Surveying a Mountain Highway with UAS

In the steep canyons of the Republic of Macedonia, AKTOR ADT, an international construction company based in Athens, Greece, is building a highway that will traverse a natural gorge, cross the Vardar River, and help complete Corridor X, the most important north-south route through the country. Due to the area's very challenging geomorphology, the survey project is being undertaken with great regard for the environmental conditions.

The effort, which requires construction of millions of cubic meters of earthworks as well as heavy structures, includes two twin tunnels, six bridges, more than 100 culverts, five overpasses, seven underpasses, two interchanges, high embankments and deep cuts. As a result, it requires regular monitoring of the amount of material removed, landslides and other variables, and progress-reporting to government ministries.

To conduct the survey, AKTOR ADT has contracted with AVIATOP pc, which employs unmanned aircraft systems (UAS) to provide aerial mapping and surveying services. The firm is using a Trimble UX5 UAS to fly over the project corridor and collect data every two months. Equipped with a high-resolution camera, the UX5 captures images needed to measure the slope edges of cuts and fills and the surface of the roadway. George Papastamos, a surveying engineer and AVIATOP's founder and CEO, is the lead on the project.

The Challenges

The highway's path snakes through deep gorges, with a 6-percent grade and crossing bridges up to 90 m (300 ft) in height. Following a river, the gorges' corridors produce winds with speeds greater than 90 km/hr (60 mph). These conditions make aerial surveying very challenging. "It is a quite demanding project," said AKTOR ADT Civil Engineer Konstantinos Simou. "Our quantity surveys and 3D geometry need to be accurate within a few centimeters. Anyone who tried to achieve this with conventional methods [e.g., land surveying] would realize that monitoring a project of this scale is expensive. However, using UAS we manage to have a full view of the activities and the progress in near real-time."

According to Papastamos, the area's mountains and very rough surface can cause sudden air turbulance, and the narrow passages make landings extremely difficult. Additionally, the limited line-of-sight minimizes the range of the radio link. In spite of the challenges, AVIATOP has been able to conduct the UAS aerial survey by closely monitoring wind conditions and carefully choosing takeoff and landing zones—thanks to the UX5's excellent performance.

The First Five Flights

In order to clear the tops of the hills along the project's path, Papastamos flies the UAS just above the edges, which yields a ground sample distance (GSD) of about 10 cm (4 in). Because each survey requires at least six flights and Papastamos needs to find a suitable landing area for each one, each aerial survey takes two to three days, with each flight lasting 30 to 40 minutes.

The very rough terrain also requires densely-spaced ground control points (GCPs). Papastamos sets them every 250 m (820 ft) on each side of the flight area using Trimble R6 and R8 GNSS receivers and re-uses them. In areas with sharp elevation differences, he installs as many as needed to produce a correct model.

Aerial images capture construction progress and high-level project overviews.

The Deliverables

Project deliverables include georeferenced orthophotos of the project, aerial videos, a 3D surface model, profile sections, quantity surveys, horizontal plans and virtual reality videos. To produce the required information, AVIATOP uses the collected point cloud data and break lines, as well as situation maps of areas where material can be deposited, and locations of planned access roads and stream or utility diversions.

The survey so far shows that AKTOR ADT has been removing about 500,000 cubic meters (650,000 cubic yards) of dirt every month.

Lessons Learned

"Using the UAS, we are able to document the progress of our project month-by-month with photographs," Simou said. "The virtual reality videos we produce and publish via the local media have greatly helped to inform the public that the project is progressing and their money is not wasted."

"This project taught us how to optimize the installation of benchmarks to get accurate results in such a rough area," says Papastamos. "It also taught us how to land the aircraft in very narrow and difficult areas and to pay close attention to weather and lighting conditions."

Simou explained that by providing clarity and transparency, the UAS survey enabled AKTOR ADT to reinforce the trust and the confidence of all the stakeholders and the public. It also saved time for the company's top managers, because the videos minimized their need to visit the project in person. "From my experience, I estimate that a UAS survey is at least three times cheaper than a conventional survey and eight to ten times faster for large-scale projects," he said. "In addition, we are getting all the other products—orthophotos, a dense 3D model, videos, and virtual reality—as well as the ability to zoom in on any area and get details up to a 1-2 cm (0.4-0.8 in) resolution."

Given that the project requires repeating the UAS survey every two months until completion, that's a lot of savings.

Project technicians use UAS imagery to create flyover videos. Click here: https://www.youtube.com/watch?v=jCuBl_PZPoo
https://www.youtube.com/watch?v=R6JNBk14Kpk

See feature in Geoinformatics' October 2015 issue:
www.geoinformatics.com

Long shadows from the incomplete bridge piers indicate the size of the project.