The Fixed wing UAV usage on Land use Mapping for gazetted Royal land in Malaysia

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Abstract. The study deals with the usage of fixed wing unmanned aerial vehicle (UAV) in verifying boundary for gazetted royal land, which the other sight of efficacy of UAV has been tested in area of urban planning. The specific flight planning had been arranged and tested to royal land of Pekan in order to identify the settlement (kampongs) boundaries. Royal land in Pekan was the significant land that existed since 1919, which established under the Royal land Enactment 1919. It accommodated more five thousand residents in the 919 hectares of area with five villages (kampongs). The combination method of aerial mapping and vector digitization in structured a spatial database have been conducted by combining both output from UAV and GIS. The finding shows the royal land boundary was clearly identified in UAV orthophoto; further refine output of its database in GIS data. The additional info building footprints in 5 kampongs land lots also appeared very well in final output. Result shows that, the simple conclusion on the efficacy of fixed wing UAV in managing a land in urban planning, it also proved the dependency of decision makers should oriented more on geospatial applications since it was reliable and able to be used in many planning aspects in order to ensure a sustainability and resiliency of living.

Keywords: UAV, fixed wing, GIS, royal Land and urban planning

1. Introduction

Unmanned Aerial Vehicles (UAVs) are to be understood as unhabitated reusable motorized aerial vehicles [9,18]. It remotely controlled, semi-autonomous, autonomous or have a combination of these capabilities. UAV can be classified into two groups: rotary wing and fixed wing. Among the gigantic number of fixed wing’s applications, surveillance seems to be the most common [16]. A fixed-wing drone is generally composed of a central body, which houses all the drone's electronics, and two wings. The aerodynamic profile of the wings enables the drone, once in flight, to generate lift that compensates for the weight of the aircraft. The recognition of UAVs as a powerful geospatial information acquisition tool is ubiquitous. Furthermore, the main benefit using UAVs that it can be used in high risk situation without endangering human life in inaccessible area. Moreover, it has the real time capability and ability for fast data acquisition. In addition, due to low operating altitude, UAVs achieve a very high resolution, in terms of ground sampling [5]. Fixed wing UAVs are used in numerous very huge number of fields consist of archeology, architecture, land surveying, land registry and many types of applications in urban planning [18,11,1]. Every mapping project is unique; even within the same industry, each project will have its own distinct challenges. Selecting the right equipment is therefore key to getting
the job done. Unmanned aerial vehicles (UAVs) or drone have emerged as a solution for many mapping and surveying projects including giving a solution for land use matters. The utilization of UAV in urban planning become more important in recent. Not only subject to bird eyes observation on video capturing, but it goes beyond mapping to the advance analysis of pairing with digital photogrammetry such laser scanning and GIS technologies [18].

Royal land or crownland or demesne in certain countries is territorial area belong to monarch, who personifies the crown [25,19,14]. Specifically, Malay royal land related to royal town, which is royal town has been described as a town that has a strong relationship between the community, defense fortress and the king fort where by the royal administrative district are located [22,23,12]. The Malay royal town are scattered around peninsula Malaysia consist of Arau (Perlis), Anak Bukit (Kedah), Kuala Kangsar (Perak), Klang (Selangor), Sri Menanti (Negeri Sembilan), Muar (Johor), Pekan (Pahang), Kuala Terengganu (Terengganu) and Kota Bharu (Kelantan) [23,22]. The component of land use for royal town includes a king”s palace, traditional Malay settlements and fortification systems; with, commonly having eight (8) prominent physical character namely, royal palace complex, fortress, mosque, public open space, marketplace, settlement, gateway, river and jetty. Royal town has been described as a historic town that has a good quality of cultural, historical significance and have a good relation between the community and the development of the urban setting. The settlement becoming residential district; market place and jetty farming commercial districts. Therefore, this study attempts to use of fixed wing unmanned aerial vehicle (UAV) in mapping a land lot boundary for gazette royal land settlement, which the other sight of efficacy of UAV has been tested in area of urban planning. Prospective site was identified based on oral tradition, written record and inspection using images [7,13,12]. In this study, the specific flight planning had been arranged and tested to royal land of Pekan in order to identify the settlement (kampongs) boundaries. The combination method of aerial mapping and vector digitization in structured a spatial database have been conducted by combining both output from UAV and GIS. This is expected able to assist the palace administration in order to manage their geospatial databases efficiently.

2. study Area

The study area was approximately 1849.09 acres in size and was conducted in Pekan, Pahang. Its name comes from a flower, the *Bunga Pekan*. The royal land of Pekan is situated nearest Pahang river at the coordinate location of 3.48395 latitude and 103.385010 longitude, 70km from its capital city of Pahang which is Kuantan (Figure 1).

![Figure 1: The study area located in specific geographical coordinates.](image_url)
Buluh, iv) Kg.Pekan lama and vi) Kg.Padang Polo (Bernama,2019). The royal land was existed a hundred years ago under the Royal Land enactment 1919 (Enakmen Tanah Kesultanan, 1919). The rule of settlement commonly was rewarded by the King to their selected citizens that give their services to the palace and kingdom. The land tenants are required to pay a low land tax to the king upon their settlement.

3. Material and Methods

The general mapping process shows the outlines of main stages in our study. The three main stages consisted of data preparation, data pre-processing, and post processing. In data preparation, we have collected and used three types of data that obtained from the source of fixed wing UAVs, cadastral royal land lot, and additional GIS vector data for recent land use information in study area. The vector also contain cadastral sheet of royal land was obtained from Palace office and Pekan Local Authority. The used flight system used for mapping was a fixed wing radius by Shengzen Joyton Technology. This smallest and lighter professional hand-launched mapping drone which guarantee good flight stability with wind resistance < 6 force 6 wind. Flight times of up to 85 min with a maximum payload capacity of 200g are possible. The maximum takeoff weight should not exceed 0.98kg (Table 1).

Table 1: Specification of UAV data acquisition for study area

| Types of Data                              | Radius Fixed Wing         |
|--------------------------------------------|----------------------------|
| Aircraft weight                            | 0.98kg                     |
| Endurance                                  | 85 minutes                 |
| Maximum Payload                            | 200g                       |
| Battery                                    | 11.1V, 6400mAh Li-on Battery |
| Wingspan                                   | 920mm                      |
| Max.Flight height                          | 3500m AMSL                 |
| Camera Model                               | DSC-WX220                  |
| Cadastral Sheet for Royal Land from Palace office |                          |
| Land use vector database Pekan Municipal Authority |                      |

For position determination, the UAV is equipped with a GNSS, a barometric height sensor, a compass and an inertial measurement unit (IMU). While flying on the path that has been defined during the flight planning, the device can hold its own position via GPS (Global Positioning System) information. For this project, the UAV was equipped with a DSC-WX220 RGB sensor model. The camera can be tilted to any angle along the vertical and horizontal axis.

Table 2: Specification of Radius Fixed wing data acquisition information for study area

| Parameters            | Specification   |
|-----------------------|-----------------|
| Number of images      | 1903            |
| Projection            | WGS 84          |
| Number of Take off    | 3 Take off      |
| Timing (morning)      | 2.30 hours      |
| Sensor Types          | RGB             |
| Ground resolution (GSD) | 9.19cm/pixel  |
| Coverage area         | 16.3 sqkm       |
| Flying altitude       | 378m            |
| Overlapped (Side/front) | 70/60         |
With the provided flight planning software of Joyton, flight missions are planned for autonomous flights with the specific parameters as in table 2. The flight planning process was obtained based on few planning steps such as i) defined the mission area, resolution and overlap, ii) generate 3D flight planning, iii) Define take-off and landing points, iv) monitor and adapt during flight v) Launching drone and vi) in flight monitoring. This fixed wing UAV is therefore suitable for aerial photography, verification and mapping from the air. The transmission time for live view is instantaneous. However, the images are stored on the flash-card of the camera mounted on the UAV for further processing at the later stage. The UAV method for the acquisition of geodata is based on good and appropriate flight planning. In this project, a set of flight mission flown according the specific parameters to suit the purpose of output. The waypoint has been established covers the specific area of study and extended about 5km in radius. The flight was flown at the altitude of 350meters with 3 times take off in duration of 2.5 hours. Additionally, the front and side lap were used: 70/60 and the desire spatial resolution of digital maps (ground sampling distance) for this study was determined based on ground covered by one pixel (p) in the image and is a function of the resolution of the camera sensor, the focal length (f) of the camera and the flying height (H = the distance between camera and ground) (Barnes et al., 2014). The formula is:

\[
\frac{\text{GSD}}{p} = \frac{H}{f}
\]

In figure 2 (b) the waypoint that established in flight planning for the study area is shown, using the Joyton provided the UAV manufacturer.

**Figure 2:** Data preparation and pre-processing stage a) Waypoint that established for the site and b) mosaicking process that combined 1903 images that obtained from the UAV.

In the pre-processing stage, the UAV flight output was processed without ground control points (GCPs). In the former case, GCPs and the georeferenced information registered by the UAV’s autopilot were used in the aerial triangulation phase to accurately place the photogrammetric block into a coordinate reference system (CRS). The main photogrammetry process is divided into 3 main stages: aerial triangulation, Digital Surface Modeling (DSM) and orthomosaicking that involved 1903 images of UAV captured in earlier stage (Fig. 2b). The post processing stage is involved royal land digitization and extracting the building footprint for the land lot. The individual land lot within the royal land boundary was digitized and the orthophoto was performed the semi-automatic building footprint process in order to extract the building footprint for every settlement in that royal land. Then further were being overlapped to get the final result of complete geospatial mapping of royal land and its settlements.

### 4.0 Result and Discussion

A total one mission was flown, with a specific procedure has been determined during flight planning setup. Result of preprocessing stage has produced the digital surface model (DSM) and orthophoto after mosaicking 1903 images of the site. Figure 3 shows the output of orthophoto and DSM, from the point
of view of image interpretation, a good spatial resolution of ±9cm per pixel (GSD) has been obtained and the image shows clearly the location of site and its component of land uses (road, building, palace, field and mosque) and DSM result shows the acceptable resolution per pixel and cloud point density per square meter as stated in caption.

![Figure 3: a) The result of orthophoto and b) Digital surface model for Pekan; resolution of 18.4cm/pixel; and point density of 29.621 points per square meter (Sqm).](image)

The further result obtained in the post processing stage are the data acquisition process that involve the digitization and extracting building footprint for the settlement building in study area (Figure 4).

![Figure 4: Result of post processing showing the result of digitization for royal land of Pekan a) Overlaid with Orthophoto; b) Overlaid with vector map.](image)

The final result of mapping is assembling data with building footprint. Building footprint was performed in ArcScan functions generated vector (line of building) from orthomosaic raster file. The output of vectorization is sufficient in order to extract building settlement in royal land area. The building able to extract settlement boundaries from aerial image; based on image contrast and its textures.
**Figure 5:** Result of land verification – royal that has been overlaid with land based on Orthophoto output

**Figure 6:** The final map for gazette Royal land showing land lot and building footprint that cover five villages.
The result indicated that the efficacy of fixed wing orthophoto in extracting building footprint can easily assimilate by virtual analysis. The clarity of element of royal town and location of each settlements within the land lot boundaries was clearly depicted on the map. It clearly shows the evidence in previous findings that’s stated the royal town has a strong relationship with community on their finest connection with the settlers and surrounding urban growth. The result also proved that, the theories on Malay royal town settings that basically from form a single center district that centralized between field, mosque and palace complex. The settlement area that commonly located at the back and surrounding of king palace was clearly presented in the figure 5 and 6. The settlement area was the supporting character that make identity of Malay royal town highlighted.

5. Conclusion

This study has shown that UAV system are useful complements for heritage mapping. In this study, we have presented a result of the efficacy of UAVs approach in mapping royal land lot in Pekan Pahang. Specifically, the UAV mapping technique was used based on a few stages of preparation that involve the data preparation, procedure step in flight planning, pre-processing and post processing in determining the desire output for this study. The result indicate the UAVs approach coupled with advanced geospatial technology of GIS could quickly achieve the detail mapping for gazette royal land. Concerning spatial resolution, an appropriate flight planning procedure considered as an important parameter because of the degree detail achieved in the orthomosaic image to be used to for analysis and study in detailed mapping context. Additionally, adequate values of altitude, front and side overlap and GSD settings have to be applied because of their impact on flight duration and positional accuracy of absolute and relative accuracy obtained. Whenever possible, higher percentages of forward and side overlap are recommended for UAV flights. It also shows that the UAV approach with appropriate photogrammetric evaluation methods offers a great potential to gain information from the captured data that are useful for cadastral applications and this case the gazette royal land. These derivates from UAV measurements can present a great additional benefit to users of cadastral data, such as urban planners, architectures and conservators.

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