Catching FIRE

Ohio is blazing trails with exponential LiDAR applications.

BY BRIAN STEVENS, CP. SP.

From locating orphaned oil wells in farm fields to detecting land subsidence near interstates, the state of Ohio and many of its local governing entities are finding new purposes for orthoimagery and LiDAR data.

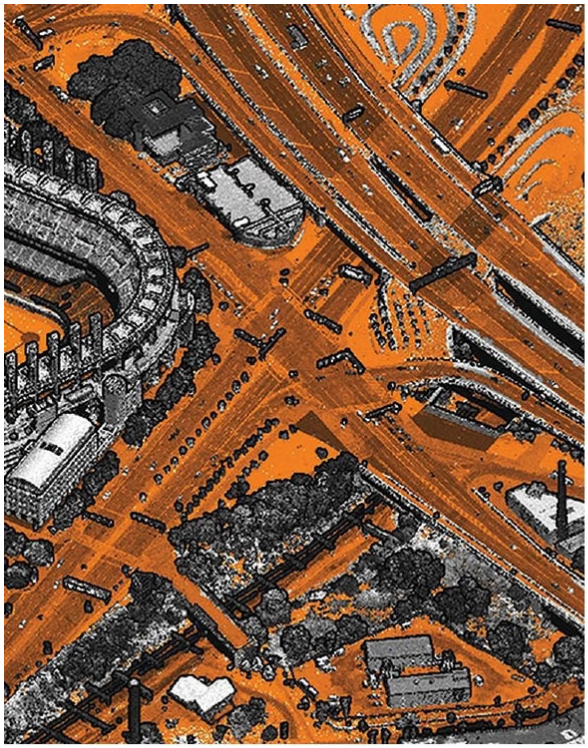
Woolpert — an architecture, engineering and geospatial (AEG) firm headquartered in Dayton, Ohio — is collecting updated LiDAR data for the entire state as part of the U.S. Geological Survey (USGS) 3D Elevation Program (3DEP).

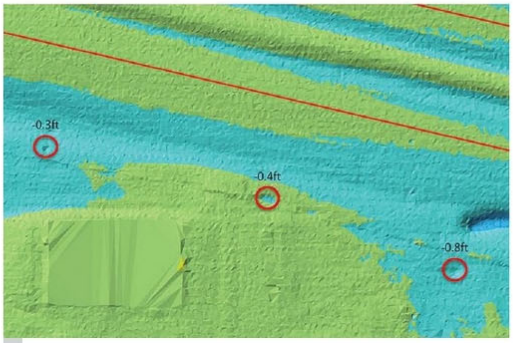
The Ohio 3DEP program coincides with ongoing aerial imagery collections to support the Ohio Statewide Imagery Program (OSIP). The multi-year contract is set up as a cooperative purchasing agreement to allow counties and municipalities to take advantage of economies of scale and choose from a wide array of products.

These derivative products include ortho and oblique aerial imagery, contouring, parcel mapping, GIS base mapping, and remote sensing to detect land use, land cover, crop delineation and change detection.

The demand from the public and private sectors for the latest datasets continues to rise, with more than 60 of Ohio's 88 counties having participated in the program, according to David Blackstone, executive director of the Ohio Geographically Referenced Information Program (OGRIP).

"From the traditional mapping perspective, we had ideas of what orthoimagery could be used for during our first iteration in 2006," Blackstone says. "The data and the sensors have gotten better and more accurate over time, and what's





ABOVE: Ground subsidence, such as this location along a state route in Ohio collected in 2016, can be detected in a 3D colorized point cloud. LEFT: Various colorized maps can be derived from today's high-resolution LiDAR data, such as this graphic of downtown Cleveland. IMAGES COURTESY OF WOOLPERT

driving the program now are the non-traditional uses that no one had thought of."

LIDAR QUALITY LEVELS

The USGS has outlined quality levels that define the minimum acceptable parameters of LiDAR data. In Ohio, the USGS is paying for a base collection at Quality Level 2 (QL2), which means 2 laser point pulses per square meter and an average vertical accuracy of +/- 4 inches.

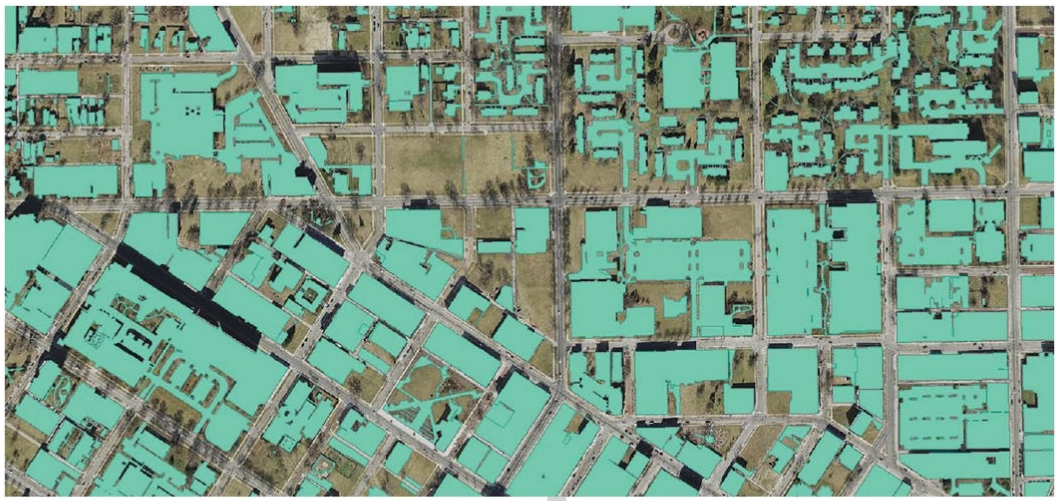
Ohio's base collection is being acquired at a greater point density, or QL1, which equates to 8 points per square meter and an average vertical accuracy of +/- 4 inches. Some local governments, including the city of Columbus and Cuyahoga and Fairfield counties, bought into the contract to receive greater point density and vertical accuracy, or QL0, which in this case provides 12 points per square meter and an average vertical accuracy of +/- 2 inches.

"The geospatial community knows we're getting the best data that we've ever had at the cheapest prices we've ever had," Blackstone says.

Each quality level represents millions of points obtained from the Leica Geosystems TerrainMapper LiDAR sensor, as deployed from an aircraft, to map Ohio's diverse surface. The 3D point clouds and digital elevation models (DEM) that are produced from the seamless data can be integrated with layers of information to address an expanding list of applications. These include the routing of emergency responders, planning and design of transportation infrastructure, permitting and code enforcement, property tax assessment and change detection.

Jeff Lovin, Woolpert senior vice president and market director, notes that financial constraints are always in play, and those constraints implore state and local governments to get the most out of contracts with private entities.

"When you can find a technology that helps lessen financial strains, it's always a positive thing," Lovin says. "Part of the



Impervious surfaces in Toledo are highlighted in this product derived from USGS QL0 LiDAR data. IMAGE COURTESY OF WOOLPERT

challenge now is getting the word out and educating people about the possibilities."

60,000 MILES

Woolpert uses multiple aircraft to cover the state, with 3DEP missions phased over three years. Acquisition for the northern portion of the state began in the fall of 2019 and will be completed this spring. The southeastern portion will be flown this fall and through the winter/spring of 2021, and data for the southwestern portion of the state will be collected in the fall of 2021 and continue into the winter/spring of 2022.

Collections for local governments within Ohio who exercise the opportunity to upgrade or "buy-up" to a greater point density and vertical accuracy occur during the state's predetermined acquisition schedule.

The flight line patterns for collecting LiDAR data resemble plow lines in a farm field. The quality level of the data that is being collected determines the number of and distances between the flight lines — the higher the quality level, the tighter the pattern and more numerous the flight lines.

Woolpert has set out to fly 60,000 linear miles of aerial LiDAR, which will map the state's nearly 41,000 square miles. The aircraft employed to acquire the LiDAR fly at an altitude of approximately 7,000 feet and at a speed of approximately 175 mph. The aircraft can collect data under the clouds but not above or through them, and collections take place after the leaves have fallen and before snowcover.

"When collecting LiDAR, you want to collect it in 'leaf-off' conditions to get the most accurate representation of the ground," Lovin says. "This gives us a very narrow window in the spring and fall to collect all of this data."

As Woolpert collects LiDAR data to support 3DEP, the firm also continues to collect aerial imagery to support OSIP. The current base contract calls for 6-inch pixel resolution 3-band orthoimagery, which was initiated in 2017 as a four-phase program.

The new base orthoimagery provides a foundation for the state's GIS initiatives. Orthoimagery and other datasets as part

of the imagery program are accessible and have proved beneficial for multiple state agencies, local governments, private entities and organizations.

HOW ORTHOIMAGERY AND LIDAR ARE HELPING MULTIPLE STATE AGENCIES

The Ohio Department of Transportation (ODOT) initially used orthoimagery to identify and analyze crash-prone areas and track the conditions of assets such as street signs and guardrails. With today's high-resolution LiDAR data, ODOT has identified several applications for the data to conduct in-depth safety analyses and for roadway construction.

Transportation engineers can calculate the grading of roadways and determine whether curves are too sharp or can be tightened to improve line-of-sight issues and comply with federal safety guidelines.

"ODOT has moved away from traditional on-the-ground surveying methods to using LiDAR for roadway designs and other transportation projects," Blackstone says. "We like to follow the motto, 'Create it once and use it a bunch.'"

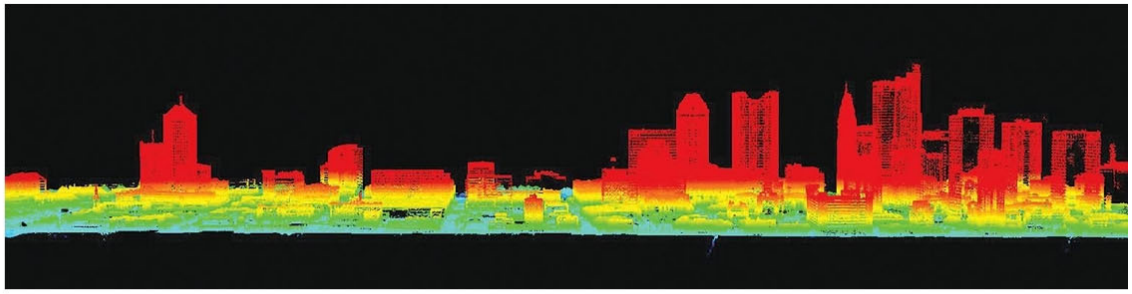
Referring to OSIP, Blackstone adds, "The data and all the derivative products the state and local governments have access to through the contract is a perfect example of that."

In 2006 and 2007, the Ohio Historical Society used LiDAR data to locate and map American Indian mounds. Blackstone likened that work to how aerial imagery and LiDAR data are being used in South America to locate lost structures from ancient cultures. With updated and denser LiDAR, the historical society will be able to continue their archeological studies and refine the ground features identified.

ODOT and the Ohio Department of Natural Resources (ODNR) are using LiDAR data to identify areas of land subsidence, i.e. areas of karst and abandoned mines where there's a risk of collapse near parks or interstates and state-managed routes. Lovin said land slippage is a concern for multiple Ohio counties.

"During heavy or prolonged rain events, land slips occur because the ground becomes saturated and unstable," Lovin says. "Analyzing the data for change detection enables the state to identify areas of concern and be proactive before a collapse occurs or before land slippage impacts infrastructure."

ODNR is also using the data to delineate existing wetland areas, which need to be protected from development to maintain water quality by acting as natural filtering mechanisms. ODNR is also planning to utilize the new aerial LiDAR to identify orphaned oil and gas wells. Ohio experienced a boom in oil production in the late 19th and early 20th centuries, when prospectors drilled wells all over the



state. Over time, many of the wells were abandoned, and the state has a program in place to cap the wells to prevent oil or natural gas leakage into the environment.

The point clouds that can be derived from raw LiDAR data reveal the orphaned oil and gas wells as dimples in the middle of farm fields, forested areas and residential backyards. Utilizing the orthoimagery from OSIP strengthens and validates the identification of those features by providing additional indicators, such as the plow line patterns and how farmers navigate around ground features.

'BUY-UPS' BY LOCAL GOVERNMENTS

In combination with OSIP, county auditors and engineers utilize the QL1 LiDAR to delineate ground features including buildings, landcover and roadway infrastructure. They can generate contours, perform change detection, calculate road grade and curve, calculate cut-and-fill volumes and delineate slope for crop analysis among other tasks.

In addition, engineers in counties and cities can utilize the QL1 or higher-density LiDAR data to delineate county- or citywide assets, like pavement markings, guardrails, decorative landscaping and the edges of pavement, to name a few. The new LiDAR data has proved effective for stormwater management efforts, commercial and residential development planning, and smart car technologies. Local governments are also using LiDAR data to delineate parcels of land to detect changes in the environment.

The city of Columbus bought in to receive QL0 data at 12 points per square meter, which was collected over approximately 680 square miles in central Ohio in 2019. That data is being used to support preliminary engineering for Blueprint Columbus, an innovative public utilities program aimed at redirecting stormwater runoff out of the sanitary sewer system through lateral lining, roofwater redirection, a sump pump program and green infrastructure.

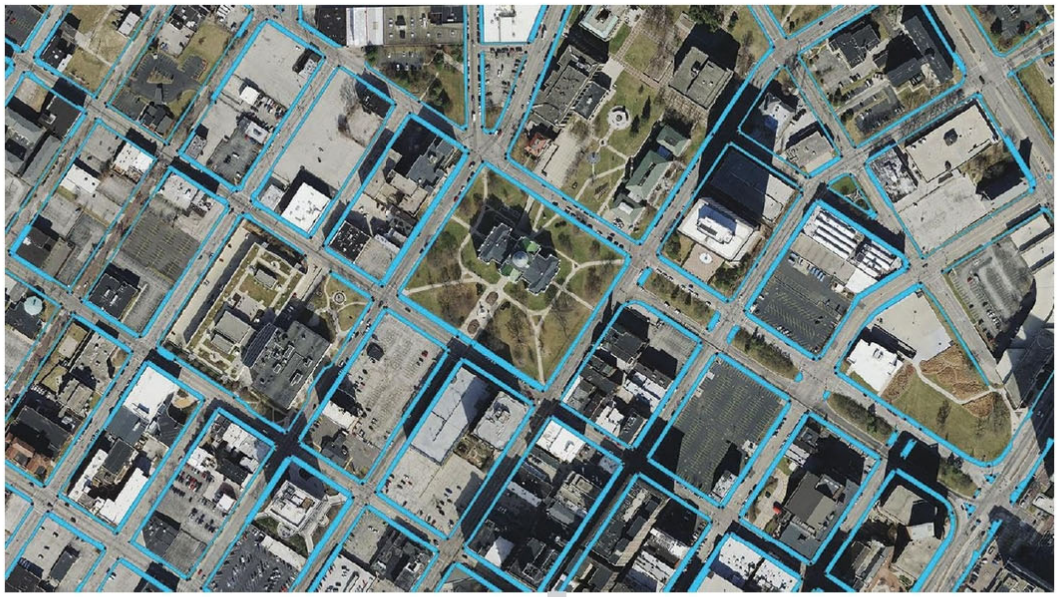
> **"OSIP has led to tremendous cost savings and efficiencies, and the importance of coordinated geographic information cannot be overstated... "**

This consistent, seamless data is used to create the 3D point clouds and DEMs, which help engineers identify the best locations to create bioswales, rain gardens and other features that help reduce overflows and filter out pollutants.

"More counties, municipalities and state agencies are participating in the state program as more applications are discovered. The improved LiDAR point density from 3DEP and imagery resolutions from OSIP have opened people's minds to looking at things differently and enabling planners, engineers, auditors and GIS managers to be more accurate and focused on the right solutions," Lovin says. "The data is so much better than it's ever been, which is driving artificial intelligence and machine learning to discover new applications and provide improvements to existing processes."

THE CONTRACT AND ROI

In combination with the federal government, three state agencies are funding Ohio 3DEP — ODOT, ODNR and the Ohio Environmental Protection Agency (OEPA). The two federal funding part-



Sidewalks in Toledo are delineated in this product derived from USGS QL0 LiDAR data. IMAGE COURTESY OF WOOLPERT

ners USGS and the Natural Resources Conservation Service.

The OSIP contract extends the opportunity to all local governments within Ohio to procure a higher imagery resolution and accuracy, which provides Ohio with a significant return on investment. Consider that since the first collection in 2006, the state has contributed approximately 15 percent of the total costs for all the products that have been delivered.

For real property tax valuation Fairfield County auditor Jon Slater says OGRIP services are "highly valued across the state."

"OSIP has led to tremendous cost savings and efficiencies, and the importance of coordinated geographic information cannot be overstated," Slater says. "OGRIP ensures key data programs, relied upon daily, work."

The same buy-up opportunity has been extended to all local governments within Ohio for the current 3DEP LiDAR initiative. These options are more limited as compared to the imagery program, but basically consist of an enhancement from the QL1 standard to the QL0 standard, which provides for an increased vertical accuracy and point density.

"In 2006, there was no authoritative version available for accurate aerial imagery. When we received that first statewide dataset of imagery collected in roughly the same time frame, suddenly everybody had this ability to either create GIS datasets or validate existing GIS datasets," Blackstone says. "Once we started to put it out there, that was probably the most requested public record we had."

Brian Stevens is a GIS professional and photogrammetrist with 24 years of experience in the geospatial industry. He currently serves as vice president and geospatial program director with Woolpert. Working out of the firm's office in Columbus, Ohio, he has led the Ohio Statewide Imagery Program since its inception in 2006.