A NEW LOW-ALTITUDE SURVEY TECHNOLOGY

Mapping a Landslide Using UAS

An Unmanned Aerial System (UAS) was used to acquire images of a small area in Italy for the purpose of post-landslide monitoring. The entire chain from aerial survey up to the automatic generation of maps and contour lines could be conducted within two days – one day surveying and one day processing – thanks to the use of sophisticated photogrammetric software. The quality of the final products is comparable with those achieved using conventional photogrammetry, while the throughput is faster.

After occurrence of a landslide, reliable, accurate and timely data is required in order to enable authorities to take proper measures. In the southern Italian municipality of Vibo Valentia (Calabria) located in the massif of Monte Poro, five areas are at high risk of landslides due to severe hydrogeological instability (Figure 1). Although these areas are rather small, the impact of landslides on infrastructure and urban

Unmanned Aerial Systems

This article is the second in a series of articles focusing on experiments carried out to test the aptness of Unmanned Aerial Systems (UAS) for a broad spectrum of potential applications. An Unmanned Aerial Vehicle (UAV) is the carrier of sensors and systems used for geodata acquisition. The platform together with the on-board sensors constitute a UAS. The applications may include land administration, map updating, landslide and dike monitoring, and biodiversity and heritage conservation. UAS technology is a low-cost alternative to classical manned aerial photogrammetry and is obviously growing mature. If you would like to contribute to the series, please contact wim.van.wegen@geomares.nl

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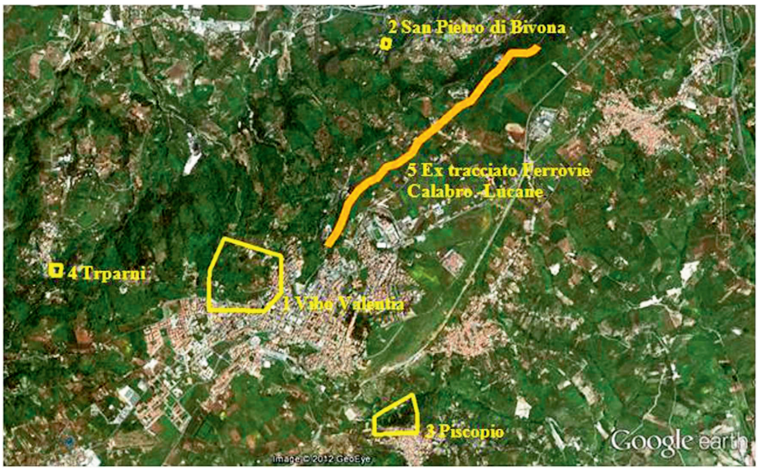


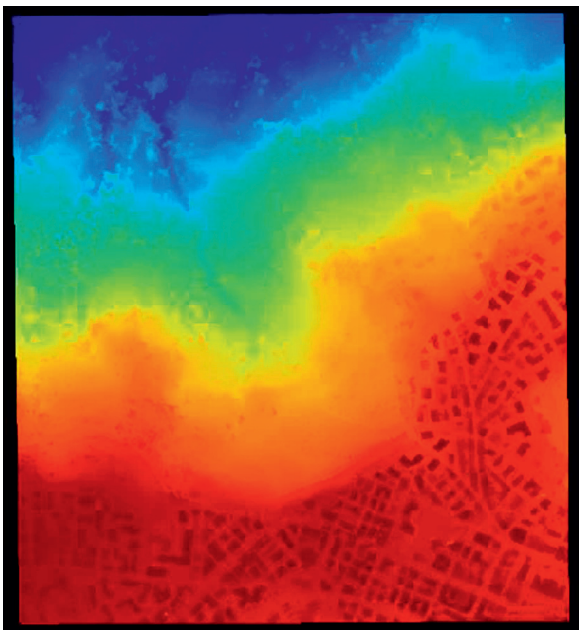
◀ *Figure 1, Vibo Valentia, San Pietro di Bivona, Piscopio, Triparni, and ex-track railway Calabro-Lucane are prone to landslides.*

▼ *Figure 2, Swinglet CAM micro UAV.*

centres may be large. The relatively large size of 1.43km^2 of the Vibo Valentia landslide area, where the height differences reach over 250m, and its proximity to the city triggered the authorities to carry out a survey after the occurrence of a landslide. The authorities chose Unmanned Aerial System (UAS) technology as they recognised its time-saving and cost-efficiency benefits.

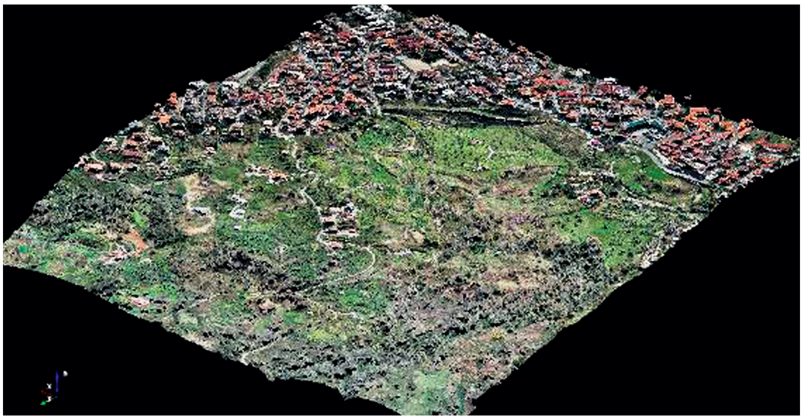
UAS USAGE

UASs are piloted remotely. Depending on the sensor types on board, UASs allow monitoring of urban areas, archaeological sites and other areas. Since data processing can be carried out highly automatically, the use of a UAS enables quick and cost-effective multi-temporal analysis of small areas. In the Vibo Valentia project, a Swinglet CAM was used. This lightweight fixed-wing drone weighs 500g and has a flight endurance of about 30 minutes (Figure 2). The cruise speed is 36 km/h and the maximum wind speed for smooth operation is 7m/s (4 Beaufort; moderate breeze). It is remotely controlled via a PC and equipped with a 12 megapixel digital camera, GNSS and Inertial Measurement Unit (IMU). The latter consists of a combination of accelerometers and gyroscopes. The focal length of the camera is 24mm and typical flying heights lie between 50 and 1,000 metres, resulting in Ground Sample Distances (GSD) varying from 2 to 40cm. The images are taken automatically; since the maximum rate is one image per four seconds, around 400 images can be captured during one flight. The UAS lands

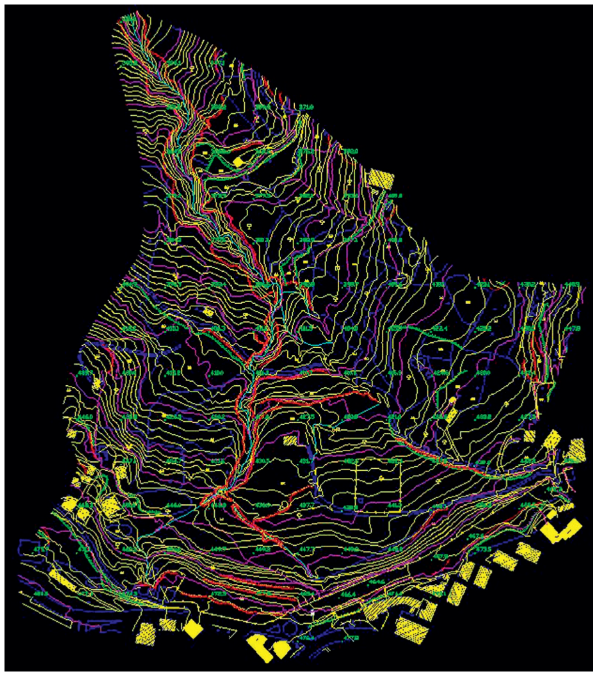


▲ *Figure 3, Colour-coded DSM with resolution 40cm.*

▲ *Figure 4, Orthomosaic.*



▲ *Figure 5, 3D representation: orthomosaic draped over DSM.*



▲ *Figure 6, Map including contour lines and heritage buildings in the Vibo Valentia landslide area.*

by gliding down, circling around a waypoint with a minimum radius of 20m.

PREPARATION

In the preparation stage, maps, aerial photos and other data were used to study the morphology of the Vibo Valentia landslide area and its changes over time. A proper landing place for the UAV was indicated and a flight plan prepared. The main tuning parameters of the flight plan are the rate of taking images, flying height, flying speed, and the interval between successive flight lines. The setting of the values of these parameters depends on the desired along-track and across-track overlap, the required GSD and the speed and direction of the wind. Both the along-track and the across-track overlap were set to 80%. The GSD was set to 5 to 8cm and the flying height to150m. Given the maximum battery life time at an altitude of 200m, three flights were conducted. Each flight lasted 27 minutes and the total flight time was 81 minutes.

ON SITE

On site, the flight plan was uploaded to the computer on board the UAS and pre-flight checks were carried out. The footprint of the images is continually displayed on the screen of the operator's PC, thus allowing checking of coverage and avoiding gaps. 932 images were taken in total. The use of ground control points (GCP) enables the precise reconstruction of the terrain in the form of a Digital Surface Model (DSM), contour lines and other derived products. Six GCPs were placed along the border of the area at locations clearly visible in the imagery. They were measured with DGNSS in RTK (Real Time Kinematic) mode with a precision of 5mm.

PRODUCT GENERATION

After the air survey, the quality of each image was examined. Using the APS Menci software and the GNSS-IMU data, the images were georeferenced through bundle adjustment. Tie points were automatically detected and matched using stereo image matching software. Stereo image matching was also used to generate a DSM from which contour lines, orthophotos and orthomosaic were automatically derived. The grid interval of the DSM was set to 40cm, i.e. five times the GSD of the images (Figure 3). The grid interval of the orthomosaic was set to 10cm (Figure 4). The orthomosaic was draped over the DSM to obtain a realistic 3D impression of the area (Figure 5). To obtain a better 3D impression, Z-map photo software allows overlapping images to be viewed in stereo. Furthermore, a detailed map – including contour lines – was generated of the Vibo Valentia landslide area, providing authorities with the necessary information to support recovery and reconstruction of heritage buildings in the city (Figure 6). The interval of the contour lines on this map was set to 1m. Conducting the chain from aero-triangulation up to the finalisation of the maps took 4 hours and 40 minutes.

CONCLUDING REMARKS

The level of detail of the derived photogrammetric products meets the needs of the authorities. The experience we gained during the present study makes us confident that UASs may be fruitfully employed not only for landslide monitoring but also for a variety of other applications such as topographic and environmental mapping, surveying and monitoring of construction sites – including road and rail – and environmental impact assessment. ◀

FURTHER READING

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