

LIDAR

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MAGAZINE

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Nearly 2,000 U.S. landfill facilities stand to gain from cost-effective and quick UAS technologies

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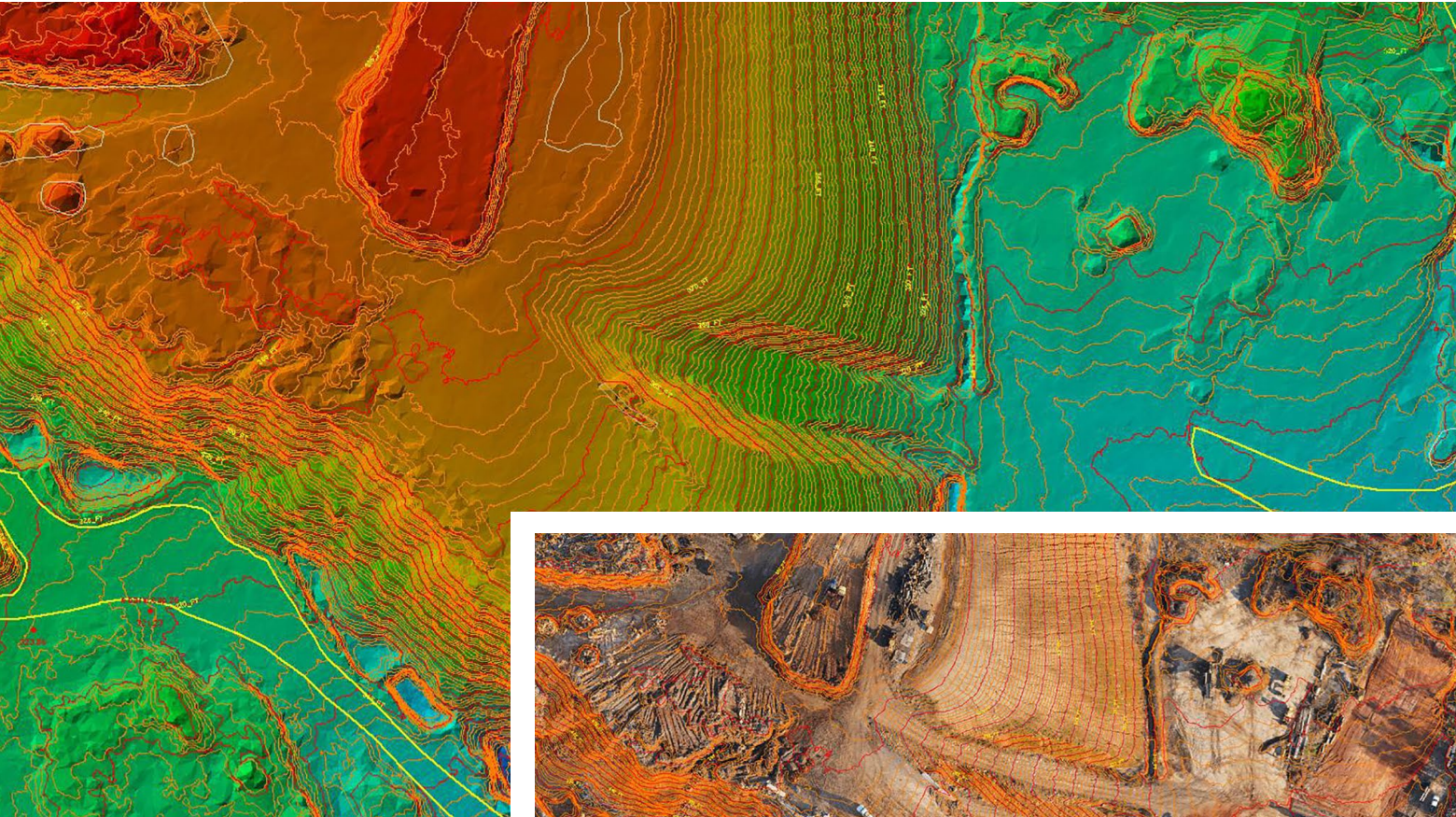
SLAM algorithms utilise information from sensors to estimate a device's location and map around it

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For more than twenty years, FEMA's engagement w/LIDAR has promoted guidelines & specifications



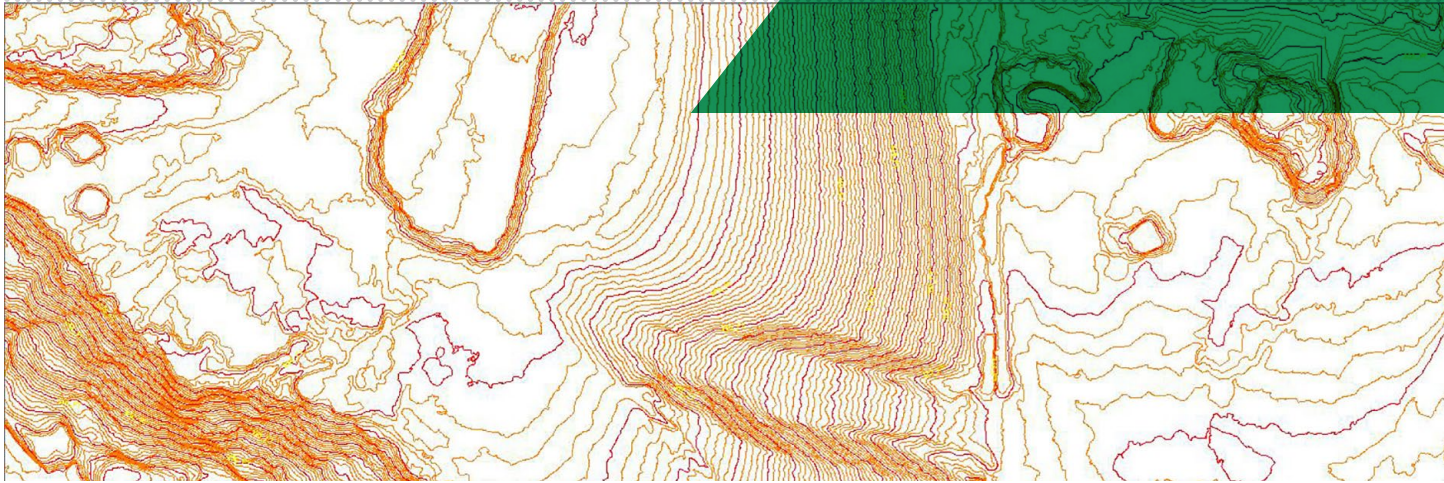
Exploring UAS Effectiveness for Landfill Surveys: A Case Study



DEM with contours

Ortho with contours

BY CHRISTIAN **STALLINGS**



1 ft. contours extracted from point cloud

Can the rapidly advancing technology of unmanned aerial systems (UAS), a.k.a. “drones,” be effective in collecting data on the nearly 2,000 landfill facilities in the U.S.? In February 2016, McKim & Creed, Inc., a national engineering, geomatics and planning firm, teamed with landfill engineers Garrett & Moore, Inc. to find out.

The Team and the Premise

Garrett & Moore is a Cary, North Carolina-based firm that designs and engineers landfills for municipal solid waste and coal combustion residuals. McKim & Creed, Inc. provides comprehensive engineering and geomatics services throughout the U.S. One of the firm’s newest service offerings is UAS data collection.

During the construction and operation of landfills, Garrett & Moore relies on aerial mapping data to perform volumetric analyses. Additionally, this data can be collected via conventional ground survey, fixed-wing aerial photogrammetry, or LiDAR.

On February 10, 2016, Garrett & Moore and McKim & Creed conducted

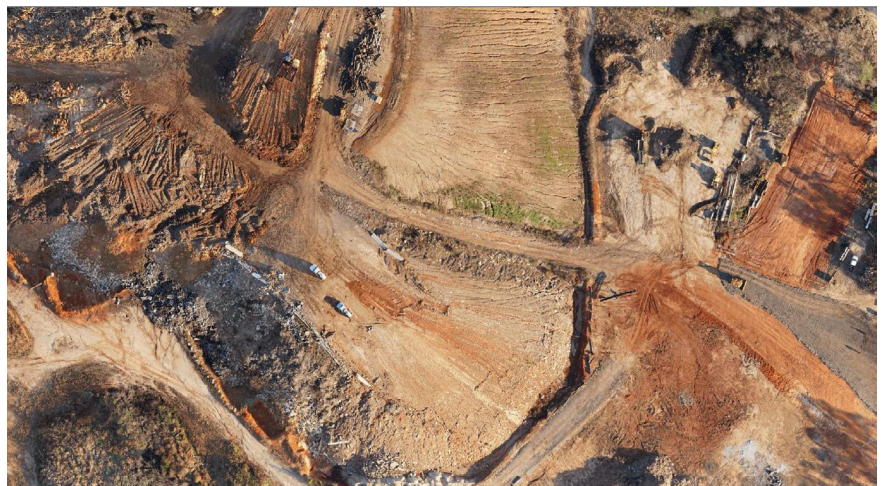
a case study to explore the efficacy of employing UAS technology for landfill surveys. The project was conducted at a land clearing and inert debris (LCID) landfill near Raleigh, North Carolina that has been operational since 1985.

Equipment

For the study, McKim & Creed used a 3D Robotics Solo (N993DR) equipped with a Sony QX1 camera. McKim & Creed chose the Solo for several reasons. Weighing only 3.3 lbs. (3.9 lbs. with payload), the aircraft is under

the 4.4-lb. threshold that, based on pending FAA regulations, will become increasingly important for commercial operations over populated areas or infrastructure. After extensive testing, we found the Solo airframe to be reliable, easily programmable for photogrammetric mapping, portable with quick setup time, and inexpensive compared to similar setups.

The Sony QX1 camera was fully integrated into the Solo using the onboard companion computer and accessory bay. The Sony API made



3.5 GSD ortho



Flight pattern of unmanned systems. Flight 1 is indicated in green, and flight 2 is in yellow.

it possible to remotely control the Solo, telling it when and where to take photos. Unlike cameras on similarly sized drones, the Sony QX1 is perfectly designed for photogrammetric mapping. The sensor is 20.1 megapixels, and the Sony E-mount allowed us to utilize various prime lenses that are ideal for mapping. For this mission, a 16-mm prime lens was used.

Methodology

The site was approximately 60 acres and consisted mostly of cleared, bare earth. A north-south flight pattern was chosen with a forward overlap of 78% and a side overlap of 60%. The mission was flown at 400 ft. above ground level (AGL), giving us a ground sampling distance (GSD) of approximately 3.5 cm. Due to temperature and wind conditions, we conducted two flights to ensure proper battery failsafe.

Five photo-identifiable control targets were collected over the site, and four additional photo-identifiable

checkpoints were collected to verify the results. During the first flight, 108 images were collected, and 98 images were collected during the second flight.

After the data was collected, McKim & Creed used Agisoft Photoscan Pro to tie the images together and perform a bundle adjustment using the five control points. Once completed, dense image matching (DIM) was used to create a point cloud of the site at a point density of approximately 14 points per square meter (pp2m). The DIM was processed at medium density; however, high density would have yielded closer to 40 pp2m. Along with the DIM, an ortho photograph of the site was produced with a GSD of 3.5 cm. These base products were used to create several derivative products, including 1-ft. contours, bare earth surface model, planimetrics, and volumetric calculations of individual piles.

To independently verify the accuracy of the surface created from the DIM, a bare earth point cloud was created using

proprietary ground filtering techniques. A triangulated irregular network was then compared to the check points and control points. The tested vertical accuracies are listed below:

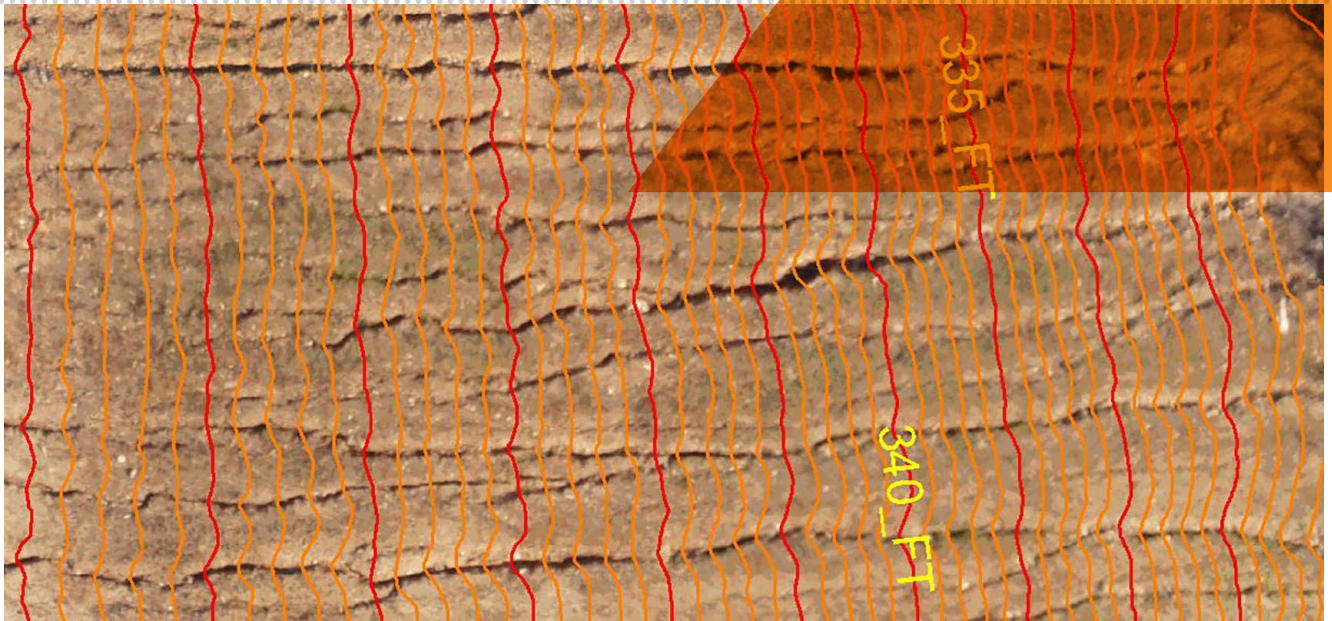
Vertical RMSE:	2.25 cm
Vertical NMAS/ VMAS Accuracy (90% CI):	3.71 cm
Vertical ASPRS/ NSSDA Accuracy (95% CI):	4.45 cm
Vertical Min Contour Interval:	7.31 cm (0.24 ft)

Results and Conclusions

McKim & Creed found that the surface model created exceeded the expectation of the project. The project was designed to meet ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014) for a 5 cm RMSEz vertical Accuracy Class equating to NVA = +/- 9.8 cm at 95%. Using UAS technology, our results were 4.45 cm. The level of detail collected in bare earth areas was also beyond what was expected. In areas where the hill was washed out, each channel could be identified in the surface model.

Some of the limitations we found in the UAS technology were in highly vegetated areas. Similar to traditional aerial photography, it is difficult to capture bare earth data in highly vegetated areas. In areas where vegetation is thick, it may be necessary to supplement UAS with ground survey.

Using the unmanned system, McKim & Creed was able to capture the data in less than an hour, verify the data on site, and complete the point cloud creation in less than 24 hours. This



Close-up view of washout with contours



McKim & Creed's FAA Section 333 exemption/Certificate of Authorization—and the firm's fully licensed and insured pilots and certified operators—enable them to deploy more than 1,200 different airframes into FAA-controlled airspace up to 400 feet above ground.

allowed us to more rapidly extract planimetrics, contours and volumetrics, when compared to conventional ground survey, aerial photogrammetry or LiDAR. We also found that this was the most cost-effective approach for this type of project. On average, using

UAS for landfill surveys proved to be approximately 10-20% cheaper than conventional ground survey, 30-40% cheaper than aerial photogrammetry, and 40-50% cheaper than LiDAR.

“The timeliness and accuracy of the aerial data, by using McKim & Creed's

approach, will allow us to better serve our clients' needs in assessing landfill airspace use,” said Bernie Garrett of Garrett & Moore, Inc. ■

McKim & Creed is an employee-owned engineering, geomatics and planning firm with nearly 400 staff members in offices throughout the U.S., including North Carolina, Florida, Georgia, Virginia, Texas and Pennsylvania. McKim & Creed specializes in mechanical, electrical, plumbing, civil and structural engineering, and industrial design-build services, as well as airborne and mobile LiDAR/scanning, unmanned aerial systems, subsurface utility engineering, hydrographic and conventional surveying services for the energy, transportation, federal, land development, water and building markets. For more information about McKim & Creed, visit www.mckimcreed.com.

Christian Stallings, CP is a certified photogrammetrist and licensed pilot who specializes in unmanned aerial systems and serves as research and development manager with McKim & Creed, Inc. He is involved with UAS projects across the U.S., and has conducted UAS webinars for the American Council of Engineering Companies, as well as numerous regional and local associations.