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Drone Application in Topography Services - Case Study

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***Abstract*— This article had the purpose of developing an alternative and innovative procedure for the field of civil engineering, with regard to topography services, the study was carried out in a stretch of the Leo Extension, in Manaus-Am.As a tool was used an Unmanned Aerial Vehicle (UAV), specialized software for the elaboration of the flight plan and image processing, orthophoto mosaic, point cloud, Digital Surface Model (MDS) and Digital Terrestrial Model (MDT) of the area under study. The stages of this case study were divided into three: preparation of the flight plan, its execution and the processing of the data of this survey. The objective is to demonstrate some of the main results that will be collected from the processing of these aerophotos and, in addition, propose a critical approach about the method elaborated and results collected. In view of the final results, it is certain to say that the use of drones in this area of operation is highly beneficial, more precisely in relation to time and cost.*

I. INTRODUCTION

Topography has existed since the beginning of humanity, because there has always been a need to describe the environment in which we live. Even without the technology we have today, with rudimentary methods, data were collected that allowed the existence of the first charts and geographical plants for war and commercial purposes (DronEng, 2020).

Topography is the science that studies the exact and detailed description on the surface of a locality. It aims to graph through topographic surveys all the characteristics of a given area (JARDIM & GOMES, 2019), including geographic coordinates, relief, level curves, area calculation, quoted points and etc. Being fundamental support both in the project stage and in the execution of a work.

When referring to topography services, take into account three important steps, the first is data acquisition, the second step is processing or calculation and the third step is the preparation of technical parts.In conventional topography, data acquisition takes place through topographic surveys using technology such as Total Station, Theodolith, Topographic Levels and GNSS (Global Navigation Satellite System) Receivers.

The topographic surveys are constantly evolving and among several options of equipment and methods, it is up to the engineer responsible for the execution of the project to choose which will be the best method for each type of enterprise, considering its economy, quality and productivity.

According to Jardim & Gomes (2019), the topographic survey can be divided into two parts: the planimetric survey (determines the points in coordinates X and Y) and the altimetric survey (dimensions or altitudes of a Z point). Thus, one of the main methods for determining coordinates in topography is polygonation.

With this new digital age, many working methods and services have suited digital tools, in response to this high demand, most markets, industries, construction companies have sought intelligent solutions both for product development, as well as for service execution, and the main tool used is technology.

This technological advance is present in the civil engineering sector, currently we find several software that are able to perform services that previously required a high demand for time and team, today through technological advances, these same services are carried out remotely, enabling a greater advantage in optimizing time.

With the development of technology and computers in recent times, there was the need to improve the activities of topography, making room for the use of drones in topography services, which through software embedded in these aircraft has facilitated access to photogrammetric survey.

The topographic survey that was previously done with a team of approximately five or more people in the field, with large equipment and facing difficulty in accessing the information for data collection, today, through unmanned aircraft, can be done remotely, in the short term, with a maximum amount of at most two people in the field and an equipment that depending on the model can be transported in a backpack.

To make use of this method is necessary only one specialized drone and software, not necessarily the professional needs to be present in each area to be lifted and acquire the data.

In the construction market the drone has conquered its space, providing intelligent solutions from the preliminary phase, elaboration and development of project, until the later phase of engineering services.

The word Drone is of English origin which, translating to Portuguese, means "zangão", since this equipment produces a buzz similar to that of the insect (FALORCA & LANZINHA, 2018; VILAR, 2019). This term became worldwide popular to designate Remotely Piloted Aircraft (ARP). However, in addition to this, in Brazil it is technically known as UAV (Unmanned Aerial Vehicle), (SIGNIFICADOS, 2015).

Drones are usually used as a Hobby, but are currently employed in various activities and increasingly assist civil construction (FEITAL, 2017).

In planialtimetric topographic surveys, optical equipment such as the Total Station and the level are currently used, in addition to GNSS (Global Navigation Satellite System) receivers, however, these equipments require that data be collected on site, as well as the area of geoprocessing that currently still makes use of airplanes and helicopters to obtain images areas, the great difficulty of these types of services is pricing, which results in the lack of realization of them, compromising a range of information necessary for an optimal performance of the projects.

Because of these occurrences is that the application of drone in topography services has stood out, because the acquisition of the product is more accessible, has a greater ease in the execution of surveys and generates data rich in information.

With technological advances and new equipment, the conventional methodology has been replaced by methods that use the Drone, which does not necessarily require on-site data collection (FETAL; FERREIRA & ROSALEN), this can be done over long distances. However, there is a need to carry out studies that analyze the feasibility of this technology in carrying out these surveys (FERREIRA & ROSALEN, 2017)

Drones have been widely used by transport and traffic control agencies to monitor the surroundings of accident highways and paved structures (PURI, 2005; KARAN et al., 2014); in inspection of structures as a non-destructive method in the detection of pathological manifestations in construction through image capture (LISBOA et al,2018); for 3D mapping and modeling, and can be a low-cost tool, simple to manipulate, flexible and fast, and capture images from various angles (MELO,2016).

The use of a drone in mapping services enables an affordable and lower-cost alternative, especially when the area to be mapped is difficult to access.

It is important to highlight and consider the increased risk to people caused by remotely piloted aircraft in airspace, compared to the benefit that the new technology provides (LICCIARDI,2019).

For the application of this method it is important to comply with some laws. The flights performed to collect data from this article were carried out in compliance with ica 100-40 instructions on "Unmanned Aircraft and Access to Brazilian Space" following all the guidelines required by the Department of Airspace Control (DECEA).

This article aims to carry out an aerial mapping project with drone in Rama do Leão in the municipality of Manaus, Amazonas-Brazil.

To verify in practice the advantages and disadvantages of the use of drones as technological innovation in topography services, through a technical view, evaluating the differential and limited points of this new method as:

a) Demonstrate the processing time to generate the final products;

b) Describe the main complications of the extension.
c) Assess the differential and limited points of this new method.

In the following topics, a case study of drone application in topography services in an extension in the state of Amazonas for experimental purposes will be presented.

II. METHODOLOGY

In order to analyze the data obtained through the applicability of the use of UAEs in topographic mapping in a stretch of the Lion Extension, the present study is proposed, of exploratory-descriptive and qualitative methodological character.

In this case study we used drone technology for experimental research purposes, however, the research result will serve as the basis of preliminary studies for the development of extension recovery project.

1. CHARACTERIZATION OF THE STUDY AREA

The study area is located in the Extension of the Lion in the state of Amazonas, in the municipality of Manaus, according to the map below, (Figure 1).

To elaborate the flight plan, a technical visit is made in the field of the overflight area, where it is possible to detect all the difficulties that would be faced during the execution of the photogrammetry.

Fig. 1: Ramal do Leão. Source: Google Maps

2. FLIGHT PLANNING

The flight plan is an essential step, because it is through it that we define the resolution of the mapping, the number of flights, the amount of days or hours required and the layout of the flight.

The data will be collected using the phantom 4 RTK model drone (Figure 2), this drone has an RTK GPS module integrated directly into its body, is an aircraft designed and developed for this purpose, providing global positioning data at centimetric level in real time, enabling better accuracy of captured images. This RTK module can offer positioning accuracy of up to 1 cm horizontally and 1.5 cm vertically, generating an absolute accuracy of 5 cm in the generated digital models. And for this case study, we are expecting the planimetric accuracy to be around 3 to 4 cm and the altimeter is between 8 and 9 cm providing a more efficient accuracy. A modem with internet access was also used.

The flight plan will be drawn up using specialized software. The program interface shows all the pertinent information to deliver results faster and with a better quality, generating data with a high level of detail, providing a faster pace in productivity for the preparation of final products.

Fig. 2: Drone modelo PHANTOM 4 RTK. Fonte: NW Shop (2021).

3. IMPLEMENTATION OF THE FLIGHT PLAN

For the execution of the flight plan, it is essential the authorization of the National Civil Aviation Agency (ANAC) and also the Department of Control of Brazilian Airspace (DECEA), where the day, time and duration of the flight, the description of the equipment used, the purpose of the same and the name of the user responsible for the areonave is scheduled.Through the sarpas system available on the DECEA website we enter the sisant record of the engineer responsible for the execution of the flight which was recognized as a pilot and released to fly over the area of the experiment. Sent the flight request, about 20 minutes later, the authorization was obtained.

4. PREPARATION FOR DATA COLLECTION

Initially, with the help of Global Positioning System (GPS) resources, we located the terrain where the points and the base of the route and the location boundaries will be defined, all through the software.

The type of operation is performed through the DJI GO software, responsible for scheduling the flight execution of the aircraft path, through these settings is defined the duration of the flight, the memory capacity of the drone, the ambient temperature, wind speed, flight speed and overlaps.In this case study, the time in the field was 1h30 minutes and the duration of the overflight of 45 minutes, the amount of battery used was only one, 180 images captured.

In the execution of the flights is used a remote controller, where the pilot connects by the iPad 8 Apple device (Figure 3) a specialized application, where the elaborate flight plan is previously transmitted, you can view the images that the drone is doing, as well as the overflight in the defined graph, this whole process is done remotely on the tablet screen and in the palm of the hand and in case of any problem, you can change the flight plan by the app itself.

The maximum height range defined in the DECEA register is 120 m and during the execution of the flyover was reached up to 80 m (Figure 4), with Ground Sample Distance (GSD) of 3 cm, longitudinal overlap of 70% between the images and lateral of 70%, maximum speed of 15 m/s.

Fig. 3: Remote controller and iPad used. Source: prepared by the author (2021).

Fig. 4: Execution of the flight. Source: prepared by the author (2021).

To perform the flight, we opened the DJI GO and calibrated the aircraft, marked the home point, checked the available capacity of the memory card and then started the flyover. Professionals involved in a total of two people in the field to perform the photogrammetric survey.

III. RESULTS

1. CORRECTION OF IMAGES – ACCURACY

When we started the project, a GSD of 3 cm was used, that is, each pixel represented through the image is equivalent to 3 cm² and it is perceived that the higher the spatial resolution is, the greater the chance of dragging between the images causing blurs. In order for these drags not to impair the preparation of the final products, a report with all the execution data, called accuracy, is generated.

The program through calculation and statistics can calibrate the images, it is important that this correction with control point is made, because avoid errors according to (Table 1).

Table.1: Accuracy - Control Point Source: Prepared by the author (2021).

GCP name	X ERROR (m)	Y ERROR (m)	Z ERROR (m)	Projection Error [pixel]
A1	-0,036	0,043	0,028	0,673
A2	0,012	0,019	0,021	0,531
A4	-0,013	0,016	-0,038	0,618
A6	0,01	0,016	-0,013	0,996
A6	-0,027	-0,037	-0,044	0,878
A9	0,042	0,012	0,046	1,137
A10	0,006	0,062	0,029	0,9
MEAN (M)	-0,000916	0,001081	0,004137	
SIGMA (M)	0,024524	0,034092	0,0332	
RMSE (M)	0,024541	0,034109	0,033457	

After correction with the control point, it can be analyzed that the amount of errors reduced considerably according to (Table 2) with excellent accuracy, we reached 1.7 cm in X and 5.1 cm in Y and finally 8.2 cm in Z. Taking into account that for a topographic survey that lasted about 45 minutes, the results were satisfactory enabling the field measurements.

Table.2: Accuracy- Check Points. Source: Elaborated By the author (2021).

CHECK POINT name	X ERROR (cm)	Y ERROR (cm)	Z ERROR (cm)	Projection Error [pixel]
A3	-0,0069	0,0499	-0,0852	0,7451
A6	-0,0233	0,0644	-0,0344	0,6408
A7	0,0182	-0,0344	-0,1098	0,5538
MEAN (M)	-0,004034	0,026634	-0,07647	
SIGMA (M)	0,017061	0,043592	0,03139	
RMSE (M)	0,017532	0,051084	0,082662	

2. IMAGE PROCESSING

Later the execution of the flight, through the images obtained, can be carried out the processing of the same through the Photocan software, where it is possible to produce the mapping from the captured aerial images, each photo collected is georeferenced, that is, a coordinate is assigned for each pixel of the image,allowing several measurements of this image, with data and dimensions generating the cartographic base of the terrain, which is composed of: Orthophoto Mosaic, Digital Surface Model (MDS), Digital Terrain Model (MDT), and Point Cloud.

According to Woff (1983) orthophotos are geometrically equivalent to conventional planialtimetric maps, which show the true orthographic positions of objects. The Orthophoto Mosaic or Orthomosaic is a product used to acquire various data and information from the study area flown through the various images acquired by the drone. Through orthomosaic we can perform direct measurements of distances, areas and angles of the terrain.

These data are indispensable for the elaboration of information directly related to topography, which is fundamental for architectural design and other engineering projects, as well as in the feasibility decision process through the preliminary study and in the generation of the pre-project recovery of the extension.

Based on these images it is possible to calculate the variation of terrain levels (level dimensions), their area, as well as the volume, between other solutions.

The mosaic of properly georeferenced orthophotos (Figure 5) was obtained after a series of steps that involved the removal of errors from the entrainments and distortions of the photos caused by the process in capturing the images.

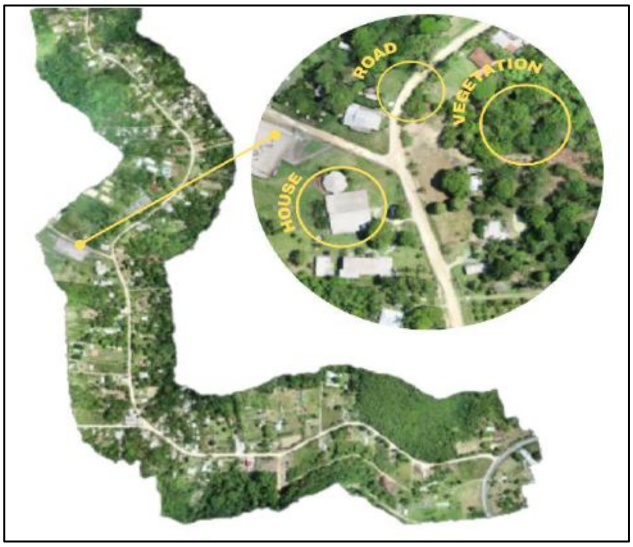

Fig.5: Orthophoto mosaic. Source: prepared by the author (2021).

3. DIGITAL SURFACE MODEL

By running the correction program at the control point, two types of maps are generated which is the Digital Surface Model (MDS) where it is possible to make terrain-specific volume measurements, providing information such as actual size of objects, can be seen in (Figure 6)the elements arranged in the raised area, including buildings, road, vegetation. MDS is a unique product of photogrammetry, since it is not possible to obtain the same through conventional topography.

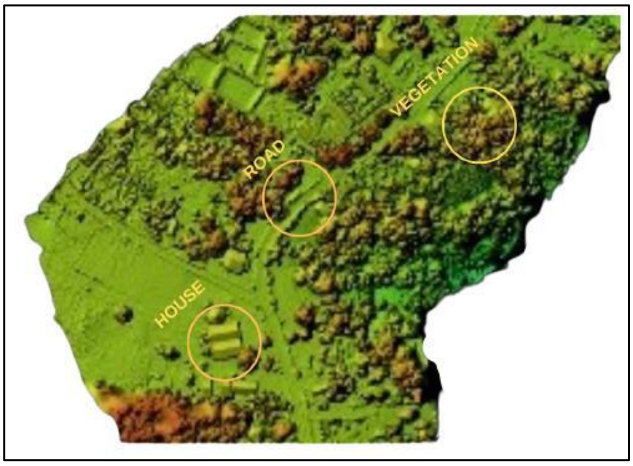

Fig. 6: Digital Surface Model (MDS). Source: prepared by the author (2021).

4. DIGITAL TERRAIN MODEL

Another map generated through the flyover, is the Digital Terrain Model (MDT) according to (Figure 7), which through the filtering made in the MDS obtained the altimetry of the terrain, taking into account only the relief and slope, used in the topography.

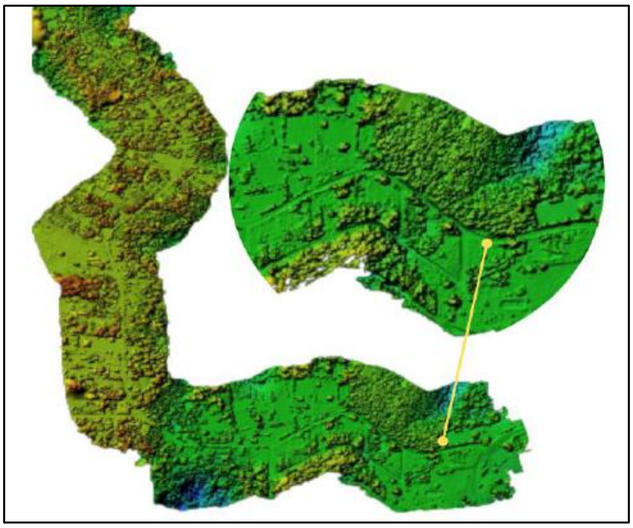

Fig. 7: Digital Terrain Model (MDT). Source: prepared by the author (2021).

5. POINT CLOUD AND LEVEL CURVE

The collection of the point cloud (Figure 8) is the basis that allows us to generate the 3D model of the current extension stage, which will serve as a realistic visualization of the area of interest, because each point is created through mathematical methods of triangulation.

The point cloud and level curve are key parts for a topography project. The level curve is the vectorized representation (Figure 9) of the altitudes of the mapping area, they are imaginary lines that characterize the flat surface and also the slope of the soil, serving as the basis for the leveling of the extension of this case study.

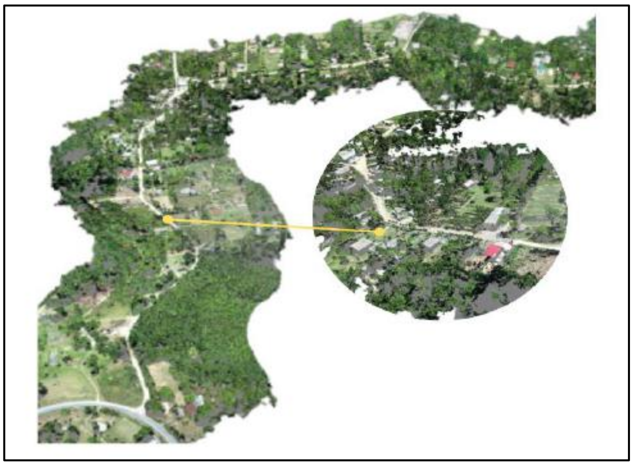

Fig. 8: Point Cloud. Source: prepared by the author (2021).

Fig. 9: Level Curve without lines. Source: prepared by the author

(2021).

The analysis of the main complications in the extension was performed through aerophotos, where we can notice that there is a small part of the asphalted extension (Figure 10) the results show that there is a great need for recovery, drainage and paving of the same.

Fig. 10: Start of paved extension. Source: prepared by the author

(2021).

Each project has its particular characteristics as is the case of the Lion Extension, with some areas where the forest is denser, making access to data collection more difficult and time-consuming, if we used traditional methodologies for the topographic survey of the area, in many places the data would be unattainable due to the lack of accessibility of the site.

IV. DISCUSSION

Topographic surveys aim to perform measurements of angles, distances and unevenness, which allow representing a portion of the earth's surface in an appropriate scale. From linear and angular measurements, areas, coordinates and volumes are calculated, among other elements, which can be graphically represented on maps or plans. The topographic survey aims to provide a planialtimetric representation of notable points, geographic accidents, earth moving volume and other relief details in areas where engineering works are being carried out.

Through the analysis of this study we can evaluate the differential and limited points of this new method.

Based on the results described above, it became feasible to conference the measurements in the field, obtaining the Orthophoto Mosaic, MDS, MDT, Level Curve, Point Cloud. Freeing up commuting everywhere, reducing spending and time on the field. Through specialized software it is possible to collect information such as distances, areas, volumes and sections of the extension.

One of the formidable advantages is undoubtedly the time savings and profit in productivity. The UARs can elaborate in minutes results that would take days to be collected in the field, with the high cost to maintain a team of six or more people and also with the rental of professionals and conventional equipment, especially in areas of difficult access.

The great accuracy of the collected data is through the high quality and resolution of the images obtained, enabling a detailed design with all the important and complete conformations of the terrain.

Drone topography offers a more detailed level of terrain, much higher information than conventional topography, but also offers a virtual reality of the terrain that cannot be generated only with topography.

The photogrammetry features that was somewhat restricted to large companies and public agencies, today through the drone, becomes accessible to small and medium enterprises.

However, the use of this new method also requires specific care and guidance to maintain safety during the use of this aircraft. Currently there are laws in force for the execution of unmanned aircraft flights.

In Brazil the agencies responsible for the registration, control and license of unmanned aircraft are: National Civil Aviation Agency (ANAC) is responsible for registering in the Unmanned Aircraft System (SISANT), with the National Telecommunications Agency (ANATEL) which is the mosaic system and also the Department of Airspace Control (DECEA), which is a sarpas system developed in order to enable the request for overflights in Brazilian airspace.

The guidelines found on the DECEA website describe where you can't and why you shouldn't lift the flyby. Most accidents with this type of aircraft occur due to misinformation of legislation and irregularity in use.

It is true to say that one of the relevant advantages regarding the use of drone in topography services is safety, this is because through the drone it is not necessary to travel several points of the terrain, you can perform the survey through a single starting point.

Despite all the positive results found in the application of drone use in the topography service of this case study, it is worth mentioning the limitations found in this method.

To meet the experiment of this case study we performed a flight with the phantom 4 drone, which lasted about 45 minutes, which was full of strong winds, the equipment was stable, but presented problems of distortions of the images obtained. In the execution of the flight at a faster speed, the propellers appeared in some images, causing the damage of the image and in relation to the propellers it is necessary to be removed every time the use of the drone ends and has to load compared to other aircraft that the propellers are foldable and more portable and easy to handle.

Also with regard to equipment in the field, only one battery was used, it is worth mentioning that the batteries of the phantom 4, have a high cost, so a greater investment is needed to obtain other batteries. It can be proven that the equipment is not so discreet, it is a drone that emits a high sound volume at the time of performing the flyover.

Moreover, the disadvantages of the phantom 4 line based on the experiment done in the field, it can be said that it would be the size of the equipment, because it is a large aircraft compared to other models on the market which hinders its mobility, which is not as easy and practical as other equipment that can be handled with greater ease and fits in a backpack for example.

In terms of camera quality, signal, rotation use the drone of the Phantom 4 Pro line is an impressive drone, with excellent features, and that meets the needs to perform a topographic mapping.

V. CONCLUSION

Topography is a technology where information is collected from the ground, being on the ground, that is, it is necessary to occupy the points that one wishes to obtain the information, with the use for example of the Total Station.

The photogrammetry is promising, because it presents a fast result compared to conventional methods, because the use of drone for topographic work, reduces the operating time, as well as the cost of equipment and people in the field, but does not eliminate the need of the professional, since the professional is responsible for creating and executing the flight plan of the aircraft, i.e the drone is a tool for providing service and does not replace the professional.

Compared to equipment, manpower, it can be said that this method is partly very profitable, because it provides an optimization time, fast results, with excellent images that allows a faithful analysis of the survey and in high resolution.

The use of this innovative technology ensures reliable and judicious results, so the performance of surveying services with drone has its positive and negative points and especially its limitations. According to the project it is possible to choose the best science in question to be used and get more interesting data.

Based on this study, it is evident that the construction scenario is in line with the new digital model implemented in its services, thus, studies such as these become essential to maintain the training of an innovative and up-to-date professional.

This case study aimed to demonstrate the use of photogrammetry for topographic purposes, that is, the survey was done remotely, a way to map the terrain without having to occupy the same.

The system used in this research does not aim to propose the substitution of conventional topography methods, but rather to add a new approach to data collection maximizing information from the terrain through georeferenced images.The same envisions a positive impact on the application of drones in topography services, enabling a broad view of this new opportunity that is emerging and inform the providers of this type of service, the relevance of knowledge and acceptance of new technologies in the market, projecting a new and updated course for civil construction.

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