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LIDAR

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SPECIAL ISSUE

MAGAZINE

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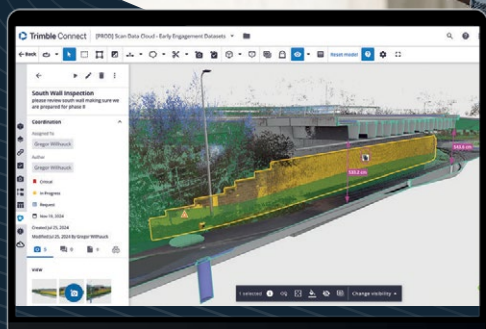
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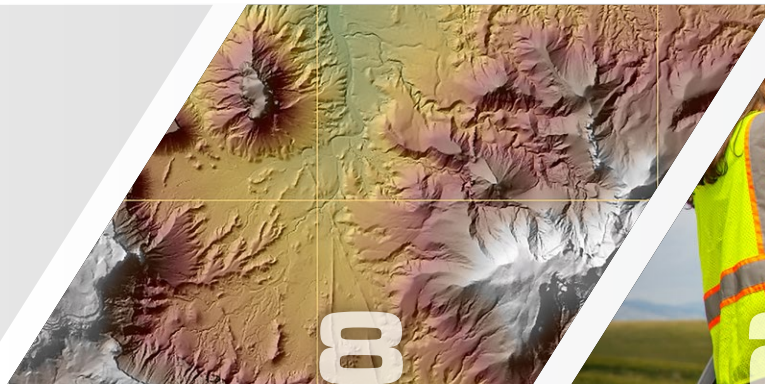
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Interferometric synthetic aperture radar (InSAR), once limited to specialized research and military reconnaissance, has emerged as a pivotal technology in modern geospatial intelligence, offering highly precise and temporally rich measurements of ground deformation over time. While the core technique has been around for decades, recent advancements in satellite technology, data availability, and processing power have unlocked new applications that are transforming how we monitor and understand changes in the Earth's surface. At its foundation, InSAR leverages the phase difference between radar signals acquired from orbiting satellites on multiple passes over the same area. These signals, reflected off the Earth's surface, are processed to generate images called interferograms, which can reveal minute changes, of the order of millimeters, in ground elevation over time. Historically, InSAR was limited by the availability of suitable satellite data and the complexity of the processing workflow...

BY BRYAN DESLAURIERS, SIMONE FIASCHI,
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For years, the promise of seeing beneath the surface to reveal hidden infrastructure remained just out of reach for widespread adoption in utility and transportation infrastructure projects. With technological advances such as AI adoption, ground-penetrating radar (GPR) is becoming more fully integrated into broader civil infrastructure workflows. Previously, GPR processing to extract information from the raw data could be laborious, but in recent years software has made significant advances. Despite historical challenges, sensor integration is now transforming surveying, civil engineering, and road construction/maintenance by offering accurate and efficient methods to generate comprehensive datasets. Mobile mapping is widely used to capture large volumes of geospatial information more quickly than traditional survey processes (Figure 1), and multi-array GPR plays a crucial role in locating buried utilities and detecting subsurface pavement anomalies. Integration of the two technologies enables simultaneous data collection at normal driving speeds, eliminating traffic interruptions and...

BY SKYLER NEUMEYER

36 Elevations for the Nations – Part III

Mapping activities for the United States are centrally regulated for a land area of 3.8 million square miles, whereas lidar coverage of Europe's 3.9 million square miles is managed through a complex patchwork of governance levels—sometimes nationally, sometimes regionally, and occasionally at even more localized levels. The European Union still does not regulate mapping activities at the supranational level; instead, this responsibility is distributed across various administrative levels within and below Member States. Consequently, lidar coverage across Europe varies not only between countries but also within them, leading to fascinating variations and distinctive characteristics that reflect different political structures and administrative traditions. This fragmented approach has created a complex panorama where some areas boast extensive, cutting-edge lidar datasets, while others remain in the early stages of implementation. Access to funding often proves crucial, as many public agencies responsible for lidar coverage lack dedicated budgets and instead rely on commissions from other public...

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◀ ON THE COVER

Lidar-derived digital elevation model (DEM) over the state of Utah. U.S.A.

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Lidar, InSAR, GPR – better together

During my editorship, I have attempted to provide readers with material not only on lidar, but also on other active sensors, such as radar and sonar. In this issue, our annual Sensor Integration Spotlight, we've procured several examples of high-level integration in action. This month's cover story recaps the manner in which the Virginia-based geospatial powerhouse Dewberry has collaborated with the renowned Italian company TRE ALTAMIRA on interferometric synthetic aperture radar (InSAR), a source of highly accurate data on elevation change. The authors begin with useful background material on lidar and InSAR, then showcase lidar's role in complementing InSAR such that the two technologies are used in the optimum way. There's a sidebar giving the approbation of two NOAA experts on the beauties of InSAR.

Following that thread, I have been pursuing various people for years in search of an article on ground-penetrating radar (GPR) – the use of radar sensors, usually deployed on vans or trucks, or on carts pushed by hand, to discover and map underground infrastructure such as pipes and cables. Finally, Trimble has answered my call, with an article on page 24 presenting three short case-studies demonstrating the power of systems that integrate Trimble's MX series of mobile mapping systems with third-party GPR sensors. The positive results echo those that I reported from the recent Hexagon user meeting in Las Vegas.

On page 36, you'll find part III of the series, "Elevations for the Nations," by Ada Perello of EAASI, addressing lidar-related developments in Austria, Croatia, Germany, Greece, and Italy—five countries with very disparate geographies and cultures, resulting in different challenges to the creation of nationwide elevation programs. Such programs often represent the evolution of initiatives that began at the provincial level then diffused to the entire land area, the ultimate integration of sorts.

Closing out this edition, we present another installment of the "Content to Serve" column from contributing writer John Welter, revealing his thoughts on the evolution of lidar – why certain developments took place when they did. John confirms that an update of the Leica SPL100 single-photon system is imminent, so we eagerly await INTERGEO 2025 in Frankfurt in October. Adjacent technologies such as GPS and IMUs have been influential, as have UAVs and self-driving cars. The marvelous systems we deploy today have their history in both technological advances and responses to customer demand.

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PUBLISHER Allen E. Cheves
publisher@spatialmedia.us

MANAGING EDITOR Dr. A. Stewart Walker
stewart.walker@lidarmag.com

ASSOCIATE EDITOR Dr. Austin Madson
austin.madson@lidarmag.com

ASSOCIATE PUBLISHER Kevin Grapes
kevin.grapes@spatialmedia.us

EDITOR EMERITUS Marc S. Cheves, LS
marc.cheves@spatialmedia.us

CONTRIBUTING WRITERS

Dr. Qassim Abdullah
Jason C. Fries
Dr. Al Karlin
Antero Kukko
Dr. David Maune
Amar Nayegandhi
John Russo
Mike Shillenn
Evon Silvia
Dr. Jason Stoker
John Welter
Dr. Michael Zanetti

The staff and contributing writers may be reached via the online message center at our website.

GRAPHIC DESIGN LTD Creative, LLC
AUDIENCE DEVELOPMENT Edward Duff

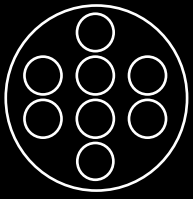
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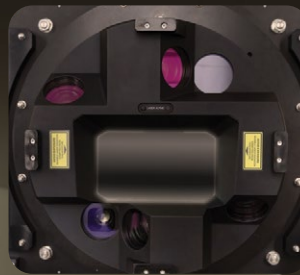




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I count myself privileged to have attended five very different but extremely informative events this year. These are reported on our website, yet it is worthwhile to reflect. Geo Week in Denver in February¹ seems a long time ago. It was vibrant and still growing, a demonstrable success on the part of Diversified Communications, with a particularly strong exhibition and decent marketing of World Lidar Day. This is the “go to” event for North American practitioners in photogrammetry, remote sensing and lidar. The 59th Photogrammetric Week in Stuttgart in April² served up the traditional mixture of invited speakers reviewing the state of the art, short presentations by industry representatives and strong demonstrations of the latest products. The standard this year was spectacular.

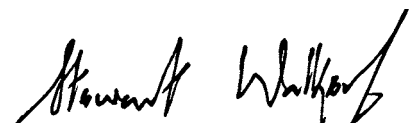
PhoWo would be expected to be entirely different from Hexagon LIVE Global 2025 in Las Vegas in June, not just because the weather was 50 degrees cooler. I enjoyed the Hexagon event so much that I was unable to rein in my loquaciousness and the report stretched to four parts.³ The usual razzamatazz was there, yet there seemed to be a little more gravitas than some earlier instantiations and both the Hexagon and customer presentations were solid and sometimes inspiring. I was able to talk to the right people to go more deeply into airborne sensors, GPR, and the user of lidar in security systems.

All five events noted here are serial, i.e. they repeat annually or biennially. The Esri International User Conference in San Diego in July⁴ was the 45th in the series, attracting 20,000 customers from 130 countries. The big plenary on the opening day, with Jack at the podium for much of it, was as well orchestrated as ever. I was especially struck by two of the presentations I attended about soliciting public comment to proposed urban developments. There’s a lot in common between these developments, by the companies Houseal Lavigne and inCitu, working with their customers, and an article from Esri recently posted on our website about the use of a digital twin in planning by the city of Magna, Utah.⁵ It was abundantly clear that digital twins have already gone far beyond “posh 3D models” to working systems able to support decision-making, some of it in near-real-time. The examples of the Port of Corpus Christi and San Francisco International Airport were especially compelling.

Lastly, I’m writing this on my return home from the 15th session of the Committee of Experts on Global Geospatial Information Management (UN-GGIM) at the United Nations in New York.^{6,7} This is entirely different. Delegations from UN member states confer with a view to consensus on policies for the generation and use of geospatial data, especially the UN Integrated Geospatial Information

Framework. The pursuit of the UN Sustainable Development Goals is pervasive throughout the meeting. The structure, jargon and protocols of UN-GGIM require work to understand, but progress is being made. UN-GGIM has some regional centers of expertise and the one in Bonn is making substantial progress on the “global geodesy supply chain”.

There’s a well written piece in the current issue of *Photonics Spectra* about underwater lidar⁸. Readers who enjoyed part III of Gottfried Mandlbürger’s “Airborne lidar: A tutorial for 2025”⁹ will find the complementary information in this article valuable. The focus is a quantum lidar system from Quantum Computing. This is a single-photon lidar prototype, but the article also describes production systems such as Leica CoastalMapper, Teledyne Geospatial CZMIL SuperNova and YellowScan Navigator, which is also integrated by Volatus Aerospace on Dragonfly UAVs. The article ends with a discussion of subsea lidar, i.e. sensors mounted on remotely operated submarines. A system from 3D at Depth was used to scan the Titanic at a depth of 4000 m. Onward and downward! ■



A. Stewart Walker // Managing Editor

1 <https://lidarmag.com/2025/02/27/big-gest-geo-week-ever/>

2 <https://lidarmag.com/2025/05/27/59th-photogrammetric-week-stuttgart-1-4-april-2025/>

3 <https://lidarmag.com/2025/07/15/hexagon-live-global-2025-las-vegas-16-19-june-2025-a-retrospective/>

4 <https://lidarmag.com/2025/08/05/esri-international-user-conference-san-diego-14-18-july-2025-a-retrospective/>

5 <https://lidarmag.com/2025/08/13/magna-mappa/>

6 <https://lidarmag.com/2025/08/15/15th-session-of-the-un-ggim-in-new-york>

7 <https://ggim.un.org/meetings/GGIM-committee/15th-session/>

8 Schlett, J., 2025. Underwater lidar gives maritime and subsea applications the green light, *Photonics Spectra*, 59(7): 42-47, July 2025.

9 Mandlbürger, G., 2025. Airborne lidar: A tutorial for 2025. Part III: Bathymetric lidar, *LIDAR Magazine*, 15(2): 20-29, Spring 2025.



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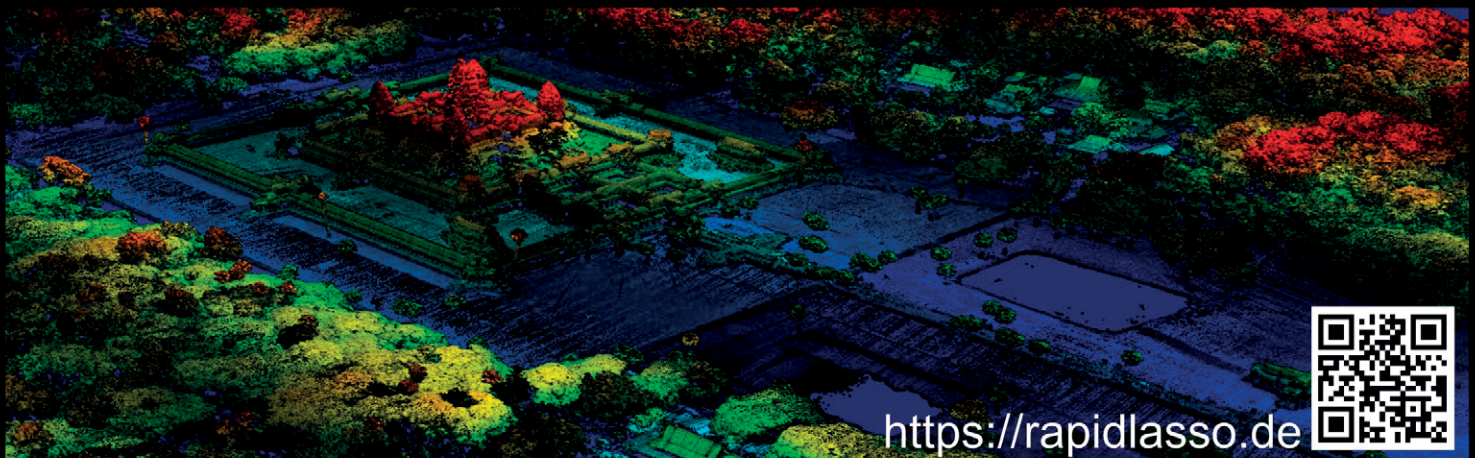
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Leveraging InSAR Technology to Optimize Lidar Data Collection

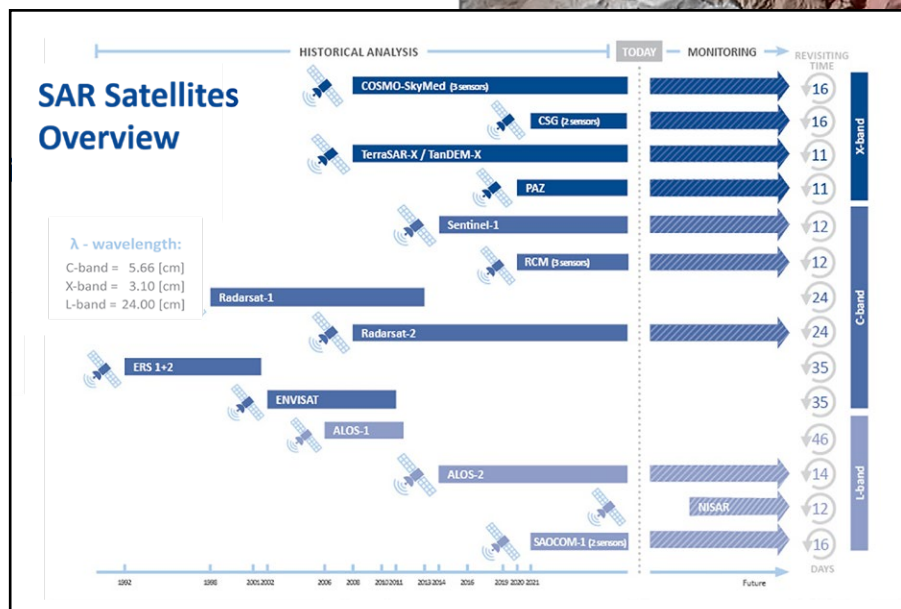
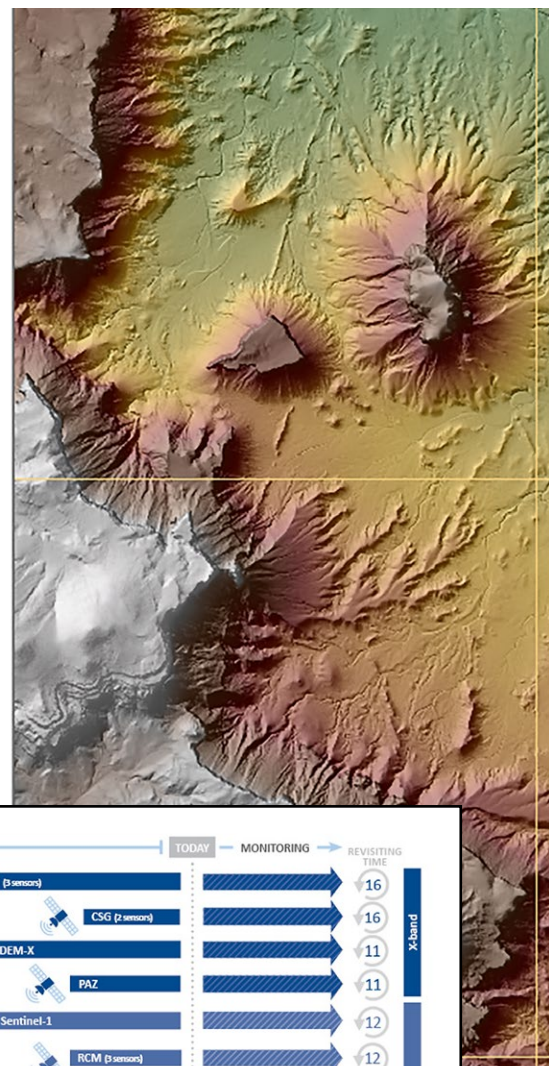
How InSAR improves efficiency, coverage, and cost-effectiveness in lidar surveys

InSAR: an old technology with new applications

Interferometric synthetic aperture radar (InSAR), once limited to specialized research and military reconnaissance, has emerged as a pivotal technology in modern geospatial intelligence, offering highly precise and temporally rich measurements of ground deformation over time. While the core technique has been around for decades, recent advancements in satellite technology, data availability, and processing power have unlocked new applications that are transforming how we monitor and understand changes in the Earth's surface.

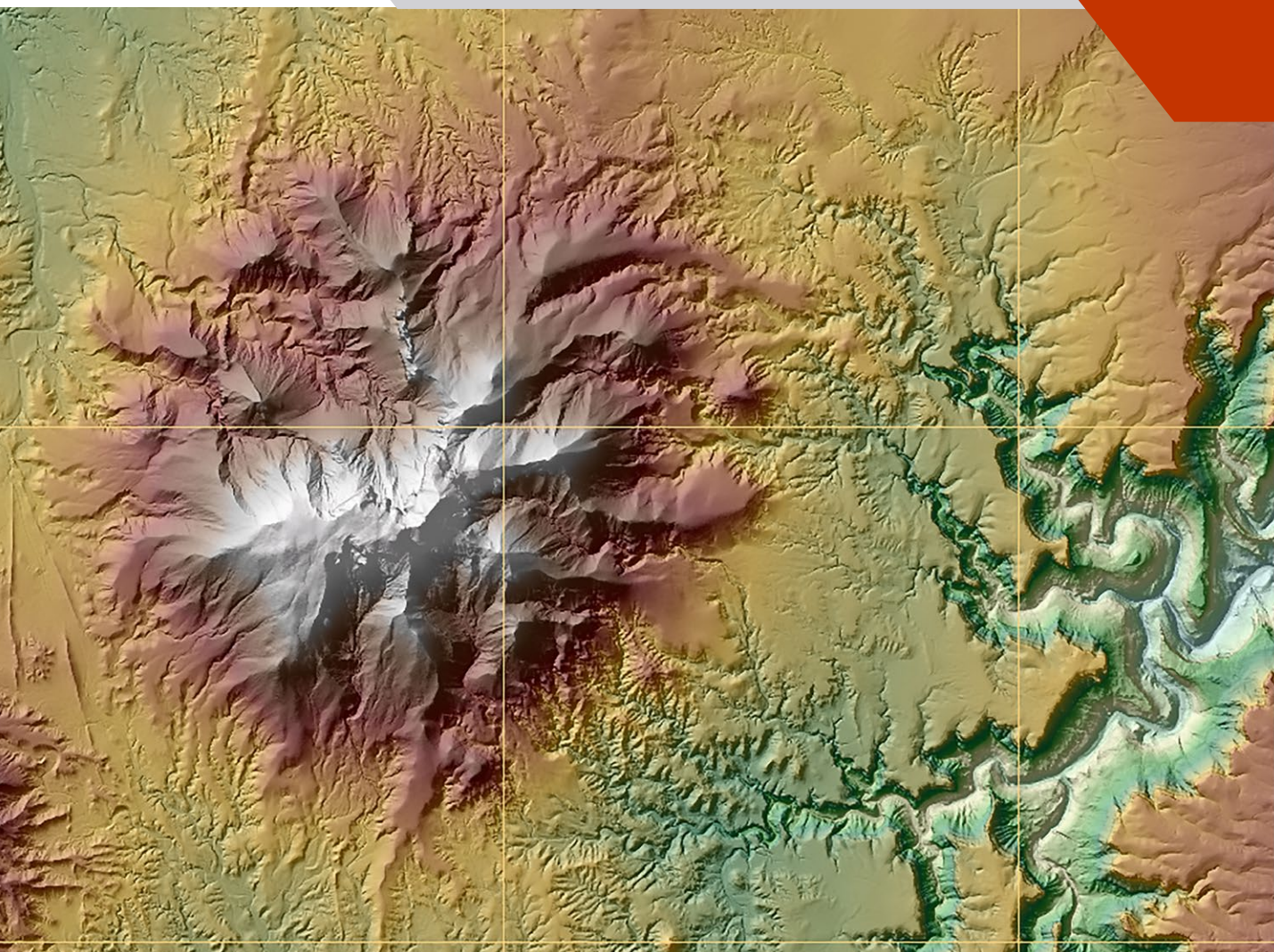
At its foundation, InSAR leverages the phase difference between radar signals acquired from orbiting satellites on multiple passes over the same area. These signals, reflected off the Earth's surface,

are processed to generate images called interferograms, which can reveal minute



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BY BRYAN DESLAURIERS, SIMONE FIASCHI, SARA DEL CONTE



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Figure 2: Lidar-derived DEM over the state of Utah.

changes, of the order of millimeters, in ground elevation over time.

Historically, InSAR was limited by the availability of suitable satellite data and the complexity of the processing workflow. However, with the advent of missions like the European Space Agency's (ESA) Sentinel-1, which provides free and open-access synthetic aperture radar (SAR) data, and of commercial constellations, high-resolution,

high-frequency radar imagery has become more readily available.

Moreover, advances in time-series analysis techniques, such as Persistent Scatter InSAR (PS-InSAR) and Small Baseline Subset (SBAS), have enhanced the accuracy and reliability of measurements when tracking long-term surface movements over hundreds of SAR images. Combined with modern cloud-based processing platforms and

powerful open-source tools, InSAR has entered a new era defined by routine, operational monitoring rather than episodic analysis.

This unprecedented accessibility has fueled a wave of innovative applications across the public and private sectors in environmental monitoring, disaster response, and infrastructure management. For instance, in the aftermath of an earthquake, volcanic eruption, or landslide, InSAR data can be used to map ground displacement over large

areas within days, even in regions that are otherwise inaccessible. Similarly, long-term monitoring of urban subsidence caused by groundwater extraction or mining operations can be conducted using historical InSAR data archives, providing decision-makers with a non-invasive, low-cost method to assess and mitigate geohazards.

As the demand for resilience and proactive risk management continues to grow, InSAR stands out as a cost-effective, scalable, and evolving solution that complements and enhances other remote sensing tools, such as lidar. While lidar excels at generating highly accurate 3D terrain models and structural detail, it represents a snapshot in time. In contrast, InSAR adds the temporal dimension, revealing how terrain or infrastructure is changing. Together, these technologies offer a comprehensive perspective on both form and function, enabling smarter decisions in urban planning, environmental management, and infrastructure resilience. While InSAR may be considered an old technology, its rebirth in the age of big data and remote sensing democratization makes it one of the most exciting tools in today's geospatial toolbox.

A brief history of InSAR

InSAR may be enjoying a resurgence in popularity today, but its conceptual roots date back over half a century. First developed as a military reconnaissance tool in the 1940s, modern InSAR emerged from the idea that repeated radar observations from orbiting satellites could detect changes in the Earth's surface through analysis of phase differences in the radar returns. Practical applications, however, were

limited by data scarcity and computational constraints.

For most of the 20th century, satellite-based remote sensing was focused on optical systems. SAR missions were very rare, and typically limited in spatial resolution, temporal coverage, and data accessibility. Radar imaging, especially the coherent processing required for interferometry, remained within the purview of government research laboratories and defense agencies, far from the reach of commercial use.

That changed dramatically in the 1990s. A defining moment came with the 1992 Landers Earthquake in Southern California. French researchers working with data from the ESA European Remote Sensing Satellite-1 (ERS-1) applied InSAR techniques to generate interferograms that visually represented ground deformation caused by the quake. These results were groundbreaking, as they not only revealed surface changes with unprecedented clarity, but also demonstrated that InSAR could offer a cost-effective, space-based alternative to traditional geodetic field surveys.

This event marked a turning point in the history of InSAR. The scientific community soon paid attention, and InSAR research proliferated. Throughout the late 20th century and early in the 21st, a series of new missions, including ERS-2, RADARSAT-1, and ENVISAT, expanded the availability of SAR imagery. With improved orbital repeat cycles and broader coverage, these missions allowed researchers to apply interferometric techniques to a growing number of use cases: glacier motion, volcanic activity, subsidence

from groundwater extraction, and infrastructure monitoring.

Still, challenges persisted. Processing SAR data into reliable interferograms remained resource-intensive, requiring specialized expertise and powerful computing systems. Moreover, SAR data was not always easy to obtain, as many missions continued to operate under restrictive data policies or were cost-prohibitive for routine monitoring.

The past decade, however, has seen an explosion of innovation and accessibility that has fundamentally reshaped the InSAR landscape. High-resolution SAR sensors are now common, and constellations from multiple national space agencies and commercial providers have put routine interferometric monitoring within reach for a wide range of users.

One of the most significant enablers has been the Sentinel-1 mission, launched in 2014 as part of the Copernicus program. With its open data policy, twin-satellite configuration, and C-band radar payload, Sentinel-1 has made continuous, global SAR coverage a reality. It dramatically lowered the barriers to entry for researchers and practitioners, spurring the development of open-source processing software and cloud-based analysis platforms capable of handling large volumes of data.

SAR imagery today typically utilizes three primary wavelengths and various ground resolutions, each suited to different geophysical characteristics. X-band (3.1 cm wavelength) generally provides finer spatial resolution ideal for urban and infrastructure applications. C-band (5.6 cm wavelength), used by Sentinel-1, strikes a balance between resolution and coherence, performing well in moderate vegetation.

L-band (23.6 cm wavelength), the newest of the three, offers superior penetration through vegetation, snow, and loose soil, making it useful to detect motion in certain land cover situations. The satellites housing these intricate systems move in a near-polar ascending, south to north, or descending, north to south, orbit.

As of 2025, nine active and four retired satellites, or constellations of satellites, are currently, or have been, in orbit around the Earth contributing to SAR data collection for InSAR applications. These include government-sponsored missions such as Sentinel-1 (ESA), ALOS-2 (JAXA), and the RADARSAT constellation (Canada), as well as newer commercial platforms such as COSMO-SkyMed Second Generation (Italy), which provide tasking and high-resolution imaging for commercial clients (**Figure 1**).

The most anticipated newcomer to the SAR assemblage is the joint U.S. National Aeronautics and Space Administration (NASA) and Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR) mission, successfully launched on July 30, 2025. NISAR is the first radar mission specifically designed to observe and monitor the Earth's dynamic processes on a global scale. Uniquely equipped with both L-band and S-band (9.4 cm wavelength) radar sensors, NISAR will deliver a powerful combination of surface penetration and temporal consistency. Its dual-frequency approach will enhance monitoring of ice sheets, coastal subsidence, forest biomass, and tectonic movement with unparalleled fidelity. Moreover, in line with NASA's commitment to open science, NISAR's data will be available to the public.

"NOAA and many others have identified InSAR as a reliable technology, in tandem with GNSS and lidar observations, to measure various types of land movement with high precision, including tectonic deformation from earthquakes, volcanic activity, ground subsidence due to fluid extraction, landslides, glacial flow, and even subtle changes in infrastructure stability. This in turn can help communities increase their resilience to coastal hazards. The expanding availability of InSAR-derived vertical land motion data offers an exciting opportunity to add an additional dynamic element to our models and maps so communities can pinpoint higher risk areas and improve their long-term planning efforts."

— Mike Aslaksen and Jamie Carter, NOAA

Enhancing lidar data with InSAR

Light detection and ranging (lidar) technology is considered the current gold standard for acquiring high-resolution elevation data. Whether deployed via aircraft, drone, or ground-based systems, lidar provides unparalleled detail for mapping terrain, vegetation, infrastructure, and coastal bathymetry. It is the backbone of topographic and bathymetric datasets used in everything from floodplain management to transportation planning. Despite its precision and versatility, however, lidar has limitations, particularly in cost, logistics, and its ability to monitor change over time.

Lidar systems emit laser pulses towards the ground and measure the time taken for those pulses to reflect back to the sensor. By doing so, scientists can calculate precise distances and generate dense point clouds that can be processed into three-dimensional digital elevation models (DEMs), canopy height models, and countless other derivative products (**Figure 2**). These outputs are typically accurate to within a few centimeters and can resolve fine-scale surface features that radar systems cannot detect. Nevertheless, lidar collection missions require favorable weather and ground conditions, and the use of

specialized equipment. The logistics of acquiring lidar data over large or remote areas can be resource-intensive. Thus such collections are usually infrequent, often spaced several years apart owing to cost and operational complexity.

In contrast, InSAR offers a complementary and increasingly indispensable tool for tracking surface deformation over time. While both sensors are able to function any time of day, InSAR uses radar signals from satellites that can penetrate cloud cover and operates regardless of weather conditions. This allows for the delivery of regular, repeatable observations over the same area (**Figure 3**). With the global SAR satellite constellations now offering revisit times of up to a few days in some regions, InSAR enables frequent monitoring of surface elevation changes.

The synergy between lidar and InSAR is where the real value emerges. Lidar provides the "what" in exquisite detail, a snapshot of the current surface, while InSAR provides the "when," revealing how that surface has changed over time. If used together, these technologies produce a more comprehensive picture of the state and behavior of the Earth's surface. For example, a high-resolution lidar survey may detect a depression or bulge in the landscape, but without repeated measurements the timing

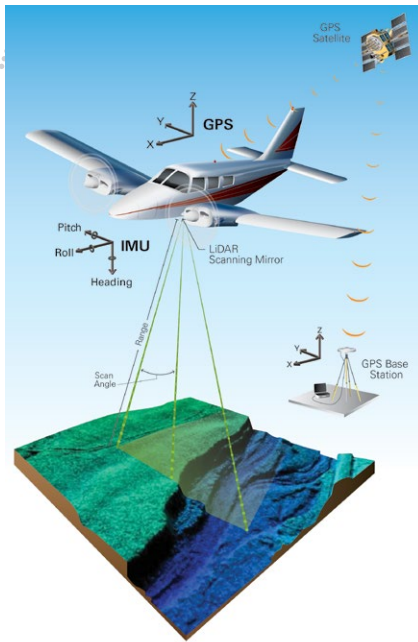


Figure 3: Comparison of lidar and SAR satellite data collection techniques. © 2025 Dewberry and © 2025 TRE ALTAMIRA

and cause of that feature may remain unclear. InSAR, on the other hand, can reveal whether that feature is actively changing, whether deformation or subsidence is accelerating, and whether it correlates with anthropogenic activities such as groundwater withdrawal or naturogenic events like tectonic shifts (**Figure 4**).

InSAR can also help guide and optimize lidar deployments. Given its low cost and frequent coverage, InSAR is well-suited for wide-area recognition to identify regions experiencing significant vertical movement, whether subsidence or uplift, that merit more detailed investigation. Once identified, these hotspots can be prioritized for high-resolution lidar acquisition to quantify change, validate deformation models, or assess risk to critical infrastructure. This targeted approach confirms that lidar is deployed where it can provide the greatest value, making the most of limited resources.

Conversely, lidar-derived elevation data is increasingly being used to

enhance the accuracy of InSAR processing. High-resolution DEMs generated from lidar can be used to correct for topographic phase contributions in InSAR interferograms, especially in areas with steep terrain or complex urban environments. This fusion of datasets improves the overall accuracy

of deformation measurements and facilitates more reliable interpretations.

A recent demonstration of an integrated data approach is the U.S. East and Gulf Coast Historical InSAR Analysis project completed by Dewberry and TRE ALTAMIRA for the National Oceanic and Atmospheric Administration's (NOAA) National Geodetic Survey (NGS). This involved NOAA's collaboration with Dewberry and TRE ALTAMIRA to conduct a large-scale analysis of around 3500 Sentinel-1 SAR images acquired along 17 different, ascending orbit tracks and covering more than 500,000 km² of the eastern seaboard of the U.S., from the Gulf Coast of Texas to the rugged coastline of Maine (**Figure 5**). The study spans six years (2017–2023) and delivered 150 million measurement points at full resolution, which were calibrated with NOAA's Continuously Operating Reference Stations (CORS) GNSS network. The quality of the vertical land motion data was confirmed

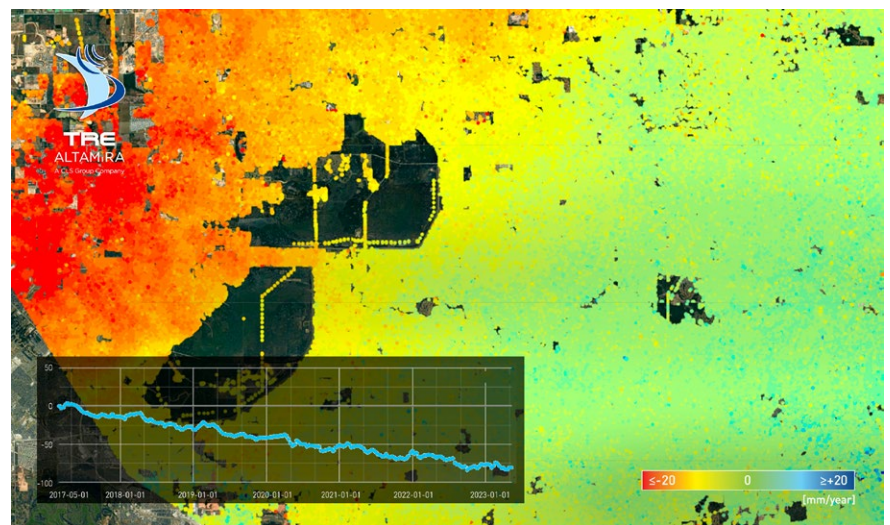


Figure 4: InSAR analysis of Houston, Texas. The data shows vertical ground displacement rates in the range of 20 mm/year. Contains modified Sentinel-1 data 2017-2023. © 2025 TRE ALTAMIRA.

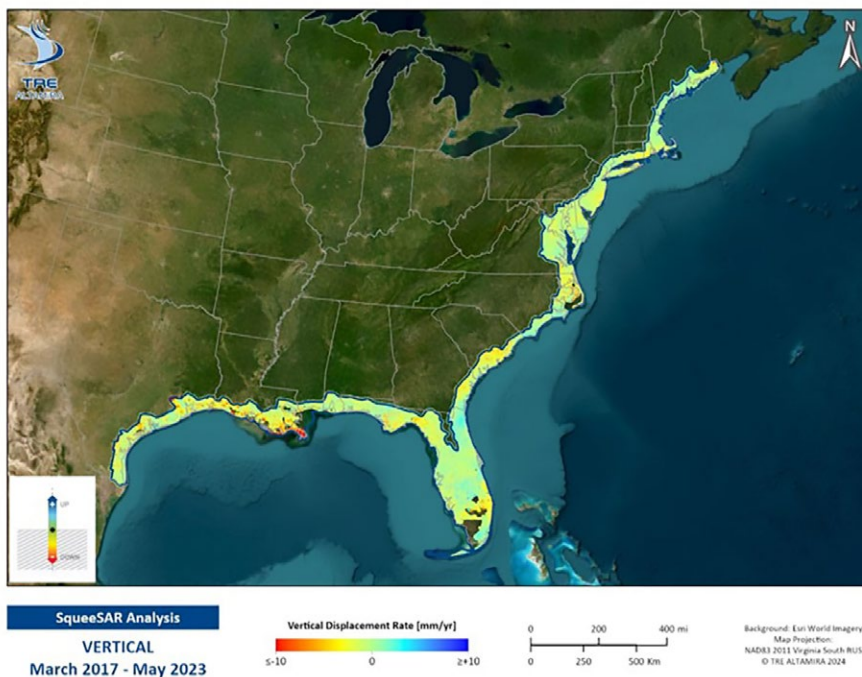


Figure 5: InSAR analysis for the NOAA U.S. East and Gulf Coast Historical InSAR Analysis Task Order. Contains modified Sentinel-1 data 2017-2023. © 2024 TRE ALTAMIRA.

by the submillimeter differences between InSAR and GNSS displacement rates, averaging a rate difference of 0.1 mm per year and a standard deviation of ± 0.3 mm per year. Using historical SAR data and advanced time-series InSAR techniques, the project provided a detailed picture of where and how the coastline is shifting due to subsidence, tectonic lift, and other geological processes.

These findings are already influencing how NOAA is approaching coastal resilience planning. InSAR results from this study are being used to verify vertical datums, inform sea level change projections, and prioritize regions for lidar and geodetic surveys. In places where InSAR detected persistent subsidence, such as parts of the Mid-Atlantic and Gulf Coast, NOAA can now deploy lidar and ground survey more strategically, validating deformation trends with high-resolution data and integrating the results into predictive models for flood risk and infrastructure stability.

The Dewberry and TRE ALTAMIRA project exemplifies the growing recognition that no technology alone can fully

address the challenges of a changing Earth. But when combined, they can produce a more complete, multidimensional view of the terrain – spatially, vertically, and temporally.

A harmony of solutions

As the geospatial industry continues to embrace integrated, multi-sensor solutions, the role of InSAR in augmenting lidar is expected to expand. With commercial SAR constellations now offering affordable, high-cadence data streams and lidar technologies advancing in portability and automation, the opportunities for constructive collaboration will only grow. Cloud-based platforms are already facilitating the fusion of InSAR and lidar datasets, enabling seamless workflows that leverage the strengths of each system in unified analysis.

In summary, InSAR does not replace lidar. It enhances it. By identifying where the surface is moving, how fast, and in what direction, InSAR promotes smarter, more focused use of lidar and other remote sensing resources.

Together, lidar and InSAR form a powerful framework for environmental monitoring, disaster response, land-use planning, and infrastructure assessment. They support proactive decision making by not only identifying existing conditions but also predicting future trends. This dual perspective is increasingly critical in an era of geographic discovery, urban expansion, and aging infrastructure. ¹



Bryan Deslauriers, CP, PMP, GISP is a senior project manager at Dewberry who specializes in managing projects focused on coastal resilience and hazard monitoring. He is also a subject matter expert in elevation and coastal management programs, bringing deep technical knowledge and practical insight to a wide range of geospatial solutions. In addition to his work with NOAA, Bryan also leads Dewberry's contract with the USACE St. Louis District to provide photogrammetry, lidar, surveying, and mapping services.



Simone Fiaschi holds a PhD in earth sciences from the University of Padova (Italy) and is an InSAR data analyst at TRE ALTAMIRA (Vancouver). With more than ten years of experience in earth observation, he is an expert in the analysis and interpretation of InSAR data for various applications, including geohazard and infrastructure monitoring at local and regional scales.



Sara Del Conte is a senior geospatial data analyst and technical advisor at TRE ALTAMIRA (Vancouver). She holds a PhD in earth sciences from the University of Florence (Italy) and has more than 15 years of experience in leading InSAR projects for mining, oil and gas, and natural hazards applications.

TRIMBLE

APPLICATIONS:

- REALITY CAPTURE
- MODELING
- CONSTRUCTION
- SURVEYING
- MAPPING
- GIS
- TRANSPORTATION
- INFRASTRUCTURE

COMPANY PROFILE

Trimble is a global technology company that connects the physical and digital worlds, transforming the ways work gets done. With relentless innovation in precise positioning, modeling and data analytics, Trimble enables essential industries including construction, geospatial and transportation. Whether it's helping customers build and maintain infrastructure, design and construct buildings, optimize global supply chains or map the world, Trimble is at the forefront, driving productivity and progress



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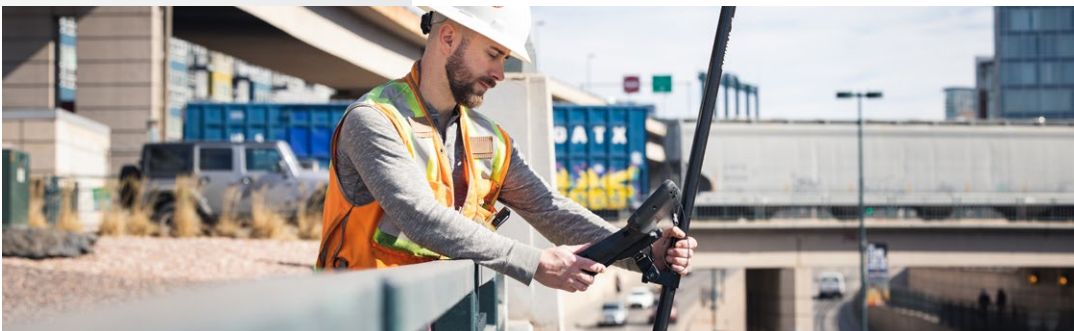
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Boost Efficiency and Data Reliability with Cloud-Enabled Survey Workflows

Disconnected data creates costly delays, rework and miscommunication. When field data is lost or incomplete, confidence erodes and efficiency suffers.

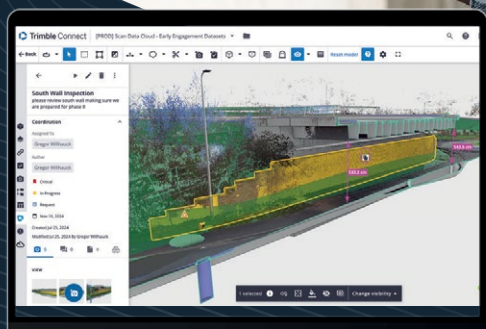
Trimble cloud-enabled survey workflows transform how teams operate. GNSS and total station data sync securely between field and office, enabling timely updates, seamless collaboration and full data traceability. Projects move faster, and decisions are based on the most current information—every time.



Turn complexity into confidence.

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Stonex USA

COMPANY PROFILE

Stonex is recognized as one of the world's leading companies in the production of measuring and surveying instruments, with headquarters in Italy and a dedicated office in the USA to support the North American market. With a global network of over 200 qualified distributors and partners, Stonex delivers high-quality products and services worldwide, ensuring customer support both during the purchase phase and in after-sales.

The company places maximum focus on innovation, offering advanced solutions for geospatial applications, precision positioning, GPS networks, and 3D scanning.

The Stonex portfolio includes:

- Total Stations (Conventional and Robotic)
- High-precision GNSS Receivers
- Handheld GPS/GNSS Solutions for GIS and Mapping
- CORS Network Systems
- Rugged Instruments for the Construction Sector
- Laser Scanners and 3D Scanning Solutions
- GIS, Topography, and Surveying Software
- Precision Farming and Machine Control Systems

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APPLICATIONS

SURVEYING

MAPPING

GNSS NETWORKS

GIS

3D SCANNING

MONITORING

PRECISION FARMING

MACHINE CONTROL

Stonex Laser Scanners are the Perfect Companions for Your Field Surveys

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Stonex laser scanners deliver precise and user-friendly solutions for detailed 3D point cloud collection.

The **X70GO SLAM** combines an inertial navigation module, high-performance computing, and a 360° rotating head to provide real-time, high-precision 3D model reconstruction. Its X-Whizz function merges mobile and stationary surveying seamlessly.

The **X120GO SLAM** offers 360°x290° coverage with a 360° rotating head and three 5MP cameras delivering a 200° horizontal and 100° vertical field of view. It's ideal for large-area surveys, including vehicle-mounted operations.

The **X200GO SLAM** is a versatile scanner designed for both mobile and static surveys, featuring extended range, high accuracy, and

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The **X40GO SLAM** is a lightweight, portable SLAM scanner perfect for quick indoor mapping and small to medium projects, combining compactness with reliable accuracy.

The **XVS vSLAM** Scanner is a unique handheld device integrating high-resolution images, inertial sensors, and advanced algorithms to generate 3D models via photogrammetry. It's as easy to use as a smartphone but powerful like a professional scanner.

The **X100** tripod scanner is compact and lightweight, suitable for fast indoor and outdoor scans with an integrated panoramic camera for colorized point clouds.



SLAM LASER SCANNER X70GO



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SBG SYSTEMS



APPLICATIONS

AIRBORNE
AUTOMOTIVE
DEFENSE
MAPPING
SURVEYING
UNMANNED

COMPANY PROFILE

SBG Systems is a leading French company specializing in high-performance motion sensing solutions. Founded in 2007 and headquartered in Paris suburb, it designs and manufactures cutting-edge inertial sensors such as IMUs, AHRS, and INS/GNSS systems. Leveraging MEMS technology, SBG Systems delivers compact, cost-effective, and highly accurate navigation tools for industries like aerospace, marine, robotics, surveying and autonomous vehicles. Their product are known for their precision and reliability in harsh environments. With offices in the U.S., Singapore, Germany, Australia, Japan, India, UK and other global locations, SBG Systems supports a worldwide client base. Their commitment to innovation, quality, and customer satisfaction has positioned them as a trusted partner in the field of inertial navigation and motion tracking.



1 avenue Eiffel
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sales@sbg-systems.com

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The New Ellipse: A Leap Forward in Inertial Navigation Technology

SBG Systems has unveiled the New Ellipse, an enhanced firmware upgrade available at no cost for all users of compatible Ellipse Series devices (version 3.x), including AHRS and INS models. This update transforms existing hardware into a more accurate, reliable, and versatile inertial navigation system ready for advanced applications across industries.

Precision and Stability Upgraded

The upgraded Ellipse features a cutting-edge sensor fusion algorithm that raises the bar in navigation performance. With improvements in attitude, heave, and position estimation, the device performs reliably even in high-dynamic conditions — from robotics and vehicles to marine operations — ensuring stable navigation under demanding environmental factors.

Robust GNSS-Denied Functionality

A standout feature of the New Ellipse is its enhanced GNSS-denied capability. It now includes built-in detection flags for GNSS jamming or spoofing events, allowing users to selectively disable or re-enable external

sensors without interrupting the internal estimation filter. This boost in operational awareness strengthens reliability in contested or signal-challenged settings.

Simplified Integration & Developer Tools

Designed for seamless deployment, the New Ellipse delivers full RESTful API support and an intuitive command-line interface for swift configuration. The upgrade simplifies integration within broader systems, enabling rapid setup and adaptation to unique project requirements.

Free Firmware Upgrade

The firmware is available as a free download from SBG Systems' website. Installation instructions are provided to guide users through the upgrade process.

With this firmware update, SBG Systems not only enhances its inertial navigation family but also reinforces its commitment to delivering advanced, field-ready solutions — all while adding substantial value for existing customers.



SBG SYSTEMS

Motion & Navigation
you can trust



Inertial Navigation Solutions

High-Performance INS for Surveying applications:

- High-performance in the Smallest Package
- Designed for Seamless OEM Integration
- Robust to Vibrating Environments
- Post-processing with Qinertia PPK software



Carlson Software

APPLICATIONS

(LAND) SURVEYING
MINING
(CIVIL) ENGINEERING
GIS
MAPPING
MACHINE CONTROL
CONSTRUCTION



COMPANY PROFILE

Carlson Software has innovated for the land development and mining industries with software and hardware solutions built to work for the clients that depend on them every day. As a one-source solution, we provide CAD design software, field data collection, and laser measurement products for the surveying, civil engineering, GIS, and construction industries.

We have a large user base and an exceptional rate of customer retention over our 41-year history, and we are the only company to provide free tech support since the day of our founding.

Our wide product range includes Carlson PhotoCapture for photogrammetry and UAV mapping, Carlson Precision3D for engineering design in 3D, and solutions that include SurvPC data collection software, data collectors, GNSS receivers, robotic total stations, and laser scanners.



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Integrated Photogrammetry + LiDAR Solutions

Carlson's photogrammetry solutions take you from flight planning, through image processing, to point clouds, to surfaces, elevation models, and CAD deliverables.

Carlson's solutions for photogrammetry and LiDAR range from sUAS solutions with LiDAR and photogrammetry capabilities to Carlson PhotoCapture, which provides powerful, versatile, scalable photogrammetry processing with LiDAR integration, to Carlson Point Cloud, which enables powerful point cloud manipulation and provides output to CAD. Carlson PhotoCapture is available in two versions:

Carlson PhotoCapture Online may be used on any device with access to the internet. All that's required is a yearly membership and the purchase of processing capacity as needed. No minimum monthly fees, and projects may be shared for collaboration with coworkers and clients.

Carlson PhotoCapture Standalone is for customers who need Carlson's photogrammetry

solution but want to process locally. Now anyone lacking high speed internet, working in remote locations, or requiring enhanced security has the option of bringing the ease and power of PhotoCapture to their own computers.

Carlson Point Cloud provides powerful tools for processing of point cloud files from aerial or surface sources, whether of laser or photogrammetric origin. Employ the bare earth filters to create surfaces, or use the identified above-ground cloud for feature extraction of point clusters. Use point cloud files to create profiles, sections, contours, breaklines, and finished plats, or export surface models, points, linework, etc. to CAD.

Whether you're working with public LiDAR data, fly your own UAV, or work with terrestrial scanner files, Carlson's industry-proven solutions provide the workflow options to produce the deliverables you need for your clients.

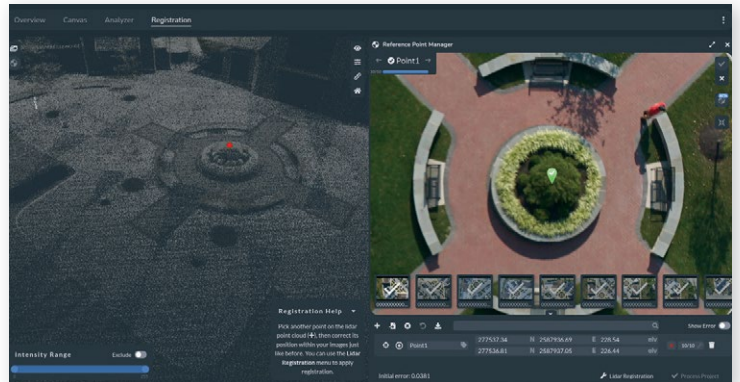
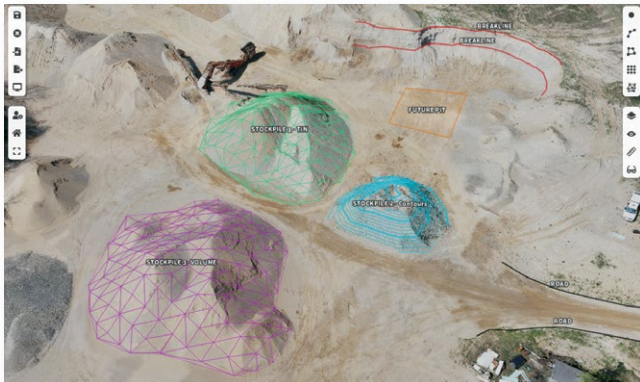
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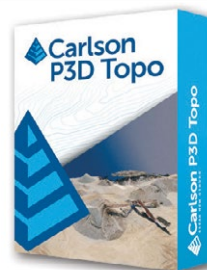
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- Export in a wide variety of file formats



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GEOCUE

APPLICATIONS

MAPPING
PROCESSING
SURVEYING
UNMANNED
AERIAL
CONSULTING



COMPANY PROFILE

GeoCue is the largest supplier of kinematic lidar processing tools in North America and LP360 is one of the world's most widely used tool for exploiting point cloud data. In 2022, GeoCue and Microdrones joined together to bring geospatial experts the very best in drone surveying equipment, geospatial software, workflow, training and support for high accuracy LiDAR and drone mapping to help civil engineering and surveying professionals achieve successful data collection, processing, and management.

With TrueView drone LiDAR/Imaging sensors, LP360 point cloud data processing software, and fully integrated systems from Microdrones, we are the leader in LiDAR mapping processing in North America able to meet customers where they are in terms of technology adoption, budget, and resources.



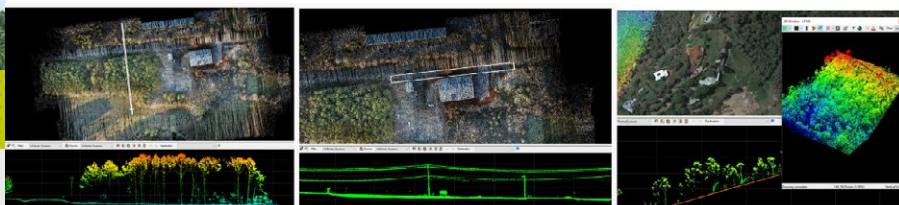
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GeoCue's True View 3D Imaging Sensors offer an innovative drone mapping solution supporting LIDAR, photogrammetry, and direction geo-referencing solutions integrated in lightweight payloads. GeoCue focuses on offering full solutions rather than individual parts. Unlike other drone LIDAR providers, GeoCue includes post-processing software and a data management portal to provide users with a complete solution from flight to post-processing and data delivery.

Utility-Grade to Survey-Grade 3D Imaging

GeoCue offers a series of True View 3DIS systems ranging from utility grade to survey grade ensuring successful drone mapping projects no matter the application. The True

View 3DIS includes all the components and software necessary to collect LIDAR and RGB image data and process these data to a 3D colored point cloud in LAS format. True View systems use Applanix POS for best-in-class position and orientation accuracy.

LP360 LiDAR & Photogrammetry 3D Point Cloud software

Whether it's airborne or terrestrial collected LIDAR data, 3D point clouds have become a critical element in mapping. LP360, an advanced desktop LIDAR software package, makes easy work of extracting information and generating deliverables in an intuitive GIS environment. Now, with an ever-growing collection of cloud-based tools and resources that will make it easy for you to manage, archive, share and collaborate on geospatial projects.



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Process, analyze, and maximize L1/L2 LiDAR survey data, producing valuable information and deliverables



Manage your coordinate
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Advanced tools



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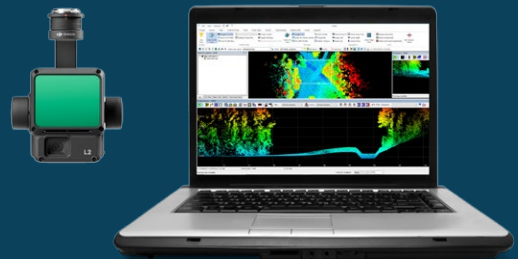


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Breaking Through: Integrating Mobile Mapping and Ground-Penetrating Radar for Better Infrastructure Intelligence

Three use cases demonstrate how combining mobile and subsurface mapping technology produces comprehensive 3D digital twins to document utility and transportation infrastructure.

For years, the promise of seeing beneath the surface to reveal hidden infrastructure remained just out of reach for widespread adoption in utility and transportation infrastructure projects. With technological advances such as AI adoption,

ground-penetrating radar (GPR) is becoming more fully integrated into broader civil infrastructure workflows. Previously, GPR processing to extract information from the raw data could be laborious, but in recent years software has made significant progress.

Despite historical challenges, sensor integration is now transforming surveying, civil engineering, and road construction/maintenance by offering accurate and efficient methods to generate comprehensive datasets. Mobile mapping is widely used to capture large

BY SKYLER NEUMEYER



Figure 1: Views of the Trimble MX60 MMS, which contains an accessory port for the connection of complementary systems such as GPR.

volumes of geospatial information more quickly than traditional survey processes (**Figure 1**), and multi-array GPR plays a crucial role in locating buried utilities and detecting subsurface pavement anomalies. Integration of the two technologies enables simultaneous data collection at normal driving speeds, eliminating traffic interruptions and greatly reducing exposure to hazards for the field crew.

The data from these complementary technologies can produce an all-inclusive 3D digital twin that provides critical information about above- and below-ground features to all stakeholders, which benefits the construction and management of utility and transportation infrastructure.

Three recent use cases demonstrate methods of combining mobile mapping and GPR and describe the benefits.

WestLAND Group: Integration yields intelligent dataset

Based on decades of experience, multi-discipline engineering and surveying firm WestLAND Group (WLG)¹ knew that most large-scale construction projects required data both above and below the surface. Matthew H. Okubo, president, principal partner, and licensed land surveyor at WLG,

decided to explore how simultaneous data collection could, "... save time, reduce the number of trips, and provide an underground constraints map before breaking ground."

Mobile mapping systems (MMSs) are commonly used to obtain pre-construction survey data and as-built information, while the collection of underground data was traditionally done by people walking along a street with a GPR pushcart, often putting them in danger near traffic. New GPR

technology installed on a vehicle is replacing the time-consuming manual process, making large-volume GPR data collection feasible for the first time.

WLG experimented with the integration concept by installing a multi-array GPR and a Trimble MX9 MMS on the same vehicle (**Figure 2**)², so that

² Further detail on WLG's system and its operation is available in videos: <https://youtu.be/buGtoOgcmk8>; <https://youtu.be/9qOpMRauTvK>; <https://youtu.be/qMZ-KOYwuz0M>.



Figure 2: WLG's equipment for data collection. A Trimble MX9 MMS is mounted above the bed of the pickup truck and an impulseRADAR Raptor GPR system mounted to the rear.

¹ <https://westlandgroup.net/>

point-cloud data, imagery and GPR data could be collected simultaneously at normal driving speeds.

“The physical integration of hardware isn’t difficult, but bringing the data together in the processing phase can be more of a challenge,” says Okubo. “The mobile mapping point cloud is fairly simple to interpret visually, but understanding the subsurface data requires a different expertise.”

After perfecting the process, WLG is confident that the sensor integration produces reliable results to support data collection for design and construction activities. The possibility of serious injury to workers is significantly reduced, with the added benefit that GNSS positioning from the MMS improves the accuracy of the GPR data. Integrating advanced technology allows WLG to achieve better results while maintaining high productivity.

Kontur: Subsurface detection averts trouble

Around the world, government entities are struggling to keep up with repairs and maintenance on extensive transportation networks as bridges and roadways deteriorate and create driving hazards. Expanding the use of mobile mapping and GPR for asphalt and roadway management would help with early detection of surface problems like potholes and subsurface issues such as sinkholes, cracks, delamination and stripping.

Departments of Transportation would benefit from cost-effective pavement data collection to help avoid larger, more costly problems in the future. Automated tools for pavement analytics are now available to review large volumes of data and prioritize



Figure 3: Cargo van with Trimble MX50 MMS mounted on the roof and Kontur AIR system mounted to the rear.

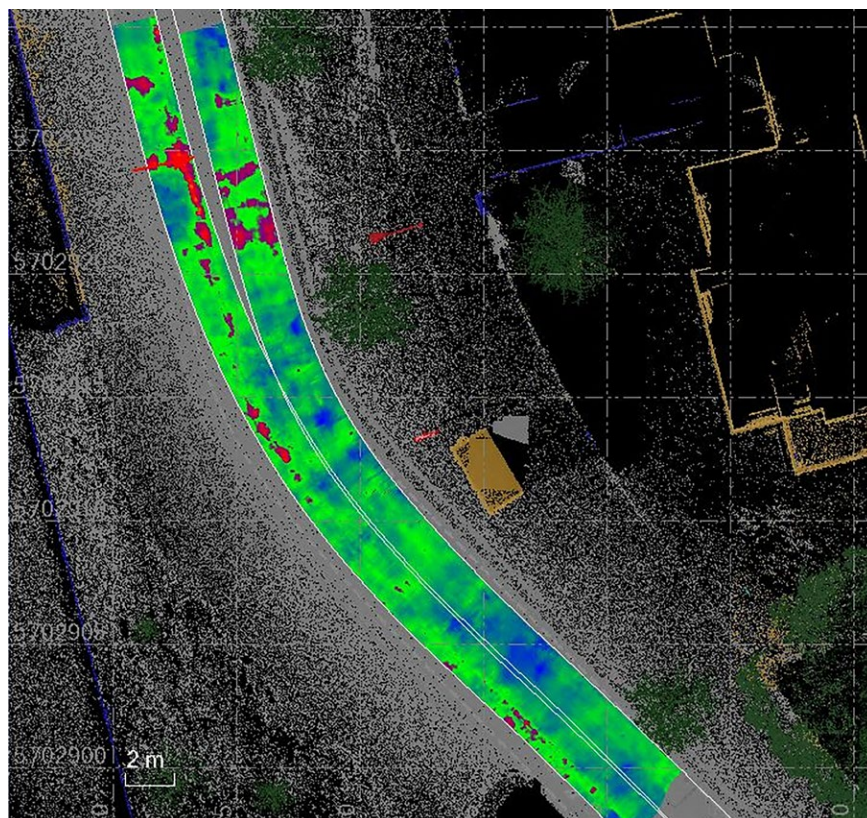


Figure 4: Results obtained from MMS and GPR system developed under a joint project conducted by Trimble and Kontur.

repairs and better support predictive and proactive routine maintenance.

Norwegian company Kontur³ manufactures multi-array GPR units suitable for transportation infrastructure projects and subsurface utility location. In 2024, Trimble and Kontur executed a joint project in Italy that involved capturing data from a vehicle equipped with a Trimble MX90 mobile mapping system and a Kontur GPR system (**Figure 3**). The data-processing workflows were aligned to improve data integration and report generation (**Figure 4**). The use of Trimble Business Center software and Kontur software in combination resulted in enhanced data interpretation.

Italgas: Digital twins go underground

As part of its digital transformation strategy, Italgas⁴ has pioneered 3D Asset Mapping, a comprehensive digital twin of its gas distribution network, capturing both surface and subsurface infrastructure across its service area. This initiative enhances operational efficiency, improves safety, and streamlines maintenance and planning activities.

Starting with a pilot project focused on 5500 km of pipeline, Italgas implemented a new process for field surveys to identify underground gas pipes using georeferenced geo-radar scans, while simultaneously collecting lidar and panoramic images above ground.

They placed a GPR antenna on a van and installed a Trimble MX50 mobile mapping system on the roof of the same vehicle. In addition to being fast and accurate, vehicle-based data capture is conducted without interrupting traffic and avoids placing the field crew in danger.

The new mapping approach was deemed a success and was extended to the entire service area. The workflow from field to data processing is fully integrated to create a digital twin that is regularly updated and available on the web at any time or place, including information on surface and subsurface infrastructure elements. Any problems related to asset depths can be identified to prevent excavation accidents, and convenient sharing of information yields time savings for operations, emergency response and other third-party subservices.

Italgas benefits from access to up-to-date and complete information, which reduces costs and improves efficiency and safety. The integration of all known GIS asset information with mobile mapping and GPR data provides a true 3D digital reconstruction of the network.

Bridging surface and subsurface

The integration of mobile mapping and 3D GPR technology represents a significant advance in infrastructure management, bridging the gap between surface and subsurface data collection that has long challenged the industry. By combining these complementary technologies on a mobile platform

capable of simultaneous data capture, the barriers of operational complexity, safety risks, and traffic disruption have been substantially reduced. This evolution transforms what was once a specialized, time-intensive process into a routine data collection operation that can be seamlessly integrated into standard infrastructure workflows.

The resulting comprehensive 3D digital twins provide stakeholders with visibility into both above and below-ground infrastructure networks, enabling more informed decision-making throughout project lifecycles. As these integrated systems continue to mature, they are positioned to become the new standard for infrastructure asset management, utility coordination, and transportation planning. The technology's ability to deliver accurate, efficient, and safe data collection while producing digital representations of complex infrastructure networks marks a turning point in civil engineering and construction practices, promising to enhance project outcomes while reducing costs and risks associated with subsurface uncertainties. ■



Skyler Neumeyer is an applications engineer on the Mobile Mapping team within Trimble's Field Systems Division. He began his work with the group during the launch of the MX9 system, later transitioning to Trimble's machine control solutions before returning to Mobile Mapping during the development of the MX90 and MX60. Today, Skyler plays a key role in bridging customer needs with engineering and development teams. He focuses on supporting emerging workflows, addressing specialized system applications, and serving as a technical resource for both customers and sales teams.

3 <https://www.kontur.tech/>

4 <https://www.italgas.it/en/>

Woolpert

APPLICATIONS

GEOSPATIAL

ARCHITECTURE

ENGINEERING

LIDAR

COMPANY PROFILE

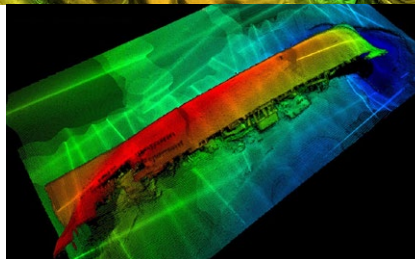
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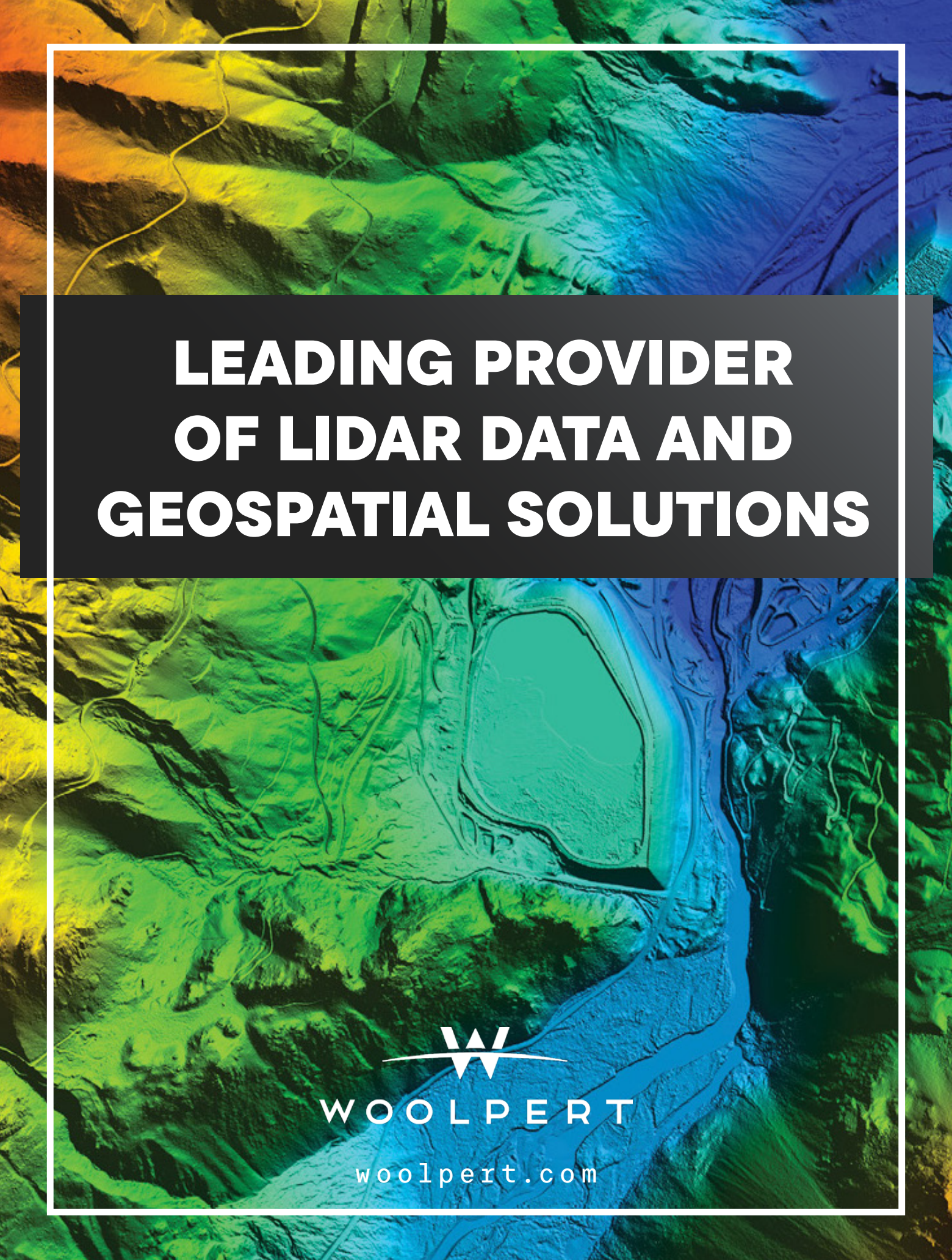
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Woolpert is a Leading Global Provider of Advanced, Comprehensive Geospatial Solutions

Woolpert lives where proven methodology and disruptive technology collide. As a leading provider of state-of-the-art geospatial services, we see how the locations of our world relate to each other. For more than five decades, we've applied our big-picture view to some of the country's largest regional and national geospatial projects—and our panorama now includes nations around the globe.

Woolpert is known worldwide for our high-resolution lidar and sonar; proprietary sensor development; mobile fleet of crewed and uncrewed aircraft, vessels, and vehicles; and accurate data processing. Joined by family companies Murphy Geospatial and Bluesky, we help to set the standards for data collection, and we lead global conversations about the application of geospatial information to a myriad of real-world challenges, including disaster response, seafloor mapping, land management, and defense and intelligence.

The background of the entire image is a high-resolution aerial photograph of a river delta, likely the Mississippi River Delta. Overlaid on this photograph is a color-coded elevation map. The colors range from dark blue (low elevation) to yellow and orange (high elevation), showing the intricate patterns of the river channels and the surrounding land. The text is centered in a dark grey rectangular box that spans across the middle of the image.

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SURVEY

MGIS

UNMANNED

SCANNING

MONITORING

PRECISION AG

BUILD & CIVIL
CONSTRUCTION

COMPANY PROFILE

Frontier Precision's measure of excellence can be traced to 1988. We've been at the forefront of technology, continually offering customers new tools and solutions, all with our end goal of making our customers more efficient, productive, and profitable with today and tomorrow's technology. Frontier Precision is an employee-owned company—offering solutions in Survey, Mapping & GIS, Drones/UAS/Unmanned, Build Construction, Civil Construction, Scanning/Imaging, Mosquito & Vector Control, Precision Ag, Water Resources, and Invasive Plant Control. We became one of Trimble's largest geospatial dealers worldwide by offering our customers the solutions they need. Every day, we bring it to life by seamlessly connecting our physical and digital worlds to use technology to improve how we interact better with the earth—in all kinds of meaningful ways.



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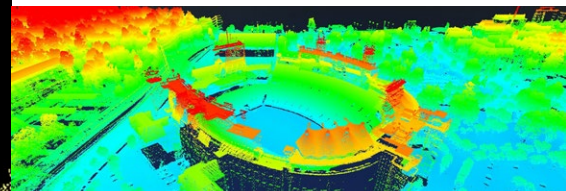
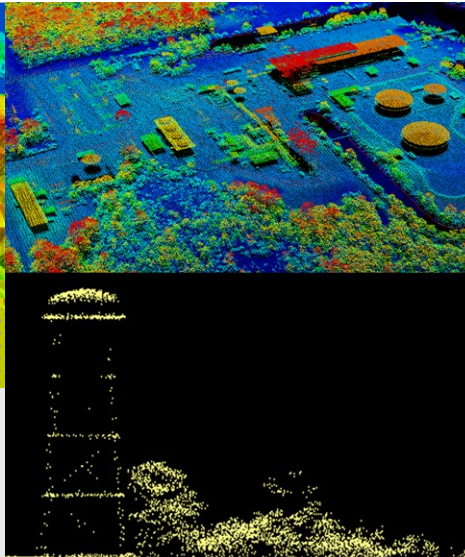
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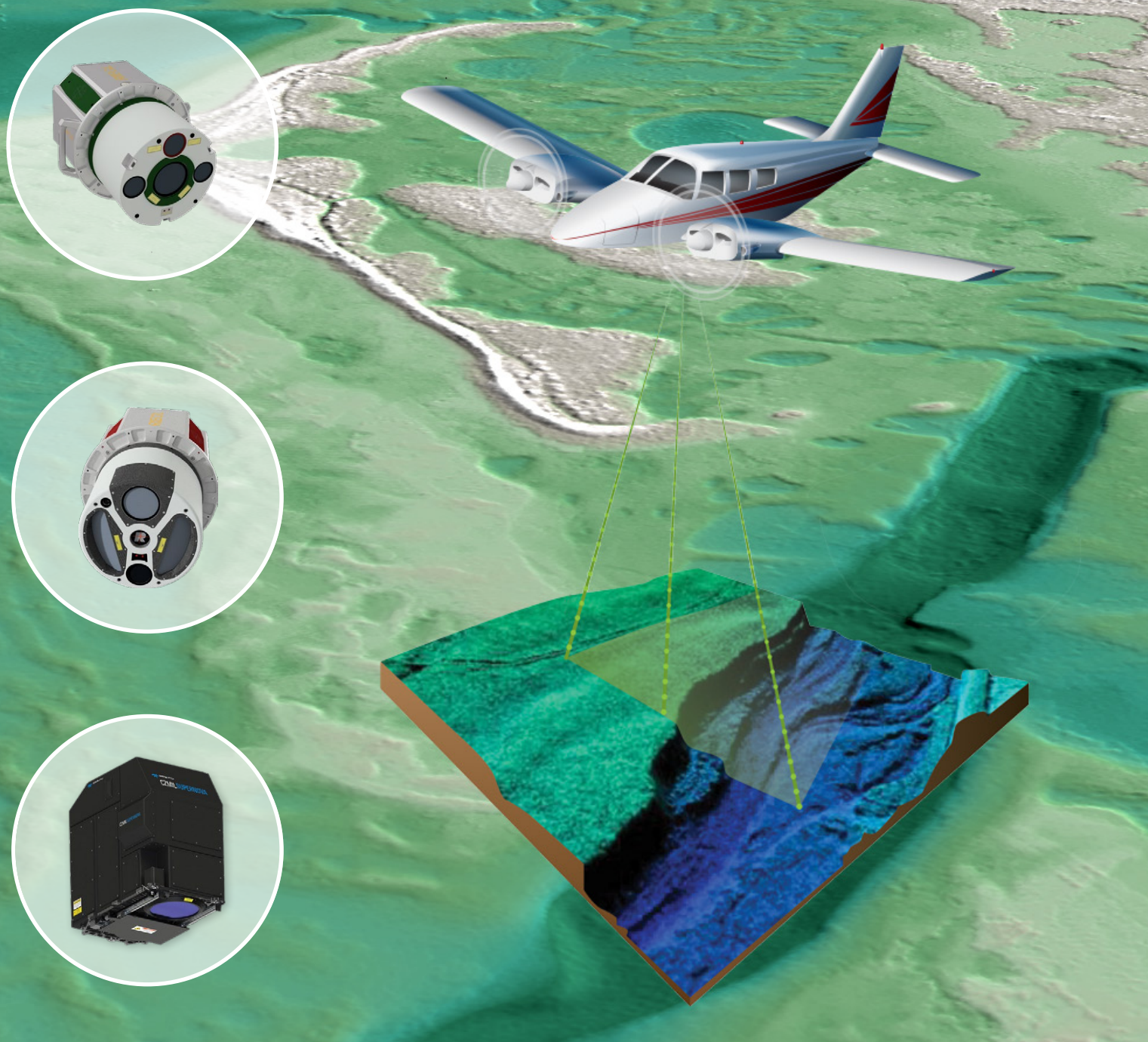
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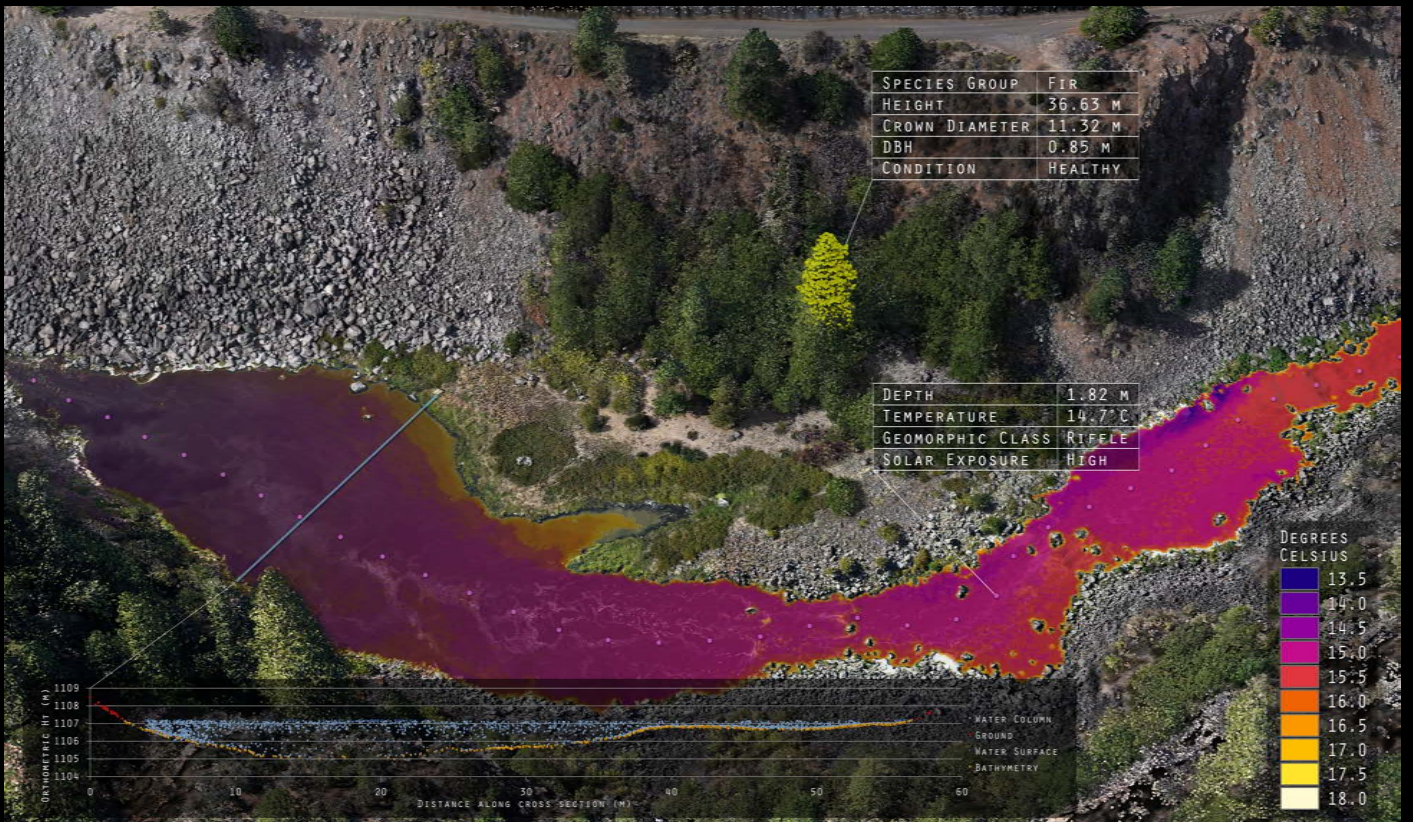
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Classified RGB-colored lidar point cloud of Lübeck, Germany. This type of high-resolution 3D data, showing buildings, vegetation, and infrastructure, forms the basis for Germany's nationwide Digital Twin project. The initiative, coordinated by the Federal Agency for Cartography and Geodesy (BKG), aims to deliver a consistent, classified lidar dataset to support environmental management, urban planning, and infrastructure monitoring across the entire country.

Elevations for the Nations

Understanding
Europe's varied
approach to lidar
mapping

PART III

Mapping activities for the United States are centrally regulated for a land area of 3.8 million square miles, whereas lidar coverage of Europe's 3.9 million square miles is managed through a complex patchwork of governance levels—sometimes nationally, sometimes regionally, and occasionally at even more localized levels.

The European Union still does not regulate mapping activities at the supranational level; instead, this responsibility is distributed across various administrative levels within and below Member States. Consequently, lidar coverage across Europe varies not only between countries but also within

them, leading to fascinating variations and distinctive characteristics that reflect different political structures and administrative traditions.

This fragmented approach has created a complex panorama where some areas boast extensive, cutting-edge lidar datasets, while others remain in the early stages of implementation. Access to funding often proves crucial, as many public agencies responsible for lidar coverage lack dedicated budgets and instead rely on commissions from other public organizations for specific projects—such as flood risk assessment or forest monitoring.

Building on previous installments that explored lidar progress in Denmark,

BY ADA PERELLO

Finland, France, the Netherlands, Portugal, Spain (Elevations for the Nations)¹; and Belgium, Poland, Romania, Switzerland, and the United Kingdom (Elevations for the Nations II)², the European Association of Aerial Surveying Industries (EAASI)³ continues its survey of national mapping agencies across the continent. This third part examines the current state of lidar mapping in **Austria, Croatia, Germany, Greece, and Italy**—five countries that illustrate both the challenges and remarkable achievements emerging within Europe’s diverse geospatial landscape.

Austria: from regional response to national coordination

Austria has a long-standing tradition of using airborne laser scanning (ALS) for public administration, environmental monitoring, and scientific research. For many years, however, lidar coverage developed through regionally driven initiatives. Each of the country’s nine provinces (Bundesländer) carried out ALS campaigns based on their specific needs, technical capabilities, and available funding. While this decentralized approach yielded important datasets—especially in flood-prone and alpine regions—it lacked uniform standards or national coordination.

The adoption of ALS accelerated in the early 2000s, particularly following the catastrophic flooding in 2002, which

exposed the need for more accurate terrain data to support hydrological and risk-management planning. In response, several Austrian provinces initiated their own lidar programmes. Between 2005 and 2010, repeated ALS acquisitions were conducted in specific regions, often triggered by natural events such as the 2005 floods. The province of Vorarlberg, for example, developed a recurring lidar dataset to monitor river dynamics and assess geomorphic changes caused by flooding.

In the 2010s, projects like ENVICHANGE integrated ALS data with satellite imagery for multi-temporal environmental monitoring. These initiatives focused on mountainous regions, particularly in the western part of the country, where lidar helped detect rockfall hazards, monitor forest boundaries, and assess the condition of protective infrastructure. These regional efforts created a solid foundation for what has now become a more structured and nationally coordinated system.

Today, Austria is steadily progressing toward full national lidar coverage, supported by a strong partnership between federal and provincial authorities. Data acquisition is now carried out for approximately 55 percent of Austria’s territory by the Federal Office of Metrology and Surveying (BEV)⁴, with access to this data secured for the provinces by cooperation. While data collection continues to follow regionally agreed priorities, national coordination has significantly improved, leading to more standardized data products across the country.

BEV plays a central role in this process, offering a unified national digital terrain model (DTM) derived from ALS data at a 1-meter resolution, along with a 1-meter

resolution digital surface model (DSM). Both datasets are produced in close collaboration with the provinces. For broader-scale applications, a 10-meter DTM is also available. However, this coarser model is not derived from ALS data but from stereoscopic analysis of aerial images. This method, which covered small parts of Austria each year, is being phased out in 2025. The dataset will remain available, but no further updates will be made.

Austria’s geospatial infrastructure is further strengthened by a well-established aerial image acquisition programme. Since 2010, the entire country has been photographed every three years using digital large-format cameras that capture RGB and near-infrared (NIR) bands. These aerial images support the production of orthoimages at a 20-cm ground sampling distance and contribute to the creation of DSMs. While historical aerial imagery dating back to 1949 is maintained in BEV’s archives, the number of analogue images no longer increases, as all current data collection has transitioned to digital platforms. The 0.5-meter DSM, produced through automatic image matching from aerial photographs, will continue to be updated regularly.

A key advancement in Austria’s geospatial framework is the establishment of a common minimum standard for ALS point density. In recent years, the minimum standard has been set at eight points per square meter (ppsm), ensuring high-quality data suitable for a wide range of applications. In some specialized research areas or pilot projects, point densities have reached as high as 15-24 ppsm.

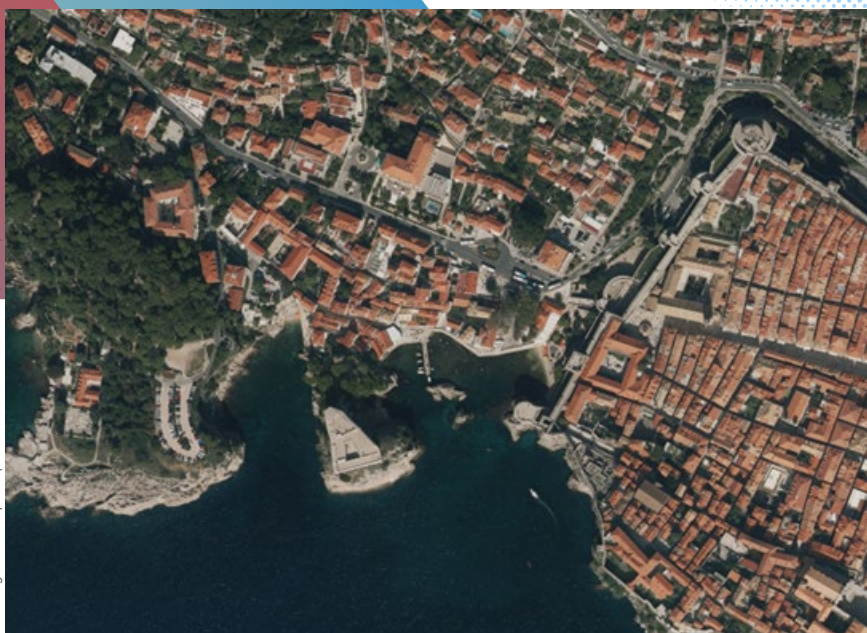
Complementing the elevation models, BEV released a national land cover dataset in 2024 with a spatial resolution of 20 cm. The dataset classifies

1 Perello, A., 2023. Elevations for the nations: understanding Europe’s varied approach to lidar mapping, LIDAR Magazine, 13(3): 41-45, Fall 2023. <https://lidarmag.com/2023/10/07/elevations-for-the-nations/>

2 Perello, A., 2023. Elevations for the nations: understanding Europe’s varied approach to lidar mapping, Part II, LIDAR Magazine, 14(3): 40-48, Fall 2024. <https://lidarmag.com/2024/09/22/elevations-for-the-nations-part-ii/>

3 eaasi.eu

4 <https://www.bev.gv.at/en.html>



Aerial view of Dubrovnik, Croatia, one of many European cities benefiting from high-resolution lidar data for urban planning and heritage conservation. The EAASI Summit 2025 will take place here (18-21 November 2025), gathering aerial surveying leaders from across Europe.

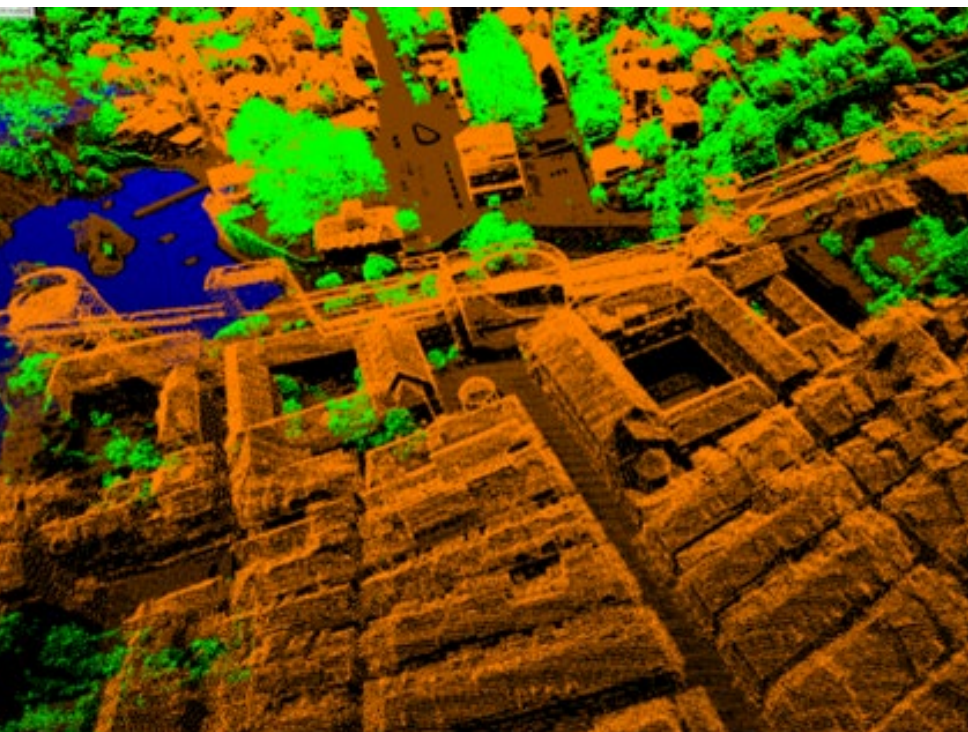
acquisitions driven by shared priorities, Austria is well-positioned to support environmental resilience, smart infrastructure planning, and advanced geospatial analysis.

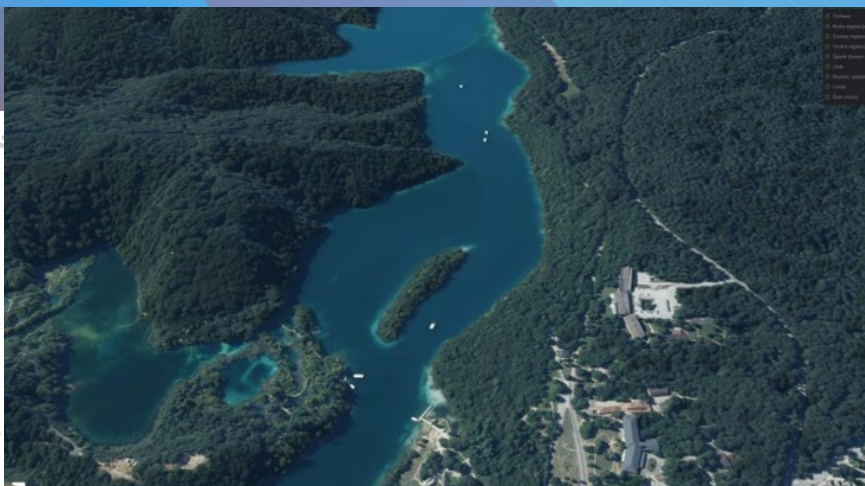
Croatia: European leadership in national coverage

In just a few years, Croatia has positioned itself as a European leader in lidar data acquisition, accessibility, and application. Between 2022 and 2023, the country successfully completed a nationwide airborne lidar campaign covering its entire territory. Simultaneously, high-resolution corridor surveys were conducted along 3501 kilometers of riverbanks, targeting areas of particular relevance for hydrology, flood risk, and environmental management.

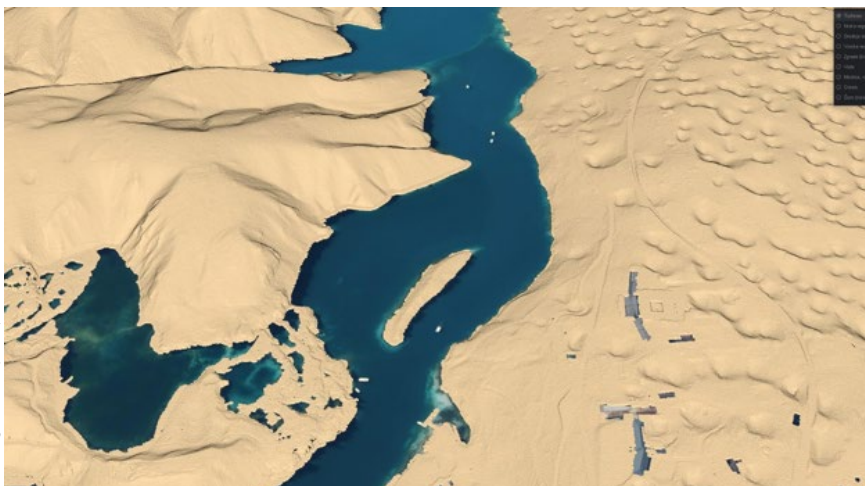
The scale and technical quality of Croatia's recent efforts place it among

Lidar point cloud visualization of Dubrovnik's historic Old Town, Croatia, showcasing the detailed three-dimensional mapping capabilities achieved through the country's nationwide campaign, which was completed in 2023. The color-coded data reveals building structures (orange), vegetation (green), and water surfaces (blue) with exceptional clarity. Croatia's ambitious lidar program achieved point densities exceeding 15 ppsm nationally, with some areas reaching over 40 ppsm—making it one of Europe's most detailed national datasets and demonstrating how advanced lidar technology can capture both cultural heritage sites and natural landscapes with unprecedented precision.





Digital terrain model visualization of Plitvice Lakes, Croatia, demonstrating the precision of lidar technology in capturing complex karst topography and hydrological features. The bare-earth model reveals the intricate limestone formations and terraced lake system that characterize this UNESCO World Heritage site. Croatia's nationwide lidar campaign, completed in 2023, achieved exceptional point densities that enable detailed analysis of such sensitive environmental areas, supporting both conservation efforts and sustainable tourism management in the country's most visited national park.



3D view of the lidar-derived DTM textured with high-resolution aerial imagery at Plitvice Lakes National Park, showcasing the country's comprehensive approach to geospatial data collection. The crystal-clear waters and dense forest canopy illustrate the challenging terrain conditions that Croatia's advanced lidar systems successfully penetrated during the 2022-2023 nationwide survey. With point densities exceeding 15 ppsm, the dataset provides unprecedented detail for monitoring this fragile karst ecosystem, where water levels and forest health are critical indicators of environmental stability.

Europe's frontrunners. The lidar survey was meticulously planned according to international standards for large-scale and national mapping projects. Original specifications called for minimum point densities of 4 ppsm in non-urban areas, 8 ppsm in urban environments, and 20 ppsm along river corridors. The final results far exceeded expectations: the national average reached over 15 ppsm across the entire territory, while river corridor areas achieved densities exceeding 40 ppsm. These figures represent one of the highest standardized lidar datasets available in Europe today.

Equally notable is Croatia's open data policy. In accordance with national regulations promoting transparency and innovation, all lidar products are freely accessible to users. This policy has already yielded impressive

results. Within the first year of data availability, more than 600 users across public authorities, academia, private industry, and civil society downloaded and utilized the datasets. Applications span urban and spatial planning, environmental protection, disaster risk management, infrastructure development, and scientific research. This high level of engagement demonstrates both strong domestic demand and readiness for broader regional integration. Access to the data is available via the State Geodetic Administration website⁵.

Croatia is also positioning itself as a potential contributor to a future pan-European lidar dataset. Its national program demonstrates both technical capability and commitment to open

access that aligns well with European Union data strategies. The combination of complete coverage, exceptionally high point density, and unrestricted availability offers a valuable model for other countries in the region.

Germany: federal structure meets national vision

Germany's approach to lidar data acquisition reflects the country's federal political structure. For years, airborne laser scanning campaigns, data processing, and public access were managed individually by each of the 16 federal states (Bundesländer). This decentralized model resulted in widespread but uneven lidar coverage, with variations in data formats, point densities, update cycles, and access policies. However, this structure also enabled states to tailor

5 <https://dgu.gov.hr/>

data collection to local needs and build early momentum in key applications such as forestry, flood modeling, and archaeology.

By 2025, nearly all of Germany will have been surveyed at least once with lidar, with most states offering DTMs and DSMs at one-meter resolution (DGM1). Point densities across these state-led initiatives typically range from 4 to 8 ppsm, though higher densities—10 to 20 ppsm—are occasionally achieved in urban or specialized areas. Data acquisition usually occurs during

Geodesy (BKG⁶) as part of the “Digital Twin Germany” project. Running from 2024 to 2026, this federal initiative aims to generate a consistent, high-resolution, three-dimensional dataset for the entire country. Unlike earlier state-led efforts, the federal campaign is conducted during the vegetation season and includes the acquisition of both lidar and aerial imagery from the same platforms. Sensors such as the RIEGL VQ-1560 II-S, VQ-1460, VQ-780II-S, and Leica SPL100 are being deployed across eight regions simultaneously.

A national point density of 40 ppsm has been selected—a resolution first tested in a 2021-2022 pilot project in the Hamburg metropolitan area. This density represents a practical balance: dense enough to support high-precision applications such as three-dimensional object recognition, vegetation structure analysis, and infrastructure modeling, yet still viable in terms of cost and processing. The full dataset is expected to be available to the federal administration by mid-2026, with broader public access likely to follow.

Lidar data in Germany already supports a broad spectrum of applications, including flood risk mapping, environmental monitoring, transportation planning, and cultural heritage conservation. The Digital Twin Germany project is expected to significantly expand these capabilities. Once the nationwide dataset is complete, federal authorities plan to perform change-detection analyses using repeat acquisitions to identify temporal trends in land use, vegetation, and infrastructure.

Although a unified pan-European lidar dataset remains a complex goal due to organizational and technical challenges, Germany sees bilateral harmonization—especially in cross-border areas—as a more achievable first step. Designing tools that can operate across varying resolutions and acquisition timelines will also be essential for scaling up analysis at the continental level.

Germany’s geospatial strategy is evolving. While the federal system has enabled diverse and locally responsive data programs, the emerging national framework signals a shift toward greater standardization, integration, and analytical ambition. With both state and federal initiatives now advancing

“Lidar data in Germany already supports a broad spectrum of applications, including flood risk mapping, environmental monitoring, transportation planning, and cultural heritage conservation. The Digital Twin Germany project is expected to significantly expand these capabilities.”

leaf-off seasons to improve ground visibility, and delivery formats vary slightly between states. Open data policies have become increasingly common, with many states—including North Rhine-Westphalia, Thuringia, Berlin, and Bavaria—providing free access, through state-level geoportals, to both raster models and, in some cases, classified point clouds.

A major transformation is currently underway at the national level. For the first time, Germany is conducting a nationwide lidar survey, coordinated by the Federal Agency for Cartography and

The deliverables will include colorized and classified point clouds following a standardized classification scheme based on Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland (AdV) and American Society for Photogrammetry and Remote Sensing (ASPRS) standards. These classes will distinguish features such as buildings, bridges, ground, vegetation, power lines, and water bodies.

6 <https://www.bkg.bund.de/EN/Home/home.html>

in parallel, Germany is establishing one of the most detailed and future-ready three-dimensional geospatial infrastructures in Europe⁷.

Greece: modernizing through aerial innovation

Over the past three decades, Greece has undergone a remarkable transformation in modernizing its geospatial and cadastral systems. At the heart of this transformation lies the national cadastral project—one of the most ambitious infrastructure initiatives ever undertaken in the country—and increasing reliance on aerial surveying technologies to build a comprehensive, authoritative mapping framework.

Historically, Greece lacked a national land registry. Land ownership was managed via fragmented, manual registries (*ypothikofylakeia*), often based on narrative descriptions and lacking precise spatial reference. This situation posed major legal and developmental challenges, including land disputes, inefficient urban planning, and delays in infrastructure projects.

In response, the government launched the Hellenic Cadastre project in the late 1990s, aiming to develop a unified, modern, spatially accurate cadaster. Over time, the project has evolved into a complex, multi-phase national initiative, integrating geospatial data, legal ownership records, and topographic mapping.

The transition from analog to digital spatial data required a consistent strategy and massive geospatial data acquisition efforts, often led by aerial surveys.

The public body responsible for this development, now known as Hellenic Cadastre (*Ktimatologio*), is charged with creating and maintaining the cadastral base for the entire national territory. Coverage currently spans both urban and rural areas and integrates land parcel boundaries, orthophotos, and other foundational geospatial data.

A key enabler of the cadaster's progress has been systematic use of aerial surveying technologies, particularly aerial orthophotography. These methods provide high-resolution, spatially accurate data that serve as the geospatial backbone for the land registry.

According to Dr. Panos Lolonis, Head of the Geospatial Information Department at Hellenic Cadastre, aerial surveys have been systematically conducted to support various phases of the cadastral project. The core dataset is built on orthophotos derived from aerial imagery, with varying spatial resolutions depending on application: urban areas utilize orthophotos generated from imagery with 20-centimeter resolution, while lower-density rural areas are mapped with 50-centimeter resolution.

These orthophotos are produced using block adjustment processes and form the basis for digitizing parcel boundaries, interpreting land use, and supporting legal adjudication. The imagery has been integrated into web services and GIS platforms used by municipalities, engineers, surveyors, and the public.

Aerial imagery acquisition was performed in cooperation with private surveying companies, ensuring

consistency across regions. As of 2024, Greece had achieved complete national coverage in terms of orthophotos—a significant milestone considering the country's diverse topography and thousands of islands.

Until recently, lidar had not been widely adopted across Greece's cadaster, due partly to cost and limited capacity. However, this is changing rapidly.

Lidar integration is now seen as a strategic priority for the future. As Lolonis emphasized during his 2024 EAASI Summit presentation, incorporating lidar into the national mapping portfolio would significantly improve three-dimensional cadastral applications and enable more detailed DTMs and DSMs, especially in areas prone to landslides or flooding.

Future projects include detailed DSM and DTM development at one-meter grid size, set to cover southern Greece by 2025. A follow-up project for the northern half will be launched afterwards. The data will include classified land categories such as buildings, vegetation, and water, improving environmental and urban planning capabilities.

The expectation is that as funding and policy alignment with European digital and environmental initiatives improve, broader lidar coverage will follow. Forthcoming EU directives on Green Deal implementation, nature restoration, and disaster resilience are expected to catalyse investment in lidar and related technologies.

Greece is also involved in the Open Maps for Europe project⁸, aiming to create a seamless cadastral and topographic dataset for Europe. These developments will contribute to establishing a modern

⁷ For readers seeking a detailed, interactive overview of current lidar data availability and access portals by state, an up-to-date resource is available at lidar Availability in Germany, by Jens Wiese-hahn. This site provides a map-based summary of which German states offer open lidar data, including specifics on data formats and download options. It is regularly updated to reflect new releases and changes in access policies.

⁸ <https://www.mapsforeurope.org/>



Italian Remote Sensing

These high-resolution 5-centimeter pixel oblique and nadir aerial photographs of Rome's Colosseum, captured by Italian Remote Sensing from aircraft, exemplify the precision achievable through modern airborne remote sensing technologies. As Italy transitions from fragmented regional lidar projects to its ambitious nationwide mapping campaign launched in 2024, such detailed aerial imagery demonstrates the country's growing capacity to document and preserve its unparalleled archaeological heritage alongside comprehensive topographic surveying of the entire national territory. EAASI companies CGR SpA (Compagnia Generale Ripresearee) and Italian Remote Sensing Srl won the tender and will carry out the data capture for Italy's national lidar program.

National Spatial Data Infrastructure (NSDI).

Italy: from fragmentation to national unity

Italy's journey with lidar has long been marked by fragmentation. For years, the country lacked a coordinated national strategy for airborne laser scanning. Instead, lidar coverage developed through a patchwork of regional and thematic projects, often driven by local needs such as flood risk mapping, coastal management, or archaeological research. While these efforts produced valuable datasets, they were limited in scope and coverage, leaving large parts of the national territory unmapped.

Several significant initiatives laid the groundwork for today's progress. The *Piano Straordinario di Telerilevamento Ambientale* (PST)⁹, conducted in phases between 2008 and 2015, targeted coastal zones and areas classified as hydrogeologically vulnerable. Lidar data from this program supported the development of DTMs for flood prevention and environmental protection, but never extended to the entire country. Other regional projects—such as those in Lazio, Calabria, and the Po river basin—also produced high-resolution DTMs (often with resolutions of one to two meters),

frequently with specific applications in forestry management, hydrology, or archaeological site preservation.

Recent efforts have continued this thematic focus. The *PNRR MER project* (*Marine Ecosystem Restoration*)¹⁰, running from 2024 to 2026, is applying lidar and other remote sensing technologies to map Italy's full coastline and marine habitats. However, as with earlier initiatives, the project is geographically limited to coastal and marine zones.

A major shift began in 2024, when Italy launched its first-ever nationwide

9 <https://gn.mase.gov.it/portale/en/ordinary-plan-of-remote-sensing>

10 <https://www.isprambiente.gov.it/en/projects/sea/pnrr-mer-marine-ecosystem-restoration>

lidar mapping campaign. Led by the Ministero dell'Ambiente e della Sicurezza Energetica, this project represents a milestone in Italian geospatial policy and data infrastructure. For the first time, the entire national territory will be surveyed using airborne laser scanning, with uniform technical standards and centralized coordination. Scheduled for completion in 2026, the project sets a high benchmark with

areas exceeding—standards set by other European countries. The transition from scattered regional projects to a unified national dataset marks a major step forward. If successfully completed and fully opened to public use, the national lidar program will equip Italy with the foundational data needed to manage natural risks, protect cultural and environmental assets, and foster digital transformation across sectors.

challenges. Whether supporting flood risk management, environmental monitoring, urban planning, or heritage preservation, high-resolution elevation data has become indispensable for evidence-based decision-making.

As Europe continues evolving its geospatial capabilities, the experiences documented in this series—spanning 16 countries across three instalments—provide valuable insights into both the opportunities and challenges that lie ahead. The path towards greater coordination, standardization, and accessibility remains complex, but the progress achieved by individual nations offers encouraging evidence of what can be accomplished through dedicated investment in aerial surveying technologies and open data policies. ■

“The campaign’s goals are comprehensive. It is designed to support flood risk assessment, environmental monitoring, sustainable land use planning, forestry, agriculture, and heritage preservation.”

a target point density of 10 ppsm, placing it among Europe’s most detailed national lidar programs to date.

The campaign’s goals are comprehensive. It is designed to support flood risk assessment, environmental monitoring, sustainable land use planning, forestry, agriculture, and heritage preservation. In contrast to past efforts that served narrow institutional needs, the new dataset will be made available for widespread use across government, academia, and the private sector. By delivering consistent, high-resolution topographic data, Italy aims to modernize its geospatial infrastructure and unlock new applications in climate adaptation, biodiversity conservation, and digital innovation.

With the project now well underway, Italy is catching up with—and in some

Looking forward: Europe’s geospatial evolution

The experiences of Austria, Croatia, Germany, Greece, and Italy illustrate both the diversity and dynamism characterizing Europe’s approach to lidar mapping. From Croatia’s rapid achievement of complete national coverage to Germany’s ambitious Digital Twin initiative, from Greece’s systematic cadastral modernization to Italy’s transition from fragmented regional efforts to unified national strategy, each country demonstrates unique pathways towards comprehensive elevation data infrastructure.

These national efforts, while distinct in their approaches and timelines, collectively represent Europe’s growing recognition of lidar technology’s critical importance for addressing 21st-century

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Dipl.-Ing. Wolfgang Gold, BEV - Bundesamt für Eich- und Vermessungswesen (Federal Office of Metrology and Surveying, Austria); dr. sc. Marijan Marjanović, dipl. ing. geod., Državna geodetska uprava (State Geodetic Administration, Croatia); Andreas von Dömming, Bundesamt für Kartographie und Geodäsie, Federal Agency for Cartography and Geodesy (BKG), Germany; Panos Lolonis, Ph.D., Hellenic Cadastre, Greece



Ada Perello is the Communications Manager of the European Association of Aerial Surveying Industries (EAASI), where she works to raise awareness of the essential role that crewed

aerial surveying plays in delivering accurate, large-scale geospatial data. Through articles in leading industry publications, she helps showcase the unique capabilities of technologies used in crewed aerial platforms, such as lidar, aerial imagery, and sensor fusion. With 20 years of experience in communications, including roles at the International Maritime Organization (IMO) and the Food and Agriculture Organization of the United Nations (FAO), her expertise lies in making complex technological concepts accessible to diverse audiences.



Introduced in 2002, the Leica ALS40 provided 45 kHz max pulse rate and 70 Hz max scan rate.

Author, continued from page 48
capturing elevations of the ground below – something image-derived photogrammetry could not do in densely vegetated areas. Post-processing analysis could be performed on the laser data to differentiate return pulses that had reflected off treetops and building structures from those that had struck the ground, thus generating true bare-earth digital elevation models.

The next innovation revolutionized airborne laser profiling and transformed it into what could really be called laser mapping. A scanner was placed below the laser, so that the light pulses were scattered towards the surface in wide swaths instead of a single line, capturing terrain measurements across broad areas. Installing these new laser scanners in fixed-wing aircraft able to fly faster and higher greatly increased collection capacity and overall cost-effectiveness.

For lack of a better term, this early version of airborne laser scanning is often referred to as linear-mode lidar.

Airborne linear-mode lidar was increasingly viewed as a viable mapping technique. Accurate, bare-earth elevation models could now be made with point spacings of only a meter or two, even under vegetative canopies. Among the many initial applications of

this technology was the creation of highly precise hydrographic maps that could be used to determine where surface water would flow in the event of flooding situations.

Two vital innovations, however, enabled lidar to take this gigantic leap forward in terms of accuracy and its widespread use by mapping organizations.

Enablers and drivers

The first was the introduction in the late 1990s of the GPS/Inertial Measurement Unit system, or GPS/IMU, onboard the aircraft. Simultaneous with capture of elevation points, this device collected precise coordinates of the aircraft's location as well as its orientation (pitch and roll) in flight. During post-processing, this GPS/IMU data was combined with the lidar data to determine remarkably accurate X, Y, and Z coordinates for each elevation point.

The second key enabler was the dawning of the digital era in mapping and remote sensing. Traditional photogrammetry was undergoing a shift from an analog process to a digital one thanks to softcopy photogrammetry. Shortly thereafter, digital airborne sensors were replacing film cameras for optical image capture. In a very short time span, the entire mapping process with remotely sensed imagery – from collection to output – had become digital.

For many long-established aerial mapping companies, this “greased the skids” for quick adoption of lidar. Because lidar was an inherently digital technology and airborne remote sensing was rapidly becoming the same, surveyors had already set up end-to-end digital

processing workflows. The enormous digital lidar point clouds were not as intimidating as they might have been just a few years earlier, and the laser scanner was welcomed as a viable new source of map data.

Other factors fueled the growth of airborne lidar adoption in the late 1990s through the early 2000s. Several hardware companies, such as Optech (now Teledyne Geospatial) and Azimuth Corporation (acquired by Leica Geosystems in 2001), were manufacturing commercial airborne systems, and the competition was driving them to build more powerful units capable of making measurements at tighter point densities on the ground. Their systems could capture increasingly more accurate data at higher airspeeds and altitudes.

This market force-multiplier drove down product prices at the same time as flight operations became more cost-effective due to technical innovations.

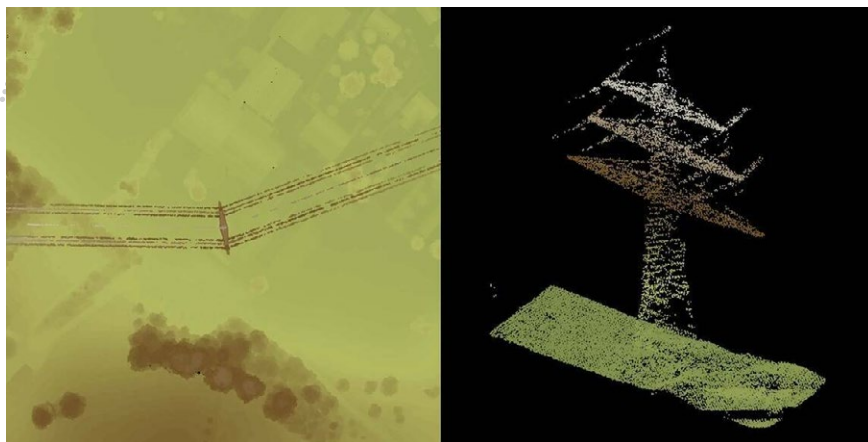
The other market force spurring lidar adoption was customer demand. End-users of elevation data, especially in coastal areas like Louisiana in the US, where the modeling of complex tidal and flood-flow regimes depended on data accuracy and point density, were drawn to lidar. The interpolation of 3D values with optical imagery was not good enough, and geospatial end-users began asking for lidar technology by name in requests for proposals.

State and federal government agencies were instrumental in this. Although the 3DEP initiative did not officially begin until 2012 with the requirement for lidar use, USGS and other organizations were specifying its use for several years before then. Since then, national mapping agencies around the world

have launched similar 3D programs that mandate lidar.

Drive toward simplicity

As competition drove airborne lidar to paint the Earth's surface with a greater density of laser pulses while flying faster and higher, the laws of physics and the capabilities of linear-mode technology were being tested. To scale performance, systems incorporated multiple-pulse-in-the-air technologies, and later gateless multi-pulse capability, to allow overlapping pulses in flight – overcoming the limitations of the speed of light. With millions of overlapping pulses per second being emitted, the device had to keep track of them, which became extremely complicated, especially in cityscapes.



Data captured with single-photon lidar.

Tall buildings, for example, caused some return pulses to reach the sensor before those emitted earlier, as well as other out-of-sequence challenges.

As a result, scaling up the performance of linear-mode lidar systems became excessively complex. The solution was to create massively parallel sensors, which

single-photon and Geiger-mode lidar both represent.

In the case of the Leica SPL100, for example, the system essentially operates 100 linear-mode lidars operating at up to 100,000 pulses per second with very simple multi-pulse functionality, from which it is much easier to resolve correct range measurements in complex

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The Leica TerrainMapper-3 linear-mode system combines a lidar unit and a camera system in a single pod. Its modular design allows for easy replacement, repair, or upgrade of individual components.

terrain. Geiger-mode employs a similar technique, but with a rotating scanner array operating as if it contains thousands of very simple single-pulse-in-the-air linear-mode devices.

These two variations may sound complicated, but are actually simpler because of the massively parallel design. The result has been that single-photon and Geiger-mode systems are easier to operate and maintain, while also achieving massive data collection rates over broad areas – even with extremely large variations in terrain elevations – with higher-speed aircraft.

While the overall accuracy of these systems currently approaches that of linear-mode, they capture over 10 times as much data in a flight hour, dramatically improving the overall cost-efficiency of airborne lidar. In other words, the recent evolution of airborne lidar systems has made it possible to measure a much higher density of elevation points on the ground over vastly larger geographic areas per flight at a much lower cost.

Self-driving cars drive innovation

Another key factor in this evolution, however, is the technological

improvement in the lasers themselves. Laser range-finders are utilized in several very demanding industries, autonomous vehicles being the most notable. Manufacturers of self-driving cars have been scrambling to obtain lasers that are better, lighter, smaller, and cheaper than ever.

One challenge for laser manufacturers has always been developing systems that turn on and off very cleanly as each pulse is emitted. Otherwise, “jitter” or noise is introduced to the collected data sets, creating ambiguity and inaccuracy in the measurements. While linear-mode systems would measure a range over many hundreds or thousands of photon returns which would average out this laser jitter, in the single-photon case – as the name suggests – the range measurement is measured by one or two photons, so any jitter is immediately visible in the height accuracy. The developer of the laser unit incorporated into the single-photon systems today has significantly reduced the jitter in these products, with due acknowledgment to self-driving cars pushing the technology development rapidly.

At the same time, suppliers have been developing more lightweight lasers at lower price points to accommodate

the automotive industry. In general, lasers can now capture high-quality data with less power, which means lower weight. This, in turn, has enabled lidar system suppliers to build more compact instruments that can be flown on smaller aircraft and even unmanned aerial vehicles (UAVs) – another leap forward for the mapping industry.

While the economics of aerial elevation mapping have been significantly enhanced over the past 25 years due to evolution in the basic technology and system design, the financial aspect has also benefited from a change in development philosophy. Leica Geosystems’ airborne lidar systems, for example, are designed with an upgrade path in mind. These products are built to incorporate at least two, or possibly three, next-generation overhauls before being replaced with new purchases.

Numerous other lidar improvements are in the works – driven by factors both inside and outside aerial mapping. On the market now for 25 years, the technology shows no signs of slowing down—it’s still accelerating rapidly. In the next article, we will look at forthcoming changes that will accelerate airborne laser scanning well into the future.

Acknowledgement

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John Welter is president of Geospatial Content Solutions at Hexagon’s Geosystems division. Based in Northern Arizona, USA, he has three decades of extensive and demonstrated experience in the information technology and services industry. His expertise includes geospatial services, airborne mapping technology, big data concepts and IT strategy.

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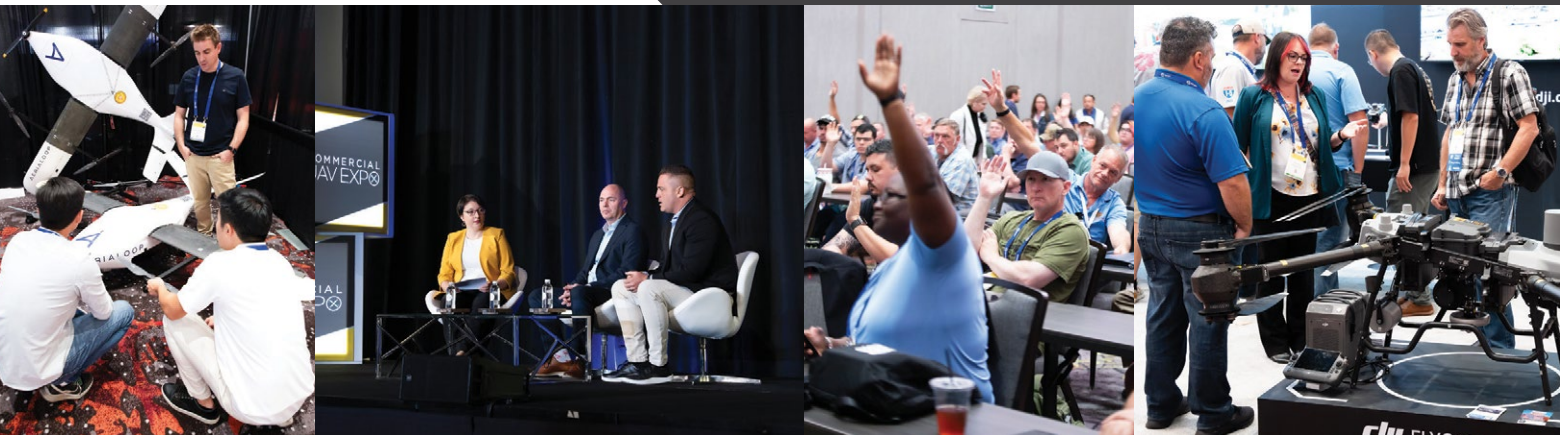


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Airborne lidar: An evolution of technology and applications

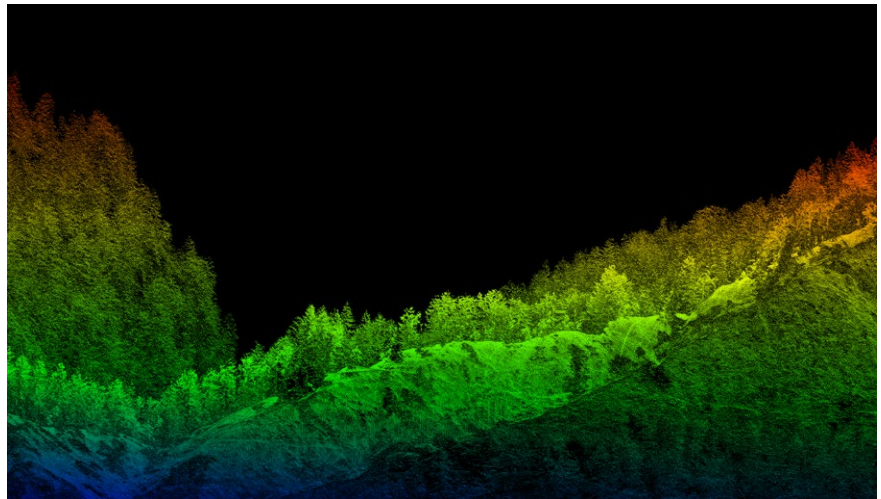
In the coming months, Hexagon will unveil the next-generation single-photon lidar (SPL) airborne sensor. An upgrade from our extremely popular Leica SPL100 wide-area elevation mapping system, the new product will incorporate the latest in SPL technologies with an eye towards significantly reducing the aerial collection costs associated with updating large terrain mapping projects, such as USGS's remarkably ambitious and successful 3D Elevation Program (3DEP).

The commercial mapping industry in general is experiencing a period of exciting transformation, and the lidar segment of the market is growing as fast, or faster, than any other. Like many technologies, lidar's evolution has been driven by a combination of breakthroughs in technical innovation and customers' changing economic and end-user requirements.

To fully understand where lidar technology stands today, how far it has come in a short period of time, and where it is going, we thought it would be valuable to revisit the evolution of airborne laser scanners, now known as lidar, or light detection and ranging. This will also help differentiate current variations of systems that fall under the term 'lidar.'

Laser profiling proves potential

The aerial technology we know today originated as 'laser profiling,' carried out using helicopters equipped with laser range-finding devices. As the



Elevation data captured in Switzerland with Leica TerrainMapper-3. Today, lidar can penetrate forest canopies to accurately measure tree height, canopy density, and ground elevation.

helicopter moved at a relatively slow speed compared to fixed-wing aircraft, the instrument onboard emitted laser pulses at a rate of about 1000 to 2000 per second in a single line toward the terrain below.

These pulses were reflected off the ground, returned to the sensor, and were translated to distance measurements with a simple time-of-flight calculation. Combined with the helicopter's known altitude, each calculation was converted into an elevation measurement for a point on the Earth's surface. The collected data created a narrow profile of the terrain due to the fact that the device only emitted light pulses in a single line as the helicopter traversed the landscape.

Laser profiling was very expensive, and its applications were limited to narrow corridor data collection, usually for energy utilities and pipeline operators. Otherwise, laser profiling was often relied upon to spot-check other elevation data sets, especially in photogrammetry. But the potential of the technique was obvious. Until then, most airborne terrain mapping was conducted with photogrammetric analysis of optical images, involving interpolation for the vast majority of surface points.

Not only did lasers directly and accurately measure points instead of estimating them, but the light pulses slipped between tree canopies, *Welter, continued on page 44*

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