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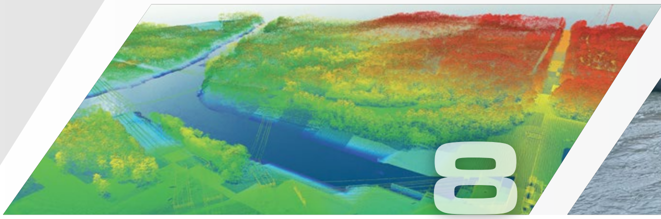

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Bathymetric data for Valdez Glacier Lake, Alaska. Data was collected up to the face of the calving glacier, where depths reached up to 192 m (632 feet). Image courtesy of Woolpert.


PURE
SLAM
POWER

DR. A. STEWART WALKER

Lidar is All Around

LIDAR Magazine wishes all readers a happy, healthy, fulfilling 2026. We appreciate you taking time to browse our pages. Composing this during the breathless run-up to Geo Week 2026, I am conscious that the festive season ended quite recently. Many of us enjoy family traditions during the holidays. One of ours is to view the soppy 2003 British romcom Love Actually. Its multiple, improbable threads include a fine performance by Bill Nighy as an aging rock star who unexpectedly tops the charts with a song called "Christmas Is All Around," based on a 1967 Troggs classic. Lidar's the same – everywhere. This column has often included mentions of lidar in the world press, but now it's coming close to home. A photograph published in my local paper not so long ago showed speed cops on motor bikes, positioned beside State Road 67 in southern California, ready to pounce on speedsters[1].

I reported on the discussion during Intergeo last October in Frankfurt on the skills required of today's professionals to evaluate AI results[2]. This topic, too, made an appearance in my local paper[3]! Indeed, the role of AI in the geospatial industry now is the leading 2026 trend identified in Qassim Abdullah's perspicacious article in this issue. He takes the debate a step further, for example advocating for the development of standards surrounding the geospatial use of AI.

Qassim also highlights the increasing performance of sensors and the sheer volume of data capture that is now possible. Two of this issue's articles underline this. Ryan Cross brings a beautifully illustrated piece from Woolpert about hydrographic surveys of the Port Valdez inlet near Valdez, Alaska and the nearby Valdez Glacier Lake. Authoritative data on these water bodies is essential to the management of both marine traffic and local urban development. Søren Jespersen of Hexagon goes nationwide, however, covering the generation of DSMs and DEMs for all of South Africa, a truly massive project successfully executed through the collaboration of GeoSpace International, Hexagon and RiskScape.

Although ubiquitous, the trends described by Qassim are probably most readily observed in leading-edge private geospatial services providers or national mapping agencies (defense and intelligence

1 Gallant, J., 2025. Sheriff's and CHP collaborating to improve safety on SR-67, *Poway News Chieftain*, 73(12): Section A, 1, 14 August 2025.
2 https://lidarmag.com/2025/11/06/intergeo-2025-a-retrospective-2/
3 Churchill, B., 2026. In the age of AI, schools must prioritize critical thinking, *Poway News Chieftain,* 73(32): Section A,4, *1 January 2026.*

LIDAR MAGAZINE

www.lidarmag.com

2026 Vol. 16 No. 1
© Spatial Media LLC

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FROM THE EDITOR

organizations too). At the other end of the scale, to what extent does a two-person professional land survey firm use AI to demarcate a property boundary so the owner can erect a new fence? Between these extremes, Geoff Wade of Esri explains how the operations of a private forestry company in Louisiana with a long history of successful silviculture have been transformed by the adoption of GIS, satellite imagery and tablets. AI is embedded in the software used in the process and is permeating the processes that the company, RoyOMartin, follows to optimize planting, growth and harvesting.

Florian Caraveo of YellowScan and Evert Mulder and Nick Brown of the UN Global Geodetic Centre of Excellence discuss the challenges of discontinuities between topographic and bathymetric or sonar data. Florian presents examples captured by the YellowScan Navigator topobathymetric UAV-lidar sensor, whereas Evert and Nick are more geodetically inclined, charged with providing advice to UN Member States.

We're approaching the XXV Congress of ISPRS, in Toronto in July. A well-known figure in ISPRS circles is Prof. Ruisheng Wang, who moved from Calgary to Shenzhen in 2024. He presents BuildingWorld, a remarkable dataset of five million LoD2 – and a few LoD3 - building models in 44 cities across five continents. This work of Ruisheng and his team ties in nicely with the highlighting of digital twins by both Qassim Abdullan and Amar Nayegandhi, whose *Full Coverage* column complements Qassim's piece. So positive was the response within Woolpert to Qassim's article that the company conducted a questionnaire of 31 senior managers to assess what trends they identified as important. This reflects a document I was given by Trimble just before Intergeo, summarizing a similar exercise[4]. Talking to senior, experienced folk in world-class organizations is surely the best way to probe what is really going on.

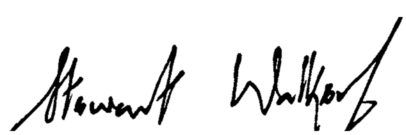
While unsurprisingly echoing many of Qassim's thoughts, Amar provides some insights of his own. He stresses pressure on water, energy and transportation systems, the influence of data center construction and operation, intensifying global competition and the continuing integration of geospatial data into decision-making. He ends with insights into workplace culture during these changing times. These viewpoints from Woolpert leaders matter: treat them as cut-out-and-keep guidelines to the geospatial future.

Our podcast series continues apace and I am both delighted and privileged to have enjoyed two wonderful conversations, the first to be posted in 2026. These were with Alex Brihac, Vice President, Head of Strategy and M&A at Hexagon Geosystems, and Grayson Omans, founder and CEO at Phoenix LiDAR Systems. Alex is brilliant, dynamic, perceptive and a master of the world of mergers and acquisitions. Grayson is more relaxed, both in command of the technology and able to solve customer problems himself, while managing the affairs of a growing company on the business side. Enjoy!

Perhaps owing to the arrival of 2026 and the proximity of Geo Week, news is arriving thick and fast. I'll mention just a few titbits that caught my attention.

John Welter left Hexagon on 23 January. I had some email discussion with him, asking him why he was making a change while absolutely at the top of his game. I can understand his response – at age 55, one has to decide whether to do the same work until retirement, or reach for the stars. We await a formal announcement of his revised orbit, but I see that his Linked In page gives his role as "SVP, Geospatial Strategy" and his location as Starbase, Texas. Any ideas?

Thus we've brought you five articles from US authors, covering trends and locations from Alaska to Louisiana to Singapore. To these we've added one from a French author about rivers in western Europe, one from authors in Germany and Singapore talking about geodetic aspects of integrating topographic and bathymetric data, and one from a Swedish author talking about South Africa. Lidar is indeed all around.



A. Stewart Walker // Managing Editor

4 Walker, A.S., 2025. *Ibid.*

Mapping the Future: Critical Geospatial Trends for 2026

The geospatial mapping sector is experiencing a period of significant technological evolution, propelled by breakthroughs in advanced sensors, sophisticated processing software, increased automation, and the widespread integration of artificial intelligence. And what's most interesting is that the biggest breakthroughs are not loud revolutions — they're quiet, steady advances reshaping how we map, measure, and understand the world.

Simultaneously, the geospatial mapping industry is grappling with significant obstacles related to securing project funding and obtaining government contracts, challenges that persist across global markets. Looking ahead through 2026, several influential trends are set to transform the foundational approaches and operational workflows within mapping. These changes will impact how professionals manage data quality, deliver projects, and embrace innovation, ultimately redefining industry standards and expectations across the field.

1. The confusion revolution: Uncertainty around adopting and adapting to AI

AI is entering a pivotal new era characterized by seamless integration and increasingly autonomous decision-making capabilities. We are experiencing a fundamental transformation in the geospatial industry: AI is no

BY QASSIM **ABDULLAH**

longer a concept on the horizon — it is actively shaping the present landscape of geospatial workflows. Examples of powerful capabilities include automated processing, advanced anomaly detection, efficient feature extraction, and the rapid creation of mapping products.

Nevertheless, there is still widespread uncertainty within the industry regarding the ultimate impact AI will have on mapping methodologies, the roles of professionals, and the processes for ensuring data quality. There is likewise ambiguity around best practices for validating the outputs generated by AI and incorporating these results into established geospatial standards.

Executives and managers in our industry are seeking answers to these complex questions: Can AI replace fieldwork? Will AI work everywhere equally? Will AI remove the need for standards? Does AI guarantee accuracy? Will AI eliminate the need for highly trained professionals? With AI, do we need data governance?

Here are my insights and advice:

- **Can AI replace fieldwork?** AI is unlikely ever to replace fieldwork fully unless we achieve a level of super artificial intelligence beyond our current understanding.
- **Will AI work everywhere equally?** Not at this time. Models developed for a specific region or sensor frequently encounter challenges when applied to different regions or sensors.
- **Will AI remove the need for standards?** No, deliverables must still comply with standards such as those of the American Society for Photogrammetry and Remote Sensing and the 3D Elevation Program specifications of the U.S. Geological Survey. AI only streamlines compliance by making it easier.
- **Does AI guarantee accuracy?** AI will continue to support the attainment of required accuracy. Its performance depends, however, on external factors like sensor quality, occlusions, biased training data, ground control accuracy, and environmental complexity, all of which fall outside an AI agent's direct control.
- **Will AI eliminate the need for highly trained professionals?** AI will not replace highly trained professionals, but it enhances what they can achieve. Our role is to guide and use AI for better, faster, and more reliable geospatial intelligence. The future is augmentation powered by automation — professionals must remain involved.
- **With AI, do we need data governance?** Yes, poor metadata, labeling, or lineage makes AI results unreliable.

2. The drone revolution enters its next phase

Unmanned aircraft systems are seeing widespread and rapidly growing adoption throughout both government and private organizations. Recent innovations in autonomous flight controls, beyond visual line of sight capabilities, and the integration of advanced lidar and imaging sensors are dramatically improving the efficiency and affordability of drone-based aerial data collection.

These technological improvements are reshaping how projects are planned and executed, leading to significant changes in budget allocations, project timelines, and the models for delivering geospatial information. As a result, government agencies, utilities, engineering firms, and environmental organizations are increasingly turning to drones not only for efficiency but also for advanced types of monitoring, including coastal erosion, forest health, infrastructure inspection, and construction progress.

This strong demand, prompted by accelerated aerial mapping deployment and more consistent, repeatable data acquisition cycles, continues to advance mapping workflows and elevate industry standards. **Figure 1** illustrates the rapid growth in the drone mapping market. The chart is produced using publicly reported Fact.MR estimates for the global drone mapping market (2023 data and compound annual growth rate (CAGR)). The values are generated by applying the reported CAGR (17.1%) to the 2023 baseline of USD 1.0222 billion to estimate 2022–2026 values.

3. From big data to trusted data: The demand for quality at speed

Recent advances in using complementary metal-oxide semiconductor-based digital cameras, AI and machine learning accelerators, embedded graphics processing units, solid-state microelectromechanical systems, and single-photon and Geiger-mode lidar have dramatically increased the productivity of sensors used in aerial, terrestrial, and marine mapping, enabling these systems to collect enormous amounts of high-resolution data at unprecedented scales. However, the primary challenge has shifted from data acquisition to the critical task of converting this raw data into trustworthy, actionable information products.

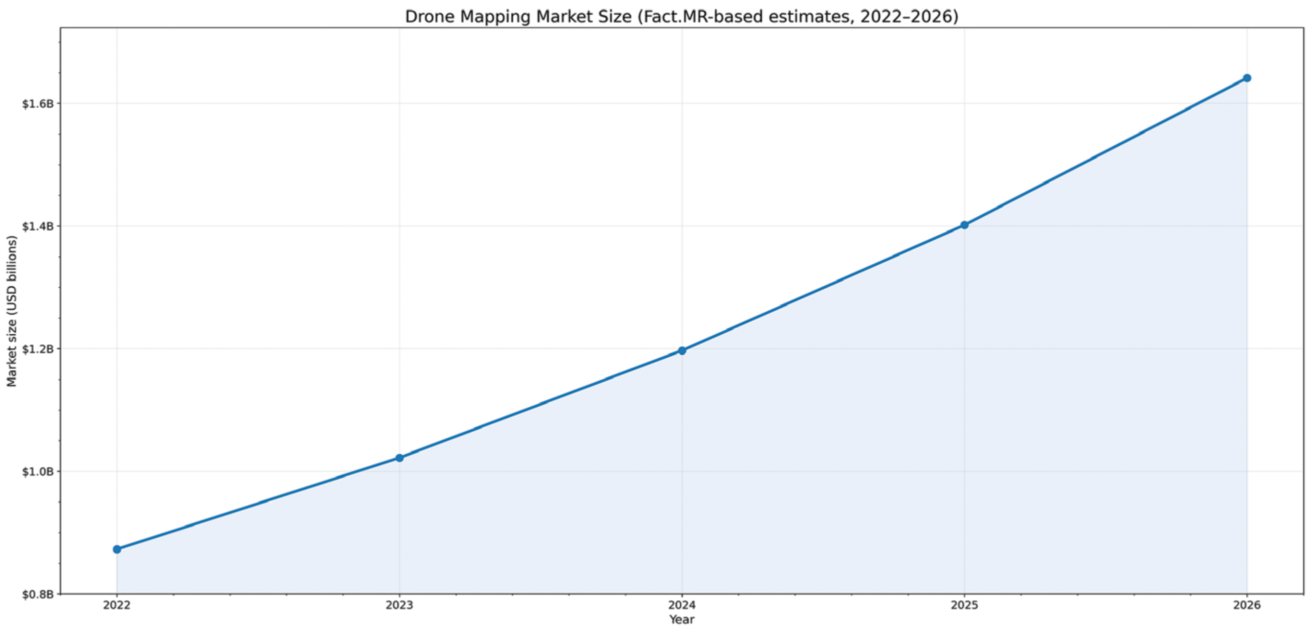


Figure 1: Drone mapping market size (source: Fact.MR (2023 market size and CAGR)].

To address this bottleneck, the industry is increasingly relying on robust automation strategies. These include the use of explainable AI to clarify decision-making processes, the implementation of automated quality assurance and quality control procedures to verify data integrity, and the adoption of comprehensive metadata standards to document workflows and data lineage. Collectively, these measures are essential for delivering credible and defensible mapping results within increasingly compressed project schedules, meeting the growing demand for rapid and reliable geospatial solutions.

4. Bathymetry's moment: A global push to map the seafloor

Despite technological advances, most of the world's oceans remain unmapped to modern standards. This gap has triggered renewed global investment in bathymetric mapping, driven by international missions such as Seabed 2030[1], as well as coastal resilience, maritime safety, and national security priorities. Modern tools such as multibeam echosounders and remotely operated surface vessels are at the forefront of these efforts, while large-scale initiatives like Seabed 2030 work to systematically address and eliminate major gaps in underwater data coverage. Advances in high-resolution airborne bathymetric lidar mapping have enabled the mapping of nearshore coastal zones with greater accuracy in clear to moderately turbid water environments. Improving seafloor mapping is not only vital for ensuring the safety of maritime navigation and protecting national interests, it also plays a crucial role in managing marine environments and fueling sustainable economic development in coastal and ocean sectors.

1 https://seabed2030.org/

5. Consolidation and collaboration in a tightening market

The geospatial mapping industry in the United States is currently grappling with significant challenges stemming from reduced federal spending and a decline in government contracts that once fueled research and technological advances. In response to these shifts, geospatial mapping product manufacturers are rethinking their approaches, implementing strategies aimed at downsizing their workforce while striving to preserve both productivity and innovation.

As the market moves toward 2026, adaptation to this new reality of shrinking federal engagement will be critical. The coming years are likely to see increased mergers, strategic alliances, and collaborative efforts among leading industry participants. Faced with pressures to remain viable, many competitors are choosing to work together, pooling their resources and talent to tackle larger, more complex projects that demand consolidated expertise and infrastructure. This trend toward partnership and integration marks a significant evolution in the industry's approach, signaling a collective effort to navigate an environment defined by fewer federal opportunities and heightened competition.

6. Cloud-native geospatial pipelines become the new normal

The shift to cloud-native workflows has reached a tipping point. Elastic pipelines to scale computing resources automatically based on workload demands can now:

- Ingest massive datasets
- Perform distributed processing and AI inference
- Generate both versions and archives
- Support multi-user collaboration worldwide

These capabilities will enable organizations to scale projects quickly and maintain consistent, defensible production workflows.

7. The rise of data standards and cross-vendor interoperability

The geospatial industry is undergoing a major shift toward open standards, interoperable formats, and vendor-agnostic workflows. Formats such as Cloud Optimized GeoTIFF, SpatioTemporal Asset Catalog, and Cloud Optimized Point Cloud, along with emerging Open Geospatial Consortium application programming interfaces, enable seamless sharing, reuse, and integration of datasets and models.

As datasets grow in size and complexity, and as AI and cloud-native technologies reshape workflows, the ability for systems, tools, and organizations to seamlessly share, interpret, and process geospatial information has become essential. This movement is redefining how data is created, stored, analyzed, and delivered across the entire mapping ecosystem. It will also empower users, reduce vendor lock-in, and ensure long-term data accessibility. Soon we will see interoperability becomes a core requirement, not a feature.

8. What's coming in the next 3-5 years

As we look beyond 2026, the geospatial industry is poised to develop into a dynamic and interconnected ecosystem over the next three to five years. The current surge of innovation — fueled by advances in AI, cloud-native pipelines, open data standards, and real-time processing — shows no signs of slowing down. We can expect the transformative momentum we are experiencing now to intensify in the coming year and persist well beyond 2026. This ongoing revolution will not only enhance the integration of geospatial intelligence across sectors but also foster a collaborative environment where rapid data-to-insight workflows, cross-vendor interoperability, and operational digital twins become standard. As these trends accelerate, the geospatial landscape will continue to redefine its role as a strategic driver for industries worldwide, ensuring its growth and influence for years to come.

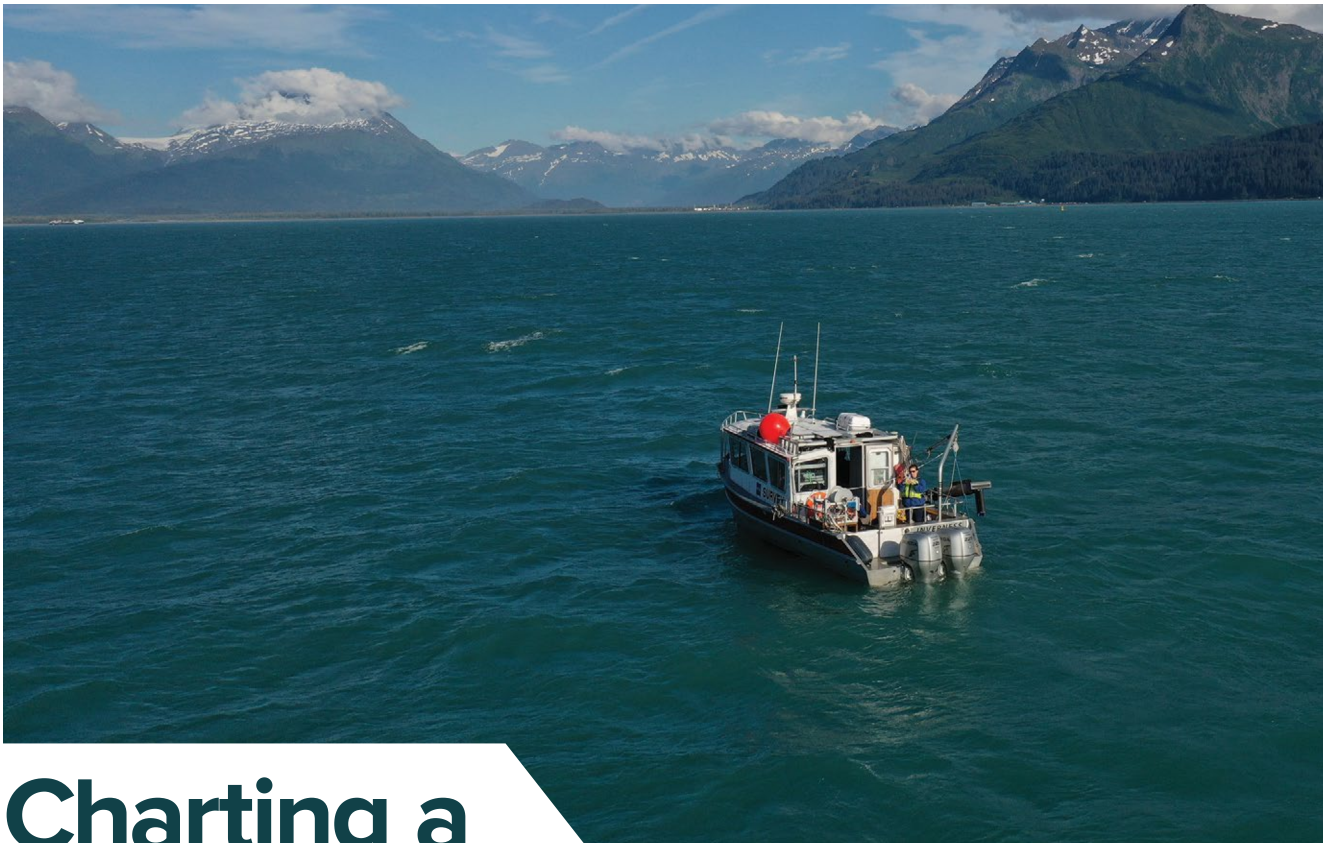
Conclusion

2026 signals the dawn of a transformative era. In this period, advances in AI, autonomous systems, sensor technologies, cloud infrastructure, and large-scale global projects will coalesce. As a result, geospatial intelligence will become more rapid, seamlessly interconnected, and significantly more influential across industries than ever before, driving strategic decision-making and delivering unprecedented value.

I hope you find my insights on these topics to be helpful and informative. Happy 2026!

Note: This article is running in both *LIDAR Magazine* and *Photogrammetric Engineering & Remote Sensing.*

Woolpert Vice President and Chief Scientist **Qassim Abdullah, PhD, PLS, CP**, brings over 45 years of combined experience in industry, research and development, and academia, specializing in analytical photogrammetry, digital remote sensing, and civil and surveying engineering. When not presenting at geospatial conferences worldwide, Dr. Abdullah teaches photogrammetry and remote sensing at the University of Maryland and Penn State, writes a monthly column for the ASPRS journal *Photogrammetric Engineering & Remote Sensing*, serves on NOAA's Hydrographic Services Review Panel and the Geo Week Advisory Board, and mentors R&D projects at Woolpert and beyond. Qassim is a licensed surveyor and mapper in four states. As an ASPRS fellow, he has received both the ASPRS Lifetime Achievement Award and the Fairchild Photogrammetric Award.



Charting a Sea of Change in Valdez

The City of Valdez, Alaska, partnered with NOAA to gather hydrographic data in support of navigation safety, disaster preparedness, and the region's economic interests.

Alaska is home to some of the most breathtaking and volatile landscapes in the world, and Port Valdez is no exception. Fed by relentless snow accumulation in the high peaks and icefields of the Chugach Mountains, glaciers carved deep U-shaped valleys through the land over thousands of years, and the Pacific Ocean gradually flooded the freshly scoured earth. At the head of this millennia-old glacial fjord, flanked on both sides by steep mountain slopes, is the City of Valdez.

Valdez is located roughly 100 miles due east of Anchorage as the crow flies but is 300 miles by car due to the heavily glaciated Chugach Mountains. As the northernmost ice-free port in the U.S., the city was chosen as the terminus of the Trans-Alaska Pipeline

BY RYAN **CROSS**

System in 1975. In 1989 the infamous Exxon Valdez supertanker struck a reef in Prince William Sound shortly after departing Valdez. Lessons learned from the incident are still being leveraged to improve how we prevent and respond to oil spills in complex environments worldwide.

Today, Valdez ships over 150 million barrels of crude oil from its port to the lower 48 states of the U.S. and other areas of the world annually. Fishing, both recreational and commercial, and tourism also play important roles in the city's economy. Likewise, multiple government agencies depend on Port Valdez as a critical hub for maritime safety, transportation infrastructure, and national security operations.

Because there is only one road in and out of the city, the economic success and welfare of Valdez and its citizens depend on reliable port accessibility. As with much of Alaska, Port Valdez is an incredibly tectonically active area, necessitating accurate hydrographic mapping to identify and study submerged hazards.

Historical background of Valdez and the need for updated hydrographic data

Glaciers constantly grind down mountains and discharge massive amounts of glacial flour by way of rivers laden with sediment. As these silty rivers reach the calm waters of Port Valdez, the sediment is deposited as river deltas that border the steep-sided fiord. During a very large seismic event, this unconsolidated sediment is likely to slump and slide catastrophically in what is known as a submarine or underwater landslide. This sudden displacement of a large mass of land underwater generates a tsunami, which can inundate the coastline with little or no warning.

The primary surveying vessel next to the skiff used for navigating Valdez Glacier Lake.

The City of Valdez is no stranger to landslide-induced tsunamis. In 1964, a 9.2-magnitude earthquake, also known as the Good Friday Earthquake, triggered multiple underwater landslides in the Valdez Basin and subsequent tsunamis, which struck the city, claiming the lives of 30 people. In the aftermath, the U.S. Army Corps of Engineers moved the community from its original site to a new location with more bedrock and stable soil.

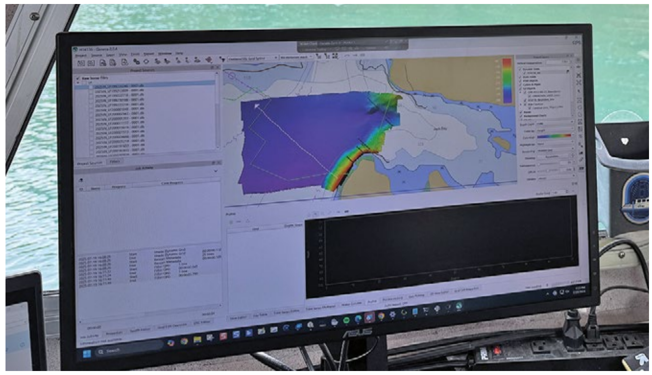
Most recently, in 2020, the terminus of the Valdez Glacier collapsed, sending a mile-long section of ice into the glacier lake and its outflow. The glacier lake, located about seven miles northeast of Valdez, is surrounded by high, mountainous slopes. As the glacier continues to retreat, these slopes become increasingly vulnerable to potential failures. When the glacier's front collapsed, it exposed a significant portion of the lake that had never been surveyed.

To be able to manage the impact of these events appropriately and mitigate future disasters, the city needed to acquire new hydrographic surveying data of Port Valdez and the glacier lake. The last survey of Port Valdez was conducted in 2002, and since that time multiple significant changes to the landscape have occurred.

"With over 22 years of change and evolution, we figured it was time to get some new data to have a better understanding of what's going on under the water here locally on our coastline," Valdez City Manager Nathan Duval said.

Updated maps of the ocean floor and glacier lake have proved vital to navigation safety, assessing current and potential hazards, and protecting the public and critical infrastructure.

Woolpert hydrographer onboard the survey vessel collecting bathymetric data.



Monitor onboard the surveying vessel displaying bathymetric data.

Acquiring the data and funding the project

The emergency manager for the City of Valdez, Aaron Baczuk, contacted the National Oceanic and Atmospheric Administration's (NOAA[1]) Alaska Navigation Manager[2] to ask about acquiring updated bathymetric and hydrographic data to support the city's population and economy. During discussions, it was suggested that the city apply for the Brennan Ocean Mapping Fund[3], named after Rear Admiral Richard T. Brennan, who passed away shortly after becoming the director of the NOAA Office of Coast Survey. The program invites non-federal entities to partner with NOAA on ocean and coastal mapping projects of mutual interest using NOAA's geospatial contracting vehicles. The program relies on NOAA's mapping, charting, and geodesy expertise, appropriated funds, and its authority to receive and expend matching funds contributed by partners to conduct surveying and mapping activities.

1 https://www.noaa.gov/
2 https://nauticalcharts.noaa.gov/customer-service/regional-managers/index.html
3 https://iocm.noaa.gov/planning/contracts-grants-agreements.html

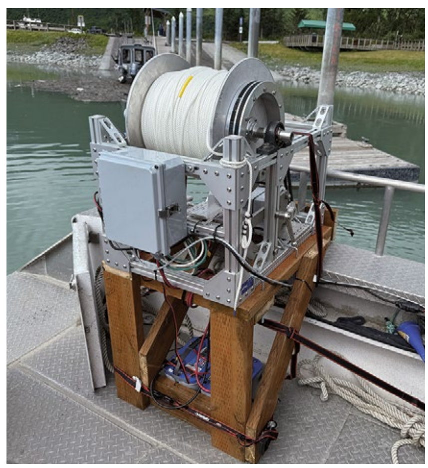
"[Brennan] was a real passionate guy about hydrography, about surveying, about the people in the community—but, in particular, really reaching out to additional folks," said Captain Sam Greenaway, chief of the Hydrographic Services Division for the Office of Coast Survey. "In projects like this, we're working closely with the city, we're working on geological hazards, we're updating the chart—he was pushing for this for years. It's good to see this vision come to fruition."

In November 2023, the Port Valdez area was selected as a partner project for the Brennan Ocean Mapping Fund opportunity, with mapping scheduled to occur in 2025 via NOAA's hydrographic services contract vehicle[4]. This opportunity leverages NOAA and non-Federal partner funds to acquire more ocean and coastal mapping data from qualified contract surveyors, which represents cost savings for the Federal government to advance such work. "It's always beneficial to partner with other organizations like NOAA to help spread out the cost of these types of projects," Duval said.

4 https://nauticalcharts.noaa.gov/data/hydrographic-surveys-contract-vehicle.html

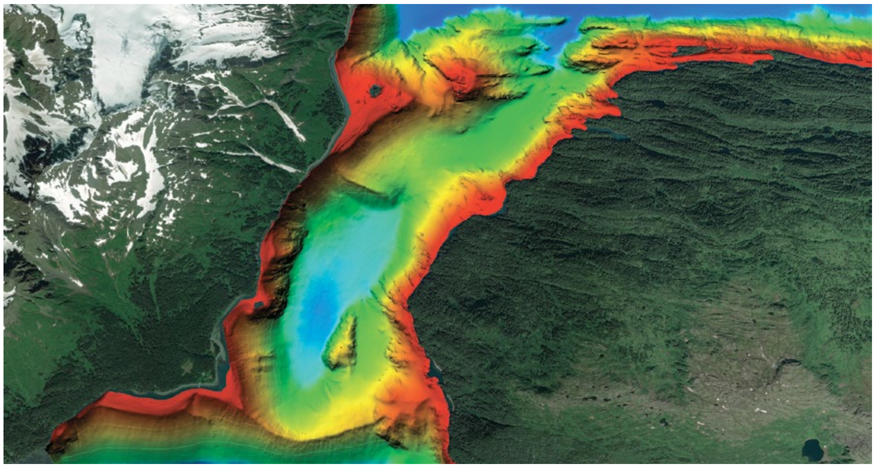
NOAA selected Woolpert as the contractor most qualified to conduct this work from the pool of NOAA's hydrographic survey vendors. Woolpert is a global architecture, engineering, and geospatial firm with a long history of supporting NOAA and collecting large-area topographic and bathymetric data across Alaska.

"Woolpert has been mapping Alaska for over 20 years, with offices in Anchorage and Wasilla, and staff embedded across the state," said Dave Neff, a certified hydrographer who



The high-speed winch used to model spatio-temporal variations in the water column and correct for refraction.

leads Woolpert's geospatial maritime team. "We've supported projects from Southeast Alaska to the North Slope to the farthest remote tips of the Aleutian Islands. Our work includes mapping for telecommunications cable route surveys, harbor mapping, navigation and charting, as well as emergency response efforts like the Barry Arm landslide risk."



Oil tankers navigate the Valdez Narrows to deliver crude oil from Alaska to the lower 48, while bathymetric data reveals a seafloor shaped by glacial processes.

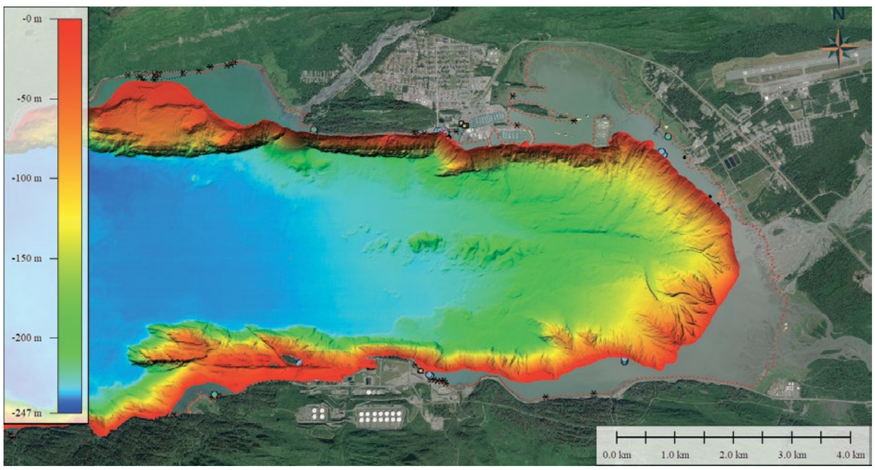
Mapping the Valdez Basin and Valdez Glacier Lake

The depth of the Valdez Basin ranges from just a few feet near the shoreline to about 1000 feet. Woolpert's survey covers depths down to 1042 feet. To map the Valdez Basin, Woolpert's hydrographic survey team used both high- and low-frequency multibeam sonar to map all depths within the project area. This sonar's wide dynamic range of frequencies, from 90 to 450 kilohertz, enabled the team to reach the highest resolution possible for both the shallow and deep water.

A unique challenge the Woolpert team had to address was refraction. The cold freshwater rivers flowing into the survey area cause sound velocity changes in the water column, resulting in distortions in the bathymetric data. Woolpert prepared accordingly by bringing a high-speed winch and freshly calibrated sound velocity profilers. These tools enabled Woolpert to model the spatio-temporal variations in the water column and correct for refraction. In total, the port survey covered an area of approximately 34 square nautical miles.

Having completed the first survey, the team shifted its focus to Valdez Glacier Lake.

"After the city was awarded the original contract for the hydrographic survey, I reached out to NOAA and explained the situation with Valdez Glacier Lake," Baczuk said. "Typically, NOAA works with ocean surveys, but because of the proximity of the lake to the ocean and to our critical infrastructure, they were willing to include that survey at no additional cost to the City of Valdez."



A complex depositional environment is revealed in the bathymetric data adjacent to the City of Valdez.

In comparison, the two square nautical miles of Valdez Glacier Lake were considerably smaller than the port's survey area. Nevertheless, the lake's water depth reached 656 feet, very impressive for such a small body of water. These depths meant that the Woolpert team needed to use the same deep-water, high-resolution multibeam sonar to acquire accurate data.

The challenge, however, was that Valdez Glacier Lake had no boat launch and was choked with a labyrinth of icebergs. Woolpert could not launch its survey vessel into the lake, and the vessel was too large to navigate safely through the icebergs.

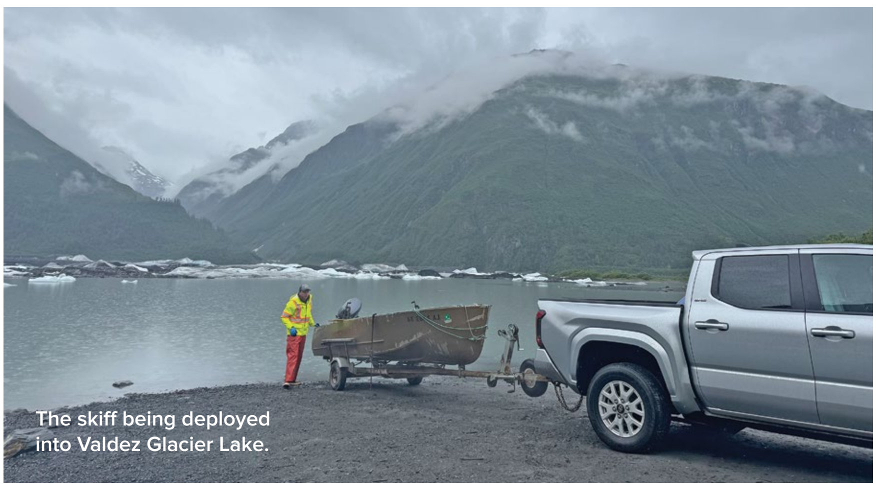
Valdez Glacier Lake and its labyrinth of icebergs.

The figure and the skiff indicate the scale of a large iceberg inside Valdez Glacier Lake.

"Valdez Glacier Lake required innovative approaches," Neff said. "We employed an uncrewed watercraft with custom equipment to safely and accurately survey this remote and dynamic landscape."

Woolpert's uncrewed survey vessel was accompanied by a skiff and by Baczuk, who came out in his personal kayak to help escort the team through the icebergs. This strategy allowed Woolpert to use its deep-water, high-resolution multibeam sonar to successfully map all the way to the glacier's face, including the deepest parts of the lake.

Michael Stephens, contracts team lead of the Hydrographic Surveys Division for the Office of Coast Survey, was "impressed with how much data they were able to collect in such a harsh environment with so many logistical challenges as well."



The skiff being deployed into Valdez Glacier Lake.

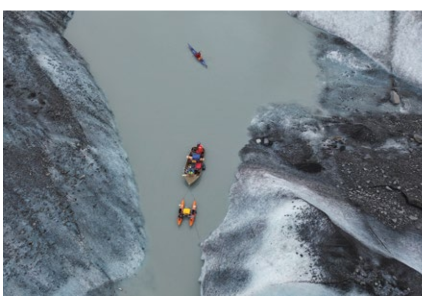
The broader benefits of seafloor mapping and utilizing federal grant programs

Updated bathymetric data from these surveys support many other critical applications in addition to disaster preparedness. Accurate data ensures that vessels in Valdez's waters can navigate safely and avoid underwater hazards. It also supports industries such as fishing and tourism, as well as planning new infrastructure, for example, identifying locations for underwater fiberoptic cables. Other possible uses include habitat modeling and resource management.

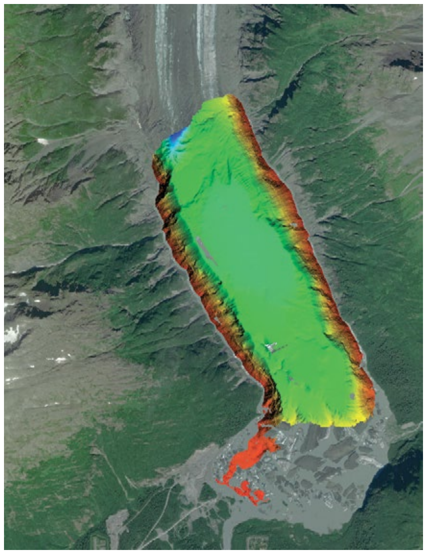
"The maritime economy is largely invisible to most Americans, but

The uncrewed surveying vessel with the deep-water, high-resolution multibeam sonar.

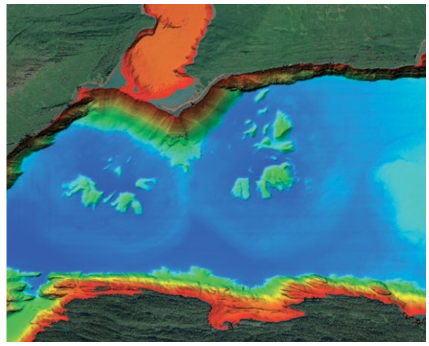
The Woolpert team surveying Valdez Glacier Lake, accompanied by an uncrewed vessel equipped with a deep-water, high-resolution multibeam sonar.



Drone photograph of Aaron Baczuk, the City of Valdez emergency manager, in his kayak leading the Woolpert team in their skiff as they pull the uncrewed surveying vessel through the icebergs.



Bathymetric data for Valdez Glacier Lake. Data was collected up to the face of the calving glacier, where depths reached up to 192 m (632 feet).



Submarine landslide debris are clearly visible in the bathymetric data. With heights up to 40 m, these slump deposits lie at the base of the glacial fjord, showing evidence of prior slope failures.

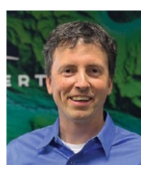
it's fundamental to the functioning of our economy today," Greenaway said. "Whether you think about grain exports coming down the Mississippi River and heading overseas, or oil moving from, say, Valdez down to a refinery on the West Coast, the supply chains are so important to ... every aspect of our economy, and it's critical that we have updated navigational products to support that."

Furthermore, these mapping projects demonstrate to non-federal entities, such as cities like Valdez, the advantages of partnering with federal agencies to leverage their expertise, contractor networks, and resources.

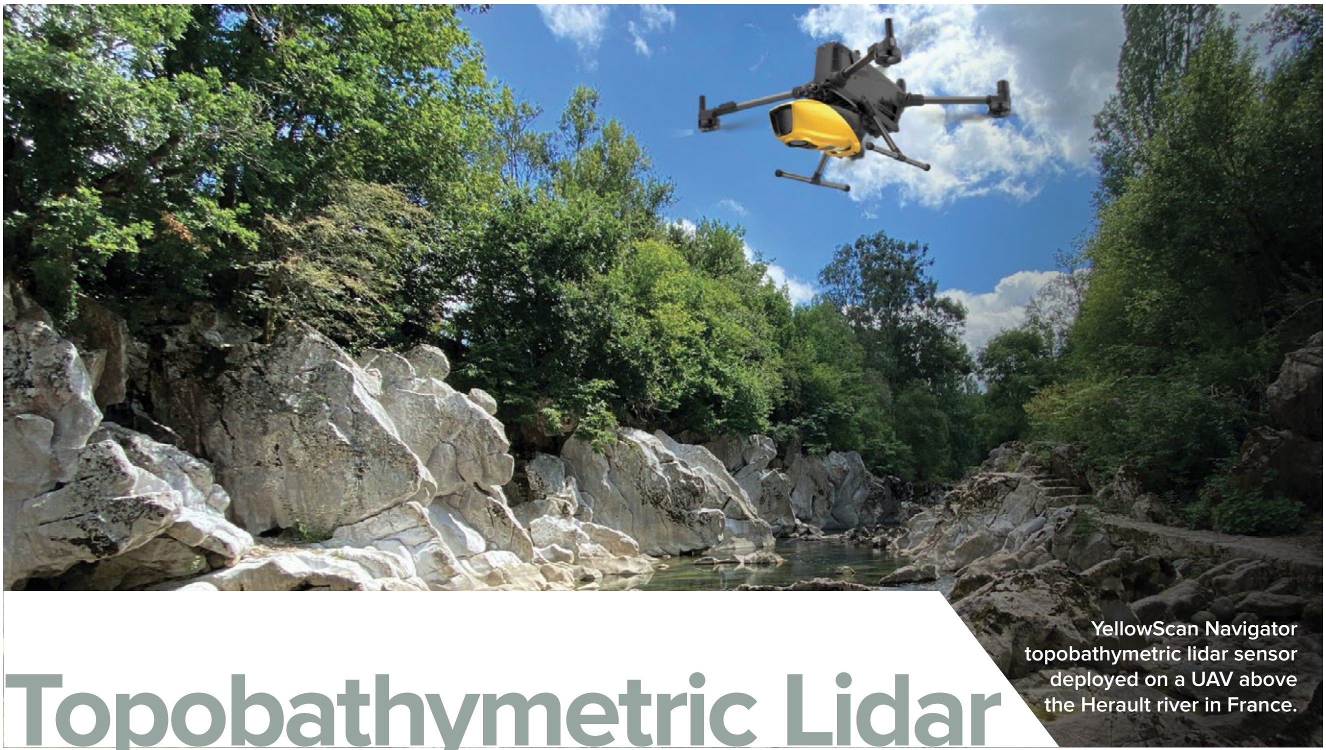
"You never know down the road who you may have worked with or partnered with—how that relationship is going to be beneficial in the future," Duval said. "Working with NOAA and Woolpert, those were relationships that we were able to establish and connections that may be used for other projects, but it may also just be something that helps us understand their processes for a future grant or other opportunities that may come up."

"NOAA was a fantastic partner for the City of Valdez in this project," Baczuk said. "At the very beginning, they helped us understand whether our project and what we were trying to accomplish would work with the Brennan Ocean Mapping Fund."

He also highlighted the contributions of Woolpert, saying, "… when it came to the Valdez Glacier Lake, they were tenacious in helping us to acquire that data."



Woolpert Lead Hydrographer and Project Manager **Ryan Cross, CH**, has expertise in collecting, processing, and analyzing spatial data. He specializes in vessel operations and data acquisition and is responsible for leading field operations and maintaining proper protocols. As a geophysicist and project manager, Cross merges rigorous scientific standards with business requirements, working closely with clients and colleagues to see projects through the initial planning to the final deliverables. He earned his BS and MS in geology and geophysics, respectively, from the University of Alaska Fairbanks.



YellowScan Navigator topobathymetric lidar sensor deployed on a UAV above the Herault river in France.

Topobathymetric Lidar for River Mapping: A Complementary Solution

YellowScan sensor facilitates modeling river channels and floodplains

Mapping major and minor riverbeds, particularly for river mobility studies, requires various cartographic methods. Topographic lidar is ideal for modeling riverbanks with centimeter-level precision and a strong ability to penetrate vegetation. However, it cannot map the submerged part of the riverbed, necessitating a second method to complete the data.

Combining topographic and bathymetric methods

Depending on the site, accessibility may allow for regular transects to characterize different flow patterns in the riverbed. This conventional method is reliable and effective in many situations, offering centimeter-level precision. Nonetheless, operators may face challenges in navigating wooded or rugged river environments, deep zones, or strong currents.

BY FLORIAN **CARAVEO**

YellowScan Navigator topobathymetric lidar sensor deployed on a UAV above Le Pont du Diable, a bridge on the Herault river in France.

Conventional survey of a river using a total station and graduated rod.

In such cases, using a boat or a surface drone (USV) equipped with an echo sounder is effective in less cluttered waterways with moderate currents. This also requires good site accessibility to transport equipment.

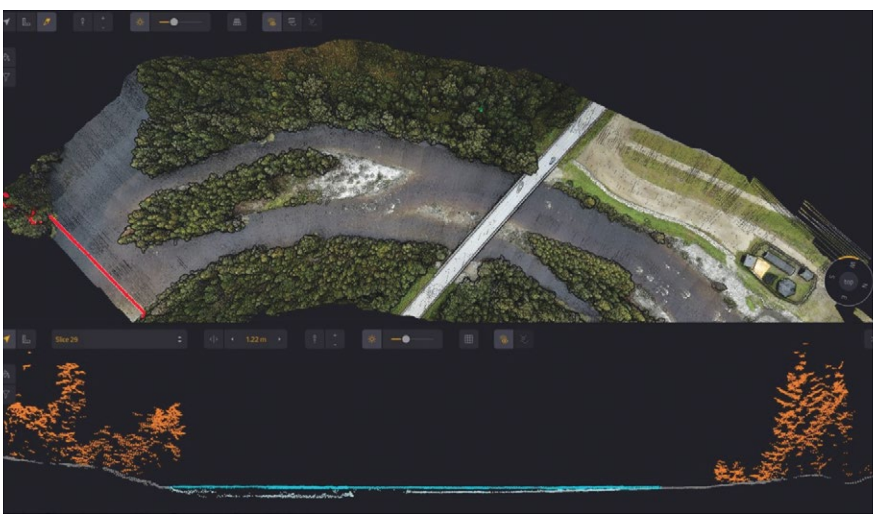
Complementarity of methods

Conventional bathymetric methods, such as using poles or echo sounders, can be combined with topographic lidar to create a robust cartographic database. However, integrating topographic and bathymetric data can be time-consuming and may result in gaps or discontinuities between terrestrial and underwater data.

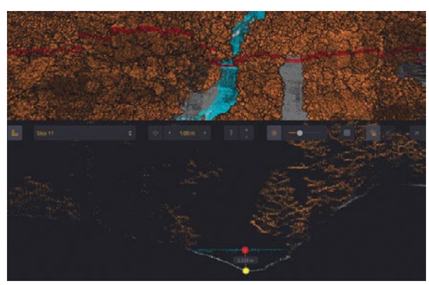
A new comprehensive method: Topobathymetric lidar

Topobathymetric lidar offers a significant advantage: drone-based acquisition can model the riverbed, water layer, submerged areas, and banks in a single operation. This creates a unified digital terrain model (DTM) with seamless continuity between underwater and terrestrial data, generated simultaneously. The point density underwater ranges from 20 to 50 points/m^2.

The ability of topobathymetric lidar to penetrate vegetation ensures continuity between the water surface and wooded banks, integrating riparian vegetation into topographic data. For example, a 309 m river section with 50 m of bank on either side can be mapped in 10 minutes, with data processing completed in under two hours.

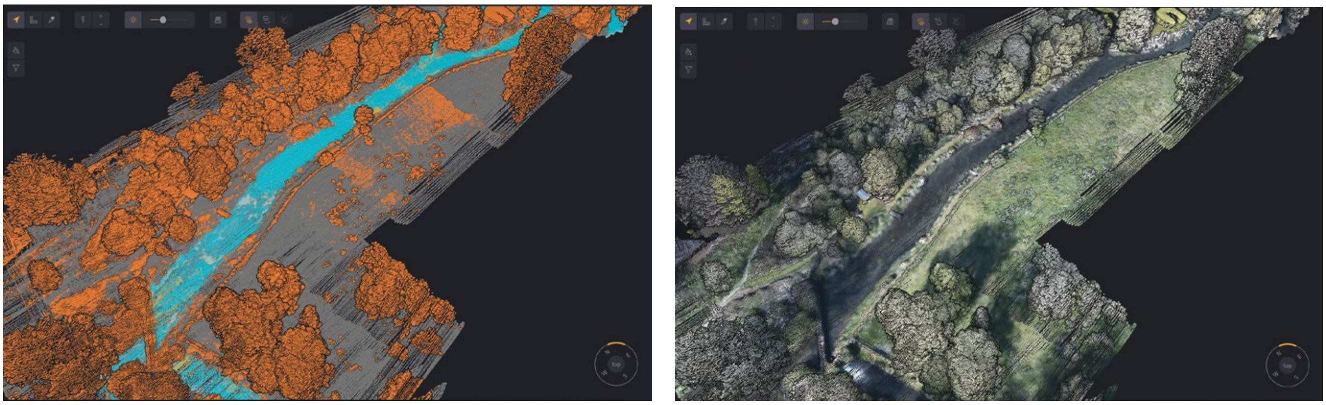


This stretch of river in Scandinavia exemplifies the complexity of a riverine environment. The position of the cross-section in the lower part of the graphic is shown in red in the upper part.



Example of a cross-section where vegetation cover extends over the river. Data is continuous even underwater at depths of over 2 m.

Three visualizations of a data set of the Lez River in France. From left to right: point cloud colored by elevation; point cloud classified into trees, water and other types; and point cloud filtered while retaining the water layer and the soil layer.



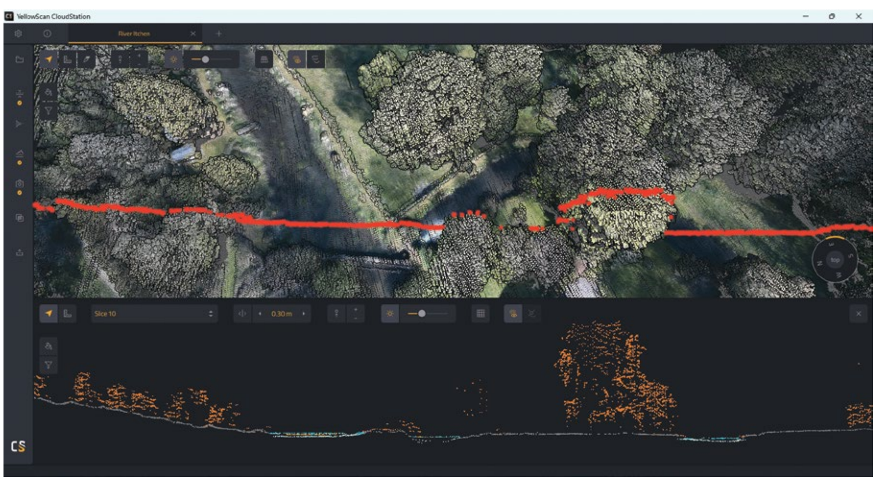
A data set covering part of the River Itchen in England. On the left, the points are classified according to their type. On the right, the data is colorized using imagery. Combining these two views can improve detailed data analysis, including estimates of aquatic plant surface area and volume.

Limitations of laser technology

The primary constraint is the ability of light to penetrate water and reflect off the bottom. Unlike echo sounders, lasers do not propagate through fine sediments. The generated points represent water depth without accounting for sediment thickness, such as silt or mud.

The performance limit is expressed in Secchi units, measured using a Secchi disk. The YellowScan Navigator topobathymetric lidar sensor can acquire data up to two Secchi depths. In rivers, if the Secchi depth is 3 m, it can map deep pools of 5 to 6 m. The reflection of the light beam depends on the coloration of the substrates, which must be considered when deploying this technology and processing data.

Mapping a river while taking into account the alluvial forest provides a useful basis for addressing environmental issues in the most effective way possible. Lidar data analysis tools can be used to classify points and, in particular, to isolate vegetation from the rest of the data. This makes it possible to distinguish the relief of riverbanks, detect signs of erosion, and identify secondary riverbeds hidden by dense vegetation cover.



Cross-section of part of the River Itchen data set.

Example of a river with clear evidence of erosion on the far bank.

Colorizing of points and nature of substrates

Colorized point clouds can be generated when lidar data is combined with imagery. This is a feature offered by the YellowScan Navigator lidar with an integrated camera.

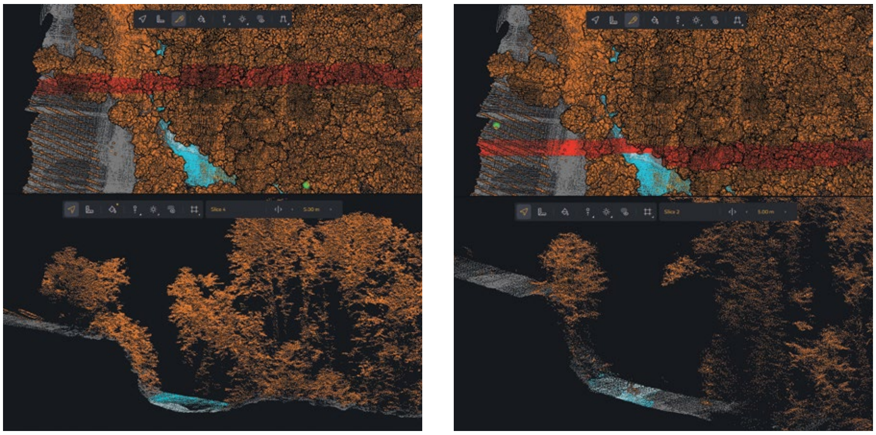
Depending on the clarity of the water and the bottom, the natural colors of the riverbed can be distinguished.

Aquatic vegetation can appear as "noise" in bathymetric data. The identification of "patches" of seaweed can be done in conjunction with the colorizing of points.

The mapping of a watercourse with diversion channels and hydraulic structures is much easier with the topobathymetric lidar data and accompanying imagery.

Contexts can sometimes be complex to map on foot, for example, changes in properties between diversion channels and the original riverbed. UAV-lidar scans properties without needing to conduct surveys on the ground or in the water.

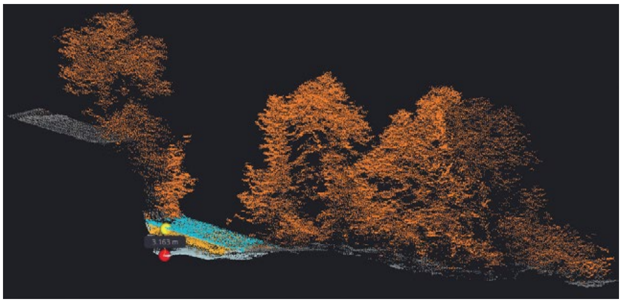
Depending on their shape and size, structures appear in the digital terrain model. However, the terrain will need to be surveyed to obtain more accurate dimensions when sluices or underground channeled sections are present.



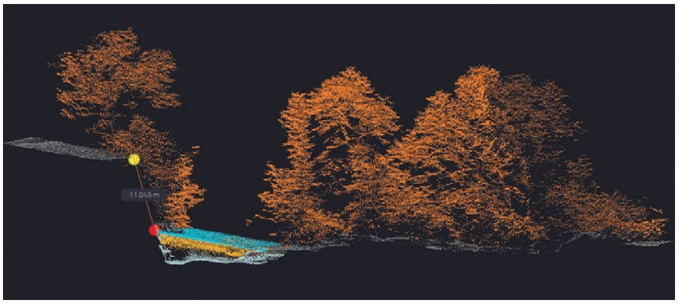
Two examples of data sets of areas with significant erosion. On the left, a cross-section with a steep, vegetated bank upstream of an eroded area. On the right, a cross-section with a very steep bank subject to severe erosion.

Erosion monitoring

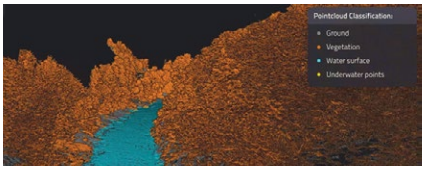
The repeatability of UAV-based mapping is an asset for tracking erosion



This example is a visualization of a steep, vegetated bank and a pool with a depth of 3.16m.



The height of the vegetated bank can be easily measured in a classified lidar point cloud. Here, there is a difference in elevation of over 11 m.



Visualizing a classified lidar point cloud of the Herault river in YellowScan CloudStation software. This automated functionality is a first step in leveraging field data. It is possible to refine this automatic classification to assign points to the data class according to best match.

Visualization of terrain relief and vegetation without the "water" layer and without the points suspended in the water which can be linked to several components (vegetation, bubbles, suspended particles...).

after each flood. For river mobility studies, topobathymetric lidar provides precise data to locate and measure problematic areas and assess sediment volumes from bank erosion.

Often, one bank of a river is very steep and is frequently eroded by flooding. This is exacerbated where the bank is not properly protected by tree roots and vegetation. Lidar mapping can help river authorities to monitor erosion sites and plan actions where the situation may become dangerous.

Conclusion

Topobathymetric lidar technology complements traditional, robust methods used by surveyors and scientists. While aerial devices for river mapping are not new, the nature of the data produced has evolved.

The limitations of the technology, however, must be recognized :

- The laser's ability to penetrate water restricts its use to clear water and low-flow periods.
- Deploying a UAV with topobathymetric lidar requires a certified pilot and compliance with aviation regulations. Some airspaces may be restricted, necessitating authorization.
- Given typical UAV flight times and maximum payloads, topobathymetric missions are best accomplished by powerful and reliable UAVs to map over the water with a payload of more than 4 kg.

The advantages of topobathmetric lidar performed with UAVs are considerable:

- Easy deployment on various terrains, even rugged or wooded areas
- Rapid data acquisition and processing

Visualization of terrain relief, which is mainly associated with mineral substrates and rock outcrops.

- Single DSM or DEM integrating terrestrial and subaquatic data
- Highly precise repeatability for mapping operations by reusing flight plans.

While topobathymetric lidar cannot replace all traditional river mapping and monitoring procedures, it is extremely valuable for fast, large-scale mapping.

Florian Caraveo is community manager for YellowScan, the French UAV-lidar supplier. He has built a career at the intersection of environmental expertise, marketing, and technological innovation. Committed to ecosystem preservation, he brings diverse experience in natural environment management, water habitat mapping, and science communication. Since 2023, he has specialized in UAV-lidar at YellowScan, discovering the performance of the company's tools to advance environmental understanding and monitoring. By connecting innovation with sustainability, he contributes to projects that use lidar for population safety and environmental research.

A Geodesist's Guide to Joining Land and Sea Datasets

Bridging the gap between terrestrial and marine elevation data

Topobathymetric lidar, a laser-based system that captures both land topography and shallow-water bathymetry, represents a significant leap in coastal mapping. When conditions are favourable, such airborne surveys can produce continuous models across the shoreline, reducing one of the most persistent headaches in coastal data collection: stitching together datasets from different sensors on land and at sea.

Topobathymetric lidar performance is highly dependent on water clarity, sea state, and environmental conditions, however, and often cannot penetrate sufficiently or provide reliable data. In such cases, one must fall back on traditional approaches, combining datasets acquired through different sensors — for example terrestrial lidar with marine sonar, each with their own coordinate reference systems and accuracy specifications.

Even when topobathymetric lidar works successfully at the coastline, it does not actually eliminate the integration problem; it simply shifts it elsewhere. Users may still need to integrate near-shore lidar with deeper water multibeam sonar surveys, offshore satellite altimetry, and terrestrial digital twins or national elevation models.

Fragmented data: Why it matters

Land and sea data may be acquired through specialised sensors, and measurement approaches tailored to particular domains and environments. Effective decision-making for coastal management is hindered by this fragmentation of land and sea data. When datasets are collected, stored and managed independently, the result may be inconsistencies, inefficiencies, and gaps in critical information. This lack of integration limits the ability to address cross-domain challenges such as infrastructure development, mitigating climate change, coastal erosion, and maritime security.

To enhance data-driven policymaking, there is a need for clear and practical advice on how to align or integrate land and sea data. At this time, this is not available in a clear, structured and concise manner. The United Nations Global Geodetic Centre of Excellence (UN-GGCE) in conjunction with TU Delft is trying to fix that.

A classic example is flood-risk modelling. Land topography is often tied to a National Height Datum (NHD), typically established decades ago using tide-gauge observations of Mean Sea Level (MSL). Bathymetric surveys, by contrast, are usually referenced to a Chart Datum (CD), commonly Lowest Astronomical Tide (LAT). If these datasets are combined without proper vertical transformation, height mismatches can appear as artificial cliffs or trenches along the shoreline, distorting the resulting flood-risk models. While this example focuses on flood modeling, the same integration errors propagate across all cross-domain applications.

Institutional divides intensify the issue: national mapping agencies typically use NHDs or geoids; hydrographic offices prioritise safe navigation and therefore maintain LAT-based systems; environmental agencies may use several tidal datums depending on regulatory needs; and utilities or private contractors often introduce their own *ad hoc* local reference frames. Mismatches and inconsistencies between these can create safety risks, cost overruns, and poor resilience planning.

BY EVERT **MULDER** AND NICHOLAS **BROWN**

For instance, if bathymetry is misaligned, dredging plans may overlook critical features, dredge too little, or operate inefficiently, which could lead to reworking or significant budget inflation. Misaligned data can also compromise navigation safety, increasing the risk of grounding, vessel damage, or even total loss. In the context of resilience planning, inaccurate elevation data will skew risk assessments (e.g. flooding or sea-level-rise adaptation), potentially underestimating vulnerability or overstating system stability, which in turn can lead to inadequate protective measures.

As noted earlier, topobathymetric lidar may help to some extent, but merely shifts the integration challenge rather than eliminating it.

APPLICATION EXAMPLE: COASTAL INFRASTRUCTURE PLANNING AND COMPREHENSIVE FLOOD-RISK MODELLING

The integrated dataset should be suitable for immediate use in planning and risk assessment. This means that it needs to be accurate as well as practical and physically meaningful, with heights with respect to the geoid (i.e., orthometric heights).

Example input data includes:

- Lidar-derived topobathymetric datasets referenced to an ellipsoid (e.g., ITRF2020, WGS84)
- Land-domain datasets (e.g., terrestrial digital twins) referenced to an ellipsoid or NHD
- Sea-domain datasets (e.g., from bathymetry surveys) referenced to a CD

To produce the required dataset, all input data must be referenced to the same height reference system — the geoid. This requires the following transformations:

- Ellipsoidal heights (h) → orthometric heights (H), requiring the application of a **Geoid — Ellipsoid Separation Model (N)** for data that is referenced to an ellipsoid
- Heights with respect to Chart Datum → orthometric heights (H), requiring the application of a **Chart Datum — Geoid Separation Model** for data that is referenced to a CD
- Working within local NHD frameworks involves additional transformations: Orthometric Heights (H) ←→ heights with respect to NHD, requiring the application of a **National Correction Surface Model (C).**

Beyond height reference alignment, all data must of course be referenced to a common epoch. This means that temporal corrections may also be required, e.g., to account for sea level changes and land motion.

Please refer to **Figure 1** for a visual overview.

Heights explained — a quick primer

In this process, it is important to understand the options, their technical meaning, and their relationships. A height reference system is a coordinate system used to define the height of a point above or below a reference surface. Each height reference system requires three fundamental components: a zero-point (datum point), a unit of measurement, and agreement on the type of height being used - the latter determining the path along which distances to the reference surface are measured. A height datum is the practical realization of such a height reference system through physical ties to the Earth's surface.

Height determination requires care due to the number and type of datums or surfaces to which heights can be referenced, including:

- Ellipsoid: A smooth mathematical model of the Earth, used by GNSS (Global Navigation Satellite Systems) such as GPS. This is convenient and global, but has no physical meaning, i.e., for water flow.
- Geoid: An undulating surface representing equal gravity potential, approximating Mean Sea Level (MSL). Orthometric heights, i.e., heights with respect to the geoid, measured along the plumbline, are physically meaningful.
- Mean Sea Level (MSL): The average sea surface observed over a long period — often at a tide gauge. MSL is local, variable, and changes with climate.
- Lowest Astronomical Tide (LAT): The lowest tide that can be predicted under average meteorological conditions and any combination of astronomical conditions. LAT serves as the internationally recognised reference for Chart Datums (CDs) and water depths on nautical charts.
- National Height Datum (NHD): Each country's official height reference system, typically established from tide-gauge observations of MSL at specific locations and periods. NHDs are not always consistent with the geoid or with neighbouring countries.

The relationships between these models are illustrated in **Figure 1**.

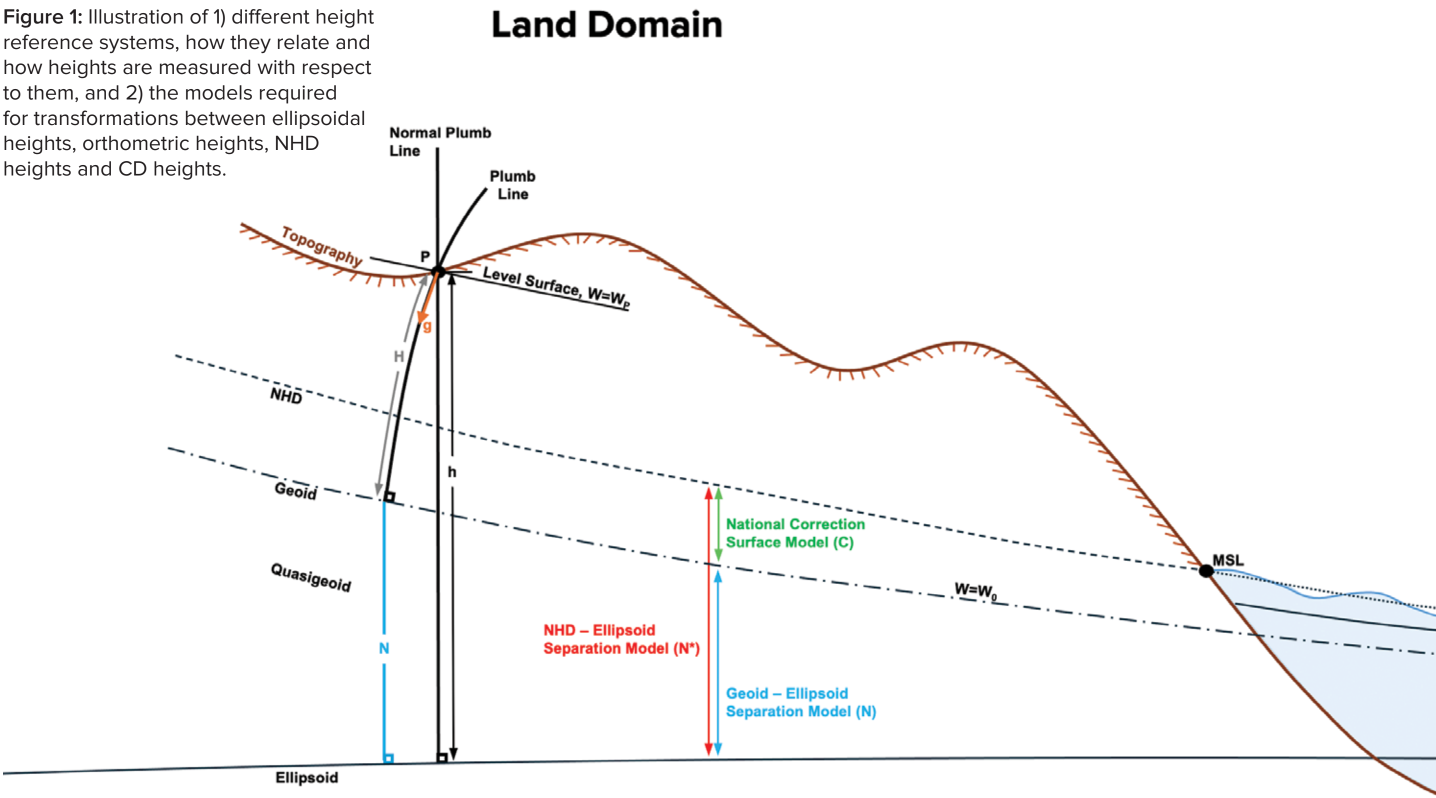


Figure 1: Illustration of 1) different height reference systems, how they relate and how heights are measured with respect to them, and 2) the models required for transformations between ellipsoidal heights, orthometric heights, NHD heights and CD heights.

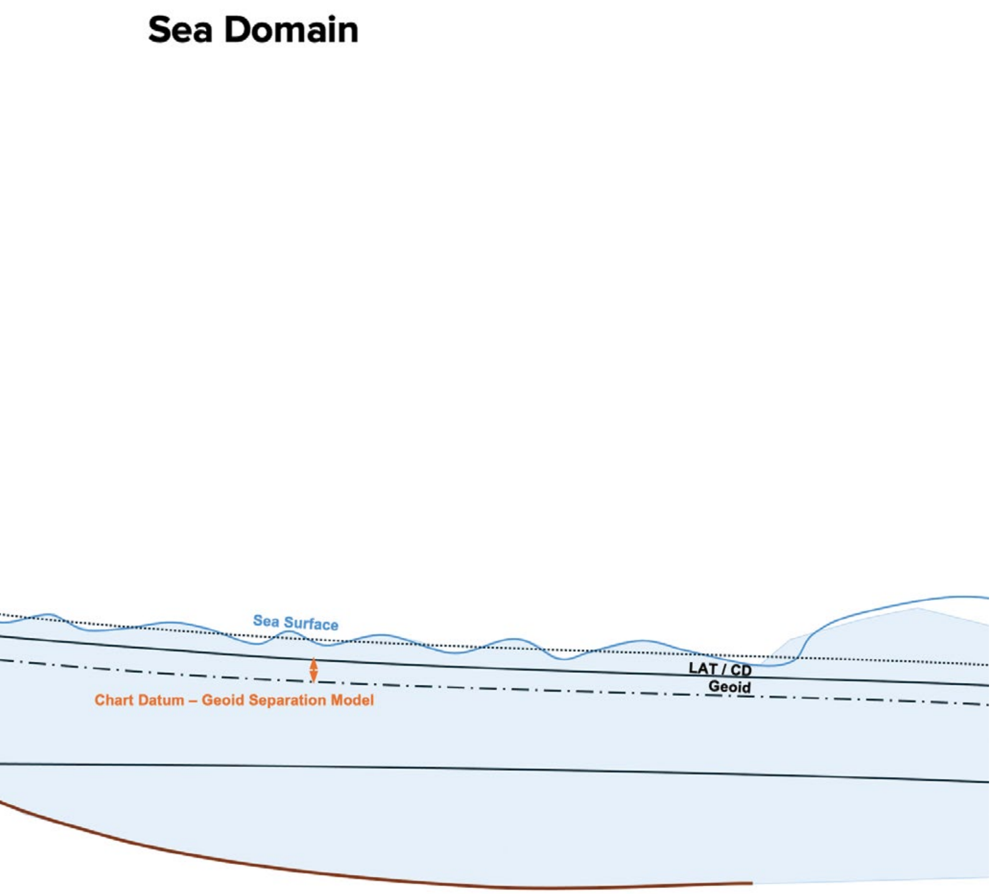
Please note that this list is non-exhaustive and there are others, especially in the sea/tidal domain.

Practical pathways to integration

Integration with onboard GNSS systems ensures that lidar data is referenced to an ellipsoid. However, for practical applications — especially in coastal engineering or navigation, flood defense, and climate resilience work – heights must be referenced to a physical height datum such as the geoid, legacy datums such as NHD (if different from the geoid), or operational datums such as CD (i.e., LAT). Hence, transformations are unavoidable in these contexts.

To achieve these transformations and integrate land and sea datasets, one or a combination of the following models may be required:

1. **Geoid — Ellipsoid Separation Model (N)**: to transform ellipsoidal heights (e.g., from GNSS) directly into orthometric heights. Global models like EGM2008 offer coarse solutions, while regional or national geoids, established using a combination of dense gravity surveys, GNSS and levelling observations, provide much better solutions, achieving centimeter accuracy in data-rich areas.
2. **National Correction Surface Model (C)**: to transform orthometric heights into heights with respect to NHD. This is essential where NHD diverges from the geoid, and requires a network of co-located points where both GNSS and levelling observations are available. This model is commonly adopted to tie legacy systems to the geoid.
3. **National Height Datum — Ellipsoid Separation Model (N*)**: to transform ellipsoidal heights directly into heights with respect to NHD. While convenient, this approach is less accurate overall because it combines two models (i.e., **N+C**), and thereby also their respective uncertainties.
4. **Chart Datum — Geoid Separation Model (…)**: to transform heights with respect to the CD to



orthometric heights. This model can be derived using comprehensive hydrodynamic models combined with satellite altimetry data and tide gauge observations. It is adopted to tie sea-domain datasets (e.g., bathymetric surveys) to the land.

Common pitfalls (and their consequences)

Even with access to appropriate transformation models, projects stumble on the same recurring implementation problems. Understanding and avoiding these pitfalls is crucial for successful integration.

- Datum confusion: The different versions of WGS84 (World Geodetic System), ITRF (International Terrestrial Reference Frame) and altimetry-specific ellipsoids like TOPEX are similar, yet slightly different. The differences, if not accounted for, can cause height offsets in the decimeter range, which can compromise flood-risk models, leading to inadequate coastal defences that could fail during extreme weather events.
- Timing and epochs: Absolute sea level changes with time and relative sea level is known to rise or fall owing to the impacts of land motion. Datasets from different years must therefore be adjusted to a common epoch using accurate geophysical models. Ignoring temporal changes can introduce significant errors.
- Positive up versus positive down: In the land domain, heights are typically recorded above a datum, whereas in the sea domain, "heights" (i.e., depths) are often recorded below one. Mixing them carelessly will generate false cliffs or trenches. These artificial features could cause dredging contractors to excavate non-existent shoals, wasting considerable money in unnecessary work, while missing actual navigation hazards.
- Poor metadata: Too many lidar products arrive without full documentation of their vertical reference. Guesswork is dangerous and can have far-reaching impacts.

The implications are straightforward: integration errors have financial and safety consequences. Investing in correct height reference management as part of the normal workflow is just as important as investing in hardware. Besides, the cost of the required geodetic expertise upfront is typically a small fraction of project value — far less than the cost of fixing integration errors later.

Institutions matter too

Even with the existing technical tools and approaches, institutional divides still persist. Hydrographic and mapping agencies maintain separate reference systems, and many national legacy systems were established decades to over a century ago, creating a patchwork of reference systems that can differ even within a single country.

Integration is therefore both a technical and an organizational challenge. Success requires building relationships across institutional boundaries and developing standards that respect

UN-GGCE IMPLEMENTATION GUIDANCE

The vision of the United Nations Global Geodetic Centre of Excellence (UN-GGCE) is a future where all countries have strong support for geodesy which enables them — together — to implement the General Assembly Resolution 69/266 and accelerate the achievements of the Sustainable Development Goals to derive social, environmental and economic benefits.

To assist with the challenges associated with joining land and sea data, UN-GGCE is developing practical implementation guidance. It addresses a key need identified in the UN-GGIM compilation report on "Integration of Terrestrial, Maritime, Built and Cadastral Domains" (*https://ggim.un.org/meetings/GGIM-committee/15th-Session/documents/Compilation_Report_Integration_Terrestrial_Maritime_Built_and_Cadastral_Domains.pdf*), which analyzes broader aspects of domain integration across Member States, covering governance frameworks, institutional arrangements, capacity building needs, and strategic approaches.

For more information about the UN-GGCE please visit: ***https://ggim.un.org/UNGGCE***.

each agency's mission while enabling interoperability.

For lidar professionals, this means working closely with geodesists, hydrographers, and standards bodies, not just delivering point clouds. Early engagement with end users is essential, to understand their referencing requirements, and design data products that bridge institutional divides rather than perpetuate them.

The way forward

Here is what lidar professionals, managers, and academics need to keep in mind:

- Recognise that integration challenges remain, just that they may be shifted elsewhere.
- Adopt transformation workflows early — any lidar project must account for transformations into geoid-based systems, CDs, or NHDs, depending on the application.
- Plan for hybrid requirements — a single project may need data expressed with reference to multiple height datums (e.g., CD for navigation, geoid for flood risk).
- Coordinate actively — include geodetic expertise in lidar workflows. Don't treat vertical referencing as an afterthought.
- Support data governance reforms — push for agencies to modernize geodetic infrastructure and publish relevant separation/correction models. This makes life easier for every downstream user.

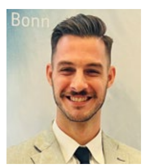
Conclusion

Topobathymetric lidar may provide continuity across the shoreline, removing one of coastal mapping's biggest challenges. Nevertheless, integration of different datasets, acquired by different sensors and referenced to different height datums, may still be required. The integration problem may have shifted, but certainly has not disappeared.

Successful data integration demands both technical understanding and institutional coordination. High-resolution data means little without trustworthy alignment into consistent, physically meaningful height reference systems. The consequences of poor integration — compromised flood-risk models, project cost overruns, safety failures, etc., underscore why geodetic expertise must be embedded in lidar workflows from project inception.

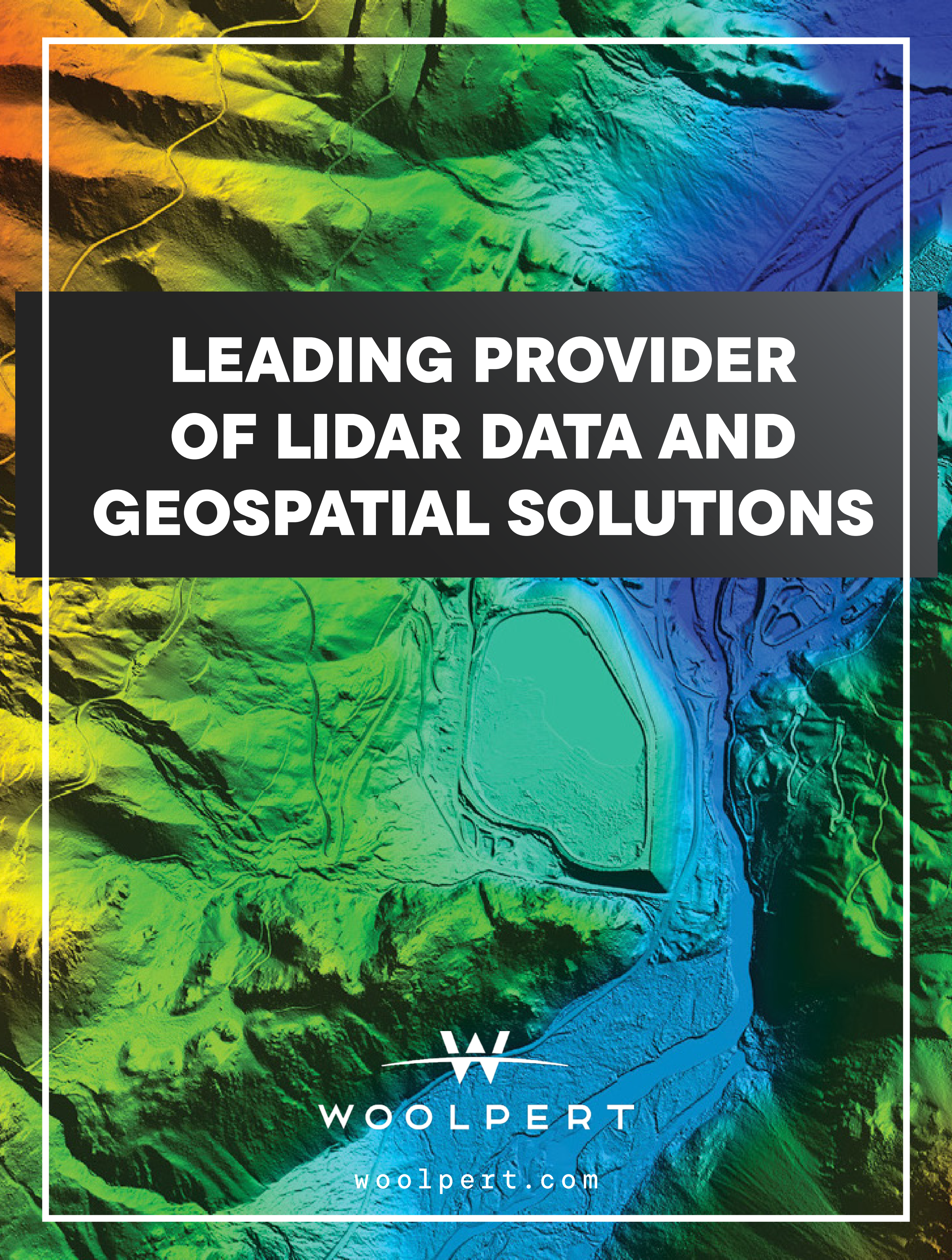
The path forward requires lidar professionals to incorporate necessary transformations early in their workflows, plan for multiple height datum requirements, and coordinate actively with geodesists and standards bodies.

While the shoreline may no longer be the primary obstacle, the fundamental challenge of integration remains as critical as ever. Addressing it successfully requires both technical excellence and international cooperation — which is precisely what the UN-GGCE's implementation guidance aims to support.



Evert Mulder is Geomatics Manager, Geodesy & National Mapping at the Singapore Land Authority (SLA). He spearheads Singapore's geodesy initiatives, including datum modernization, land motion monitoring and land-sea integration programs, while advancing geodetic capabilities across government agencies. As technical adviser at UN-GGCE, he focuses on capacity building and developing technical guidance, with an emphasis on land-sea integration.

Nicholas Brown is Head of Office for UN-GGCE. He works with Member States and organizations to strengthen their collective impact to enhance investment in the global geodesy supply chain, build capacity, and make geodesy and its benefits more visible and understandable to society.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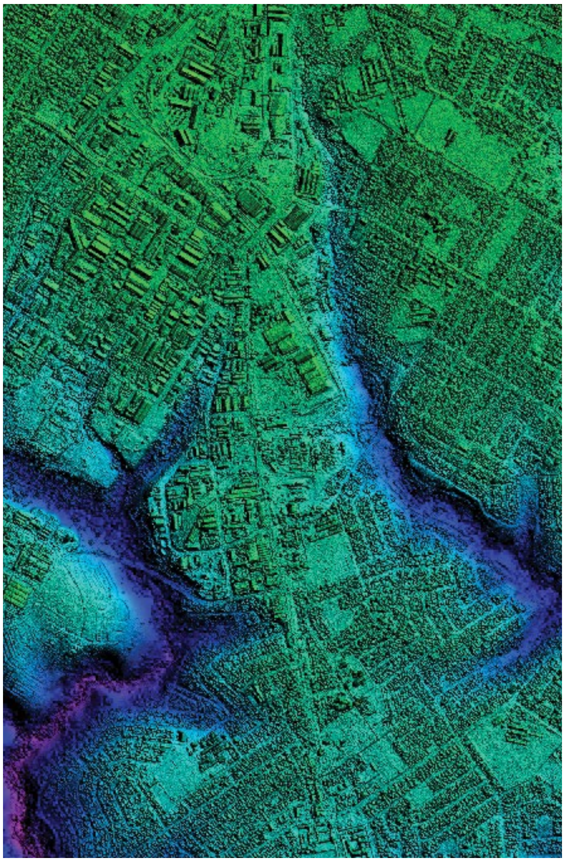
Building South Africa's Nationwide, High-Resolution Elevation Model

GeoSpace International teams with Hexagon and Riskscape to create DSMs and DTMs for all South Africa, using photogrammetry for a project area of 1.2 million km^2.



In 2022, a leading South African geospatial services firm identified a growing need for higher-resolution elevation data to satisfy applications in multiple sectors across the nation. A 25-meter digital elevation model (DEM) had been developed years before, but the mapping community in South Africa required 1- and 2-meter resolution elevation data for modern applications.

The geospatial firm GeoSpace International[1] had been awarded numerous surveying and mapping projects by the country's national mapping agency, the Chief Directorate: National Geo-Spatial Information (CD:NGI). GeoSpace saw a unique opportunity to drive a major new DEM project that would benefit end users throughout South Africa.

Fortunately, much of the high-quality aerial imagery that could serve as the basemap for the project was already collected. Annually, CD:NGI publishes tenders to capture aerial imagery and orthophotos, covering several quarter-degree blocks. In 2017 GeoSpace began capturing imagery for CD:NGI using the Leica DMC III airborne mapping sensor. Seven years later, it had flown the entire land area of the country, 1.2 million square km^2, at a resolution of 25 cm.

GeoSpace saw this imagery as the foundation for the higher-resolution DEM datasets and sought partners to make the nationwide project a reality.

Building a solutions partnership

The aerial imagery was an ideal start to the elevation project due to the DMC III's large-format design. Made for photogrammetric mapping, it captures aerial data with high accuracy both horizontally and vertically, and achieves a GSD of 25 cm from an altitude of 20,000 feet AGL with 60/25 percent overlap.

The desired 3D elevation data could be extracted from the imagery that had

1 https://www.geospace.co.za

BY SØREN VOSGERAU **JESPERSEN**

already been captured. The challenge, however, was processing the massive volume of raw imagery to derive the elevation products. The computer power and processing capabilities required for the project and its short timeline of two years would be enormous and did not exist in South Africa.

"We are an aerial mapping company and did not have the resources to handle an elevation data processing project of this scope," said Bernhard Jacobs, Director of GeoSpace. "The Hexagon Content Program, on the other hand, already had the resources in place to do it."

The Hexagon Content Program[2] was already completing projects at this scale in North America and Europe. It had the processing software, computer infrastructure, and knowledge to generate the elevation models from the imagery for all of South Africa. The Leica HxMap post-processing workflow is a key component of these processing capabilities.

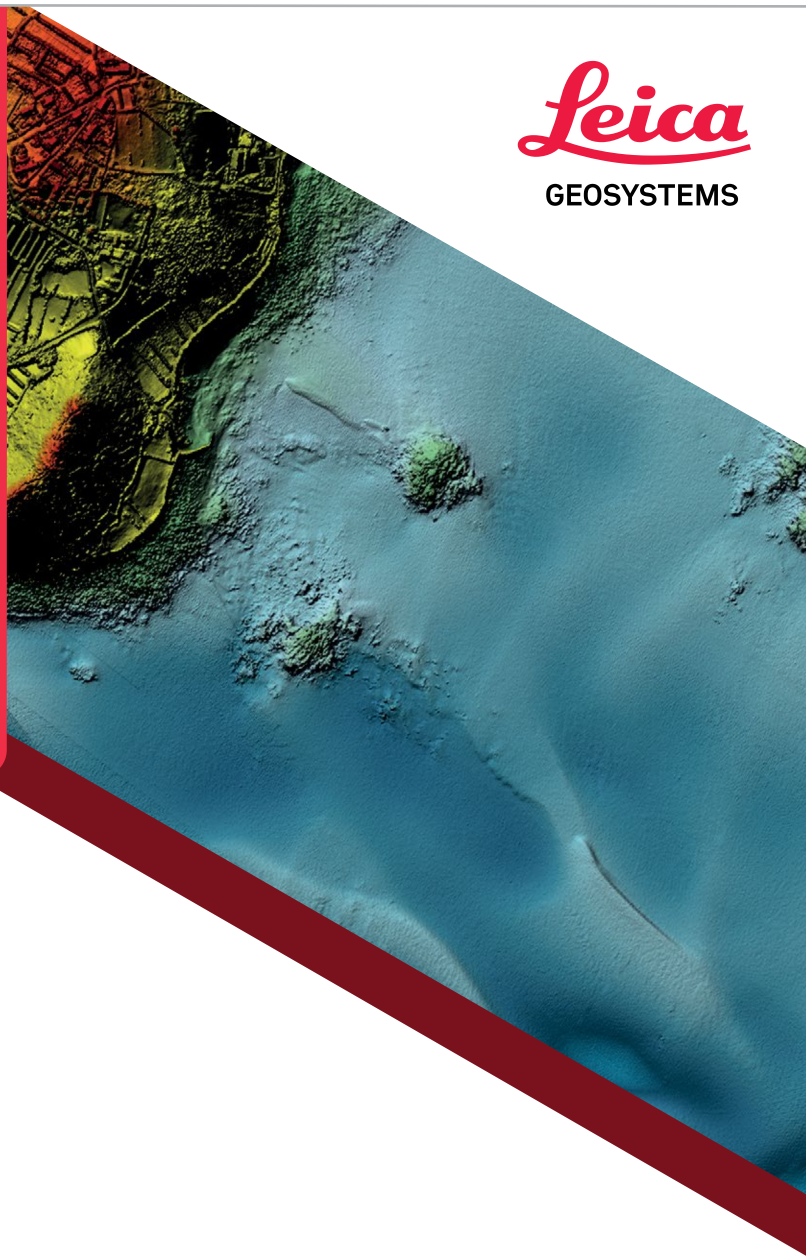
As Hexagon's reseller in Africa, GeoSpace conferred with Hexagon to collaborate on the elevation project. The structure for the partnership already existed in the Content Program, which engages acquisition partners to collect aerial data. Meanwhile, Hexagon conducts the data processing using standardized cloud-based workflows to deliver consistently high-quality products regardless of geographic location.

"Hexagon had the processing capacity available in the cloud to partner with GeoSpace on the project," said Stephen Minnaar, MEA Sales Manager

2 https://hexagon.com/products/product-groups/geospatial-content/hxgn-content-program

Figure 1: RGB (left) and NIR (right) point cloud data sets were generated using the HxMap software.
Source: Hexagon.

Figure 2: Orthoimagery (top) overlaid with NDVI (bottom).
Source: Riskscape.



Leica
GEOSYSTEMS

Leica CoastalMapper

Bathymetric & Topographic LiDAR data collection in one system

HEXAGON

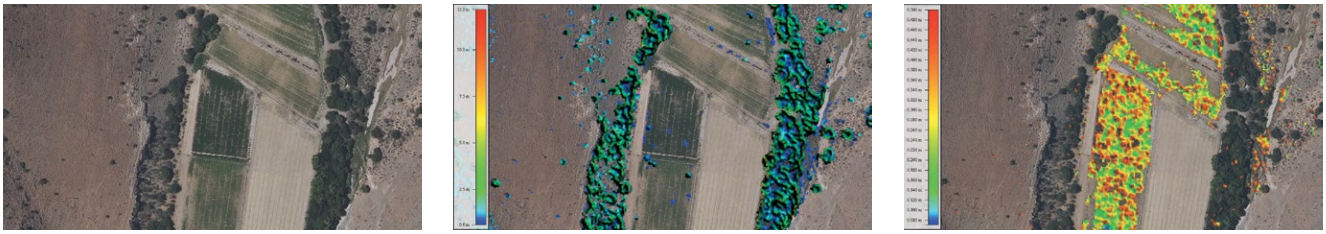


Figure 3: Variation in vegetation roughness shown over grass or ground-based vegetation and trees/bushes or non-ground vegetation. Orthoimagery (left) overlaid with the rougher non-ground vegetation (center) and smoother ground-based vegetation (right).
Source: Riskscape.

at Hexagon. "We essentially used the same standards, workflows and procedures developed for the Content Program and applied them to the South Africa DEM project."

To assist with the extraction of vegetation layers and building footprints in the project, GeoSpace partnered with Riskscape[3], a South African geospatial and actuarial company which specializes in the application of machine-learning algorithms for determining risks related to disasters, climate change, and other phenomena.

Figure 4: Building footprints extracted and created by the machine-learning model.
Source: Riskscape.

Deriving elevation from aerial imagery

As GeoSpace continued collecting aerial imagery with the DMC III, Hexagon began processing the four-band data to initiate the photogrammetric extraction of elevation points. Working with the HxMap software, Hexagon's photogrammetrists generated a point cloud and an initial digital surface model (DSM) using the semi-global matching process.

The point cloud contained surface elevation values at a spacing of 25 cm on the same grid system that divided the nation into 439 quarter-degree square blocks of about 2800 km^2 each. Because the points were determined photogrammetrically, they represented elevations of surface features, including trees, building structures and other objects on the ground, but the files also contained the spectral data (red, green, blue, NIR) from the raw imagery that would assist in mapping the bare-earth terrain.

Hexagon delivered the DSM and point cloud to Riskscape for additional processing. The firm applied filtering and automated classification techniques to the point cloud to differentiate non-ground from ground features — a key aspect of generating bare earth or digital terrain models (DTM).

Riskscape's technicians initially applied automated feature classification algorithms to the point cloud to separate out water, vegetation, and building features. A normalized difference vegetation index (NDVI) was then used to distinguish vegetation by type and also differentiate non-vegetation ground surfaces.

"Being able to extract vegetation information from the point cloud was quite critical in getting rid of the non-ground information," said Thorgny Fjastad, GIS Specialist at Riskscape, adding that this process did not create a final DTM because not all vegetation is above ground level.

Grass, for instance, essentially represents the ground or terrain elevation

3 https://www.riskscape.pro

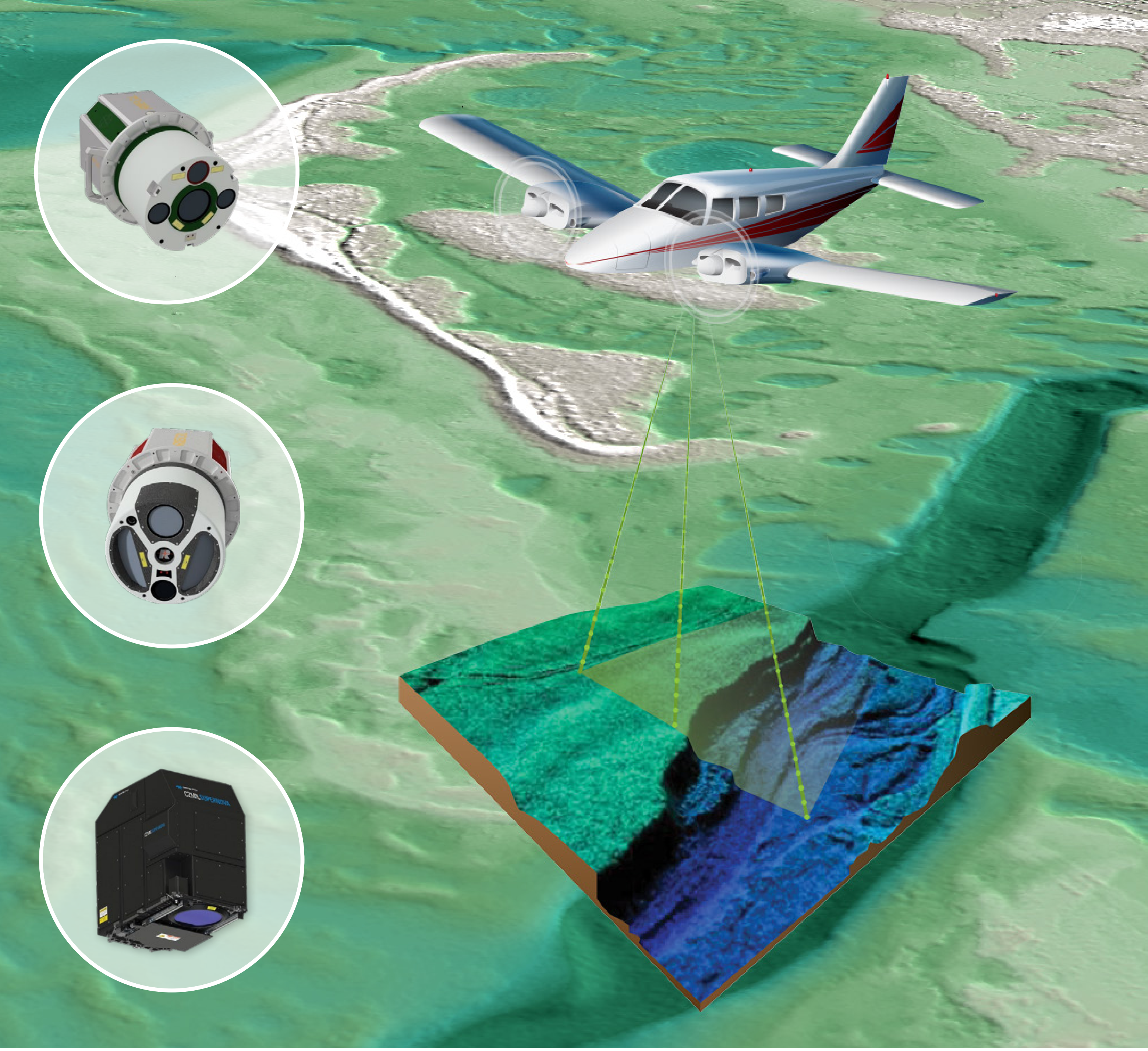


Figure 5: RGB orthoimagery (top) compared with final "pseudo-image" (bottom), where each color represents a different classification.
Source: Riskscape.

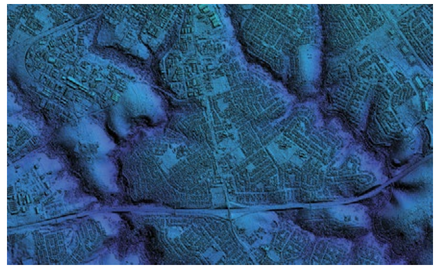


Figure 6: Final 1-meter DSM product.
Source: Hexagon.

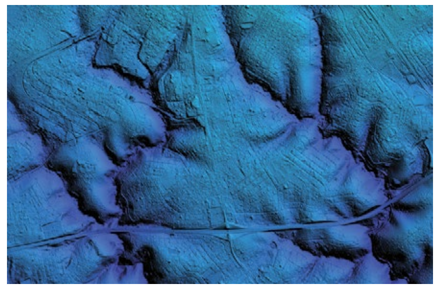


Figure 7: Final 2-meter DTM product.
Source: Hexagon.

because it is short. Riskscape used a surface roughness filter, derived from the initial DSM, to further distinguish grass at ground level from bushes and trees above the ground. Grass typically has a smooth texture compared to other vegetation. This prevented short vegetation from being unnecessarily filtered from the DTM generation process.

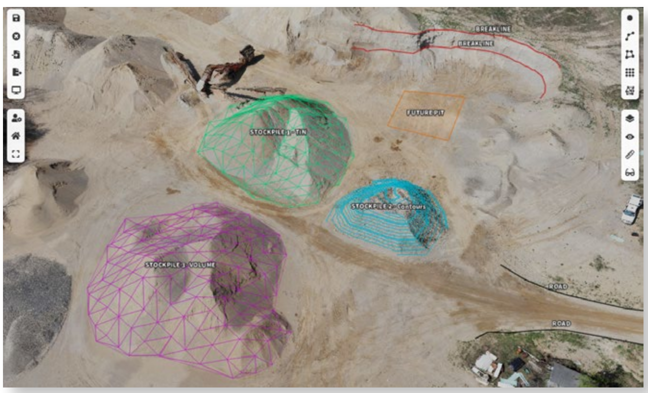
In the final phases of generating the DTM and supporting data sets, Riskscape applied machine-learning algorithms to extract building footprints. The firm also extracted water bodies and gradients from the point cloud and then delivered the DTMs to Hexagon along with data layers containing the surface roughness categories, building footprints, and vegetation classes for the generation of product deliverables.

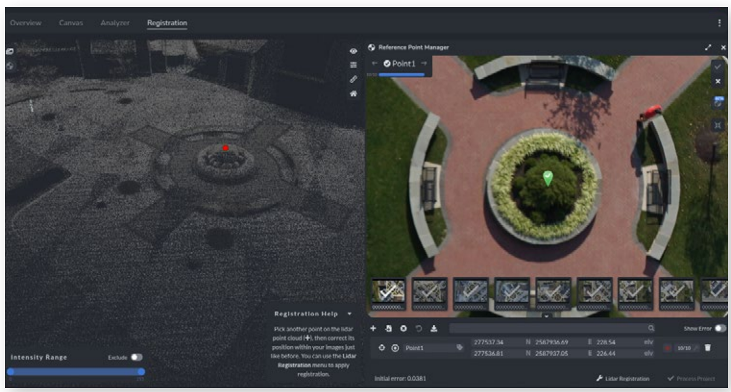
Hexagon merged all these feature layers with the point cloud data into a "pseudo-image," or raw DSM, colorised with the orthoimagery's spectral data. Hexagon's photogrammetrists performed additional classification of the ground and non-ground points to generate the final DTMs, with 95% of all features more than 1.5 m in height removed.

"The team ultimately produced a 1-meter DSM as well as 2- and 5-meter DTMs nationwide," said Minnaar. "The resulting products constitute the first homogeneous, countrywide and current commercial elevation dataset available for South Africa."

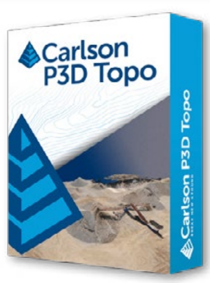
The DSM and DTM datasets provide the accuracy and detail required for projects related to 5G telecommunications, defense and intelligence, hydrologic analysis, digital construction and planning, and more.

Søren Vosgerau Jespersen is Vice President Operations, EMEA, Airborne Mapping Services, within the Geosystems Business Unit at Hexagon, where he leads operational activities across the region. He brings more than 25 years of experience in surveying, mapping, and geospatial services, having held senior leadership and project roles in Denmark and internationally.





Carlson Point Cloud
Carlson Point Cloud



Carlson P3D Topo
Carlson P3D Topo

BuildingWorld: A Global Structured 3D Building Dataset for Urban Foundation Models

New dataset, available free of charge to researchers, includes five million LoD2 buildings spread over five continents, as well as Cyber City, a fully procedural virtual city engine.

BuildingWorld[1] is the first large-scale global LoD[2] building reconstruction dataset, designed to provide a unified, systematic, and highly diverse benchmark for 3D urban modeling and building reconstruction research. The dataset integrates real and high-quality simulated aerial lidar point clouds from multiple continents, encompassing diverse urban morphologies and architectural styles, and aligns them with structured building models in a one-to-one manner. This unprecedented scale and geographic diversity enable comprehensive evaluation and learning-based approaches for 3D building reconstruction. A paper describing the BuildingWorld dataset has been accepted by the 40th Annual AAAI Conference on Artificial Intelligence (AAAI 2026).

Introduction

When a city is struck by flooding or a large-scale power outage, the decisions made in the subsequent minutes can determine millions of dollars in economic losses and, in some cases, the trajectory of public safety. Even under normal conditions, cities must continuously address complex operational challenges—how to coordinate transportation during extreme cold events, how to plan the deployment of solar energy infrastructure, or how to monitor increasingly aging urban facilities.

Digital twins offer a promising solution by replicating the operational state of a city in virtual space, enabling predictive analysis and informed decision-making for urban management. At the core of any urban digital twin system lies a large-scale three-dimensional city model, with accurate building geometry serving as its fundamental backbone. When building shapes or spatial layouts are imprecise or misaligned, the effectiveness and reliability of digital twin systems are significantly compromised.

With the rapid advance of artificial intelligence, the primary challenge in constructing city-scale digital twin systems has gradually shifted from algorithmic design to data availability. Today, the true bottleneck lies in the lack of high-fidelity 3D building data that can be directly used for training learning-based models. This data scarcity severely

1 https://szusic.github.io/BuildingWorld

2 Huang, S., R. Wang and X. Wang, 2026. BuildingWorld: A structured 3D building dataset for urban foundation models, 40th AAAI Conference on Artificial Intelligence (AAAI 2026), Singapore, January 20-27.

BY SHANGFENG **HUANG**, RUISHENG **WANG** AND XIN **WANG**

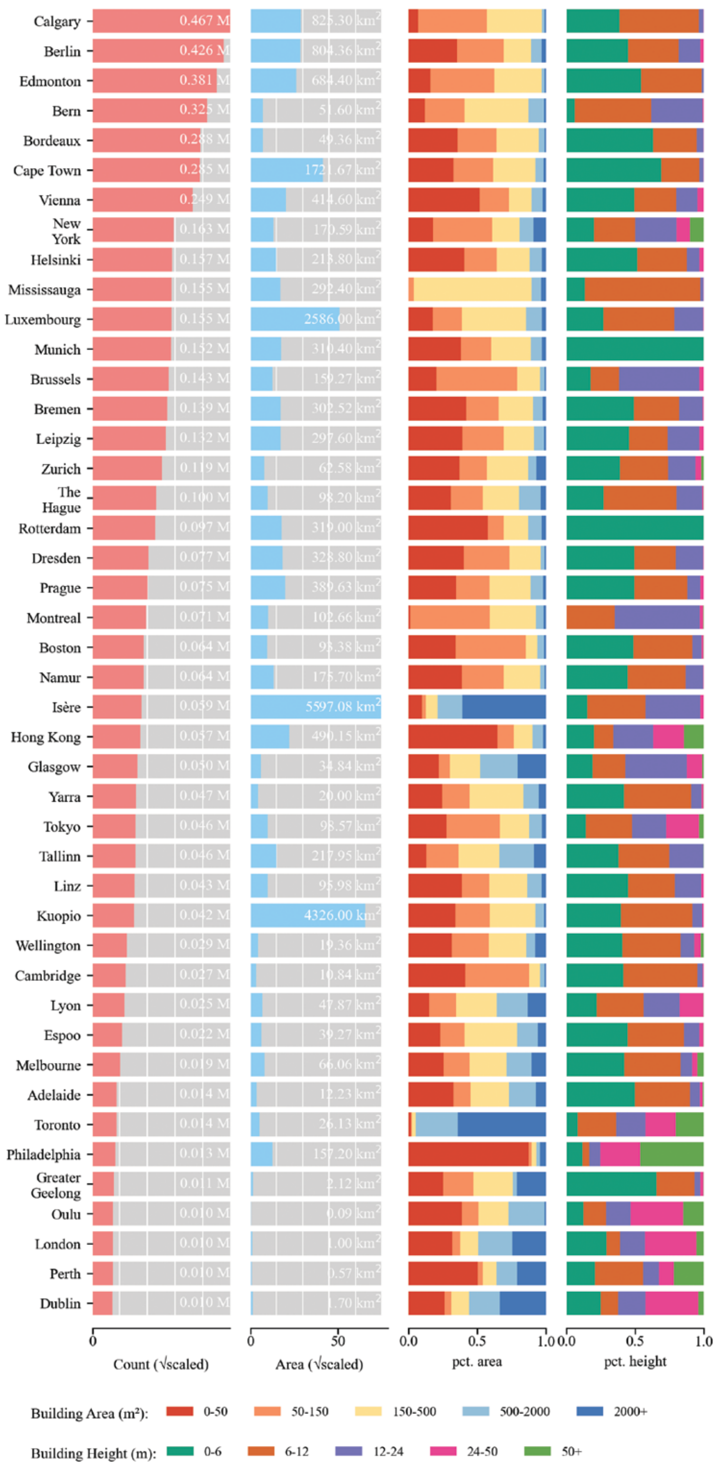


Figure 1: Statistical overview of the BuildingWorld dataset. Area bars indicate scene sizes, while percentage area and height metrics highlight the diversity of building structures.

limits the generalization ability of existing modeling approaches across different cities and scenarios and also hinders progress in related research fields.

BuildingWorld is a precise response to this challenge. The project focuses on building a large-scale, high-quality, and globally diverse 3D building dataset to meet the growing demands of next-generation world models for data scale, structural consistency, and geographic diversity. By providing reliable and structured 3D building data, BuildingWorld aims to support the development of urban-scale AI systems and advance the practical deployment of digital twin technologies.

High-quality 3D models

BuildingWorld aggregates approximately five million LoD2 building models from 44 cities across five continents, including North America, Europe, Asia, Africa, and Oceania, making it one of the largest and most geographically diverse 3D building datasets currently available. Each building is represented in a structured geometric form using a unified data format and includes detailed roof structures, providing critical support for building reconstruction, urban simulation, and AI-driven data analysis and processing.

As illustrated in **Figure 1**, the variations in building footprint area and height distributions across different cities clearly reflect their distinct spatial morphologies and urban structures. These differences also highlight the rich diversity of building types and architectural forms captured by the dataset. Owing to its extensive coverage, BuildingWorld not only serves as a solid geometric foundation

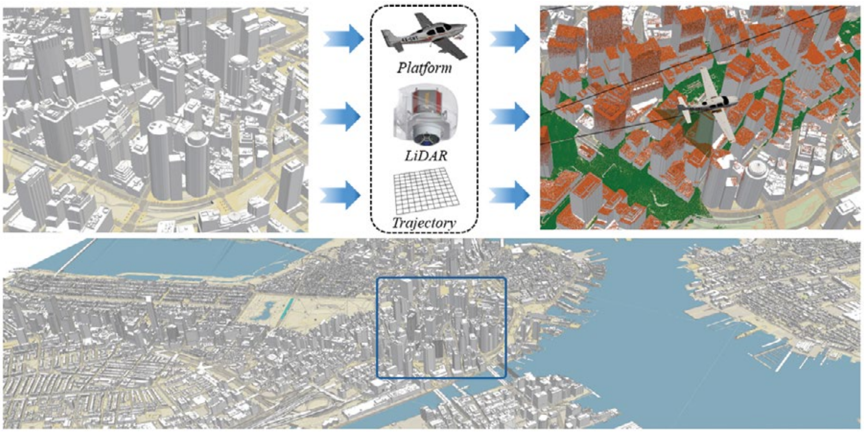


Figure 2: Illustration of the construction process of the BuildingWorld dataset. A glimpse of the LoD2 digital city model of Boston is shown. The zoomed-in downtown area illustrates simulated aerial lidar point clouds, generated using a predefined airborne platform, lidar sensor, and flight trajectory.

for constructing high-fidelity digital twin systems but also provides essential data conditions for the training and evaluation of next-generation 3D foundation models, enabling robust performance across cities, regions, and even continents.

In addition to the LoD2 data, BuildingWorld includes LoD3 building models for selected cities such as Hong Kong and Greater Geelong, offering enhanced geometric detail. These higher-fidelity models further support tasks that require more precise building reconstruction and fine-grained evaluation.

Real and simulated lidar

BuildingWorld provides both real-world and high-quality simulated aerial lidar point clouds. As illustrated in **Figure 2**, the simulator performs virtual laser scanning over city models by moving a simulated lidar sensor along predefined flight trajectories at specified speeds. During simulation, key factors are systematically taken into account, including occlusion effects, sensor viewing angles, flight speed, pulse repetition frequency, scan rate, and flight altitude. As a result, the generated simulated point clouds closely reproduce structural patterns and incompleteness commonly observed in real aerial lidar data, such as spatial distribution characteristics, point sparsity, and local missing regions.

Furthermore, when applicable, tree models are incorporated into the urban scenes to simulate building occlusions and environmental interference more realistically. This design enables the simulated point clouds to reflect real-world scanning conditions more faithfully, further narrowing the gap between simulated and real data.

In addition to the simulated data, several government agencies have released real aerial lidar point clouds for the same cities. However, these scans are often collected at different times and are not always spatially aligned with the corresponding building models, which makes them unsuitable for direct use in supervised deep learning. BuildingWorld therefore performs unified preprocessing and standardization on these real-world point clouds, enabling their use in domain adaptation, model validation, and reinforcement learning scenarios. This integration further enhances the practical applicability and robustness of learning-based methods in real-world deployment settings.

Cyber City: Generating unlimited virtual urban worlds

Beyond real-world city models, BuildingWorld introduces Cyber City, a fully procedural virtual city engine designed to recombine globally diverse architectural styles and generate novel urban configurations. As illustrated in **Figure 3**, Cyber City consists of multiple procedurally generated components, including terrain, road networks and parcel layouts, building placements, and vegetation.

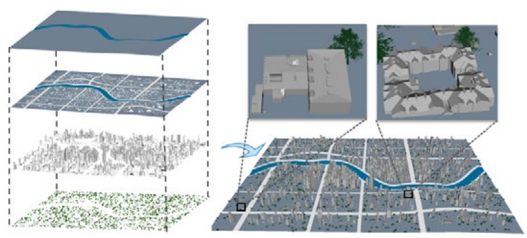


Figure 3: Cyber City consists of four main components: terrain, road and building footprints, buildings, and vegetation.

It is important to emphasize that the goal of Cyber City is *not* to create new digital cities that aim to replace real-world urban environments. Instead, by systematically varying terrain morphology, vegetation distributions, and building layout strategies, Cyber City deliberately constructs point cloud distributions with a high degree

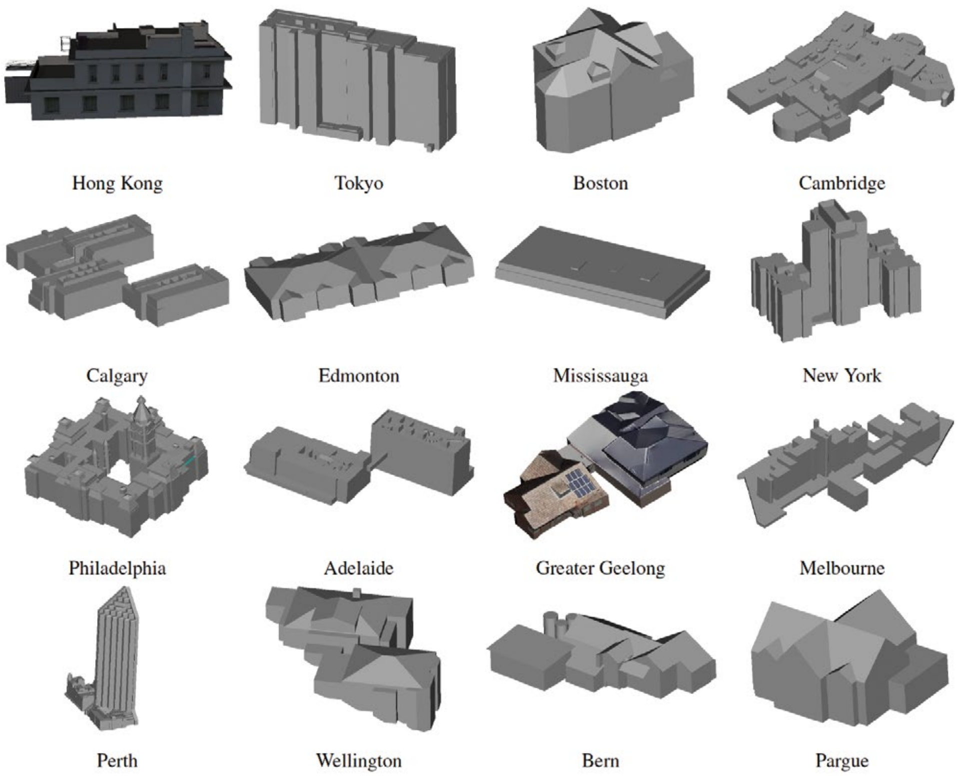


Figure 4: Examples from the BuildingWorld dataset.

of diversity. This design substantially expands the diversity of training data in terms of spatial and structural distributions, thereby strengthening the adaptability of AI models to real-world scenarios and improving the robustness of 3D building reconstruction algorithms under varying environmental conditions.

Dataset overview

Figure 4 illustrates a building model from each of several of the cities in the BuildingWorld dataset, revealing the wide stylistic and functional diversity of structures, ranging from dense residential neighborhoods and urban commercial districts to industrial areas and leisure-oriented facilities.

Shangfeng Huang is currently working on his PhD. As a member of Intelligent Geospatial Data Mining Lab at the University of Calgary, he focuses his research on 3D building reconstruction from point clouds.

Dr. Ruisheng Wang is a distinguished professor in Shenzhen University. He was a professor in the Department of Geomatics Engineering at the University of Calgary from 2012 to 2024. Before that, he worked from 2008 as an industrial researcher at HERE Technologies (formerly NAVTEQ) in Chicago, USA. His primary research focus there was mobile lidar data processing for next-generation map-making and navigation. Dr. Wang holds a PhD in Electrical and Computer Engineering from McGill University, an MScE in Geomatics Engineering from the University of New Brunswick, and a BEng in Photogrammetry and Remote Sensing from Wuhan University.

Dr. Xin Wang is a Professor and Schulich Research Chair in the Department of Geomatics Engineering at the University of Calgary. She joined the Department of Geomatics Engineering in July 2007. She holds a BSc in Computer Science, MSc in Software Engineering from Northwest University, China and a PhD in Computer Science from the University of Regina. Her current research interests are spatial databases and spatial data mining, big spatio-temporal data analytics, artificial intelligence and machine learning for spatial applications, data mining for transportation, oil and gas, ontology and knowledge engineering in GIS, web GIS and location-based social networks. She was an executive member and treasurer of the Canadian Artificial Intelligence Association (CAIAC) from 2015 to 2021.

RoyOMartin's High-Tech Forestry Approach Poised to Meet America's Housing Crisis

A century-old family business like RoyOMartin survives and succeeds by recognizing risks and opportunities. Today, as the US faces a critical housing shortage, the company has positioned itself to deliver affordable construction materials grown and manufactured in Louisiana and Texas.

"You really start to wonder if the American dream of owning a home has been lost for a whole generation because of affordability and availability," said Spencer Martin, vice president of information systems at RoyOMartin and a fourth-generation family member.

But RoyOMartin is doing its part. Approximately 80 percent of the plywood and panels it produces flows directly into multifamily or residential housing.

"Part of our future challenge is what do we do with all the timber that we're so good at growing," Martin said. The company currently has an abundance of raw materials. "The seedlings have gotten so good, and our prescriptions have gotten so good, we're growing too much timber."

The story behind this bounty starts with RoyOMartin's embrace of the latest tools, including drones, imagery, and geographic information system (GIS) technology. This digital transformation has helped the company adapt precision agriculture practices for its 550,000 acres of forestland, increase efficiency across operations, and stay agile through market shifts.

BY GEOFF **WADE**

Transforming timber production

When foresters at RoyOMartin head into the field, they carry the history of the forest with them. On GIS maps, they can instantly see soil types, drainage patterns, growth histories, and planned treatments for any point on the company's vast holdings.

"We've untethered these foresters from the desktop," Martin said. "When they leave their house in the morning, they can go straight to the woods without passing by the office."

Using tablets loaded with GIS, foresters access apps designed for their workflows: tree surveys, harvest scheduling, site preparations for planting, thinning, spraying, and more. The real-time data shared on these apps flows across the organization to support informed decisions at all levels.

Ed Poole, the company's forest management information systems manager, explained the impact. "You can look at what you did and see how it worked. 'We did this type of spray. I don't think that worked,' or 'It worked really well. Let's do that again.'"

RoyOMartin first used GIS to map landholdings and record forest management practices. Now, the technology has evolved into an enterprise system that serves as the backbone of operations.

"We've got 21 years of data on our forests," Martin said. "The mapping has been improving every year. It's really become a platform for decisions."

Drones and satellites provide a game-changing perspective

Drones have revolutionized how foresters decide which trees to plant where, transforming field operations more dramatically than any other technological advancement. "We used to have guys that went out and did field audits of harvesting operations," Poole said. "They had to walk through the woods, covering 40 acres a day. It takes a while, and there's inherent danger."

Drones have made harvest surveys simpler, safer, and quicker. "At 400 feet or lower, the resolution of the images is really good," Poole said. "We can tell if any trees were missed and how many stems were harvested."

Drone imagery of harvests, along with detailed data layers about soil and conditions, are all viewed and shared within GIS. The insights inform planting plans that start the whole cycle again. With every generation of trees, the data and prescriptions get better.

RoyOMartin has also integrated satellite imagery into its GIS to capture larger areas at regular intervals. Resources, such as Sentinel imagery, provide updates every two to three weeks to improve monitoring of its vast land holdings.

Satellite imagery proves especially valuable for checking timber harvesting progress by outside contractors. "We know exactly the tract of land each vendor has booked, and we could see if they started harvesting when they said they would," Poole said.

Remote monitoring with drones eliminates countless hours of travel to distant sites, significantly reducing fuel and vehicle maintenance costs while allowing foresters to focus on high-value activities instead of driving between locations.

The combination of imagery and mobile apps has radically improved the company's operational capacity. "It has really opened up a lot of possibilities for us to put eyes and boots on more tracts of land over the course of a year," Martin said.

It would be impossible for the crew to drive and view all of RoyOMartin's 550,000 acres (860 square miles) in a single day, but with GIS, they can.

Knowing where to do what

The modern approach contrasts with how Poole started in the industry a few decades ago.

"Everything was cookie-cutter," he said. "We used a 3-in-1 plow for site preparation, applied some herbicide, put the trees in the ground, and waited to see what happened."

Now, professional foresters use a method known as "prescriptions" to plant the right tree, tailor treatments to conditions, and document growth. In effect, they dial in the details for an efficient cycle from planting to harvesting. Even this practice has evolved quickly.

"In the last decade or so, we've been able to map soils comprehensively and then tailor prescriptions to soil types," Poole said. GIS aids in the understanding of soil properties, assessing which treatments are working, and in making cost-effective decisions.

"If you dump fertilizer on to a sandy site, you're not doing anything because it's going to leach right out," Poole said. "But on a loamier soil, with a finer texture, the nitrates, phosphorus, and potassium molecules will stick. They'll have a higher potential to be taken up by the tree, which means higher growth rates and taller trees in shorter amounts of time."

RoyOMartin's Corrigan manufacturing facility in Oakdale, Louisiana produces a variety of oriented strand board (OSB) panels.
Photo courtesy of RoyOMartin.

Using location-based analysis, RoyOMartin teams have also dialed in how different tree species respond to different growing conditions.

"Some trees grow better on wet sites. Some trees grow better on drier sites. Some trees will respond better genetically to applications of herbicides and fertilizers," Poole explained. This knowledge allows foresters to plant the right tree in the right place for optimal growth.

This new level of precision helps speed the growth of trees so they can be harvested sooner for a faster return on investment.

"There's a lot of upfront cost to put trees in the ground," Poole said. "If you can shave a year or two off of waiting to harvest, it's a huge saving."

Growing from generation to generation

The shared awareness GIS brings to RoyOMartin operations makes comprehensive management possible in ways previous generations could never have imagined.

The sophistication of today's approach stands in stark contrast to the company's humble beginnings. When Roy O. Martin purchased a small sawmill in Louisiana in 1923, he surely had no designs for the vast forestry holdings and lumber mills his family would be stewarding a century later.

But the succession plan was clear from the beginning. "He raised his three sons to continue the business," Martin said. That commitment to family stewardship now extends to all 184 living family members across six generations, with generations three, four, and now five working for the business.

With every generation, the company has diversified and grown its forest holdings and mill operations to become more vertically integrated. It added retail lumberyards early on, then expanded into hardwood sawmills in the 1980s, followed by yellow pine plywood mills in Louisiana, and oriented strand board (OSB) panel mills in Louisiana and Texas.

The move to OSB allows RoyOMartin to make use of smaller trees that are thinned as the forest grows. OSB is environmentally friendly and indicative of the company's ethos not to waste effort. The family is committed to the stewardship of their land so RoyOMartin can continue operations far into the future.

Meeting market challenges

Recent market contractions threaten traditional uses for timber, but RoyOMartin's investment in technical innovation supports strategic moves to new opportunities.

"We just had a paper mill close last month, which will severely impact pulpwood thinning operations for any landowner within an 80-mile radius," Martin said.

Amid these challenges, an intriguing opportunity has emerged in central Louisiana that could fill the looming gap for young trees. SunGas Renewables has proposed opening a green methanol production facility nearby.

"They're going to be converting biomass into methane because their largest customer is Maersk, the shipping giant, which wants to purchase 30 percent of their fuel as green methane," Martin said.

The facility would consume two million tons of pulpwood, and the output would link to the newly opened liquified natural gas export facility on the coast of Louisiana.

Spreading efficiency across the supply chain

To counteract market competition and buffer against the loss of pulpwood markets, RoyOMartin has intensified its focus on operational efficiency and proactive risk management.

The company's use of GIS to track forest conditions, growth rates, and optimal harvest times provides the contextual awareness needed for precise planning and sustainable management.

GIS also gives RoyOMartin leadership real-time awareness of its own timber resources and that of suppliers. "We don't exclusively cut our own timber for our mills. It's about 50 percent outside wood to 50 percent company-owned wood," Martin said. This balance provides stability in an industry known for price volatility.

The company has extended its application of GIS to benefit stakeholder relationships. Specialized GIS portals give logging contractors access to maps, invoices, and contracts. "The things that we can now push out to the tablet or phone is a game changer for how we conduct forestry operations," Martin said.

When asked about his vision for the future, Martin offered a succinct summary: "Less paper internally and more sharing externally." This simple philosophy guides the company's ongoing digital transformation.

A fifth generation of family leadership will soon take charge at RoyOMartin. They inherit a company with workflows optimized to produce abundant, high-quality lumber and construction materials while pioneering new applications for forest products.

Further reading

Learn how GIS provides a new window into forestry operations.

This article originally appeared in Esri Blog.

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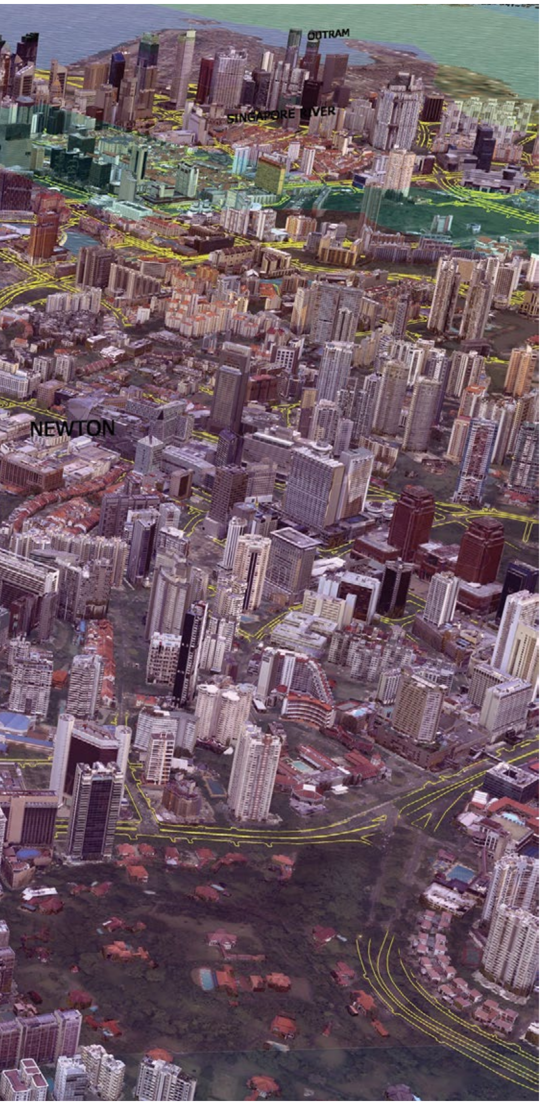
demand, requiring updates to master plans and municipal criteria. With tightening water-quality regulations and improvements in monitoring capabilities, infrastructure will need shorter life cycles and more flexible design approaches. Regionalization of water providers is expected due to cost pressures and staffing shortages.

Energy systems will similarly be shaped by the intersection of AI, natural gas reliability, and global energy security. Demand for liquefied natural gas exports is projected to grow, and infrastructure resilience will become a major form of capital discipline as companies rely on spatial digital twins for real-time monitoring.

Transportation systems in the United States are influenced by both federal funding uncertainty and a rapid embrace of digital and autonomous technologies. State and local agencies must prepare for the continuation — or potential disruption — of grant programs established under the 2021 Infrastructure Investment and Jobs Act. Meanwhile, policymakers are advancing high-definition maps, IoT standards, and real-time monitoring systems to boost safety and predictive maintenance across roads, rails, and bridges.

Airports face a combination of electrification challenges and digital transformation. Peak power demands may double or triple without major grid



Woolpert conducted aerial lidar and imagery surveys in Singapore and produced derivatives including digital terrain models and photo-realistic 3D models, supporting the creation of a nationwide digital twin. These datasets are being used for urban planning with vector overlays including transportation networks and zoning boundaries.

upgrades. Airports will also increasingly serve as digital hubs, supporting network operations and data centers while integrating smart charging systems, eVTOL infrastructure, and advanced air mobility concepts.

Defense, military planning, and the Indo-Pacific region

U.S. military planning is undergoing significant shifts, with nearly $20 billion allocated in FY2026 for global construction, including hangars, command centers, and housing, as well as the location, extraction, and transportation of critical minerals. U.S. strategic interests in the Indo-Pacific region, Africa, and Europe will continue to leverage geospatial technology and remote sensing.

In the broader Indo-Pacific region, nations are pushing for greater digital and physical infrastructure ownership, increased data governance capacity, and expanded regional collaboration.

Global defense and intelligence agencies are leveraging digital twins, GIS, lidar, UAV-based surveys, and GeoAI for faster, more integrated design and planning and maintaining data sovereignty. AI agents will support intelligence gathering and analysis, creating more dynamic and proactive workflows.

Coastal resilience, climate adaptation, and natural infrastructure

Coastal resilience programs are benefiting from massive data availability, enabling the use of machine learning and analytics for better project decisions. Nature-based infrastructure solutions are becoming more popular as understanding grows around the natural processes shaping water resources. Policy changes are likely under shifting federal leadership, creating demand for innovative, adaptive approaches.

Workplace culture and AI — a new standard for inclusivity

Finally, workplace culture in 2026 is expected to be transformed by AI-driven work design, ethical governance, and human-centered hybrid work models. Organizations must focus on psychological safety, values alignment, and creating meaningful, inclusive environments to avoid burnout and polarization.

This increasing alignment across industries is an opportunity to focus, collaborate, and drive innovation in a way that will benefit people around the world. I am looking forward to what we can accomplish together in 2026.

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AMAR NAYEGANDHI

2026 AEG trends across industries highlight increasingly interconnected world

Building on the outstanding response to Woolpert Chief Scientist Qassim Abdullah's annual article on forecasting geospatial trends (on page 8 of this issue), we polled 31 experts across Woolpert to hear what they considered the top trends and topics to watch for in multiple markets across the architecture, engineering, and geospatial industry this year.

In addition to the value these discussions provided individually, it was exciting to see several recurring themes emerge: the accelerating influence of AI, pressures on energy and water systems, rapid digital transformation, heightened global competition, and the continued integration of geospatial and sensor-driven data into decision-making.

This natural alignment highlights an increasingly interconnected world where infrastructure, technology, and environmental constraints converge.

Digital infrastructure, data centers, and AI-driven demands

Across multiple application areas, from data center decarbonization to energy and water supply, our experts emphasized the enormous pressures created by AI computation. Data centers are moving toward decarbonizing mechanical and electrical equipment, though the supply chain is still behind in providing credible carbon documentation. They also face intensifying public scrutiny and must improve collaboration with communities affected by rising power and water use.

AI is also dramatically reshaping asset management and monitoring practices. In structural and geotechnical monitoring, AI is enabling a shift from reactive to predictive, risk-based maintenance, raising questions about data quality, explainability, and integration into legacy management systems. Similarly, agentic geospatial AI will allow large language models to interact more naturally with geospatial models, increasing demand for accurate data and transparency.

Data centers also exemplify a broader concern: both power and water constraints are poised to become major limiting factors for growth in advanced technology industries. Experts note that water supplies, energy capacity, and aging infrastructure will be key bottlenecks unless significant investment and innovation occur.

Geospatial technologies, remote sensing, and digital twins

One of the strongest trends across industries is the explosion in remote sensing, high-resolution mapping, and adoption of digital twins, which are evolving into "living" models that incorporate real-time survey and sensor data, enabling more informed decision-making.

Global geospatial programs are expected to expand in economic impact, with new opportunities in sectors such as agriculture, water, and environmental monitoring. In the United States, once the 3D Elevation and Hydrography Programs (3DEP and 3DHP) are completed — using high-resolution data from airborne lidar and IfSAR sensors for the topographic part — it will produce an advanced 3D National Topography Model (3DNTM) that integrates elevation, hydrography, and bathymetry. This initiative represents an early step toward creating a comprehensive nationwide digital twin, promising many exciting future applications.

Precision from space is also expected to increase, with technologies like GNSS, IfSAR, IoT, and satellite communications integrating more seamlessly to deliver reliable ground movement data. In hydrographic and aerial survey sectors, unmanned surface vehicles, topobathymetric lidar, and semantic change intelligence are advancing rapidly, enabling automated compliance tracking and 4D environmental understanding.

Critical infrastructure: Water, energy, transportation, and airports

Water systems face several immediate challenges. Data center expansion is driving dramatically higher water

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