Reporter 71

The **Global Magazine** of Leica Geosystems

- when it has to be **right**

Leica Geosystems

PART OF HEXAGON

Editorial

Dear Readers,

Mobility is vitally important to our daily lives. It is mobility and the capability of moving rapidly and readily that ensures our high-quality standard of living. And, in particular, it is a key driver of a successful economy: increasing transportation not only creates jobs, it brings workers, travelers and vital materials and supplies to where they are needed, as needed. In order to move, infrastructures need to be built and quite often these structures demand very exacting requirements – from logistics to safety – and depend on geospatial data.

Mobility is unthinkable without geospatial data. The enormous infrastructure project, the Crossrail Railway in London, depicts just how reliant on this data our society has become – especially since the railway is being built without any interruptions to daily urban life. The Crossrail project's slogan "Keep London moving", wouldn't be possible without total stations. Also the remote British island of St. Helena, depends on mobility from its upcoming airport to provide a sustainable economy.

The article on the construction of the third Bosphorus Bridge, connecting Europe with Asia, can also be seen as a symbol of economic success and prosperity by means of freedom through mobility and describes how the Leica Nova MS50 MultiStation contributes to the success of this project. The solution offered by the construction company ICA added value by using 3D geodata that also plays a very important role in the success of the mobile future.

Enjoy your read!

Juergen Dold
CEO Leica Geosystems

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Cover: © David Franck
Artist Klaus Dauven and professional climbers are creating a mural with high-pressure cleaners on a dam wall.
Read the article on page 10.

Connecting Continents

by Ruth Badley

The third bridge above the Bosphorus, with its over 300 metre high pylons pairs, is a monumental masterpiece of engineering. It will help to reduce traffic between the Europe and Asian continents and is equally a symbol of Istanbul's prosperity and economic growth. The Yavuz-Sultan-Selim Bridge is being built by the Turkish company, ICA Construction, and creates not only a motorway with a railway line, but also an additional connection for the transcontinental metropolis between the two continents. During the construction of the suspension bridge, the Leica Nova MS50 demonstrated its many diversified application possibilities.

ICA utilised the Leica Nova MS50 MultiStation, along with the Leica Viva GS15 GNSS receiver and other additional Leica Geosystems sensors, during construction for a great number of surveying, control and deformation measurements. With the new scanning function, the latest construction progress of the pylons could be compared with the architectural plans.

The highest bridge pylons in bridge construction

Four huge pylons connect the substructure of this bridge. With a height of 309 metres (approx. 1014 feet), they are the highest found on any suspension bridge worldwide. The two obliquely designed pylon pairs complete the top of the bridge and are hollow inside. Every day, these pylons grow approximately 2,5 metres (8,2 feet) – a challenge for the engineers, who must constantly check for deviations from the design of the ever-growing outer concrete shells of the pylons. Due to stringent demands of the construction requirements, there is only a short period of time available to check the pylons, nevertheless, these controls are absolutely imperative. Because any small deviation from the design would have an enormous impact on the subsequent stages of the bridge construction.

The laser scanning function and long range measurement of the Leica Nova MS50 was used to determine the concrete surface deviations against the design and was processed with Leica Cyclone point cloud software. To achieve the highest accuracy of the scanned data, the MS50 was set up over control points established using Leica Viva GS15 GNSS static observations and processed in Leica GeoOffice.

An additional challenge was the harsh environment in which this work was carried out. The Bosphorus Strait connects the Black Sea to the Marmara Sea and workers have to contend with a cold northernly wind, together with haze and humidity, which can persist throughout the winter months. All Leica equipment that was used for this project could easily cope with these challenging conditions. The Leica Nova MS50 has a working temperature range of –20°C to +50°C and IP65 dust and water protection.

High-quality measurements

Most of the work was carried out from three ground control points. Two were located on nearby hills to offer a clear line of sight to the pylons and construction site and the displacement control was carried out on a weekly basis to check if the coordinates were stable and to compare with the architectural designs for deviations.

© Bora YAVUZ

In addition, vertical alignments of the pylons were checked using several Leica TS30 total stations. Measurements were taken during construction from different positions in order to verify the accuracy in real time of as-built plans.

The Nova MS50 was set up over the control points, a scan window defined and a point cloud measured with a density of 1 cm every 100 m over a distance of 150 m. After collecting scan data from all sides of the pylons, vertical slices, created in Leica MultiWorx were checked against the design (CAD) data.

Fast and accurate scans

Surveying manager Yasar Hacieyupoglu commented, "We had complete confidence in the Leica Nova MS50 and Viva GS15 GNSS receivers to deliver the accurate long range measurement required for this project. The Nova MS50 is the only instrument which can scan accurately and at speed over the range required."

"Leica Geosystems has been a collaborative partner on this project – the construction company ICA, the main contractor, HYUNDAI Eng. and the surveying team, ENDEM Cons all use Leica Geosystems' products and know they can count on the support, training and service they receive from the manufacturer and market leader." ■

You can check the latest news about the third bridge by visiting the company website below:
http://www.3kopru.com

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Light at the end of the tunnel

by Norbert Benecke, Volker Schäpe
and Volker Schultheiss

Across the globe, more and more tunnels (and longer tunnels) are being built. Currently, the longest tunnel in the world is the 57 km (35 mi) long Gotthard Base Tunnel in Switzerland, but this could change in the decades to come with the planned 123 km (76 mi) under-sea tunnel to be built between the Chinese cities of Dalian and Yantai. Every tunnel project is a multi-million dollar investment, and the level of accuracy required for tunnel measurement increases continually. When trains are expected to travel through at a speed of up to 300 kph (186 mph), the planned tunnel's axis has to be maintained with maximum precision. In the case of tunnel construction in ground water such as with the Elb Tunnel in Hamburg, the giant tunnel boring machine has to be driven into a special water-sealed target construction with centimetre precision when finished. The smallest directional error in the heading can lead to considerable technical problems and financial risks when working on critical projects of this magnitude.

The tunnel surveyor plays a crucial role in making sure that the breakthrough of the tunnel occurs precisely at the specified target point. The challenge is to guide both sides of the tunnel in the right direction. The measurements for directional transmission occur using elongated traverse lines, which can only be connected to a control network of a known point at the tunnel's entrance. There is no way to check the directional accuracy of the advancing opposite end of the tunnel. As tunnel length increases, configuring both ends for the correctness of proper tunnel direction result in considerable risks and uncertainties.

Surveying under difficult conditions

Many tunnel tubes have entry starting shafts. From these starting shafts, fixed-point coordinates are transfered down to the tunnel's level so that the tunnel can be bored correctly and navigated toward its target, this being the other end of the advancing tunnel. This process, known as plumbing, always involves an element of risk, when transferring fixed reference points in such small and narrow shafts. If the measured data is so much as a millimetre inaccurate, this inaccuracy compounds itself and leads to

considerable deviations in the lateral traversing line of the tunnel's many curves and its direction.

The measuring risks in the tunnel itself occur when the line of sight is diverted and subject to refractive influences such as temperature differences, humidity or dust. These make measuring angles and reliable measurements difficult and errors unavoidable. This applies even more due to the fact that in most tunnels the surveying points cannot be situated in the centre of the tunnel for logistical reasons and must therefore be located at the tunnel walls. Targeting close to the wall increases the risk of refraction even further. Tunnel courses with numerous (and tight) curves also require maximum accuracy.

As the tunnel length increases, errors from plumbing and refraction can add up to as much as several meters, making breakthrough at a desired position impossible. A considerable amount of additional work is then often required in such cases.

The solution is a "toy"

Previously, miners and tunnel builders solved this problem using compasses. In the modern tunnels of today, however, this is not possible due to the considerable amount of iron and steel used. Initial developments in solving this problem using gyroscopes came about in the early 1950s.

Just about everyone is familiar with gyroscopes from childhood, when playing with a spinning top. We are constantly using the underlying physical principle of precession in our daily lives, for example, when we take our hands off a bicycle's handlebars while riding and continue going straight as if by magic.

Precession is the directional change of the axis of a rotating body (a gyroscope) when external forces apply torque to it. If such a gyroscope is built into a measuring device which is positioned somewhere on the Earth for a certain period of time, the Earth's gravity will act on this gyroscope as the external force during this time. The gyroscope tries to counteract this external force and to remain in its original position. If it then manages to measure these values, such a gyroscope can be used to determine the direction to the Earth's axis (cartographic north).

DMT and Leica Geosystems – 20 years of close cooperation

For the Gyromat from DMT to work, it requires a fixed connection to a high-performance theodolite. Once the gyroscopic measurement has taken place in the Gyromat, the direction is transferred to surveying points in the tunnel network via the theodolite. DMT made the decision to work closely together with Leica Geosystems over 20 years ago. Current Leica Geosystems instruments fit the DMT Gyromat perfectly and are reliable and rugged for use under difficult tunnel conditions. Data transfer functions flawlessly, and thanks to the outstanding cooperation between the development engineers at Leica Geosystems and DMT, model changes are also easy to manage.

The ability to outfit theodolites or total stations individually enables their use in geodetic applications and control tasks in unlimited ways. The Gyromat 5000 is compatible with the high-accuracy total stations from Leica Geosystems, including of course current models such as the Leica Viva TS11 and TS15, Leica TS30, TM30 and TM6100A and the new Nova TS50 and MS50 MultiStation.

DMT (Deutsche Montan Technologie) developed one of the first high-precision surveying gyroscopes for the German coal mining industry. The Gyromat was subsequently further developed for a variety of tasks, e.g. tunnel construction and ship building. The current model is the Gyromat 5000, which is by far the world's most accurate surveying gyroscope, thanks to its angular precision of 0.8 mgon, corresponding to an arc deviation of about 1.2 cm (0.5 in) over 1 kilometre (0.62 mi).

The Gyromat in use around the world

Gyroscope-based traverse line measurement for safeguarding the heading direction experienced its breakthrough in guiding the heading of the Channel Tunnel between England and France. When the tunnel breakthrough occurred in 1990, a lateral deviation of just 35 mm (1.4 in) over a total tunnel length of 55 km (34 mi) was achieved. This was only possible due to the use of the then-current Gyromat 2000, with which DMT carried out independent check measurements on the English and French sides.

Since then, DMT experts have successfully carried out more than 3,500 gyroscope campaigns across the globe using high-accuracy Gyromats and Leica Geosystems total stations. Whether it's the CERN particle accelerator in Geneva, hydroelectric plant construction in Lesotho or Iceland, the Gotthard and Brenner base tunnel projects and similar projects in the Indian Himalayas, US waste water tunnels or the world's current largest waste water project (the Emscher conversion) in the Ruhr region of Germany, DMT experts equipped with the Gyromat and Leica Geosystems total stations are there to independently check the tunnel direction and, if necessary, make corrections. DMT surveyors also participated in the construction of the infrastructure for the Winter Olympic Games in Sochi and in subway construction in a number of cities on every continent.

DMT surveyor Volker Schultheiss comments: “Thanks to our independent check measuring, we are able

Camels attentively watch Volker Schultheiss during calibration measurements on-site in Abu Dhabi.

to assure the owners and the construction company carrying out the work that the tunnel is heading exactly where it's supposed to. With minimal financial outlay, we are able to safeguard a multi-million Dollar investment. In roughly 70% of measurements, we can confirm that the heading is moving within the permissible tolerances, but in about 30% of cases, corrections need to be made based on our measurement results. In one extreme case, a correction of over 3 metres (9.8 ft) was necessary. Thanks to corrections like this, considerable additional expenses can be avoided."

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DMT

DMT GmbH & Co. KG is a company of the "TÜV Nord Group" and an internationally active, independent engineering and consulting company focusing on raw material exploration, other exploration, mining and coke oven technology, construction and infrastructure, product testing, building safety and industrial testing and measurement technology. A special strength of DMT is the development of innovative geodetic, geotechnical and geophysical measuring devices for special tasks based on its own practical experience with special customer requirements.

In addition to tunnel construction services, Leica Geosystems partner, DMT, also sells the combination Gyromat/Leica Geosystems theodolite to customers, primarily in the areas of tunnel construction, ship building, military applications and the production of fiberoptic gyroscopes (the Gyromat is used to calibrate the gyroscopes produced). The Gyromat is sold directly by DMT and is also available through the Leica Geosystems worldwide dealer network.

Surveying as art

by Roman Martinek

Art and surveying. When you first think about it, these two words seem to have little in common. Art is free of all constraints and knows no limits in form. With surveying, on the other hand, the world is represented on maps and plans are transferred to the real world. Surveying is strictly bound to numbers. And yet there are projects where "art is surveyed". Together with reverse graffiti artist Klaus Dauven, the Geosys-Eber engineering company in Munich has already made a host of large-sized art projects a reality across the globe as part of a cultural sponsorship program by the Kärcher company.

The large walls of dams in the countryside aren't usually a pretty sight. That's precisely why these art surveying projects aim to lend the dam walls an artistic flair rather than monitor them geodetically, as one might at first have suspected. And total stations from Leica Geosystems were used in the process.

Artist Klaus Dauven utilises the Kärcher company's high-pressure cleaner to create reverse graffiti. As the name implies, nothing is sprayed on the object. Instead, something is "sprayed off" under high pressure, namely algae, moss and lichens which have built up on the dam wall over the years. The motif becomes visible in the contrast between the processed and unprocessed surfaces, for example

two trout entitled “Fischreich” or Fish Realm on the wall of the Eibenstock Dam wall in Saxony, Germany. However, the dimensions are the real eye-opener. And the monumental results of the almost 200 metres (218 yards) wide and over 50 metres (55 yards) high artwork means this graffiti won't fit in any museum.

■ **Staking out points on the dam wall**

From a technical standpoint, the task is hardly different from a common staking out process. Regardless of the topography and incline, the structures have to maintain the planned dimensions and angles. With a special task like this, the proportions of the work of art have to remain recognizable by the viewer regardless of the wall shape and incline. So the “only” thing that needs to be done is to flip the standard surveying task to the vertical plane and then, of course, continue it in the third dimension.

The motif was transferred to the layouts of the dams on a DIN A4 template as accurately as possible and then digitalised on the screen. The spacing between points was supposed to be no more than 2 to 3 metres (7 to 10 feet) later on so that the men with the high-pressure cleaners, who were hanging on the side of the wall by a rope, could orient themselves better.

Leica Geosystems total stations made this task easy to manage without reflectors from a distance of about 200 metres (219 yards). The points transferred to the instrument after digitalisation could be quickly staked out using a simple workflow, whereby the next nearest point was always chosen. This also helped the professional climbers of the GSAR company to negotiate the shortest paths possible on the almost completely utilised 10,000 m² (11,960 yd²) surface while hanging by a rope as they marked the points with yellow modelling clay. Adding the measured point to the intended location was accomplished using the total station's internal software. It determined where the positions were to be, then these were transmitted to the climber on the wall via a wireless device.

This active support for the climbers made it possible to stake out the two trout motifs (each of which had over 1,000 points) on the inclined and divided dam wall surfaces in such a way that the viewer recognises the motif without any distortion of perspective, allowing the dam wall to provide an impressive view.

This art work is transitory, however, as over the years moss and lichens once again accumulate on the surface, making it eventually impossible to distinguish between the surfaces cleaned today and the surfaces which were left alone. In this way, nature itself provides space for new art once again. ■

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Forest animals crossing

At the Olef Valley Dam near Hellenthal in the heart of the High Eifel region close to the Belgian border, Klaus Dauven had already created an oversized "painting" some time ago, creating a mural of forest animals and other wild creatures from the area, including birds, roe deer, red deer and a fox. In the background, fish traverse the plane. No paint at all was used. Instead, the contours appear from the contrast between cleaned and uncleaned sections of the weathered concrete surface. The motif was drafted on a DIN A4 sheet and then transferred to the existing dam wall layout, and the points were digitalised and then staked out on site at a spacing of 2 to 3 metres (7 to 10 feet) with a Leica TPS1100 total station.

An airport to sustain lives

by Fredrik Rudqvist

St. Helena, located in the South Atlantic Ocean, is a small tropical island island of volcanic origin, measuring 17x10 kilometres (11x6 miles) and is an overseas territory of the United Kingdom, even if the island is almost 7,000 kilometres (4,670 miles) away. It is one of the most remote places on earth. The closest landmass is Africa, roughly 2,000 kilometres (1,333 miles) away from the island. Cargo, mail and equipment transportation limitations make life for the residents of St. Helena difficult and when the aging British ship, the RMS St Helena, broke down in 1999, the 4,000 residents of St. Helena were stranded with no means of coming or going and with no delivery of vital supplies because this ship was the island's only transportation to the mainland. It was decided to finally construct a green field airport, an airport built from scratch on an undeveloped site, on St. Helena and replace the ship as the main access provider to the island. After many years of negotiations and planning, the project commenced in 2012 with a budget of roughly £ 240 million (398 million USD, 300 million Euro), scheduled to be completed in 2016.

"Without a modern airport, there is very little chance of economically competing with anything," says Nigel Kirby, Project Manager at the British Department for International Development. This international airport

Laying the concrete surface for St. Helena's airport runway.

represents a historic milestone for St. Helena and will offer the island a chance to create economic opportunity by developing tourism and jobs, perhaps eventually leading to the island's economic self-sustainability. The project of building this airport is one of the largest being undertaken in the southern hemisphere and was given to the South African construction group, Basil Read.

The construction site, located in the eastern part of the island, near Prosperous Bay, was one of the few areas to actually come in question because of the island's rocky terrain and environmental issues. Dry Gut is the name of the gorge that will be part of the future airport's runway. This gorge had to be drilled, blasted and filled with 8 million cubic metres (8 million cubic yards) of blasted rock for a depth of over 100 metres (328 feet) in order to become part of the airport's 2,000 metre (6,562 feet) runway. After the gorge was filled, it had to sit for at least six months to avoid settlement problems and cracks in the runway, after which paving could begin.

But first the resources and equipment had to be shipped to the island. Basil Read contracted the NP Glory 4, a massive cargo vessel to transport amongst other things, a slipform paver equipped with Leica Geosystems PaveSmart 3D machine control, which was also used with Wirtgen Group's paving & milling equipment, Leica Viva TS15 total stations and 45,000 m³ (58,860 yd³) of dune sand from Namibia, which was needed to pave the runway. To mix the concrete, more than five million kilograms of sand was needed and this was shipped in plastic bags weighing 1,000 kg (2,205 lb) each.

Before the ship set off from Namibia, both the Leica Geosystems specialist and Wirtgen technician worked together on a pre-delivery inspection. With the ship's journey taking five days and only traveling once a month, all equipment had to work, even if an extra set of all equipment was also on-site.

The paving width of the paver is 2.8 metres (9.2 feet) and was designed to match the capacity of the concrete batching plant, which could, at peak operation times, run two shifts six days a week. The teams were able to keep up with concrete production using Leica Geosystems PaveSmart 3D machine control and Leica Viva TS15 total stations. Together, they achieved an optimised yield of concrete by means of measuring with the total stations to precisely track the paver's position and elevation and sending any tracking corrections back to the PaveSmart 3D machine control, which calculated and corrected the paver's positions. This helped simplify the logistics of the paving immensely.

Paving work started with the apron, a parking area for the aircraft not in use, and a concrete slab of 150 by 75 metres (492 by 246 feet) where the passengers will board and the planes will refuel. Also, close to this area will be a special surface dedicated to the private business jets.

Using the Leica PaveSmart 3D software, together with the TS15 total stations also saved the need to stake out with strings and eliminated the associated manual labour and expense necessary to set them up. The paver, concrete trucks and site vehicles no longer needed to drive around strings and decreased their workflow. Also when crews worked in low light conditions, the string-free work site was by far safer plus there was no accidental repositioning of the guidance strings at any time.

The unique desert ecosystem of Prosperous Bay also profited by the use the Leica PaveSmart 3D machine control. The machine control system minimised vehicle movement on-site and also reduced trips to transport materials. This kept the footprint of the airport project as compact as possible.

Basil Read is also well into completing the airport's terminal building, air traffic control tower, fire facility and fuel storages, all part of a modern airport's infrastructure and the first international flight should land on the completed runway by February, 2016. Basil Read, together with Lanseria, will also continue to maintain the airport for an additional ten years.

Besides building a link to the modern world and providing a fast and dependable means of modern transportation and delivery of necessary supplies, Basil Read, with the help of Leica Geosystems products and solutions, has brought about much needed employment opportunities and the hope of a better economic future with a better standard of living for the population of St. Helena. ■

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Challenging logistics

The logistics of the project were extremely challenging for Basil Read and properly planning this project has been a key to its success. There had never been a docking area for ships nor any major construction equipment on the island. Therefore, a temporary landing area at Rupert's Bay to accommodate a small shipping vessel had to be built in order for the equipment and materials to be unloaded directly on land.

St. Helena is also an island with limited infrastructure and there is a lack of construction materials – there's not even sufficient sand on the island to make concrete. Since all local roads have a maximum capacity load of 7 tons (7,716 tn.sh.) it was necessary to build a winding 14 km (9 mi) access road from the dock to the airport construction site.

In July 2012, the first ship loaded with supplies landed directly on the dock of St. Helena Island and since then around 30,000 tons (33,069 tn.sh.) of cargo has been unloaded to date. In November 2013, an additional contract was signed to build a permanent wharf. Both of these wharves were milestones for the people of the island, as it will be the first time that a ship could actually dock on a wharf in the island's history. Before the wharves were built, all cargo had to be reloaded onto small diesel-fueled barges and hoisted to shore by gigantic cranes.

Lana shines with new brilliance

by Toni Everwand

More than 1,500 lights have to be recorded and categorised in the South Tyrolean market town of Lana. The background of this action is a resolution by the South Tyrolean government which intends to optimise public street lighting with regard to energy efficiency and minimised light pollution. Light planner Christian Ragg developed a master plan for public lighting which focuses on saving energy and curbing light pollution in the night sky. This plan was implemented with the Leica Zeno 5 and support from mobileGIS.at.

Christian Ragg, a light technology engineer from the neighbouring country of Austria was commissioned with illuminating Lana in the area of light. "Step one is to take inventory of public lighting, and step two is to develop a light plan with which the town can comply with the stipulations of the local government's ordinance."

One requirement of the town of Lana was that the contractor would have to acquire geo-referenced data and provide it to the management in such a way that it could be integrated into the regional geographic information system. This is why Ragg chose to rely on support from Leica Geosystems for

Light pollution and energy conservation in public spaces

Light pollution refers to brightening of the night sky from artificial illumination. Light pollution interferes with the astronomical observance of the night sky, irritates nocturnal insects and migratory birds in their orientation and navigation and also negatively affects the growth cycles of plants in the city. Modern lighting can make a contribution in the area of energy conservation. Contemporary lighting systems with LED light technology consume up to 80 % less energy than outdated systems equipped with mercury vapor bulbs, for example.

his commissioned task. He contacted DI (FH) Martin Trimmel of “mobileGIS.at”: “As a light technician, the geographic location of recorded points isn't part of my daily work. Martin Trimmel provided me with a hand-held Zeno 5 GPS from Leica Geosystems, a device which I could use to carry out my job efficiently and within a time frame acceptable to everyone.”

After a brief training period, Ragg got started. He hopped on a bicycle and rode to all the lights in the city, point by point. “I was happy to be equipped with such a lightweight and handy device,” said Ragg. While the device determined the position of the light point, Ragg filled in the predefined entry fields, such as light type, bulb type, age of the light and light point height, on the device and was able to cover about 170 to 180 lights per day.

Because recording the outdoor lighting of a town isn't part of Ragg's everyday work, he decided to have the GIS evaluations carried out by mobileGIS.at. He sent the data gathered with the Leica Zeno 5 to Martin Trimmel, who prepared it for the light technician using the Zeno Field & Office software and sent it back to him for further evaluation in the form of Excel tables and a PDF location plan with streets and integrated light points. The city of Lana, on the other hand, received direct GIS-capable shape files from Trimmel. Using these files, further development of the lighting network could be documented and controlled.

Using the survey as a basis, the second part of Ragg's task could begin – the creation of a light plan. He will develop a proposal where inefficient lights and lights which create a large amount of light pollution will be replaced with efficient light systems with the least possible light pollution. “This proposal will be discussed with the town and implemented in steps,” said Ragg. It will enable Lana to be illuminated in an energy-efficient, economical and environmentally friendly way. The town agreed to it, and Ragg is implementing it using Leica Geosystems technology as a foundation. ■

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Moving London safely forward

by Natalie Binder

Paddington Station – famous worldwide not only for its creator Isambard Kingdom Brunel but also for a small marmalade loving bear. An average of 26,500 passengers travel from Paddington station every day. Despite its Victorian elegance and regality, plans were developed to build a brand new underground station directly beneath the historic landmark. This infrastructure project has been undertaken by Crossrail and forms part of Europe's largest construction project. The new station will be known as the Crossrail Paddington Station.

Since July 2011, plans have been developed by Crossrail to complete a new underground network for London. In August 2011, working as a joint venture on behalf of Crossrail Limited, Costain Skanska was awarded Crossrail contract 405 to complete the complex £14.8 bn rail project. This project is creating a major new railway line, stretching 118 kilometres (approx. 73 miles) from Reading and Heathrow to the west of London, to Abbey Wood in the east. It will also pass directly underneath central London. The new network will now connect seven brand new main-line underground stations, all of which are important interchanges between existing Network Rail services and the London Underground. One of these new stations is the Crossrail Paddington Station.

Meticulous planning to monitor structures above and below

Working directly under the very heart of London has many challenges. The city is home to over eight million people and its underground handles a billion journey's per year. The new Crossrail station at Paddington is surrounded not only by modern buildings but by historic ones as well. It is also located in the densely built-up zone of central London with its maze of pipes, cables and sewers, making it an extremely complicated construction project. Since London is

■ **Up to 49 Leica TM30 total stations were used to monitor building movement in the surrounding Paddington Station.**

considered a global city, it had to work without disruption, even for a project of this magnitude. Therefore, the Crossrail station is being built as a four-storey top down construction, with two-way live traffic above ground as excavation carries on below.

With all this digging, loosened dirt in central London could settle unevenly and potentially cause structures to tilt or severe cracking could develop. Constant monitoring of buildings in this area was vital to avoid possible damage and this is how Leica Geosystems products and solutions play an important role in securing the success of this new railway line by monitoring structures and the degree of earth settlement.

Robotic total stations observing Paddington 24/7

Costain-Skanska decided to implement real-time monitoring solutions by using 52 Leica TM30's, especially for monitoring designed total stations, and over 1,800 monitoring prisms of all types in and around the Paddington area. The equipment was attached to various key positions on the outside of buildings. Highly accurate 3D data is collected from the total stations that measure key reference points of the various prisms placed strategically throughout the area's buildings. These measurements, roughly 8,500 points a day, are made in daily cycles. At the recent phase of the project which was called "the bulk dig", the data capture for the majority of the area's total stations takes place at six hour intervals each day, after which the data is sent to be processed with Leica GeoMoS, which sends the results to the web portal before they are distributed to the construction team. The use of Leica Geosystems monitoring sensors, software and communications is vital to the Crossrail project, as these accurate measurements provide information on any variations in structures caused by earth movement and minimise risks, not only to the buildings themselves, but also to public safety.

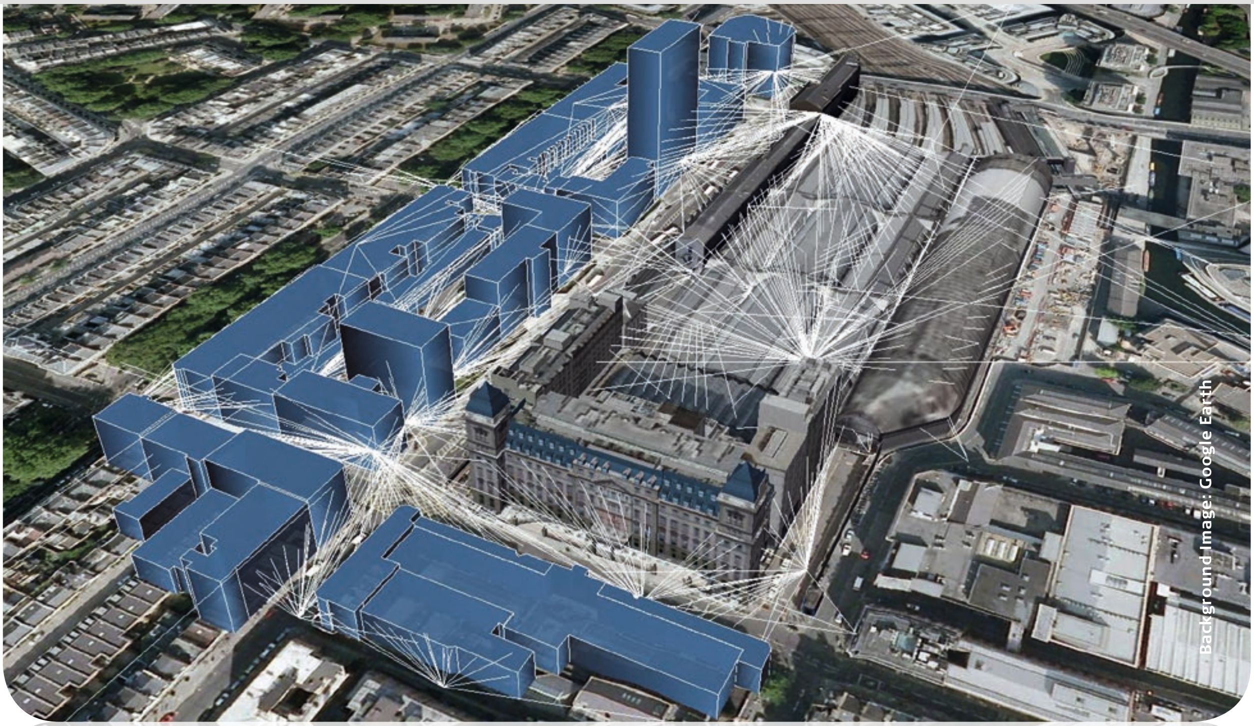
Automated data processing in near real-time

Such projects require constant observation, repetitively measuring the same routes and reference points several times daily throughout the entire project's life span. By using robotic total stations such activities can be done automatically and data is directly transferred for processing using Leica GeoMoS, GeoMos Adjust and GeoOffice software.

Three interlinked servers are used to run the Leica Geosystems software programs at the Crossrail construction site. The software is used to detect and analyse ground movement and the deformation of buildings above and below the site, and also helps to speed up and simplify the processing of real-time data collected by the total stations by up to 90%, allowing data to be available from field to issue quickly. This software solution for the new Crossrail Station is entirely from Leica Geosystems, and is the largest of its kind existing anywhere in the world. Engineering Survey Manager for Constain-Skanska Joint Venture, Steve Thurgood, reports "The software systems have to be very prescriptive and procedural to control the quality and repeatability of the project, yet also allow for dynamic change in the environment and construction phase changes. Our operation runs non-stop, we manage the software system to minimise and repair any faults that might occur. Both software systems log a phenomenal amount of data which correlates with an astonishing degree of accuracy and precision."

The Leica GeoMoS software solution is a fully automated system for data generation. It offers automated processing and evaluation using statistical analysis, comparing new data to the original base model by using easy to understand graphs. The software also continuously updates deformation analysis and network adjustment with vast volumes of real-time data received by the 44 to 49* total stations, resulting in highly accurate data delivered fast.

When the data is processed, it is additionally optimised by network adjustment software for co-ordinated geometry, topography and accuracy. Should any of the data not be within a ±10mm sphere of the previously collected data (generally not older that approx. six hours), it is considered incorrect. The engineering surveyors overseeing the operation evaluate and compare the data with deviations to the predefined data parameters and quickly decide if measures need to be taken.



A depiction of the vast monitoring network covered by the total stations surrounding Paddington Station area.

The co-ordination of displaying the processed data with on-site construction teams helps considerably to complete technical work without disruptions. GeoMoS increases not only productivity uptime by displaying real-time data but also simplifies workflows by constantly validating data before issuing it to the teams.

Dedicated teams and reliable equipment

Dedicated round-the-clock operation and maintenance teams actively maintain the entire Crossrail project's Leica GeoMoS software solution and also clean and maintain the 42 to 49 total stations and over 1,800 prisms. The total stations take six people to run plus an additional part time support staff of five persons in the field. All involved total stations are serviced and maintained at Leica Geosystems Service Centre in Milton Keynes.

"Crossrail's motto is 'Moving London Forward'. Within our engineering surveying team who run the precise levelling scheme and the largest Leica Geosystems homogeneously adjusted total station scheme in the world, we adopted a complementary motto due to the success we've had to 'Moving surveying for monitoring forward'. None of the above however would be possible without the continued support of Leica Geosystems and its supply chain partners", concludes Steve Thurgood, Engineering Survey Manager for Constain-Skanska Joint Venture.

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* Figure variation due to working environment changes.

Maximising space while preserving history

Built in 1854, Paddington Station is a fine example of an English Heritage grade 1 listed building and is site to the world's first underground railway, opened in 1863. The new Paddington Station will maximise space while preserving its historic features. The underground consists of a station box that is 28 m deep, 265 m long and 26 m wide (approx. 91 ft deep, 869 ft long and 85 ft wide). Constain-Skanska JV was awarded £14.8 billion (24 billion Dollars, 18,5 billion Euro) to complete this complex rail project and they choose to use Leica Geosystems products for this extremely meticulous project.

A tourist attraction below undefined boundaries

by Katherine Lehmuller

The Dachstein Glacier borders two Austrian states: Upper Austria and Styria. Exactly where these two borders meet was vaguely declared in 1949, after Linz and Graz, the capital cities of the two federal states, decided to end their parliament meeting by declaring that the border between the states ran along the watershed and the rocky cliffs.

In 1969, after the completion of the Dachstein cable car, which leads to the Hunerkogel Upper Station on the Styrian side of the glacier, the area became a popular destination for walkers and skiers. Over the last twenty years, mass tourism found its way to the glacier when Styria completed the Skywalk, the Suspension Bridge and the Ice Palace, top tourist attractions that were always believed to have been built on Styrian land. In recent years, the glacier has decreased and the watershed dividing the borders has changed in volume and flow.

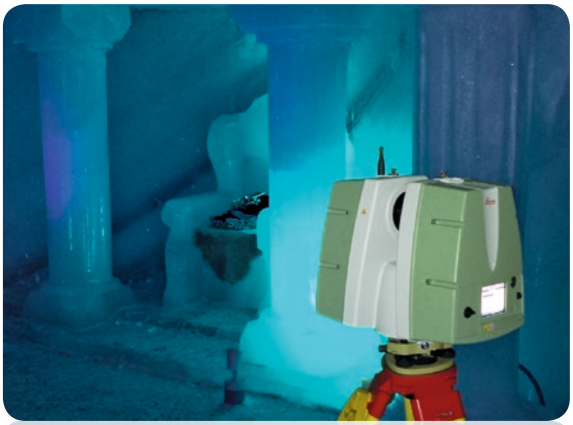
In order to define and digitalise data for future cadastral maps an official measurement of the glacier's topography was carried out using modern surveying technology. In doing this, one of Styria's top tourist destinations, the Dachstein Ice Palace, has become a topic of discussion because exactly where, more specifically, in which state, the attraction is located has still to be decided.

The Ice Palace is located underneath the Dachstein Glacier, in its inner depths and is a mystical experience out of ice, light and sound. It is only a three minutes' walk from the upper station of the cableway to the Ice Palace. An exact measurement of the tourist attraction with its 40 metre (131 ft) long tunnel system was never made and it was decided to select the long-standing Leica Geosystems customer, Consultant Surveying Engineer Peter Badura, to produce precise 3D animations and maps of the underground Ice Palace.

Mr. Badura's many years of surveying experience on the Dachstein Mountain, working on such projects as lift towers extensions and reconstructions of the Ice Palace, both inside and outside made him the logical choice. Mr. Badura decided to use the Leica TPS 1200 total station and the Leica ScanStation P20 because they wanted to try out the often-heard-of 3D surveying technology and also be able to offer more value to their end customers by handing over a virtual 3D visualisation of the entire Ice Palace.

The Badura Surveying Team defined the coordinated points with the TPS1200 robotic total station that are needed to geo-reference on a map and then began

scanning with the ScanStation P20. They could easily set up and scan from station to station, throughout the entire tunnel, because the ScanStation P20 is similar to using a Leica Geosystems Total Station and has the same intuitive user interface. "We can easily switch between the entire Leica Geosystems product portfolio. This brings us quite a few technical advantages and also saves us considerable time. I think we get substantial value for our money." says Peter Bedura, who together with his young and competent surveying team, measured the entire tunnel system of the Ice Palace. "The ScanStation P20 had to be capable of scanning smooth, rounded surfaces because the lines in the Ice Palace have been carved out of the ice and are not straight. This is the industry's best performing laser scanner; no other scanner even came in question for us." explains Mr. Badura. Another factor that needed to be taken into consideration were the icy cold temperatures of the underground tunnel system. The products selected had to be robust and be able to withstand extreme temperatures, "The Leica ScanStation P20 was absolutely the perfect product for us to use to scan the Ice Palace. It's very robust and can withstand temperatures of – 20°C. The Ice Palace is about – 10°C and not all scanners can do that."



The ScanStation P20 scanning the Ice Palace.

The Ice Palace's realistic 3D colour point cloud also has an extra advantage: It can be used for marketing purposes. Global visitors can take an interactive virtual tour through the entire tunnel system from anywhere via the Ice Palace website or it can be used as a marketing film at the entrance to the cableway. "This project should help us to make this technique more public – also, it should show the Ice Palace from a completely different perspective; one never seen by visitors before."

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Adding real customer value

by Angus W. Stocking, LS

WestLAND Group, Inc., founded in 2000 in Rancho Cucamonga, California, spent years looking for the right 3D laser scanner. The firm had a definite need for various projects. But there wasn't a huge demand; buying a dedicated scanner seemed like too much of an investment. Also, WestLAND's topographic and as-built survey workflow is already quite efficient; ideally, scanning would fit into and extend this workflow, not be a separate solution with parallel-but-separate field and office workflows.

The company looked with special interest at the first instruments that combined total stations and scanners into one housing. They weren't impressed. The ones WestLAND looked at just didn't provide the speed, point density and precision that they needed. On the occasions they needed a scanner, they needed a complete high-definition solution.

That changed in December 2013, when WestLAND took delivery of a Leica Nova MS50 MultiStation. The fact that the Nova MS50 is a complete robotic/reflectorless total station that could be put straight to work on WestLAND's typical topo, boundary, and construction surveys made a lot of sense. When they received the initial demonstration, the surveyors could tell that this instrument was the 'real deal' for regular surveying work and for scanning. They could put it to work immediately in the field, and were able to create opportunities to integrate scanning into design and as-built surveys, and that would be a great way to market scanning and expand their services into scanning-specific projects.

After a couple of months working with the Nova MS50, WestLAND Group is confident they made a good choice. It's already proved itself to be a very effective scanner – they were scanning 20 minutes after it was delivered – and have now performed several scans for rail, building façade and pipeline as-built surveys. It really is simple to switch from

conventional surveying to scanning, and they have found that processing and adjusting point cloud data is a relatively easy extension of the current workflows.

Since acquiring the Leica Geosystems instrument, WestLAND has been in the same position as any firm that has just made a big investment in capacity; they've been learning to use the Nova MS50 on the job, finding ways to use the new data forms, and looking for opportunities to market their new deliverables. Three early projects managed to do all these things at once and are excellent examples of how to get started scanning.

Much better deliverables for as-builts

One of several scanning opportunities for WestLAND came from an existing client, CGM Development located in the City of Industry in Southern California. CGM asked for an as-built survey of an office building, to support redevelopment as a condominium. WestLAND surveyed the building interior and submitted a condominium plan. They were then asked to provide a survey to support redesign of the exterior for ADA (Americans with Disabilities Act of 1990) compliance and facade renovation. As they were going to be there anyway, they decided to scan the facades as well. The client wasn't paying, specifically, for scanning. However, WestLAND had already learned that they could perform and process scans quickly; on this project, the Nova MS50 was used to provide a much better deliverable with small extra investment in time and the client was delighted. It also gave them the opportunity to see how scanning would support WestLAND's BIM work.

They did not actually create a complete BIM model because that would typically include a complete intelligent 3D model of the building exterior and interior with utilities, walls, structural components, etc. Instead, after processing the point cloud in Infinity and importing it into Revit and AutoCAD Civil 3D, WestLAND Survey/GIS Analyst Matt Corcoran modelled and rendered the building exterior and sur-

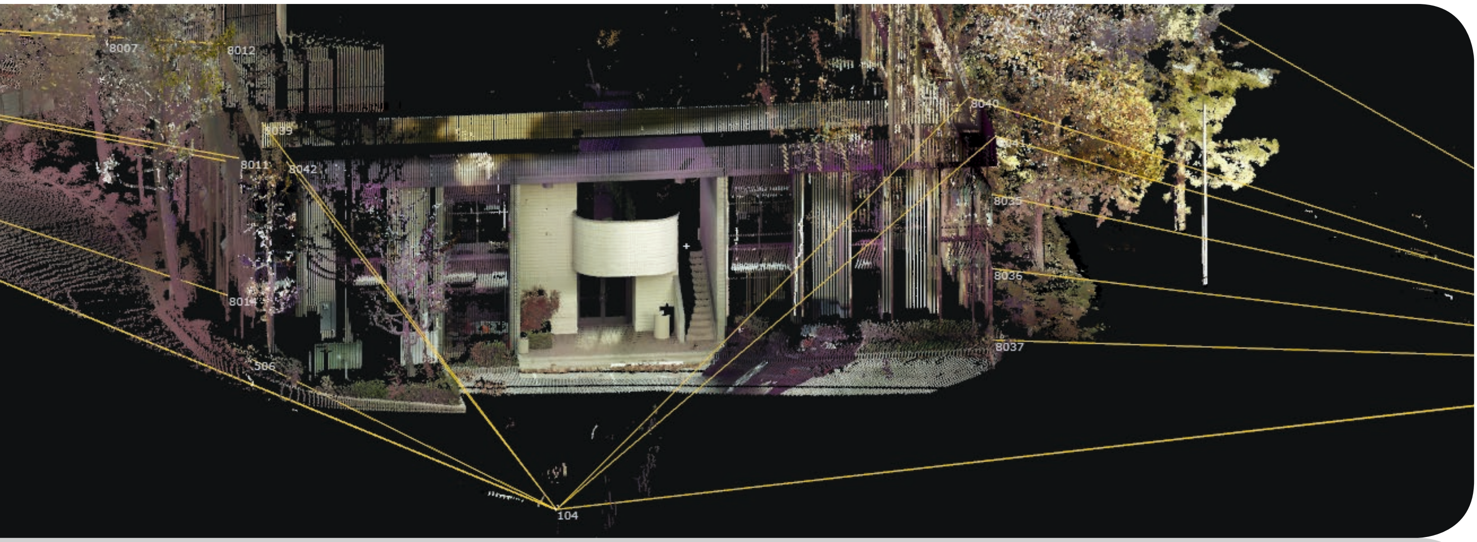
WestLAND Group Inc.

WestLAND Group, Inc., founded in 2000 in Rancho Cucamonga, California, is a mid-size, well-established firm that provides civil engineering, GIS, surveying and mapping, and also planning to clients in energy, rail, construction, municipal, and development, spent years looking for the right instrument. For many of the contracts the company was awarded, the Nova MS50 turned out to be the perfect solution.

The Nova MS50 combines a robotic total station with a reflectorless range of 2,000 meters (6,561 feet) with an impressive built-in scanner that has a scan range of 1,000 meters (3,280 feet), millimetre precision, and up to 1,000 points a second. GNSS can be integrated, and the Nova MS50 also has very good imaging capacity and image-assisted documentation. The operation and the workflow with the Leica Nova MS50 are the same as with a total station. In this way, WestLAND Group was able to seamlessly integrate scanning into their familiar workflows and deliver cost-effectively added value to their customers by providing 3D models.

For more information about WestLAND Group, visit http://westlandgroup.net.

rounding topography, and provided a deliverable to the project architect that was created in the familiar native Revit environment. Basically, the idea is to scan existing buildings when appropriate, and deliver the data to the design firm as a starting point or "shell" for an actual BIM model. In this case, WestLAND said the client loved it, because they were able to use the data for design and for presentation purposes. WestLAND expect them to ask for similar models when requesting work for future projects.



WestLAND Group expands into 3D laser scanning with the Nova MS50 maintaining familiar total station workflows.

Adding scanning to a familiar workflow

Another project started with another request from JLP. They asked for an clearance survey of an existing bridge, together with surrounding topography along existing tracks in a railroad yard. WestLAND had done similar projects for JLP, but this time, thanks to the good outcome of a previous tunnel project, scanning was specified.

WestLAND confirms that the fieldwork was straightforward. They had to set up on both sides of the bridge anyway, for control and conventional topo, so the additional scanning only took about an hour. This time, they performed a total of four scans, five to fifteen minutes apiece depending on density, from setups they were using anyway. They also took reflectorless shots on key features to compare these to the point cloud for QA/QC purposes, and everything is always within millimetre accuracy.

After that, the entire project – point cloud, control, and topography – went straight into Leica Infinity office software for adjustment and then into JLP's preferred CAD environment for line work, breaklines and contours. It only took about an hour to review and incorporate the point cloud into the drawing. It was a good example of a pilot project paying off with new work.

All-in-one surveying

A surveyor at WestLAND says the Leica Nova MS50 lives up to the claims. "After a few hours training from the dealer, we were able to get to work immediately on actual projects and provide high-quality 3D deliverables with minimal extra time. Processing all the points we gather, in one environment, is a real time saver. We're looking forward to using it more. We're already under contract to provide an as-built of a pipeline network located in a steam power plant; that's work that would be very difficult for us to perform cost-effectively without a good scanner."

About the author:
Angus W. Stocking, L.S. is a licensed land surveyor who has been writing about infrastructure since 2002.

Clearing snow safely and with certainty

by Karin Fagetti

The beautiful spring day in the valley belied the oft prevailing conditions at the Oberalp Pass in Grisons, Switzerland. For years, large masses of snow have made it impossible for even experienced building authority employees to say exactly where mountain passes run. This results in laborious, imprecise and often dangerous clearing work. With the iCON alpine, Leica Geosystems provides satellite-based machine control for preparing tracks which are also optimally suited for snow blower vehicles. Supported by Grünenfelder und Partner AG, testing showed that this innovative controller was capable of precisely displaying the course of the road down to a few centimetres, which makes snow clearing work considerably more efficient and safe.

"Our main expectations for this new system are greater efficiency and a reduction in costs by 10 to 20 percent," explained Marcus Valaulta, Head of Public Works Service District 6 in Grisons, on location during a test run at Oberalp Pass. The usual method of removing snow with the use of probe poles and

The iCON alpine display also supports operators safety with warning signals.

snow poles to help determine the course of the road and then removing the masses of snow layer by layer with a snow blower can lead to excessive clearing in the wrong spot. The information gathered in this way is too imprecise. Oftentimes, the snow poles at the edges of roads (which serve to orient clearing crews under normal winter conditions) are buried under masses of snow or are broken off by avalanches.

The Leica iCON alpine, which was originally developed for snowcats and use in skiing areas, clears away these inaccuracies. A small receiver, two GPS antennas and a clear display in the operator's cab provide the clearing team with precise information on the course of the road.

During the summer when there was no snow, engineering firm Grünenfelder und Partner AG, a company of the Swissphoto Group in Switzerland and a partner of Leica Geosystems, surveyed the two kilometre test section of the mountain pass using GPS and then created a basic 3D model. This digital data on the lane edges was transferred to the Leica iCON alpine system for the test. A display in the operator's cab then shows the exact course of the road and supports the operator with arrows and warning signals.

The advantages are clear: no more idling, which means faster and more precise clearing, more efficient use of personnel and greater safety for people and machinery.

Marcus Valaulta would like to see the snow poles at the edge of the road done away with entirely. He is convinced that "the iCON alpine system makes it possible to get rid of them. Installing the poles is both laborious and dangerous to motorcycle drivers in the summer."

Since snow has to be removed layer by layer from top to bottom, a lack of precise control can also lead to a driver unknowingly driving into a retaining wall with his snow blower and, in the worst case scenario, fall over the embankment.

Satellite-based machine control was able to determine the course of the road down to a few centimeters during a test run on the Oberalp Pass. Experts on location for the test were impressed. "This definitely has a lot to offer," said the operator of the snow blower after the extensive testing. He has been clearing the Oberalp mountain pass for years (always equipped with an avalanche beacon) together with a colleague in just about every weather condition and took the occasion to tell about wasted clearing effort in the wrong location, dangerous situations in blind areas, mist and snow flurries and multi-metre-high snow piles which buried the poles.

After this successful test, it's possible that the employees of the Grisons public works service will be clearing the canton's mountain passes with the iCON alpine system starting next winter.

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