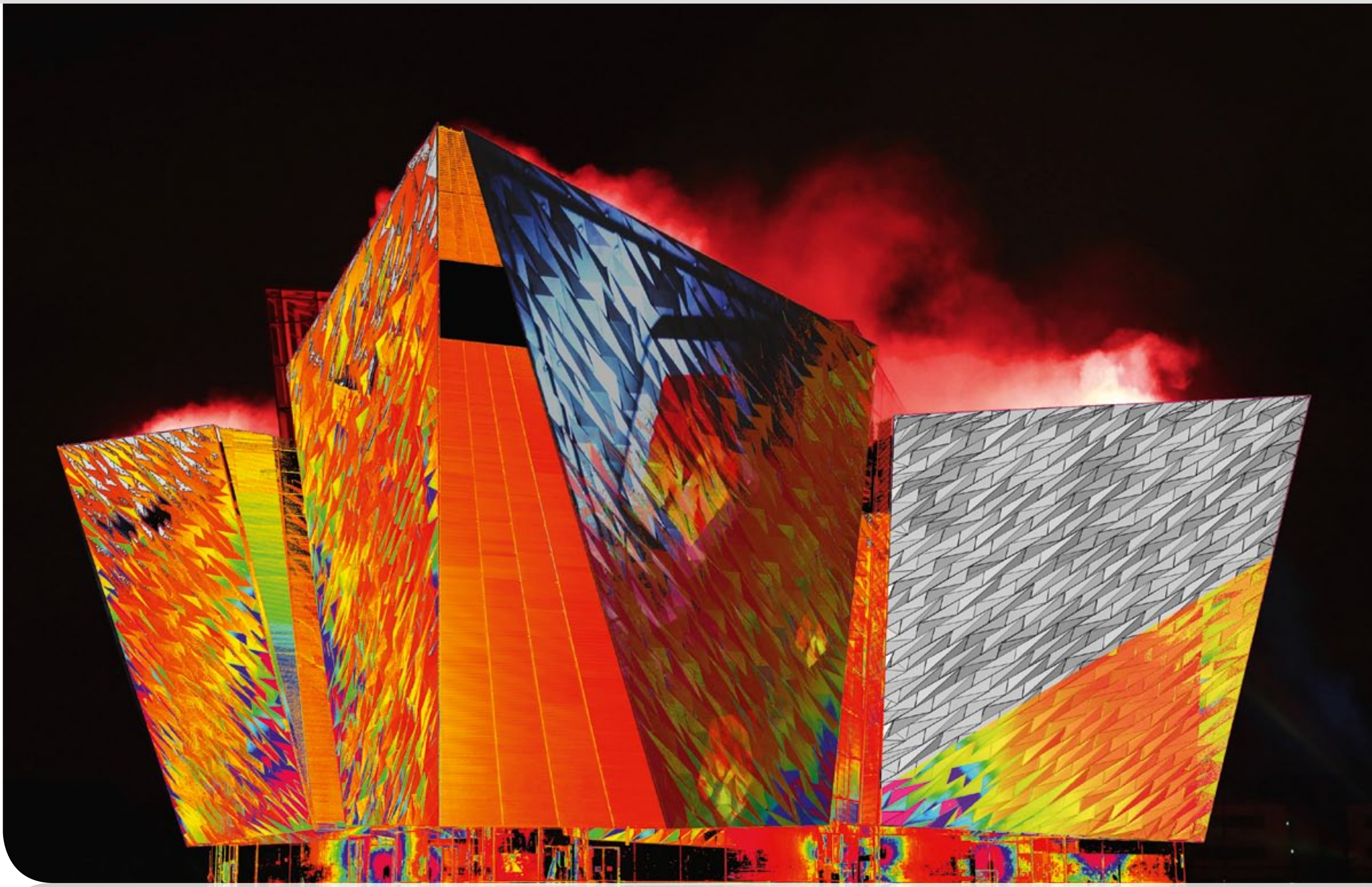

Light Show for Titanic Belfast

by Mark Hudson

The Titanic was making headlines in April as Belfast marked the 100th anniversary of the ship's sinking. Coastway, a chartered geospatial engineering company based in Co Kildare, Ireland, was retained by UK interactive arts and technology collective, "seeper", to produce a 3D model of Belfast city's newest tourist attraction, Titanic Belfast.

Titanic Belfast is a 14,000 m^2 (16,700 yd^2) state-of-the-art visitor center telling the story of RMS Titanic from its conception to the ship's tragic maiden voyage. The Belfast City Council and The Northern Ireland Tourist Board organized a festival to commemorate the Titanic story. The highlight of the Titanic Belfast Opening Festival was a spectacular 3D motion graphics and pyrotechnics light show produced by seeper. It was for this light show that seeper required Coastway to provide them with a highly accurate 3D Model of Titanic Belfast to enable them to plan, design, and execute a fully immersive light show using 3D projection mapping onto the building façade.

The Challenge

Whilst Coastway has significant experience in producing 3D Models of façades using High-Definition Laser Scanning technology, the unique architectural design of the Titanic Belfast building presented them

More than 3,000 irregular façade panels of the visitor center were scanned for the light show.

with a number of challenges during the laser scanning and modeling process due to its asymmetrical structure and use of specialized façade materials: The building façade is comprised of over 3,000 irregular anodized aluminum satin finished panels.

Coastway's Solution

Following a detailed study of the building, Coastway proposed using laser scanning to produce a 3D model and then transferring it to seeper's required Cinema 4D format. Coastway used the Leica HDS6200 3D laser scanner to survey the exterior face structure of the Titanic Belfast building. The survey was performed using a 2 m (6.6 ft) tripod and elevated platforms and by scanning from the roofs of the protruding hull structures. The survey was completed in three days on-site with a further three days to register the collected laser scan data and geo-reference the resulting point cloud to Irish National Grid Co-ordinates.

Coastway were required to achieve accuracies of ±10 mm (0.39 in) with the final model. The Leica HDS6200 quoted accuracy of 2 mm (0.078 in) on a modeled surface when combined with survey control accuracy of ±2 mm (0.078 in) enabled us to achieve and exceed the desired accuracy. To further ensure the accuracy of the 3D Model, Coastway collaborated with EDM Spanwall to verify each panel against the fabrication dimensions.

The full 3D model of the building façade took three weeks to produce. Each of the 3,000+ irregular panels had to be individually modeled in Leica CloudWorx for AutoCAD plug-in and in additional modeling software.

The Titanic

Built in Belfast, Nothern Ireland, the RMS Titanic passenger liner was the second of three Olympic-class ocean liners – the others were the RMS Olympic and the HMHS Britannic (originally named Gigantic). They were by far the largest vessels of the British White Star Line's fleet, comprised of 29 steamers and tenders in 1912.

The ships were constructed by Belfast shipbuilders Harland and Wolff, who had a long-established relationship with the White Star Line dating back to 1867.

The RMS Titanic sank in the North Atlantic Ocean on 15 April 1912 after colliding with an iceberg during her maiden voyage from Southampton to New York City.

The sinking of the Titanic caused the deaths of 1,514 people in one of the deadliest peacetime maritime disasters in history. She was the largest ship afloat at the time of her maiden voyage.

Source: Wikipedia

The complicated building façade and highly reflective surface of the anodized aluminum satin finished panels created problems for ensuring a complete return of laser scan survey data. Return signals to the Leica HDS6200 were just about at their limit at a range of 79 m (259 ft) from the instrument set up to the very top of the building. Access to top of the building was limited but Coastway had to ensure they could capture any remaining areas that could not be surveyed from the ground. Coastway would certainly consider using the Leica ScanStation C10 laser scanner on future similar projects, where the extended range would enable a larger proportion of laser scan data to be captured from the ground stations.

The completed façade model was saved as a Cinema 4D format for seeper to use for the production of their light and pyrotechnics shows.

The Titanic Belfast Light Show was held on 5 April 2012 and was watched by an estimated 60,000 people. The show consisted of projection mapping onto different sides of the building simultaneously combining pyrotechnics, fireworks, and soundtrack to tell the story of the Titanic. ■

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Monitoring Pays Off

by Konrad Saal

During the night of 14 May this year, 300,000 m³ (392,000 yd³) of rock broke off the Valegion mountain and crashed down 1,000 m (3,281 ft) to the valley floor in the Swiss canton of Ticino, near the village of Preonzo. Thanks in part to Leica Geosystems' Deformation Monitoring solution GeoMoS local authorities were able to evacuate the valley's industrial zone and to close the A2 highway and several cantonal roads at an early stage.

The community Preonzo between Biasca and Bellinzona in the canton Ticino/Switzerland has lived with rock falls for several years. Ten years ago, a huge rock mass slid into the valley. The Cantonal Forestry Office has been watching the danger zone since 1998, and has been relying on automatic monitoring systems from Leica Geosystems AG for the past two years. Cantonal geologist Giorgio Valenti says: "We have regularly experienced small movements over the years, especially in spring time. Since the end of April of this year, the movements measured have increased to several millimeters per hour, which made the safety measures necessary."

Smallest Movements Determined from Precise 3D Data

The automatic monitoring system has provided continuous information about every movement in the affected zone. Two years ago a Leica TM30 Monitoring Sensor was installed on a stable pillar below the slide area and connected to the Leica GeoMoS monitoring system. Since then the sensor has monitored 15 observation points located inside and outside the danger zone every hour, 24/7. The results are automatically forwarded to an FTP server in the Forestry Department and then analyzed by experts.

Michael Rutschmann, Product Manager at Leica Geosystems and technical consultant for this project, also has access to the data: "For years we have been able to track three-dimensional data with millimeter-accuracy in real-time, knowing when movements took place and in which direction. The responsible experts were able to analyze developments and trends, and combined this data with additional information. The complete measurement history is very valuable to the geologists' further analysis."

The experts were kept informed by SMS about the movements. As their speed continued to increase, it became clear that the rock would soon break off.

Leica TM30 monitoring the area.

■ **This is where 300,000 m³ of rock crashed down 1,000 m to the valley floor.**

Geodetic Monitoring Systems Help Save Human Lives

Based on the analysis of Leica GeoMoS and extensometer data, the necessary safety measures could be initiated early. The industrial area at the foot of the mountain, which is important for the local economy in this region, could be evacuated in time. The police also closed cantonal roads and the highway. It could not be predicted if the mass would reach and damage the industrial zone when the one million ton load crashed down to the valley.

Future Measures

The 70 employees of the six companies in the industrial zone have resumed their work. But even after this event in Preonzo the Leica Geosystems monitoring system will continue to monitor the slope accurately to protect the people. "Some of the observation points were destroyed during the rock fall. More observation points will be installed in an extended parameter around the fracture area and will be continuously monitored for their stability," said Michael Rutschmann.

Two years ago the community of Preonzo and the Forestry Office of the Canton Ticino (Sezione Forestale, Cantone Ticino) decided in favor of funding and commissioning an additional Leica Geosystems monitoring system to observe the area. ■

Find a video about the rock fall on youtube:
www.youtube.com/watch?v=Q6JCR1HZpeE

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The Shard: London's New Skyline

by James Whitworth

Byrne Bros is both one of the UK's and the world's leading formwork construction companies. They were appointed by main building contractor Mace to carry out the concrete substructure and superstructure works for Europe's tallest building – The Shard in London – in a contract worth more than 64 Mio. Euro (78.5 Mio. US Dollar). In the summer of 2009, Leica Geosystems was approached by Byrne Bros to develop a real-time slip-form rig positioning system, used to construct the central concrete core of The Shard.

The substructure of The Shard adopted 'top down' techniques and the main structural core was slip-formed in parallel solutions, which delivered significant program advantages. Slip-form construction is perhaps one of the safest, efficient, and most economical methods of building vertical structures. It enables formwork construction to rise at rates of up to 8 m (26 ft) in 24 hours. Traditional methods of controlling the position of a slip-form rig as it rises are often time consuming and labor intensive. Normally a site surveying team will compute traverse computations from observations taken with total stations and precise optical plummets. These calculations allow the position of the rig to be obtained in the site grid coordinates. As the vertical concrete core has known offsets from the rig it is therefore possible to guarantee the core is being constructed vertically in relation to its design coordinates.

Tight Tolerances

The required tolerance for The Shard project was that rig plan position should not exceed ±25 mm (±0.98 in) deviation against the design coordinates. After some consultation between Leica Geosystems and Byrne Bros a combined system of total stations, GNSS, and dual axis inclinometers was agreed upon. Real-time GNSS positions allowed determination of the rig's position. Both the translation and rotation of the rig could be determined using GNSS technology, but it was unable to provide information on the rig's inclination which could have been up to ±75 mm (±2.95 in) over the 20 m (66 ft) square rig, depending on the correction factors applied by the rig man-

ager. It was therefore necessary to calculate the tilt on the rig. This was achieved using data acquired from four dual axis inclinometers. By using the virtual sensor functionality within the Leica GeoMoS Monitoring software it was possible to compute a tilt compensated position of all four corners of the rig. The inclination sensors were chosen due to the large expected range of tilt and were integrated into the systems via a Campbell Scientific Datalogger.

Setting Up a Reliable Construction Monitoring System

As with any other city, working with GNSS technology in London can often prove challenging. Existing buildings and infrastructure can obscure satellite signals, resulting in unreliable positions or even no possible calculation. For this reason 360° prisms were co-located with the Leica AS10 GNSS antenna to allow both total station and GNSS observations to be gathered simultaneously, which would also provide a check on the GNSS results, particularly while the rig was near ground level and the potential for difficulties with a clear satellite window were greater.

To allow the GNSS and total station results to be correlated a set of transformation parameters were calculated within Leica GeoOffice.

In addition to the problem of actually using GNSS technology in the 'urban canyon', the provision of both reliable and stable reference stations was extremely difficult. Often easy access to a stable location that provides both the necessary power supply and communication was hard to obtain. Negotiation with other building owners and businesses could have been prohibitively expensive. Finally it was decided to use a real-time data feed from Leica SmartNet NRTK correction service.

The four GMX902GG receivers were connected to the site computer running on the rig. Leica GNSS Spider received the incoming data streams for these receivers and a real-time data stream from the SmartNet service. Internet connectivity was provided by a WLAN bridge system, comprised of two directional antennas, which guaranteed reliable Internet connectivity to the site computer on the rig as it rose nearly three meters per day.

The position of each antenna on the rig was computed with respect to the nearest SmartNet reference station which was approximately 2.4 km (1.5 mi) away. This yielded a three-dimensional coordinate quality of better than ±25 mm (±0.98 in).

Computing Positions Every Second

GNSS positions were computed every second within Leica GNSS Spider and the median result of these observations were sent to Leica GeoMoS every 10 seconds where they were synchronized with the data from the dual axis inclinometers and the wind speed. A computation was simultaneously carried out within GeoMoS, applying the lateral shift caused by the tilt of the GNSS antenna to the vertical position.

The rig positioning interface used the open architecture of Leica GeoMoS, which is built on a Microsoft SQL database. An ODBC (Open DataBase Con-

The Shard

Renzo Piano, the architect for The Shard, considers the slender, spire like tower a positive addition to the London skyline. The sophisticated use of glazing with expressive façades of angled panes is intended to reflect light and the changing patterns of the sky, so that the form of the building will change according to the weather and seasons. The Shard towers 306 m (1,017 ft) into the sky and is the tallest building in the European Union. Since its completion in April 2012 it soars more than 70 floors above London. The Shard houses offices for Transport for London, a hotel, and luxury apartments, all with exclusive views over the capital.

'When it comes to structural monitoring, there is no room for risk. It is integral for us to be able to work with a technology that is adaptable to the project and delivers without fail. That's why we chose Leica Geosystems and that's why we were able to deliver one of the largest engineering projects with absolute precision.'

Donald Houston, Byrne Bros

nectivity) link was established between the GeoMoS database and the bespoke interface, which displayed the results graphically, so that it was easy to understand by the rig manager. This interface enabled the rig manager to make adjustments to the rig position using hydraulic pumps. A traffic light system of warnings was displayed within the interface. If the computed results exceeded ±25 mm (±0.98 in) lateral displacement against the design position of ±4 mm per meter (±0.05 in per foot) of tilt on any corner of the rig, then an orange display was shown. An exaggerated rig display and level 'bubble' display allowed instant visualization of results.

Project Results

This new and innovative approach to controlling the position of a slip-form rig proved highly successful on The Shard project. The fact that the results obtained could be verified and correlated to those obtained via traditional methods was extremely important in building confidence in the system. This, allied to the fact that the Leica Geosystems Monitoring Support team could support this system remotely even 24/7, meant that, particularly in the early stages of this project, confidence in the system was assured. Other tall buildings being constructed in London using slip-form methodology have already adopted this system and Byrne Bros plan to use this system again on future projects. ■

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3D Laser Scanning Boosts BIM

by Geoff Jacobs

There's a lot of buzz about BIM – Building Information Modeling – and what its rapid adoption means to surveying, design, and construction professionals. BIM allows the generation and management of physical and functional properties of a building by digital representation. The surveying and mapping firm Woolpert was recently involved in a large BIM project that took advantage of current advances in field data capture and office processing based on Leica Geosystems laser scanners and point cloud software. These advances significantly improved the efficiency of applying 3D laser scanning for the creation of accurate, intelligent 3D models – the foundation of BIM.

The Woolpert team and the architecture and construction firm Beck Group were contracted by the United States General Services Administration (GSA) to provide accurate BIM deliverables for federal buildings in Atlanta, Georgia. The two firms had previously teamed up for a similar project at the same campus as part of a pilot "scan-to-BIM" study that GSA had sponsored. For this second project with five

■ **Operating the Leica ScanStation via tablet.**

buildings – two 30-floor buildings and one each of six, nine, and ten floors dating back to the 1920's – GSA had a fixed budget allocated for data capture and BIM creation. To meet the budget constraints and an ambitious schedule, and to try to exceed client expectations, both Woolpert and The Beck Group turned to innovations based on Leica Geosystems laser scanning tools.

Woolpert's final deliverables to The Beck Group were registered, geo-referenced point clouds. The end client (GSA) required Autodesk®Revit® BIM models of each building, with separate models for interior, structural, façade, as well as site models. Separate BIM models enabled the client to keep each Revit file below 100 MB. In total, Beck had to deliver BIM models covering 420,000 m^2 (502,000 yd^2) of building area. So, both in field and office work this was a large project and it entailed significant office time to create the models.

Field Innovations

For the new project, Woolpert used their two new, compact, and versatile Leica ScanStation C10's. Woolpert developed an innovative field approach for their ScanStation C10's that enabled them to beat the efficiency of their prior approach and exceed client expectations.

Woolpert placed each of two ScanStation C10's on rolling tripods and used a wireless tablet controller to execute field scanning and photo capture. The rolling tripod reduced the time for set up, tear down and moving of the scanner from station to station. It also eliminated powering off and re-booting each ScanStation C10 between setups. A crew of three operated both 3D laser scanners simultaneously.

Eliminating scanner setup, tear-down, and powering off/on between stations saved five minutes per setup, resulting in a time reduction of 36 percent. With more than 400 setups, the net savings were significant.

Using a wireless tablet with a larger display to control scanning, photo capture, and target acquisition provided high visibility for scan quality monitoring and better zooming resolution for critical aiming at targets. In addition, operators were free to roam while scanning and were able to record targets with the tablet while walking to the next location.

Comparing field efficiency of the new approach to pilot project metrics, the overall average time per scan was reduced by 23 percent.

Office Innovations

There were also two innovations on the office side of the project – one by Woolpert related to monitoring field capture progress and the other by The Beck Group for speeding up the processing of registered scans into intelligent 3D BIM models.

The buildings were secure government offices in Atlanta, more than 1,000 km (700 mi) from Woolpert's main laser scanning administration office in Dallas, Texas. The Beck Group office was in Atlanta. To improve internal communications and client interaction during the two-week scanning portion of the project, Woolpert integrated Leica TruViews directly into AutoCAD® drawings of the buildings. TruViews – lightweight file sets that enable intuitive, panoramic viewing of scans and photos over the web – enabled internal, client, and partner staff to easily monitor scanning progress and ensure that areas being scanned were the right ones, thus avoiding return trips to the site. Users could also measure from scan images, pan/zoom, mark-up, and even link images to other content.

In the early stage of creating Revit models, The Beck Group staff modeled based on old drawings and CAD files. To ensure accurate "as-is" model geometry, BIM

■ **Model buildings in 3D from the point cloud using Leica CloudWorx for Revit.**

models and registered point clouds were overlaid in Navisworks® and compared. The BIM model was adjusted as needed and then re-checked in Navisworks. However, simply opening large point clouds within Navisworks took a long time and the process was not as exact as being able to create the BIM model directly from point clouds.

Beck looked for an alternative solution to increase production of as-built models. When Leica CloudWorx for Revit first became available in January 2012, Beck's staff was eager to try it out for this project. Leica CloudWorx plug-ins enable users to work efficiently with point cloud data directly within CAD (e.g. AutoCAD) and VR (Virtual Reality) applications. They have been very popular ever since they were first introduced in 2001. Today, there are eight different Leica CloudWorx plug-in's for specific CAD and VR applications. Leica CloudWorx for Revit is the latest addition to the Leica CloudWorx family.

One immediate benefit was Beck's ability to open registered scan files directly from CloudWorx' Cyclone database and project file structure without any data conversion steps. However, Beck also found some limitations in this first release version that prevented them from using it the way they needed to – which was to create BIM models directly from point clouds.

Beck's BIM Manager, Jason Waddell, worked directly with Leica Geosystems Product Manager, David Langley, providing input about their initial findings. This resulted in a second version of Leica CloudWorx for Revit that did everything Beck expected.

Beck could now readily manage very large point cloud files and quickly manipulate scans – even high density areas – for efficient 3D viewing. He was also able to quickly slice and crop point cloud areas of interest directly. Furthermore, the new version allowed him to perform fast, accurate elevation & plan sectioning, set levels & work-planes, and directly place doors, light fixtures, and even model piping from point clouds (in Revit MEP).

Ultimately Beck was able to eliminate the previous workflow steps of loading and viewing point clouds and models in Navisworks and/or Revit. Overall, using Leica CloudWorx for Revit enabled Beck to increase office productivity for creating accurate BIM models based on laser scan data by about 50 percent – significant savings for a large project like this. ■

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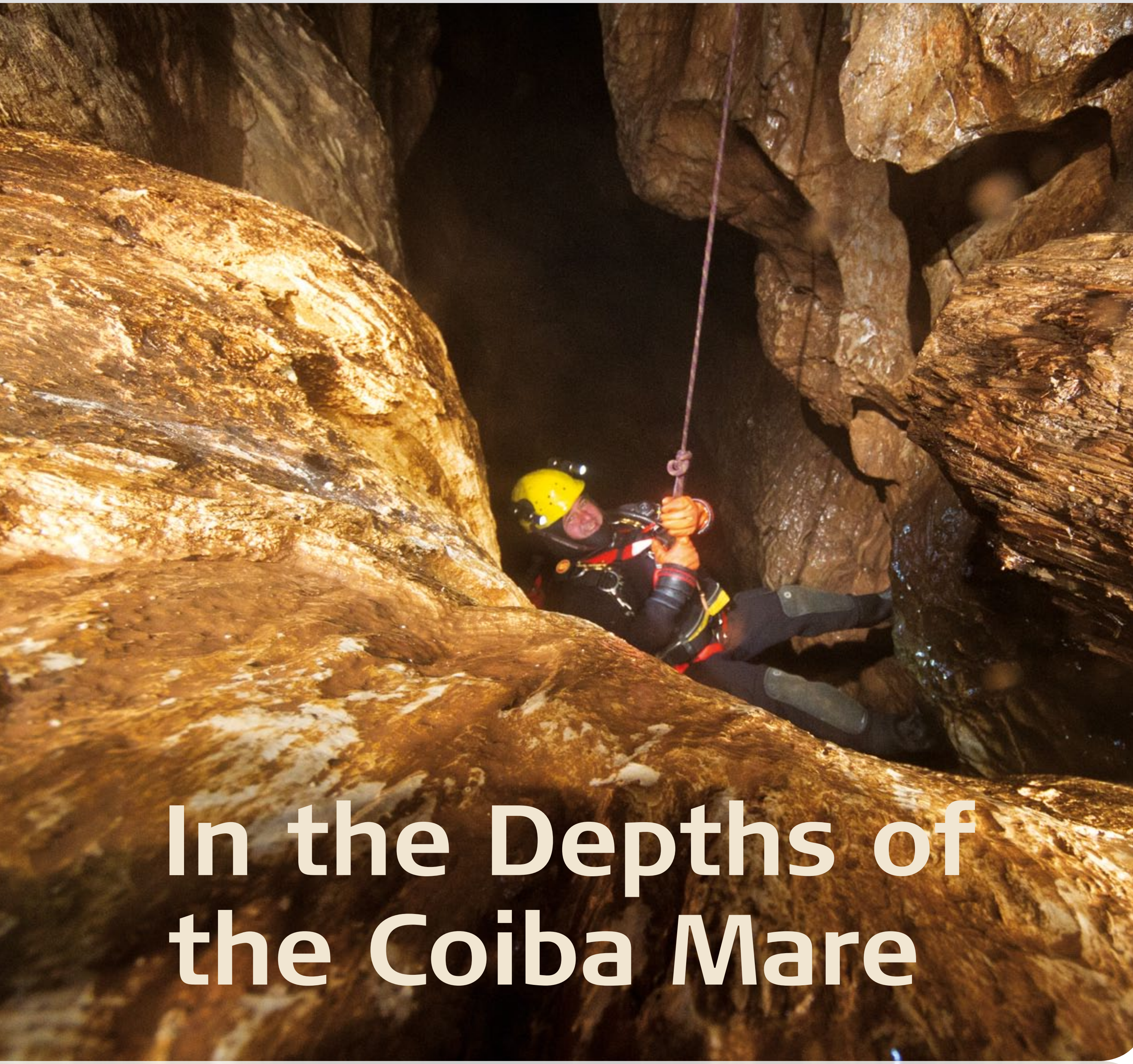


In the Depths of the Coiba Mare

In the summer of 2011, a cave research team from Austria set off to Romania on an expedition into the Western Carpathian Mountains. The objective was to survey the dry area, what speleologists consider the accessible area, of the Coiba Mare cave. Of particular interest was the course of the water in the cave system. Romanian experts have long suspected that the cave is connected to a much more extensive system of underground passages. The survey team took along a Leica DISTO™ D3a to survey the dry area of the Coiba Mare.

by Walter Huber

The Coiba Mare cave system extends over a total length of 5,042 m (16,540 ft). The major part of this cave system consists of a labyrinth, which begins just inside the huge entrance portal. After 727 m (2,385 ft), the water running through the cave disappears into the Lacul Mortii final sump. Cave researchers use the term sump to describe a section of cave under water. Hydrological investigations have shown that the final sump must be connected to the Izbucul Tauz karst spring, which emerges about four kilome-

■ **Small and efficient: The Leica DISTO™ D3a with integrated tilt sensor.**

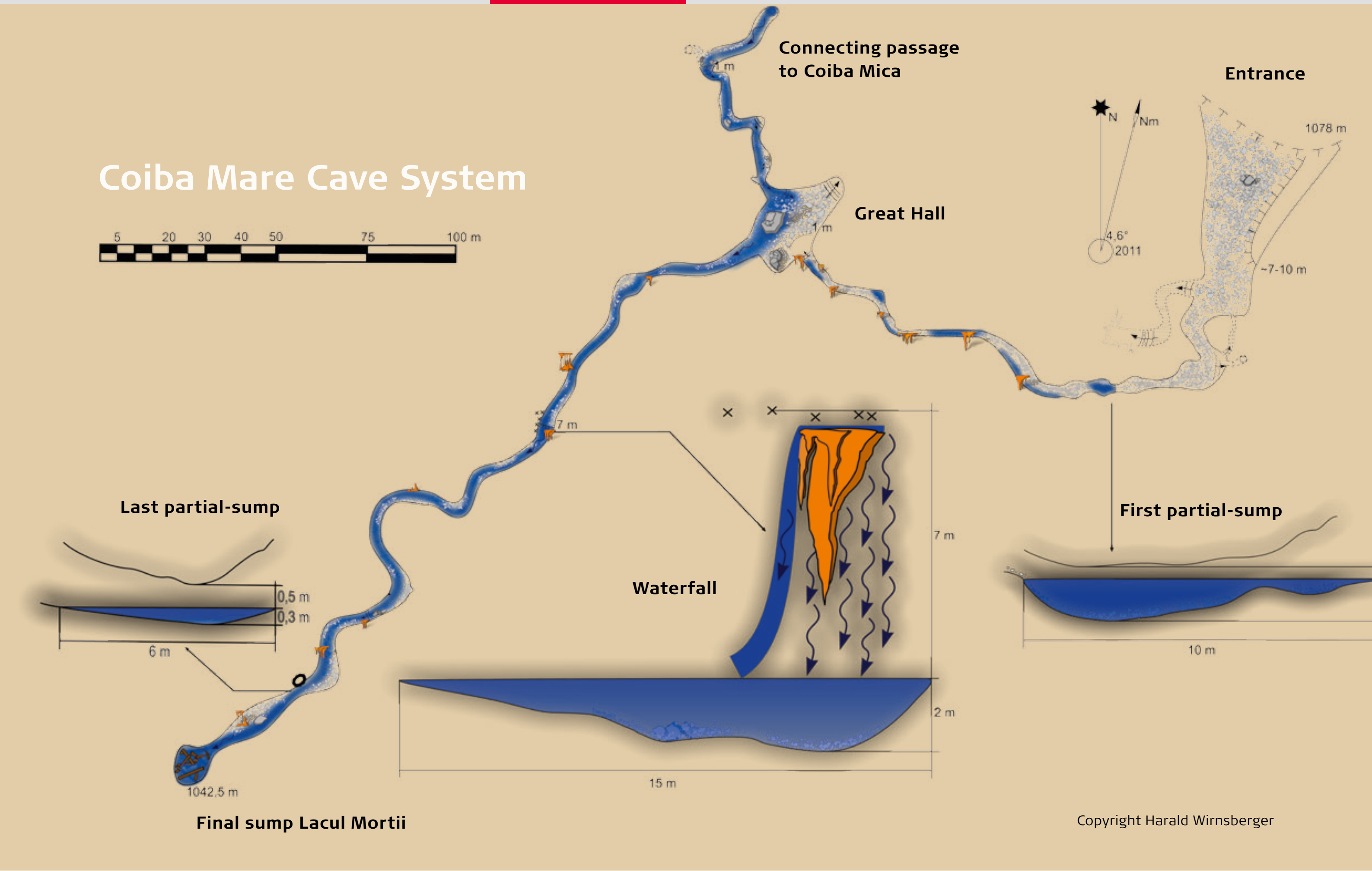
ters further down the valley and, at –87 m (–285 ft) lower than the cave opening, is one of the deepest known sumps in Romania. This is where the water of the Coiba Mare reappears at ground level.

Because of the complexity and extreme conditions in the two connected cave systems a precise and conclusive layout drawing and a 3D model were required to continue research. From the beginning, it was clear that only extremely durable surveying equipment could be used – in addition to everything else, the humidity throughout the cave system is more than 90 %, with areas of flowing or standing water as well as some narrow partially water-filled partial-sumps. A layout drawing would also be enormously helpful for the planning of the transport of several hundred kilograms of equipment. The small, robust Leica DISTO™ D3a, with its precision laser for distance measurement and integrated tilt sensor, was the ideal instrument for the job. An azimuth compass provided the bearings. The team also had the important task of determining the precise elevation of the Coiba Mare final sump.

The cave entrance is gigantic – at more than 50 x 70 m (165 x 230 ft), the cave portal is the second largest found so far in Romania – and attracts many tourists every year. In spite of direct sunlight and long sight distances, it had never been possible to produce a precise and detailed survey of the portal. The Leica DISTO™ D3a performed brilliantly to overcome this first challenge.

After the first 150 m (500 ft) the cave becomes wet and narrow before it reaches the start of the first partial-sump. At this point, the cave roof is as little as 30 cm (12 in) above the water surface. For surveying beyond here, we had to wear our drysuits. The partial-sump is 11 m (36 ft) long and about one meter (3 ft) deep. The next leg of the survey, a wet part of the cave with over 90 % relative humidity and an ambient temperature of 6° C (43° F), was a really hard test for the Leica DISTO™ D3a.

After a further leg of 200 m (656 ft), we reached the great hall, which has a branch leading into the Coiba Mica cave. The longer distances in the hall were measured successfully despite the high relative humidity. The passageway in this section is more than 10 m (33 ft) high, several meters wide and breathtakingly beautiful. The mineral deposits create fairy-tale rock forms. We then made a 130 m (426 ft) detour along



the gallery to the north in the direction of the Coiba Mica cave system.

Back in the great hall, after a leg of 140 m (459 ft) we reached a 7 m (23 ft) deep waterfall, which required safety harnesses and ropes to descend. The topographical features made the choice of survey points difficult and the measurements had to be taken while roped up. The reliability of the DISTO™ D3a was a great advantage to us here.

Once we were down, the passage headed off in the direction of the Lacul Mortii final sump, which translates as "Lake of Death". After overcoming another partial-sump, 40 m (131 ft) from the final sump, we surveyed the leg down to the final sump, 285 m (935 ft) from the waterfall. Unfortunately, we were not able to survey the final sump due to driftwood barring our path.

By using GPS to determine elevations above national datum of the entrance to the cave system and the Izbucul Tauz karst spring, we hoped to confirm our assumption that the passageway from the Lacul Mortii final sump must rise again. We believed that beyond the submerged section, which unfortunately was blocked, there must be another dry passageway before the water finally reaches –87 m (–285 ft), its lowest level in the system, in Izbucul Tauz.

Based on the survey, we now know that there is a height difference of over 200 m (656 ft) between the Coiba Mare final sump and Izbucul Tauz. This means the final sump of the Coiba Mare must actually be higher. Therefore there must be another dry section after this sump. Romanian researchers had long speculated that there was a further major system of passageways half-way (by distance and height) between the final sump and Izbucul Tauz – which would then be Romania's longest cave labyrinth. Until now, however, nobody had found the "key".

Using the Leica DISTO™ D3a, the team was able to complete the survey in considerably less time than it would otherwise have taken. The integrated tilt sensor enormously increases efficiency when surveying caves. Distance measurement produced extremely reliable results because common sources of error,

At the bottom of the 7m (23 ft) high waterfall, onwards to final sump.

such as the sagging of steel tapes, misreading tape markings, etc., were eliminated. Despite the high relative humidity and low temperatures, battery life was sufficient. We can confidently say the DISTO™ D3a withstood the endurance test in Romania's Western Carpathian Mountains.

About the author:
Walter Huber is a diving instructor and as Regional Manager of the International Diving Educators Association (IDEA) his responsibilities include the association's activities in Romania (www.idea-romania.org).
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The Coiba Mare Expedition

Duration:	3 days (23 hours)
Total length of watercourse:	924.4 m (3,032.8 ft)
Height difference (w/o final sump)	– 35.5 m (– 116.5 ft)
Furthest distance from entrance:	726.8 m (2,384.5 ft)
Highest surveyed point:	1,078 m (3,536.7 ft) (entrance)
Lowest surveyed point:	1,042.5 m (3,420.3 ft) (final sump)
Number of survey legs:	75
Average leg length:	15 m (49.2 ft)

Expedition team:
Harald Wirnsberger
Rainer Kraberger
Walter Huber
Joachim Haschek
Erwin Sipos

Further information about the team and their diving projects can be found at: www.bluesunlight.info
Photographs © by Joachim Haschek, www.haschek.eu

Sustainable Use of Land and Forests

by Gregor Bilban

Since gaining independence in June 1991, Slovenia has become a modern state and a member of the European Union. In 1993, the Farmland and Forest Fund of the Republic of Slovenia was established with the purpose of managing and disposing of farmland, farms, and forests owned by the Republic of Slovenia. The Leica Zeno GIS solution is used by the affiliated department "Geodesy Service" that represents the fund in different land surveying issues, in the surveying administrative proceedings, and in other administrative proceedings involving surveying and mapping services.

Slovenia's territory was divided into three equally sized areas, each of which is supervised by a Geodesy Service survey field crew. Each crew is equipped with a Zeno CS10 and an external Leica AS05 antenna, necessary to achieve the requested accuracy of 0.5 m (1.6 ft). The field crews collect land cadaster data, forestry management data (forest border lines, type of forests, forest management units), land use, water resources, illegal dumps, etc. Leica Zeno is mainly used to stake-out points, lines, and polylines to locate leased or rented real estate. With the data collection the true use and cultivation of land is verified. "The Leica Zeno GNSS/GIS handheld is a user friendly device with integrated GSM modem and NTRIP support. With the support of GLONASS, we have a better signal availability," comments Miha Zupančič, BSc. and Director of the Geodesy Service.

Easy Update of GIS Data

Miha Zupančič says, "The data necessary for the field work is simply checked-out with EasyOut, an automated workflow within the Leica Zeno Office software. In some cases, when there is no GSM link in the field, we collect GNSS raw data and post-process it within the integrated EasyIn workflow. Afterwards, we import the collected data into the main GIS database, which is an easy and very smooth process. The common look and feel combined with a simple data transfer makes the system easy to handle. As a GIS company we use ESRI ArcGIS. Another reason Leica Zeno GIS fits very well into our enterprise system."

"All field crews appreciate the simple user interface of the Leica Zeno GIS, the powerful graphical support, full integration into our office software, great and robust handheld controllers, and especially the additional support of GLONASS satellites. We also appreciate the integrated GSM modems, true NTRIP support, and real-time status window that gives us additional confidence in the field," says Zupančič.

The Leica Zeno CS10 provides a user-friendly interface and enables standardized data collection through efficient customization and procedures. The use of Zeno Field software enables the operator to take all required ESRI ArcMap elements into the field for maximum efficiency.

"Based on good experiences with the local Leica Geosystems representative, Geoservis d.o.o., we can also rely on total customer support, plus using the DGNSS service from Geoservis' private reference station, which is an additional financial benefit," concludes Miha Zupančič.

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REPUBLIC OF SLOVENIA
Farmland and Forest Fund of the Republic of Slovenia

The Farmland and Forest Fund's responsibility and basic objectives are defined by the Law on Farmland and Forest Fund of the Republic of Slovenia, with the Strategy of Slovene Agriculture Development and in the Program for the Development of Slovene Forests. The fund implements the Slovene farmland policy and with due prudence manages the trading with this land, puts it out to lease or grants concessions. In doing so, it promotes the land's cultivation and preservation for production, research, and learning; environmental protection and preservation; and sustainable development of forests. By purchasing, selling, and exchanging of land situated inside the state owned complexes, it assures the reasonable unity of land and the production units and the improvement of the ownership structure of farmland.

Cochem Tunnel: A Tight Fit

by Gerhard Weithe

Trains have been running through the Kaiser-Wilhelm Tunnel under the center of the historic town of Cochem on the Mosel in Germany for 130 years. Renovations are now being carried out on this tunnel, while at the same time work is in progress on a second tunnel. The new tunnel is 4,242 m (2.64 mi) long and scheduled to open to rail traffic in 2016. The 200 Mio. Euro (261 Mio. US Dollar) tunnel construction project is part of the Deutsche Bahn plan to extend the Coblenz/Trier line and bring its infrastructure up to current safety standards. Due to critical geological conditions, an automatic monitoring system was developed to transmit measurement data to the shield driver on the tunnel boring machine in real time.

The tunnel can be divided into sections based on the ground conditions it runs through. There is a 3,750 m (2.3 mi) section through sand- and mudstone and a 500 m (1,640 ft) unconsolidated rock section. This section passes under numerous buildings and roads and was driven in closed earth-pressure balance mode by the tunnel boring machine (TBM). The tunnel excavation work started in relatively favorable conditions at the southern portal in a sparsely populated valley of a Mosel tributary. The adverse effects of a TBM excavating a 10.12 m (33.2 ft) diameter tunnel below them were not felt much by the people living here. Not so to the north on the Cochem side, where the tunnel goes directly under the suburbs of Cochem and ends in the historical town center.

Continuous Deformation Measurements

Tunneling under the critical buildings of uptown Cochem required special ground improvement measures, a grout curtain injected ahead of the machine, and an extensive monitoring program. Even with continuous monitoring using numerous sensors, tunneling just three meters (10 ft) under four of these critical buildings was delicate business. A further 50 buildings were within the influence zone of the tunnel construction works.

To detect damage to buildings as early as possible, all points were monitored around the clock for any movement. A parallel system of high-precision hydrostatic pressure sensors captured deformations of the critical buildings in the sub-millimeter range. In the critical phase with minimum cover, these measurements were sent to a control center at ground level and continuously entered into an information system. If necessary, grout could then be injected under the buildings when required as the work progressed.

To comply with the special requirements for monitoring, the metrology department at tunneling contractor Alpine BeMo Tunnelling GmbH (ABT) developed an extensive modular measuring and monitoring system concept with long-term Leica Geosystems partner VMT GmbH (VMT). This allowed the automatically collected monitoring data to be transferred to the shield driver in the control cabin of the tunnel boring machine in real time.

System Characteristics and Components

The automatic deformation monitoring system in the city of Cochem was designed on a modular basis. More than 150 prisms were installed and monitored as necessary for the current excavation progress by up to nine Leica TS30 total stations. Additional satellite-supported baseline points were measured with GNSS sensors, then processed and evaluated with the terrestrial measurements in the VMT TUnIS deformation software with real-time network corrections. Three extensometers measured movements in the subsoil.

The site network and TBM results were visualized using a secure Internet data communications link with VMT's IRIS (Integrated Risk and Information System). This guaranteed complete monitoring of the points in real time and automatic notification. The project duty personnel were informed as soon as the values exceeded the predefined limits.

Tunneling Under Cochem

Detailed planning of the surface metrology began in December 2010 with the preliminary design of an extensive metrology program. The concept called for the continuous monitoring of all buildings within a 30 m (98 ft) corridor around the tunnel. The obvious sensor choice was the high-precision Leica TS30 total station, as this is the only instrument that could meet the project requirements with respect to accuracy of the measurement results and distances to be measured.

Schwelm-based Goecke GmbH, a long-established Leica Geosystems GmbH Vertrieb marketing partner, provided the technical infrastructure for the installation of the system components. The instruments were cost-effectively protected against weather and vandalism on special consoles with plastic cladding and a roof-like cover.

Special Wi-Fi technology continuously transferred measurement data via access points from the total stations and meteo sensors to "mesh nodes", which were able to work together intelligently and bypass any failed nodes in the system.

■ **The tunnel crosses under numerous houses in Cochem, some a mere three meters above.**

In case of component failure the back-up systems were particularly important. For example, UMTS routers could operate the system if DSL failed. In the end, the reserve components were never called upon during tunneling.

A team of surveyors, electricians, construction engineers, operatives, and IT specialists were on site for several weeks installing the extended monitoring system. The system was commissioned and tested before the approaching tunnel boring machine reached town. By the time tunneling started in October 2011, no malfunctions had occurred and the monitoring system went live with an excellent reliability and accuracy record.

■ **Current measurements at the TBM control center.**

Monitoring Made an Essential Contribution

As tunnels excavated by a mechanized drive afford less opportunity than conventional tunneling methods for underground deformation measurements, for this project it was particularly important to continously monitor deformations of the above-ground infrastructure.

The project partners had access to current data at all times on the information system IRIS supplied by VMT. A monitor in the control cabin of the boring machine displayed the instantaneous position of the machine in real time on the satellite photo image and showed all the surface sensors along with the current measurement results.

In the area of the critical buildings the designer's calculations proved to be accurate: the predicted and actual settlements of the buildings were almost exactly the same throughout the tunnel driving.

On 7 November 2011, the tunnel boring machine precisely broke through the portal in downtown Cochem. Without the excellent standard of metrology with high-precision instruments and the reliable operation of the automated deformation monitoring system, this challenging project could not have been completed. ■

About the author:
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Inspiring the Next Generation

In November 2011, Leica Geosystems began a partnership with the Class of Your Own (COYO) initiative to raise the profile of architecture, engineering, and professional construction careers in UK schools.

Through practical workshops students will plan, manage, and complete their own sustainable building project, learning about new technology, such as 3D laser scanning and BIM (Building Information Modeling), sustainability techniques, and environmental issues; as well as gaining a clear appreciation of the wide range of career opportunities in the Built Environment, from architect and surveyor to structural engineer and construction manager.

"Young people spend all day in buildings, be it in school, at home, or their local shopping center. If we can encourage them to see the industry as a thoroughly exciting place to be, they are well placed to contribute to the demanding tasks as the next generation of construction professionals," comments Alison Watson, Co-Founder of COYO.

"I am pleased to have the support of such a reputable and world-renown organization. Kids get thoroughly excited when they work with genuine professional equipment. I'm really grateful to the team at Leica Geosystems who so generously support our young people by providing them with access to the latest technology, from the handheld Leica DISTO™ to 3D laser scanners."

David Price, Managing Director Leica Geosystems Ltd UK, says "Class of Your Own is a unique program offering young people a chance to experience the excitement, the buzz, and the pride of working in our industry. We are proud to be able to support such a ground-breaking cause, to not only help raise the profile of the industry and inspire a new generation of people to enter the profession, but also to provide students with an authentic sense of project ownership and inclusion."

With this in mind Leica Geosystems, with support from COYO, invited local school students to take part in a competition to find out what it's like to be a Surveyor for the day and to win a classofyourown® Design, Engineer, Construct! curriculum, which encourages young learners to discover the professional Built Environment.

For more information about the project visit www.classofyourown.com

Precisely Set-out

by Konrad Saal

Architects' creativity in the design of fascinating modern buildings knows no bounds. State-of-the-art CAD programs, structural engineering software, and the visualization of 3D models allow almost any conceivable form of building to be designed to millimeter accuracy. However, these increasingly complex buildings must also be built to this fine level of detail, which is a great challenge for surveying and construction engineers. The choice of the right instrument is crucial to achieving the required accuracies and to translating building geometry from a drawing into reality.

In the Algerian capital of Algiers the huge complex "Medina" is being created on the Mediterranean coast, on just one square kilometer (0.4 mi^2). An ambitious project, it is intended as a symbol of the

Curtain wall façades

Curtain wall façades are lightweight and ensure the building envelope is sealed without affecting stability or structural engineering of the building. They withstand extreme temperatures and noise, while offering the building better protection in the event of earthquakes, explosions, and fire. Furthermore, curtain walls allow more efficient use of the internal space and flood the building with light. They consist of a frame, usually made of aluminum, fitted with glazed infill panels. Important elements of the façade are generally prefabricated and are always mounted on brackets at the ends of the concrete floor slabs. The brackets must be very accurately positioned in a set pattern. They hold the façade elements in place and provide very little scope for adjustment during installation. Therefore checking the building geometry is one of the most important surveying tasks on these projects – it involves the precise surveying of level differences on concrete floor slabs, their evenness, and vertical alignment. The actual values in these projects must not deviate from the design values by more than 2 cm in any direction.

country's modernity. In middle of this site two 97 m (318 ft) high buildings with curtain wall façades will soon be soaring skywards.

The decision to have a curtain wall façade on the building – particularly a prefabricated one – commits the contractor to on-going surveying during construction. Ideally this should be done from the start, since displacements or distortions of the building shell can cause the installation to impose stresses or distortions on the façade. This could entail higher costs for rework, additional tailor-made brackets, or cutting back of concrete slabs.

To ensure the façade bracket positions were precisely set out, the façade contractor called on the expertise of Upgrade Topographie, a small engineering consultancy headquartered in Capbreton in southwest France. Since its founding ten years ago, the consultancy has concentrated on engineering and industrial surveying and has successfully provided the same service on several projects of this type. For this project Upgrade Topographie first established a highly accurate network of points around the two towers. Surveying engineer Julie Deléglise opted to use a high-precision Leica TS30 total station, which can achieve an angular accuracy of 0.5" and 0.6 mm (0.02 in) distance accuracy, for all measurements, taking due account of barometric pressure, relative humidity, and temperature. While surveying for the network, she captured points on the building's basic shell to compare the survey results of the existing structure with the design. After calculation of the network coordinates, they were transformed into the local tower site coordinate system.

Upgrade Topographie relied on Leica Geosystems original accessories for the surveys. "We avoid the risks associated with using third-party accessories. Millimeters matter for the positioning of the curtain wall façade and therefore we have to transfer distances and levels precisely." For the Medina project, as with many projects of this kind, the client required Upgrade Topographie to submit current test and calibration certificates for the Leica TS30, which the consultant requested from its authorized Leica Geosystems Service Center.

On many previous projects based on networks of points, Upgrade Topographie had also used the Leica ScanStation C10 to check floors, as the task of modeling is simpler in Leica Cyclone software and differences to design coordinates can be superbly visualized. "This 3D laser scanner considerably improved our method of working and increased our efficiency, principally in the capture of building geometry," says Julie Deléglise. However, in this project the Leica TS30 was used to survey 1,500 points in reflectorless mode over the course of two days to check the building geometry.

After installation the curtain wall façade brackets had very little play left for readjustment to achieve the design positions. The plans specify that the brackets be attached to the edges of the concrete decks. The prefabricated frames have to be installed precisely

About Upgrade Topographie

Vincent Hubert, the founder of Upgrade Topographie, and his team are specialized in precision surveying for construction and industrial engineering, including precision leveling. The company's projects are extremely diverse and extend from industrial surveying in the production halls of Airbus and precision surveying of railway tracks to controlling tunnel boring machines and load testing. Although the consultancy was established only ten years ago, it is already well regarded for the reliability of its precision surveying. Its projects have taken Upgrade Topographie all over the world, from Algeria and Morocco to Angola, the Dominican Republic, and Qatar. An area of specialization is precision surveying for the installation of curtain wall façades.

on the brackets to later accept the glazed elements without causing distortion or imposing stress.

"When we transferred the survey data into the digital design models, we found differences in the verticals of the building of up to five centimeters (2 in). Furthermore, we discovered that the concrete slabs were not level enough. On one floor slab, the height differences between the highest and lowest points were up to six centimeters (2.4 in)!" said Julie Deléglise. Discussions then took place with the site manager on the measures to be taken to set out the brackets within the permitted tolerances.

The coordinates of the instrument station for the stakeout were calculated for each story using free stationing. Further auxiliary points were set out using tripods with forced centering. These points were surveyed using automatic target recognition. Experience has proven to Julie Deléglise that this method is more accurate than manually targeting points.

With the Leica TS30 and a mini prism, points were set out in two locations on each story using the Stakeout program in the SmartWorx on-board software package. This program allows the user to choose whether the instrument automatically positions to the next stakeout point. "This function is very useful because it saves considerable time. We were able to set out 200 points per day." ■

■ **Precision stakeout of the curtain wall façades: surveying engineer Julie Deléglise with the Leica TS30.**

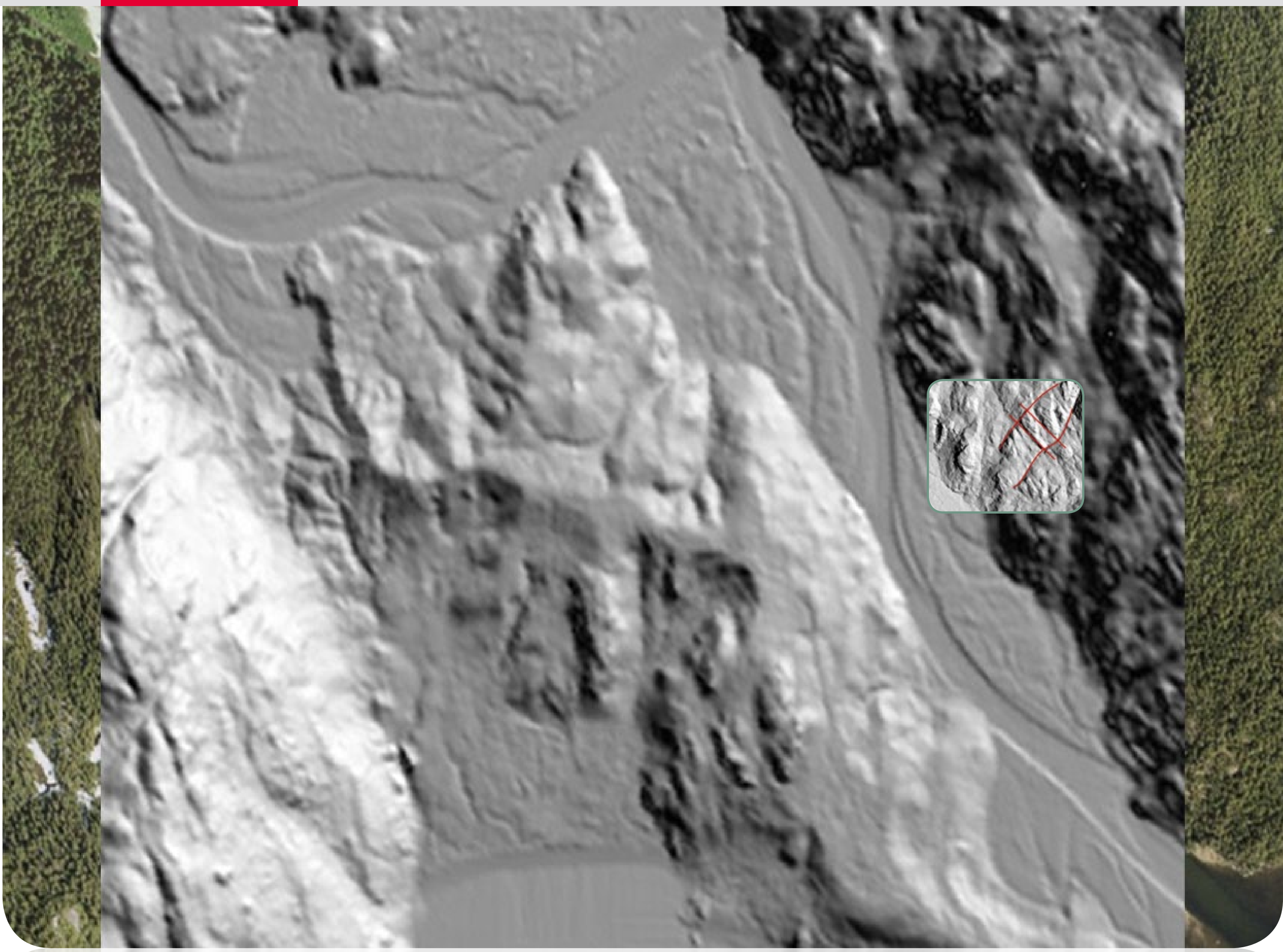
Going for Gold with LiDAR

by Kevin P. Corbley

Airborne LiDAR is a fast and relatively inexpensive means of gathering topographic information critical to the success and safety of mining operations. McElhanney Consulting Services Ltd. of Vancouver, B.C., Canada, has introduced two new bare-earth mapping services developed specifically for the exploration and exploitation phases of the mining industry. In the first application, McElhanney used LiDAR to find surface structures and lineaments that have been missed by aerial photography and satellite imaging because of dense vegetative cover. McElhanney, an engineering, mapping, and surveying company, verified the use of LiDAR bare-earth digital elevation models (DEMs) for lineament and fault identification in a gold mining district of British Columbia.

Surface lineaments are linear ground features associated with complex subsurface geological structures, including faults, fractures, and other features such as contacts between different rock types. Sometimes just a half meter wide, lineaments may extend for hundreds of meters in length. Due to their large scale, these features can be difficult to spot from ground level, and they can be even harder to see in most remotely sensed imagery if obscured by vegetation or loose sediment.

"Lineaments provide clues to underground geology and are a valuable aid to geological mapping – a crucial part of any gold exploration or mine engineer-



ing project," says Azadeh Koohzare, Ph.D., P.Eng. "Geologists can interpret the pattern and direction of these surface features and, as many gold deposits are associated with geological structures, use this information when selecting and prioritizing exploration targets."

High Point Density Required

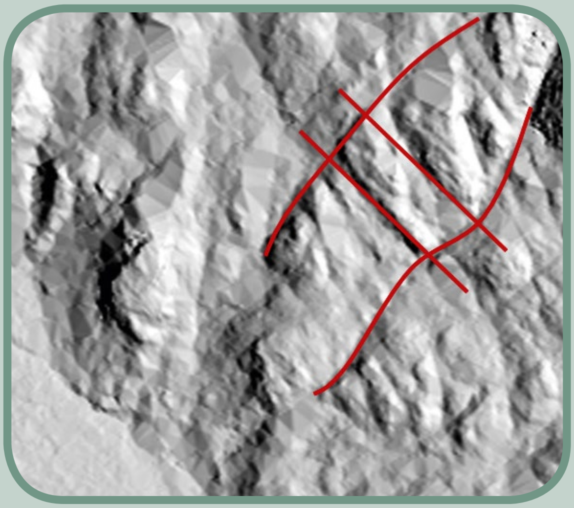
The key to revealing the hidden surface geology is a powerful multipulse airborne laser scanner, or LiDAR, explains Koohzare. McElhanney, which owns three Leica Geosystems LiDAR scanners and two Leica Geosystems ADS digital cameras, initiated the lineament mapping project using the Leica ALS60 and is upgrading to the more powerful 500 kHz ALS70-HP system.

These LiDAR systems provide the minimum two points per square-meter (two points per 2.4 square yards) density required to generate bare-earth DEMs with an accuracy and resolution sufficient for revealing the narrow linear surface features. In the British Columbia pilot project, McElhanney operated the LiDAR at an altitude of 2,500 – 3,000 m (8,200 – 9,800 ft) above mean sea level to collect the data set. Standard processing removed the returns associated with vegetation to generate a bare-earth DEM with 10 cm (4 in) vertical and 30 to 50 cm (12 to 20 in) horizontal accuracy.

"The Leica Geosystems ALS LiDAR operates with a high pulse rate to ensure the vegetation is penetrated with a point density that is sufficient to find surface lineaments measuring just 50 cm (20 in) in width," says Koohzare. "And the high power of the unit means the dense point data can be captured at high aircraft speed, which saves time and money."

Ground Subsidence

McElhanney devised its idea for ground subsidence monitoring in Saskatchewan where potash deposits are mined and used for fertilizer. Potash extraction poses a higher risk of ground subsidence than many other types of mining because the evaporate



■ **With vegetation removed from the LiDAR data, geologists can identify possible gold deposits by viewing the bare-earth surface structures.**

deposits are found in soft rock formations that are structurally less than ideal for tunneling. As a result, potash mines must be continually monitored for subsidence or sinking of ground above and around the excavation site.

"Subsidence above the mine gives advance warning that personnel inside may be at risk of a cave-in or collapse," says Koohzare, adding that subsidence and uplift can cause problems for up to 5 km (3 mi) in any direction from the mine site. In addition to dangers inside the mine, the ground movement can also sever pipelines, damage roads, and crack building foundations in the affected region.

Monitoring subsidence around potash mines – and other mineral extraction projects – is typically carried out using traditional ground survey techniques, which are expensive and time consuming. Based on LiDAR operations in hundreds of projects, many involving energy and mining clients, McElhanney says that airborne LiDAR is the fastest and most cost-effective way to monitor ground subsidence.

The 10 cm (4 in) vertical accuracy of bare-earth DEMs routinely generated from the firm's Leica ALS60 and ALS70 laser scanners can identify significant shifts in the ground surface – either up or down – that may signal dangerous conditions in the mine. McElhanney recommends collecting an initial baseline data set above each mine site and then continuing to collect new data every year. Once subsidence is revealed, monitoring flights should be repeated while steps are taken inside the mine to minimize the danger.

As is the case with the lineament mapping, the high-pulse rate of the LiDAR sensor is crucial to penetrating the vegetative canopy around the mine site to get extremely accurate elevation measurements of the ground surface, or bare earth, according to Koohzare.

The Leica ALS70 is one of the few airborne laser scanners with the power and multi-pulse capability able to provide the quality of bare-earth DEM required for these mining applications. ■

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@round the World

For a picture contest called "@round the world with Leica Geosystems" we asked our customers to post their application images with Leica Geosystems instruments on our Facebook page *www.facebook.com/LeicaGeosystems* and vote for their favorite.

The winner was awarded a ruggedized Leica DISTO™ X310 handheld laser distance meter. Here is a random selection of numerous submitted photographs. We would like to thank all participants who made this contest such a great success!

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- when it has to be **right**

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