# Feasibility Analysis of Unmanned Aerial Vehicle Survey for Outer Boundary Surveys

AMP Athukorala[1#], WMIU Adikaram[1], HHKT Bandulasoma[1], OJ Perera[1], SR Wijewardhane[1] and KP Manuranga[1]

[1]*Faculty of Built Environment & Spatial Sciences, General Sir John Kotelawala Defence University, Sri Lanka*
#37-sps-0007@kdu.ac.lk

***Abstract:*** *Cadastral surveying is the intellectual and technical process by which the boundaries of each of the land parcels within a given area are defined in a consistent manner. The main problems of the Sri Lankan cadastral system are increased time consumption, high cost and inefficient methods for data acquisition. In cadastral surveying mainly there are three operations. Those are determination of boundaries, survey of boundaries, and the demarcation of boundaries. This paper presents a modern method of close-range photogrammetry using Unmanned Aerial Vehicle (UAV) as a solution in the scope of determining and surveying boundaries. This study analyses the capability of UAV surveys to function as a rapid, cost effective and accurate alternative to current data acquisition techniques in the hope of accelerating the cadastral mapping process of the country. The accuracy of UAV to survey outer boundaries was measured by comparing land extents of typical land parcels obtained via two methods, UAV and Total Station (TS). The results of this study show the point cloud generates from UAV images generate a similar extent output as conventional methods. The only limiting factor was boundary visibility which was not an issue in the research scope. The advantage of UAV systems lies in their high flexibility and efficiency in capturing the surface of an area from a low flight altitude*

***Keywords:*** *Boundary detection, Cadastral Surveying, Mapping, Surveying, Total Station, Unmanned Aerial Vehicle*

## 1. Introduction

Cadastral mapping is a vital and complex process of a country. Cadastral mapping is not just about surveying the geometric area but maintaining the legal aspect as well. Choosing a proper cadastral mapping method has many advantages for the land management and administration of a country. Currently in Sri Lanka, the cadastral mapping process is conducted under the guidance of the Survey Department of Sri Lanka. The process has been going on for decades. Even though the cadastral mapping process has been completed in certain regions, still a major part of the country has not been surveyed for cadastral purposes. Furthermore, a proper method for updating cadastral maps has not been employed in Sri Lanka as of today. Total Stations are widely used in Sri Lanka for cadastral data collection. Recently the survey done using Global Navigation Satellite System (GNSS) was accepted by the Survey Department of Sri Lanka for the cadastral data collection (Sri Lanka Survey Department, 2020). Still the gaps in the local cadastral systems to become an efficient system have not been fulfilled. By switching the data collection method over to a low cost and quick method, the cadastral mapping process can be drastically accelerated. It is a global growing interest in updating geo-data (3D data and cadastral data) to be used in GIS and mapping tasks. There is a current high demand for a quick-efficient surveying method that integrates additional information for data acquisition to derive different outputs such as orthoimages, 3D-models of buildings and infrastructure, and elevation models. UAV is one such method (Manyoky, et al., 2011).

UAVs are a cutting-edge platform for carrying sensors and flying at the needed heights, in contrast to conventional aerial

photogrammetry. UAVs are capable of transporting Lidar, multispectral, thermal, optical, and thermal sensors. They are now used to obtain aerial photos from below the cloud cover, with a high ground resolution, and in a safer and more cost-effective manner than manned aircraft thanks to the recent rapid development of UAVs and the advancement of automatic navigation technology and stable imaging gear. In light of this, UAVs are able to conduct airborne operations at various altitudes in accordance with the needs of the mission, obtaining high- spatial-resolution photographs and creating orthophotos, digital surface models, and topographic maps. Safety of surveyor in dangerous places is also increased by the use of UAVs. In a study of feasibility assessment for boundary verification survey using UAV in Taiwan, it was discovered that UAV aerial photogrammetry can generate many landfill points, more detailed maps, and orthoimages. The digitized cadastral maps in Taiwan showed great similarity to collected data (Chio & Chiang, 2020).

The need for an efficient cadastral mapping system has been emphasized by the global surveying organizations. The cadastral system is expected to be fully digitized in the future and cadastral mapping is expected to be substituted with cadastral modelling (Kaufmann & Steudler, 1998). To be in sync with these growing needs modern technology should be integrated to the local cadastral system. This study was initiated with the hope of discovering methods to assist the local cadastral system. The results show that UAVs are well equipped for boundary detection. Further research in various conditions can be done to determine the limitations of UAVs.

## 2. Methodology

The methodology used in this study is shown in Figure. Initially a field survey was conducted using total station to acquire Ground Control Points for geo-referencing the UAV images. Survey points were also collected simultaneously for parcel delineation in the Total Station method. The UAV method for data collection was done using "Pix4Dcapture" software. The grid method was used to generate appropriate flight plan for autonomous flight and the flying altitude used was 60m. But the UAV was navigated using assisted flight mode around building complexes. Both front overlap and side overlap was assigned as 70% in this process. The camera angle was also maintained at 90°. The output image was then processed using "Pix4Dmapper". This software package facilitated the georeferencing process as well as point cloud generation. The boundary of the parcel was extracted, and area was calculated using "AutoCAD" software. The same software was used to calculate the extent of the parcel obtained using Total Station Survey. For the area comparison of the two different methods, they were applied to six study areas shown in Figure 1,2, and 3 that could simulate the environment for various but typical cadastral mapping instances. All the study areas shown below are located within Kotelawala Defence University – Southern Campus premises.

## 3. Analysis

The outputs from UAV and Total Station were compared and the area of each study area was compared. The Difference in extent is mentioned in **Error! Reference source not found.** 1.

Table 1: Difference of extent in study areas

| Location | Area (Perch) | | Difference (Perch) |
|---|---|---|---|
| | UAV | Total Station | |
| Bo Maluwa (L01) | 20.81 | 20.83 | 0.02 |
| Parade Ground (L02) | 309.72 | 309.9 | 0.18 |
| Basketball Court (L03) | 16.87 | 16.89 | 0.02 |
| Volleyball court (L04) | 22.39 | 22.34 | 0.05 |
| Faculty Garden (L05) | 25.34 | 25.38 | 0.04 |
| Netball Court (L06) | 17.37 | 17.34 | 0.03 |

Figure 1: Left: Basketball Court (L03), Right: Volleyball Court (L04)

Figure 2: Left: Overview image of Boo Maluwa (L01), Right: Image of Parade Ground (L02)

Figure 3: Left: Faculty Garden (L05), Right: Netball Court (L06)

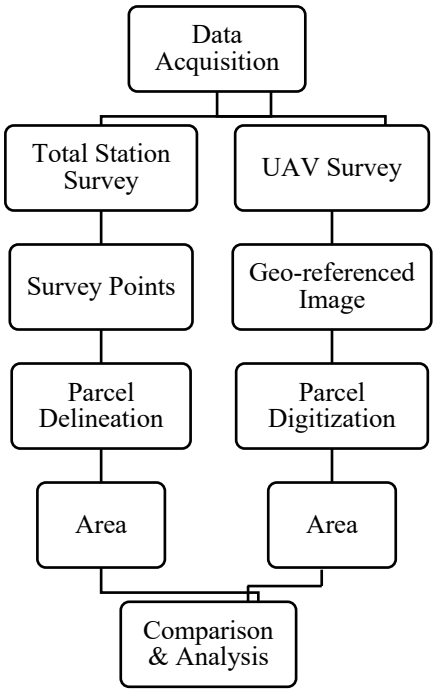


Figure 4: Methodology

## 4. Discussion

The future cadastral system is expected to be completely digital and cost recovering (Kaufmann & Steudler, 1998). The cadastral surveying system allocates top priority for the records of parcel boundary survey than physical location landmarks on the ground. So, the total land area that exists in the land totally depends on the parcel boundary. UAVs can capture a large area within a shorter period. Also, UAVs can easily access areas that humans can't access. This research focuses on accelerating the cadastral surveying process of the country. By using UAVs, even human resource utilization in surveying can be reduced. This can speed up the process and reduce costs as well. A UAV takes up less time when compared to almost any other field survey method. But there are limitations when using UAVs for getting information about the ground features. During data acquisition using traditional methods, much time is taken up to collect data in places with abrupt variations, such as curves, circles, and other irregular features. Time taken by UAV surveys do not depend on the physical shape of the feature. When there is a high canopy area, determining the actual boundary is a problematic. Selecting the best overlapping criteria is crucial. If it is not properly selected, the orthomosaic layer cannot be modelled from the UAV images. When performing field tasks valuable features can be lost and the possibility of missing data in the field may be very low when having UAV images. This is because in UAV surveys often redundant data are obtained and they reside in photographs. The UAV images act as pictorial evidence of the boundary conditions at the time of survey. This cannot be seen in conventional data collection methods.

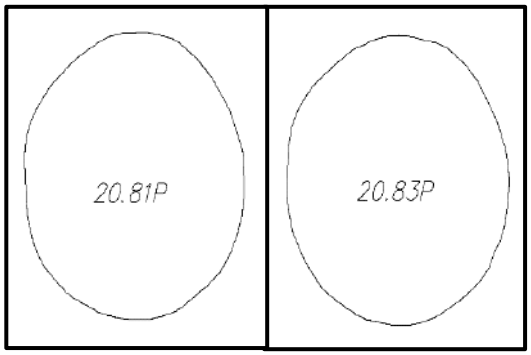


Figure 5: Left: Output of study area L01 from UAV, Right: Output of same study area from TS

One of the limitations of UAVs is battery power. A high-capacity battery pack can develop the capabilities of UAVs. In the past when using UAVs, a well-trained person was essential to pilot the UAV. But currently most UAVs are equipped with automation and flight planning systems that has reduced the need for high qualifications for the pilot. The analysis of point cloud data can also be done with ease using new software to extract parcel boundary records. Some such analyzing software are Pix4Dmapper, ArcGIS Pro, Trimble Business Center (TBC), Autodesk ReCap, Autodesk Civil 3D etc. The point cloud data from UAV images can also be used to drive alternative products that can assist the cadastral modelling sector too.

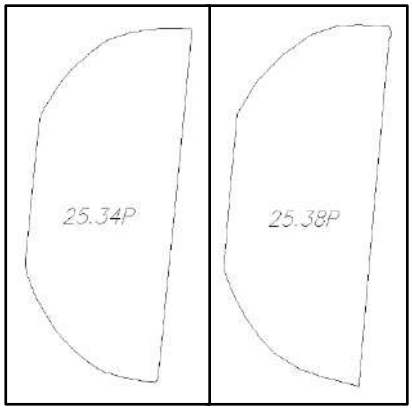


Figure 6: Output of study area L05 from UAV, Right: Output of same study area from TS

## 5. Conclusion

The purpose of this study is to accelerate the current cadastral procedure by suggesting an alternative to conventional methods. The study focuses on determining capabilities of UAVs. In terms of accuracy, thoroughness, and time commitment, UAVs appeared to be equivalent. The advantage of using UAV systems is their fast surface scanning capabilities while flying at low altitude. UAV systems have shown to be a useful

adjunct to conventional surveying techniques for acquiring additional data through the acquired photographs, such as overview images or orthoimages.

**References**


Chio, S.-H. & Chiang, C.-C., 2020. Feasibility Study Using UAV Aerial Photogrammetry for a Boundary Verification Survey of a Digitalized Cadastral Area in an Urban City of Taiwan. *Department of Land Economics, National Chengchi University.*

*I.* Kaufmann, J. & Steudler, D., 1998. The Six Statements on Cadastre 2014. In: *Cadastre 2014.* s.l.:FIG Commision 7, pp. 15-25.

*J.* Manyoky, M., Theiler, P., Steudler, D. & Eisenbeiss, H., *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences,* Volume XXXVIII-1/C22,, pp. 57-62.

*K.* Sri Lanka Survey Department, 2020. Control Surveys. In: *Departmental Survey Regulations.* s.l.:s.n., pp. 3-4.



**Acknowledgment**

I would like to thank lectures of the Faculty of Built Environment and Spatial Sciences, General Sir John Kotelawala Defence University. And I wish to express my sincere thanks and gratitude to all the people who helped us in many ways.


**Author Biographies**

**Mr. A.M.P. Athukorala** is an undergraduate of General Sir John Kotelawala Defence University reading the BSc. (Hons) Surveying Sciences. I'm interested in modern survey techniques and spatial data analysis. Following the module of cadastral studies, here we have prepared a feasibility analysis of UAV survey in Outer Boundary Surveys.

**Mr. W.M.I.U. Adikaram** is an undergraduate of General Sir John Kotelawala Defence University reading the BSc. (Hons) Surveying Sciences. I'm interested in modern survey techniques and spatial data analysis. Following the module of cadastral studies, here we have prepared a feasibility analysis of UAV survey in Outer Boundary Surveys.

**Miss.H.H.K.T. Bandulasoma** is an undergraduate of General Sir John Kotelawala Defence University reading the BSc. (Hons) Surveying Sciences. I'm interested in modern survey techniques and spatial data analysis. Following the module of cadastral studies, here we have prepared a feasibility analysis of UAV survey in Outer Boundary Surveys.

**Miss. O.J. Perera** is an undergraduate of General Sir John Kotelawala Defence University reading the BSc. (Hons) Surveying Sciences. I'm interested in modern survey techniques and spatial data analysis. Following the module of cadastral studies, here we have prepared a feasibility analysis of UAV survey in Outer Boundary Surveys.

**Miss. S.R. Wijewardhane** is an undergraduate of General Sir John Kotelawala Defence University reading the BSc. (Hons) Surveying Sciences. I'm interested in modern survey techniques and spatial data analysis. Following the module of cadastral studies, here we have prepared a feasibility analysis of UAV survey in Outer Boundary Surveys.

**Syr. K.P. Manuranga,** I have Obtained BSc Surveying Sciences (Surveying and Geodesy) from Sabaragamuwa University of Sri Lanka. I'm interested in modern survey techniques and spatial data analysis. Following the module of cadastral studies, here we have prepared a feasibility analysis of UAV survey in Outer Boundary Surveys.