



UAS APPLIED

EDITOR'S NOTE: Our October 2013 issue features a UAS evaluation by a surveying firm in Ireland; they conducted field tests using UAS photogrammetry and compared the results to traditional survey techniques. Now this company has put their UAS to use commercially on a first-of-its-kind project. This article provides an excellent example of where a UAS survey can help overcome many project-specific challenges.

Surveyors provide a topographical survey of a harbor in Ireland with a UAS, thus avoiding significant disruption (and risk) that would have been created by a conventional survey.

By Paudie Barry and Ross Coakley

Baseline Surveys was awarded a contract to survey approximately one square km (about 247 acres) of the seaside town Dun Laoghaire in County Dublin, Ireland, specifically the town center and marine harbor area. The deliverable was to be a topographic survey for a detailed engineering redesign of the existing port; the client was the Dun Laoghaire Harbour Company.

Project Specifics

Site conditions were such that conventional survey methods would have been labor-intensive and hazardous. Survey work next to tidal water had to include a retaining wall and all waterside features down to low water, and survey work outside the confines of the harbor on public and private roadways with live traffic was specified.

Gaining access to the private property would have been unusually complicated. The harbor area is occupied by individual stakeholders, clubs, and statutory bodies. Entry to these sites and the timing was subject to individual consent outside the Harbour Company's direct control. Although every effort would have been made by Harbour staff to facilitate the survey in advance, the final consents were a matter for liaison by the successful surveyor. Each required a minimum notice of two weeks to facilitate any entry permits.

TOP: The Dún Laoghaire promenade in Ireland would have taken a ground survey crew three to four months to survey—*image courtesy of Wikipedia*



Additionally, conventional survey methods would have required a traffic safety management system, which would have caused substantial disruption to traffic for the duration of the survey. A special track-side permit would have had to have been obtained from Irish Rail, and there would have had to have been special safety considerations in order to ensure the safety of surveyors working at sea-front locations.

Additional requirements included:

- Entry to individual buildings was not envisaged; however, spot levels to define building heights were required.
- Contour mapping of open areas at 0.1m intervals was required.
- A list of typical features in the specification to be surveyed included cover level and location of underground services, overhead services, all street furniture, curb lines,

fences, road markings, buildings with heights, etc., all to be located within an accuracy of +/- 25mm.

- The final output data format was to be in AutoCAD dwg format.

Typically, a project such as this would have taken a ground survey crew three to four months to complete.

Using UAS on the project eliminated all these obstacles. The data capture took less than one hour for the entire site, and the final survey was produced within 10 days while achieving all the requirements as set out in the client's survey specification.

Pre-flight Planning

Attaining a permit for this work was a challenge, as normally in Ireland UAS are not

allowed to fly over congested areas and must fly within a visual line of site of 500m (.3 miles). Our unmanned aircraft required a take-off and landing area of 100m x 100m cleared land. The nearest suitable land was a soccer field, which was 1200m from our flight location, directly over a congested town center.

For the required aerial works application we prepared a detailed operational risk assessment and mitigation matrix on hazard identification in the target and surrounding areas, including weather requirements, an outline of our crew's ex-

perience to date, and operational altitude and location information.

The Irish Aviation Authority was very helpful in assisting us in preparing the operational risk assessment and granted us the permit to execute the work.

We generated a flight plan with an 80% overlap and an 80% side-lap and an altitude of 120m to provide an expected grand sample distance (GSD) of 2cm. Flight direction was plotted at 90 degrees to the actual wind direction to maintain a constant ground speed.

Data Acquisition System

The data acquisition system we used on this project was a C-Astral Bramor UAV, the same model as described in the evaluation feature in the October 2013 issue of this magazine. As during that test, we used the RTK GPS to establish ITM (Irish Transverse Mercator) coordinates on our specifically designed

ABOVE, INSET: Baseline Surveys tested the C-Astral Bramor UAV extensively before undertaking this project.



LEFT: This 3D point cloud derived from the aerial imagery has 2cm absolute accuracy.

ground markers to provide photo control. The GPS unit has an expected spatial accuracy when operated in the subject region of 10-25mm.

Site Conditions

The prevailing weather conditions on the day of our flight were overcast, with a wind speed at our flying altitude of 120m above ground level (AGL) at a maximum of 7m/s.

ers using Network RTK GPS in Irenet95 coordinates and then downloaded the data into Geosite office 5.1 and exported it to AutoCADlt 2014.

We downloaded 2,800 photographs from the Bramor UAS along with the flight log file. We imported the photos and the logfile into Agisoft photoscan, and using the software we eliminated superfluous photographs by deleting photos

and the DEM was outputted at 50mm pixel size.

The resulting geo-referenced orthophoto was imported into AutoCAD for the process of heads-up digitizing, which accurately defined the photographic features in CAD. The ground points were isolated in Agisoft Photoscan and exported as a bare earth surface into Global Mapper, where we generated 10cm contour file and spot levels for export to CAD.

This project proves that survey-grade mapping is now possible using remotely piloted aircraft systems.

The topography of the site had a 17m variation in terrain and had buildings, church spires, and tower cranes up to 40m tall, which would all contribute to turbulence at our flying altitude.

As mentioned previously, the site is in a marine harbor for maritime recreational use, with live road traffic and vessel sailings for the duration of the survey.

Data Processing

Just as we did during our earlier evaluation, we first surveyed 10 ground mark-

ers with high roll values. The refined 2,000 photographs were then used for the photo alignment stage.

We then imported the 10 control stations into photoscan and identified the center of each control point marker on each photo and attached it with its appropriate coordinate value.

Next we processed the data into a 3D model for subsequent orthophoto and digital surface and bare earth model output. The orthophoto was outputted at a resolution of 20mm pixel size

Results

The outputs were:

- AutoCAD topographic survey in 2D or 3D
- Orthophoto for CAD/GIS underlay
- DSM & DTM geotiff
- Lidar point cloud

Ground Truth

Once the survey was complete, we returned to the site to ground truth our final survey with 20 GPS check points on already-defined features throughout the extent of the survey. The GPS Z value was compared with our ready-made height model value at the same point. The mean difference between the UAS survey and RTK GPS ground truth survey results was 2cm.

This project proves that survey-grade mapping is

now possible using remotely piloted aircraft systems. By using UAS to carry out topographic surveys, European government agencies (and mostly likely soon U.S. agencies) can now look forward to spending less money on better geographic information so they in turn can make better informed decisions with less risk to life and less disruption to traffic. This geographic data can be recycled for multiple geographical analyses and design uses across a range of departments.

To represent the landscape, the orthophoto can be combined with the DEM to produce very accurate photorealistic 3D models in AutoDesk, ArcGIS, and MapInfo products and can be analyzed to yield highly accurate earthmoving volumetric calculations, and viewshed and flood analysis, as well as offering a tool to aid geographical communication throughout the lifetime of any given project.

We carried out this UAS operation in a safe manner in accordance to our aerial works permit and operations manual. The flight was without any incident or occurrence, and I particularly thank the Irish Aviation Authority for their helpful and progressive attitude. †

Paudie Barry founded Baseline Surveys Ltd and is a committee member of Unmanned Vehicle Systems International.

Ross Coakley, BE, MIEI teamed with Baseline Surveys to develop a UAV aerial photogrammetry and GIS data-capture service.