PHOTOGRAMMETRIC SURVEYS OF IRREGULAR SETTLEMENTS

UAVs as Tools for Urban Planning in Uruguay

Irregular settlements, also known as '*villas'* or '*favelas'*, present a big challenge in urban planning. When collecting data, whether to determine the existing situation or to plan future projects, topography plays a fundamental role. Not only is a large amount of information required but is also often difficult to access the locations, which makes capturing information much more complex than in the case of classical topography. Photogrammetry is the ideal methodology in such areas, and the unmanned aerial vehicle (UAV) is a perfect tool for this type of aerial survey. Read on for details of this project in Uruguay.

(By Patricio Birriel and Raúl González)

The areas of cities occupied by irregular settlements are 'conflict areas' from an urban point of view. Among other problems, land tenure is not legal, regulations are not respected, and city services are irregular or even fail. Planning for the regularisation of such areas begins with both social and topographical data collection. Good data collection will form the foundation for better planning and projection in order to be able to regularise the situation. Therefore, the collection of topographic data is a fundamental part of future urban development projects in such areas. All new subdivisions, streets, sanitation and other services should be projected, and in turn it must be ensured that these will all work properly with the rest of the city. Irregular settlements are typically characterised by high-density housing, irregularly shaped and very precarious constructions, and some accommodation may be located in flood-prone areas. All these features mean that the collection of topographic data is actually very complex. An aerial survey is therefore the best option, and the results obtained with UAV systems meet the technical requirements.

UAV Surveys

In the department of Maldonado, Uruguay, a survey was conducted of the San Antonio squatter settlement which is in the draft stage. With a total area of 11.57 hectares divided into three sectors (A, B and C), it is an irregular settlement with high-density housing. The contractor, the Government of Maldonado, required information as the basis for urban projects. The survey was required to comply with very precise and rigorous technical specifications, and the contractor requested a survey of all the existing elements including houses, fences, passageways and streets, and waterways. Since the resulting data needed to meet the demands of future urban development, cadastre projects and engineering services, the tolerances were 3cm in planimetry and 5-6cm in altimetry. A survey of this area and with these features with classical topography (GPS and total station) would take 20 days of fieldwork with 10 days of processing, taking into account the need for surveyors to return to the site several times to capture missing points. Furthermore, the survey would surely be left with gaps in information due to the inaccessibility of certain locations. Traditional photogrammetry (using aircraft) would be considerably more costly to fly a small area and would need to use powerful cameras to achieve the required accuracy. UAV systems comply with all the technical requirements, fly at low altitude to produce very good accuracy, and are ideal for flying small areas.

Photogrammetry is the proper survey technique in settlements due to the large amount of information required.

Flight Programming

This survey used the md4â€1000 UAV from the company microdrone. It is a rotating-wing UAV that has the necessary systems, such as GPS, gyroscope and radio link with the base station, to allow photogrammetric flight-path programming. The camera used is a SONY Nex7 24MP camera with a 16mm focal lens. To achieve the required urban cartography datasets, the flight altitude was set at 80m above the ground producing a theoretical accuracy on the ground of 2cm. The flight programming was carried out using the mdCockpit software (microdrone's own software) that is based on the information provided by Google Earth. This allowed the UAV to fly at a constant height above the ground, keeping the photographic scale and homogeneous precision for all the work. Photogrammetric urban mapping using UAVs often employs both longitudinal and transverse coatings of the environment: 80% and 60% respectively. Due to the characteristics of the area, which is predominated by precarious low-rise dwellings, it was decided to decrease the coatings in order to obtain altimetric accuracy (the greater the longitudinal coating, the lower the altimetric accuracy), arriving at a longitudinal coating of 66% and an altimetric accuracy of 5.1cm in keeping with the precision required for this work. Cross overlay was set to 25%. Reduction of both longitudinal and transverse coating allowed a flight to be performed of shorter duration, fewer frames and shorter restitution. Based on these parameters, one flight was scheduled for each area of the settlement.

Restitution of whole area and correct distribution of support points in order to ensure uniformity throughout the work area.

Support and Control Points

Support points are integral in the process because the overall accuracy of the work depends them. In urban surveys, the support points are traditionally taken once the flight has been performed by measuring the photo-identifiable points. Taking into account the difficult accessibility of certain parts of the area and considering traffic routes, support points were established while programming the flights, before flying commenced. White spray-painted crosses as markers ensured that the points were very clearly visible on the black or grey pavements. Establishing the support points prior to the flight enabled them to be distributed more effectively and to be placed in the areas that would be of greatest interest during processing. Once programmed, the flight points were placed in areas of the transverse overlap and each four models of the longitudinal overlap. These points were taken with RTK GPS dual frequency.

	SECTOR A	SECTOR B	SECTOR C
Area (hectares)	2.73	4.42	4.42
No. of flight lines	3	3	3
No. of images per line	11	15	18
No. of images	33	45	54
Flight time (minutes)	13	15	17
No. of support points	16	21	25
Planimetric accuracy	2.5cm	1.7cm	2.1cm
Altimetric accuracy	5.6cm	5.0cm	5.6cm

Table 1, Flight planning: low flight altitude and high restitution accuracy.

The control points are photo-identifiable points which are taken while the support points are placed. These points are placed halfway between the support points in areas where the model errors will be higher. These points serve as quality control for the work. These points are not provided to the person responsible for the restitution since they are analysed once the aerial triangulation and restitution processing is completed. Data from control points must be within acceptable margins of error. If the errors are greater, the potential sources of error are discussed and corrected in order to ensure uniformity in the quality of the work.

Conclusion

Due to the large amount of information and the high precision required for surveys of irregular settlements for the purpose of urban projects, UAV photogrammetry is the ideal choice. The orthophoto mosaic produced from a low-altitude flight offers a number of details which are otherwise impossible to obtain. Thanks to the uniformity of work, the quality is guaranteed to meet the accuracy requirements with precision across the entire area. In such complex areas, with limited visibility between stations, that is very difficult to obtain when working with classical topography.

About the Authors

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