UAV Photogrammetry Implementation Based on GNSS CORS UDIP to Enhance Cadastral Surveying and Monitoring Urban Development (Case Study: Ngresep Semarang)

B D Yuwono[1*], A Suprayogi[1], R Azeriansyah[1] and D Nukita[1]

[1]Geodesy Department, Faculty of Engineering, Diponegoro University, Tembalang-Semarang, Postcode 50277, Indonesia

bdyuwono92@gmail.com

Abstract. Unmanned Aerial Vehicle is unique to the field of mechanic which has the ability to fly through the air without a human operator on board, and perform complex and viable option for a number of different tasks, monitoring, coastal environment, cadastre, earthwork analysis. Land Registration is a major issue encountered in developing countries such as Indonesia. Registration of land that had been done in the form of terrestrial measurements expected to be addressed in the next few decades. Monitoring of urban development became a critical problem for urban planning. UAV technology is obtained is used as an alternative to accelerate both processes. The method used in this UAV is photogrammetry to obtain ortho map. The aim of this research is to evaluate the use of UAVs photogrammetry based on GNSS CORS UDIP to enhance cadastral survey and monitoring urban development.

Keyword: Land Registration, UAV Photogrammetry, Orthomap

1. Introduction

The land Surveying which related to the law and land ownership and the definition of property of boundary called cadastral surveying. It consists of interpreting and advising on boundary locations, on the status of land ownership and on the rights, restrictions, and interests in property, as well as the recording of such information for use on plans, maps, etc. It does the physical delineation of property boundaries and determination of dimensions, areas and certain rights associated with properties, whether they are on land, water or defined by natural or artificial features.

Cadastral surveys are generally performed to subdivide the land into parcels for ownership under a land title and to re-establish boundaries of previously surveyed properties to determine the physical extent of ownership or to facilitate the transfer of the property title. Cadastral survey became a part of land registration. Acceleration of registration of land is an urgent issue to be addressed urgently. [1] concluded the latest technology in the field of measurement and mapping and the Community involvement is needed to solve the problem. The method used for measuring the terrestrial mapping exercise with a number of 48 million packages will still be certified [2]. As a result, at the current rate, Indonesia required about 33 years to complete the mapping. Driven by the increased need for information on land in various fields, as well as a number of projects related to increasing land registration agencies with regard to the problem of land became the focus of improvements that are consistent with cost and time savings.

Land administration function can put the needs of the different and varied depending on geography and density of land use [4]. Therefore, when determining the technology and investment choices, the design approach must be "fit-for-purpose" that meets the needs of today's society and can gradually be increased from time to time - not follow the standard exists [5]. The use of UAV orthoimage is also for updating cadastral maps [7].

This research is going to seek to develop a new approach using UAV to support the cadastral boundary data acquisition and enhancing the application of photogrammetry UAV for identifying the hazard and urban development.

2. Data and Methods

The new phenomenon in the technology of photogrammetry applied in positioning is UAV. Unmanned aerial vehicles (UAVs) reached popularity in remote sensing because of they provide a rapid, low-cost and flexible acquisition system and produce a high-resolution data including digital especially of Digital surface models (DSMs), orthoimages and point clouds [3]. UAV can be applied in form 2D and 3D information from acquired images. UAV for 3D Data Recording shown in Figure 1**.**

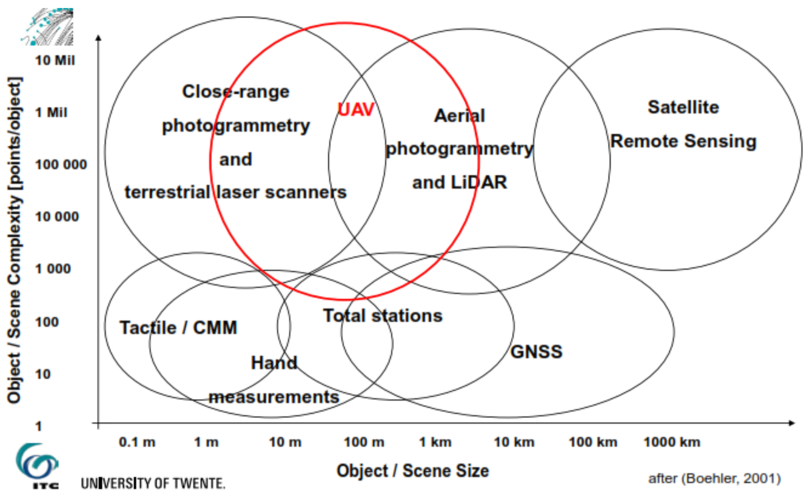


Figure 1. UAV Data for 3D Recording [8]

Cadastral mapping has become a part of the application for UAVs [6]. Cadastral maps show the extent, value and ownership of land, are combinable with a corresponding register and are considered crucial for a continuous and sustainable recording of land rights Using Manual delineation of visible cadastral boundary.is the next level after UAV Processing. An overview of case studies investigating the potential of UAVs for cadastral mapping and their approaches for boundary delineation is provided in

The methodology research framework that has been conceptualized around the central aim of automated feature extraction for cadastral boundary delineation and monitoring urban development. The framework includes four research objectives of which the first one is based on a literature review and the remaining three consist of the technical design and realization of the boundary delineation tool taking into account different spatial data sources.

2.1. Data Capture

The Study used a DJI Phantom 3 Professional equipped with a compact Sony EXMOR 12,4 M camera with a FOV 94° 20 mm lens. The platform has a single-frequency GPS receiver and IMU,

IOP Conf. Series: Earth and Environmental Science **165** (2018) 012031 doi:10.1088/1755-1315/165/1/012031

which enables registration of approximate components of the external reference for each image. The UAV can fly at the altitude of 75-750 m and the design overlap of pictures it can take ranges from 60 to 90 percent. For control point will be conducted using GPS Geodetic Surve which GNSS CORS UDIP as Base Station. To observed control point using GPS Geodetic Topcon Hiper II and Hiper Gb.

Table 1. Test package

No	Parameter	Description
1.	Number of rows	4
2.	Camera / focal length [mm]	3,61
3.	Overlap (along/cros track direction)[%]	65/50
4.	Flight Altitude [m]	182m
5.	Camera Matrix pixel	1,56 μm

Reseach conducted with test package consisted of 1.387 digital photos taken by 4 independent flights within a single mission in Ngresep, Tembalang shown in table 1. The study measured coordinates of the 15 benchmark (12 for control and 3 for checkpoints. The coordinate of Benchmark was measured with Static GPS survey with two hours observation with the longest baseline about 3,181 km. The root means square error of coordinate was approx. 0.0058 m. Can be seen in Figure 2.

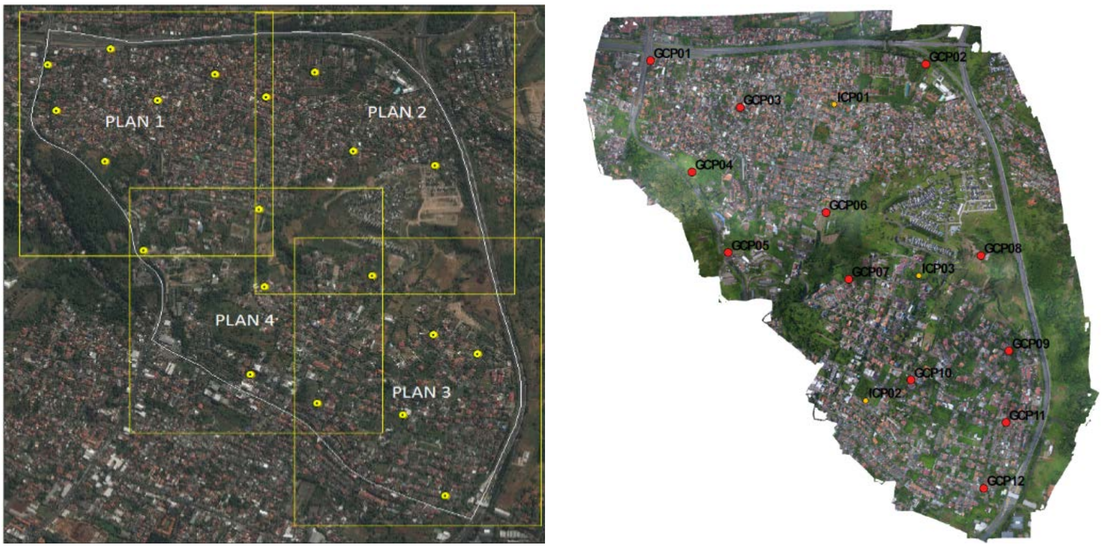


Figure 2. Design Flight and distribution of GCP [10]

2.2. Data Processing

After processing shown the mean error of a typical observation was 1.56 µm / pixel. The root means square errors in X Y positioning of the control points ranges from 0.0019 to 0.0032 And for the independent control point RMS errors ranged from 0.0372 to 0.0607 seen in Table 2.

Table 2. Accuracy of UAV

Items	Decription
σ0 [μm] /[pix]	1,56
Number of Control Points	12
Number of Check Points	3
RMS error for control point (X,Y,Z} [m]	0,0032; 0,0048; 0,0019

IOP Conf. Series: Earth and Environmental Science **165** (2018) 012031 doi:10.1088/1755-1315/165/1/012031

Items	Decription
RMS error for control check point (X,Y,Z) [m]	0,0607; 0,0411; 0,0372

2.3. Ground Sample Desain

The digitized results obtained in this study used baseline data from orthophoto obtained from the aerial photography. This aerial photography using UAV aircraft with the value of GSD (Ground Sampling Distance) 7,8648 cm/pixel. GSD is a pixel size value on the ground surface that is used as reference specifications of photographic images. This GSD calculation is based on the SNI aerial photogrammetry which can be calculated as follows:

$$GSD = \frac{Flight\ Height}{Focus\ Lenght} x\ pixel \quad (1)$$

Based on the above formula obtained GSD value of equal to 7.8648 cm.

Geometric precision is done by calculating the value of CE90 and LE90. The formula to find CE90 can be seen in the formula (2) the RMSe used in accordance with RMSe Report results checkpoints on the results orthorectification. The geometry accuracy testing referring to Geospatial Agency Regulation No. 15 the year 2014. About the Technical Guidelines, Basic Map Accuracy can be seen in Table 3.

$$CE90 = 1.5175\ X\ RMSE_r \quad (2)$$

$$LE90 = 1.5175\ X\ RMSE_z \quad (3)$$

Base on equation 2 and 3, It can be conclude that both vertical and horizontal accuracy reach Map scale 1: 1000 class 1. For detail can be seen at Table 3.

Table 3 Accuracy of UAV

RMS_E (m)	CE90 (m)	Maps Scale	class
0.0735	0.1212	1 :1000	1
RMS_Z(m)	**LE90 (m)**	**Maps Scale**	**class**
0.0373	0.0566	1 :1000	1

3. Result and Discussion

3.1. Comparison Land Registration Map and Orthophoto UAV

Characteristic of Land Registration Map is a thematic map, the map that informs about the shape, boundary, location, field number of each parcel and used for field accounting purposes.. The various of cadaster map scale are 1: 1000, 1: 2500 and 10.000. The boundaries of parcels identified on the map should be measured in the field (Regulation of The State Minister of Agrarian Affairs /BPN No.3 Year 1997). One of several the cadastral map functions is as the accounting of land parcels and preventing double registration. Any change or addition of parcel will be on registered map sheet and shall be drawn on the map. It’s not necessary to put a building on the cadastral map unless they are used for the reconstruction of the plot boundary.

The analysis is done by comparing Land Registered Map and The delineation boundary from Orthophoto UAV. In this study, we used Land registration map with scale 1: 2500. The stereo plotting process is based on the appearance of the visible object on the aerial photograph. The digitized objects from the aerial photograph are a settlement, housing, vacant lot.

Figure 3. Orthoimage based on UAV imagery with vector layers of boundary vacant lot

To analyze the quality of the geometric orthoimage, accuracy was analyzed in absolute terms by reference to an independent control measurement. Accuracy can be expressed as the root mean square errors:

$$m_{ortho} = \sqrt{\left(\frac{d}{n}\right)} \quad (4)$$

d = deviation means the area base on Land Registration Map and area on the orthoimages to area determined in Orthophoto
n = number point

The analysis taken after comparing the area and the field distance that has been registered, there was delineation method with fix boundary and general boundary methods. Fix boundary is presented by the Land Registration Map of the data plots conducted from the registration measurement land in the field. Besides the general boundary method performed on orthophoto UAV Image. Reference data is the data area of the result of the fixed boundary. The large value of the residuals illustrated the disparities of the boundaries and areas of the parcel which might have caused by the systematic error of the method to delineate the boundaries. The analysis data divided in type vacant lot and residential area. The vacant lot means that there are not have the boundary at surrounding parcels. Base on equation (4) geometric accuracy of orthophoto at vacant area reaches 0.04. Delineation of the Vacant lot can be seen in figure 3. The percentage of area difference average between land registration map and orthophoto is 17 %. The Detail of comparison the parcels of the vacant lot can be seen at Table 4.

Table 4 Vacant lot Comparison

Parcel	**Orthophoto (m^2)**	**Land Registered (m^2)**	**Differences (%)**
1644/1643	379,594	396,594	17
2375	3033,324	3016,317	17

Table 5 shows there are some significant differences exist in the parcel boundary with the parcels Id; 1648, and 1646 with a different area of 8.26 m2 and 7,84m2. The causes significant difference area among others; (1) the one side of the corner boundary grow large trees that pre-mark is not visible, (2) some of the boundary monument has been move. Base on equation (4) geometric of orthophoto at residential area reaches 0.35 [11]. Based on the tolerance of National Land Agency, among 19 parcels studied, there are parcels that fulfill the tolerances and three others do not fulfill tolerances. The percentage of area difference average between land registration map. and orthophoto is 4,10%. Comparative analysis of area to know the difference of area is done by using paired t-test (paired sample t-test). In table 6 shown t_{obs} = 2,324 and t_{crit} = 2,10. *Since* $t_{obs} > t_{crit}$ we reject the null hypothesis and conclude with 95% confidence that the difference in area orthophoto and Land Registered Map has a significant difference seen at Table 6.

Table 5 Comparison UAV Photogrametry and Land Registration Map

Parcel	Orthophoto (m^2)	Land Registered (m^2)	Diffrences %	Parcel	Orthophoto (m^2)	Land Registered (m^2)	Differences %
2491	215,166	220,000	5	1646	182,599	190,436	8
2490	216,909	220,000	3	1645	181,023	186,254	5
2489	221,143	220,000	1	2260	260,987	266,987	6
2488	223,848	220,000	4	2257	198,465	200,000	2
2487	216,769	220,000	3	2256	198,969	200,000	1
2486	219,787	220,000	0	2254	203,003	200,000	3
2485	266,639	264,000	3	2253	196,956	202,259	5
2117	320,337	316,693	4	2250	195,195	203,044	8
1648	220,656	228,934	8	2249	193,976	200,000	6
1647	186,406	183,229	3				

Figure 4. Orthoimage base on UAV imagery with vector layer of residential area

Table 6 t-test (t paired sample test)

	Land Registered	*Orthophoto*
Mean	219,044	216,7806842
Variance	1062,385781	1158,377585
Observations	19	19
Pearson Correlation	0,992815365	
Hypothesized Mean Difference	0	
df	18	

	Land Registered	*Orthophoto*
t Stat	2,324300506	
P(T<=t) one-tail	0,016005735	
t Critical one-tail	1,734063607	
P(T<=t) two-tail	0,032011469	
t Critical two-tail	2,10092204	

3.2. Hazard dan Urban Development Monitoring

The need of land use map due to rapid growth in urbanization and industrialization, there is pressure on land, water, and environment. Urban sprawl may be found everywhere in the major city. The principle difference between land cover and land use. Land cover is the that which covers the surface of the earth and land use describe how the land cover is modified. For urban and spatial planning the land use is indispensable. A map that describes the information on the distribution of land utilization Area. Land use is a tangible manifestation of the influence of human activity on some physical surface of the earth.

Identification of land use and land cover is made easier by using orthophoto UAV image. Caused among others the visualization of the study object becomes clearer and has a large map scale. The results of orthophoto UAV analysis indicate that there are housing, residential area, trades, landslides, and open space was detected clearly. The figure 5 shown comparison between land use map and orthophoto image. The map of Orthophoto shows some changes land use. Changes in the land use include conservation became settlement and conservation area became trade area.

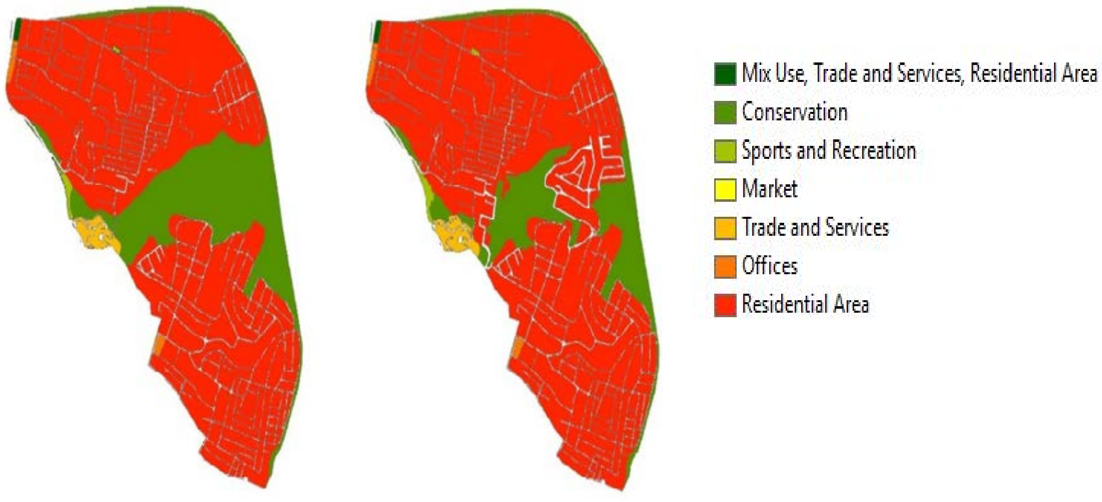
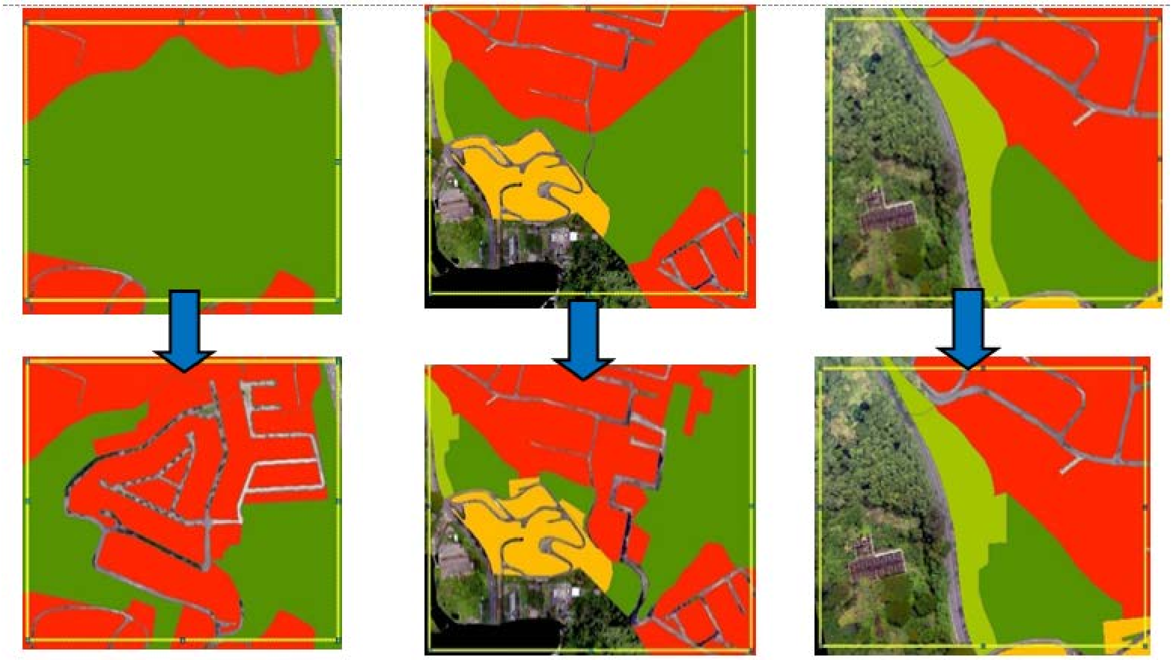


Figure 5. Comparison of landuse area observed by (a) UAV and (b) land use map

The Detail of land use can be seen in figure 6. (a) and (b) Shown the changes area from conservation became the residential area. The figure (c) Increasing of trade and service area.



(a) Residential Area (b) Residential Area) (c) Trade and Service

Figure 6. Orthoimage base on UAV imagery

The detail of each area of land use map has been evaluated using Orthophoto. Change for settlement increased by 15.94 ha, while for trade area increased by 0.2 ha.Table 7 shown comparison between orthophoto map and land use map. The map is consist of Mix Use, Trade and service, Residential Area, Conservation, Sport and Recreation, Market, Trade and Services, Offices and Residential Area.Resume of the calculated area can be seen at Table 7.

Table. 7 Comparation between Orthophoto digitation and Land Use Map

Area	Land Use Map (Ha)	Orthophoto (Ha)
Mix Use, Trade and Service,Residential Area	0,395	0,395
Conservation	48,776	32,834
Sport and Recreation	0,893	1,012
Market	0,012	0,012
Trade and Service	2,656	2,863
Office	1,109	1,109
Residential Area	175,312	187,367

Figure 7. Landslide identification base on UAV imagery [10]

Figure 7 show that there are several differences between area observed by UAV and landuse map. On the UAV orthophoto looks that the area is a housing estate area whereas land use map is a consevation area. One of the advantages of the orthophoto observed by UAV map is to identify landslide. Figure 7 about 2 landslide area which located in ngesrep.

4. Conclusion

This research has been conducted to prove that UAV photogrammetry could provide the accuracy for horizontal scale1: 1000. By using UAV can be generated an orthophoto which can be used for delineation of parcels boundaries. This technology can achieve an accuracy of GSD 7.86 cm. The results have sufficient standards to be used as a base map. The result represents the residuals between observed and referenced value from the model fitness toward the data, the smaller the value, the closer the result is to the data. The difficulty encountered from data acquisition with UAV to enhance cadastral mapping is is the delineation of borders to field boundaries. Because actually in field observation not all boundaries of the object clearly visible. UAV platform has good ability in terms of area identification and visualization, especially for land use and landslide hazard.

References.

[1] Anshari R 2007 The Indonesia Land Administration System Decision Makers Meeting : Good Administration of Land in Asia and the Pacific: Land Administration for Poverty Reduction and Economic Growth: Tokyo Japan 21-22 June 2007 1–6

[2] Abidin, H Z, Haroen, T S, Adiyanto F H, Andreas H, Gumilar I, Mudita I and Soemarto I 2015 On the Establishment and Implementation of GPS CORS for Cadastral Surveying and Mapping in Indonesia Survey Review 47(340) 61–70 doi:10.1179/1752270614Y.0000000094

[3] Colomina I and Molina P 2014 Unmanned aerial systems for photogrammetry and remote sensing: A review *ISPRS J Photogrammetri Remote Sensing* **92** 79–97

[4] Enemark S 2013 Fit-for-Purpose: Building Spatial Frameworks for Sustainable and Transparent Land. Governance. *Land and Poverty Conference 2013 The World Bank*. Retrieved from

http://vbn.aau.dk/ws/files/77941985/Washington_2013._Paper._Enemark._WB_Land_and_P over ty_Conf._docx.pdf

[5] Enemark S, Bell K C, Robin C L and McLaren R 2014 Fit-For-Purpose Land Administration ISBN 978-87-92853-11-0 2015 *International Federation of Surveyors (FIG) Geospasial Agency Regulation* No. 15 year 2014

[6] Manyoky M, Theiler P, Steudler D and Eisenbeiss H 2011 Unmanned aerial vehicle in cadastral *applications. Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci* **63** 1–6

[7] Kedzierski M, Fryskowska A, Wierzbicki D and Delis P 2015 Cadastral Mapping Based on UAV Imagery *15th International Scientifi c and Technical Conference* “From imagery to map: digital photogrammetric technologies”

[8] Nex F and Remondino F 2014 UAV for 3D mapping applications a review https :// www.researchgate.net /publication /260529522

[9] Regulation of The State Minister of Agrarian Affairs / Head of National Land Agency on Provision of Land Registration Pub L No. 3 1997

[10] Reyhan A 2017 Identification Analysis Impat of Landslide hazard using UAV (Aerial Vehicle (UAV) (Case Study: Ngesrep, Semarang) Under gradute Geodetic Department Diponegoro University

[11] Rokhmana C A and Utomo S 2016 The Low-Cost UAV-Based Remote Sensing System Capabilities for Large Scale Cadaster Mapping. *IOP Conference Series: Earth and Environmental Science* numbered section of the paper

Acknowledgment

Authors would like thank Faculty of Engineering Diponegoro University for supporting the research funding, and also BPN Kota Semarang who has permitted field data collection at research area.