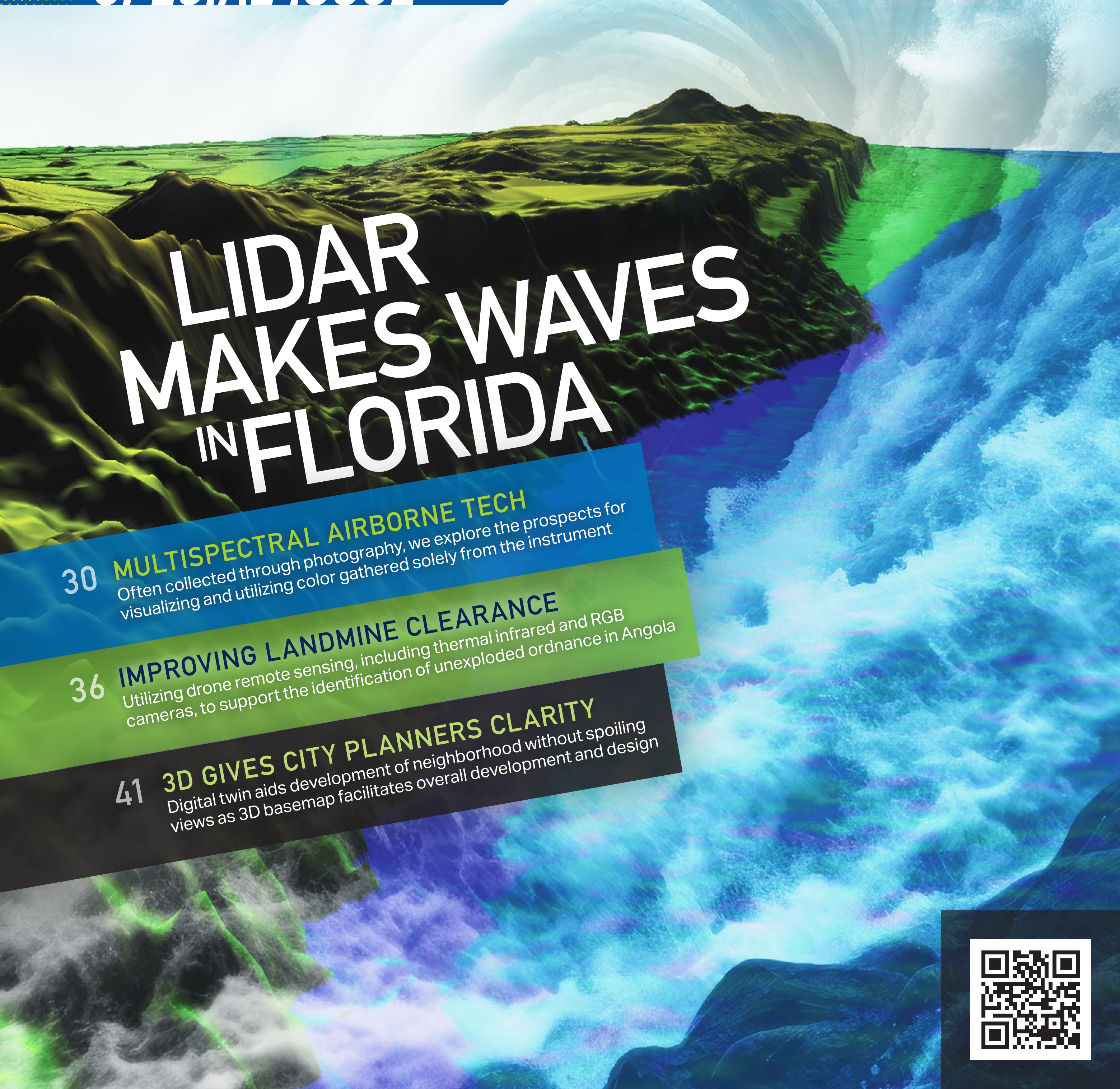
VOLUME 3 ISSUE 4

LIDAR MAGAZINE

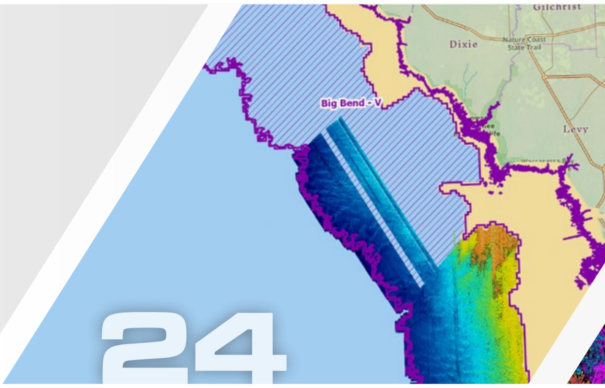
NOV/DEC 2023

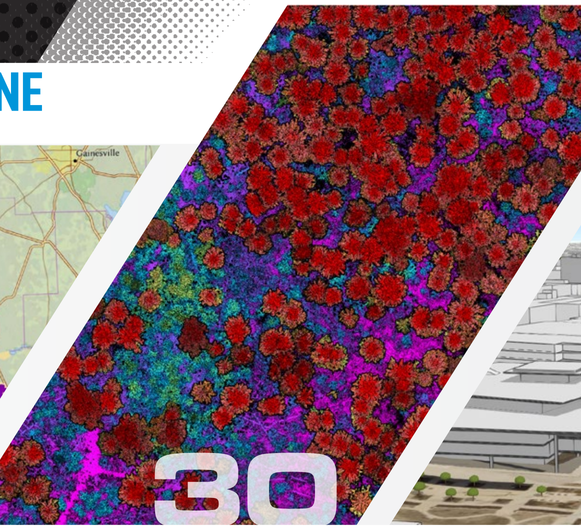
SPECIAL ISSUE



LIDAR MAKES WAVES IN FLORIDA

LIDAR MAGAZINE





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LIDAR To Go!
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◀ ON THE COVER
Summer Haven in St. Johns County, Florida, was hit particularly hard by Hurricane Ian in late September 2022. This colorized image of a 1-foot-resolution DEM model shows how the extreme weather event damaged the Old A1A Beach Access Point.
Artist's rendition. Colorized DEM courtesy of Woolpert.

DR. A. STEWART WALKER

Communications Trifecta

We have become a podcaster![1] Three episodes of *The LIDAR Magazine Podcasts* have been recorded. These podcasts are sponsored by rapidlasso GmbH[2], the lidar software supplier founded by the late Dr. Martin Isenburg. The guests in our first podcast are two Woolpert managers, Volkan Akbay and Rick Householder, discussing how they flew lidar for St. Johns County, Florida, before and after major weather events. There's nothing new about comparing lidar acquired after a disaster with whatever is already available, to see what has changed. But in this case, the project is designed to facilitate detailed, accurate, informative comparisons. This is of major value in reacting to events, preparing for future ones and increasing resilience, and there's another advantage: the very presence of good elevation data and derived products is a prerequisite for certain types of federal funding. Turn to page six for more information on this project.

The guest in the second podcast is Jason Fries, one of our Contributing Writers, who heads 3D Forsensic, a San Francisco company that uses lidar to support evidence given in court. Jason gives fascinating insights into his firm's work, particularly on cases involving shootings or road accidents. The acceptance of this sort of evidence in courts of law is relatively recent and it's fascinating to learn, from a pioneer, how this occurred. The third guest is a French entrepreneur and international executive who lives in Switzerland, Vivien Hériard-Dubreuil, president and chief executive of mdGroup Germany GmbH, of which Microdrones and GeoCue are the main components. Mergers and acquisitions have certainly shaped our industry over the years—think of Hexagon and NV5—so it's intriguing to hear Vivien recount the history, justify some of the decisions and give his views on changing technologies and markets. mdGroup has been providing support for Microdrones products from the GeoCue campus in Alabama for more than a year now and we learn why mdGroup is moving manufacturing and some of its R&D from Germany stateside. Its NDAA-compliant EasyOne UAV-lidar systems, which include GeoCue's LP360 software (which in turn is the result of an acquisition, of QCoherent Software back in 2009!), will be made there. One of the aspirations of mdGroup, however, is that LP360 should have a wider appeal, embracing users of "guest sensors".

1 This outrageous use of the royal "we" is whimsical, an allusion to the notorious words, "We have become a grandmother", announced by Margaret Thatcher to the press outside 10 Downing Street on 3 March 1989.

2 rapidlasso.de

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This strategy was reflected in a recent GeoCue webinar about processing DJI L2 data.

In the new year, we intend to develop more podcast sessions, many of which will support topics covered within the magazine. Beyond Woolpert's St. John's County piece, we have two pieces in this edition from Contributing Writer Dr. Al Karlin, whom we congratulate on his recent election as vice president of ASPRS. Beginning on page 14, you'll find a report on the spring 2023 Lidar Workshop in Florida, the 14th in the series. These workshops are packed with lidar content and attract multiple presenters from government, the private sector and academia. We're going to change our policy, by posting shorter accounts of these workshops on the website, in the interests of immediacy, then pursuing some presenters for full articles.

Al's second piece (page 24) reports on the Florida Seafloor Mapping Initiative, a huge project to provide data in support of the state's recovery and resiliency as the frequency and severity of weather events grow. The plan is mapping out to the 20 m isobath with lidar, then to the 200 m isobath with sonar. Dewberry has been one of the contractors involved—we will try to solicit articles from the others—and has used its new CZMIL SuperNova sensors from Teledyne Geospatial. There's a tinge of sadness here, though. I learned a lot about the SuperNova at Intergeo in Essen in October 2022, from Teledyne expert Don Ventura We have a little in common. We were born in the same part of Scotland (Lanarkshire), then he went into the Navy and became an accomplished hydrographic surveyor, whereas I entered academic life. Then we ended up on the supplier side of the geospatial industry in North America. How sad that he passed on too early, on 5 March 2023[3].

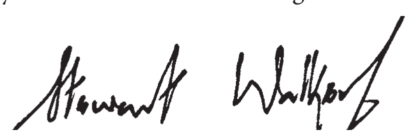
On page 48, Prof. Ruisheng Wang and co-authors from the University of Calgary (yes, the same school where Prof. Derek Lichti, the Congress Director for the XXV ISPRS Congress in Toronto in July 2026, works—it attracts numerous brilliant scientists!) give a description, already published on our website[4], about the creation of point clouds and derived models for buildings. This benchmark dataset will enable researchers to develop urban modeling methodologies using high-quality data from real buildings. The generation of such datasets is perhaps not the most exciting task to which to direct our sharpest minds, but these tools are essential if we are to advance in an authoritative way, because without them new developments cannot be verified.

Antero Kukko is a professor from the Finnish Geospatial Research Institute and we welcome his contribution on multispectral lidar. Addressed on page 30, his Institute has developed a system with three lidar sensors at different wavelengths and he explores the value of the data, especially in environmental applications. The power of multiple-wavelength lidar systems is unarguable. The concept is applied in a different, but no less powerful way, in Woolpert's amazing BULLDOG topobathymetric system, as reported in *LIDAR Magazine* at the end of 2021[5]. Some time ago Teledyne Optech, as it was then, offered the Titan system, based on the multiple-wavelength principle.

The article that begins on page 36 is another that we read with mixed feelings. The UK lidar system supplier Routescene has been working with non-profit The Halo Trust on mine clearance. The initial tests were in Scotland, but the focus of the article is Angola. It's heartening that less dangerous approaches to mine detection are being developed and that lidar is a useful tool in this essential humanitarian effort, but sad that we have to use it to ameliorate horrors that we occasion upon ourselves.

It's not long now till we present the 2024 Lidar Leader Awards in Denver and once again many superb candidates were nominated. Like the podcasts, the Lidar Leader Awards highlight the people behind the technologies and the applications through which lidar makes the difference.

Thus we contend that *LIDAR Magazine* has a modern footprint to suit the preferences of our audience: compelling, topical articles in print and on the website; news, updated daily, on the website; podcasts; and the Lidar Leader Awards. We're going to be busy, reporting and celebrating as lidar becomes increasingly pervasive, solving problems, improving lives. Thank you for reading. *LIDAR Magazine* wishes you a successful and fulfilling 2024.



A. Stewart Walker // Managing Editor

3 legacy.com/us/obituaries/legacyremembers/don-ventura-obituary?id=50112032

4 lidarmag.com/2023/10/18/building3d-an-urban-scale-dataset-and-benchmarks-for-3d-building-reconstruction-from-airborne-lidar/

5 woolpert.com/news/articles/next-generation-topo-bathy-sensor/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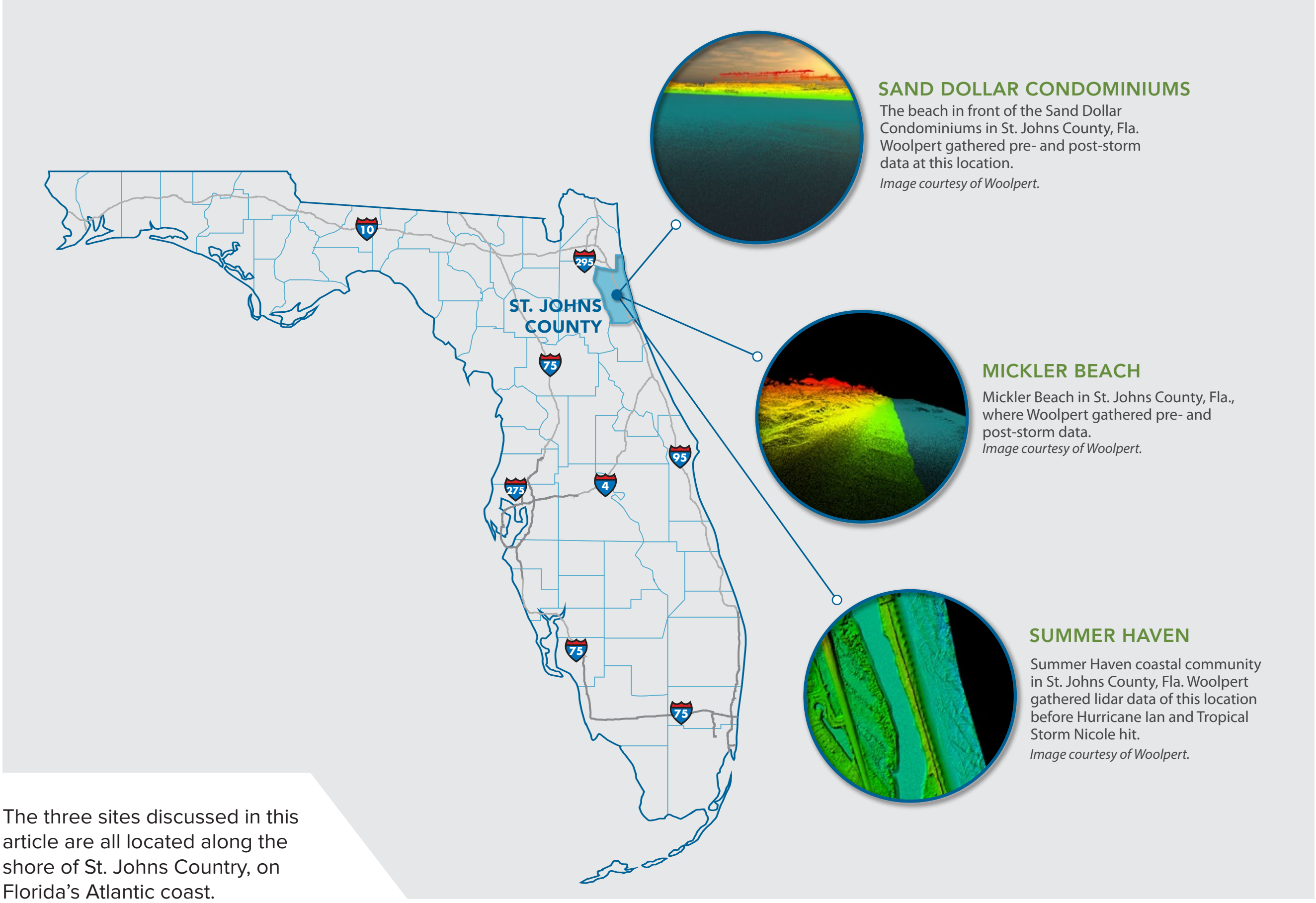
Lidar Making Waves in Florida Beach Resilience

Lidar helps coastal communities respond to and prepare for extreme hurricane seasons



The three sites discussed in this article are all located along the shore of St. Johns Country, on Florida's Atlantic coast.

BY VOLKAN **AKBAY** AND RICK **HOUSEHOLDER**

In 2019, Woolpert suggested a novel concept to officials in St. Johns County, Florida: use lidar technology to acquire coastal elevation data before and after hurricanes to help the county monitor beach erosion and support dune maintenance. The county agreed to the proposition, understanding the potential future value of the effort. However, it wasn't until 2022 that this value was realized after Hurricane Ian and Tropical Storm Nicole barreled through St. Johns County.

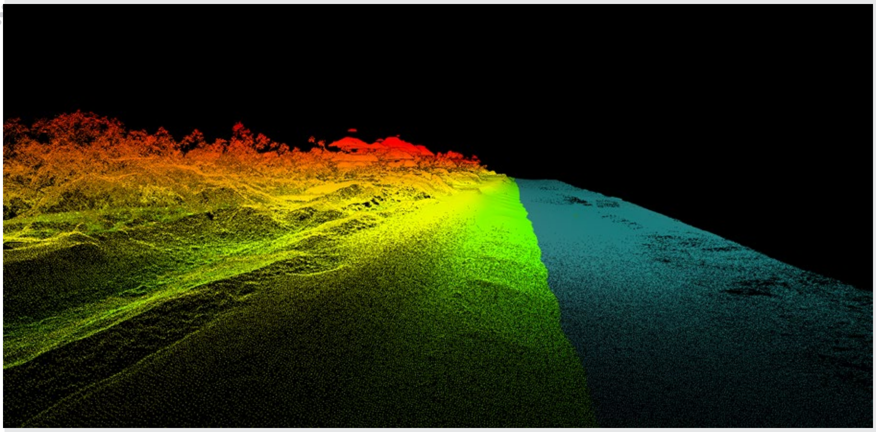
Upon making landfall on mainland Florida on September 28, 2022, Hurricane Ian hit St. Johns County, causing erosion, outages, downed power lines and trees, and significant flooding[1] in downtown St. Augustine, Hastings, Summer Haven, Matanzas Inlet, and Flagler Estates. On November 9, 2022—just six weeks later—Tropical Storm Nicole raged across St. Johns County, breaking and flooding parts of the Coastal Highway[2] and causing devastating beach erosion. Despite this swath of destruction, the pre- and post-hurricane elevation data acquired by Woolpert supported a fast and comprehensive emergency response from St. Johns County.

A clear reason despite unclear conditions

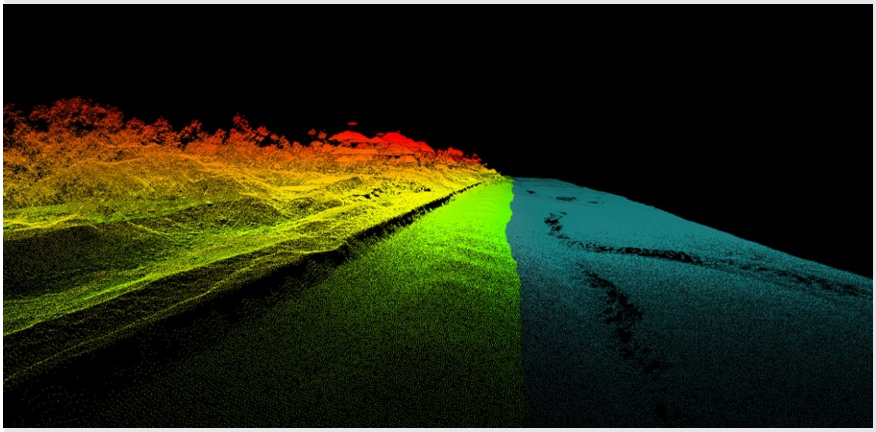
In anticipation of Hurricane Ian's arrival, Woolpert flew lidar on September 23, 2022, between the Duval-St. Johns and Flagler-St. Johns boundaries, extending from the Atlantic Ocean shoreline to

1 jacksonville.com/story/weather/hurricane/2022/09/29/hurricane-ian-st-johns-county-florida-reports-significant-flooding-water-rescues/8126097001/

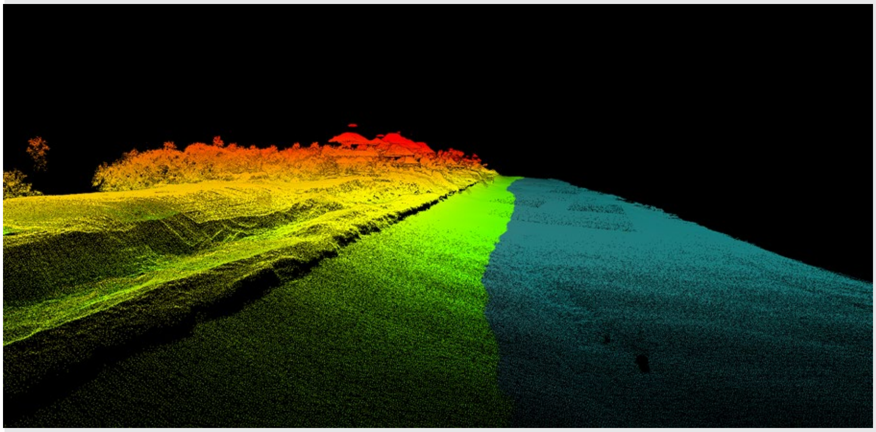
2 nbcnews.com/news/us-news/hurricane-nicole-makes-landfall-florida-rcna56522



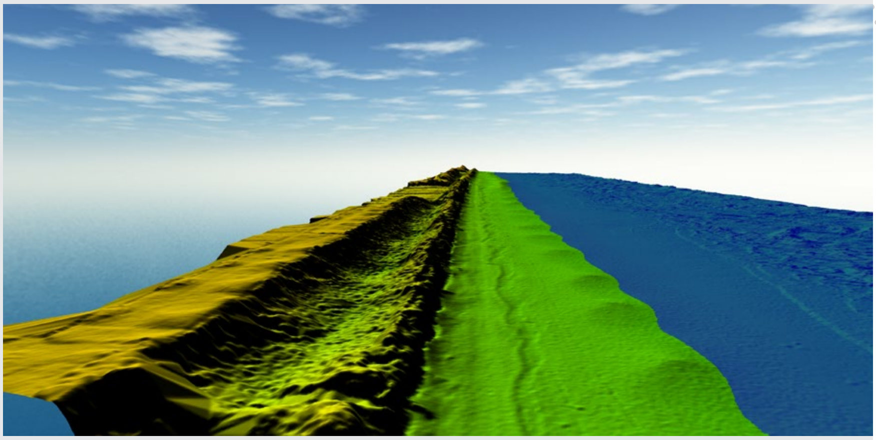
This oblique image of a ground DEM showcases what Mickler Beach in St. Johns County, Florida, looked like before Hurricane Ian and Tropical Storm Nicole hit.
Image courtesy of Woolpert.



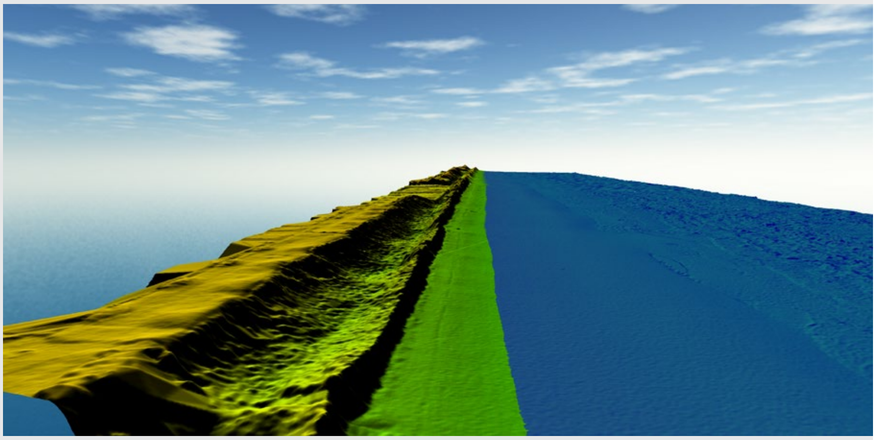
A significant amount of sand was washed away from Mickler Beach in St. Johns County, Florida, after Hurricane Ian tore through the community.
Image courtesy of Woolpert.



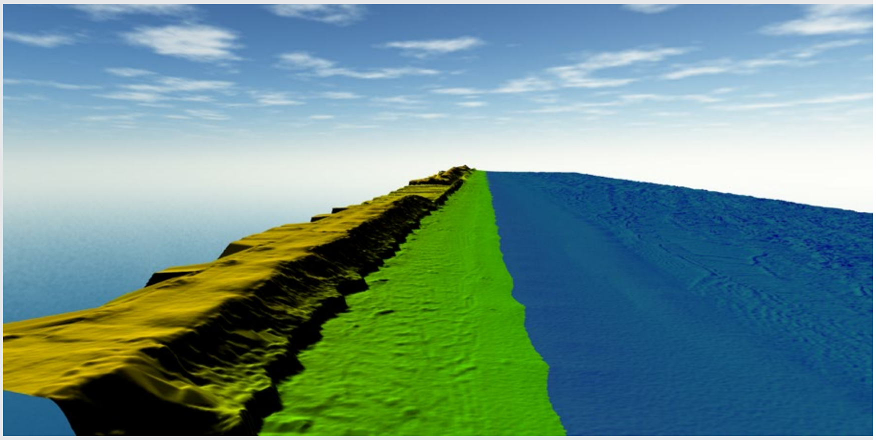
Once Tropical Storm Nicole passed through St. Johns County, Florida, Woolpert used an oblique view of a colorized, 1-foot-resolution ground DEM to highlight the changes to Mickler Beach.
Image courtesy of Woolpert.



An oblique view of a colorized, 1-foot-resolution ground DEM, this image shows the beach in front of the Sand Dollar Condominiums in St. Johns County, Florida, before Hurricane Ian.
Image courtesy of Woolpert.



This oblique visual depicts how much beach was lost in front of the Sand Dollar Condominiums after Hurricane Ian hit St. Johns County, Florida.
Image courtesy of Woolpert.



Tropical Storm Nicole came several weeks after Hurricane Ian, eroding more beach in front of the Sand Dollar Condominiums in St. Johns County, Florida.
Image courtesy of Woolpert.

three varying distances landward of the waterline. After the first extreme weather event, Woolpert flew again on October 11, and began processing the data to assess the damage Hurricane Ian had caused to the St. Johns County coastline. Before the firm could provide the deliverables to officials, however, Tropical Storm Nicole hit, requiring Woolpert to fly lidar for a third time on November 18.

"In 2022, we had the opportunity to gather pre- and post-hurricane elevation data for the first time since the program's inception," said Michael Meiser, Woolpert vice president. "In previous years, St. Johns County didn't have hurricane events of this magnitude, so there wasn't enough to merit data acquisition. But the 2022 storms provided multiple reasons to investigate and evaluate what happened to the St. Johns County coastline."

While the justification was there, one challenge still existed: accurately timing the data collection. This step was imperative for developing a complete picture of the destruction caused by each storm. Gathering the data within a week of each event was ideal but mobilizing aircraft so quickly can be quite challenging.

"We knew that other people would try to fly in that airspace, especially for emergency response," said Sam Moffat, Woolpert geospatial program director. "Coordinating the airspace and collecting lidar data soon after Hurricane Ian and Tropical Storm Nicole required significant effort. After strategizing with St. Johns County officials to get a thumbs up to gather post-storm elevation data, we had to navigate tidal and weather patterns as well as obtain airspace approval."

Once the airspace was secured, the next step was acquiring high-quality data despite dreary, rainy, and cloudy conditions caused by remnants of the extreme weather events. For the best chance to gather consistent data, Woolpert flew lidar within approximately one hour on either side of astronomical low tide in the adjacent Atlantic Ocean. The data acquisition took place when the atmosphere was primarily clear of poor conditions and other phenomena that would hinder or negatively impact the success of the data collection effort. Additionally, Woolpert flew at an altitude of approximately 2400 feet above mean terrain.

"At this altitude, we could fly under the clouds that are so prevalent along the eastern coast of Florida during the summer and fall," Moffat explained. "This altitude also produced a point cloud with more than 20 points per square meter."

This strategy resulted in an extremely dense and precise surface model with a vertical accuracy of approximately 5 centimeters, enabling Woolpert to provide multiple deliverables, including ground-derived digital elevation models with 1-foot resolution and 8-bit grayscale intensity images, which vividly portrayed the damage to St. Johns County's beach areas. These portrayals showed a level of devastation the coastal county had rarely seen.

"On average, Hurricane Ian wiped away approximately 50 feet of beach and Tropical Storm Nicole eroded around 60 feet," Meiser said. "Both storms hit some places in the county harder than others. For example, in Summer Haven, these natural disasters moved the community's entire beach west across an intercoastal waterway."

Forward-thinking approach to response and resilience

Rebuilding damaged areas along the St. Johns County coastline was essential after Hurricane Ian and Tropical Storm Nicole. Tourism is the county's primary economic engine, benefiting businesses, investors, and residents, and is continuously growing. According to Downs & St. Germain Research[3] over 10 years ago, St. Johns County generated $712 million annually from visitors; between July 2021 and June 2022, that figure jumped to $2.4 billion. This revenue supports jobs, businesses, and investors as well as programs and attractions that visitors and residents alike enjoy.

Without tourism, the St. Johns County economy stands to take a significant hit. Preserving tourist revenue was a primary reason that officials used the pre- and post-hurricane elevation data to support and enhance their response and resilience efforts. It's also why the county maintains the coastal management team that spearheaded the dataset implementation.

"Our coastal management team is a well-rounded group that's dedicated solely to coastal management—it's what we think about all the time," said Stephen Hammond, St. Johns County coastal environment project manager. "The county recognizes that the beaches are extremely important, and we need to know what's going on with them. Data is critical to help to determine that."

Once the coastal management department saw the destruction Hurricane Ian and Tropical Storm Nicole inflicted on the county's beaches, they used the data to develop a multi-pronged approach. One of the department's first steps was to alert county leaders and the general public to the significant storm-related damage. This visibility promoted cooperation in designating resources to rehabilitate the areas needing the most attention.

"We were able to show the public which areas of the coastline were most impacted by the storms. While everyone could see the damage with their own eyes, we came up with damage estimates based on actual data. It was really important to put numbers behind the visuals for our leaders to share how severely our coastline was hit with different organizations and levels of government."

> "The pre- and post-storm elevation data has value beyond engaging the public and moving response and resilience projects through the pipeline. It will also be beneficial in attracting funding for ongoing efforts."

3 co.st-johns.fl.us/tdc/media/Florida-%20Historic-Coast-July-2021-June-2022-Economic-Impact-Report.pdf

Along with providing impact estimates to the public and county leaders, the coastal management department showcased pre- and post-event DEMs using Woolpert's Smartview Connect™, a web-based tool offering visual representations of the destruction to St. Johns County's coastline.

"A picture is worth 1000 words," said Ben Beckman, geospatial team leader at Woolpert. "Using Smartview Connect, the department could show residents and leaders the extent to which the beaches were wiped away after Hurricane Ian and Tropical Storm Nicole. That imagery is a great resource to provide to those who aren't familiar with lidar technology."

The coastal management department also used the data to determine how much sand was lost in the upper, dry-beach portion of the dune system and what remained behind the elevations of the existing dunes, which were there to protect the upland infrastructure.

"We used this information and worked with FEMA and our consultants to determine the eligibility for a FEMA category B berm," Hammond explained. "This type of project is considered emergency repair of the dune system. Rather than rebuilding all the sand the storms took away, we were enhancing what was left behind on large, impacted sections of the beach. We had to show the elevation of the remaining dunes to determine if a section was eligible for this type of project, so having the pre- and post-storm elevation datasets available was critical. An additional criterion for eligibility is starting construction within six months of the storm declaration, which is extremely hard to do. However, having the datasets available quickly supported the fast analysis needed to meet this tight timeline."

The coastal management department also sent the data to its consultants and partners working on varied projects across the community. With 42 miles of coastline, St. Johns County had 10 active projects on different sections of the beach. Two of the projects—the South Ponte Vedra and Vilano Beach project and the St. Augustine Beach project—were with the U.S. Army Corps of Engineers.

"These two Corps projects were emergency renourishment initiatives," Hammond said. "Before these storms hit, we were planning to place around 2,000,000 cubic yards of sand on those project sites. After Hurricane Ian and Tropical Storm Nicole passed, we worked with the Corps to reanalyze the conditions on the beach and project areas, using the pre- and post-storm elevation data to update that number. We actually increased the amount of sand we needed to bring into the project areas because the storms washed away so much of the existing sand."

Additionally, the department used the datasets to update various project bid plans. Without the post-storm data, potential bidders would not have had an accurate picture of project areas. When the department delivered the updated data to its consultants, they paired it with new exhibit bid documents to accurately showcase how significantly the project sites had changed after each storm. The timely data served to ensure bidders were aware of the new reality facing the projects and that they had the most current information to complete them successfully.

Parting the waves to receiving long-term federal funding

For St. Johns County, the pre- and post-storm elevation data has value beyond engaging the public and moving current or reactive response and resilience projects through the pipeline. This annual dataset will also be beneficial in attracting funding for ongoing efforts.

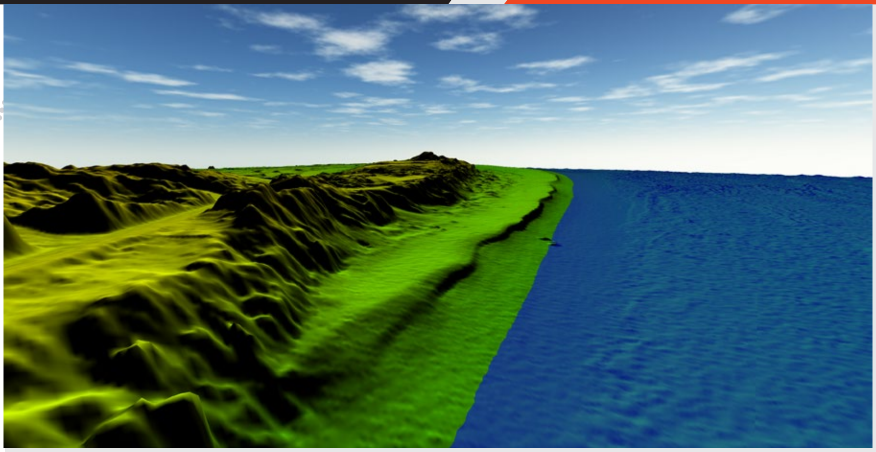
> "If coastal communities gather pre- and post-storm elevation data, their engineering groups can use the data for all kinds of analysis, planning, and mitigation procedures to keep their beaches and economies strong."

"We're working toward a coastal management plan that will hopefully set us up for the next 50 years and advise on future project needs along the coastline," Hammond explained. "The coastal management plan is a long-term initiative that will include tracking what's happening on the beach and the areas of erosion so that we know when to start planning projects and seeking funding. This data will be extremely helpful in supporting that effort."

Regular pre- and post-storm elevation data will improve St. Johns County's chances of success in securing funding. Similar to other coastal communities, St. Johns County has many engineered projects: once the coastal management department constructs a shoreline project, the beach is categorized as engineered. Engineered beaches impacted by storms are eligible for additional funding, so possessing accurate pre- and post-storm elevation data gives the department an advantage with respect to securing money when projects are needed.

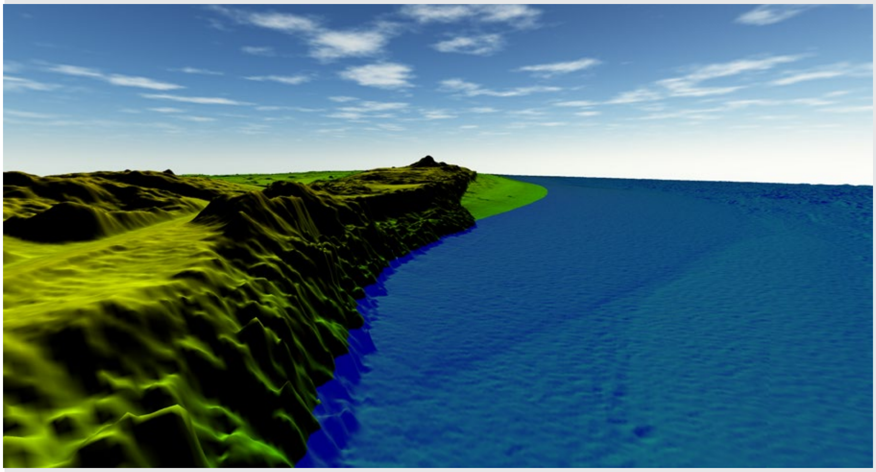
When explaining how pivotal the datasets are in securing funding, Hammond referenced a recent project for which the county acquired funding as a result of Hurricane Ian and Tropical Storm Nicole. "We just did a local- and state-funded project in South Ponte Vedra Beach, where we constructed a full beach restoration of the dunes and berm—but it washed away in about six months due to the impacts of Hurricane Ian and Tropical Storm Nicole," Hammond said. "We were able to use the lidar data and additional underwater bathymetric data to determine how much sand was lost. FEMA will help reconstruct the project with Category G funding. If we didn't have a project there already or the lidar dataset, there wouldn't be funding sources like this to help us, and we would have to fund it either locally or hope the state sends some money our way."

The coastal management department also wants to use the data regularly to discover areas that are eligible for Corps projects. According to Hammond, these projects are the "gold standard" because they are funded by a cost-sharing partnership between the Corps and the county. This arrangement ensures that major storm damage to the county coastline will be mitigated by Corps funding, at least in part.



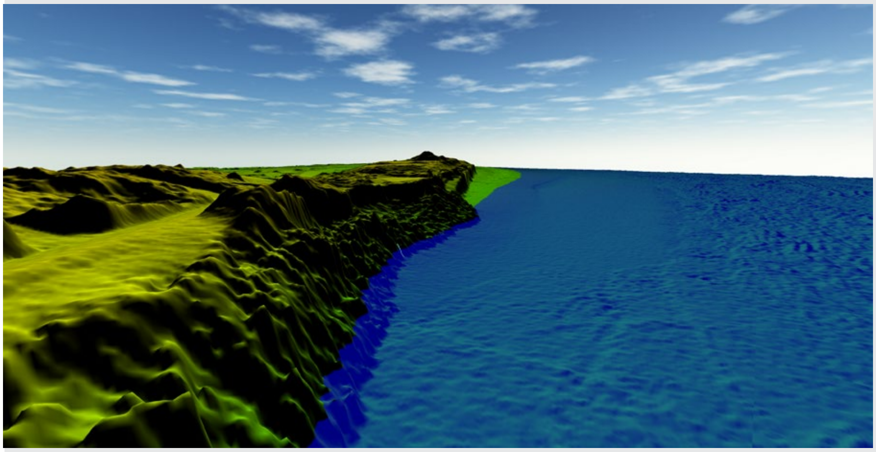
A colorized image of a 1-foot-resolution ground DEM, this visual depicts Old A1A Beach Access Point in Summer Haven, a coastal community in St. Johns County, Florida. The imagery shows what the access point looked like before Hurricane Ian and Tropical Storm Nicole.

Image courtesy of Woolpert.



Summer Haven in St. Johns County, Florida, was hit particularly hard by Hurricane Ian. This colorized image shows how the extreme weather event damaged the Old A1A Beach Access Point.

Image courtesy of Woolpert.



This colorized image of a 1-foot-resolution DEM model illustrates the changes to the Old A1A Beach Access Point after Tropical Storm Nicole passed through.

Image courtesy of Woolpert.

“Working with the Corps is an amazing opportunity,” Hammond says. “If it’s a non-federal project, the county must cover the cost of rebuilding after a storm. But if a declared storm impacts a Corps project and we have data supporting the need for restoration of the project, the federal government will pay for 100% of it.”

When commenting on all the benefits St. Johns County has seen from the data, Jeff Lovin, senior vice president and senior strategist at Woolpert said, “We are extremely grateful for the nearly 30-year partnership with St. Johns County and that most recently we were able to provide them with valuable pre- and post-storm data to aid in their recovery. As the frequency and intensity of storms battering our coastlines increase, more coastal communities in Florida and throughout the nation should look at similar programs.”

Coastal communities need to prepare

Hurricanes have increased in intensity over the past four decades, leading to more destruction. With seas becoming warmer, the likelihood of a hurricane turning into a category three or higher storm, with winds traveling at more than 110 miles an hour, has increased by 8% per decade since 1979. A 2023 report by First Street Foundation even suggests that, in the decades ahead, stronger storms will impact communities deeper inland, potentially damaging 13 million properties that are typically unaffected[4].

While coastal communities can’t negate the effects of natural disasters, they can put themselves in a position to respond quickly to hasten their recovery. By flying lidar over shorelines before and after hurricanes, coastal communities can pinpoint their beach areas needing the most attention and then effectively design solutions and implement plans.

“Having the before and after elevation data will really help counties make accurate and more scientific decisions on the next steps for their coastlines,” Hammond said. “In the long term, counties can be more proactive than reactive to storms. Right now, everything going on is reactive, so putting a long-term monitoring program like this together can really help counties develop a proactive approach.”

Additionally, counties can use the data to help secure federal funding for resilience and response initiatives. Extreme weather events have significant economic impacts on communities, and Rick Spinrad, administrator at the National Oceanic and Atmospheric Administration (NOAA), told *USA Today* that since January 2023, “There have been a record-setting seven disasters that have totaled a billion dollars or more each in damages.”[5]

To help coastal communities become more resilient, the U.S. Department of Commerce recently announced a $2.6 billion grant, which includes $575 million for regional challenge grants provided by NOAA. Securing these grants will be easier for coastal communities that have data depicting their shoreline damage.

With secured funding, coastal communities can rehabilitate damaged beach areas to keep residents, businesses, and investors happy and, more importantly, maintain their biggest economic driver—tourism. Recreation and tourism in shore-adjacent communities in the U.S. account for $143 billion in gross domestic product[6]. If those coastal communities can’t rehabilitate their beaches and entertainment districts after hurricane season, the number of visitors will inevitably decline. Less tourism means less money.

“Beaches are what draw people every year to many coastal communities, especially in Florida,” Moffat said. “They are the engine for Florida’s economy and all of the coastal communities in the state. Even if you aren’t overly concerned with the general health of the ecosystem, the health of these beaches is important for the economy and attracting tourist dollars. If coastal communities use lidar to gather pre- and post-storm elevation data, their engineering groups can use the data for all kinds of analysis, planning, and mitigation procedures to keep their beaches and economies strong.”

Woolpert Geospatial Project Manager **Volkan Akbay** is an ASPRS-certified photogrammetrist and a project management professional with 24 years of industry experience. Akbay is currently a project manager for several lidar and mapping programs serving local, state, federal, and private clients.

Woolpert Geospatial Program Director **Rick Householder** is an award-winning GIS leader who has spent nearly three decades advancing Florida’s geospatial capabilities. Before joining Woolpert, Householder worked at the South Florida Water Management District as a scientist, geographer, and geospatial section leader. For further information, email rick.householder@woolpert.com.

4 nbcnews.com/science/environment/hurricanes-push-deeper-us-coming-decades-rcna70134

5 usatoday.com/story/news/nation/2023/06/21/noaa-2-6-billion-in-infrastructure-act-money/70292991007/

6 coast.noaa.gov/data/digitalcoast/pdf/econ-report.pdf

Government, Industry and Academe Advance Florida Lidar

Synopsis of the 14th UF/FL-ASPRS Spring 2023 Lidar Workshop

BY AL KARLIN

The Florida Region of the American Society for Photogrammetry and Remote Sensing (FL-ASPRS) and the University of Florida (UF) Geomatics Division continued their biannual lidar workshops on 8 June 2023. The workshops continue to meet, in-person and virtually, at the Mid-Florida Research & Education Center of the University of Florida's Institute of Food and Agricultural Sciences and over Zoom. The workshops are open free-of-charge to all interested persons. The Spring 2023 Workshop hosted 68 participants on-site and 78 virtual, the latter from California, Minnesota, Canada, the West Indies and India as well as Florida. With respect to the ASPRS mission statement, "to promote a balanced representation of the interests of government, academia and private enterprise", the program includes presentation sessions devoted to each of these three sectors.

The business meeting

The workshops provide an opportunity to conduct a biannual region meeting for the members, as well as an educational and social function for the community. At this meeting, the region introduced one newly elected Director, Eric Householder, and thanked Fredrick Hartless for his service to the Board as he cycled off it. Fred was presented with an inscribed Survey Monument commemorating his time on the Board. The retirements of two past, long-serving directors, Brenda Burroughs and Dr. Bon Dewitt, were also announced. Both will be missed.

On an upbeat "retirement" note, the region announced the sunsetting of its old logo (**Figure 1A**), now over 15 years old, and revealed the updated one (**Figure 1B**).

Figure 1: Retired region logo (A) on the left and newly adopted region logo (B) on the right.

The region will also be updating banners and other promotional materials with the new logo.

Session 1: State and Federal Updates

The workshops begin with 10-minute briefings from state and federal agencies focused on Florida-based projects. In this workshop, Suwannee River (SRWMD) and Southwest Florida (SWFWMD) Water Management Districts, the Florida Department of Environmental Protection

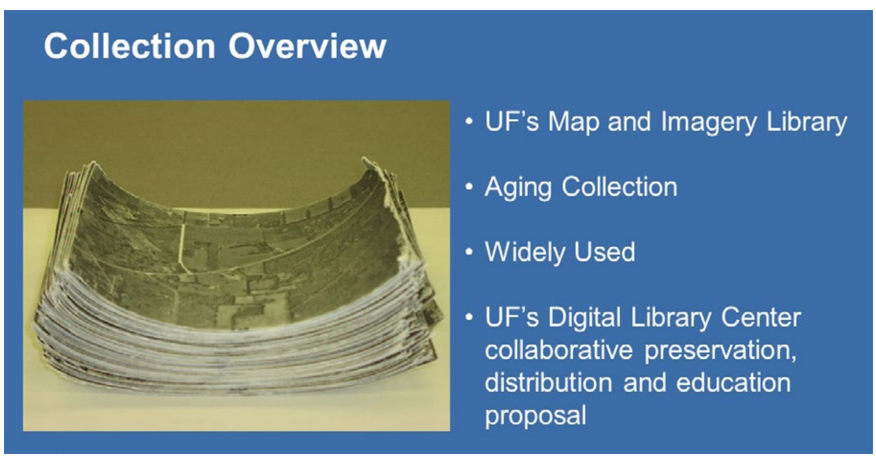


Figure 2: An overview of the historical images at the University of Florida Smathers Libraries.

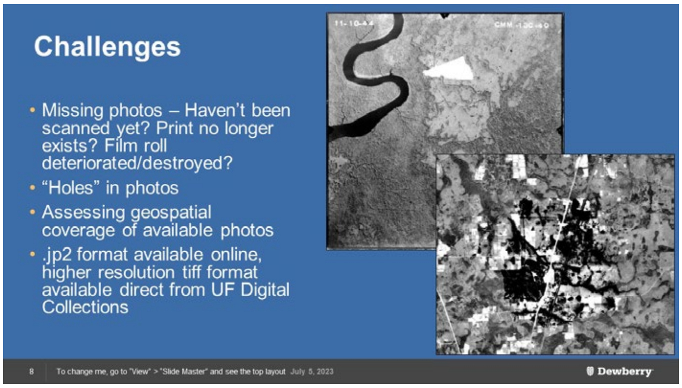


Figure 3: Challenges to constructing seamless historical mosaic images.

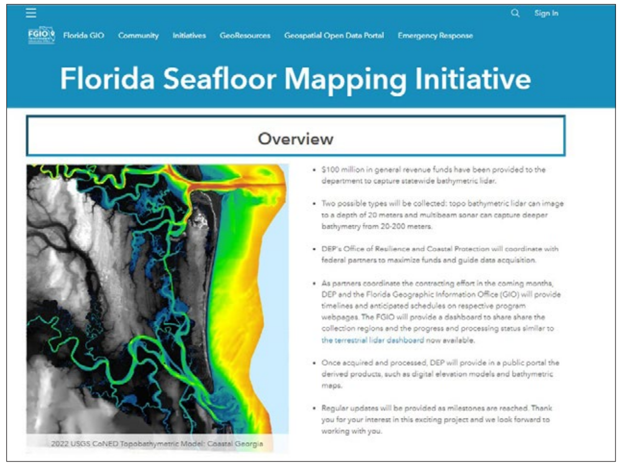


Figure 4: The Florida Seafloor Mapping Initiative (https://www.floridagio.gov/pages/fsmi) public-facing website.

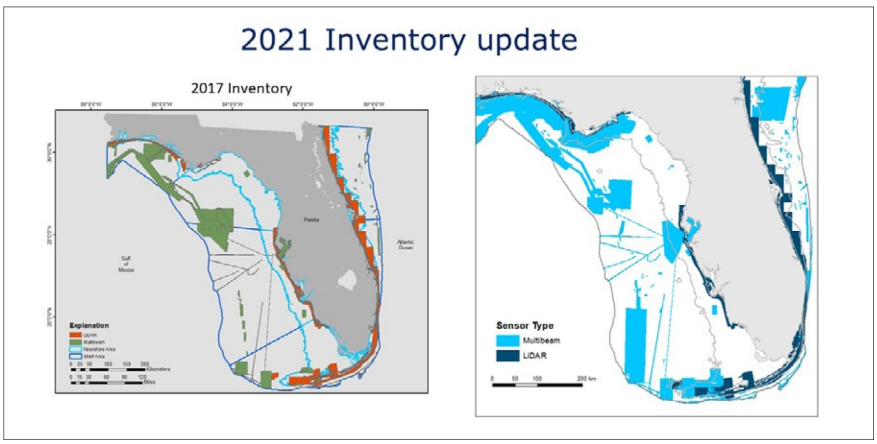


Figure 5: FCMaP update to the available seafloor data for Florida.

(FDEP) and the Florida Coastal Mapping Program (FCMaP) represented the state agencies, while the US Geological Survey (USGS) and the National Oceanic and Atmospheric Administration (NOAA) presented updates on national projects in the state.

SRWMD: Joe Aufmuth, GIS Librarian—George A. Smathers Libraries at the University of Florida, started the update with a public-private project to georeference historical aerial imagery. Joe discussed the historical image holdings, the workflow by which the images were scanned, and means to access the collection (**Figure 2**). Joe handed the presentation over to Chad Lopez (Dewberry), to discuss the "private" side of the partnership.

Chad discussed the SRWMD contract with Dewberry to assemble county-wide photo-mosaics of the historical images to help the SRWMD engineers understand historical water flow prior to the intensive agriculture of the mid-20th century. The project initially involved Bradford and Union Counties, but subsequently included Levy County. Individual scanned frames were geo-referenced, their collars removed, then color balanced into a single, seamless mosaic, before being tiled to the Florida Division of Revenue Aerial Index. Chad finished by highlighting some of the challenges (**Figure 3**).

SWFWMD: Nicole Hewitt confirmed that all the lidar data from the USGS (2018) Peninsula Project and the SWFWMD enhancements had been published. She finished with a compelling argument, citing FEMA flood protection, habitat destruction via controlled and uncontrolled burning, natural disasters from hurricanes and tropical storms, for the multiple uses of recently collected lidar data and suggested that data be collected at intervals of no longer than six years, coinciding with the Florida County Digital Orthoimagery Program.

FDEP/Florida Seafloor Mapping Initiative (FDEP/FSMI): Alex Reed (FDEP Office of Resilience and Coastal Protection) provided an update on FSMI and introduced its web page on the Florida Geographic Information Office (GIO) hub site at: https://www.floridagio.gov/pages/fsmi (**Figure 4**). Alex discussed the funding sources and the scope of the project. She indicated that the first round of project

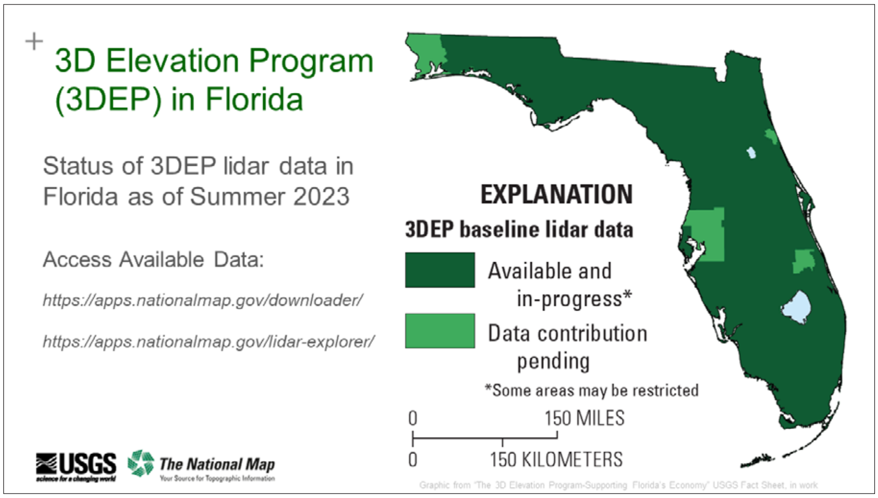


Figure 6: How to access 3DEP data through The National Map.

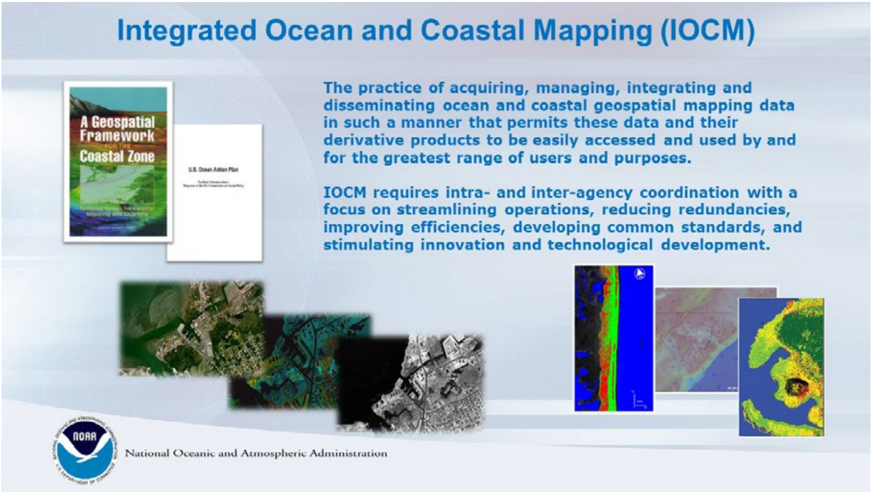


Figure 7: IOCM stressing increased intra- and interagency coordination.

assignments in the near shore (0-20 m water depth) have been issued and will focus on topobathymetric lidar.

The second round will focus on acoustic technologies for deeper waters and "filling in the voids" in the lidar. She also indicated that the GIO will be hosting a data-collection status dashboard and later providing the resulting digital elevation models as public GIS image services from the State Geospatial Open Data Portal. FSMI is coordinating with the USGS Coastal National Elevation Database staff to create a seamless DEM for Florida's coast that will be shared publicly at the project's conclusion.

FCMaP: Dr. Cheryl Hapke (University of South Florida College of Marine Science) described FcMap's role: it has evolved into a coordinating body of federal, state, and local agencies along with institutions to facilitate the collection and dissemination of coastal seafloor data. Since the original 2019 prioritization study, FCMaP has conducted an updated inventory of seafloor data in 2021 (**Figure 5**) and is deploying a similar prioritization study of the offshore (20-200 m water depth) areas in 2024.

USGS: Alexandra "Xan" Fredericks (USGS National Map Liaison) presented a variety of National Geospatial Program initiatives. She started with the current status of 3D Elevation Program (3DEP) lidar in Florida, sharing links to access and view the available data via The National Map and the 3DEP Lidar Explorer (**Figure 6**). Xan went on to discuss the 3D National Topography Model (3DNTM) and how Florida 3DEP data support this larger vision of integrating national elevation and hydrography datasets into a 3D model.

Finally, workshop participants were invited to become a member of the new ASPRS Lidar Bathymetry Working Group and attendees from outside Florida were encouraged to identify their USGS National Map Liaisons by visiting https://usgs.gov/TNMLiaisons.

NOAA: Stephen White (NOAA Remote Sensing Division) provided the update on NOAA shoreline, imagery and nearshore bathymetry projects in Florida. He began by discussing NOAA's mission and the Remote Sensing Division's role therein. He went on to describe the support of hydrographic surveys (lidar and multibeam sonar) and shoreline extraction from lidar and imagery. He provided updates on the progress of FL2201, the Indian River Lagoon topobathymetric lidar project, and the Bipartisan Infrastructure Law (BIL). He highlighted collaborations between NOAA and the Natural Resources Conservation Service, touched on "uncertainty"

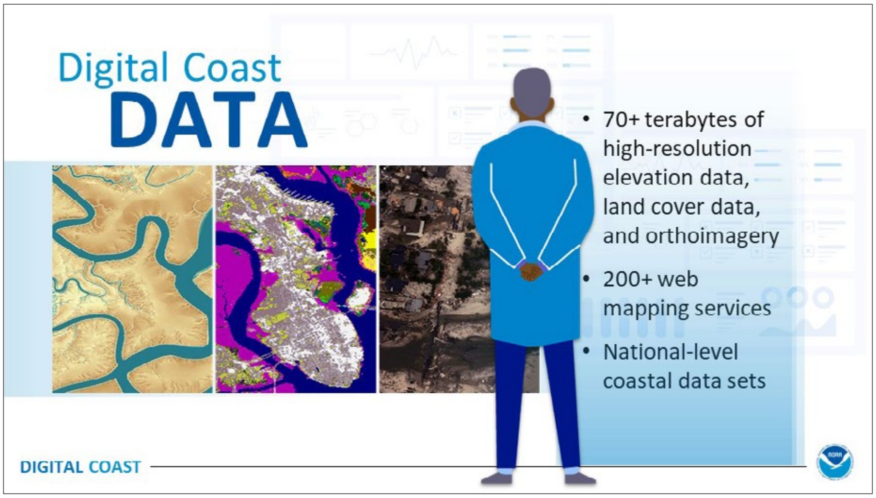


Figure 8: The NOAA Digital Coast overview of contents.

(total propagated uncertainty: TPU) in topobathymetric data, and concluded with an acknowledgement of Integrated Ocean and Coastal Mapping (IOCM; **Figure 7**).

Session 2: The Keynote Speaker

Dave Stein, from NOAA's Office for Coastal Management in St. Petersburg, Florida was the keynote speaker. Dave works in the Science and Geospatial Division, focusing on ocean mapping, GIS, and remote sensing technology, benthic habitat mapping and the application of geospatial technology to coastal zone management.

He opened with a discussion of the NOAA Digital Coast. Directing users to the website, he highlighted the data, noted the collaborations, and emphasized that the website contains a host of information, not just data (**Figure 8**).

He continued with the various datasets and tools available on the Digital Coast, such as: the Coastal Land Cover (Coastal Change Analysis Program: C-CAP) and the products available. Of special interest to the audience was the impervious surface mapping for Florida derived from 2021 high-resolution imagery, the Sea Level Rise Viewer, the Coastal Flood Exposure Mapper, and the OceanReports generator—"it's like the Zillow of the ocean".

He concluded his talk with a discussion of contracting with the Office of Coastal Management. He indicated several of the NOAA/OCM federal, state and local partners, and several of the Sample Projects from FY2022 (**Figure 9**).

Session 3: Roundtable Discussion

Representatives of the platinum-level sponsors were invited to present brief descriptions of their respective firms prior to a roundtable discussion: Amar Nayegandhi—Dewberry, My-Linh Truong—RIEGL, Tom Ruschkewicz—McKim & Creed, and Jamie Young—Pointerra (**Figure 10**).

Dr. Stephen Medeiros from Embry-Riddle Aeronautical University served as moderator of the session. The topic was the recent emergence of ChatGPT (and other generative AI technologies (ex. DALL-E and Stable Diffusion) and whether there are any opportunities or challenges presented to the industry by AI.

The consensus of the group suggested that these technologies, like several that came before, will be incorporated into the lidar industry as they mature. It is too early to tell how rapidly that will occur, but all were optimistic that there are opportunities.

Session 4: Gold-Level Sponsors

The gold-level sponsors had brief time-slots to introduce their firms and the innovations they offer. Returning

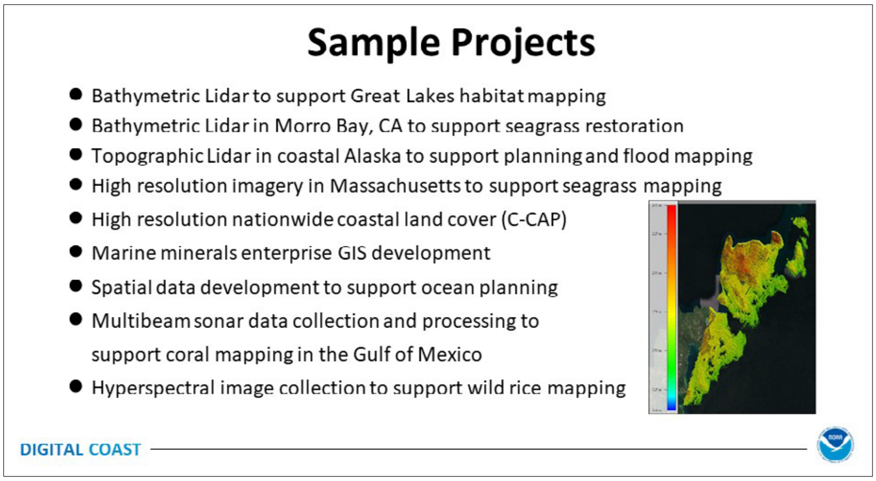


Figure 9: Sample of NOAA/Office of Coastal Management FY2022 projects.

Figure 10: Roundtable participants: from left to right Amar Nayegandhi, My-Linh Truong, Tom Ruschkewicz, and Jamie Young.

gold sponsors, GPI Spatial, Kucera International, Pickett and Associates, and Woolpert were thanked for their ongoing participation in the workshops, while new sponsors Frontier Precision—Unmanned and 3DEO were welcomed to the workshop.

Frontier Precision—Unmanned: Joey Civello discussed his firm's multiple unmanned portfolio. Of particular interest to the workshop were UAVs in compliance with the National Defense Authorization Act (NDAA) (**Figure 11** shows an example).

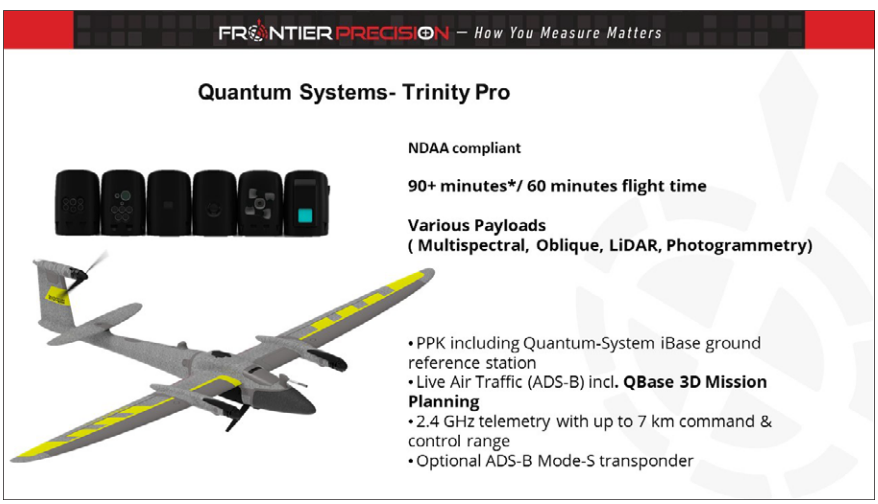


Figure 11: A Frontier Precision NDAA-compliant UAV.

Figure 12: Jamey Gray, from GPI, demonstrating the NavVis wearable mobile lidar scanner.

GPI Spatial: Mike Zoltek and Jamey Gray provided a demonstration of the capabilities of their NavVis system (**Figure 12**) by scanning the workshop space and uploading the data to the cloud for automated processing beforehand, and presenting the results in the session. Additionally, they allowed all interested parties to wear the scanner while providing an overview of the system controls and capabilities.

Kucera International: Barbora Ubar represented Kucera International. She welcomed everyone to the workshop and yielded her time to Pickett and Associates.

Pickett and Associates: Craig Emrick highlighted the multiple survey services Pickett and Associates offer and highlighted a UAV project in south Florida (**Figure 13**).

3DEO: Dr. Kimberly Reichel-Vischi represented 3DEO, Inc. She re-introduced attendees to Geiger-mode lidar technology and highlighted some of the advantages of the 3DEO Zion system. She also demonstrated the 3DEO workflow for Geiger-mode processing (**Figure 14**).

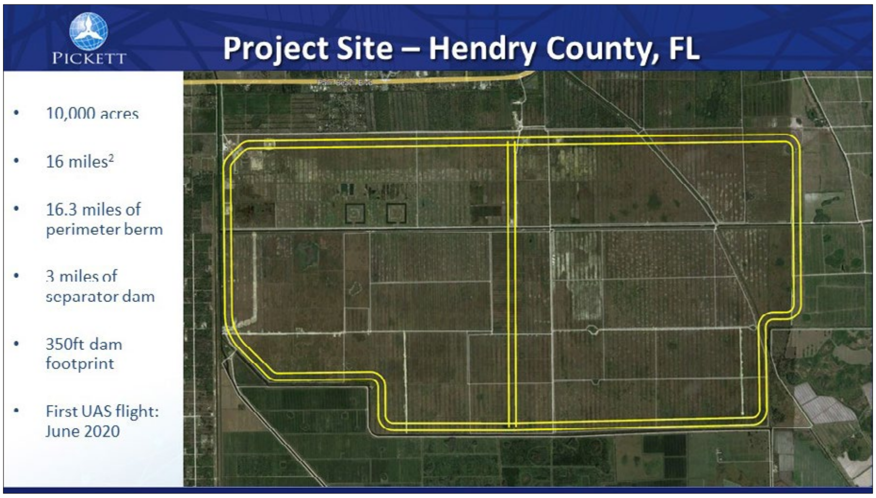


Figure 13: Pickett and Associates UAV imaging project in south Florida.

Woolpert: Geospatial program director Rick Householder represented Woolpert and discussed the firm's long history, starting with photogrammetry, along with current capabilities in the lidar, GIS and remote sensing arenas. He also described Woolpert's numerous aerial, marine and sensor assets and concluded by introducing some of the more innovative capabilities including 3D imagery and viewers, as well as cloud-based solutions.

Session 5: Academic Presentations

In accordance with the tradition at the UF/FL-ASPRS Workshops, student presenters are rewarded with an autographed copy of the ASPRS DEM manual[1] presented by one of the authors, Amar Nayegandhi (**Figure 15**). For this workshop, students from the University of Florida, the University of South Florida, Florida Atlantic University, and the University of Central Florida presented their remote sensing research.

Florida Atlantic University: Andrés Garzón-Oechsle presented his research, "In-between the sites: understanding late Holocene Manteño agricultural practices in Chongón-Colonche Mountains of Coastal Ecuador through remote sensing and excavation", on leveraging the interface between traditional archaeology, remote sensing and climate change science to understand how South American cultures of the Pacific coast responded to changing conditions from El Niño-Southern Oscillation (ENSO) and how those resiliency approaches can be used in today's changing climate.

Andrés used UAV-lidar mapping in the cloud forest of coastal Ecuador, his research study area, to reveal a modified landscape of cultivation terraces, water retention ponds, and water distribution channels (**Figure 16**). Using the combination of archaeology and remote sensing, he pieced together how the Manteño endured extreme droughts and torrential rains during the Medieval Climate Anomaly and the Little Ice Age from changing conditions in ENSO by creating a modified human landscape in the most resilient region of their territory, the cloud forest (**Figures 17A and 17B**).

University of Central Florida: Syed Zohaib Hassan presented his research, "UAV-based monitoring applications for solid waste facilities,"

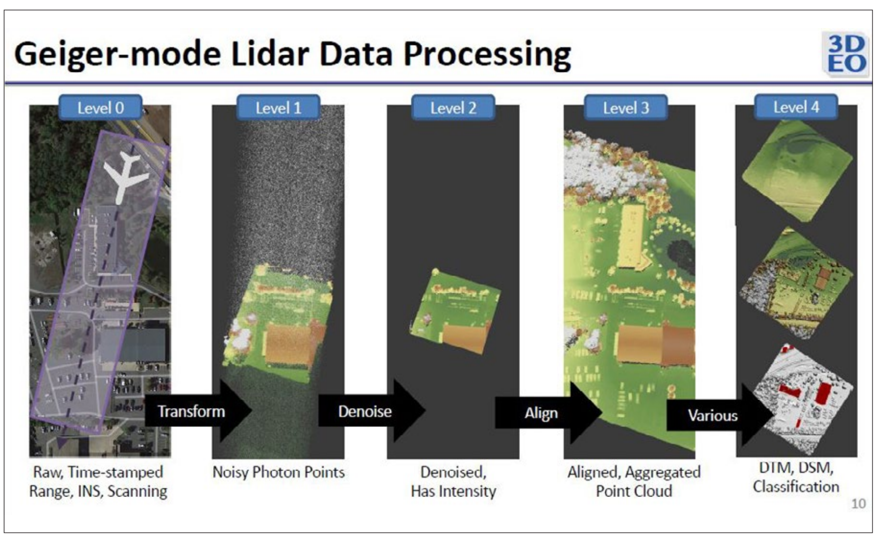


Figure 14: 3DEO workflow for Geiger-mode lidar data processing.

1 Maune, D.F. and A. Nayegandhi (eds.), 2018. *Digital Elevation Model Technologies and Applications: The DEM Users Manual, 3rd Edition,* ASPRS, Bethesda, Maryland, 652 pp.

Figure 15: From left to right, Michael Espriella (University of Florida) and Kylie Dillinger (University of South Florida) receiving autographed copies of the *DEM Users Manual, 3rd Edition* from Amar Nayegandhi (Dewberry).

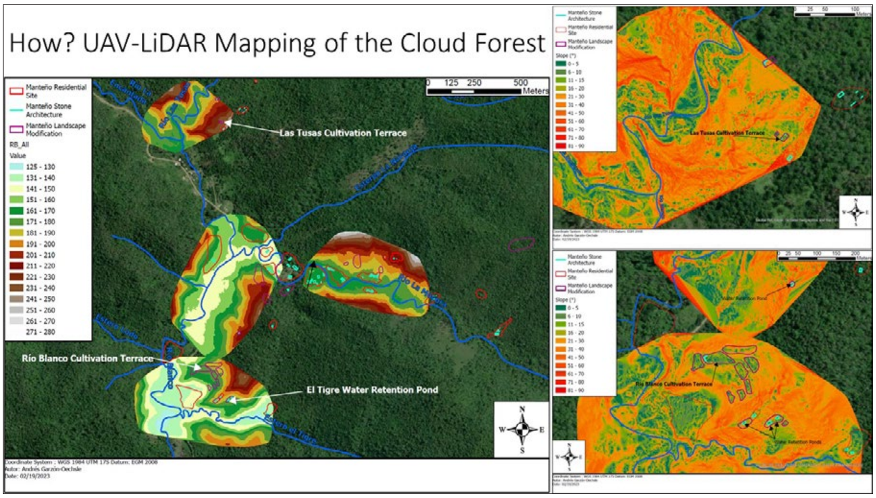


Figure 16: UAV-lidar digital elevation models showing connections between inhabited areas in the cloud forest of Ecuador.

along with co-author Dr. Patrick Sun. As municipal landfills are particularly vulnerable to hurricanes and other climate events, Syed's research considers the use of UAV technology to monitor municipal solid waste landfills. Unlike most presentations at the workshop, Syed's solution incorporated remote sensing for topography (lidar scanning), air quality (gases), RGB imaging and multi-spectral sensing (**Figure 18**).

Syed chose a study site, a county landfill, in southeastern Hillsborough County, Florida and collected the remotely sensed data both before and after Hurricane Ian in the late summer of 2022. This study was conducted to analyze the deteriorative effects and damages caused by storm water to landfill's cover.

The results of the study demonstrated the efficacy of the methodology and did not detect any gas emissions or leakage resulting from the storm (**Figure 19**). Further statistical analysis will be performed in the future. In addition to the remotely sensed data, air quality data was collected on the landfill to detect any possible landfill-gas (LFG) leakages by performing UAV-based context-aware flights over the landfill's cover. Results shows that there were no leak hot spots of methane on the landfill.

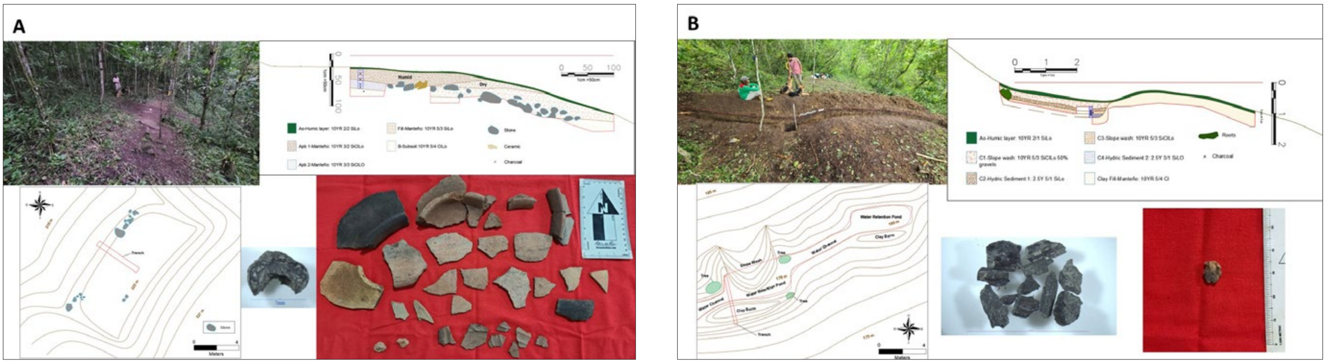


Figure 17: (A) Ground-level and profile views and artifacts associated with cultivation terraces and (B) retention ponds in the cloud forest of Ecuador.

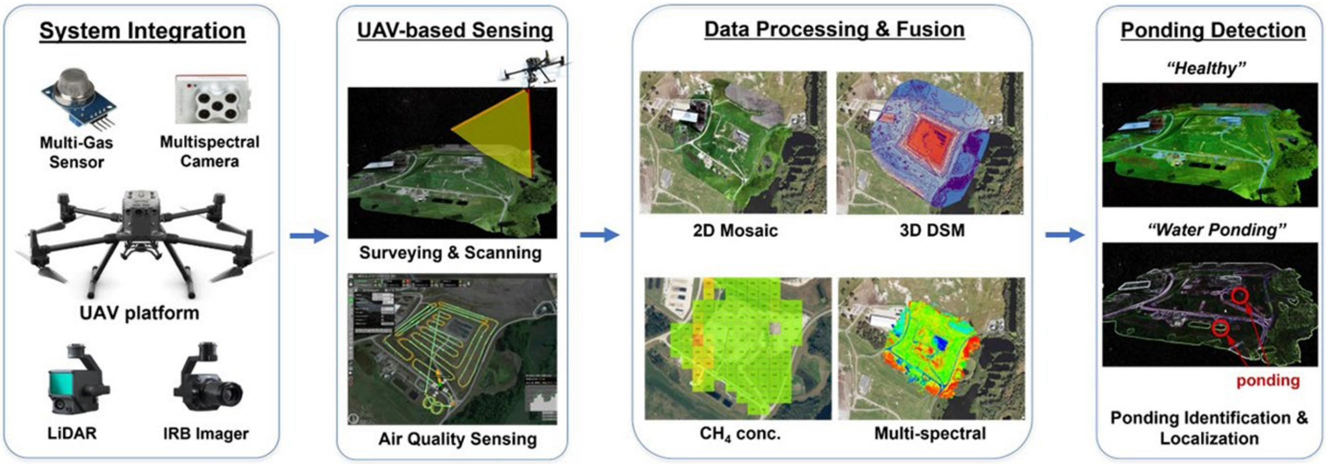


Figure 18: Proposed UAV-based data fusion technique to monitor landfill.

University of Florida: Michael Espriella presented "Monitoring intertidal oyster reefs using drone-based lidar" along with co-authors Dr. Vincent Lecours, Dr. Ed Camp, H. Andrew Lassiter, Dr. Ben Wilkinson, Dr. Peter Frederick and Dr. Simon Pittman. The research focused on intertidal habitats in Florida as these areas, particularly in the "Big Bend" area, are experiencing significant change resulting from both environmental pressures and anthropogenic factors.

Michael identified several challenges to using traditional, quadrat sampling methods (**Figure 20**) to estimate and monitor oyster population size and health. As these methods are extremely labor-intensive and time consuming, aerial sampling and high-resolution imagery from drone-based cameras may prove more efficient.

The team developed a suite of 122 surface complexity metrics from lidar point clouds, of which 46 were found to have a significant relationship with live oyster counts, including skewness of elevation values, volume-to-area ratio, and gray-level co-occurrence matrix features (**Figure 21**). The team highlighted the utility of metrics that have direct parallels to ecological processes, such as volume-to-area ratio, which can help inform oyster reef shell budget monitoring.

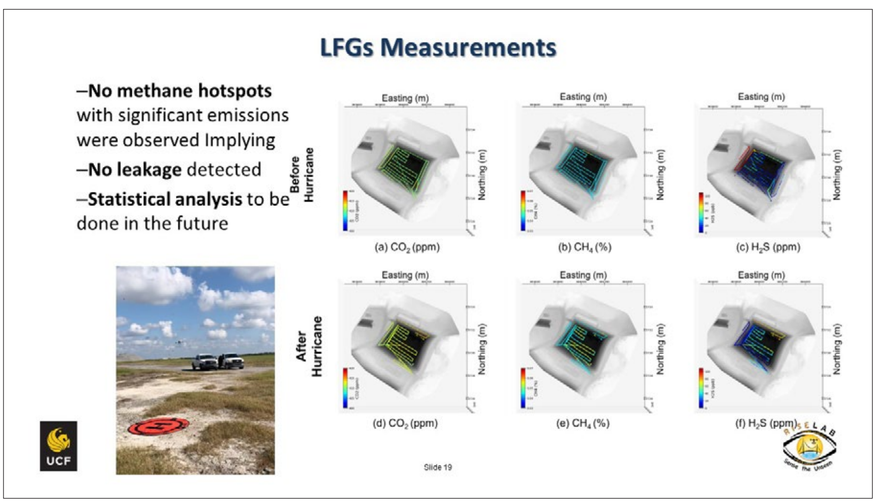


Figure 19: Results of monitoring a municipal landfill in southeastern Hillsborough County before and after Hurricane Ian (late summer, 2022).

University of South Florida: Kylie Dillinger presented her research, "Digital preservation of fading memories: virtualization and online dissemination of the WWII-era Japanese America detention camp at Granada (Colorado)," directed towards preserving a digital record of the camp that was dismantled and abandoned in 1945, with the site being designated as a National Park in 2022. The goal of the reconstruction project was to capture the entirety of the 12K Block as it currently exists and reconstruct it digitally to show how it changed over time.

Fieldwork entailed a large number of setups from different perspectives with Faro terrestrial scanners. Once

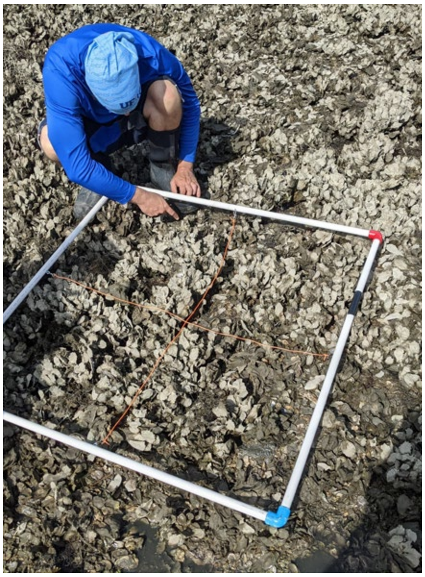


Figure 20: Conventional quadrat sampling for oyster populations.

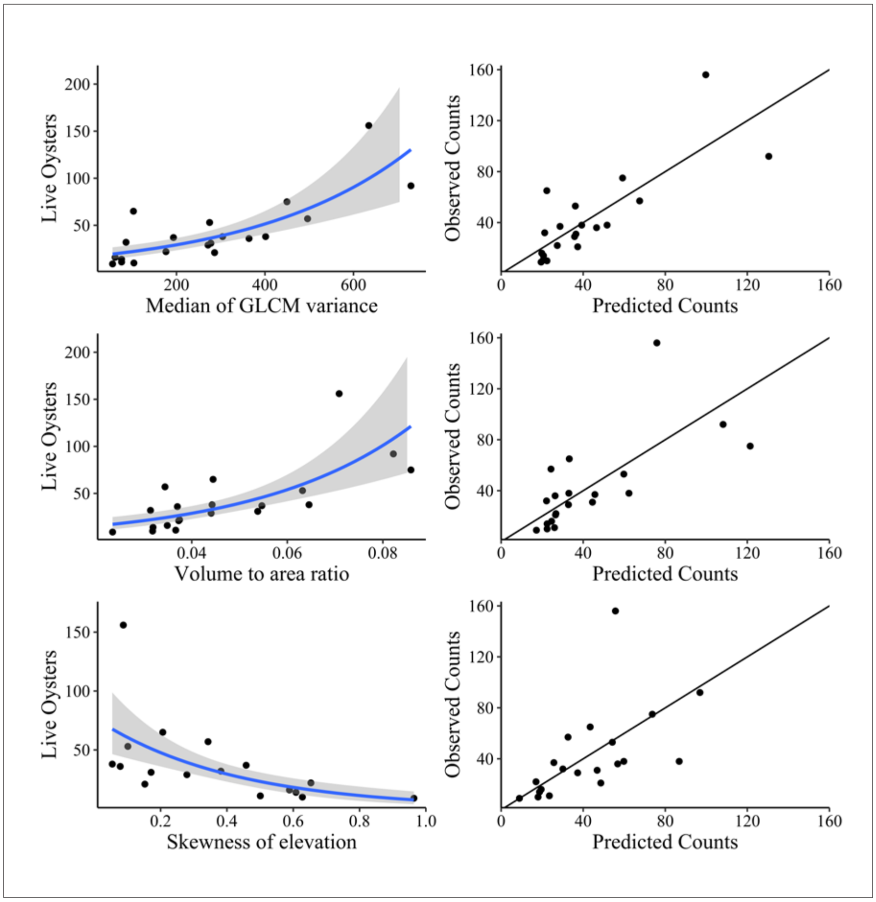


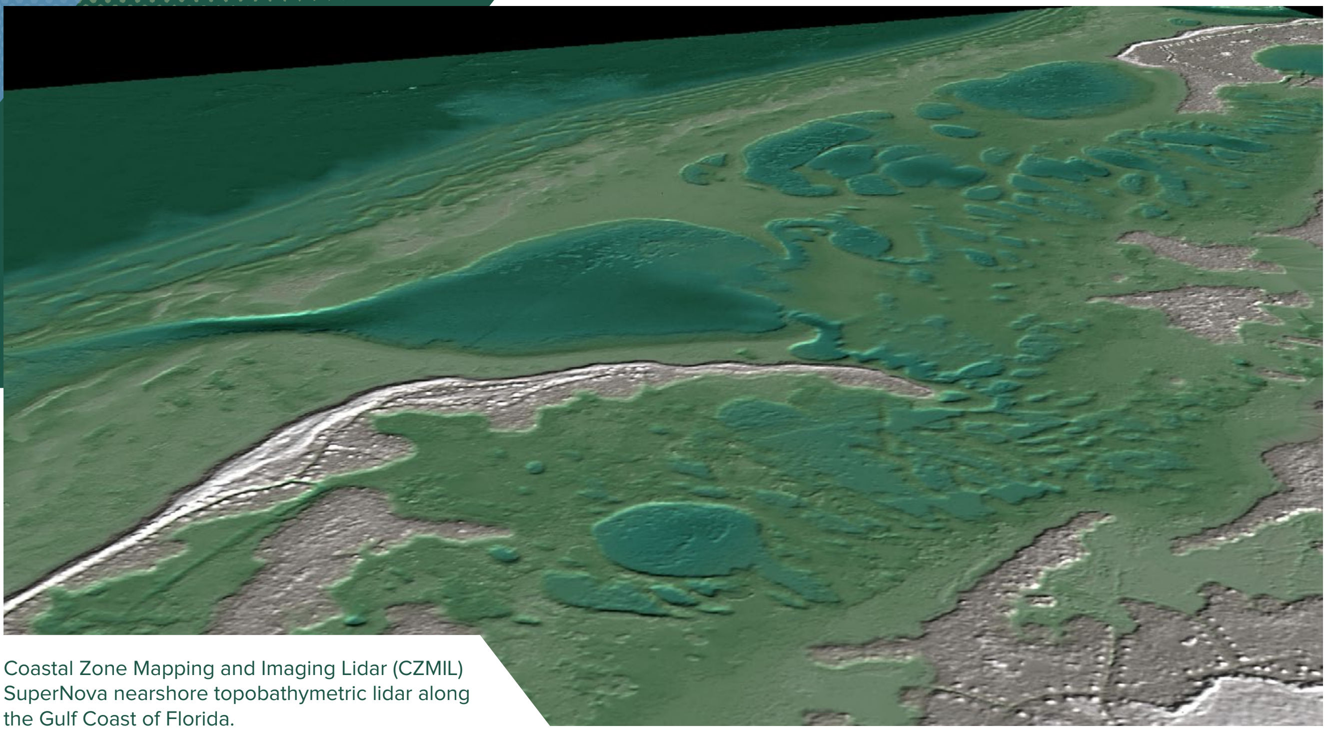
Figure 21: Three significant models representing the relationship between live oyster counts and surface complexity metrics (left). The blue line represents the negative binomial regression line, and the grey area corresponds with the 95% confidence interval. The column on the right shows predicted and observed counts for each respective model, with a one-to-one line for reference.

on-site Kylie was immediately faced with some limitations to the research: limited time (one week), a very large area (approximately 1 square mile), and inclement weather.

The project ultimately worked out well and resulted in high-resolution lidar scans of Block 12K (**Figure 22**), along with scans of a modified branch bench, the 11F Rec Hall, and a display in the Amache Museum.

Alvan "Al" Karlin, Ph.D., CMS-L, GISP is a senior geospatial scientist at Dewberry, formerly from SWFWMD, where he managed all the remote sensing and lidar projects in mapping and GIS. With Dewberry, he serves as a consultant on Florida-related lidar and imagery projects, as well as general GIS-related projects. He has a PhD in computational theoretical genetics from Miami University in Ohio. He is a past president of the Florida Region of ASPRS, an ASPRS Certified Mapping Scientist—Lidar, and a GIS Certification Institute Professional. He currently serves as a Director of the Florida Region of ASPRS, and as vice president of ASPRS at national level.

Figure 22: Terrestrial scan of Block 12K, Japanese detention camp, Granada, Colorado.



Coastal Zone Mapping and Imaging Lidar (CZMIL) SuperNova nearshore topobathymetric lidar along the Gulf Coast of Florida.

Mapping Florida Waters

Dewberry works with Florida Department of Environmental Protection to map the Gulf Coast of Florida sea floor

Florida boasts the longest coastline of any state in the contiguous U.S., with over 8400 linear miles (NOAA method)[1]. Florida also has the largest submerged shallow shelf on the Gulf of Mexico/ Atlantic Ocean and the only coral reef system (**Figure 1**) in the contiguous U.S. (Florida Department of Environmental Protection's Office of Resilience and Coastal Protection).

1 coast.noaa.gov/czm/mystate/

As about two-thirds of Florida forms a peninsula between the Gulf of Mexico and the Atlantic Ocean, the state is especially prone to tropical storms and cyclones/hurricanes. Since 1851, 121 named and unnamed hurricanes have hit Florida, more than any other state[2], and since 2017, four storms have made landfall along the Gulf Coast, including hurricanes Irma (2017), Michael (2018), Ian (2022), and Idalia (2023). Hurricane Ian was the third most costly hurricane to hit the U.S., on record with a price tag of more than $113 billion. Losses resulting from Hurricane Idalia, still being tallied, are also considerable. With increasing ocean temperatures fueling tropical storms, we can expect hurricane intensity and frequency to increase into the future.

2 cnn.com/2017/09/11/us/hurricanes-landfall-by-state-trnd/index.html

In response to the compounding effects of sea-level rise, coastal subsidence, and growing population pressure

BY AL **KARLIN**, EMILY S. **KLIPP** AND AMAR **NAYEGANDHI**

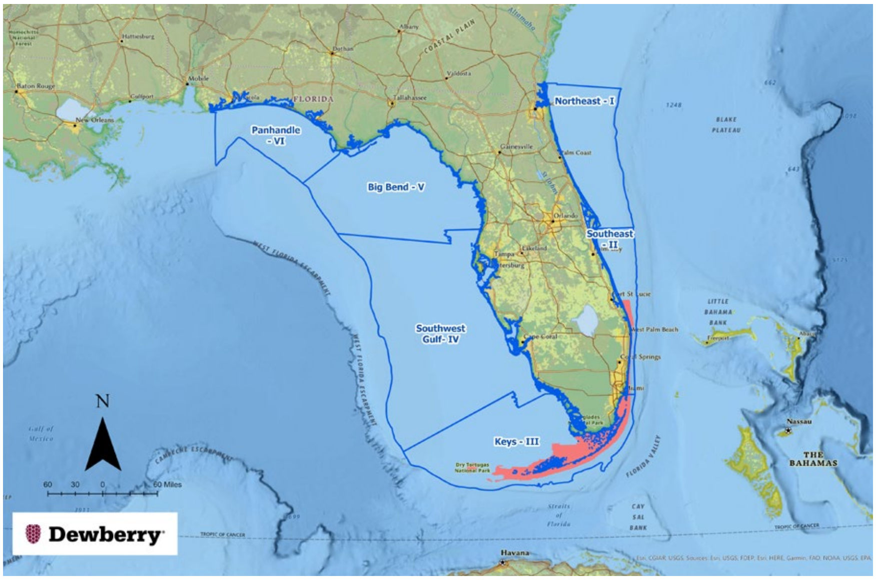


Figure 1: The six regions identified by FCMaP and subsequently adopted by FSMI. Coral reef area shown in pink.

on the coastline, Florida has been placing increased importance on coastal resilience and sustainability. In 2019, the Florida Department of Environmental Protection (FDEP) created the Office of Resilience and Coastal Protection (ORCP)[3] to guide its efforts. FDEP/ORCP has a multi-faceted approach to resilience, including coral reef protection, preservation of coastal and aquatic management areas, beach and inlet management, and the implementation of ecosystem restoration projects to prepare Florida's coastal communities and state-managed lands for the effects of sea level rise, coastal flooding, erosion, and storms.

In 2022, the Florida Legislature allocated $100 million in general revenue funds to FDEP/ORCP for the Florida Seafloor Mapping Initiative (FSMI), to capture statewide topobathymetric lidar to the 20-meter isobath and acoustic/sonar soundings from the 20-meter isobath to the 200-meter isobath. FDEP/ORCP and the Florida Geographic Information Office (FGIO) constructed timelines and published anticipated schedules on respective program webpages. FGIO produced a dashboard[4] to share the collection regions, progress updates, and data processing status.

For many of the reasons indicated above, the Office of Coastal Management (OCM) of the National Oceanic and Atmospheric Administration's (NOAA) has been updating navigation charts and coastal surveys along Florida's coastline. Since 2018, Dewberry has been updating large segments of the coastline and mapping the bathymetry using topobathymetric lidar (**Figure 2**). Some of these efforts preceded FSMI; while some areas of interest coincide with FSMI, and some are being collected simultaneously with and complement the FSMI project. This article discusses the first phase of FSMI, specifically updates to the bathymetry and shoreline mapping along the Gulf Coast of Florida.

3 floridadep.gov/orcp

4 floridagio.gov/pages/FSMI

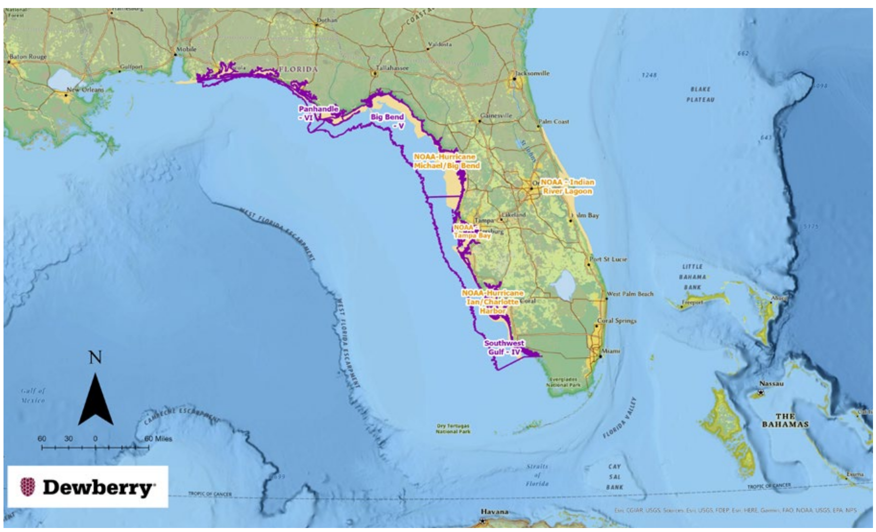


Figure 2: Dewberry/NOAA topobathymetric and shoreline mapping projects in Florida along the Gulf Coast: the panhandle of Florida through the Anclote River (Hurricane Michael/Big Bend); Tampa Bay; the Manatee River outlet through Naples (Hurricane Ian/Charlotte Harbor); and, along the Atlantic Coast, the Indian River Lagoon. Areas in purple are FSMI regions assigned to Dewberry for CZMIL SuperNova mapping.

The FSMI project area

In 2017, the Florida Coastal Mapping Program (FCMaP)[5] designated six regions of Florida as the basis for studying the quality of available bathymetric data. FDEP/ORCP adopted those six regions (**Figure 1**) as the basis for awarding contracts to topobathymetric lidar and multi-beam sonar providers. Each region was identified with a name and a region number, starting in northeastern Florida and proceeding clockwise through the Florida panhandle:

- Northeast-Region I
- Southeast-Region II
- Keys-Region III
- Southwest Gulf-Region IV
- Big Bend-Region V
- Panhandle-Region VI

The project is separated into two phases. Phase one focuses on using topobathymetric lidar to collect bathymetry to the 20-meter isobath. This topobathymetric lidar phase spans approximately 58,000 km^2 as illustrated in **Figure 2**. Phase two will focus on collecting acoustic, multi-beam sonar data for water depths between 20 meters and 200 meters.

Dewberry's role

Dewberry was awarded approximately 25,000 km^2 of the project for topobathymetric lidar mapping, including the entire Gulf Coast of Florida, from Pensacola in the western panhandle south through Naples (**Figure 3**). This includes Southwest Gulf–Region IV, Big Bend–Region V, and Panhandle–Region VI. Dewberry is deploying three CZMIL SuperNova topobathymetric lidar sensors for data collection, which were chosen based on their ability to measure up to 3.5 secchi disk depth through the water and to the 20-meter isobath. The sensors are deployed in gyroscopic mounts in Cessna Caravan airframes operating from bases throughout the project area (**Figure 4**).

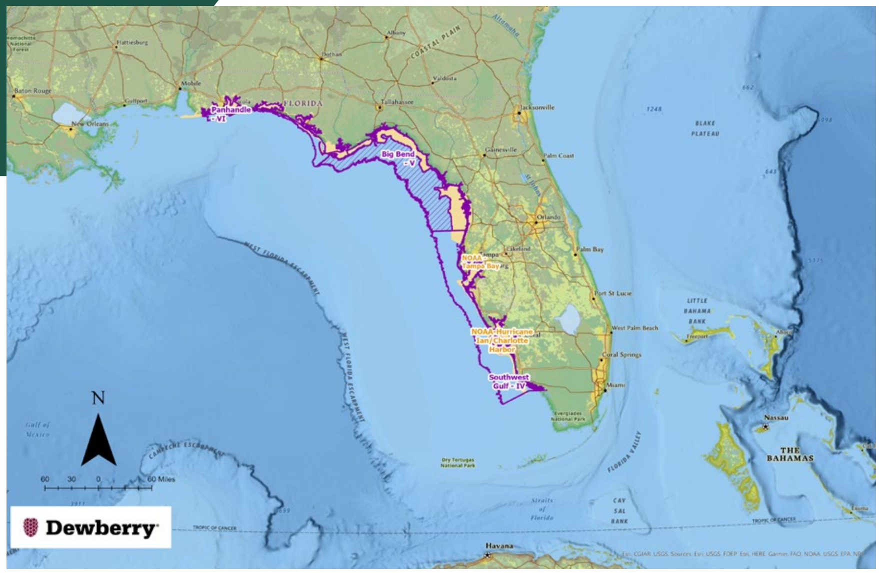


Figure 3: FSMI regions for topobathymetric lidar mapping; water depths to the 20-meter isobath in purple. Dewberry was tasked by NOAA to collect near-shore lidar bathymetry in the Big Bend-Region V area (see tan areas in **Figure 2**) for the NOAA/Hurricane Michael Relief Program. The FSMI area of interest was refined to include only the hatched area.

Current progress

Dewberry started collecting lidar bathymetry in Big Bend–Region V in July 2023 and continued through the end of August 2023, when Hurricane Idalia made landfall in the Big Bend region near Steinhatchee. By late August, Dewberry had collected approximately 31% (~3500 km^2) of the area of interest in Big Bend-Region V

Figure 4: Dewberry's CZMIL SuperNova sensor mounted in a Cessna Caravan. This sensor is housed at the Peter O. Knight Airport in Tampa, Florida.

5 fcmap-myfwc.hub.arcgis.com

(**Figure 5**), and almost 20% (~600 km^2) in Panhandle-Region VI (**Figure 6**). To date, no data has been collected for the Tampa Bay area (West-Region IV).

Preliminary results

Although Dewberry is currently processing and calibrating the initial CZMIL SuperNova data from August 2023, the Teledyne CARIS software provides a "Quicklook" feature that allows visualization of the topobathymetric lidar without expending considerable processing time and expense. **Figure 5** shows the extent of the CZMIL SuperNova data collected prior to Hurricane Idalia for the southern portion of Big Bend-Region V. The preliminary results of the topobathymetric data reveal features and bathymetry extending out to the 20-meter isobath and completely within the near-shore area of interest (**Figures 5 and 7**).

Further investigation of the Quicklook data in the Big Bend area revealed that the CZMIL SuperNova sensor was recording highly detailed bathymetric returns near the 20-meter isobath (**Figure 6**), which led the FDEP/ORCP to modify the task orders to include lidar bathymetry past the 20- meter isobath.

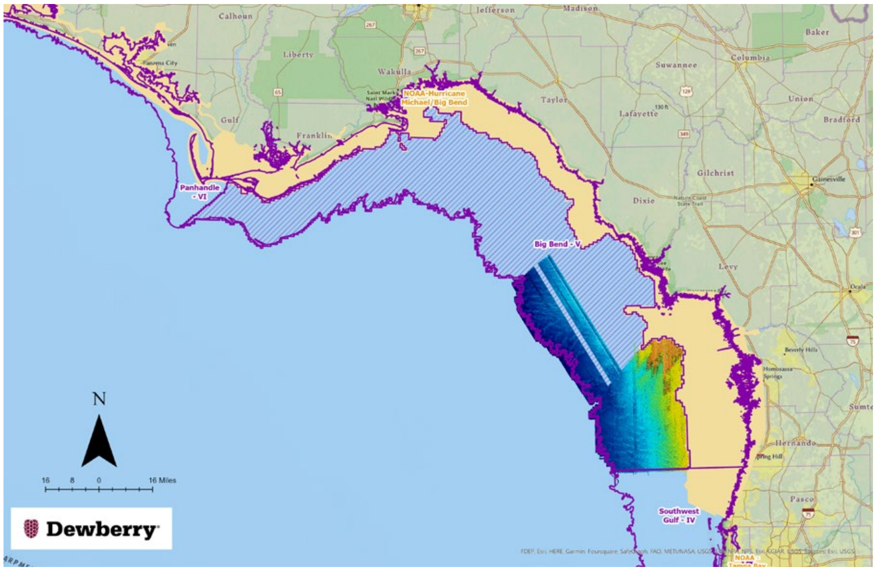


Figure 5: CARIS Quicklook showing CZMIL SuperNova topobathymetric lidar coverage collected prior to Hurricane Idalia, August 2023, in the Big Bend-Region V of the FSMI. Data coverage extends to the 20-meter isobath on the west, and approximately 30% of the Region V area. The tan area was collected for the NOAA/Hurricane Michael Relief Program.

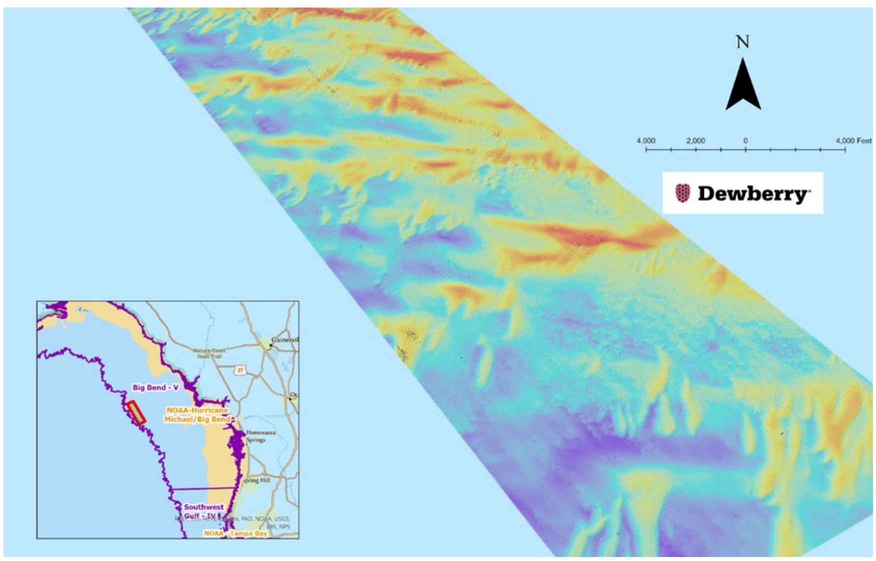


Figure 6: Detailed digital elevation model derived from CZMIL SuperNova returns near the 20-meter isobath in the Big Bend-Region V.

Innovative planning methodology

Planning aerial acquisition missions, and particularly topobathymetric missions in Florida, presents unique challenges. With the flat inland and coastal topography, even low-yield, inland rain events can result in large amounts of particulate runoff into the Gulf of Mexico. Combining the runoff with tannic components, such as those in the Suwannee River system in Big Bend, can result in poor water quality and unfavorable conditions for lidar bathymetry.

To help avoid collecting lidar during sub-optimum water clarity conditions, Dewberry has partnered with TCarta to provide satellite-derived bathymetry (SDB) for 22 selected sites dispersed throughout the regions. TCarta delivers the water clarity estimates daily based on several metrics, including the diffusion coefficient (Kd492), the backscatter coefficient (Bb492), and secchi disk depth (**Figure 8**) to help evaluate the water clarity and interpret current water conditions relative to historic norms. This methodology has helped Dewberry minimize non-productive flights, therefore increasing efficiency and decreasing environmental carbon dioxide loading.

Reference

Florida Department of Environmental Protection, 2023. Florida's Coral Reefs, https://floridadep.gov/rcp/rcp/content/floridas-coral-reefs (accessed 20 October 2023).

Alvan "Al" Karlin, Ph.D. CMS-L, GISP is a senior geospatial scientist at Dewberry, formerly from the Southwest Florida Water Management District (SWFWMD), where he managed all the remote sensing and lidar-related projects in mapping and GIS. With Dewberry, he serves as a consultant on Florida-related lidar, topography, hydrology, and imagery projects, as well as general GIS-related projects. He has a Ph.D. in computational theoretical genetics from Miami University in Ohio. He is a director of the Florida Region of ASPRS, vice president of ASPRS at national level, an ASPRS Certified Mapping Scientist-Lidar, and a GIS Certification Institute Professional.

Emily S. Klipp is a senior project manager with Dewberry and has more than 15 years of experience working with topographic and bathymetric data, vertical and horizontal accuracy assessments, and creation of a variety of digital mapping products using various software platforms. Emily has led topobathymetric and topographic lidar projects for the United States Geological Survey (USGS), NOAA, the US Fish and Wildlife Service, and SWFWMD. She is currently the project manager for the FDEP/FSMI. While at USGS (St. Petersburg, Florida) from 2007 to 2014, she authored more than 35 data series and reports for the USGS and helped manage operations and data production of the NASA/USGS EAARL sensor for the USGS Coastal Program.

Amar Nayegandhi, CP, GISP is a senior vice president with Dewberry. He leads the Geospatial and Technology Services group and provides program oversight for the execution of all remote sensing projects for federal, state, and local clients. As an expert in topographic and topobathymetric lidar data acquisition and processing, Amar was the director of the ASPRS Lidar Division. He co-edited the ASPRS *DEM Users Manual, 3rd Edition*[6] and authored the chapters on airborne topographic lidar and airborne lidar bathymetry. From 2001-2011 he managed operations and was involved in the research and development of the EAARL sensor. In 2011-2012, he developed Dewberry's Lidar Processor (DLP) to process airborne bathymetry data, which included correcting for refraction of the green lidar signal.

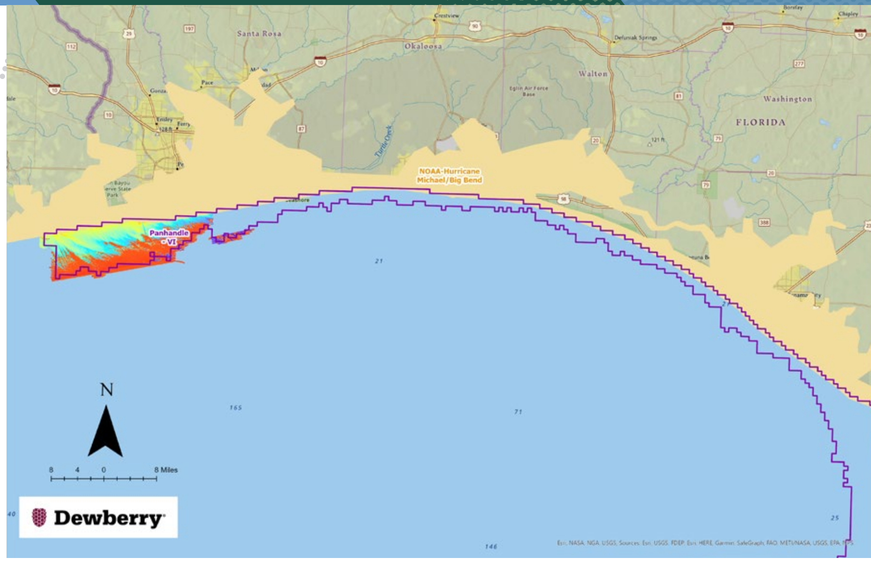
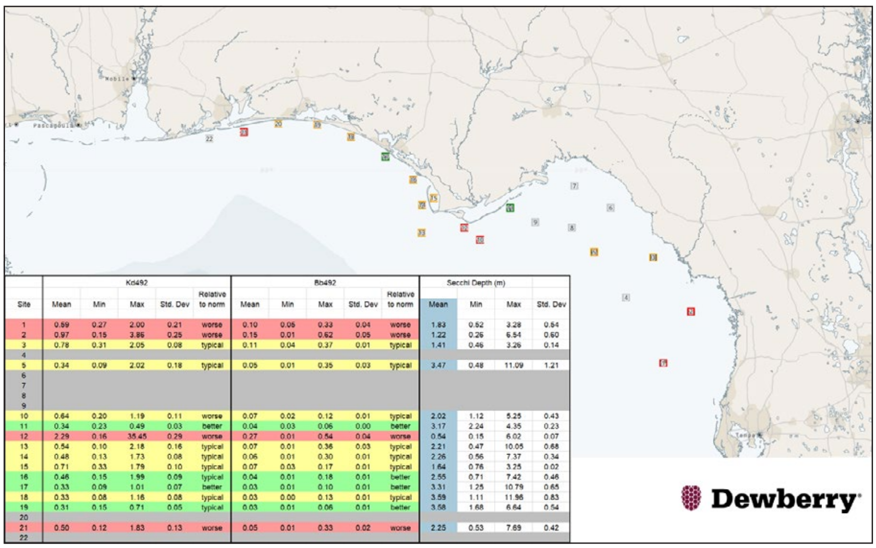


Figure 7: CARIS Quicklook showing CZMIL SuperNova topobathymetric lidar coverage collected prior to Hurricane Idalia, August 2023, in the Panhandle-Region VI. Data coverage extends to the 20-meter isobath on the south, and approximately 18% of the Region VI area. The tan area was collected for the NOAA/Hurricane Michael Relief Program.



	Kd492					Bb492					Secchi Depth (m)			
Site	Mean	Min	Max	Std. Dev	Relative to norm	Mean	Min	Max	Std. Dev	Relative to norm	Mean	Min	Max	Std. Dev
1	0.59	0.27	2.00	0.21	worse	0.10	0.05	0.33	0.04	worse	1.83	0.52	3.28	0.54
2	0.97	0.15	3.86	0.25	worse	0.15	0.01	0.62	0.05	worse	1.22	0.26	6.54	0.60
3	0.78	0.31	2.05	0.08	typical	0.11	0.04	0.37	0.01	typical	1.41	0.46	3.26	0.14
4														
5	0.34	0.09	2.02	0.18	typical	0.05	0.01	0.35	0.03	typical	3.47	0.48	11.09	1.21
6														
7														
8														
9														
10	0.64	0.20	1.19	0.11	worse	0.07	0.02	0.12	0.01	typical	2.02	1.12	5.25	0.43
11	0.34	0.23	0.49	0.03	better	0.04	0.03	0.06	0.00	better	3.17	2.24	4.35	0.23
12	2.29	0.16	35.45	0.29	worse	0.27	0.01	0.54	0.04	worse	0.54	0.15	6.02	0.07
13	0.54	0.10	2.18	0.16	typical	0.07	0.01	0.36	0.03	typical	2.21	0.47	10.05	0.68
14	0.48	0.13	1.73	0.08	typical	0.06	0.01	0.30	0.01	typical	2.26	0.56	7.37	0.34
15	0.71	0.33	1.79	0.10	typical	0.07	0.03	0.17	0.01	typical	1.64	0.76	3.25	0.02
16	0.46	0.15	1.99	0.09	typical	0.04	0.01	0.18	0.01	better	2.55	0.71	7.42	0.46
17	0.33	0.09	1.01	0.07	better	0.03	0.01	0.10	0.01	better	3.31	1.25	10.79	0.65
18	0.33	0.08	1.16	0.08	typical	0.03	0.00	0.13	0.01	typical	3.59	1.11	11.96	0.83
19	0.31	0.15	0.71	0.05	typical	0.03	0.01	0.06	0.01	better	3.58	1.68	6.64	0.54
20														
21	0.50	0.12	1.83	0.13	worse	0.05	0.01	0.33	0.02	worse	2.25	0.53	7.69	0.42
22														

Figure 8: A daily water condition report for 16 October 2023 for 22 locations distributed in the Big Bend and Panhandle Regions, showing three (Kd492, Bb592, and Secchi Depth) metrics. Gray sample locations were clouded over on the date indicated and no data was generated; pink were below normal expected values; yellow, within normal expected values; green, better than normal expected values.

6 Maune, D.F. and A. Nayegandhi (eds.), 2018. *Digital Elevation Model Technologies and Applications: The DEM Users Manual, 3rd Edition*, ASPRS, Bethesda, Maryland, 652 pp.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Multispectral Lidar for Environmental Applications

Finnish Geospatial Research Institute develops systems to explore and analyze critical changes

Lidar typically provides 3D data that facilitates visualization, so that the viewer can interpret geometries and relationships of objects and terrain. Adding color to such data is usually a part of the mapping process that is carried out with photography, either simultaneously or separately to the lidar acquisition. This article explores the prospects for collecting, visualizing and using the color information that is based solely on the lidar instrument—multispectral airborne laser scanning.

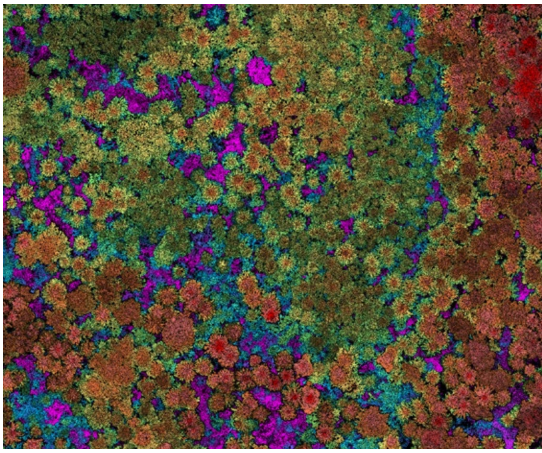


Figure 1: The HeliALS-TW multispectral laser scanning system built at FGI is operated on a helicopter and acquires 3D data with reflectances at 532, 905 and 1550 nm. The system can be fitted with passive cameras, such as Specim AFX10 and AFX17, for comparative and complementary hyperspectral data. The tilted scan plane for the frontal scanners permits records from tree stems and other vertical objects; the VQ-840-G operates with a conical scan pattern, instantiating similar capability.

BY ANTERO KUKKO

Data to address environmental change

There is a need for accurate and timely data for geospatial analysis of anthropogenic and natural phenomena in our changing environment. The vulnerability of forested and water ecosystems to different distresses is escalating due to the warming climate. Other weather-induced mechanisms that lead to ecosystem decline are of concern. Accelerating urbanization and use of natural resources have an impact on the environment and the livability of human settlements. The headlines in our daily news often report disasters arising from a chain-reaction beginning from a drought, or from wind- or snow-induced damages—these often lead to forest fires, plant diseases and pest infestations, such as spruce bark beetle. Excessive rainfall, flooding and erosion is the other group of forces to affect our environment in many ways with destructive power and long-term implications. The Finnish Geospatial

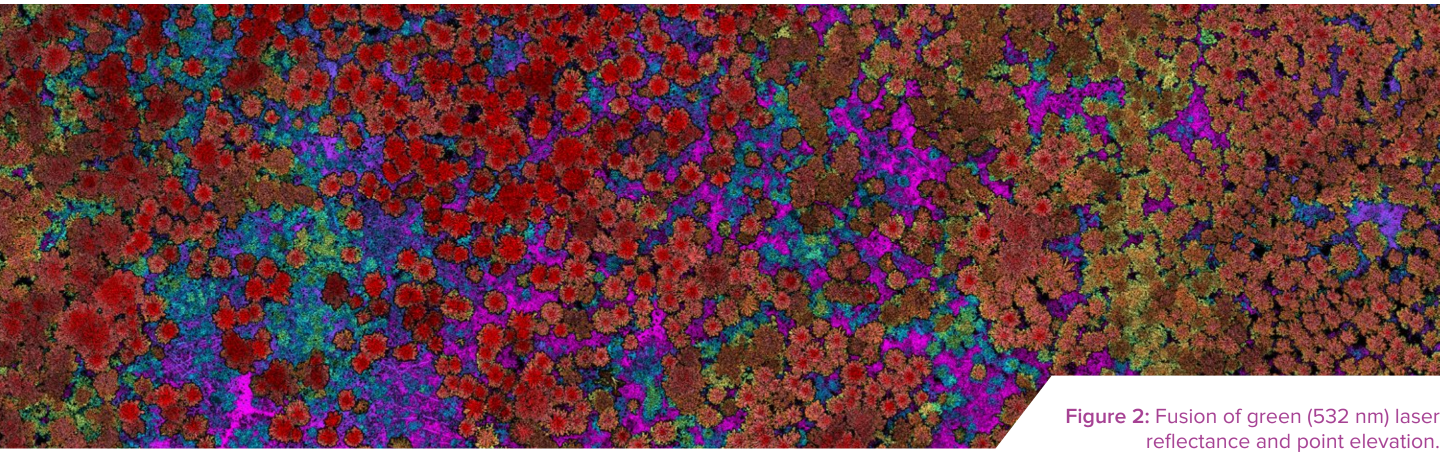


Figure 2: Fusion of green (532 nm) laser reflectance and point elevation.

Research Institute (FGI) is partnering with research, industry and public organizations in Finland, Europe and globally to address these challenges with innovations and novel technologies and approaches. These provide efficient tools and means for assessing our environment and studying mechanisms of decline, recovery and revival to help the urgent actions required to mitigate such challenges.

Multispectral laser scanning

Much is being done at the frontiers of passive remote sensing and UAV applications with the help of artificial intelligence and machine learning to interpret the massive environmental data acquired. However, there is a need for precise assessment of the ground truth, improved performance, and also new capabilities that are sought from the development and use of multispectral laser scanning. This was tried some time ago for a commercial airborne application, but has not yet found its place as an operational mapping tool, mostly due to technical issues and subsequent sparsity in the data products for reliable analysis in the early implementations.

Multispectral laser scanning, or lidar, offers the possibility to overcome certain drawbacks in passive multi- or hyperspectral imaging. With an active approach we can circumvent the effects caused by natural variation in the external light source, the Sun. Instead of calibrating and correcting the data for irregularities in irradiance, due to sun angle (seasonal and diurnal variation) and clouds, we can reduce the problem significantly by using the instrument's own light source—laser. This also reduces the effect of shadowing, since targets that are not illuminated by the beam are also not shown in the data. Consequently, however, the flight pattern needs to be planned so that data gaps are avoided in the target of interest. Active lighting by laser beams also permits color vision in the dark, which is not possible with optical imaging. This feature could have new potential in disaster management and surveillance.

FGI HeliALS-TW triple-wavelength airborne laser scanning system

FGI has built instrumentation for multispectral laser scanning to provide precise 'pseudocolor' 3D data from the air to study technical solutions, limitations and feasibility and to demonstrate new possibilities in operational mapping and monitoring applications (**Figure 1**). The current implementation probes the objects with a triplet of wavelengths, 532, 905 and 1550 nm, using three laser scanners mounted on a single platform. Operational altitudes range from 80 to 400 m above ground. Higher altitudes up to 800m can be achieved in a dual-wavelength setting with 532 and 1550 nm scanners [with inherently sparser point density]. Recorded backscattered echoes are turned into object reflectances (compensated for range and compared to a white perpendicular target at the same distance) that can be used for visualizations and data analysis

Figure 3: Reflectance composition of the multispectral 3D laser scanning data of a bark beetle study site collected with the FGI's HeliALS-TW system shows decayed trees that can be clearly detected from the data by their darker and frayed appearance. The study aims at methods for detecting early infestation and modeling and forecasting the spread, based on the first signs of foliage drying and color change.

with computational methods such as semantic segmentation and machine or deep learning.

Another advantage of the active illumination of the targets is the capability to reconstruct them in 3D. This helps assessing geometric features of the objects of interest, for example, the heights of trees, canopy structure, terrain elevation or artificial objects such as pavements, buildings or cars (**Figure 2**). It also helps in correcting for irregularities in the reflectivity data stemming from the object geometry, or detecting changes in the area, e.g. fraying of foliage indicated by increased penetration, or of a newly built structure. The penetrability of the laser pulses through vegetation allows for analysis of undergrowth and terrain features under the forest canopy, but also enables signal features to characterize the object based on the pulse scattering data, e.g. spatial echo distribution, pulse deviation and echo type.

Applications

Precise multispectral 3D point-cloud data, usually hundreds or thousands of points per square meter, allows individual tree segmentation, species classification and estimation of timber/stem quality and growth-related parameters to assess, for example, the effects of forest management. In addition to the capture of dominant trees is the capability to detect trees in the subdominant layer as well as the undergrowth better than ever before. Precise data also allows quality-related assessments, for example, stem curve and branch size distribution, or canopy damage (due to wind, snow, ice)—all parameters with an impact on forest resource management.

In an ongoing research project the group is developing methods to find indicators of the detection of spruce bark beetle infestation in the early stages of swarming of the new generation of pests, in so-called green attack phase. Severely frayed and dead trees are easier to detect and they provide an indicator of the spread of the infestation over multitemporal data to permit analysis of the effect of the forest structure and other spatial variables such as species distribution, forest density and prevailing wind conditions (**Figure 3**).

Figure 4: Reflectance composition of multispectral lidar point cloud data to study urban mapping and vegetation: 532, 905 and 1550 nm.

Urban environment and autonomous driving

Multispectral laser scanning from the air also provides new capabilities for assessing urban space and vegetation (**Figure 4**). Better data and analysis tools help manage the urban environment, land use and deployment of resources. Detailed data is explored to help automated mapping and data classification using machine and deep learning techniques to bring order and structure into the point-cloud data. In addition to urban vegetation, the data and computational technologies allow us to pursue new approaches towards maps specialized for autonomous driving use, and also for improved road asset management and urban planning.

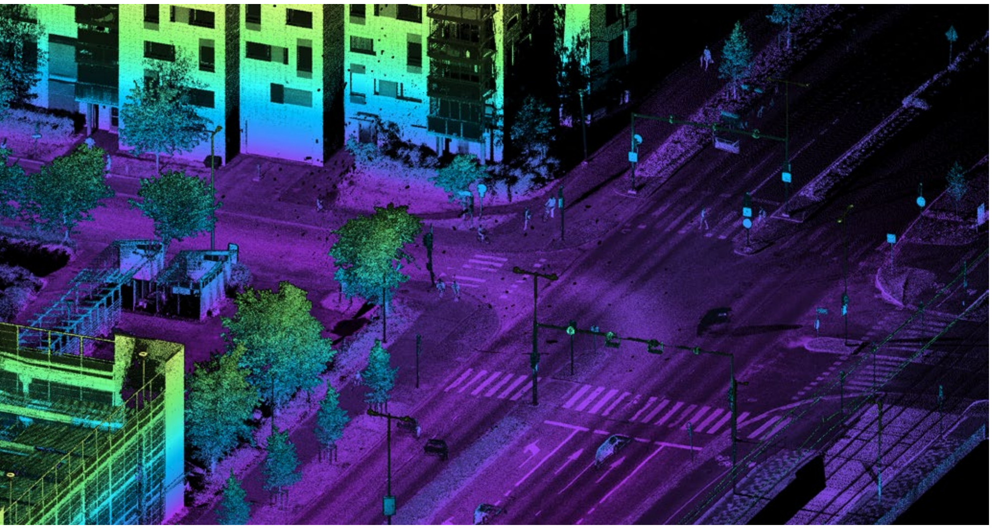


Figure 5: A street scene acquired with a two-wavelength MLS system that collects precise street and urban asset data. Reflectance data can contain valuable information for automated detection and processing. This visualization is based on fusion of the point elevation and reflectivity.

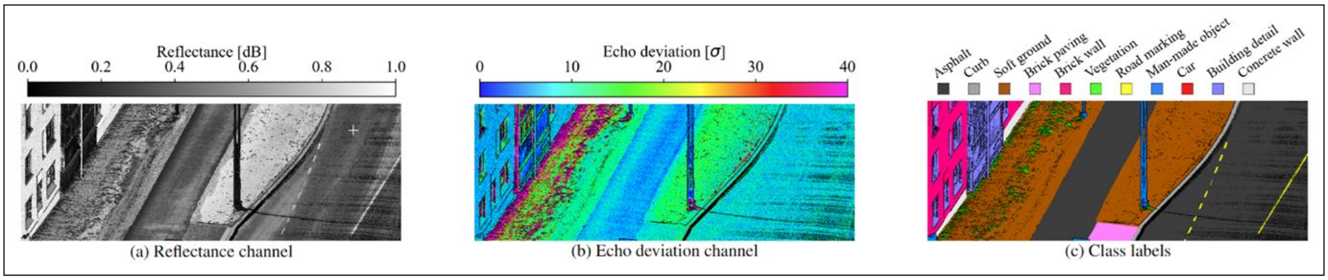


Figure 6: Training of a deep learning neural network to detect objects and materials from the dual-wavelength MLS data.
Image courtesy of Mikael Reichler, FGI, 2023.

The multispectral approach is also being developed and investigated for mobile laser scanning (MLS) on the ground. At present, however, the system uses only 905 and 1550 nm lasers (**Figure 5**). Through fusion of 3D structure, multispectral reflectance and signal echo deviation information, one can, for example, infer building and road materials and pavement defects using unsupervised and supervised learning techniques (**Figure 6**). In a forest setting, using a backpack application, there is a new method to separate terrain, tree stem, branches and foliage based on a single-profile scanner data within a deep-learning pipeline providing high reliability and computational speed. These developments provide solid steps towards real-time data

analysis, whether the data is acquired by an airborne or ground system.

Freshwater research

Arctic environments are experiencing drastic changes. Melting of permafrost increases the instability of the ground, increasing erosion and eventually loosening sediments into the arctic rivers. This has a direct impact on the fishery and river habitats in these systems. Another risk is posed by erosion of toxic sediments from mining and industrial activity caused by increased discharges in rivers close to human populations. Moreover, increasing winter rainfall and flooding as a result of oscillating temperatures during winters is expected to emphasize the effects.

Sediment transportation is also related to bed sediment roughness and vegetation. Multispectral laser scanning, along with imagery, is being investigated to develop tools to detect and monitor the geomorphological and biospheric features and indicators to model fluvial and other freshwater environments and processes. Multispectral laser scanning with the 532 nm wavelength generates bathymetry that allows us to reconstruct the complete river channel morphologies (**Figure 7**). Multispectral composition 3D data of the vegetation, point bars and other landforms provides the capability to monitor changes and evolution over time with repeated aerial or ground surveys (**Figure 8**).

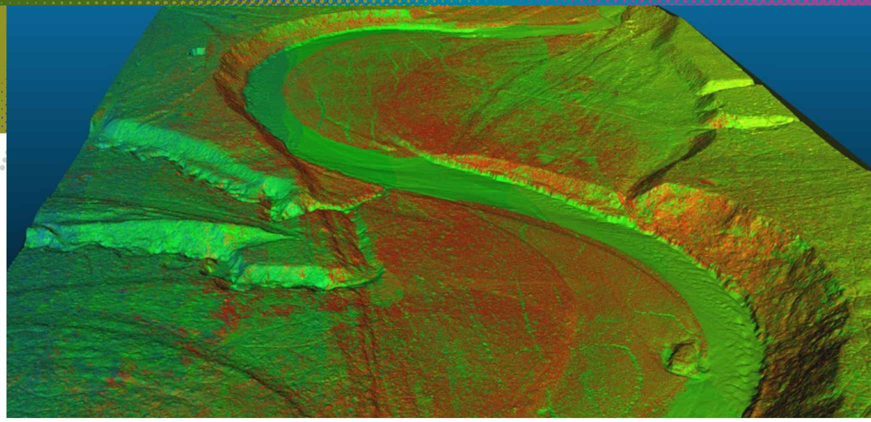


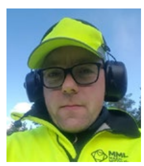
Figure 7: Shaded-relief terrain and river-bed model provides a basis for monitoring the evolution of arctic rivers and habitats critical for arctic fisheries and other species. Multispectral laser scanning provides data to monitor the changes in the environment comprehensively.

Image courtesy of Harri Kaartinen, FGI, 2022..

The effects are investigated and the feasibility of new technologies to provide data for them are explored within the Fresh Water Competence Centre and Digital Waters Flagship (DIWA), where FGI is a partner providing capabilities, expertise and innovations in laser scanning for the wider community to tackle these challenges.

Summary

The Autonomous Mapping and Driving research group in the Finnish Geospatial Research Institute conducts geospatial research by developing integrated sensor systems, data acquisition, and data processing for a wide range of applications. Dense multispectral 3D data permits development of computational methods to analyze and monitor the environment, and build map products for current and future needs. The green laser of the wavelength triplet also allows bathymetric data from water bodies. By exploring possibilities, performance and solutions provided by precise multispectral lidar point clouds, we can meet the needs for improved data and automated analysis for the benefit of society and advance the deployment of novel mapping technologies and computational methods to operational use.



Antero Kukko, DSc is a research professor at the Finnish Geospatial Research Institute (part of the National Land Survey of Finland) and leads the Autonomous Mapping and Driving research group. His research interests include integrated mobile, UAV and airborne laser scanning systems, positioning, autonomous systems, and applications and computational methods using multi- and hyperspectral lidar for geospatial research, mapping, forestry and geomorphology.

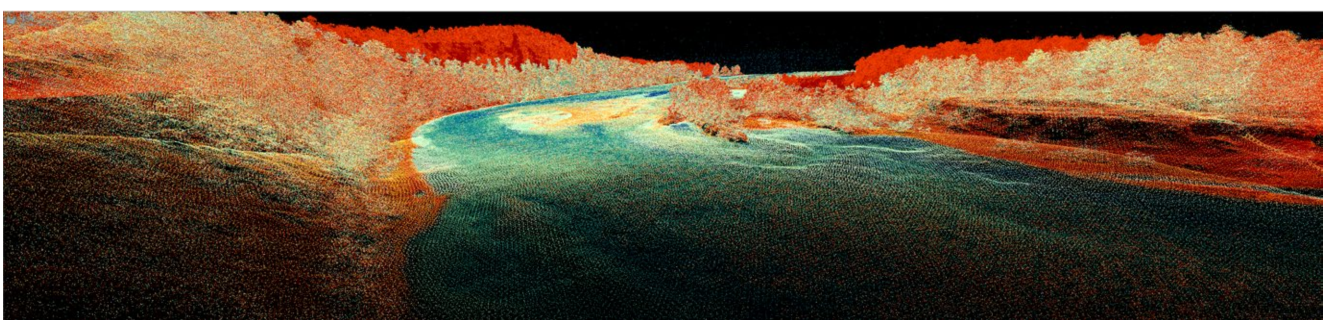
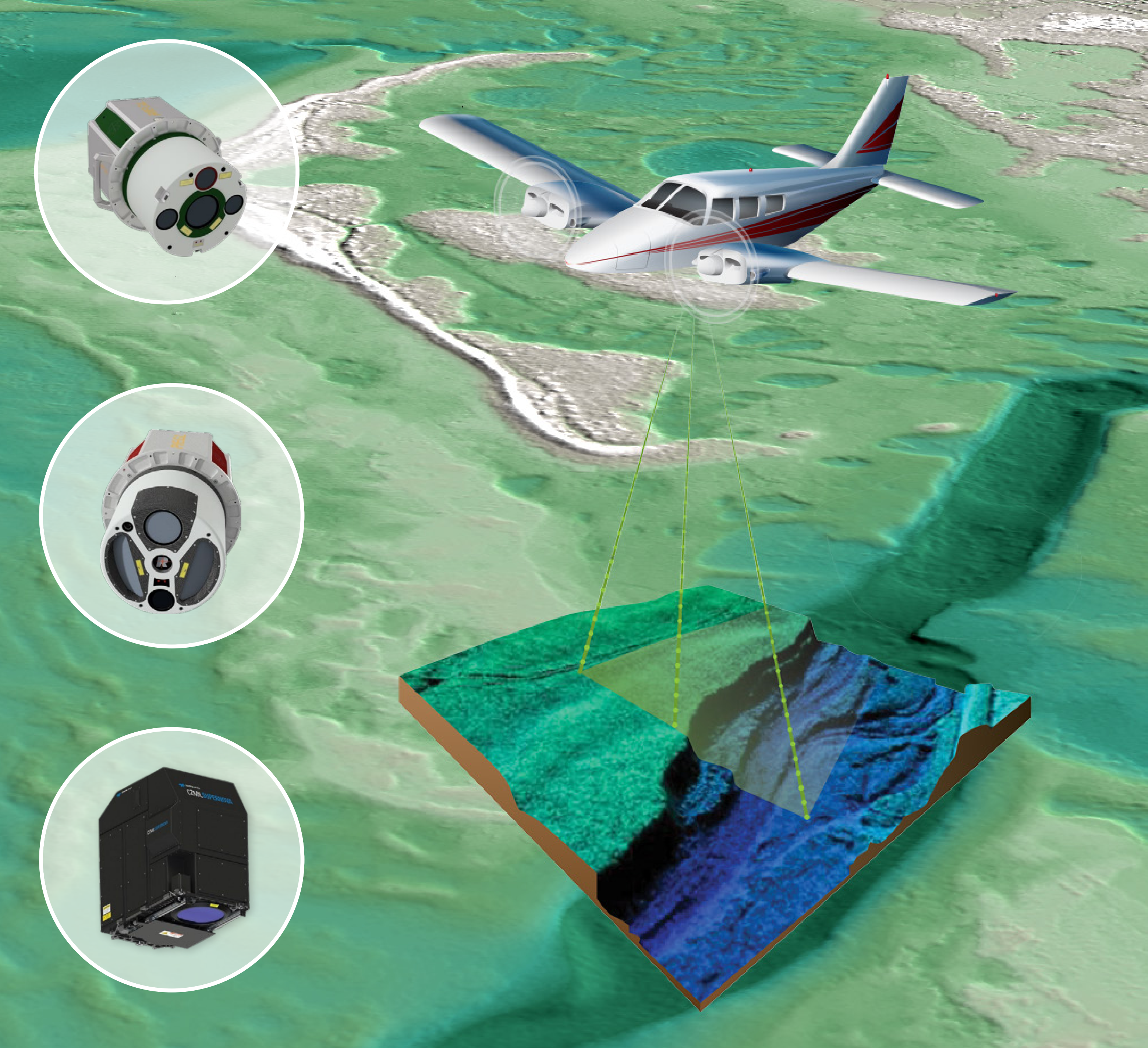


Figure 8: This cross-section of the multispectral laser scanning data from the Utsjoki river in Finland shows the river banks, surface of the water, rocks breaking the surface and bed topography down to a depth of 3 m.



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UAV-Lidar Improves Landmine Clearance Planning

Lidar technology facilitates vital humanitarian efforts

BY GERT **RIEMERSMA**, KATHERINE **JAMES** AND PEDRO **PACHECO**

Figure 1: Clearance operations in Cuando Cubango, Angola.

Casualties from landmines and explosive remnants of war have been worryingly high for the past seven years. This trend is mainly the result of increased conflict and contamination by improvised mines observed since 2015. Lamentably, most of the victims recorded were civilians and half of these were children.

As efforts continue to clear mine-contaminated land, much remains to be done. The HALO Trust, a British mine-clearance charity, has been trialling drone remote sensing, including thermal infrared (TIR) and RGB cameras, to support the identification of unexploded ordnance (UXO) in Angola. Unfortunately, many contaminated sites are overgrown with vegetation: thus the UXO and features of conflict, such as trenches, bunkers or craters which suggest the presence of UXO, are no longer visible from the ground or the air using UAV-mounted RGB or TIR sensors.

The HALO Trust partnered with Routescene, an established UAV-lidar system and software supplier, to demonstrate the benefits of UAV-lidar to detect and map minefield features to inform clearance planning. UAV-lidar's ability to penetrate vegetation enabled the survey team to map trench extents, bunkers and craters to predict where a mine line may be located (**Figure 1**). The results made clearance efforts safer and expedited a targeted approach to them.

The project was undertaken over three years, starting with a feasibility study in Scotland in 2020 before moving to Angola in 2021. To the authors' knowledge, this is the first time that UAV-lidar has been used to identify battlefield features in Angola to aid clearance efforts.

Feasibility study in Scotland in 2020

Routescene and The HALO Trust are both headquartered in Scotland and the teams performed a test drone survey

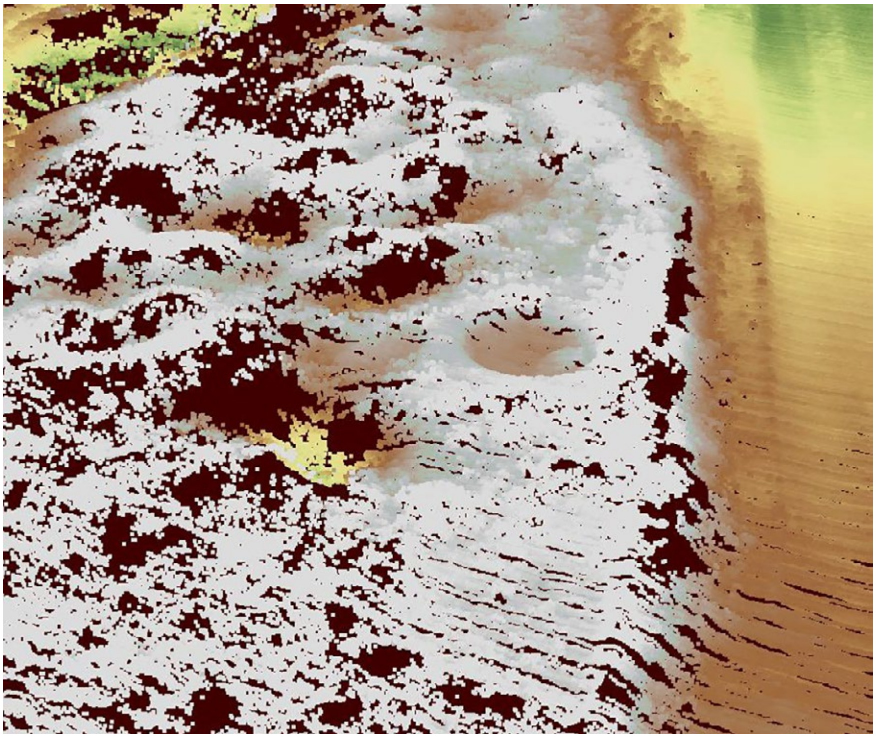

Figure 2: Point cloud stripped of vegetation showing the simulated mine crater.

Figure 3: Map showing the location of Cuando Cubango, Angola.

locally by simulating a mine crater at a suitably vegetated site. The UAV-lidar data captured was post-processed using LidarViewer Pro, Routescene's proprietary lidar-processing software. The replica mine crater was easily identified in the digital terrain model (DTM) created (**Figure 2**), validating that UAV-lidar would be capable of locating and mapping battlefield remains in Angola.

UAV surveys in Angola

Three sites in Cuito Cuanavale, in the province of Cuando Cubango, Angola (**Figure 3**) were specifically chosen for the project as each had known or suspected battlefield features, of which main trenches, communication trenches, foxholes (one-man defensive positions), shell scrapes (shallow excavations allowing soldiers to shield from shell bursts and small arms fire) and craters from detonations were expected to be detected.

The Angolan civil war was fought from 1975 until 2002 and Cuando Cubango experienced some of the heaviest fighting. The Battle of Cuito Cuanavale was the largest conflict of the war.

Throughout the conflict there was extensive mine-laying by both sides. Many of the minefield sites are 20-30 km long, including mixed threat mine belts of Anti-Vehicle (AV) and Anti-Personnel (AP) mines, which still pose a deadly threat to the local community (**Figure 4**).

Data collection

The terrain across the three chosen sites was similar in terms of elevation, all being relatively flat, however the degree of vegetation coverage varied considerably: Sites A and C had dense tree coverage whereas Site B had light coverage.

At Sites A and B lidar data was collected from 40 m above ground level (AGL) with one day of collection for each site. At Site C data was collected at 50 m AGL over three days. Due to the size of the area and time limitations the data was collected at a higher altitude than at Sites A and B.

Sites A and B were surveyed during the dry season (August 2021) when vegetation cover was at its lowest. Site C was surveyed during the rainy season (April 2022) when vegetation cover was at its highest.

Figure 4: Evidence of mine threat to the local community in Cuito Cuanavale.

Due to a lack of safe access only a partial UAV-lidar survey was completed at Site A.

Equipment and software

Routescene constructed a demonstration UAV Lidar System for this project containing a 16-channel lidar sensor, capable of collecting approximately 600,000 points per second, a GNSS/INS sensor and data storage to capture 12 hours of data. Designed to be resistant to vibrations in flight and handling by users, the system does not require mobile or internet connection to operate, providing operational autonomy and data security. GNSS data was collected for the post-processing of the trajectory to ensure the data was as accurate as possible.

The UAV Lidar System was mounted onto a hexacopter capable of lifting a 5-kg payload for approximately 15 minutes (**Figure 5**).

The raw lidar datasets were processed using Routescene's LidarViewer Pro software to create and export DTMs from each of the sites for analysis in ArcGIS Pro. In areas where there were large gaps in the mine lines or a sharp change in direction, the UAV-lidar data was analysed to identify the locations of craters from mine detonations, often caused by animal accidents and wildfires, to inform the location of the mine line.

Site A results

Site A was an abandoned military base outside of Longa village, 100 km northwest of Cuito Cuanavale. Satellite imagery showed little evidence of the historical military base: an access path was visible but it was not possible to identify other features. When it was overlaid with the UAV-lidar data, however, multiple features became apparent (**Figure 6**):

- The defensive main trench around the former base was the predominant feature and 496 m of main trench was identified.
- A communication trench branches off the northwestern internal side of the main trench; 40 m of communication trenches were identified.
- 10 foxholes follow the inside of the main trench dug as defensive positions.
- 9 crater-like features clustered inside the base with two further north near the communication trench are suspected shell scrapes.
- A line of 6 crater-like features outside the main trench, which are unlikely to be AV mines as none were found at this location, so these may be shell scrapes.

Figure 5: Routescene UAV-lidar system mounted underneath a DJI M600 Pro in Angola.

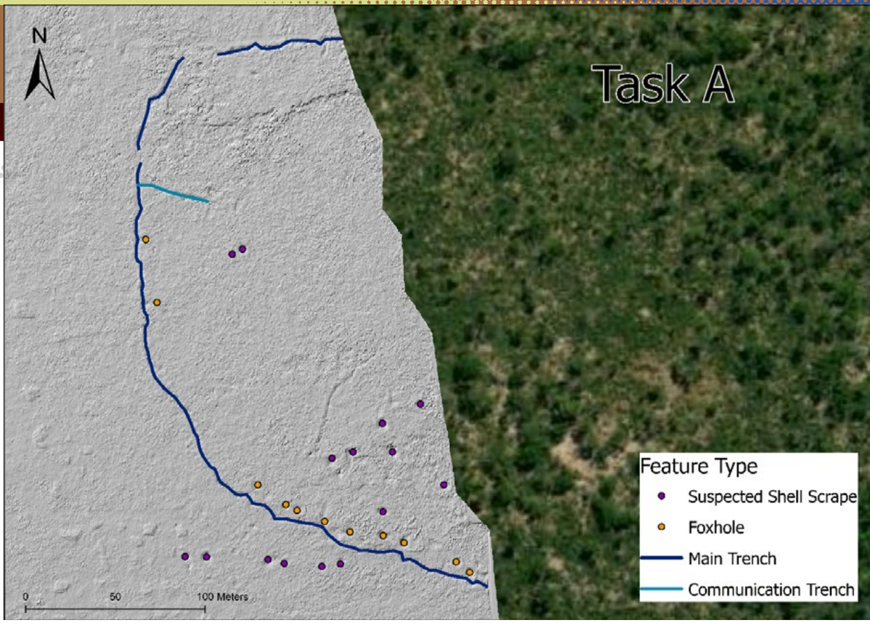

Figure 6: DTM showing the predominant battlefield feature types at Site A. Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA Farm Service Agency, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

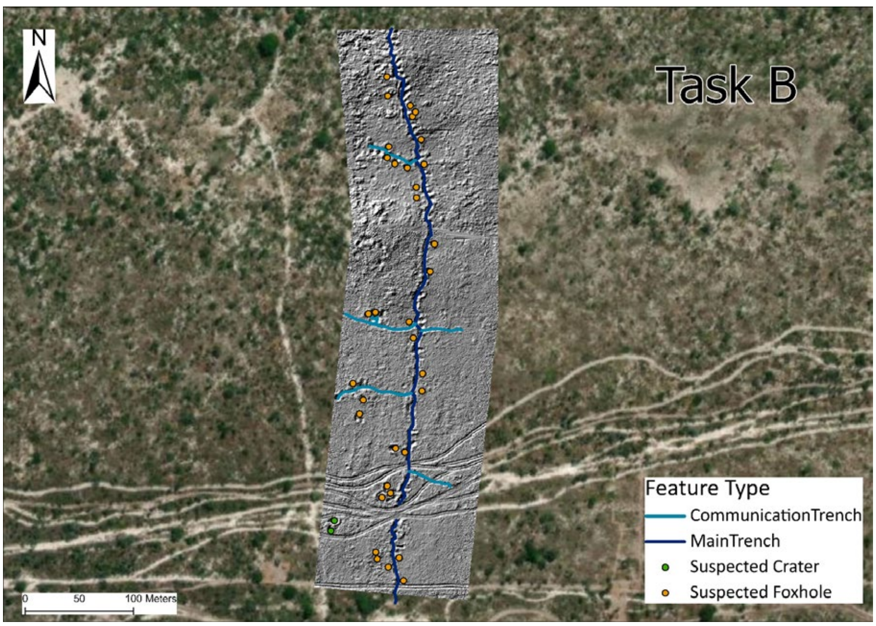

Figure 7: DTM showing the predominant battlefield feature types at Site B. Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA Farm Service Agency, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

The average depth and width of the foxholes (0.58 m and 2.36 m respectively) and the suspected shell scrapes (0.77 m and 2.38 m respectively) were similar, suggesting that these are the same feature. However, due to the suspected shell scrapes not being in the typical location and pattern of foxholes, they were identified as a separate feature.

Where accessibility and vegetation coverage allowed, the feature types were confirmed with a ground mission.

Site B results

Site B was an extensive defensive mine line with an associated trench, 9 km east of Cuito Cuanavale. Due to the lighter vegetation coverage at Site B, there was slight evidence of the main trench remains in the satellite imagery and tracks were clear to see, though other features were not visible. Again, when the UAV-lidar data was overlaid, analysis identified multiple features (**Figure 7**):

- A larger extent of the main trench, in total 500 m.
- 281 m of communication trenches.
- 34 foxholes, which averaged 0.67 m in depth and 2.54 m in width.
- 2 suspected craters, which averaged 5.85 m in width and 0.65 m in depth. Possibly from exploded ordnance but unlikely to be from AV mines, these features were in an uncleared area, so it was not possible to confirm their exact nature.
- The UAV-lidar data revealed additional historical tracks and this information was used to identify locations of possible safe access roads to the site.

Due to thick vegetation and lack of safe access at this site, it was difficult to see what remained of the trench system during field visits.

Site C results

Site C, an abandoned military base, 25 km southeast of Cuito Cuanavale, showed evidence of AP mine laying within the previous military base and was suspected to have at least a single trench and multiple foxholes. From satellite imagery and from the ground it was not possible to identify the locations of the suspected battlefield features due to the dense vegetation. The UAV-lidar data showed evidence of (**Figure 8**):

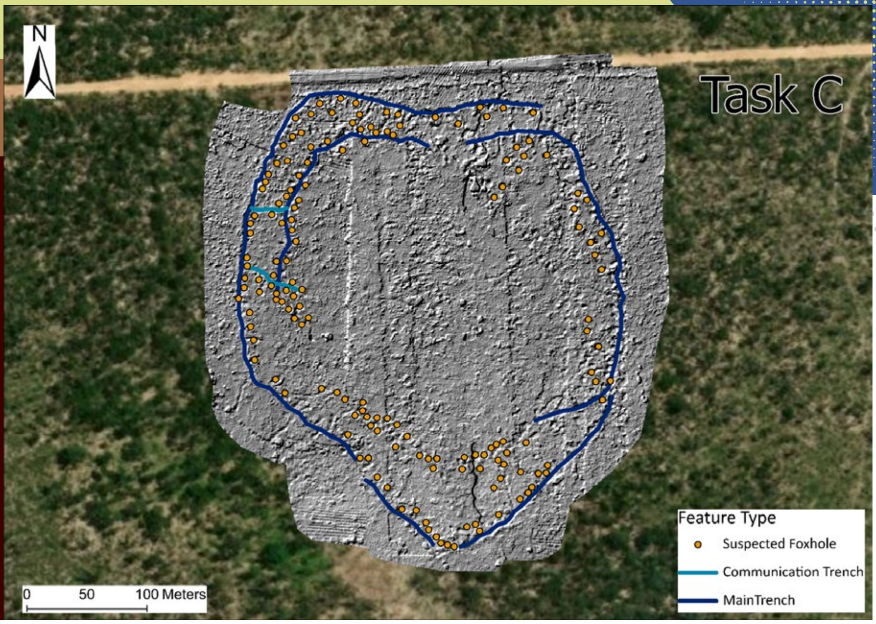

Figure 8: DTM showing the predominant battlefield feature types at Site C. Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA Farm Service Agency, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

- 2 trench systems surrounding the former base as well as communication trenches.
- 157 crater-like features which follow both trench lines, believed to be foxholes due to their regular spacing in close proximity to the trench lines.

The data highlighted gaps in the trench systems which could be explained by the infill of soil over time levelling out the ground within the trench or rain-water lying in the trench preventing the lidar pulses from reaching the bottom.

Although the trench data was incomplete, the continuation of foxholes between the two extents of the inner trench suggests that the trench once continued to create a circular inner trench system. Overall, 1429 m of main trench (828 m on the outer trench and 601 m of inner trench), 73 m of communication trench and 157 foxholes were identified at this site. The foxholes averaged 0.80 m in depth and 2.81 m in width.

The outcome

This pioneering work demonstrated that UAV-lidar data provides evidence that is not obtainable by other means, particularly when looking for battlefield features hidden by vegetation. The analysis of the DTMs created from the UAV-lidar data yielded evidence of trenches, craters and foxholes at all the sites surveyed: features which were either not detectable or only partially visible in satellite imagery, UAV RGB and TIR imagery or from the ground. This evidence was used to create targeted clearance plans, making clearance efforts safer and quicker.

Remote sensing is complementary to conventional minefield survey techniques. Within The HALO Trust's mine clearance operations in Angola, the UAV-lidar data outputs, combined with contextual knowledge on the ground, provided valuable information to supplement conventional survey operations and to target future surveys and clearance operations.

Acknowledgements from The HALO Trust

Thanks to an anonymous private donor for their extremely generous support for the UAV trials in Angola and their commitment to innovation in mine action—this project would not have been possible without their help; to Routescene for providing the UAV-lidar system, software, training and ongoing support since 2020; to Claire Lovelace and Siân McGee from The HALO Trust Angola program for their ongoing support in the field and during data analysis.

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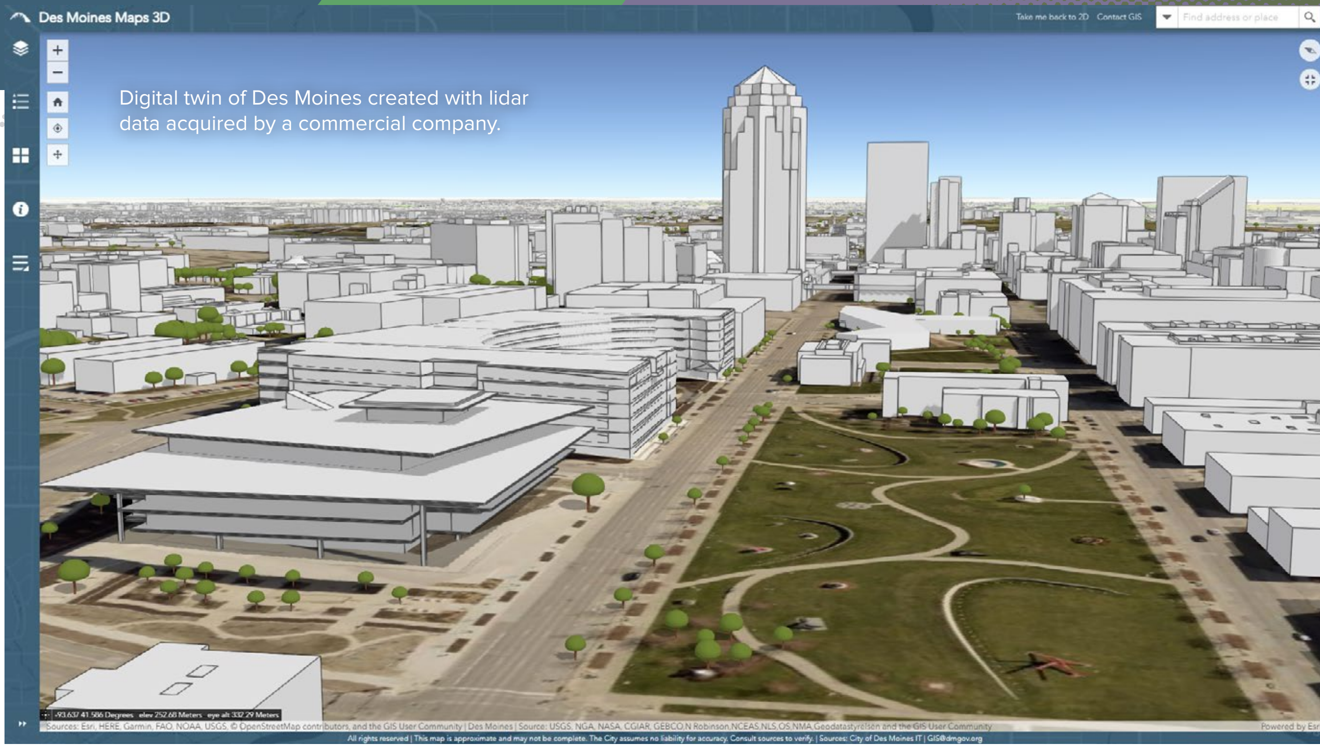


Digital twin of Des Moines created with lidar data acquired by a commercial company.

3D Gives Planners in Des Moines Clarity to Manage Economic Development Growth

Digital twin helps design new neighborhood without spoiling ballpark views

BY CHRISTINE MA

Principal Park is a great place to view the historic past of Des Moines. As the homefield for the Iowa Cubs, the city's Triple-A Minor League Baseball team, the stadium affords a picturesque view of the Iowa State Capitol, beyond center field. Iowans are justifiably proud of their statehouse. The building, constructed in a Renaissance style and topped by a gold dome, is a fixture on lists[1] of the nation's most beautiful state capitols.

But what about the future of Des Moines? Until recently, it seemed like a proposed reinvigoration of a neighborhood on the far riverbank could threaten that ballpark view. Using a cutting-edge geographic tool, city officials found a way to green-light the project while preserving the view.

The capability for such spatial analysis is arriving at a crucial time as shifting demographic patterns and spiraling living costs on the coasts and Sun Belt are resulting in a resurgence of interest in the Midwest. The population of the Des Moines region increased by 15 percent[2]

1 thrillist.com/travel/nation/most-magnificent-state-capitols-harrisburg-des-moines-richmond-silloway-clerisseau

2 businessrecord.com/Content/Economic-Development/Economic-Development/Article/Greater-Des-Moines-is-fastest-growing-Midwest-metro-/181/975/86388

between 2010 and 2018, making it the Midwest's fastest-growing metro area. In 2014, *The Atlantic* declared moving to Des Moines "the most hipster thing possible[3]."

A new neighborhood vision

In past eras, this might have been a boon to Des Moines suburbs. Today, more people want an urban experience. What better way to provide that than by reinvigorating a well-preserved but neglected reminder of the city's bygone urbanity? Enter the revitalization of Des Moines's East Village, which stretches from the statehouse to the riverbank, a longstanding project just waiting to be revived.

"You could tell that the neighborhood had that cool, urban vibe that a lot of people seek out," said Ryan Moffatt, City of Des Moines economic development coordinator. "It was the next natural path of urban development. It's adjacent to downtown, it's on the city's waterfront, and it's near a recreational trail system. Plus, it's got a great view of the downtown skyline."

The southern part of the neighborhood also lies between the statehouse and Principal Park, which raised the specter of blocked views from the ballpark. In 2017, the city began to take a closer look at a 2002 City Council agreement that capped building heights at 75 feet. A vision to expand the East Village as a "walkable, dense mixed-use neighborhood began to emerge," said Michael Ludwig, deputy director of Des Moines's development services department, "with green architecture and a focus on sustainability."

JSC Properties, a local developer, floated a proposal to create that neighborhood, transforming 40 acres of the East Village into what would be called the Market District. The plans were embryonic, but they would almost certainly include buildings that rose above 75 feet.

JSC estimated that the total cost of developing the Market District would be around $750 million. That figure—about 10 times as much (in inflation-adjusted dollars) as the cost of the capitol's construction in the 19th century—represented a huge investment in the city's future, but was it worth besmirching the fans' vision of Des Moines's shining beacon on a hill?

The true view

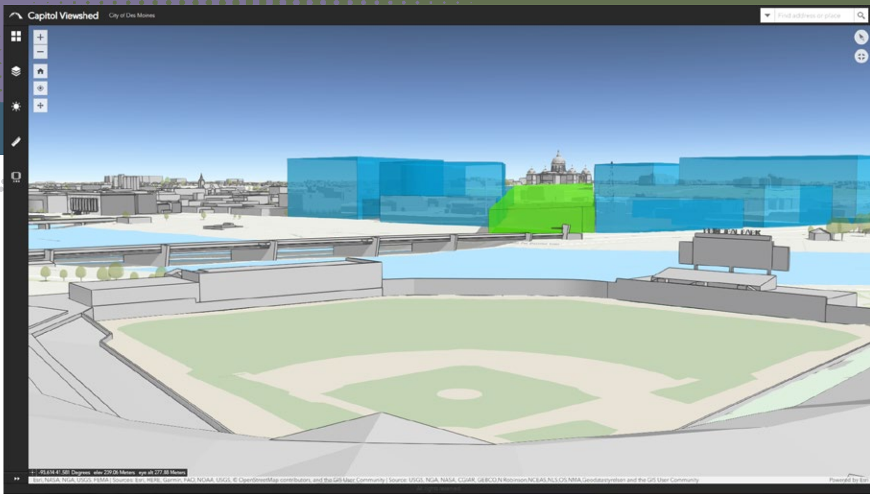
The situation was not necessarily intractable. Although the 75-foot rule was legally binding, it was merely the best guess at the time by planners who did not have the benefit of today's technology for urban planning and economic development.

More specifically, modern geographic information system (GIS) software with reality capture, imagery analysis, and advanced visualization, offered a way forward.

"The developers were talking about space, but they couldn't visualize it," said Aaron Greiner, City of Des Moines GIS manager. The city was considering

3 theatlantic.com/politics/archive/2014/10/do-the-most-hipster-thing-possible-move-to-des-moines/431382/

The view from the capitol to downtown is north of view corridor between the capitol and home plate.



Using the 3D model, planners were able to pinpoint the area that needed lower height restrictions in order to preserve the view of the capitol from home plate.

hiring a consultancy, but Greiner proposed a different option.

For $20,000—a fraction of the cost of using outside consultants—the city could hire an aerial imagery company to fly over the area and take lidar readings. Greiner's office could then use the lidar data and GIS software to build a 3D basemap.

Greiner was describing the creation of a "digital twin," a virtual representation of the processes, relationships, and behaviors of a real-world system. The concept originated in manufacturing to keep detailed records of factories and assembly lines. More recently, digital twins have been used to analyze geographies in real time.

For city planners, a digital twin functions as an authoritative crystal ball. The idea is not to create a record of the way things are (or were), but of how they might be if certain changes are made.

Digital Des Moines

Erik Brawner, a GIS analyst for the City of Des Moines, recently demonstrated how the digital twin has helped make the Market District possible. After calling up the 3D map on a monitor, he "flew" into Principal Park, showing the perspective from just behind home plate, the spot where a catcher crouches. Out in the distance, the statehouse was visible on the hill.

Brawner pointed out green shading that extended beyond the stadium. "That's the original viewshed, defined by the original 75-foot rule," he said.

On the fringes of the green were some blue areas. "That's the rest of the development area the developer is proposing," he explained. "So the digital twin is showing the height that buildings could go up to and not create too much of a tunneling effect on the view."

Working with the digital twin, JSC could collaborate with planners like Ludwig, introducing models of proposed buildings and seeing the visual effect they would have.

"This has blown his mind," Greiner said of Ludwig, "because in the past, they'd go out and do hand measurements, then put it on graph paper and scale up. They'd spend weeks, if not months, doing calculations." Now, he said, it was merely a matter of dropping building models into the digital twin and observing how they impact the view.

The Market District and beyond

Last year, JSC and the city used the digital twin to conduct an extensive viewshed analysis, discovering that some buildings could indeed extend above 75 feet without obstructing the view. Using the findings, the city approved[4] a new ordinance in January that codified how the Market District could proceed.

While the other viewsheds have not yet been tested, Ludwig explained, Principal Park offered an important proof of concept. "This was the big one," he said. "Balancing the desire any city council would have for $750 million in development with the desire to protect aesthetics and the view of the capitol building, this has been an extremely valuable tool," he added. "If we didn't have it, they would've probably said, 'Forget

4 dsm.city/news_detail_T2_R321.php

In this view of the Des Moines digital twin, just the restricted height area is highlighted.

The Iowa Women of Achievement Bridge provides one of the more striking views of the capitol.

about that 20-year-old agreement—we can't pass this up.' What this really helped us do was find a happy medium."

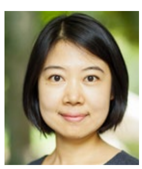
The tool is poised to help Des Moines manage its growth—especially as more people realize that, with remote work increasingly the norm in the post-pandemic world[5], they can work from anywhere. As the Market District evolves with these new arrivals, the 3D basemap that began as a way to preserve a ballpark view will help facilitate the overall development and design.

"When the individual projects come into the area, they'll give us their building plans in whatever form they have," Ludwig explained. "We can plug them into the model and see whether they're projecting through the zoning restriction ceiling, and quickly evaluate them."

The GIS office plans to make the digital twin available to other city offices. As more data increases the complexity of the tool, these managers will find new uses for it that enhance overall understanding of the area.

"Just this week, I got an email from the parks department, asking if they can use it for shadow modeling, because they're interested in finding a place for a community garden that would have adequate sunlight," Greiner said. "We haven't quite tackled that one yet, but we will."

Learn more about how planners use GIS for urban and community planning[6] initiatives and economic development[7]. This article originally appeared on Esri Blog[8].



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5 wsj.com/articles/the-breakout-cities-on-the-forefront-of-americas-economic-recovery-11620584178

6 esri.com/en-us/industries/urban-community-planning/overview

7 esri.com/en-us/industries/needs/economic-development

8 esri.com/about/newsroom/blog/

TAKE A BITE OUT OF BLIGHT

The East Village isn't the only part of Des Moines experiencing a renewal. Across the city, neighborhoods are undergoing a transformation as new arrivals pour into the city.

Two years ago, the city launched its Blitz On Blight program to identify properties that contain buildings declared to be a public nuisance. These are structures that have fallen into disrepair, and whose owners have been ordered to make certain improvements. If they fail to do so, and cannot work out a rehab agreement with the city, the buildings are demolished.

The issue of blight is often politically charged. City officials can be put on the defensive when residents ask them why certain properties are considered blighted.

To promote transparency, the Des Moines program includes an interactive data dashboard and map1 that lets the public see exactly which properties are targeted. Clicking on an icon representing a property brings up information about why the property merits the distinction, as well as the current stage of the process.

Because the process is an arduous one—Iowa has one of the longest foreclosure periods of any state—the map provides Des Moines residents with a way to assess the status of individual properties and the project as a whole. "We can now provide the public a firsthand account of what's happening in their neighborhood and the progress being made," said SuAnn Donovan, the city's assistant director of neighborhood services.

1 experience.arcgis.com/experience/991aeb2af53343f68d73476a1f56a500

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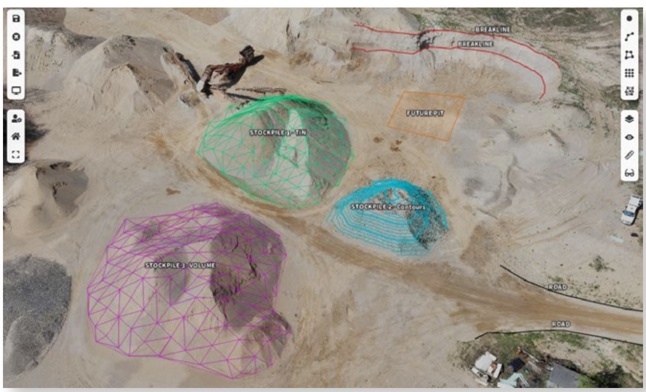

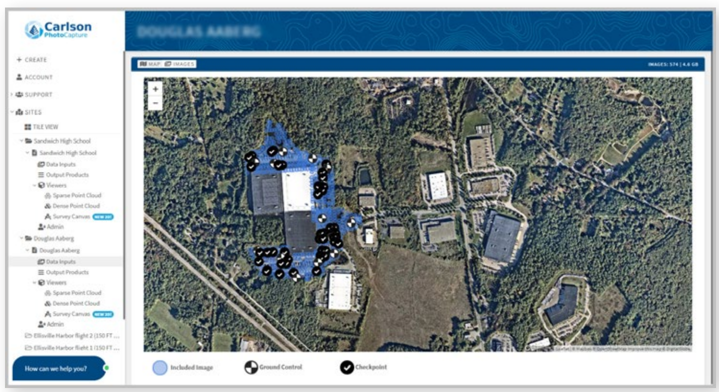

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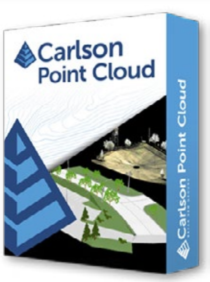

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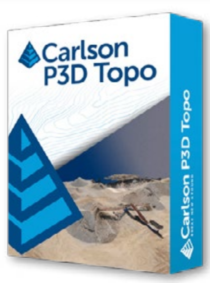

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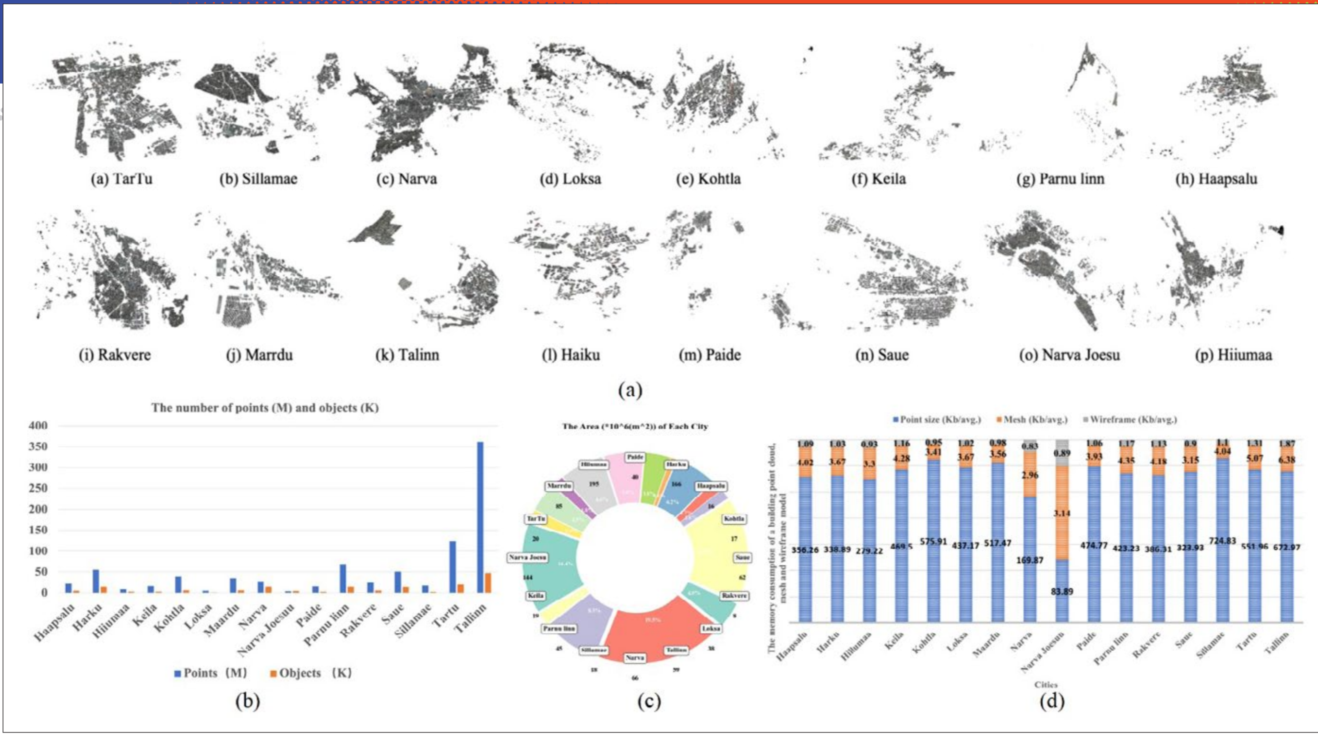

Figure 2: Details of Building3D dataset. (a) Illustration of 16 cities in our dataset. (b) The number of points and objects in each city. (c) The area of each city. (d) The average memory consumption of a building point cloud, mesh and wireframe model in each city.

Building3D, continued from page 48

point cloud, mesh, and wireframe model in each city respectively. The average memory consumption of a building point cloud is between 83.89 and 672.97 KB, while that of the corresponding mesh and wireframe models is less than 6.5 KB and 2 KB respectively. The ratio of average sizes among building point clouds, mesh and wireframe models is approximately 400:4:1.

Buildings analysis

We anticipate that Building3D and its corresponding benchmarks will bring forth new challenges and opportunities for research and industrial applications.

The dataset presents three primary advantages:

- **Authentic real-world representation:** Distinguished from existing artificially constructed building datasets, Building3D comprises buildings from Estonia, reflecting real-world structures. As depicted in **Table 1**, we computed the minimum, maximum, and average number of corners and edges in the roof structures. The results indicate that Building3D exhibits higher complexity compared to existing data.
- **Diverse range of categories:** Building3D includes a vast collection of around 160,000 3D point-cloud buildings encompassing over 100 distinct roof types as shown in **Figure 3**.
- **Abundant annotations:** The dataset includes point clouds, wireframe, and mesh models of roofs as illustrated in **Figure 4**.

Downstream task

Building3D has provided significant research prospects within the research communities. In addition, we also proposed a unified, supervised, and self-supervised end-to-end framework for 3D building modeling, dividing the reconstruction task into two primary components: 1) detecting and recognizing building edges and corners, and 2)

Table 1: Comparison of corners and edges between synthetic and Building3D.

Dataset	Minimum	Maximum	Average
	Corners // Edges	Corners // Edges	Corners // Edges
Synthetic dataset	4 // 4	11 // 15	8 // 10.6
Bulding3D	4 // 4	**52 // 65**	**15.7 // 32.8**

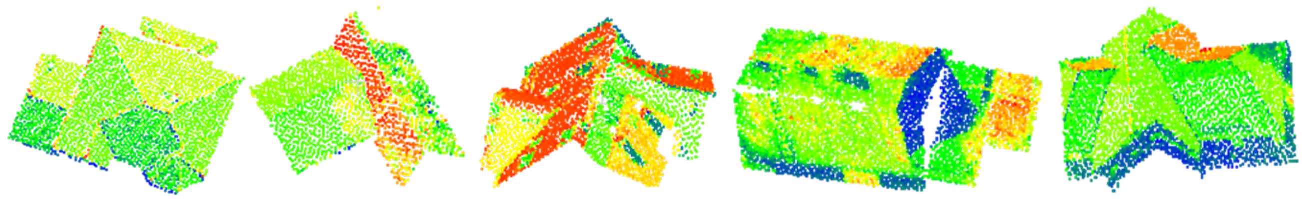

Figure 3: Illustration of diverse roof types in Building3D.

establishing effective edge connections among buildings. This dataset can be employed for the evaluation and analysis of the 3D building reconstruction.

Conclusions and future work

In this paper, we present an urban-scale dataset for building roof modeling from aerial lidar point clouds. Besides mesh models and real-world lidar point clouds, it is the first time to release wireframe models which transforms 3D building reconstruction into a classification problem. We believe that this work will help advance future research on several fundamental problems as well as common object modeling such as mesh simplification and remeshing. In the future work, our commitment lies in its continuous expansion and updates to cater to diverse research needs. Beyond its current applications, we are actively planning to explore additional downstream tasks, including sparse point cloud completion and semantic segmentation. In addition, we aim to add detailed building facade models to enable LoD3 modeling for photorealistic building model generation, and associate address data to each building for holistic 3D scene understanding.

Dr. Ruisheng Wang is a professor in the Department of Geomatics Engineering at the University of Calgary (UCalgary), which he joined in 2012. Before that, he worked as an industrial researcher at HERE Technologies (formerly NAVTEQ) in Chicago, since 2008. His primary research focus there was mobile lidar data processing for next-generation map making and navigation. Dr. Wang holds a Ph.D. in electrical and computer engineering from McGill University, an M.Sc.E. in geomatics engineering from the University of New Brunswick, and a B.Eng. in photogrammetry and remote sensing from Wuhan University.

Shangfeng Huang is currently working on his PhD. As a member of the spatial intelligence lab at UCalgary, his main research interests focus on 3D building reconstruction from point clouds.

Hongxin Yang is also currently working on his PhD and is a member of the spatial intelligence lab at UCalgary with research interests in 3D building reconstruction from point clouds.

Note about this article

This is a slightly shortened version of a published paper by the same authors, which is listed as the third reference in the bibliography below. The Building3D dataset released by the spatial intelligence lab at the University of Calgary is the first and largest urban-scale benchmark dataset for 3D building reconstruction from aerial point clouds.

Project website: building3d.ucalgary.ca

Paper URL: arxiv.org/pdf/2307.11914.pdf

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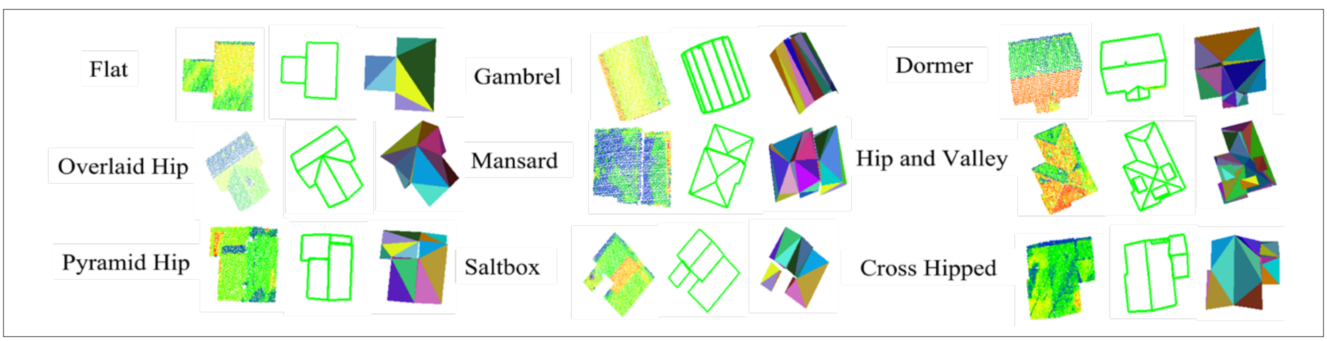

Figure 4: Illustration of diverse roof types in the Building3D.

Building3D: An Urban-Scale Dataset and Benchmarks for 3D Building Reconstruction from Airborne Lidar

Canadian research team provides invaluable tools for researchers worldwide

3D city models have found a wide range of applications such as smart cities, autonomous navigation, urban planning, and mapping. However, existing datasets for 3D modeling mainly focus on common objects such as furniture or cars. Current urban modeling datasets have been restricted to small datasets datasets (Wichmann et al., 2019) or synthetic ones (Li et al., 2022). Lack of building datasets has become a major obstacle for applying deep learning to specific domains such as urban modeling. The Building3D datasets consist of more than 160,000 buildings along with corresponding point clouds, meshes, and wireframe models, covering 16 cities in the Republic of Estonia, a total of about 998 km^2, as shown in **Figure 1**. The goal of Building3D (Wang et al., 2023) is to provide state-of-the-art data sets to research communities for advancing urban modeling research in photogrammetry, computer vision and remote sensing.

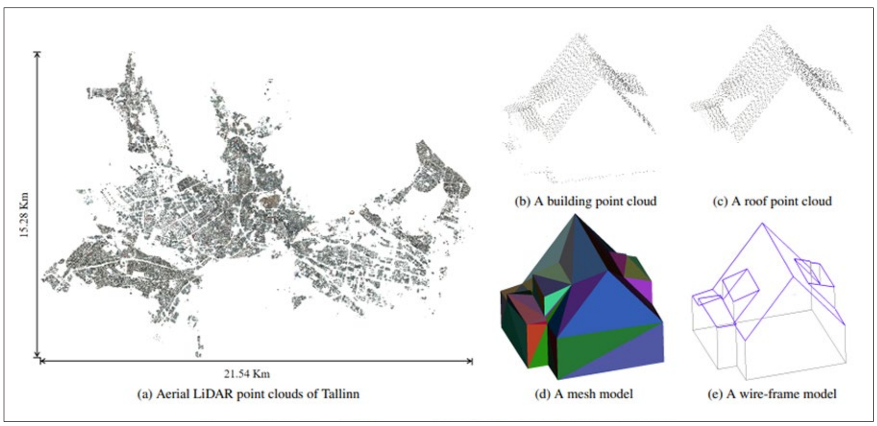

Figure 1: Tallinn city and its corresponding building and roof point clouds, meshes, and wireframe models in Building3D.

Dataset analysis

We process the raw data provided by the land board of Estonia to generate the Building3D dataset (Building 3D model data: Estonian Land Board 2022). **Figure 2** shows overall statistics of the proposed dataset, which contains about 160,000 building point clouds with corresponding mesh and wireframe models. **Figure 2(b)** shows histograms of point clouds and objects (i.e., buildings) in each city. The orders of magnitude of points and objects are indicated by symbols M (million) and K (thousand) respectively. **Figure 2(c)** shows the area of each city. **Figure 2(d)** shows the average memory consumption of a building

continued on page 46

BY RUISHENG **WANG**, SHANGFENG **HUANG** AND HONGXIN **YANG**


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