Best Practices for Adopting 3D Laser Scanning and Mobile Mapping

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SUMMARY

In the era of the Fourth Industrial Revolution and rapid technological advancement, surveyors are challenged to adapt their skills and practices to efficiently produce and manage precise geospatial data. Adopting 3D laser scanning and mobile mapping have become increasingly essential as prevalent solutions for achieving efficient, accurate and safe data collection, but they require adoption and adherence to best practices. As technology continues to advance, the criteria for defining best practices have evolved. Additionally, the surveying industry is facing a considerable shortage of skilled professionals, a factor that substantially affects technology choices for data acquisition and management. How can surveyors leverage the latest generation of automation to improve efficiency and maximise safety without compromising accuracy? Which tasks during all phases of the surveying project can be effectively replaced with technology, and which ones still require the finely tuned skills of surveyors' involvement? How can surveyors successfully streamline and scale their operations without second-guessing the results? This paper addresses these questions raised by ongoing technological innovation. Real-world examples illustrate how modern surveying and engineering firms should approach client interactions, project planning, data collection, QA/QC, reporting, deliverables, and more.

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1. INTRODUCTION

Over the last couple of decades, 3D laser scanning and mobile mapping have revolutionised field data collection in surveying and engineering (Boquin, N, 2020) by providing significant gains in efficiency and safety, along with comprehensive data capture and visualisation capabilities that were not possible with traditional methods. 3D laser scanning has enabled the creation of highly detailed 3D models of buildings and other structures, while mobile LiDAR has made it possible to collect data quickly and efficiently over large areas (Binder, N, 2017, Leica Staff, 2018). These technologies have also expanded the applications of surveying in areas such as transportation, infrastructure, building construction/building information modelling (BIM) (Burrows P., 2022), and environmental monitoring, creating new opportunities for surveying professionals to apply their expertise and provide value to the project.

However, this transformation comes at a critical juncture as the global demand for skilled surveyors is soaring (BIS Oxford Economics, 2023, Nally J., 2023, Robert, J. 2022), while the industry grapples with a shortage of qualified professionals. The ageing workforce, coupled with a diminishing influx of talent, poses a significant challenge. Amidst this backdrop, technology not only addresses operational efficiency but becomes a crucial ally in mitigating the scarcity of skilled surveyors, emphasising the need for innovative practices and continuous skill development. With each new technology innovation and improvement comes the need to re-evaluate the current state of best practices, both to ensure the quality and reliability of the results and to maximise the benefits obtained from implementing new approaches.

Many basic best practices form the foundation of good professional standards and will remain crucial as technology continues to advance. Some of these practices might become even more imperative because of changes in technology. For example, asking good questions and listening to understand client needs; communicating clearly and proactively; planning well; and maintaining rigorous Quality Assurance / Quality Control (QA/QC) procedures are all timeless protocols.

Even so, technological innovation can and does impact how we approach even the most elemental procedures. Additionally, adopting best practices is required as developments in automation and artificial intelligence (AI) shift the balance of machine vs. human tasks (Hexagon Report, 2023). In essence, what we are required to do as surveyors is not so much find and adhere to a new set of immutable best practices, but rather consider how technology influences our roles in providing an indispensable professional service and adapt our procedures accordingly.

2. THE RAPID ADVANCE OF SURVEY TECHNOLOGY

Digitization, automation, sensor innovation, cloud computing, and, more recently, AI have all had a significant impact on survey technology at every level. Today's advanced robotic total stations and GNSS receivers enable a single surveyor to do work in hours that once required several crews and multiple days to complete. The availability of tilt compensation in GNSS rovers and total station prism poles has provided a giant leap in survey productivity (Dainty, P., 2017). The addition of imaging capabilities in GNSS sensors helps ensure fast, complete data capture even in difficult-to-access areas of a project site. Modern sensors are smaller, lighter, faster, and easier to use, with automation handling many of the tasks that previously required a high level of expertise.

Laser scanning technology has also advanced significantly. Terrestrial laser scanners can now collect clean, accurate data at blazing-fast speeds while simultaneously capturing High-Dynamic-Range (HDR) imagery (Tuexsen, H.-H., 2018) and pre-registering the data in the field for a streamlined field-to-finish workflow. Compact, advanced precision imaging laser scanners offer a push-button approach to capturing complete scans with spherical images in less than 20 seconds while providing live feedback on a mobile device. The handheld imaging laser scanners provide the ability to capture data while walking, providing incredible efficiency and flexibility.

Mobile mapping, once a highly complex operation that required extensive planning as well as careful consideration of field and office resources, is now accessible to any organisation that needs to capture large area with LiDAR (Nuzzo, A, 2022). The latest technology autonomously handles calibration, accuracy estimation and in-field processing to ensure a complete, high-quality dataset. An intelligent combination of machine learning (ML) and hardware architecture empowers users to decode and extract information on the fly, with real-time blurring of identifiers such as people and vehicles to protect privacy. Guided workflows, live system feedback and in-field online support virtually eliminate the learning curve to adopt the technology. The intelligence built into the workflows dramatically simplifies preplanning and streamlines data processing.

New software developments have brought additional benefits. For example, professionals can now use mobile device apps to capture, pre-register, and examine laser scan and image data onsite in real-time. Field software can be used to pre-register and pre-align scans to streamline workflows automatically (Albano, V., 2023). The latest point cloud registration software provides drag-and-drop functionality along with multi-threaded batch routines, one-step import and processing, guided workflows, built-in QA/QC tools, and automated reporting to save considerable time and guesswork while delivering higher productivity. The mobile mapping office software uses automation and AI to simplify and streamline adjustments, classification, and other post-processing steps.

These and other advanced capabilities have transformed the way surveyors approach projects, enabling greater efficiency, accuracy, safety, and effectiveness. But how does technology innovation impact the role these professionals play now and in the future?

3. THE ESSENTIAL AND EVOLVING ROLE OF THE SURVEYORS

The global geospatial analytics market is expected to grow 12.2 per cent between 2022 and 2027 to reach US$119.9 billion (Geospatial Analytics Market, 2022). The global digital twin market size is expected to grow from $3.1 billion in 2020 to $48.6 billion in 2026, with more than half of that growth identified as geospatial opportunity (WGIC, 2022). Advanced digital twin use cases need accurate spatial data (spatial digital twins). Geospatial data is fundamental to unlocking more applications from existing or individual digital twin ecosystems. End users prefer highly accurate and intricate 3D models for improved visualisation. The metaverse relies on geospatial data to overlay the physical world with the digital world through AR/VR.

Prof. Rudolph Staiger, president of the German Association for Geodesy, Geoinformation and Land Management and a former president of the International Federation of Surveyors (FIG), aptly defines the transformation as moving from an observer to a project and data manager (Staiger, R, 2023). The primary skills required of the next-generation surveyor explains Staiger, include a thorough knowledge of measurement systems and technologies, mathematics, business administration, programming, and soft skills such as communication, presentation, and teamwork. These skills will be in increasingly high demand in the next decade as clients in industry, healthcare, municipalities, infrastructure, construction, and other areas explore ways to optimise the digital twin and the potential of the metaverse.

The field of surveying, once dominated by mathematically skilled and detail-oriented individuals, has transformed into a creative and diverse discipline that places high value on the understanding and application of precise geospatial data. Today's advanced sensors and software have taken over the tasks of calculations, data processing, and deliverable creation, freeing professionals to focus on strategic operations and data management (Staiger, R, 2023). As a result, experts in the field are concentrating more on understanding project requirements, identifying suitable technologies, recognising potential pitfalls, and enhancing services. This shift has spurred the demand for professionals capable of capturing, analysing, and applying geospatial data. The transformed role of surveyors, as data managers, allows them to leverage integrated solutions to efficiently manage and process data from various technologies, facilitating precise measurement and positioning tasks (Ostridge R. & O'Regan S., 2022). Consequently, surveyors who appreciate these opportunities and deliver indispensable services are well-positioned to excel in this rapidly evolving industry landscape.

4. THE IMPACT ON BEST PRACTICES

In the contemporary surveying landscape, the adoption of innovative technologies reshapes best practices across the project lifecycle, which can be divided into four main phases: planning, data acquisition, data process & management, and delivery (Staiger, R, 2023). Historically,

surveying decisions were straightforward, adhering to limited methods and dedicated instruments. In contrast, modern survey projects undergo a more extensive planning phase, benefiting from simultaneous data processing during acquisition with highly efficient equipment. This parallel workflow not only accelerates project completion but also enhances versatility in result utilisation (Staiger, R, 2023). The dynamic interplay between advanced technology and surveying methodologies necessitates a holistic re-evaluation of operational facets, ensuring the optimal utilisation of technology (Bonet J. & Goudard R., 2023) across client interactions, project planning, field data collection, QA/QC procedures, reporting, deliverables, and beyond. Continuous improvement in every operational aspect is essential to harness the full advantages of technological advancements, aligning survey service providers with the evolving landscape of surveying practices.

4.1 PLANNING

Planning in the adoption process involves clear goal-setting, technology selection balancing cost-efficiency, and resource optimisation amidst a skill shortage. This phase bridges the gap between client expectations and the actual project needs, ultimately promoting transparency and engagement.

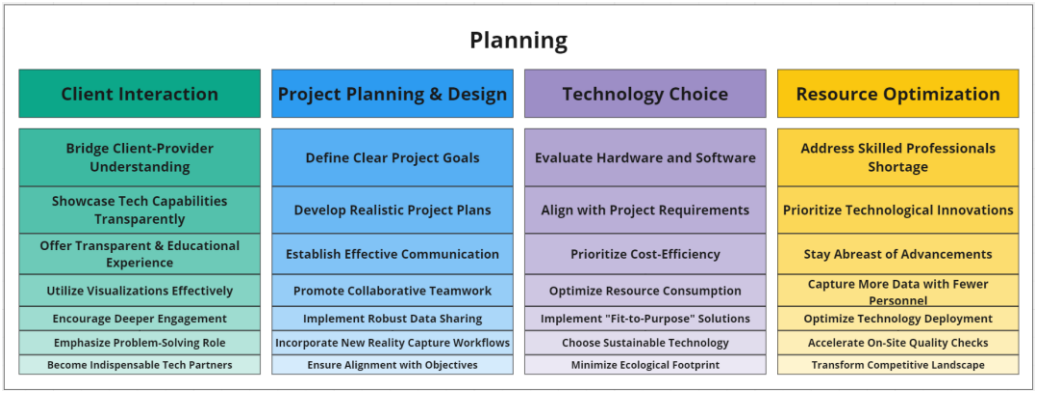

Figure 1. Best Practice in the Planning Phase of a Surveying Project

4.1.1 Client Interaction in the Era of Technological Innovation

The advent of innovative surveying technologies presents an opportunity to bridge the gap between client expectations and their actual needs. This involves fostering deeper engagement, showcasing technology capabilities, and utilising visualisations as reference points to simplify understanding of reality capture, offering a transparent and educational experience.

As the speed of data collection increases and workflows become more automated due to technology, the value proposition of surveying firms is reshaped. These firms evolve from simply providing on-site expertise to functioning as data managers and project consultants, with an emphasis on problem-solving (Lauwiner, M., 2023). Demonstrating the transformative

impact of advanced scanning technologies through tangible examples (Drisdelle, J., 2023) is integral, as these examples can challenge outdated standards and advocate for more effective methodologies during client discussions. The integration of visualisations as standard reference points enables clients to visualise challenges and conflicts, promoting collaborative decision-making. This positional shift promotes survey service providers as indispensable partners in leveraging modern surveying technologies, rather than functioning merely as data collectors.

4.1.2 Project Planning and Design

Define Project Goals and Objectives: Before starting any project, defining the project goals and objectives is essential. This includes understanding the client's needs and expectations and identifying any specific challenges or constraints that may impact the project. By clearly defining the goals and objectives of the project, you can develop a roadmap for success and ensure that everyone involved is on the same page.

Develop a Detailed Project Plan: Once you have defined the project goals and objectives, the next step is to develop a detailed project plan (Bonet J. & Goudard R., 2023). This plan should include a timeline, budget, and list of deliverables, as well as a list of key stakeholders and their roles and responsibilities. It's important to make sure that the project plan is realistic, achievable, and aligned with the project goals and objectives.

Establish Clear Communication, Collaboration, and Data Sharing: Effective communication and collaboration are essential for project success. In addition to establishing clear communication channels with the client and project team, it's crucial to integrate a robust data-sharing mechanism (Lauwiner, M., 2023). Sharing the data generated from the scans with all involved stakeholders ensures that everyone has access to accurate and up-to-date information. This collaborative approach enhances transparency, facilitates informed decision-making, and aligns all parties with the project's objectives. Regular check-ins, progress reports, and milestones, coupled with comprehensive data sharing, contribute to a cohesive workflow that keeps everyone informed, engaged, and collectively focused on achieving project success.

Establish New Workflows for Reality Capture Integration: The evolution of 3D laser scanning and mobile mapping technology has significantly impacted project planning for surveying and engineering projects. To fully unlock the potential of this technology, companies must establish new workflows that seamlessly integrate reality capture into their projects. This involves aligning different software solutions and file formats to create a cohesive and efficient workflow (Bonet J. & Goudard R., 2023, Hall S., 2022b). Whether investing in reality capture devices or leveraging external service providers, creating tailored workflows ensures that companies maximise the benefits of 3D laser scanning technology in the design and planning phases. This adaptation allows them to focus on their core competencies while efficiently incorporating reality capture and modelling advantages.

4.1.3 Technology Choice for Efficiency and Sustainability

Striking a balance between cost, efficiency, speed, and accuracy is pivotal for sustainable surveying practices. Best practices involve a meticulous evaluation of hardware and software, ensuring alignment with project requirements, budget constraints, and environmental considerations (Albano, V., 2023). Adopting such practices is essential, as it not only meets project goals but also contributes to sustainable outcomes, minimising resource consumption and ecological impact.

Efficiency in laser scanning and data processing is key to minimising the ecological footprint of surveying activities. Manually taking measurements requires multiple team members that drive to the site, and when the measurements are not accurate enough, another trip might be necessary. Repeated trips to the construction site are time-consuming and lead to higher costs and a larger carbon footprint for the company, reducing the number of projects they can work on (Albano, V., 2023, Byrne, M., 2023). Sustainable technology choices mitigate these impacts, aligning with eco-friendly practices in the construction industry. Tailoring technology to project needs using a "fit-for-purpose" solution is crucial for optimising efficiency while minimising environmental impact, showcasing the value of adopting sustainable surveying practices for a more resilient and eco-conscious future in the industry.

4.1.4 Resource Optimisation: Navigating the Skills Shortage

Amidst a construction boom, the global demand for surveyors is soaring, yet skilled professionals are becoming scarce. The industry faces a significant challenge as fewer individuals opt for careers in surveying, compounded by an ageing workforce nearing retirement, leading to a pronounced skills gap.

To overcome this challenge, surveyors prioritise technological innovations for efficient operations with limited manpower. Staying abreast of advancements is crucial to enhance efficiency and address the scarcity of skilled professionals. New technologies and equipment enable surveyors to accomplish tasks more efficiently (Boviatsou, P., Hall, S., 2022a,c, Leica Staff 2023), contributing to faster and more precise construction processes. For instance, advanced total stations facilitate on-site layout and accurate as-built QA/QC, while 3D laser scanners expedite on-site quality checks and progress documentation (Hill, C., 2023). This technology not only enhances speed and efficiency but also addresses capacity issues within the industry (Lauwiner, M., 2023), enabling the capture of more data with fewer personnel. As technology becomes more accessible, it levels the playing field, transforming the competitive landscape into one centred on service excellence and effective problem-solving for clients.

The incorporation of cutting-edge technology, such as the latest reality capture systems, not only attracts new talent but also fosters skill cultivation and retention (Murphy, R, 2022). Streamlining operations, contributes to the overall resilience and sustainability of the

profession, ensuring that the field of surveying remains competitive and centred on service excellence and effective problem-solving for clients.

4.2 DATA ACQUISITION

4.2.1 Scanning from Safe Distances

Scanning from a safe distance is a fundamental surveying practice that balances personnel safety with precise data capture. Leveraging 3D laser scanning and mobile mapping technologies enable surveyors to reduce on-site risks by maintaining a safe distance from potentially hazardous areas (Hexagon Staff, 2023, Matev, K., 2023). This approach not only reinforces safety protocols but also ensures streamlined data collection, enhancing overall project efficiency. The implementation of 3D laser scanning significantly elevates safety standards, allowing workers to avoid perilous tasks like climbing heights or navigating unsafe spaces. Portable 3D laser scanners support on-site surveying from a safe distance, fostering a protected working environment and efficient data recording, even in challenging conditions.

4.2.2 Minimal Disruption

Minimising disruptions in geospatial surveys for highways, roads, and railways is essential for safety and efficiency. Advanced mobile mapping and 3D laser scanning technologies enable remote measurement of inaccessible or hazardous areas, ensuring personnel safety and reducing interruptions by not requiring infrastructure closures (Goudard, R., 2023, Hill, C., 2022, Matev, K., 2023). This innovative approach allows rapid data collection, fostering a streamlined and secure process for assessing and maintaining transportation assets and enhancing overall project efficiency while prioritising safety.

4.2.3 On-Site Data QA/QC and Smooth Data Transfer

Effective scan progress tracking, QA/QC, and data transfer on-site are crucial elements for streamlined surveying projects. Leveraging advanced hardware and software solutions enables live visualisation of scanning progress on mobile devices, allowing field teams to ensure complete and accurate data collection (Hall S., 2022b, Goudard R., 2023). The technology provides a 2D top view and a 3D rendering of the point cloud, facilitating live scan progress tracking (completeness), and identifying areas for potential rescanning to avoid costly site revisit. The field team can upload generated data, optimising efficiency for prompt data processing by the office team while the field team continues scanning. This workflow ensures swift project completion. Upon completing the scans, seamless data transfer with compatible software expedites the final processing for the surveying team.

4.2.4 Decision Making On-Site

Efficient decision-making on-site is revolutionised through advanced scanning solutions, enabling real-time analysis and QA/QC directly in the field (Jacobsen Ch. 2022, Leica Staff, 2020). Leveraging intelligent sensors and field software, users can instantly assess various structures, such as concrete floors, buildings, or other constructions, minimising the need for post-processing in the office. This streamlined workflow not only enhances productivity but also reduces costs by minimising material waste and decreasing personnel requirements. The capability to compare, analyse, and visualise data on-site empowers professionals to make informed decisions promptly, whether evaluating flatness, verticality, or deformations in diverse applications.

4.2.5 Mastering Essential Skills: Elevate Surveying Service

The pursuit of excellence in surveying services hinges on the constant enhancement of crucial skills. Key competencies include adaptive learning, technology fluency, and business administration, augmented by strong communication and collaboration abilities (Lauwiner, M., 2023, Staiger, R, 2023). Regular training programs are significant in keeping teams abreast of technological advancements, while meticulous attention to detail is fundamental to ensure the precision and accuracy of collected data. A balanced combination of technical skills and soft traits, such as effective communication and adaptability, sets successful surveying service providers apart. In this digital era, proficiency in handling digital data is paramount for maintaining a competitive edge and ensuring consistent processes and decision-making. It is this comprehensive combination of measurement technologies, soft skills, and business savvy that defines the expertise needed for surveying services to thrive in a dynamic and demanding landscape.

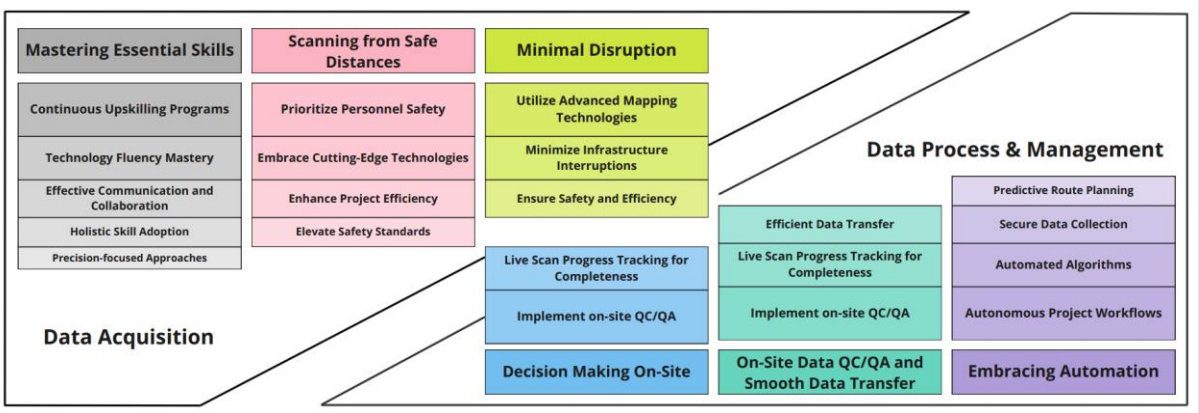

Figure 2: Best Practice in the Data Acquisition and Data Process & Management Phases of a Surveying Project

4.3 DATA PROCESS AND MANAGEMENT

4.3.1 Embracing Automation

Meeting the rising demand for enhanced efficiency and reduced manual involvement in project workflows, the mobile mapping systems empower users to confidently plan and execute projects with autonomous workflows (Albano, V., 2023). Automated algorithms efficiently handle repetitive tasks, allowing surveyors to focus on intricate data management aspects (Schrock, G, 2024). Seamlessly integrated with advanced software, the system ensures fully automated and secure data collection and route planning in the field, predicting mission durations and managing storage and battery capacity. The automated route-planning, guidance, and data collection process significantly boost efficiency, improve data quality, and reduce overall project costs (Nuzzo, A, 2022). Sensors triggered automated along the route guarantee meticulous data capture, maximising productivity with advanced scanning technologies. This innovative approach simplifies the data collection process, making it accessible to a broader user base, including those outside traditional surveying, through user-friendly learning platforms.

4.4 DELIVERY

Crafting meaningful deliverables from captured surveying data demands an efficient solution and workflow that caters to diverse stakeholder needs. Embracing best practices ensures future readiness for automated processes and evolving workflows. Adopting a versatile approach, the workflow empowers professionals to swiftly process data and export deliverables in a universally compatible format (Albano, V., 2023). Sharing these final deliverables with stakeholders is crucial for project alignment, emphasising compatibility with various software solutions. Seamless integration facilitates processing while leveraging AI and ML for autonomous data processing positions professionals to adapt seamlessly to the future landscape of automated workflows.

4.5 CONCLUSION

In the ever-evolving realm of modern surveying, adeptly mastering key best practices proves indispensable across each phase of the surveying process. Engaging clients through transparent and educational discussions, the emphasis is on showcasing the transformative impact of advanced scanning technologies. Project planning and design necessitate the definition of clear goals, detailed plans, robust communication, collaboration, and data-sharing mechanisms, while also forging new workflows for seamless reality capture integration. Meticulous evaluation of hardware and software ensures cost-effective, efficient, and sustainable surveying practices. Overcoming the skills shortage involves prioritising technological innovations for efficient operations and staying abreast of advancements. During data acquisition, safety and efficiency are heightened by laser scanning from safe distances, minimising disruptions, implementing on-site QA/QC, and ensuring smooth data transfer. Decision-making on-site is

revolutionised with real-time analysis and QA/QC through advanced scanning solutions, while continuously upskilling teams elevates surveying services. In data process & management, confidently planning and executing projects with automated workflows, leveraging automated algorithms, secure data collection, and route planning enhances efficiency. The final phase involves crafting meaningful deliverables through efficient workflows, emphasising compatibility with various software solutions. These comprehensive best practices position surveying professionals not only as data collectors but as indispensable partners, ensuring success in a rapidly evolving industry landscape.

Looking toward the future, while the rapid advancement and democratization in 3D laser scanning and mobile mapping technologies provide more efficient, accessible, and accurate tools, the role of a skilled surveyor at the helm of these tools remains irreplaceable, given their unique expertise in data interpretation, decision-making, and problem-solving in the context of spatial data management.

REFERENCES

Albano, V., 2023, Overcoming challenges in the design phase of construction projects, Hexagon Geosystems, https://blog.hexagongeosystems.com/challenges-in-the-design-phase/

Binder, N, 2017, Revolution in motion, Leica Geosystems, Case Study , https://leica-geosystems.com/nl-be/case-studies/reality-capture/revolution-in-motion

BIS Oxford Economics, 2023, Determining the Future Demand, Supply and Skills Gap for Surveying and Geospatial Professionals for Australia, Consulting Surveyors National, https://www.thesurveyorstrust.org.au/resources/Documents/Determining%20the%20Future%20Demand%20Supply%20and%20Skills%20Gap%20for%20Surveying%20and%20Geospatial%20Professionals%20-%202018-2028.pdf

Bonet J. & Goudard R., 2023, How to use reality capture technology for each stage of the heavy construction workflow, HxGN Blog, https://blog.hexagongeosystems.com/using-reality-capture-for-each-stage-of-the-heavy-construction-workflow/

Boquin, N, 2020, Nelson Boquin is Growing your Business with 3D Laser Scanning, Case Study, HxGN Blog, https://blog.hexagongeosystems.com/big-picture-growing-your-business-with-3d-laser-scanning/

Boviatsou, P. , 2022, 70 Miles of highway mapping to full engineering design in 99 days, Leica Geosystems, Case Study , https://leica-geosystems.com/case-studies/reality-capture/70-miles-of-highway-mapping-to-full-engineering-design-in-99-days

Burrows, P., 2022, How to Integrate Laser Scanning into a Closed-Loop BIM Process Using Autonomy, HxGN Blog, https://blog.hexagongeosystems.com/how-to-integrate-laser-scanning-into-a-closed-loop-bim-process-using-autonomy/

Byrne, M., 2023, Myth-busting green construction: sustainable building practices & reality capture technology, Hexagon Geosystems, https://blog.hexagongeosystems.com/myth-

busting-green-construction-addressing-the-biggest-myths-about-sustainable-building-practices-reality-capture-technology/

Dainty, P, 2017, The world's fastest and easiest-to-use GNSS RTK rover, Leica Geosystems, https://leica-geosystems.com/products/gnss-systems/smart-antennas/leica-gs18-t/how-does-it-work-what-makes-it-different

Drisdelle, J., 2023, How Leica TruView is Paving the Way for Next Gen MMS & VR Integration, HxGN Blog, https://blog.hexagongeosystems.com/how-leica-truview-is-paving-the-way-for-next-gen-mms-vr-integration/

Geospatial Analytics Market, 2022, Geospatial Analytics Market by Offering, Markets and Markets, https://www.marketsandmarkets.com/Market-Reports/geospatial-analytics-market-198354497.html

Goudard, R., 2023, Tunnelling: how reality capture technology provides a guiding light, HxGN Blog, https://blog.hexagongeosystems.com/how-reality-capture-technology-helps-tunnel-construction/

Hall, S, 2022a, Maintaining Danish Highways Driving operational efficiencies, Leica Geosystems, Case Study , https://leica-geosystems.com/case-studies/reality-capture/maintaining-danish-highways-driving-operational-efficiencies

Hall, S., 2022b, Bayer House - Moving on with reality capture solutions, Leica Geosystems, Case Study , https://leica-geosystems.com/en-gb/case-studies/reality-capture/bayer-house-moving-on-with-reality-capture-solutions

Hall, S., 2022c, Improve efficiency with High-Definition Scanning, Leica Geosystems, Case Study , https://leica-geosystems.com/en-gb/case-studies/reality-capture/output-precision-improve-efficiency-high-definition-scanning

Hexagon Report, 2023, Autonomous construction technology outlook / Achieving better project outcomes through autonomy, Hexagon Report, https://www.calameo.com/read/00191579623df28615203?authid=hMf3nNLZIzBt&utm_medium=referral&utm_source=web

Hill, C., 2022, How reality capture digitises workflows in highway design, construction & maintenance, HxGN Blog, https://blog.hexagongeosystems.com/how-reality-capture-digitises-workflows-in-highway-design-construction-maintenance/

Hill, C., 2023, The good, the bad and the ugly of the surveying profession, GIM International, https://www.gim-international.com/content/article/the-good-the-bad-and-the-ugly-of-the-surveying-profession

Jacobsen, Ch., 2022, Going down under Australia's mines with Leica Geosystems ScanCrete solution, HxGN Blog, https://blog.hexagongeosystems.com/going-down-under-australias-mines-with-leica-geosystems-scancrete-solution/

Lauwiner, M., 2023, Being a Good Surveyor is Not Good Enough, HxGN Blog, https://blog.hexagongeosystems.com/being-a-good-surveyor-is-not-good-enough/

Leica Staff, 2023, Nektar 3D Advances Transportation Engineering with AI and Mobile LiDAR Innovation, Leica Geosystems, Case Study , https://pure-surveying.com/2023/06/15/nektar-3d-advances-transportation-engineering-with-ai-and-mobile-lidar-innovation/

Leica Staff, 2018, Speeding up with mobile mapping, Reporter 81, Leica Geosystems, https://leica-geosystems.com/about-us/news-room/customer-magazine/reporter-81/speeding-up-with-mobile-mapping

Leica Staff, 2020, Inspecting the surface of a giant wastewater tunnel, Leica Geosystems, Case Study , https://leica-geosystems.com/case-studies/surveying-and-engineering/inspecting-the-surface-of-a-giant-wastewater-tunnel

Matev, K., 2023, Reality capture on the rails: railway surveying for safety, accuracy & efficiency, HxGN Blog, https://blog.hexagongeosystems.com/reality-capture-on-the-rails-railway-surveying-for-safety-accuracy-efficiency/

Murphy, R, 2022, Leveraging technology to attract talent, HxGN TV, https://blog.hexagon.com/leveraging-technology-attract-talent/

Nally, J., 2023, Severe surveyor shortage set to become worse, Spatial Source, https://www.spatialsource.com.au/severe-surveyor-shortage-set-to-become-worse/

Nuzzo, A, 2022, Smart is good, but smarter is better: how Hexagon's mobile mapping technology is optimising smart cities for residents, HxGN Blog, https://blog.hexagongeosystems.com/smart-is-good-but-smarter-is-better-how-hexagons-mobile-mapping-technology-is-optimising-smart-cities-for-residents/

Ostridge, R. & O'Regan, S., 2022, Leica Geosystems: The surveyor as a data manager, GPS World, https://www.gpsworld.com/leica-geosystems-the-surveyor-as-a-data-manager/

Robert, J., 2022, The shortage of Surveyors explained, LinkedIn, https://www.linkedin.com/pulse/shortage-surveyors-explained-joshuarobert

Schrock, G, 2024, The Essential Role of AI in Point Cloud Classification, Geo Week News, https://www.geoweeknews.com/blogs/lidar-ai-point-cloud-classification-artificial-intelligence

Staiger, R, 2023, The Surveyor 4.0, GIM International, Issue 1, 2023, Volume 37, https://issuu.com/geomarespublishing/docs/gim_bg_1-2023_lr-pdf?fr=sZTY1NDU0MjEzMDM

Tuexsen, H.-H., 2018, A New Development in Laser Scanning Technology, Leica Geosystems, https://leica-geosystems.com/products/laser-scanners/scanners/leica-rtc360/a_new_development_in_laser_scanning_technology

WGIC , 2022, Spatial Digital Twins – Trends and Opportunities, WGIC 2022 Policy Report on Spatial Digital Twins, https://wgicouncil.org/world-geospatial-industry-council-releases-a-report-on-spatial-digital-twins-trends-and-opportunities/

Hexagon Staff, 2023, Safety: How Hexagon's Tech Innovations Drive Sustainability, HxGN Blog, https://blog.hexagongeosystems.com/safety-how-hexagons-tech-innovations-drive-sustainability-safety/

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