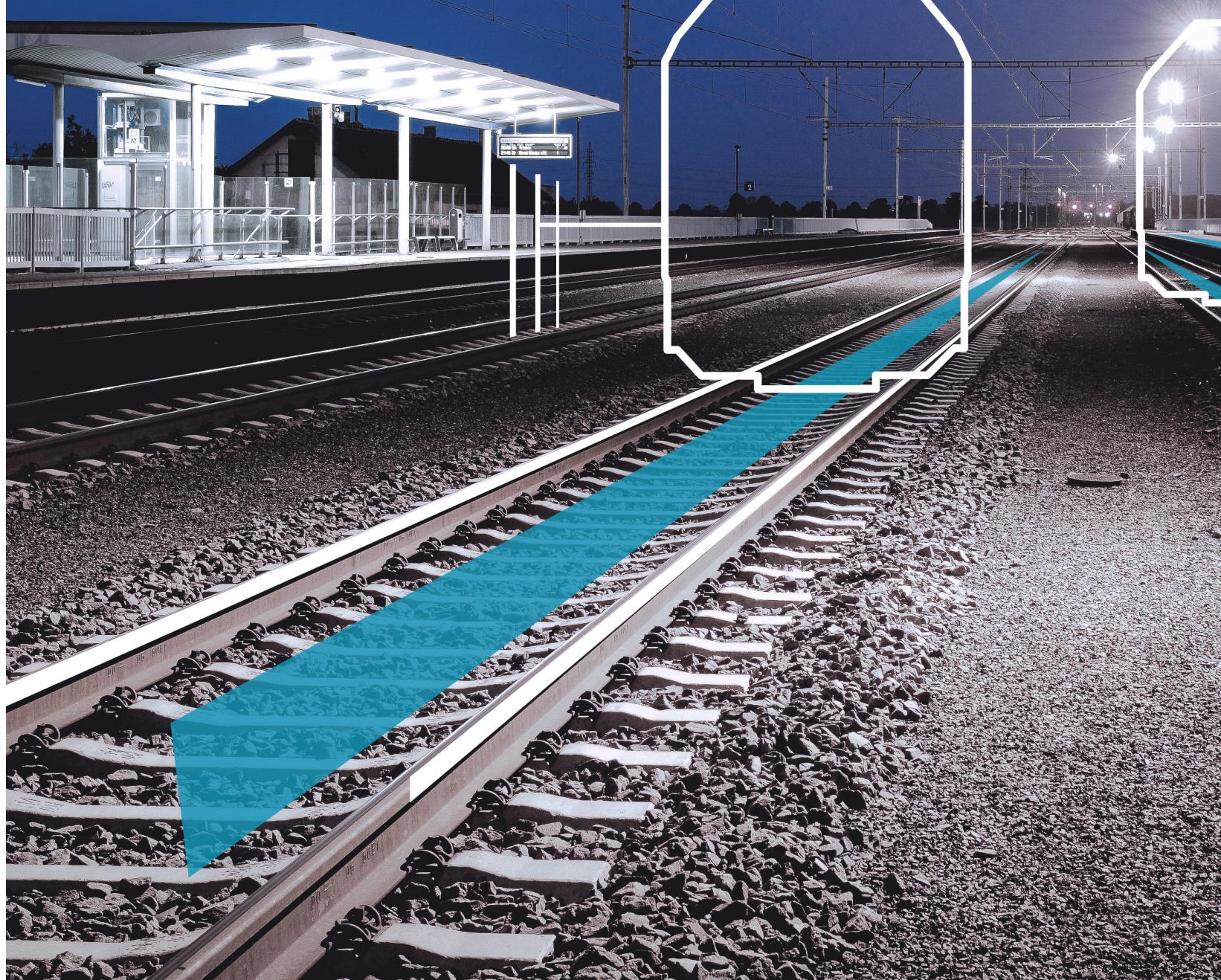




REPORTER

RAIL EDITION



HEXAGON
GEOSYSTEMS

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REPORTER RAIL EDITION



President's Message

Around the world every day, billions of people take some form of rail transportation to travel to their destinations while at the same time goods are shipped across countries' vast rail networks. Whether its national railroads or city subways and trams, this vital form of transport is depended upon to keep society moving. Through geospatial solutions, such as 3D surveying and asset management, Hexagon supports rail professionals to ensure safe, efficient and modern delivery of passengers and cargo. This edition of Reporter explores their stories.

Safety is the No. 1 concern in the rail industry. Oversized loads, such as wind turbines and transformers, are often best transported by rail. Their cumbersome sizes, though, pose many risks. To safely transport what is known as high-wide loads, the weight and dimensions must be measured precisely. Before HLI Rail & Rigging in the United States implemented a laser measurement and documentation system, the firm's professionals were required to climb and access hazardous areas to obtain what was often inaccurate dimensions. Today, with Hexagon's laser technology, the process has been streamlined for consistent and repeatable measurement accuracy.

Bringing more efficient operations to rail increases the productivity of the overall industry. When this happens, congestion on the tracks decreases, people and freight are delivered to their destinations quicker, and breakdowns and other costly delays are prevented. Heading and Associates in Australia is supporting the Metro Trains Melbourne & Laing O'Rourke GWAF project to make commuter traveling to and from the city more efficient. Using Hexagon's mobile mapping technology, the team delivered a detailed point cloud of the 26-kilometre rail line in just two days instead of two months, which is what would have been required using more traditional methods. The point cloud was then used to provide the latest conditions for accurately placing high-capacity signaling.

Modernising rail infrastructure is becoming a focus for governments worldwide. Many countries' rail infrastructure is decades out of date, resulting in dangerous and slow rides. In Italy, where some of the oldest rail lines in the world can be found, ETS Engineering has integrated various Hexagon technologies, including mobile mapping and ground penetrating radar, to determine the depth of the Olmata Tunnel's geometry and its status. The captured data, which was previously unknown, will support the modernisation of the tunnel project by Rete Ferroviaria Italiana (RFI), owner of Italy's railway network. The combined solution reduced interruption times on the tracks and enabled the firm to ensure the safe passage of special types of trains.

The rail industry is important not only for our transportation needs but also advancing global societies by providing residents and businesses a means of vital economic exchange. Our focus for rail is providing solutions that increase productivity while decreasing inefficiencies and hazards.

Enjoy your read.

A handwritten signature in blue ink that reads "Jürgen Dold".

Jürgen Dold

President, Hexagon Geosystems



KEEPING SPAIN ON TRACK WITH HIGH- SPEED RAIL

Renata Barradas Gutiérrez

Case Study

Using reality capture mobile mapping sensor platform for high-speed railway lines in Spain



Railways connect users to their workplace, homes, service and entertainment centres, restaurants and beyond. Rail transport systems linking suburbs to city centres are essential for economic and social development. Countries are adapting and expanding their railway systems to mobilise the increasing urban growth and keep the economy on the move – Spain is no exception.

Ferrovial Agroman builds and maintains current railway infrastructures through which millions of people and goods flow. Since 1927, Ferrovial Agroman has laid more than 5,300 kilometres of railway in Spain, including 1,000 kilometres of high-speed rail lines in and outside the country.

The Railways and Transport Department of Ferrovial Agroman is involved in the maintenance and construction of railway lines throughout the Spanish territory.

Among all these projects, the recent completion of two high-speed line stretches belonging to the Northwest High-Speed Corridor connecting Madrid with Galicia stand out:

- 1.** The construction of the Espiño tunnel
- 2.** The assembly and maintenance of the railway superstructure between Olmedo and Zamora.

With this amount of projects, Ferrovial Agroman needed to streamline the process of acquiring data and verifying information. The challenge was solved

using a mobile mapping system that captures the railway and all its environment with the speed and efficiency that most rail projects require – the Leica Pegasus:Two.

OVERCOMING RAIL RIDDLES

Railway tracks are purpose-built – each track is meant to smoothly guide a specific train, built with the highest specifications, so both pieces of the puzzle fit neatly together. Nothing else but the train can run or stand in the way of a railway. Surveying a railway line, therefore, requires capturing enormous amount of data with the highest precision and standards in the shortest amount of time.

In addition to the usual challenges of surveying a railway, the railway lines in Spain that Ferrovial Agroman oversees are defined by a mountainous landscape with numerous underground works and inaccessible areas. At approximately 8 km, the Espiño tunnel is one of the underground works with the longest corridor distance.

The Northwest High-Speed Corridor project, which links the Spanish cities of Olmedo with Santiago de Compostela, has more than 400 km of track assembly, of which 100 km correspond to the Olmedo and Zamora section.

"Conditions to capture railway lines are challenging. If, in addition, the project is a railway line that is in service with limited work times, the speed of



acquisition is key,” said David Rodríguez Vega, head of geomatics and topography at Ferrovial Agroman. “Having a system that captures data in a flexible and fast way is key to solving the problems that arise in a new project. The perfect ally to fulfil our goal is the Pegasus:Two, the most efficient and fastest mobile mapping system.”

SPEED AND PRECISION

Ferrovial Agroman is aware that digital representations enable professionals to make more informed decisions. For the correct execution of rail projects, it is required to have detailed digital data of all assets that form part of the railway infrastructure. To create accurate 3D models that fuse plans with the mirrored reality, experts rely on the Leica Pegasus:Two.

“Knowing all characteristics of the location is essential for studying, drafting and executing every project to determine the methodology and the cost of the venture,” said Rodríguez Vega.

To interfere as little as possible in the railway line, the Pegasus:Two is mounted on a vehicle suitable for driving on roads and rail lines, providing flexibility to leave and occupy the line.

“Having a system that provides speed and quality in the acquisition of information is decisive. The georeferenced point clouds with overlaid images obtained with this mobile mapping system have exceeded expectations and will undoubtedly be applied to new projects,” said Rodríguez Vega.

With a mobile sensor platform that captures not only point cloud and 360° imaging data from additional sensors with survey grade accuracy but incorporates GPS and Inertial Measurement Unit (IMU) positioning systems, quality of information is guaranteed.

“Our end goal is to digitalise railway lines to have all the elements that are part of the infrastructure identified geolocated, and geometrically defined. All data and models generated is the basis for all future projects,” said Rodríguez Vega. “It is without a doubt a great advance towards the digital world – an end that our main clients are demanding.”

ABOVE THE REST

The team of experts considered speed and quality of information as the main criteria when selecting a solution to capture their railway projects. Within the commercially available mobile mapping systems, Ferrovial Agroman selected the Pegasus:Two with its



specific trajectory calculation software, Leica SiRail, due to several factors that made the mobile sensor platform stand out above the rest:

- Compactness and ease of transport
- Precision with the most advanced GPS systems and IMU inertial systems
- Simplicity to assemble and disassemble the system in the vehicle, calibrate the system, and a control software that is intuitive and easy to use
- Geosystems' commitment and effort in achieving the success of the project.

A PARTNER YOU CAN TRUST

More than 90 years of experience and 55 years of international activity in 50 countries spread over five continents have made Ferrovial Agroman a leading company in the infrastructure sector.

Ferrovial Agroman trusts Geosystems solutions for large infrastructure projects with outstanding underground works, large assembly projects, and track maintenance where the details are very rigorous.

The company currently uses a wide range of

Geosystems software solutions from Leica GeoOffice, Infinity, GeoMos and Cyclone, to CloudWorx plugin for 3DReshaper.

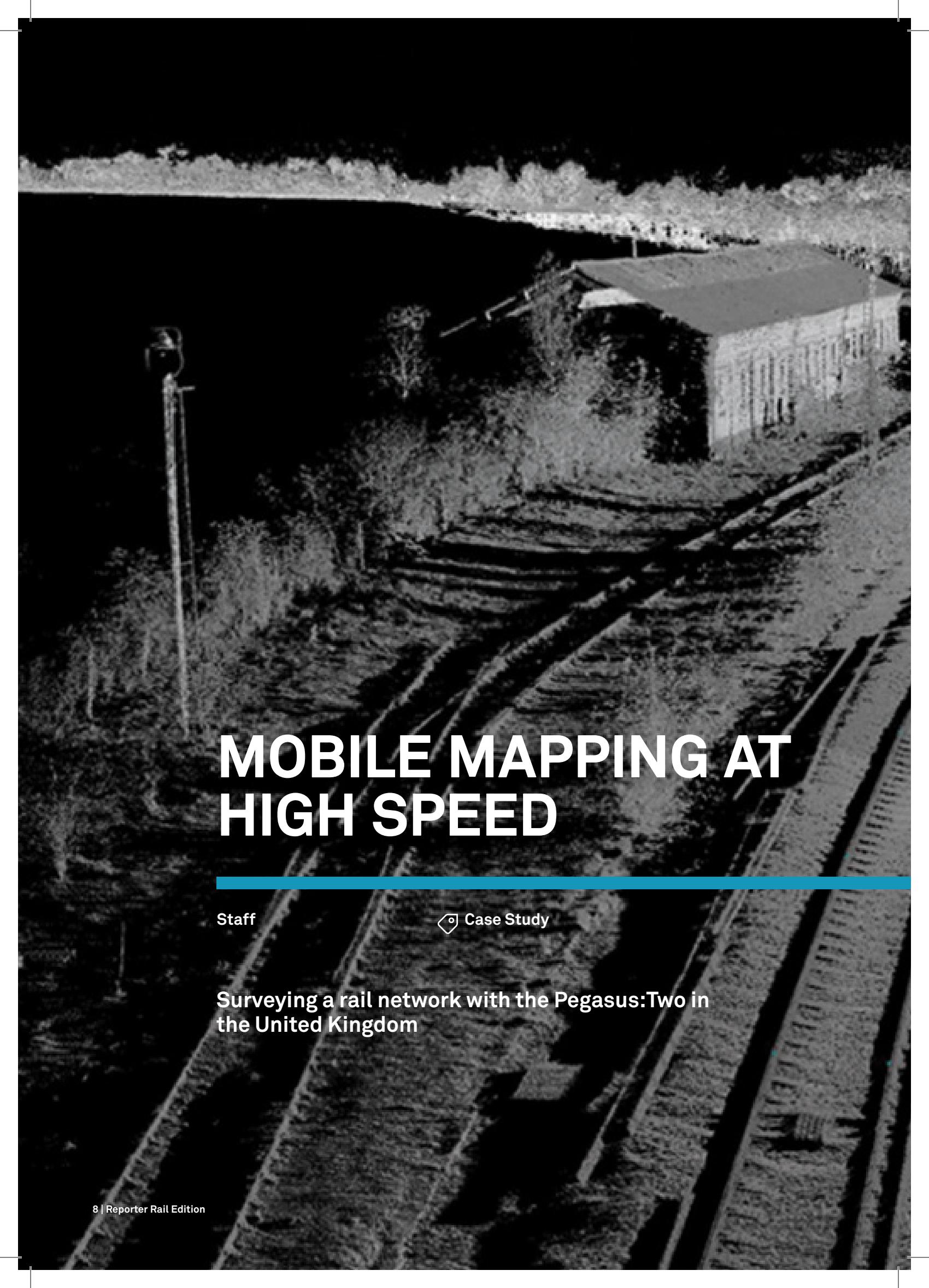
Besides the Pegasus:Two, Ferrovial Agroman uses the following Geosystems hardware equipment for their projects:

Total stations and GNSS equipment for setting out and daily monitoring of the projects, works of network calculations, auscultations and machine control;

Digital level equipment to calculate high-precision altimetric networks and auscultation work;

Laser scanners for calculating volumetrics and verifying geometries, and capture of massive information;

"One of the most influential reasons for choosing Leica Geosystems solutions, is the precision and quality of its products backed up with the ability to learn from the needs of customers and implement it in their products," said Rodríguez Vega. "They also have a wide catalogue of solutions that cover all your project's needs. Among all these advantages, the good team of professionals who respond, collaborate and solve all your needs is the most remarkable."



MOBILE MAPPING AT HIGH SPEED

Staff

Case Study

**Surveying a rail network with the Pegasus:Two in
the United Kingdom**



The Midland Mainline (MML) is an integral portion of the United Kingdom's rail network. With 639 kilometres of track, 16 tunnels and 35 stations, the MML has been serving the UK since 1870.

to keep the rail line functioning at optimal speed. As part of the MML Enhancement project, significant alterations were planned for the Market Harborough Station in Leicestershire, England to remove a major kink in the through alignment. The project required 8 km of the mainline surveying, consisting of high accuracy track alignment, structure gauging, drainage tracing and topographic cess detail.

Severn Partnership, a surveying firm of Chartered Geomatics Surveyors based in Shrewsbury, UK, was selected to provide the high accuracy surveying needed.

SURVEY GRAD RESULTS FROM MOBILE MAPPING

Severn Partnership has been involved in the MML upgrade projects since 2010. This programme of improvements to the line is the most extensive since it was completed in 1870, with Severn Partnership delivering more than 161 km of permanent survey control and subsequent permanent way (P-Way) track survey. More than 70 bridge structures and three mainline train stations were added as part of the Electrification Programme. Severn Partnership installed all surveys relating back to the original snakegrid control.

Combined with its knowledge and expertise in the rail industry, Severn Partnership, needed a safe and cost effective method of capturing topographical line side details of the 8 km site



at Market Harborough. The firm used its Leica Pegasus:Two survey grade, mobile mapping system to reduce track access requirements and to capture topographical detail.

Mobile mapping combines laser scanning technology with GNSS and motion sensors into a single unit that is easily mounted onto any vehicle. In a rail environment, Leica Geosystems considers mandatory the use of the second GNSS antenna. The Leica Pegasus:Two system requires GNSS coverage at all times, ensuring an accurate dynamic performance of the IMU by continuously calibrating it to zero drift.

Mounted on a motorised personnel carrier, it captured a 3D laser scan point cloud and imagery. This was done on a rail mounted vehicle, at 16 km/hour for the length of the site in a single 3 hour shift. The resulting data could then be digitised at the office without the time and safety pressures inherent with working on the railway network.

To maintain high accuracy, the point cloud was linked to the site grid using the newly surveyed track alignment. The rails in the scan were automatically matched to the traditionally surveyed rail strings, resulting in sub-10 mm accuracy relative to the track alignment.

"Working with the Leica Pegasus:Two on the Midland Mainline Speed Enhancement project saved us significant time and cost," said Rollo Rigby, Severn Partnership associate director.

SAFER WITH MOBILE MAPPING

The Pegasus:Two offered survey grade accuracy and high resolution images required for the project specification. Its versatility in being mounted on to any kind of vehicle enabled it to be mounted to a rail enabled vehicle as well as a road vehicle to capture all on and off track data. Using mobile mapping and the Pegasus:Two meant that the data was captured in one shift on one weekend as opposed to multiple weekends if more traditional methods were used.

Fewer rail teams were on the ground working in a potentially dangerous environment reducing risk to personnel. All detail was captured quickly and efficiently including cess detail, ballast profile, structures and vegetation, without the need for site visits. Site imagery was also shared with the project team in a 'street view' style potentially reducing the need for further site visits.

"In this project, with mobile mapping, we were able to reduce man hours on the track as well as improve the overall safety for the rail team," concluded Rigby.



CAPTURING ONE OF THE WORLD'S LONGEST TUNNELS

Monica Miller Rodgers

Case Study

As-built infrastructure documentation of the world's longest tunnel with the Leica Pegasus:Two in Switzerland



When the Gotthard Base Tunnel officially opens in June 2016 as part of the New Rail Link through the Alps (NRLA), a construction project 20 plus years in the making at 9.8 billion Swiss francs will be one of the world's longest and deepest railway tunnels. At 57 kilometres long and with a rock overburden of 2,300 metres, the tunnel increases the total transport capacity across the Swiss Alps while reducing passenger travel time between northern and southern Europe by one hour. With minimal gradient and wide curves, the route is also a flatter, lower-level journey at only 550m above sea level. The whole tunnel system measures a total of 152 km, plus almost 50 km of new built outdoor tracks.

When Grunder Ingenieure AG, a leading Swiss engineering firm specialising in rail surveys and long-time user of Leica Geosystems solutions, was sub-contracted by the Alptransit Gotthard AG, the firm knew it would be a challenging task but one for the history books. One of the main tasks, before the tracks open for the test operation, was to capture all the infrastructure of the tunnel for as-built documentation.

"There are several stakeholders working on the overall project, and we were tasked with registering the entire infrastructure to collect for the infrastructure database of the Swiss Federal Railways. All these users can now access this information," said Gilbert Roulier, Grunder's director of Imaging, Laser Scanning and Mobile Mapping. "Entering the underconstruction

tunnel and outdoor tracks also presented organising challenges that we needed to account for with our engineers and surveying instruments."

The firm selected the Leica Pegasus:Two to safely and efficiently capture the entire infrastructure of the newly-built open tracks. In combination with Leica Geosystems total stations, Grunder was able to provide a complete database of 3D imagery and point clouds covering the rails, signage, posts, electrical lines, and further installations and structural elements.

ON THE FAST TRACK

Facing a very short and divided up timeframe of only a few weeks, Roulier and his team knew they needed a fast and efficient method to capture all the available data. They found this in the Leica Pegasus:Two's seven cameras providing full 360-degree dome imagery combined with the scans of the onboard LiDAR profiler.

Easily attaching the capture platform to the prototype of the firm's specially-designed rail trolley, the engineers were able to quickly and effectively maneuver over the outdoor tracks to collect a few billion points. By constantly capturing data on the move without disrupting ongoing construction, safety increased for Grunder and other employees. No longer were the surveying engineers required to trapeze through a risk-filled construction site, and construction workers no longer needed to worry

about avoiding surveyors or instruments set up in the midst of their site.

"This non-contact and kinematic measurement ability allows us to record everything without interruption, significantly decreasing risks," said Roulier. "This mobile method also reduces the effort, saving the entire project on costs and time, with benefit for all working stakeholders."

With the complete 3D surround capture of the Leica Pegasus:Two's images and point clouds, no critical information is forgotten, either. With only one pass, all important documentation is made. The need to return to site on multiple occasions for data collection is eliminated, saving vital resources.

SENSOR MERGING FOR DIGITAL REALITY

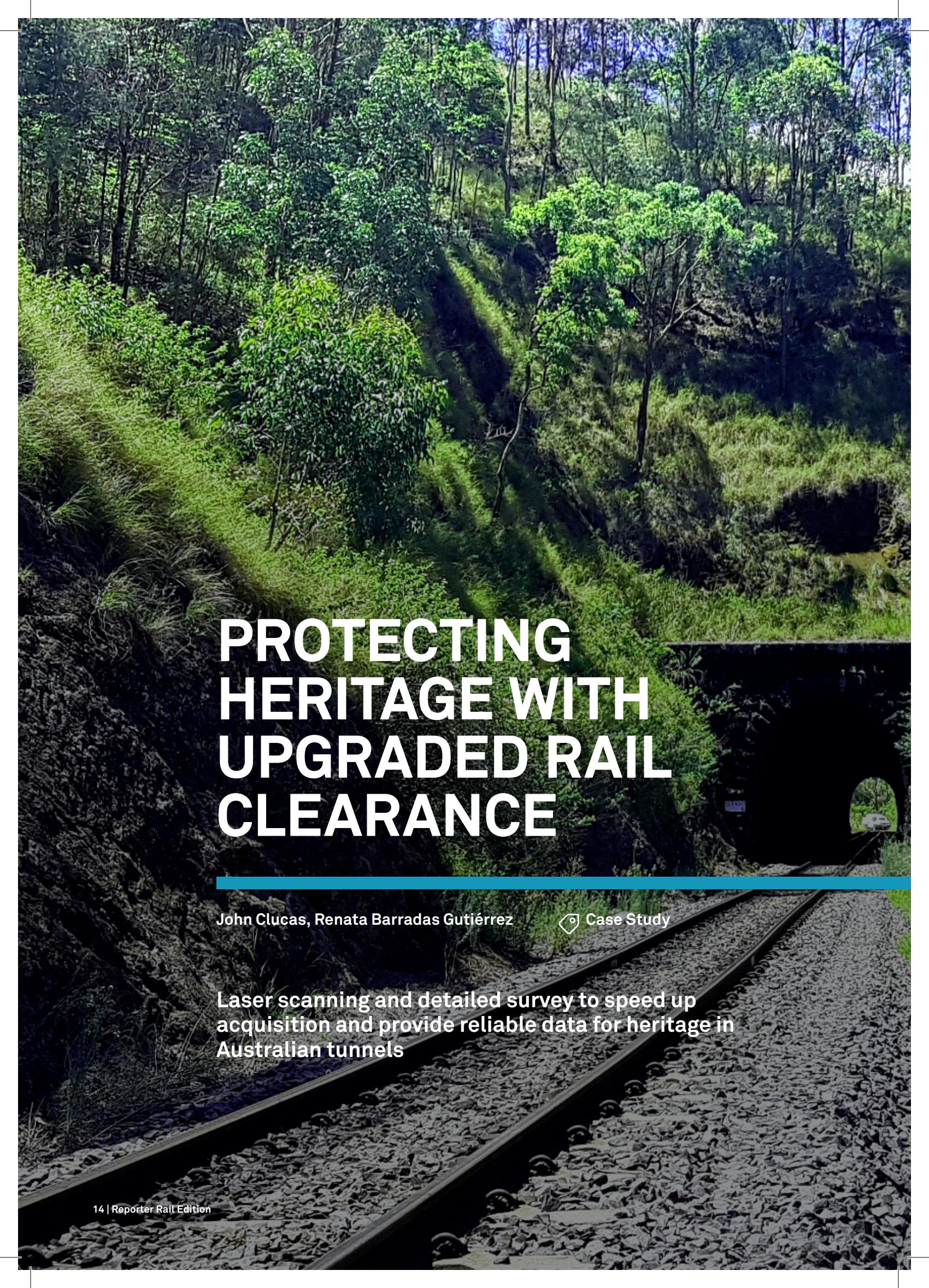
With the combination of imaging and scanning data, all visual information is brought to reality. The Leica Pegasus:Two and reality capture solutions marry traditional surveying technology, such as positioning systems, laser scanning and radar imagining, into one convenient and easy-to-use platform. A complete and fluid workflow follows reality capture

of calibration, post-processing, object extraction and GIS storage.

Enabling the engineers to work with the most accurate and current representation available, the open tracks were presented in 2D and 3D display for maximum manipulation capability. In the rail industry, working with highly realistic models translates into safer design, faster production and reduced costs.

"Being able to provide such a detailed dataset to the stakeholders enabled all interested parties to conduct their work swiftly and successfully," said Martin Baumeler, Grunder's managing director. "The Leica Pegasus:Two increases our business and ensures we provide quality deliverables to our customers."





PROTECTING HERITAGE WITH UPGRADED RAIL CLEARANCE

John Clucas, Renata Barradas Gutiérrez

Case Study

Laser scanning and detailed survey to speed up acquisition and provide reliable data for heritage in Australian tunnels



The rail line connecting Toowoomba with Brisbane has 11 heritage tunnels dating back to the 1860s. International shipping companies and local cotton and grain growers are transporting through this railway between 86 to 96 containers daily.

With shipping containers increasing in size, the old rail tunnels will soon be too small to accommodate the larger containers. Worse still, along each tunnel the width varies, roof heights are inconsistent, and walls and roofs have irregular projections. Being heritage listed, most of the tunnels need to remain untouched. Queensland Rail therefore proposed to lower the floor and rail alignments to provide sufficient clearance while minimising the impact on storm water and other underground services.

To provide the necessary freight clearance,

Bennett + Bennett, a firm providing advanced surveying, town planning and spatial solutions for nearly 50 years, surveyed 11 tunnels from up to 540 metres long.

The rail line is busy every day with passengers, coal freight and agricultural products. To minimise disruptions, full access to the tunnels was provided during a 48-hour track closure. Within this small window, Bennett + Bennett mobilised a team of eight specialists. An integrated laser scanning and detailed survey approach speed up acquisition and provided reliable data that ensured no further site visits are needed.

UNDERSTANDING THE TERRAIN WITH A CONVENTIONAL SURVEY

Bennett + Bennett exclusively uses Leica Geosystems laser scanning equipment, and



sources its equipment and support services from C.R. Kennedy – the national distributor for Leica Geosystems solutions in Australia.

Using conventional survey methods with Leica Geosystems total stations, the team of experts was able to:

- Pick up ground surface topography
- Locate underground services
- Re-establish survey control along the rail corridor
- Survey drainage for hydraulic investigation
- Verify control points
- Measure rail monuments

ACQUIRING DATA WITH TERRESTRIAL LASER SCANNER

During the 48-hour track closure, various engineers, project managers, and geotechnical and heritage consultants were also working in the tunnels. With several teams working inside of each tunnel, mobile laser scanning from a rail mounted trolley would have been impractical.

Instead, the survey team used Leica P30 and P40 ScanStations to acquire the point cloud data from 250 locations, concentrating on features, such as the tunnel approaches, portals and interiors, and the tracks. Data was recorded on a grid smaller than 5 millimetres, and more than 100 GB of data was acquired for each tunnel. C.R.Kennedy made a P40 ScanStation available for hire to the survey team at short notice. It proved so efficient that the team ended up purchasing the laser scanner.

To provide the client with a realistic colour visualisation of the data, Bennett + Bennett took 360° panoramic photographs at each control point. This required lighting inside the tunnels so portable artificial lights were placed under the tripod of the ScanStations. The project area was also captured on video for quality assurance purposes.

CREATING A PRECISE 3D MESH OF EACH TUNNEL

The raw scan data and panoramic images were imported into Leica Cyclone software for processing and registration to survey control. All rail alignments were obtained with a high precision. Features such as string, vertex, and surface were extracted from the point clouds to form a detailed survey that



was integrated with the conventional survey. High resolution was required to extract features like the track joins.

To create precise 3D digital meshes, the point clouds were imported to 3D Reshaper. Experts could experiment with point cloud sizes and mesh detail to deliver the optimum size for the client. Rail track designers will use a digital model of the new trains to ensure there is sufficient clearance to the features defined by the mesh created by Bennett+Bennett.

BETTER THAN BEING THERE

Leica TruView files generated from Cyclone were uploaded to TruView Global software, the industry leader for easily and intuitively sharing point cloud data, design models, mark ups and more. This allowed the project to come to life in dimensionally correct photorealistic digital reality, enabling everyone to view the project, pan, zoom, measure and mark up.

"TruView allowed us to deliver data to clients while other deliverables were being prepared. The clients, furthermore, found very valuable to eliminate the need for further site inspections and engineers felt TruView provided good context to complement other

deliverables," said Liam Thierens, spatial services manager at Bennett + Bennett.

DIGITAL REALITY FOR HERITAGE AND RAIL

This rail project ensures the freight hub cities stay connected while conserving the integrity and heritage status of the tunnels. Despite the short 48-hour window to acquire data, Bennett + Bennett provided high quality deliverables within two weeks of completing the field work and no further site visits were required.

All coloured point clouds, 3D meshes, TruView Global, video and detail surveys were issued within six weeks. By integrating survey data acquired from a variety of instruments, the Australian firm provided its client with high precision design criteria in a format the client can literally see, not just imagine.

Watch a sample of Bennett + Bennett's digital reality of the tunnels: [Laser Scanning - Toowoomba Range Heritage Rail Tunnels from Bennett + Bennett on Vimeo](#).

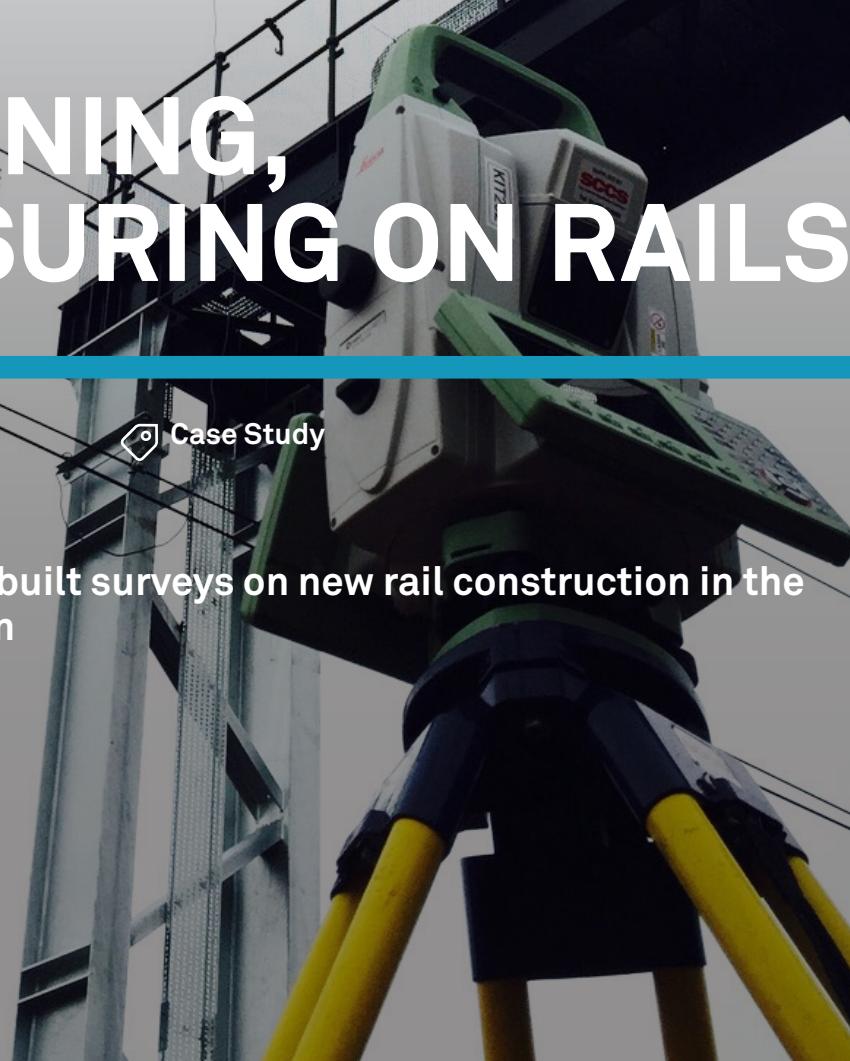


SCANNING, MEASURING ON RAILS

Dan Binney

Case Study

Performing as-built surveys on new rail construction in the United Kingdom





After several years of petitioning, a new chord to the railway line in the Ordsall area of Greater Manchester, United Kingdom, was finally opened and made operational late last year. The approximate 96 million Euro project allows 700 extra trains per day to operate in Manisty. The new link will allow trains to run between Manchester's Victoria and Picca-dilly stations for the first time.

As part of the Ordsall Chord, the flagship Network Rail project in Manchester City Centre, the construction is made up of complex geometry. Skanska Bam Joint Venture, leading development and construction companies, served as the primary contractor on the project. With a trusted relationship, the company turned to its preferred survey supplier, SCCS, for a solution that could handle such complexity efficiently and accurately. That solution was the Leica MS60 MultiStation.

"The MS60 was purchased for this project from SCCS due to its high precision accuracy, ability to perform high resolution localised scans quickly, and intuitive onboard functionality," said Ben Barnard, SCCS Survey Equipment Ltd key account manager and technical sales. "This helped maximise the surveyors' efficiency on site."

EFFICIENCY GAINS IN RAIL CONSTRUCTION

With a challenging design that includes architectural features, such as fanned pier extensions, the overall project includes the construction of:

- 7 new spans
- 300 metres of new track
- 2 widening of existing Victorian viaducts.

All the while at the centre of the project sits the iconic network arch bridge, the first of its kind in the UK, spanning 90 m. This structure had to be preserved throughout the project.

Since the preliminary stages of the project, SCCS has supplied the Skanska team with equipment, technical support and training. With the use of the MS60 MultiStation, significant value has been added to engineering and surveying procedures as well as delivering significant time savings on the Ordsall Chord project.

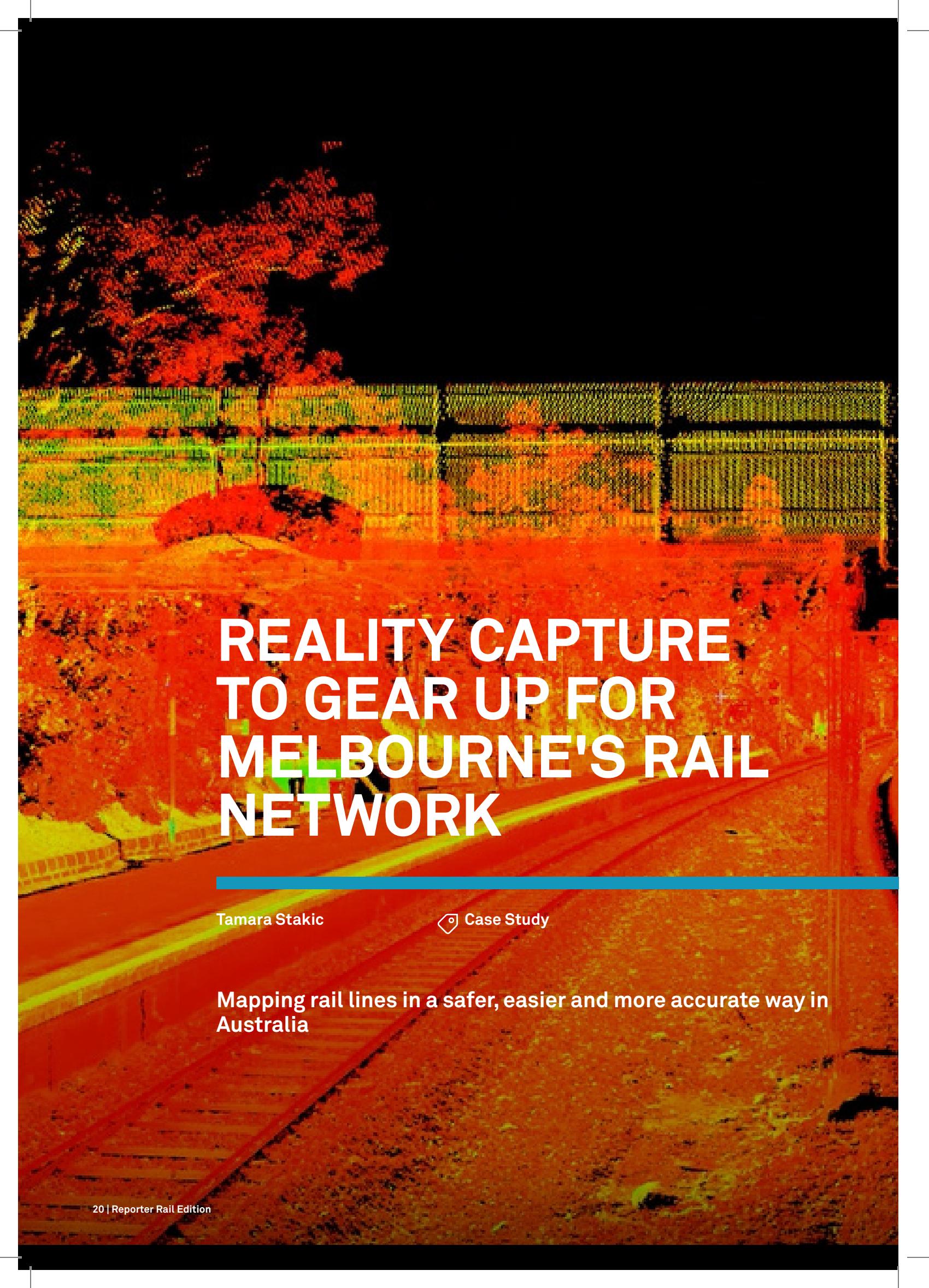
"The complex structures included in the project meant traditional checking throughout the construction process, which would have been challenging. The adoption of the MS60 allowed us to develop an innovative process of scanning and verification/clash detection to reduce risk and streamline the QA process," said Tom Emerson, Skanska engineering surveyor. "The MS60 even delivered time savings over modern dedicated laser scan systems. With the regular need for point cloud data, the MS60 made it easy to capture this in conjunction with our other site engineering and surveying duties."

SAVING TIME ON THE TRACKS

On a rail project such as the Ordsall Chord, limited access to track means time on track is precious. Efforts to capture the rail geometry must be done quickly, correctly and efficiently.

"Having the ability to complete a quick scan with our MultiStation has delivered unforeseen benefits," said Emerson. "Through as-built point cloud information, we can quickly capture what we need and make adjustments back in the office. Previously, additional track visits would have likely been required. With the captured data, we can do everything in the digital reality we have created."

With the self-learning ability of the MS60 MultiStation to adapt to any environment, scanning and measuring are made simpler in one view. On the rails, this translates to time savings and increased productivity for more efficient projects.



REALITY CAPTURE TO GEAR UP FOR MELBOURNE'S RAIL NETWORK

Tamara Stakic

Case Study

Mapping rail lines in a safer, easier and more accurate way in Australia



The train network in Melbourne, Australia, is getting a major revamp with several projects in progress to help tackle congestion. To improve travel around Melbourne, the Victorian Government is removing 50 dangerous and congested rail level crossings, which will deliver significant safety improvements for drivers and pedestrians. The eight-year project, due to be completed by 2022, will enable more frequent services for thousands of commuters travelling to the city every day.

In addition, the Metro Tunnel project will add five new underground stations and 65 next-generation high capacity trains for the metropolitan network – freeing up more trains across the Melbourne rail network. This also means that 55 kilometres of next-generation, high-capacity signalling will be installed, allowing the trains to safely run closer together and more often. This will be the first roll-out of high capacity signalling on an existing network anywhere in Australia.

To prepare for the busy piece of Melbourne's railway infrastructure, topographical surveys were needed. The Metro Trains Melbourne & Laing O'Rourke GWAF project turned to Heading and Associates, a professional surveying and project management firm specialising in survey, construction supervision, property and environmental survey, and design applications, to perform several surveys.

The project and delivery timelines provided the ideal time to upgrade to newer, faster and more efficient solutions for data capture.

SITE LIMITS AND CHALLENGES

As with all railway topographical surveys, the limitations of site access and heavy regulation in the rail environment hurdle work, especially with little tolerance on network interruptions.

As part of the Level Crossings Removal Project, the team at Heading and Associates was tasked to map out a rail line covering 26 km – a rail line where existing survey-grade data was not available.

To deliver the level of detail needed using traditional survey work, the project team would need to work at night with terrestrial laser scanners. The project timelines and budget did not allow for this – the only solution was to use a mobile mapping system mounted on a hi-rail to capture the data safely and efficiently.

GOING MOBILE

Using the Leica Pegasus: Two mobile mapping solution, Heading and Associates conducted the surveys for the 26-km rail line in just 15 minutes and delivered the data to the client next day. To put this into perspective, using traditional methods the same project would have taken an additional two months in the field to complete with the same amount of detail.



accuracy of less than 2 centimetres and deliver the project on time, on budget and with safety at the highest priority.

"We see a giant technological jump for data acquisition from the traditional total stations to the latest mobile mapping systems," said Frank Heading, operations manager of Heading and Associates. *"With the Pegasus:Two, we can easily capture high density 3D point cloud data along with quality photographs to deliver a detailed and rapid solution for our client. We saved time, reduced safety risk and maximised value by reducing a two-month project to just one day."*

By mounting Pegasus: Two to the hi-rail, the project team could eliminate danger zones and significant health and safety risks, capture high-level detail and provide the client additional data such as wire locations and overhead power lines without disruption to the network. This level of detail could not have been captured in the same amount of time using traditional survey practices.

Using the mobile mapping process and Leica Geosystems' technology, Heading and Associates could capture the rail length with a scan speed of 1 million points per second, maintain survey grade

A SMARTER WAY

Pegasus:Two allows data to be extracted from the point cloud for a range of applications including:

- Centreline alignment
- Measuring road edges and line markings
- Digital terrain models of road surfaces and surrounding corridors
- Asset identification and location; and
- Clearances to nearby structures.



Heading and Associates could use the data for dilapidation surveys to capture the current condition and safeguard their client from any additional costs. Because point clouds provide a comprehensive view, immediately required data can be extracted from the cloud to meet instant customer needs, without needing to return to the site to collect data.

Other advantages of using the Pegasus: Two include:

- As built surveys to confirm newly constructed rail works meet design specifications
- An error-free data baseline survey to allow monitor any changes to the design in the future
- Current road condition, such as cracks, potholes and, edge of bitumen for maintenance inspection purposes
- Accurately establishing rail clearances to overhead wires and station platforms.

"The point cloud data gives us that next level of confidence once we return to the office and start stringing data. With point cloud data, we can quickly and easily identify the separation needed between services, such as high voltage lines. This level of detail

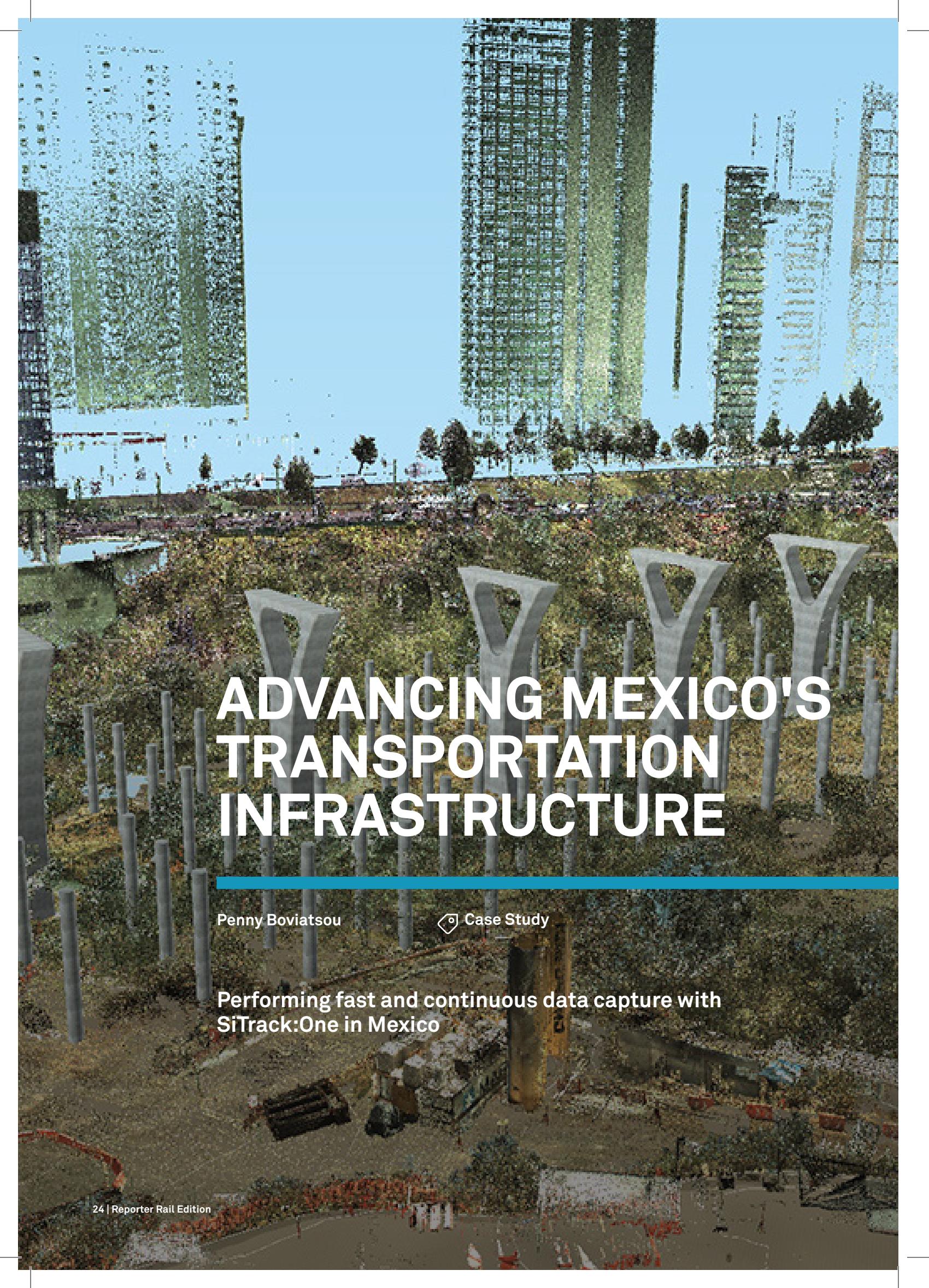
provides our clients confidence prior to releasing the design and avoids costly redesigns and error," said Heading.

MOVING FORWARD

For Heading and Associates, the survey-grade accurate data available from Pegasus:Two creates opportunities to undertake additional and larger projects since an area only needs to be scanned once to generate multiple assets.

"A mobile mapping solution opens opportunities for rail specific projects as it removes the limitations of stopping trains, interrupting the service network, and the need to survey at night," concluded Heading.

Heading and Associates are looking to apply mobile mapping technology to secure projects for the regional rail networks consisting of thousands of kilometres.



ADVANCING MEXICO'S TRANSPORTATION INFRASTRUCTURE

Penny Boviatou

Case Study

Performing fast and continuous data capture with
SiTrack:One in Mexico



Imagine an airport featuring six runways and serving up to 120 million passengers per year, located approximately 25 kilometres from one of the largest metropolitan areas in the world. That airport, the Mexico City New International Airport (NAICM), is currently the largest Mexican infrastructure project and expected to open in 2020.

Millions of travellers are expected to fly into and out of NAICM, thousands of airport personnel will commute on a day-to-day basis, and hundreds of businesses will reside within or rely on the airport business district. All these airport users depend on transport infrastructure that provides an effective solution.

Mexico's Federal Secretariat of Communications and Transport (SCT) has developed a plan in which several international and Mexican companies are responsible for the design and construction of the NAICM. Besides the NAICM, a 57.7 km high-speed, modern, efficient and safe railroad is planned for connecting the city of Toluca and Mexico City.

Consortium IUYET, a leading Mexican civil engineering services company with 40 years of experience, is actively involved in the construction of the new international airport and railroad.

RESPONDING TO GLOBAL STANDARDS

The Interurban train will provide significant transport and economic benefits for the whole Mexico City region, and, along with NAICM, will be an important contributor to Mexico's economy. This new airport will not only facilitate tourism but also trade, and it will connect widely Mexico City to the rest of the world.

For this project, Consorcio IUYET uses a variety of Leica Geosystems solutions to capture, model and analyse the data, such as total stations, the SiTrack:One rail maintenance and refurbishment solution, GNSS receivers, digital levels and

construction lasers combined with Leica Geosystems measurement software.

As part of the works performed by Consorcio IUYET for this project, 2,800 scans to cover 50 square km were captured and unified in a record time of two months, using the Leica ScanStation P40. The point clouds from these scans were cleaned and registered using the Leica Cyclone 9.1 software for the most accurate generation of the Digital Terrain Model (DTM) of the zone. These data were used to develop the land and air design of the NAICM.

"The Leica ScanStation P40 enabled us to acquire 3D point clouds of the study area to generate a Digital Terrain Model and create planimetric maps," said Guillermo Ortiz, CEO at Consorcio IUYET. "This allows us to gain reliable information and high precision data for the development of the Building Information Modelling (BIM)."

The railroad line will have four stations and two main terminals, including a station in Metepec, close to Toluca International Airport. The train will have a maximum speed of 160 km/h. The project will also involve the construction of a 3.9 km, 30 m deep tunnel to secure environmentally protected zones; this is the most challenging task. Consorcio IUYET is the first company in North America to acquire the Leica SiTrack:One, the mobile mapping platform made especially for railroad documentation, which will be used for the construction of the high speed passenger train Toluca-Mexico City.

"The SiTrack:One and its integrated P40 ScanStation will be used to obtain a highly accurate 3D point cloud of the railroad environment for applications such as rail geometry calculations, platform gauging and rail clearancing," said Ortiz. "Rail's ability to compete with other modes of transport, in particular with road, is crucial for its competitiveness. New technology such as the Leica SiTrack:One can offer much to help



modernise railways and develop a smarter and safer rail system that will benefit travellers and commuters.”

USING THE MOST SUITABLE TECHNOLOGY

The airport journey experience has a high impact on travellers' view of the quality of the airport. The route between the destination and airport will be the passengers first and last experience of Mexico.

The railroad project began construction in July 2014 and the new line is expected to open by 2018. It would be operated with a fleet of 15 trainsets giving an end-to-end journey time of 39 minutes. Using technology that allowed for easy access, the project is on track for a timely completion.

Consorcio IUYET combined several technologies in different stages of this project. The Aibotix X6 V2 unmanned aerial vehicle (UAV) was used for the photogrammetry and construction inspection while the Leica Viva GS15 GNSS antenna helped create the Geodesic Reference Network, and the Leica DNA03 digital level ensured altimetry control.

The flexibility and simplicity in the collection of the measurements allowed Consorcio IUYET to focus efforts on evaluating and analysing data rather than working out how to collect the required information.

“Thanks to the Leica Geosystems products, our project goals are clear, realistic, feasible and designed to complete the project on schedule with high quality standards,” said Ortiz.

The firm also used the Leica Nova MS50 to integrate 3D point cloud measurements that enabled the collection and visualisation of topographic survey data together with detailed high-precision scans. Ensuring fast and efficient transfer of information from field to finish is vital for this demanding project.

“The precision and compatibility between the Leica Geosystems equipment allows the best use of the resources for our company,” said Ortiz. “The need for accurate measurement is critical for our project; it supports precision and saves money and time. The reliability that our customers recognise in our work is a reflection of the quality of the Leica Geosystems solutions.”

MEASUREMENT SUPPORTS INNOVATION

Mexico City has an opportunity to enhance the development of the airport region, to ensure the airport's support to the local and national economy is increased.

For a number of reasons, the terrestrial transport is considered to play a significant role in sustainable airport access. An effective and efficient transport network is one of the most important elements to ensure that the airport is cohesively integrated in Mexico City.

“The Mexico City New International Airport and Interurban Toluca-Mexico City train line will be a presentation for Mexican innovation,” said Ortiz. “Known as the ‘Airport of the future,’ it will be one of the world’s largest airports and will revolutionise airport design.”



IMPROVING THE RAILWAY INFRASTRUCTURE OF A CAPITAL CITY

Staff

Case Study

Measuring for new rail lines in the United Kingdom



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

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

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

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

A MAJOR UPGRADE

Established in 1938, Atkins is one the world's most respected design, engineering and project management consultancies. Working closely with a wide range of clients from different sectors and

regions across the public and private sectors and local and national governments, Atkins delivers long-term trusted partnerships to create a world where lives are enriched through the implementation of ideas.

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

This major upgrade saw a broad spread of instruments:

- 1 Nova MS60 MultiStation
- 7 Viva TS161 Imaging total stations
- 4 Viva GS14 GNSS Smart Antenna
- 10 Captivate CS35 tablet computers
- 2 LS15 auto focus digital levels
- 8 full traverse kits



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

SITE LIMITS AND CHALLENGES

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

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

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

- Grade separation of Windmill Bridge Junction,
- Extension of the Selhurst Spur

- Additional track between Windmill Bridge Junction and East Croydon
- Two additional platforms at East Croydon.

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

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

LEICA CAPTIVATE SOLUTIONS HELPING THE WORLD OF RAIL

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



the new Leica Captivate range proved invaluable in this situation.

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

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

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

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

PROVIDING TOPOGRAPHICAL SURVEYS TO LONDON'S RAILWAY INFRASTRUCTURE

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

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

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

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

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

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



LASER MEASUREMENT KEEPS HLI'S HIGH- WIDE SHIPMENTS ON TRACK

Christine Grahm

Case Study

Increasing rail loads safety and efficiency in the USA



Using the SafeLoad system enables HLI Rail & Rigging to transport over-dimensional loads by rail safely and on time, every time.

Across North America and in other developed regions around the world, a rise in power requirements is fueling demand for large heavy components, such as wind turbines, transformers and boilers. Because freight trains can easily carry heavy loads across long distances at a relatively low cost, rail is often the transportation mode of choice for these and other oversized, overweight structures. But moving “high-wide” or over-dimensional loads safely and cost-effectively presents enormous logistic hurdles.

The physical limitations of infrastructure are compounded by increasingly stringent regulatory challenges that vary across different regions of the U.S., making detailed planning vital.

To obtain the required railroad clearances, the weight and dimensions of each load must be measured precisely. The weight is the easy part, often falling within one to 10 per cent of the information provided by the manufacturer. The dimensions, however, are a different story. The process of testing and disassembling large structures before shipment renders many drawings inaccurate or incomplete.

New as-built drawings must be developed to ensure the load is within clearance. However, with the traditional approach of manual measurement using man lifts, tape measures and plumb bobs, shipment delays due to dimensional measurement errors and discrepancies are virtually inevitable.

Or are they?

That was the question facing Mike Scott several years ago. As partner and director of rail operations for HLI Rail & Rigging based in Spring, Texas, USA, Scott was certain there had to be a better way of capturing accurate measurements on the over-dimensional loads that make up the bulk of the company's business.

“Our field supervisors excelled at placing a load on a rail car so that it matched the drawings and was within clearance,” Scott said. “But doing as-built measurements by hand took a significant amount of time and presented safety concerns. And if the railroad inspectors found any discrepancies during their inspection, which was also typically done by hand, the shipment could be delayed by as much as seven to 10 days as the load was reconfigured, resecured and remeasured. To me, that kind of delay was unacceptable.”



CONSISTENT, REPEATABLE MEASUREMENT

Scott scoured the Internet and spoke with colleagues who directed him to a laser measurement and documentation system designed to eliminate or reduce the safety hazards, inefficiencies and inaccuracies of measuring high-wide loads transported by rail. Called SafeLoad, the innovative system had already streamlined the inspection and clearance of high-wide loads at several Class I railroads.

Using a patented targeting system and method that references all height measurements precisely to the top of the rail and all width measurements to the centerline of the rail car, along with a high-precision laser, the SafeLoad system provides consistent, repeatable measurement accuracies that can't be achieved with manual measurement methods. Intuitive software guides users through the measurement process. The efficient workflow walks users through a consistent, logical process that establishes a standard operating procedure throughout the railroad industry. The system eliminates or reduces climbing on railcars, loads or ladders, eliminates the risk of human error in taking and recording measurements, and reduces

measurement time by at least 50 per cent compared to manual methods. Additionally, it provides instant access to comprehensive clearance reports, which streamlines the authorisation process. Measurement data can also be automatically transferred from the field to the office, and a real-time dashboard allows management personnel to view and monitor measurements as they happen.

This was the solution Scott had been looking for. In December 2014, HLI purchased its first SafeLoad system and transformed its over-dimensional transport business into a highly efficient, extremely accurate operation.

"As long as we follow the guidelines in our certification, it's foolproof," Scott said. *"The laser measurement system sets us apart in the industry by enabling us to provide outstanding service and confidence."*

OUTSTANDING SAFETY, ACCURACY AND EFFICIENCY

The investment immediately proved valuable. One client contacted HLI about a shipment of turbine components in Albany, New York, USA, that was at risk of being delayed due to a discrepancy noted in an inspection. Using its SafeLoad system, HLI quickly



measured the load and provided documentation showing that it was within clearance, enabling the shipment to proceed on schedule.

Another client in Monterrey, Mexico, needed an as-built of a boiler on a rail car. With laser measurement, HLI was easily able to determine that the load was outside of clearance. HLI's fast service enabled the client to make the necessary adjustments before the load was secured to the rail car, which provided a significant savings.

"Our clients love that we come out with a laser and measure their loads," Scott said.

As demand for high accuracy and efficiency increases, HLI's approach is creating a ripple effect across the entire rail industry.

"Our standard practice is to send a supervisor out with the rail inspector, laser measure the load, and have the inspector spot check what we measured," Scott said. *"The inspector discerns and approves what we've measured, the report goes in, and that process takes hours instead of days. It's so efficient that now the inspectors are beginning to ask for laser measurement."*

Scott, who has recently purchased a second SafeLoad

system, believes it's only a matter of time before laser measurement replaces manual measurement for all high-wide load documentation. Until then, he's happy to offer HLI's clients a technological advantage in transporting cargo by rail.

The SafeLoad system provides consistent, repeatable measurement accuracies that can't be achieved with manual measurement methods, making it ideal for measuring high-wide loads.

Laser measurement with the SafeLoad system enables HLI to quickly and easily determine whether a load is within clearance. Being able to make any necessary adjustments before a load is secured to the rail car provides a significant savings.

No more lengthy delays reconfiguring, resecuring and remeasuring a load after inspection—laser measurement with the SafeLoad system streamlines the process to a matter of hours.

The SafeLoad system uses a high-precision laser along with a patented targeting system and method that references all height measurements precisely to the top of the rail and all width measurements to the centerline of the rail car.



LASER SCANNING ON THE GO

Staff

Case Study

Ensuring safety in a rail yard project with the Leica Pegasus:Backpack in the Netherlands

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

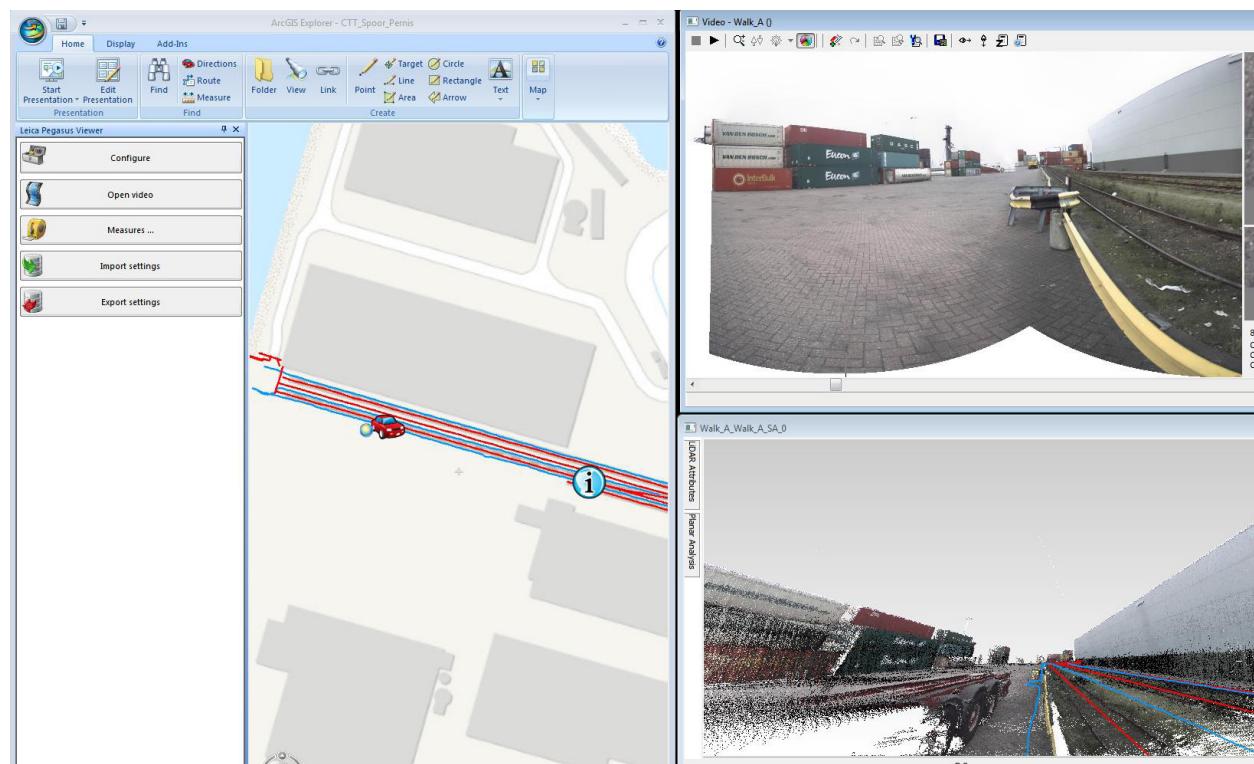
The Leica Pegasus:Backpack was invented as part of this generation of new wearable reality capture sensor systems in response to the growing global changes. The Prisma Group was the first company to use the Pegasus:Backpack in its recent infrastructure project.

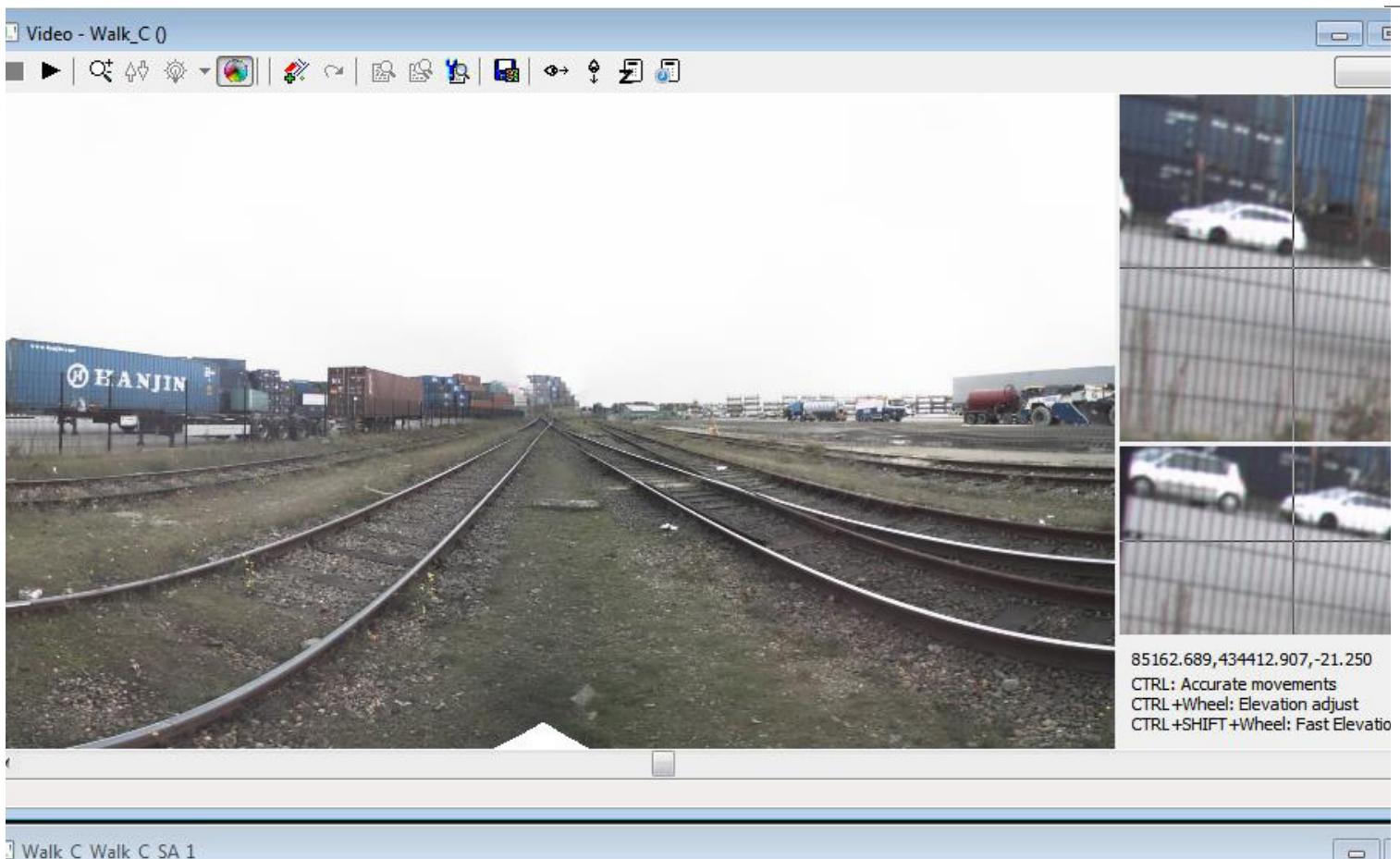
Based in the Netherlands, the Prisma Group consists of three companies: Prisma Meten, Prisma Geocensus and Prisma Van Steenis. The company has a variety of specialities including survey (rail, infrastructure, utility), industry (offshore and onshore), GIS, hydrography, geodetic measurements, 3D laser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

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

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

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





MOBILITY IN A DIFFICULT SPACE

There were many challenges working in a railway environment whilst trying to capture reality data during this project. From low-hanging electrical lines to constricted spaces around train cars, classical surveying methods can be extremely limited in this environment. Whilst working on the rail project, Prisma Van Steenis had to take the measurements whilst the yard was in use, and, therefore, there were real risks of collisions and a high risk to personal health and safety. By law, the risk area (the railway track) is not an accessible area for surveyors and is normally prohibited for inspections. Prisma van Steenis needed a safe, quick and accurate solution to collect the point clouds and 360-degree pictures needed for this scanning project. The survey needed to be collected quickly to reduce cost and lead time.

The deployment of the Pegasus:Backpack provided numerous advantages over traditional methods for the Prisma Group. The surveyors were a lot safer on the tracks and ran much less risk to their health because they did not have to enter the risk area.

In addition to this, the surveyors did not have to perform any measurements during nightfall, which is a hazard in itself with limited visibility causing many hazards. The Pegasus:Backpack was the perfect solution. Distances could be measured without entering dangerous areas with maximum effect. With one measurement from the Pegasus:Backpack, the surveyor was provided with the correct, current and

complete information on the same day. The quality of the measurements from the Pegasus:Backpack is highly accurate and best in class.

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

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

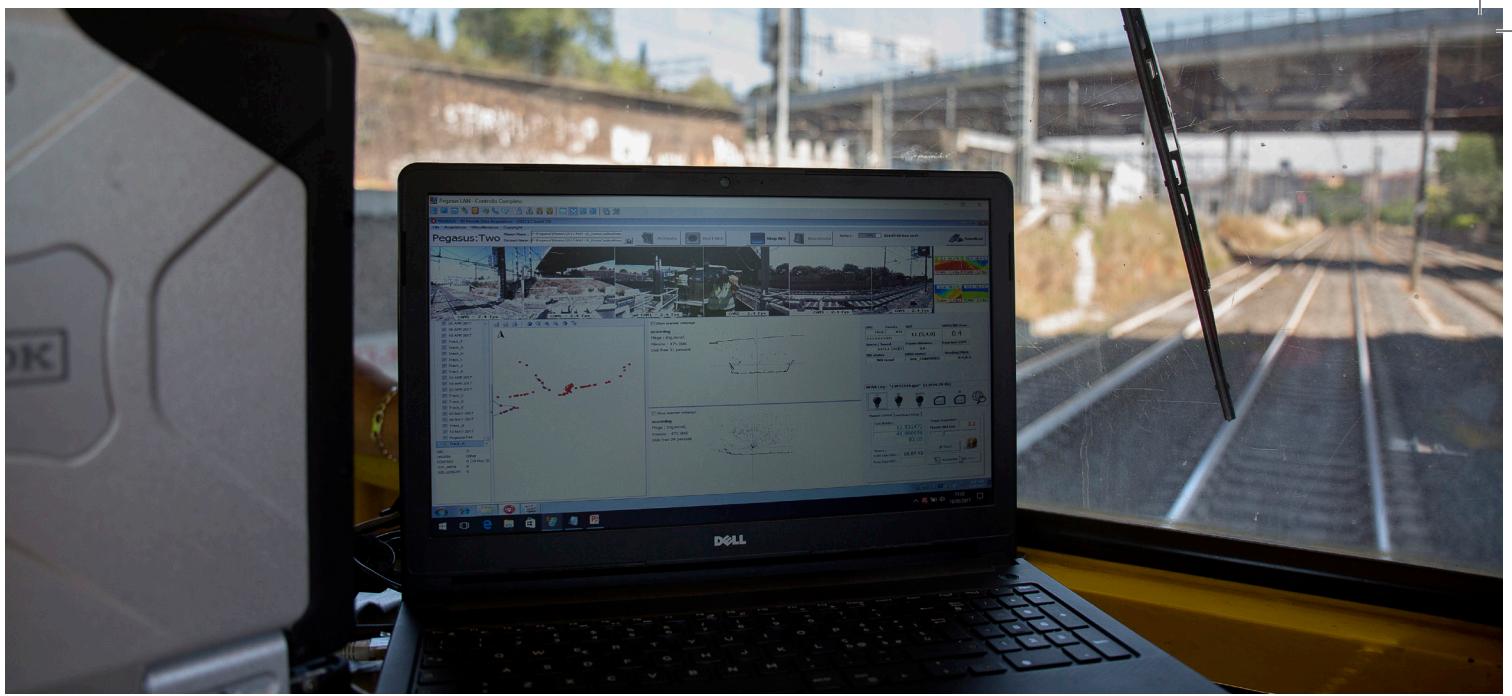


PRESERVING THE QUALITY OF HERITAGE INFRASTRUCTURE

Penny Boviatsou

Case Study

Combining technologies to plan infrastructure maintenance activities for rail in Italy



The Italian geomorphological setting heavily determined the design and construction of the national Italian railway network. Even today, we can find big infrastructures, such as bridges and tunnels, that were built in the last century and are still operational. Italy has a varied landscape and terrain and it is a treasure trove of unique places to visit. It's beautiful landscapes have given way to many infrastructural marvels.

To improve the safety of rail traffic, Rete Ferroviaria Italiana (RFI), owner of Italy's railway network, started an extended maintenance by modernising activities for all heritage infrastructures. The Olmata tunnel project is placed within this context. Olmata is a tunnel located along the oldest railway connection between Rome and Naples. The goal of the project was to determine what tasks can make certain types of train travel safer, in accordance with the existing historical and environmental context.

The 953-metre-long Olmata tunnel has a final coating composed by tuff lithoidic blocks, crossing a single layer of the tough rocks where there is an aquatic groundwater that causes significant hydrogeological problems. Before starting with the maintenance, RFI needed to know in depth the tunnel's geometry and its status, an information previously unknown. For this purpose, ETS Engineering, an Italian company of engineering and field services, used Leica Geosystems technology to accomplish this demanding task.

COMBINING TECHNOLOGIES FOR TUNNEL MAPPING

ETS Engineering created ARCHITA, a unique system that combines different kinds of measuring technologies - laser scanners, georadar and thermography, all mounted on a service train.

"The system allowed us to collect data in a continuous

way at 15-30 kilometres/hour during traffic railway interruptions and nights, with no need to remove electric power and reducing interruption times," said Gabriele Miceli, CEO at ETS Engineering.

ARCHITA is composed of:

- 1. Leica Pegasus:Two with an intergrated thermal camera**

The Leica Pegasus:Two allows to detect objects from a moving vehicle using a series of sensors that, together with the post-processing system of the acquired data, allow to obtain certain precisions. This includes:

Positioning sensors:

- Inertial system (IMU): iMAR FSAS (sampling frequency 200 Hz)
- GNSS system: Novatel OEM6 receiver with dual 703 GGG antenna able to receive GPS + GLONASS + BeiDou + Galileo
- Contactless rail odometer HMSLER Rail CORRrail 1000 (1000 Hz/m/s)

The positioning sensors work in an integrated way with a tightly coupled Kalman filter that also accepts post-processing additional information such as ground control points.

Survey sensors:

- Image system in the visible spectrum: seven cameras with a resolution of 2046 x 2046 and calibrated lenses that allow to obtain a 360° view around the system
- Image system in the thermal spectrum: four cameras Tau 2 LWIR (640 x 512 and spectral band of 7.5 - 13.5 µm with range -25 °C to + 135 °C) that allow to obtain a 360° x 270° visualisation



around the system, mounted in almost vertical configuration to capture the entire tunnel

- A scanner system: two profilers able to acquire each 1 million points per second at a maximum rotation frequency of 200 Hz and with a maximum range of 100 m

This sensor can also be used as a system for indirect repositioning by adjusting the trajectory. The two scanners are mounted at 90° to each other to perfectly capture the surfaces around the system and not leave shadows in the point cloud. Both profilometers can capture 360° profiles for complete coverage.

The system uses the GNSS and IMU sensors to calculate the vehicle's trajectory in a predefined reference system. Once the position and the arrangement of a particular point of the system is known through the knowledge of appropriate lever arms, the positions and the arrangement of the various sensors are recalculated and consequently of all images and cloud points they detect.

The precisions of the system depend on the positioning precision of the GNSS system that depend on several factors, such as the number,

the type, the visibility and the arrangement of the satellites but also the time interval since the last loss of signal. In ideal conditions, the positioning accuracy of the system, regarding the trajectory, can be equal to 2 cm, while in all other cases the precisions may increase as a function of signal interruption.

2. IDS Radar SRS SafeRailSystem with:

- 3 antennas (400 Mhz central frequency)
- 3 radar control units to manage and synchronise collected data
- 1 encoder doppler to measure distances
- 1 additional camera to capture images of the railway base

The Radar SRS SafeRailSystem allows to continuously explore on long distances the railway base with a radar, to evaluate ballast conservation and condition, the level of pollution from fine material, the presence of water inside and below the ballast, the thickness of ballast and to highlight any type of anomaly on the track (failure of the ballast or presence of underground cavities). The system's



optimal resolution is at around 2 m of depth.

EVALUATING THE STRUCTURE

The ARCHITA system acquired a lot of information in a single passage, essential for the needs of the project. More specifically:

- Georeferenced 3D point cloud of the tunnel
- Thermographic analysis with information about the coating status
- Georadar analysis with information about the ballast condition

"For the final analysis, we used the Leica SiRailScan software to perform a collision test simulating the passage of different PMO [Profilo Minimo degli Ostacoli] train shapes along the track. In this way it was possible to ensure the safe passage of special type of trains on this track, as had RFI requested," said Miceli.

With the data that resulted from the analysis, it was possible to:

- Automatically obtain track geometry (gauge and superelevation) and to check the exact position

of rails referred to point cloud;

- Simulate the passage of train design shapes to check any kind of collision with surrounding elements;
- Compute the position of electric wires in reference to rail planes and to evaluate any kind of interference with train design shapes; and
- Generate an XLS format file to where summarised collision areas are with related chainage, type of collision and entity of collision.

"With this type of analysis and after an accurate result check control, RFI could define an appropriate plan of maintenance activities in order to adapt the shape of the Olmata tunnel," said Miceli.

This mobile mapping project allowed to configure a mobile system as a valid alternative to the traditional topographic survey method, which requires extremely long times with a huge impact on the railway traffic exercise. ETS Engineering could connect different results obtained from different instruments combined in a single solution to provide detailed knowledge. In this way the RFI received all necessary information to support planning activities of maintenance of the entire infrastructure assets.



MIRRORING REALITY FOR RAIL

Renata Barrads Gutiérrez

Case Study

Laser scanning several locomotives for quality control with visual and actionable data in Spain

Train users take for granted the comfort they enjoy in their daily commuting. Reliable and safe trains, however, must follow precise specifications so they can glide perfectly through the rails and commuters can enjoy – among many other things – their daily coffee without any spills.

To do a quality control analysis in a fast and accurate way, Stadler Rail office in Valencia, Spain, the competence centre for mainline locomotives, shunting locomotives, metro trains, as well as for the tram and city lines of vehicles, reached out in 2015 to Lindes Measuring Systems. The main goal was to laser scan several locomotives for quality control before delivering them to the clients.

BEFORE LOCOMOTIVES ARE ON THE MOVE

Experts from Lindes Measuring Systems used laser scanning technology from Leica Geosystems to obtain point clouds that are an identical copy of Stadler's locomotives. The 3D data obtained with the P40 ScanStation was used to extract the dimensions of every scanned locomotive.

The team of experts had limited time to collect all data as production needed to stay on track. For this task, point clouds were obtained by scanning every

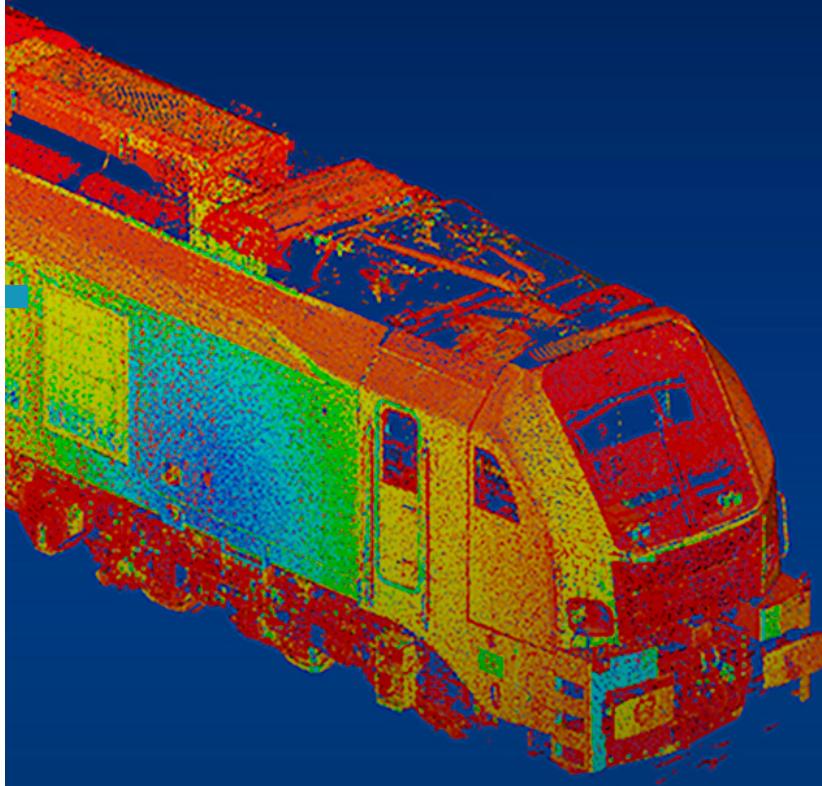
angle of the locomotives mounted on the existing rails on Stadler Rail facilities. To scan the top, experts positioned the ScanStation on an elevated static platform over the locomotive.

“When Lindes Measuring Systems proposed this kind of technology to achieve the requirements we had requested them, we were all a bit expectant. With the achievement of this project throughout two years, we have expressed our confidence and satisfaction on the results obtained,” said Felipe Torrent, quality services responsible for Stadler Rail Valencia. “We are proving to our clients that Stadler Rail is embracing the use of state-of-the-art technologies to deliver our products with the highest possible quality. If Lindes has trusted Leica Geosystems products, so do we.”

To perform a gauge and total gauge control of various locomotives manufactured by Stadler Rail for several clients, scans were post processed with Leica Cyclone 9.1.5. to obtain 3D mirrored copies of reality. Experts contrasted the 3D models with the theoretical gauge tunnel of each model or with theoretical comparison plans determined by Stadler.

QUALITY AND CONTROL FOR RAIL

Intelligent data requires to be delivered in a visual



and actionable way. The captured locomotives were not only documented with all their features and outlines, the project deliverables included a series of reports for dimensional analysis with control points and colour-coded maps that were the basis to:

- Check relative position of various components that form the locomotive on its final stages of manufacturing and assembly;
- Check and confirm that the units about to be delivered complied with customers' requirements and with internal Stadler requirements;
- Supply Stadler with accurate dimensional reports for the clients upon delivery of the manufactured units.

When contrasting the locomotive models with the rail gauge in a dimensional analysis, millimetric precision is needed. Beyond the high-speed scan rate of 1 million points per second that the Leica ScanStation P40 provides, Lindes Measuring Systems also outlined the following benefits:

- Data collection is made fast and comfortably
- Time is saved and costs are optimised

- The quality and precision of the equipment added value to projects
- With no need of physically touching the locomotive to carry out data collection, the accuracy of the equipment and safety for the engineers was ensured
- No customisation needed for the ScanStations.

“Throughout my career, I have carried out a multitude of different jobs, mainly civil engineering, and I have used several brands. Leica Geosystems solutions, however, have always given me very good solutions and total confidence,” said Cristina Alcantarilla, project manager for Lindes Measuring Systems. “I am overwhelmed by how fast you can work, the obtained accuracy, and how user-friendly Leica Geosystems hardware and software are, giving added value to our work. We’ll keep on exploring new ways to apply this technology in our sector.”

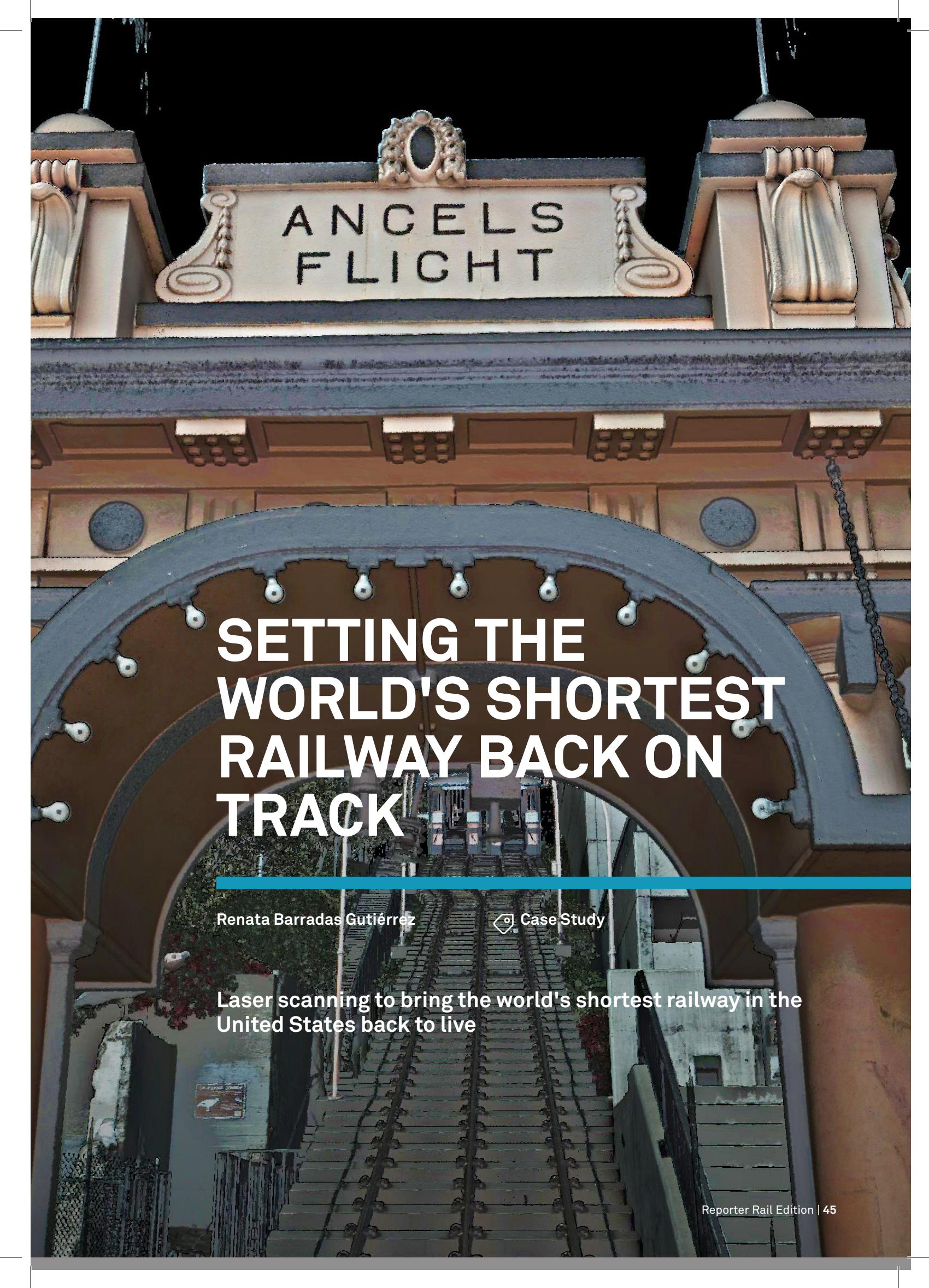
A PARTNER YOU CAN TRUST

Reality capture sensors paired with 3D point cloud processing software help customers to mirror the real world to deliver actionable information. Aware of the potential that high definition surveying



offers to turn information into smart data, Stadler Rail Valencia began in September 2015 a two-year project scanning Stadler's locomotives. Being able to collect data in a fast, safe and efficient way has enabled Lindes Measuring Systems to continue working with Stadler on other rail projects related with the scanning of railway tunnels for their Design & Development Engineering Department.

"Lindes Measuring Systems has presence in three countries and two continents. Since 20 years ago, we work with Leica Geosystems products wherever we go. When I sit to negotiate a new deal with any given client, I need to know that our technical team is going to deliver. The same goes for the equipment we are going to use – with Leica Geosystems, I am always confident on this matter. So is our client," concluded Alejandro Moure, business development manager for Lindes Measuring Systems.



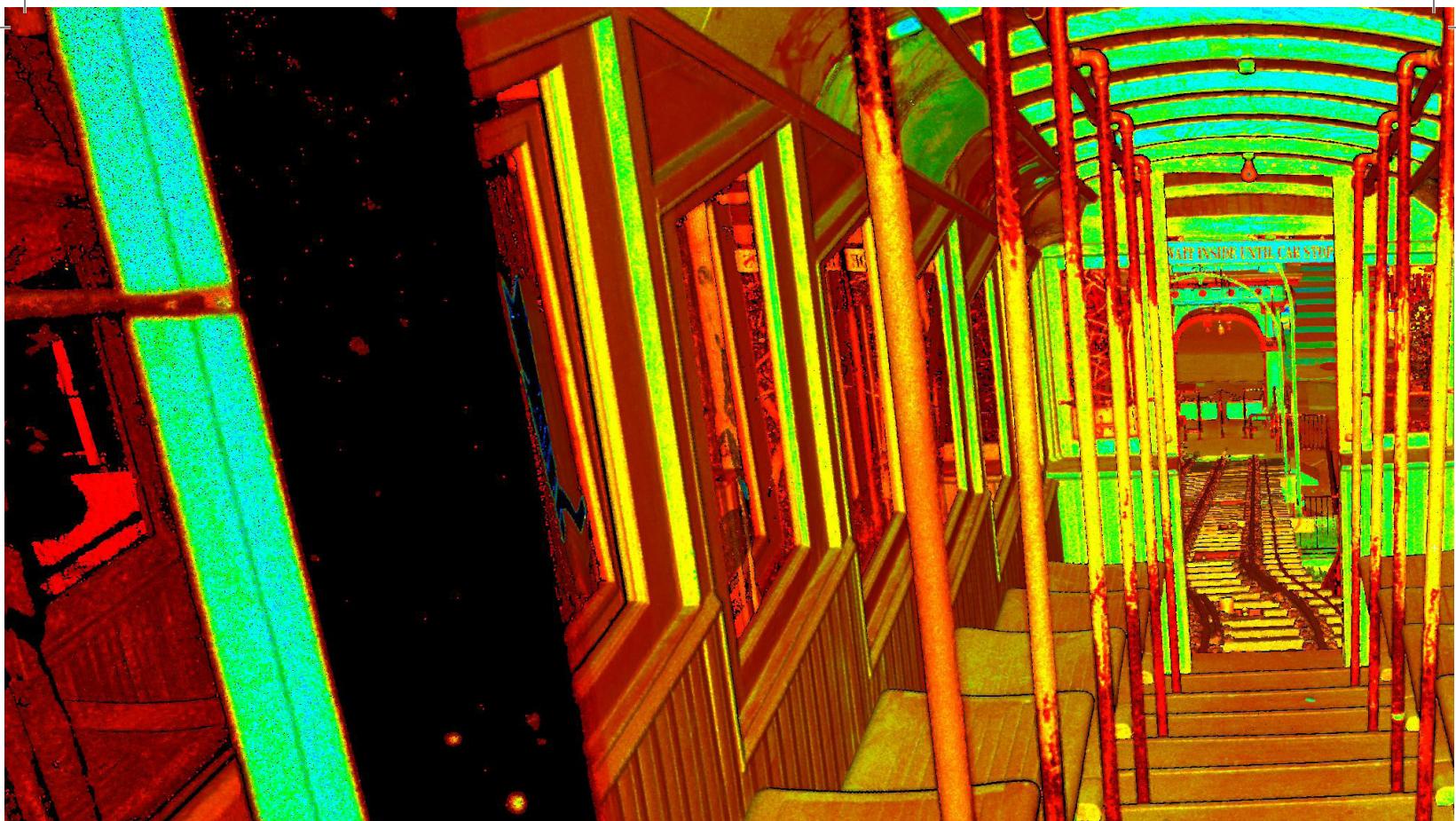
ANGELS
FLIGHT

SETTING THE WORLD'S SHORTEST RAILWAY BACK ON TRACK

Renata Barradas Gutiérrez

Case Study

Laser scanning to bring the world's shortest railway in the United States back to life



As a passenger, a railway is meant to bring us to our next destination. This funicular, however, is meant to bring us back in time. Angels Flight – the world's shortest railway standing at 99 metres in length – is an iconic landmark in the Bunker Hill District of downtown, Los Angeles, USA. This tourist novelty has carried more than 100 million passengers along its hillside track since its opening in 1901.

This city landmark, featured in more than 20 films, was last closed in 2013 due to safety issues. To carefully restore Angels Flight, Rick Engineering Company (RICK) supported the project with specialised 3D laser scanning.

RICK is far from your average engineering company. Founded in 1955, RICK has 63 years of experience, 280 employees that span across three states, and several multi-discipline specialties that, together, have completed more than 10,000 projects.

RICK's qualified experts understand that designing excellence begins with a comprehensive understanding of the existing conditions. This requires capturing the as-built conditions in a digital way, via 3D laser scanning, to leverage the construction process with smart data that is visual, actionable and interconnected. To bring back to life this iconic landmark, the site structure and railcars, named Sinai and Olivet, were captured with the Leica P40 ScanStation. The 3D CAD models, dimensioned exhibits, and interactive 3D maps obtained from the point cloud enabled the steel fabricators, Paramount Metal & Supply Company, to create a design to

modernise both elements.

WHAT DO LASER SCANNING EXPERTS AND GOATS HAVE TO DO WITH IT?

Seemingly, the 99 metres of railway would be an easy fix, although projects of any size can present unforeseen challenges.

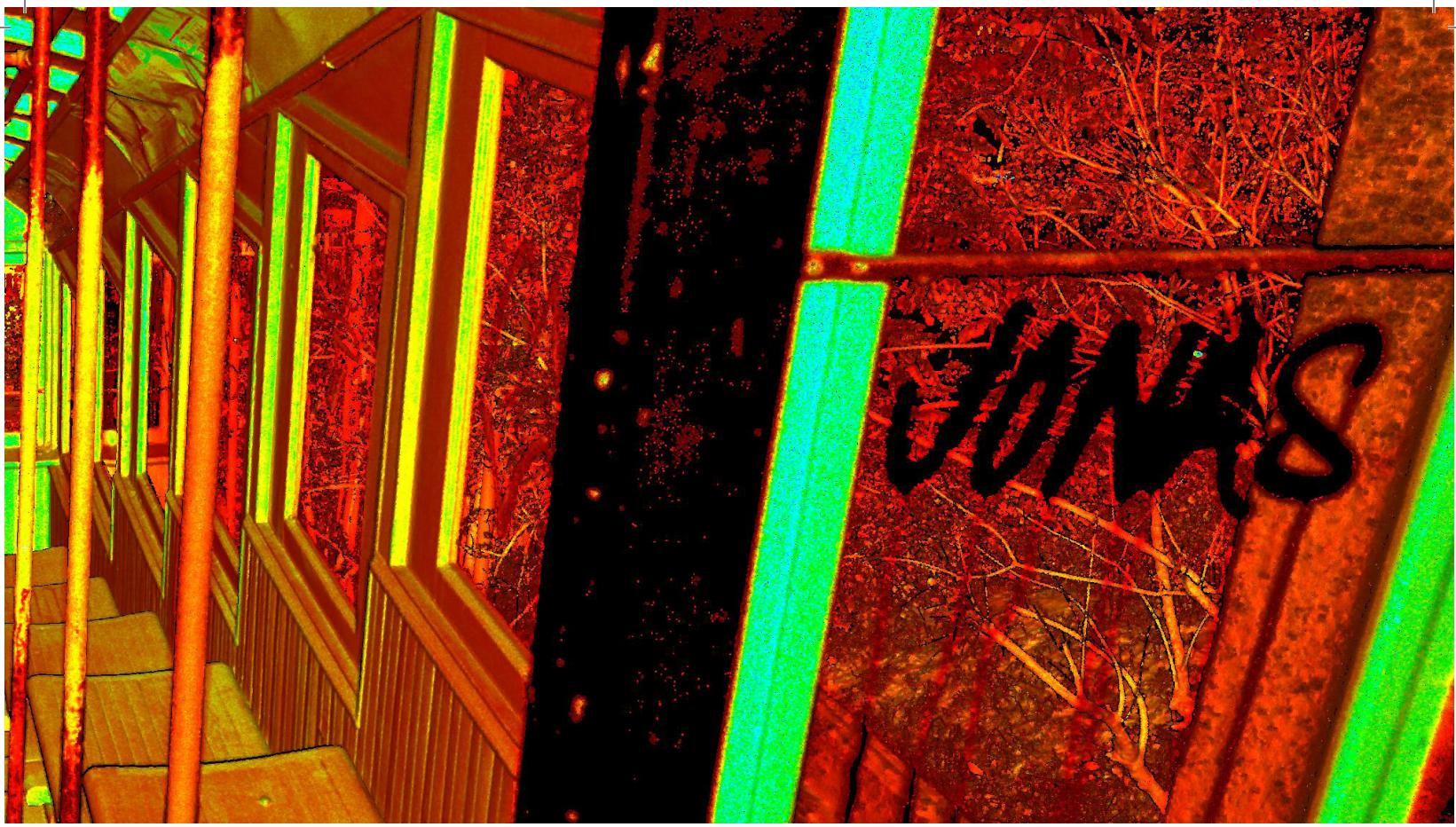
Before capturing the funicular, the site needed to be trimmed in a "green" way – goats, famous for eating noxious weed, were recruited for the job. It took nearly two weeks for 26 goats to eat all the weeds that grew during the four years of abandonment.

Once the noxious weed had been cleared and 26 scan points had been identified, two technicians set up the P40 ScanStation to measure with millimetre precision 1 million points per second. The generated point cloud was used to compile and deliver a 3D CAD model with an interactive 360° digital reality environment of the Angels Flight structure.

VISUALISING THE BUILT ENVIRONMENT TO ENHANCE DESIGN AND CONSTRUCTION

The client, contractor, alongside the design team and City, gazed at the photorealistic, interactive 360° digital reality model RICK created with Leica TruView. The software allows the project team to view and share data online which reduces site visits and offers an interactive navigation option.

"L.A. stakeholders didn't want the aesthetic structure to be tarnished and required that the new additions



could be removed for movie production. TruView offers just that: a true view that allowed the customer to see how the design would look like. Seeing the data with TruView, you will feel like you are on-site," said Brian Laird, manager for RICK.

RICK was able to quell any concerns through a TruView simulation, superimposing the new stair structures into the existing railway. Even more so, the Truview platform allowed RICK's laser scanning experts to:

- Show samples of the work to facilitate the procurement;
- Have a dimensionally-correct web view for the customer where the deliverables are actively demonstrated;
- Have a virtual tour where project partners could view, pan, zoom, measure, and markup; and
- Visualise the differentiating design alternatives including a design with installed stairs and a safe exit route in case of emergency.

After the first presentation with TruView, Paramount Metals requested technicians from RICK to add their proposed CAD designs of model alternatives into TruView. The CAD experts inserted the client's model to test and verify the design concepts. The professionals converted the polyface mesh, from a building information modelling software, into a 3D solid model using Leica Cyclone 3D point cloud processing software and published the models to TruView. Shortly after, all project stakeholders could

visualise the design prior to construction.

A RICK laser scanning extraordinaire stated proudly: "By using the most updated and real-time technology, RICK has provided a great service for the client, which saves time and money," said Jose Gonzalez.

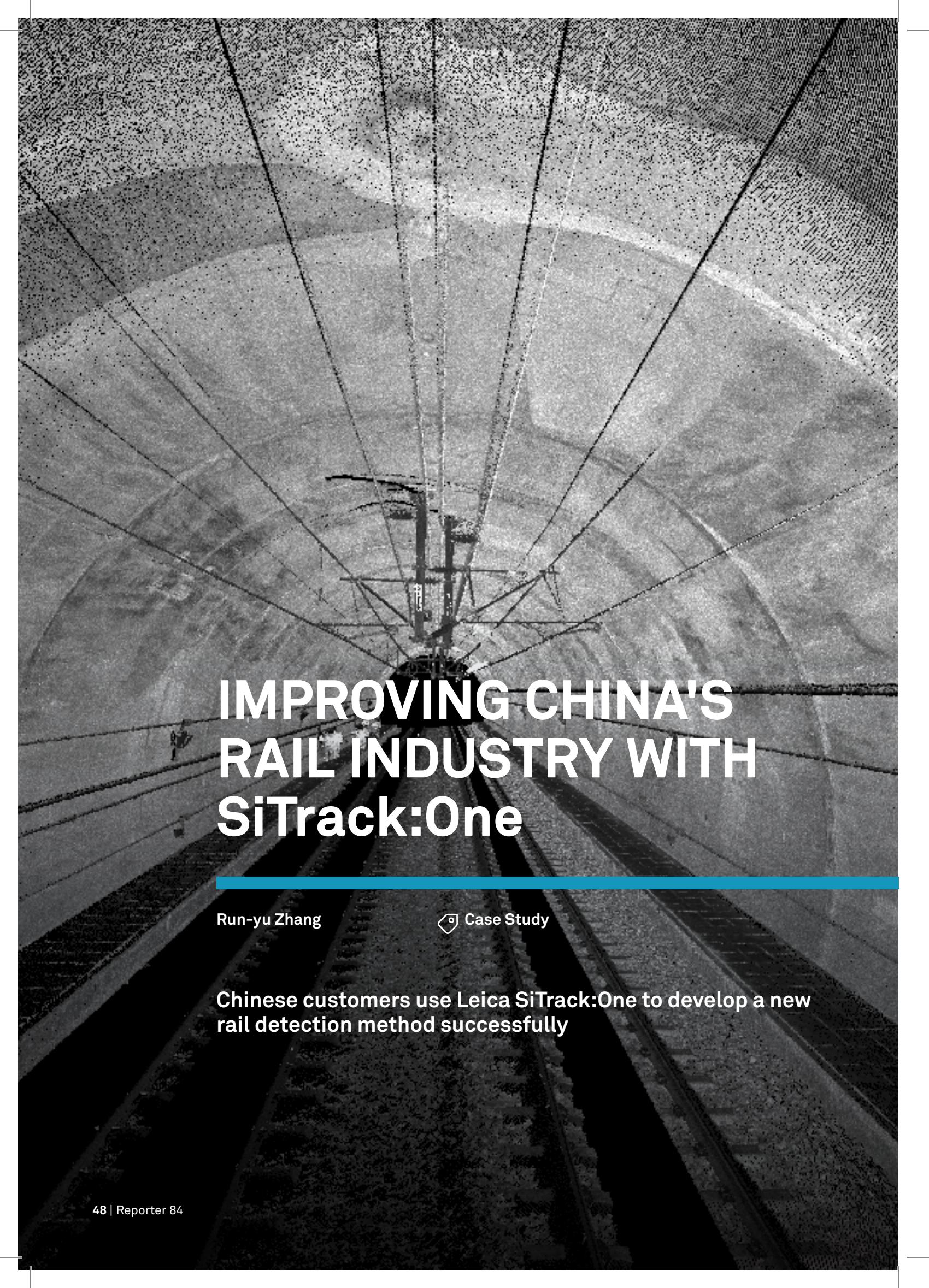
"RICK delivered an accurate model of what is out there so the client will be confident with their final design without having to second-guess themselves."

"Visualisation of the built world continues to pay dividends during design and construction," concluded Laird.

JOIN US FOR THE RIDE

Fusing the real world with the conceptualised design in a virtual, photorealistic, and animated environment are tools to engage customers and collaborate with stakeholders while simultaneously constructing great buildings, spaces and structures more efficiently. Laser scanning, along with software solutions, allows teams from varied disciplines to access smart digital realities in intelligent ecosystems, just like TruView, that are user friendly, interactive and accessible.

Angels Flight opened for a single day in 2016 to capture a scene for the film "La La Land" where Ryan Gosling and Emma Stone exchange a kiss in the historic funicular. Thanks to the summed restoration works and RICK's 3D laser scanning services, locals and tourists alike can now step back in time into an orange, one-way, railway car for only a dollar.



IMPROVING CHINA'S RAIL INDUSTRY WITH **SiTrack:One**

Run-yu Zhang

Case Study

Chinese customers use Leica SiTrack:One to develop a new rail detection method successfully



High-speed rail (HSR), the world's longest and most used HSR network, has become a famous business card of China. Subway transportation systems and HSR bring prosperity to business in China. In the long-term, by the end of 2020, the length of HSR in China will be more than 30,000 kilometres in total length. By that date, there will be, likewise, more than 40 cities having their own underground public transport systems.

The tracks, rails, tunnels and structures for the high-speed rail and the subway, need to be constructed, adjusted, checked and rebuilt. Before starting the work, all assets need to be measured with precision and efficiency.

Chinese customers, Nanjing Institute of Survey, Mapping & Geotechnical Investigation, Co.Ltd and China Railway Design Corporation (CRDC) use Leica SiTrack:One, the mobile track-scanning system with survey-grade 3D point clouds for accurate as-built drawings to successfully develop a new rail detection method.

TUNNEL DETECTION IN NANJING SUBWAY

Nanjing Institute of Survey, Mapping & Geotechnical Investigation, Co.Ltd is one of the biggest survey service companies in Nanjing city. The company are focuses on improving tunnel detection to reduce heavy nightworks and improve the efficiency of acquisition. In the past, the company used many different devices and tripods into the underground tunnel, and what is

worse, make a 500 to 1,000 metres acquisition during a general three-hour nightwork, which costed a huge amount of labour, time and money.

Now with SiTrack:One rail maintenance and refurbishment solution, Nanjing Institute of Survey, Mapping & Geotechnical Investigation, Co.Ltd can make a 4,000 m acquisition in one night, increasing efficiency by 400 to 800 per cent.

This survey-grade 3D point cloud solution can provide not only information on mileage, rail line, gauge, clearance, but also on the relative accuracy with 3 to 5 millimetres precision, meeting the needs for tunnel detection.

"We trust Leica Geosystems products and quality. We have been using Leica Nova TM50 robotic total station for automated subway tunnel monitoring for many years. With a design and quality we trust, SiTrack:One satisfies the clients' needs and our needs," said Wei Duan, general manager assistant at the Nanjing Institute of Survey, Mapping & Geotechnical Investigation. "Our company has been focusing on the engineering survey, research and application of the full life cycle of rail transit. SiTrack:One brings an innovative mobile scanning way, helping us improve the efficiency and bringing more details."

Furthermore, surveyors can use the 3D point cloud to analyse the convergence and leakage of the tunnel. With the success experience of this new mode, Nanjing Institute of Survey, Mapping & Geotechnical



Investigation has full confidence to bring the SiTrack:One to other cities in the future.

HIGH-SPEED RAILWAY BETWEEN NANJING AND GUANGZHOU

China Railway Design Corporation is one of the biggest rail survey companies in China. The company was looking for a new way to improve the accuracy of rail facilities inspection and reduce labour, time and costs of each project. The old method not only much labour and time but also often had errors and mistakes. Surveyors had a tough time arriving to right conclusion during the inspection.

Now, using SiTrack:One, experts from CRDC can scan the whole site with the Leica ScanStation P40, achieving a scan rate of 1 million points/second with an accuracy of 2 mm of CPIII, a high-accuracy control point used in Chinese HSR and required for new Chinese subways. Thanks to the larger space on the HSR, SiTrack:One can move faster, capturing from 4,500 to 5,000 m per nightwork. CRDC also uses SiRailScan software to completely extract the as-built railway network with engineering accuracy level. The intelligent rail 3D processing software automatically generates the centre line with mileage

of the railway and provides the as-built rail geometry. This new method has replaced the old labour-intensive way, and it is efficient, precise and reliable.



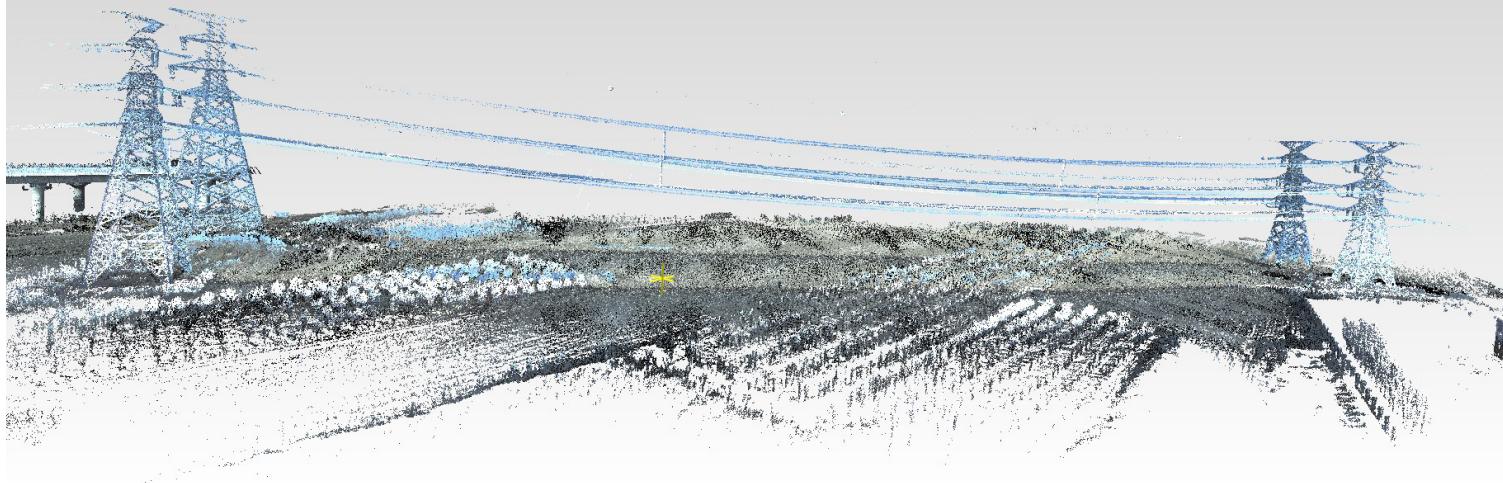


CAPTURING CHINESE HIGH-SPEED RAILS

Jing-long Xie

Case Study

Capturing rail with wearble mobile mapping sensor platform in China



High-speed rail (HSR) in China has witnessed significant development in recent years. With nearly two-thirds of the world's HSR, exceeding 25,000 kilometres in 2017, China now has the world's largest HSR network. The world's longest and most extensively used HSR network relies on leading surveying technology to keep China on the move.

Surveying rail is indispensable for rail design, construction and maintenance. China Railway Design Corporation (CRDC), a large-scale survey and design consultant enterprise, has surveyed and designed more than 40,000 km of rail, including 7,500 km of HSR. Surveying and mapping this large extension of rail brings challenges to surveyors and engineers. To overcome them, CRDC experts rely on the Leica Pegasus:Backpack wearable mobile mapping system to capture railways.

SURVEYING IN SHENYANG, CHINA

The unique wearable reality capture sensor platform has revolutionised the traditional survey methods of CRDC. With the Pegasus:Backpack's two LiDAR scanners and five high dynamic cameras, the team is improving efficiency by generating an accurate, fully registered and colourised 3D point cloud model of the rail environment, even in GNSS-denied areas thanks to the Simultaneous Localisation and Mapping (SLAM) positioning technology integrated in the reality capture platform.

The operator collecting the data turned on the Pegasus:Backpack and connected it to tablet to see in real time the data acquisition, images, LiDAR units and GNSS signal strength. With no need of using targets, CRDC surveyors walked and biked along the Shenyang rail collecting dense 3D point cloud and crisp images without worrying about GNSS coverage. One person carrying the ergonomic and ultralight Pegasus:Backpack completed the survey planned

route in one hour collecting data from inside of the rail tunnels and outdoors.

"The Pegasus:Backpack is a very powerful measuring tool. I believe this will promote the reform of new measurement methods in the near future," said Chun-xi Xie, rail survey department manager at CRDC.

BEYOND HARDWARE

Efficient technology that increases productivity goes beyond hardware or sensor integration. Of equal importance is the related software workflow and processing speed. CDRC surveyors could visualise in real time the data captured to decide if additional information layers were needed before leaving the site.

Once all data was collected, the team of experts imported the georeferenced 3D point clouds with panoramic images to Leica Pegasus:MapFactory to extract coordinates and features for a wide range of rail applications including:

- Produce topography models and plans of the area
- Draw 2D plan of a railway viaduct in AutoCAD
- Measure height and size of the high-voltage power towers near the railways
- Measure the width and features of the culvert
- Extract coordinates of railway power poles
- Create as-built models of the railways.

The core business of CRDC covers planning, survey and design, engineering consultation, and project management of rail. The workflow provided by Pegasus:Backpack solution fully meets CRDC's accuracy and efficiency requirements for preliminary railway surveys, saving time, cutting expenses, and increasing four times the efficiency in comparison with the traditional survey methods.

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