DOTs & UAVs

Image boost

Drones produce sharper pictures for mapping

By Jarlath O'Neil-Dunne
Contributing Author

Imagery often serves as the very foundation for computer-aided design (CAD) and geographic information system (GIS) transportation projects.

Yet despite its value, it is perpetually out of date and often lacking certain specifications, such as spatial resolution, to be of great utility. New imagery collections from satellite or manned aircraft are often prohibitively expensive for individual projects and delivery times can be on the order of weeks or months. For transportation activities these limitations often relegate imagery to nothing more than a base map, with costly field surveys a perquisite for any decision making.

Unmanned aircraft systems (UAS) are upending the old imagery model, providing the transportation sector with the ability to capture timely, high-resolution imagery. But not all UAS are created equal. The popular consumer quadcopters, with small video cameras, while valuable for activities such as bridge inspections and site reconnaissance, don't yield mapping-grade products suitable for integration into CAD and GIS. There are, however, a new generation of UAS, which collect imagery solely to support the creation of 2-D and 3-D geospatial products. Specifically, these UAS are capable of generating orthorectified imagery, which is free of distortions and thus suitable for making measurements, and 3-D point clouds, similar to LiDAR, that can be turned into surface models and contours. The accuracy of these products is often on par with what can be acquired by an experienced survey crew, but they can be produced in a fraction of the time. The low acquisition cost of UAS data is providing opportunities to use imagery to map, monitor and assess road and bridge transportation infrastructure in ways that were never before possible.

Learning to fly

The typical geospatial mapping UAS is a lightweight, fixed-wing system. In addition to being safer to operate than multi-rotor systems, fixed-wing UAS are able to cover larger areas. These systems are battery-powered and typically made of Styrofoam. Although they may look like toys, they are extremely high-tech, containing on-board GPS and sensors, such as pitot tubes, that monitor wind speed and direction. Imagery is acquired using digital sensors, which can range from modified consumer-grade cameras to advanced multispectral and thermal-imaging systems. The combination of this technology allows the UAS to operate autonomously, providing the capability to fly the precise flight lines crucial for gathering imagery that can then be post-processed into accurate geospatial products.

The first step in the use of these UAS systems is flight planning. Figure 1 shows an example of a flight plan generated using eMotion software for the senseFly eBee. Flight planning is relatively easy, requiring the user to enter a number of parameters from which the software computes the flight lines necessary to yield a seamless, orthorecitified image product that meets the input specifications. These parameters include the desired ground resolution of the imagery, percentage of overlap between images (more overlap generally improves accuracy and precision), take-off and landing configuration, along with the max operating altitude and horizontal extent. Launch and landing operations do require an open field, and take-off operations vary among systems. The popular senseFly eBee is launched by the user first activating the engine then tossing it in the air. A comparable system, Trimble's Gatewing, uses a small catapult launcher. Both systems land in what can best be described as a controlled flop onto the ground.

Once in the air these GIS-ready UAS execute their flight plans, gathering imagery at pre-established intervals without the need for user intervention. A data link allows for monitoring of system status, but not real-time image viewing. This further differentiates these systems from UAS surveillance systems that provide full motion video, and often alleviates the privacy concerns that often arise from UAS use.

After landing, the raw images and flight logs are downloaded where they are fed into image-processing software that uses digital photogrammetric techniques to generate the orthophotomosaics and point clouds. A single flight, covering 100-300 acres, will typically have a similar number of corresponding digital images. The GPS information from the flight logs allows the software to plot the location of each image, from which computer-vision techniques are used to automatically find matching locations between the images, allowing the images to be tied together. A typical flight plan will yield four to six overlapping images for any given location on the ground. These overlapping images, each of which was acquired from a slightly different perspective, enable the construction of a composite 3-D model of the area. This 3-D model is then used to remove distortions in the imagery, providing orthorectified imagery that can be readily overlaid with other geospatial datasets in GIS and CAD software. With a high-end computer system, the processing time for a single flight will take a few hours. For larger collections comprised of thousands of images, the processing may take 12 or more hours. Thus, mapping-grade products are typically available the very next day.


Figure 1. An example flight plan generated for the senseFly eBee UAV via eMotion software.

Now overhead

With funding from the U.S. DOT we have been evaluating the utility of UAS for transportation mapping for over two years and in the process have helped to bring UAS geospatial data products to the managers in government transportation agencies and commercial consulting groups. The low cost of creating these UAS products has allowed for novel uses of imagery. During the planning stages of bike and pedestrian improvement projects, overhead imagery is of limited use unless it is both current and captures extremely fine-scale features, such as line markings and sidewalks. We have supported a number of bike- and pedestrian-improvement projects, acquiring 4-cm resolution imagery in the weeks leading up to the planning meetings, providing the engineering teams and stakeholders with a common,

Figure 2. UAS assessment of bridge flood damage in Vermont earlier this summer.

accurate and current picture from which to guide their discussion. Overhead imagery is almost never used to monitor road construction, but UAS have allowed us to conduct regular flights over construction projects, gathering imagery prior to, during and upon completion of construction. The imagery not only serves as an unmatched mechanism for providing visual progress reports to management and stakeholders, but it also serves as a digital record that can be used to document regulatory compliance.

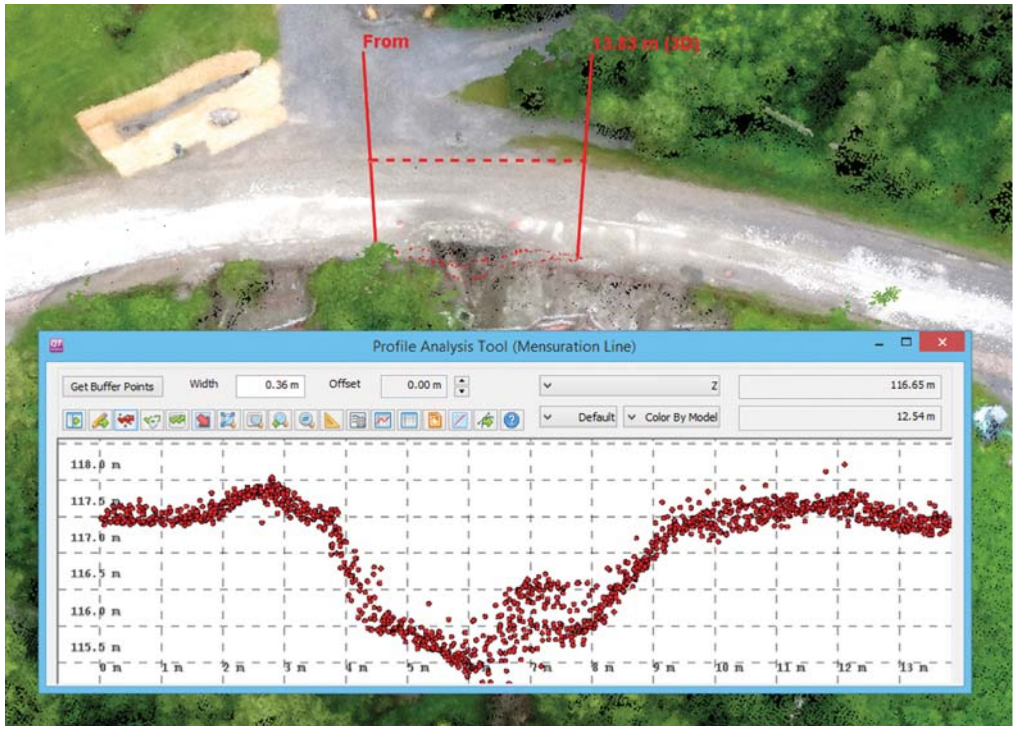

Figure 3. Data generated by UAS imagery of Figure 3's damage site.

Saturating flood coverage

Perhaps nowhere is UAS data more valuable than in the wake of a natural disaster. Vermont is a state with high topographic relief, necessitating the placement of roads along stream corridors and floodplains, which in turn makes the transportation network particularly susceptible to flooding.

In late July major thunderstorms dropped half a foot of rain in a matter of hours over a small location in central Vermont. Streams quickly rose, moving woody debris downstream where it clogged culverts and bridges. The resulting floods caused substantial damage to both roads and bridges in two towns. By deploying UAS technology in the hours after the storm we were able to document the event (Figure 2) and measure the damage using 3-D models created from the UAS imagery (Figure 3). Perhaps more importantly, we were able to conduct a detailed survey of the problematic streams and quantify the amount of woody debris that had moved during the storm and map the woody debris that would likely affect culverts and bridges in subsequent storms.

Concise and clear

The FAA is still finalizing its UAS regulations, and although the UAS operational environment currently has some uncertainty associated with it, what is clear is that UAS will revolutionize the role imagery will plan in managing our nation's infrastructure. With cost of these specialized geospatial UAS platforms being comparable to traditional survey equipment it may only be a matter of time before they come nearly as common. **R&B**

O'Neil-Dunne is director of the Spatial Analysis Laboratory at the University of Vermont.

BONUS CONTENT:

Visit *www.roadsbridges.com/great-brook-storm-damage-uas-video* to see how UAS data was used to respond to the Vermont bridge flood damage.