ACCURACY ASSESSMENT OF ORTHOPHOTO USING GROUND CONTROL POINT DERIVED FROM VARIOUS GLOBAL POSITIONING SYSTEM TECHNIQUES

NURUL HUSNA BINTI AZIZ

UNIVERSITI TEKNOLOGI MALAYSIA

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NURUL HUSNA BINTI AZIZ

A thesis submitted in fulfillment of the

requirement for the award of the degree of

Master of Science (Geomatic Engineering)

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AUGUST 2016

DEDICATION

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ABSTRACT

Unmanned Aerial System (UAS) is a rapid mapping method that is capable to capture many details in short span of time from various altitudes. UAS comprises of two components: (i) Unmanned Aerial Vehicle (UAV) and (ii) Ground Control System (GCS). The functions of GCS are to monitor and control the UAV from the ground during the process of data collection. UAS has the capability to produce accurate set of data for mapping, nevertheless, the accuracy of the data need to be assessed. The aim of this study is to assess the accuracy of mapping using UAS data based on Ground Control Points (GCP) derived from various Global Positioning System (GPS) techniques. The GCPs are used as control points for production of orthophoto. In this study, a fixed-wing UAV attached with a digital camera was flown over Universiti Teknologi Malaysia campus at an altitude of 300 m for digital aerial images acquisition. The study area is divided into: (i) small study area of Lingkaran Ilmu with approximate area of 35000 m^2 and (ii) large study area with approximate area of UTM of 7000000 m^2. These different sizes of the study area were used to investigate the effect of different GPS techniques. In this study, the GCPs location is well distributed in both study areas and the GCPs were established using three different GPS techniques: i) relative static, ii) absolute static and ii) Network Real Time Kinematic (NRTK). These different techniques were used to investigate its effect on orthophoto production. The accuracy assessment is performed by comparing the orthophoto measurements with reference values based on Check Points (CPs) established using GPS technique. Results show that the Root Mean Square Error (RMSE) of NRTK technique is consistently small with $\pm$0.39 m and $\pm$0.55 m for the small and large study areas respectively. While for the relative static technique, the RMSE show inconsistent results with $\pm$1.61 m and $\pm$0.50 m for the small and large study areas respectively. Meanwhile, absolute static technique gives the biggest RMSE with $\pm$0.84 m and $\pm$2.27 m for the small and large study areas respectively. In conclusion, NRTK technique is proved to be the best technique of GCP establishment in terms of accuracy and the UAS can be employed for mapping purposes.

ABSTRAK

Sistem pesawat tanpa pemandu (UAS) adalah satu kaedah pemetaan yang cepat yang mampu untuk mengutip banyak butiran dalam tempoh yang singkat dari pelbagai ketinggian. UAS terdiri daripada dua komponen: (i) pesawat udara tanpa pemandu (UAV) dan (ii) sistem kawalan bumi (GCS). Fungai GCS adalah untuk memantau dan mengawal UAV dari bumi semasa proses pengumpulan data. UAS mempunyai keupayaan untuk menghasilkan set data yang tepat untuk pemetaan, bagaimanapun ketepatan data perlu dinilai. Tujuan kajian ini adalah untuk menilai ketepatan pemetaan menggunakan data UAS berdasarkan titik kawalan bumi (GCP) yang dihasilkan dari pelbagai teknik sistem penentududukan global (GPS). GCP digunakan sebagai titik kawalan kepada penghasilan ortofoto. Dalam kajian ini, sebuah UAV sayap tetap yang dilengkapi dengan kamera digital diterbangkan di atas kampus Universiti Teknologi Malaysia pada ketinggian 300 m bagi perolehan imej udara digital. Kawasan kajian dibahagikan kepada : (i) kawasan kajian kecil Lingkaran Ilmu dengan keluasan anggaran 35000 m^2 dan (ii) kawasan kajian besar UTM dengan anggaran 7000000 m^2. Kawasan kajian yang berbeza keluasan ini digunakan untuk mengkaji kesan teknik GPS yang berbeza. Dalam kajian ini, kedudukan GCP adalah bertaburan secara seimbang dalam kedua-dua kawasan kajian dan GCP ditubuhkan dengan menggunakan tiga teknik GPS yang berbeza: i) statik relatif, ii) statik mutlak dan ii) rangkaian masa hakiki kinematik (NRTK). Penilaian ketepatan dijalankan dengan membandingkan ortofoto dengan nilai rujukan berdasarkan titik semakan (CP) yang ditubuhkan dengan menggunakan teknik GPS. Keputusan menunjukkan bahawa punca min ralat kuasa dua (RMSE) bagi teknik NRTK adalah konsisten kecil, iaitu ± 0.39 m bagi kawasan kajian kecil dan ± 0.55 m bagi kawasan kajian besar. Bagi teknik statik relatif, RMSE menunjukkan keputusan yang tidak konsisten iaitu ± 1.61 m bagi kawasan kajian kecil dan ± 0.50 m bagi kawasan kajian besar. Manakala teknik statik mutlak memberikan RMSE terbesar iaitu ± 0.84 m bagi kajian kawasan kecil dan ± 2.27 m bagi kawasan kajian besar. Kesimpulannya, teknik NRTK terbukti sebagai teknik yang terbaik bagi penubuhan GCP dari segi ketepatan dan untuk UAS boleh digunakan untuk tujuan pemetaan.

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GCP	Ground Control Point
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GNSS	Global Navigation Satellite System
GPS	Global Positioning System
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ISK1	Iskandarnet1
RMSE	Root Means Square Error
TTC	Trimble Total Control
UAS	Unmanned Aerial Sytem
UAV	Unmanned Aerial Vehicle

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"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Master of Science (Geomatic Engineering)"

Signature	:	.....
Name of Supervisor I	:	PM Dr. Anuar bin Ahmad
Date	:	25 August 2016

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I declare that this thesis entitled "*Accuracy Assessment Of Ground Control Point Using Different Global Positioning System Techniques For Unmanned Aerial System Data* "is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	.....
Name	:	NURUL HUSNA BINTI AZIZ
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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Ground data collection is well known as a conventional method of data collection for mapping in land survey field. This method has been proven of being able to produce a very accurate set of data collection. This explained the reason why this method has been practiced and accepted worldwide for many centuries. However, there are a lot of obstacles in practicing this conventional method. It is a difficult, tedious and intense procedure especially when trying to cover a large area with dense human population and big buildings. It is compulsory for the conventional method to be improvised as it is time consuming, non-practical and non-economical in this new era of 21st century. A rapid development of hardware and software globally has significantly impacted surveying profession. It is a brilliant idea to improve the method of data collection for mapping. Improvement is required in the aspect of time, man labour as well as workers' safety. It is in line with today revolutionary era where productivity, effectiveness and efficiency are the priority.

Therefore, a new method has been introduced in land surveyor profession. This new method was innovatively improvised based on the conventional method. This method is called Unmanned Aerial System (UAS) or also known as a high altitude survey. UAS is a system which consists of an Unmanned Aerial Vehicle (UAV) to collect detail from sky view and Ground Control System (GCS) to control the UAV. This UAS systems offers many advantages and has shown that UAS is faster, environmental friendly and safer than the conventional method. In term of number of man labour, UAS method only involved two personal in the field during flying the UAV for data collection covering large area. Thus, this method could minimize the cost as well as reduce the safety risk while conducting the survey job. It has been proven that high altitude survey is better than ground survey in the aspect of time, value of money and labour management. However, the accuracy of UAS ranges from tens of centimetre to meter level (Kung *et al.*, 2011).

The purpose of this study is to investigate the best GPS technique to improve the accuracy of the ground control point (GCP) for UAS. There is certain way to improve the accuracy of the GCP approximately to centimeters level. In this study, three different techniques were investigate and compared to determine the best technique for GCP. GCP is usually determined using GPS observation for 10 to 15 minutes. This observation is called rapid static method. This technique of observation provides accuracy of centimeter level. GPS technique of observation determines the accuracy of GCP. There are certain GPS techniques that can be used in improving the accuracy of GCP.

The first technique is static observation which uses longer observation time. Static observation mostly takes minimum 30 minutes to an hour. Longer observation is better in term of accuracy and data redundancy especially for complex area. In the field of GPS, the network help to improve the accuracy of measurement as one point is relate to one another and help to increase the accuracy. Normally the static observation is

design in a form of network. The idea is to improve the accuracy of GCP by using static observation. Many GCPs will be observed simultaneously and this synchronization helps to tie-up each other data at every point. With good accuracy of GCP, the accuracy of the image from UAV could be improved respectively. It is expected that accuracy range from tens of centimeter can be achieved, which is far better than normal accuracy achieved from normal UAV flight session.

The second technique is the current technique used rapid static. This technique is included to used it as comparison and to show the improvement of the accuracy for others method. The last technique used is another Network method, network real time kinematic (NRTK). This technique provided real time data where post process is not required. This technique gets correction from at least three Continues Operating Reference Station (CORS). These techniques is studied and investigated to prove that the accuracy could be improved and time for data collection can be speed up for UAS.

1.2 Problem Statement

Various developments in photogrammetry had changed the need especially for mapping. Ground data collection is a process of data observation which can be done using total station and GPS. However, this conventional method is time consuming and non-economical to be practiced especially to cover a large area. There are a few reasons why this method is necessary to be improvised. First, a lot of man labour either professional land surveyor or amateur freelancer are required to collect the data from one point to another while carrying heavy total station. From all the movement and heavy lifting the workers may result in extreme fatigue and this will affect the accuracy of data collection.

On top of all, this repetitive task is time consuming as a surveyor spends hours at every station to collect all the details. This will take days and months to cover an area and almost impossible to collect data from a very large area. Next, as this conventional method is based on ground survey thus from one point to another the line of sight must be visible. This is very difficult to achieve especially in a crowded area such as in a residential area or in a developing city. The line is often been blocked by human made features – buildings, houses, bridges. Plus, there are areas that cannot be accessed by this conventional equipment for example forest, volcano, and beach. Or the areas cannot be accessed by the land surveyor him/herself because of safety reason.

Therefore, by using UAS technique this issues are not a problem anymore. The UAS method has been introduced to replace the ground data collection for better cost, time and labor management. Ground data collection required a team of surveyor to move from one station to another to collect data. On the other hand, UAS method only involved two personal in the field during flying the UAV for data collection covering large area. This technique could reduce the cost, time and man labour. Plus, the surveyor safety can be guarantee as he/she will only be in a field while conducting the survey job.

Normally, in aerial photogrammetry GCP observation uses GPS absolute static technique. The observations is done by set up a GPS instrument on a point for about 10 to 15 minutes and the correction is required from base station which is set up on known point. The step is repeated for all other GCP for the project. This procedure is repetitive and required lots of time and movement. Moreover, post process had to be done to obtain the coordinate value. The overall accuracy for this technique is up to tens of centimeter to meter level. However this type of accuracy is not good enough, thus better technique for GCP observation is studied to improve the accuracy of large scale mapping using UAS.

Therefore, other GPS technique for GCP observation is studied which included relative static and network real time kinematic (NRTK). Both techniques are expected to give better result in term of accuracy as well as to speed up the process of GPS observation. Based on GPS prospective, both techniques are capable to give a good accuracy for GCP up to centimeter level as both techniques are based on network form. As a network, the GPS observation could be improved as there are many corrections and also common error can be canceled. The detail of these GPS technique is discussed in Chapter 2.

1.3 Aim and Objectives of Study

The aim of this study is to assess the accuracy of mapping using UAS data based on GPS network techniques. The specific objectives are as follows:

I. To study the accuracy of different GPS techniques for establishment of GCP.

II. To evaluate the accuracy of the orthophoto produced by the UAS based on GPS technique for two different sizes of study area.

1.4 Significant of Study

Nowadays, the development of photogrammetry can be used to improve the method for mapping and keep up with the constantly changing world. Conventional method to update map is not convincing enough as too much time, cost, work and workers are needed. The best and the fastest GPS technique to determined GCP can be identified in this study to improve the UAS procedure. Consequently, the finding of this research can improved the accuracy of UAS for mapping using the most optimum GPS technique. Eventually UAS can be recognized as a method to update the map in survey field.

1.5 Scope of Work

This study was conducted at Universiti Teknologi Malaysia (UTM) surrounding Lingkaran Ilmu. The criteria of the study area are; varying in topography, balance in crowdedness, have clear sky view for GPS observation, and free of traffic disturbances. Figure 1.1 shows the study area for UTM large area and the blue box indicate Lingkaran ilmu which is small study area.

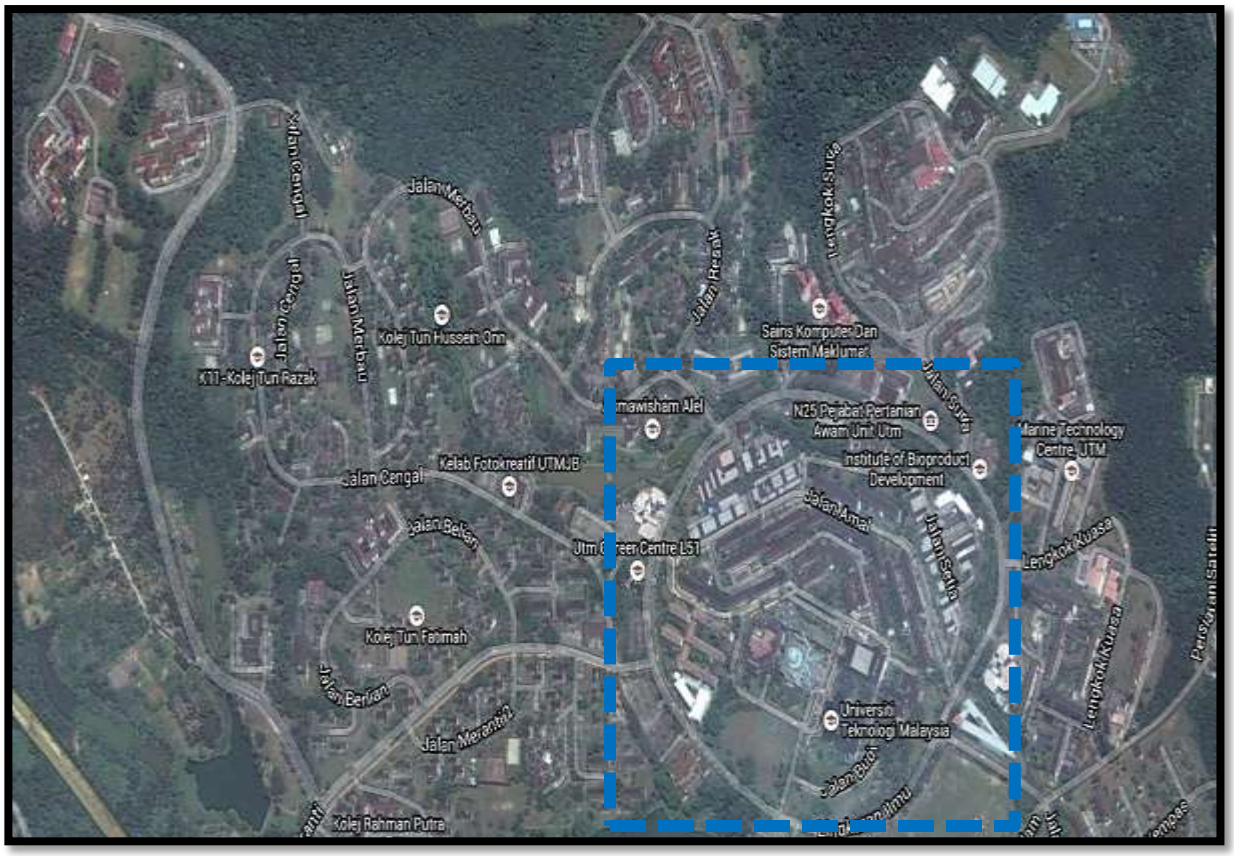

Figure 1.1: Area of Study.

There are three different GPS techniques used to be studied in this research; i) relative static, ii) absolute static and ii) network real time kinematic (NRTK). As the idea for precise mapping using UAV is demanding, the map accuracy need to be investigated. The Continues Operating Reference Station (CORS) was used for GPS processing is ISK1 at Faculty Geoinformation and Real Estate, UTM.

Data collection involved the use of fixed wing UAV known as Helang UAV that can be fully operated automatically (autonomous) from the ground. Moreover, the digital aerial images and video can be acquired simultaneously by using Helang UAV. The digital camera attached to the UAV is a nonmetric camera known as Canon SX230HS with image resolution of Canon 12 megapixel. The Helang UAV was flown on altitude of 300 m and speed at 40km/h.

The data processing involves the following:

1- Argisoft PhotoScan Pro software: This software was used to process the collected UAV digital aerial images. Subsequently, orthophoto will be produced.

2- Trimble Total Control software: GPS point observation is processed by using this software for establishment of GCP and check point (CP).

3- Global Mapper software: This software is used for data analysis

1.6 Research Methodology

Research methodology discusses the procedure for the whole step involved in this study. The stages include, literature review, project planning, data collection, data processing, result and analysis and finally the conclusion. Figure 1.2 shows the flow chart of research methodology.

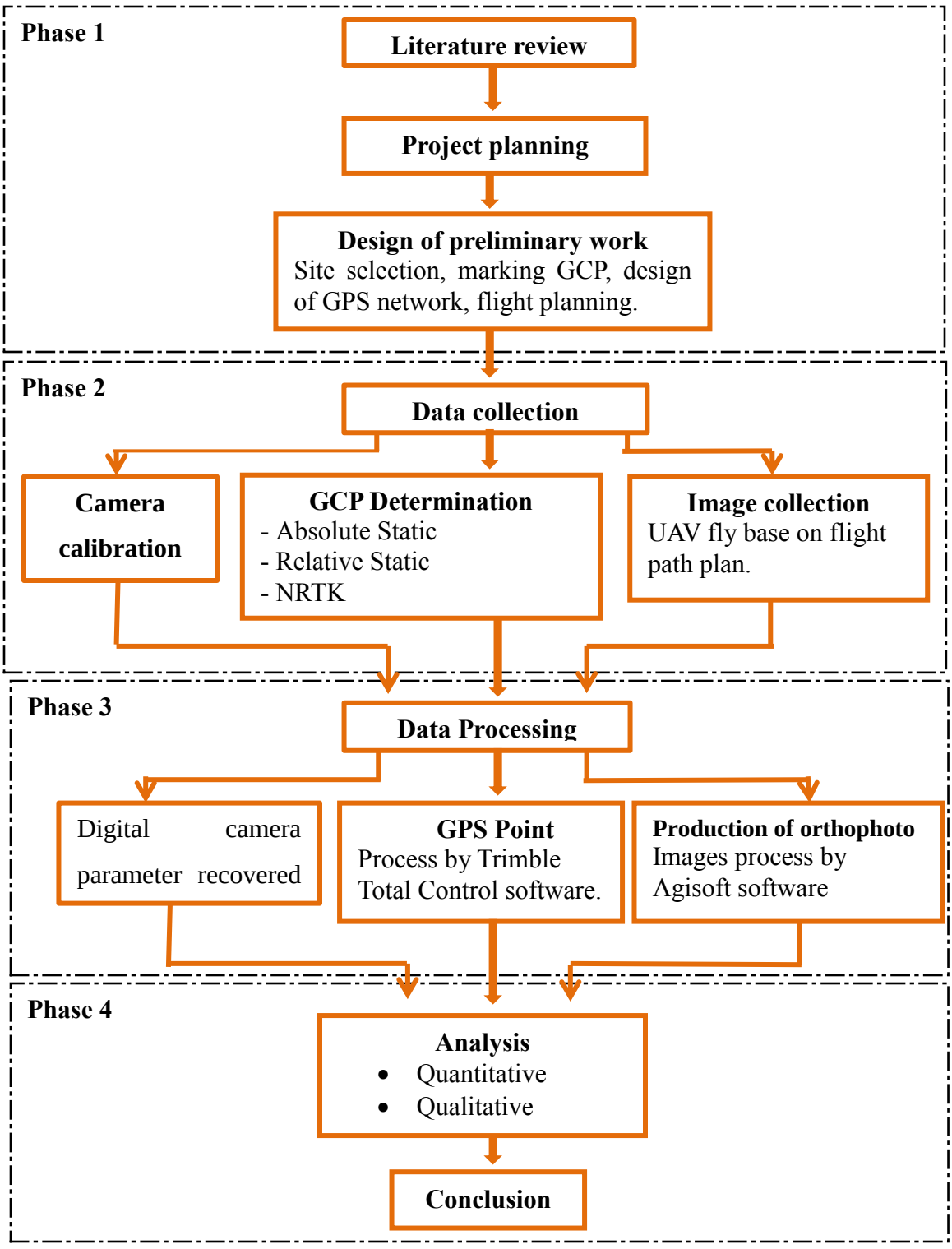

Figure 1.2: Flowchart of Research Methodology.

1.7 Thesis Outline

This thesis contains five chapters as follows:

Chapter 1: This chapter discusses the introduction of this study which compromise of background of study, problem statement, aim and objectives of study, significant of study, scope of study and research methodology.

Chapter 2: This chapter is the foundation of the study. It explains the previous study done by researcher around the world and it provides knowledge to complete this study. The knowledge area includes aerial photogrammetry, UAV, GPS and others.

Chapter 3: This chapter explains how this study is conducted. The explanation includes the step from beginning to the end, which comprise of data input, data processing, and results.

Chapter 4: The results or findings of this study are discussed in this chapter. Analyses are discussed in this chapter too.

Chapter 5: This chapter delivers the conclusion and recommendation for this study. This chapter concludes the research finding and achievement of research objectives. Finally, this chapter discussed the recommendation for future work.

5.2 Recommendation

This study managed to prove that UAS is an excellent system which has the good qualities for replacing the conventional ground survey. NRTK technique is applied to produce an accurate data of GCP which is then used in processing UAS data. Based on the finding from this study, the application of NRTK technique is the best and fastest technique in order to produce the most accurate data collection either small or large area. Therefore, NRTK technique is recommended to be applied in aerial survey to produce accurate coordinate of GCP for UAS. It is believed that the data accuracy of remote sensing can be improved by using NRTK technique, thus subsequently produce better accuracy of orthophoto. Therefore, it is recommended that UAS to be introduced globally to land surveyor as it will benefit the them at large.

For further study, it is recommended to be employed for bigger area. Small area could also be tested again as to confirm the result especially for relative static technique since it produces quite unexpected result. It is recommended for relative static technique to be repeated for even smaller. For study it, is also recommended to use rotary UAV as a platform for aerial image data collection.

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