

**VERIFICATION OF SUITABLE HEIGHT DATA ACQUISITION
METHOD FOR THREE-DIMENSIONAL NATIONAL DIGITAL
CADASTRAL DATABASE**

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VERIFICATION OF SUITABLE HEIGHT DATA ACQUISITION METHOD FOR
THREE-DIMENSIONAL NATIONAL DIGITAL CADASTRAL DATABASE

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DEDICATION

To my dearest family,

My beloved parents Abdul Rahim bin Abdul Wahab and Norishah binti Mat Noh, my sister Adilah and my brother Ariff, thank you so much for all advices and care. Without the supports from all of you, it will be hard for me to go through every difficulty during my master study. I am lost for words to express how thankful I am towards you, precious people of my life. I hope I really made you guys proud. Thanks and love you so much!

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ABSTRACT

This thesis presents a study on methods of height data acquisition towards the implementation of three-dimensional coordinates for three-dimensional National Digital Cadastral Database. At present, Malaysia's cadastre system uses a two-dimensional system. This current system stores information in two-dimensional coordinates planimetric. The existing system is barely providing more realistic and meaningful information to users. The Department of Survey and Mapping Malaysia is trying to develop a hybrid cadastre model by adding three-dimensional coordinates into land parcels. Somehow, there are some matters must take into consideration. One of the matters is the method of data collection. This study is an attempt to verify some possible techniques for data collection of X, Y, and Z coordinates. In this research, the height data is extracted from three different sources which are data from Light Detection and Ranging positioning, Global Positioning System, and topographic digital map. Then, a comparison between those techniques is made by considering the difference in accuracy of height values and other aspects related. The final output is the suitable method for data acquisition in which all three methods are best for implementation by depending on the availability of data at specific area and the usage of them for certain applications. The method selected in the final result is practical to be applied based on Malaysian cadastral environment.

ABSTRAK

Kajian ini menerangkan tentang pemilihan kaedah kutipan data ketinggian bagi pelaksanaan koordinat tiga dimensi untuk diaplikasikan dalam Sistem Pangkalan Data Kadaster Tiga Dimensi Digital Kebangsaan. Pada masa kini, sistem kadaster di Malaysia menggunakan sistem dua dimensi. Sistem ini menyimpan maklumat dalam bentuk koordinat dua dimensi planimetrik. Sistem sedia ada hampir tidak menyediakan maklumat yang lebih realistik dan bermakna kepada pengguna. Jabatan Ukur dan Pemetaan Malaysia cuba membangunkan model kadaster hibrid dengan menambah koordinat tiga dimensi ke dalam petak lot. Namun demikian, masih terdapat beberapa faktor penting yang perlu diambil kira. Salah satu faktor tersebut adalah kaedah kutipan data. Tesis ini akan mengkaji beberapa teknik yang boleh digunakan untuk kutipan data X, Y, dan Z. Dalam kajian ini, data ketinggian diekstrak dari tiga sumber berbeza iaitu data dari Light Detection and Ranging, Global Positioning System, dan peta topografi digital. Perbandingan antara teknik berikut dibuat dengan mempertimbangkan perbezaan dalam ketepatan nilai-nilai ketinggian dan lain-lain aspek yang berkaitan. Hasil akhir kajian adalah kaedah terbaik untuk kutipan data ketinggian di mana ketiga-tiga kaedah sesuai dilaksanakan dengan mengambil kira ketersediaan data di kawasan tertentu dan penggunaan data tersebut untuk aplikasi tertentu. Kaedah yang dipilih dalam output akhir adalah praktikal untuk diaplikasikan untuk kadaster Malaysia.

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LIST OF ABBREVIATIONS

3D-NDCDB	-	Three-Dimensional National Digital Cadastral Database
CALS	-	Computer Assisted Land Survey System
CDMS	-	Cadastral Data Management System
DCDB	-	Digital Cadastral Database
DOAS	-	District Survey Office Automated System
EDM	-	Electronic Distance Measurement
ESRI	-	Environment System Research Institute
F2F	-	field-to-finish
FC	-	Field Communicators
FIG	-	International Federation of Surveyors
GIS	-	Geographical Information System
GPS	-	Global Positioning System
GNSS	-	Global Navigation Satellite System
IDT	-	Issue Document of Title
IDW	-	Inverse Distance Weighted
InSAR	-	Interferometric Synthetic Aperture Radar
JPS	-	Jabatan Pengairan dan Saliran
JUPEM	-	Jabatan Ukur dan Pemetaan Malaysia (Department of Surveying and Mapping)
LADM	-	Land Administration Domain Model
LiDAR	-	Light Detection and Ranging
MacGDI	-	Malaysia Centre for Geospatial Data Infrastructure

MSC	-	Multimedia Super Corridor
NaLIS	-	National Infrastructure for Land Information System
NDCDB	-	National Digital Cadastral Database
NOAA	-	National Oceanic and Atmospheric Administration
RDT	-	Register Documents of Title
RTK	-	Real-Time Kinematic
TIN	-	Triangulated Irregular Network
TTS	-	Total Station System

CHAPTER 1

INTRODUCTION

1.1 Background

Malaysia had already implemented a fully digital cadastre system which is known as National Digital Cadastral Database (NDCDB). This current system provides two-dimensional (2D) crucial land information for most parts of the country. It is updated regularly by JUPEM. The existing 2D cadastre system does not supply more realistic and substantial data to users. The additional information into land parcel in NDCDB can produce a three dimensional National Digital Cadastral Database (3D-NDCDB). A hybrid of 2D and 3D cadastre model is preferred by the Department of Survey and Mapping Malaysia (JUPEM) since it is applicable for current situation in Malaysia. However, there are some elements must be examined. They are the data collection method, the deriving products, and the changes to the format and structure of existing system (Tan and Looi, 2013). This research is an attempt to verify suitable method for height data acquisition for 3D-NDCDB. A correlation between methods tested which are LiDAR, GPS, and topographic digital map is performed after height data is taken from all three sources by not only relying on the difference in height data accuracy but also other related factors.

1.2 Problem Statement

Current Malaysia cadastre system is based on planar map which is in 2D space. For decades, Malaysia had been using 2D cadastre system where the current system provides vital land information and is constantly revised by the JUPEM. JUPEM has a well-designed digital system called NDCDB. The existing 2D cadastre system which still stores all cadastre information in 2D nature is barely providing more meaningful and sensible information to users as described by Hassan *et al.* (2006).

Furthermore, due to the increasing number of licensed land surveyors and land management professionals; current land registration and cadastral system is no longer sufficient for the booming of complex high-density developments in urban areas. Hassan *et al.* (2008) said that there is a growing interest in using space above or below the ground surface for construction of real objects especially in big cities. The demand on 3D spatial information for cadastre system has boost as it becomes important for the intention of better spatial object localization in relation to borders and the surface of the plot as depicted by Sanecki *et al.* (2013).

At the moment, JUPEM is planning to construct a 3D-NDCDB (Looi, 2011). The additional information into land parcel in NDCDB can produces the 3D-NDCDB. Based on Mission Cadastre2014 suggested by FIG Comm 7, it said that the cadastre system in the future must not depend on 2D mapping anymore (Tan and Looi, 2013). In institutional aspects, recognition has increase in which government and institutional reform is trying to achieve any measure of resolution as primary importance (FIG, 2010). Hence, a 2D and 3D hybrid cadastre model is chosen to be implemented by taking a consideration of the frameworks from Land Administration Domain Model (LADM).

A consideration is taken for some important matter in which the matters are the technique of data acquisition, the resulting products, and the difference in format and framework of current system (Tan and Looi, 2013). This research is pursuing to verify the suitable techniques for height data acquisition towards the implementation of 3D coordinates for 3D-NDCDB. There are numerous techniques that can be used for data acquisition of the height value where they can collect 3D coordinates. The crucial data needed is the height data as the existing NDCDB has not yet consists of orthometric height, H value (Looi, 2011). Due to the dynamic state of earth surface that always changing several parameters, the earth rotation around its vertical axis and earthquakes happened sometimes. The orthometric height is the height from Geoid in which Geoid is a surface where gravity force is equal (Eleiche, 2012). The implementation of orthometric height is important for further practical purposes in engineering works.

Before a 3D-NDCDB can be developed, choosing the suitable method of data acquisition for height data is vital where some other aspects are considered. That important aspects related to the accuracy and precision of height value, time taken for data collection, cost to imply method, and also the positional accuracy. In this research study, the height data is extracted from three different sources which are from LiDAR, GPS, and topographic digital map. Real Time Kinematic (RTK) positioning is used to collect GPS data in study area. After that, a comparison between techniques is made while considering those aspects described in previous before selection can be made.

1.3 Research Problems

The scope of research problems revealed by this study are :

- (i) issues related to current 2D cadastre system in Malaysia, and
- (ii) the demand on 3D coordinates with the additional of height data for 3D-NDCDB.

1.4 Purpose

The aim of this study is to verify suitable method of height data acquisition for 3D-NDCDB.

1.5 Objectives

The objectives of this research are as followed.

- (i) To extract height value of sample land parcel from few different methods.
- (ii) To compare the difference in accuracy of height value from LiDAR, GPS, and topographic digital map.
- (iii) To verify suitable method for height data acquisition based on various aspects which are the difference in accuracy of the height value, time taken for data collection, cost to imply method of data collection, and the positional accuracy.

1.6 Scope of Study

1.6.1 Study Area

The study area for this research is Kota Tinggi with various topographic figures which are urban area and less developed area. The urban area has a stable surface curvature while the less developed area is a hilly ground. The location of study area is shown in **Figure 1.1** below.

(1°44'58.71"N, 103°53'32.68"E)

(1°44'58.44"N, 103°54'11.55"E)



(1°44'19.69"N, 103°53'32.72"E)

(1°44'19.91"N, 103°54'11.60"E)

Figure 1.1 : Location of study area in Kota Tinggi.

1.6.2 Data

The main data used in this research are LiDAR data of Kota Tinggi within area in **Figure 1.1**, the GPS samples data from GPS data collection on few land parcels in the study area and is using RTK positioning technique, and the topographic digital map of Kota Tinggi taken from JUPEM. These data are important for the evaluation of height value on land parcels and to examine the suitable method for height value data collection that will be applied into land parcels by considering various aspects. The other ancillary data used are the land parcel data of Kota Tinggi from NDCDB Johor by JUPEM and a basemap of Peninsular Malaysia to support the analysis on the main data.

1.6.3 Tools

For GPS data collection, a Topcon GR-5 Global Navigation Satellite System (GNSS) receiver is used to pinpoint coordinate data of a location on earth in which RTK positioning technique is applied. Topcon GR-5 is an advanced GPS receiver with high-accuracy and provides automatic selection and tracking of any available satellite signal. The result given by Topcon GR-5 is more robust and clean signal tracking for unparalleled results. For statistical analysis, software used is ArcGIS 10. ArcGIS 10 software is a GIS product created by Environmental Systems Research Institute (ESRI) that allows user to analyze data and manage geographic knowledge to review relationships, test predictions, and ultimately make better decisions. Other hardware used is a laptop with such specifications below.

- (i) Intel Core Duo CPU
- (ii) Microsoft Windows 7, Service Pack 3
- (iii) RAM 2 GB 2.00GHz, internal local disk of 500 GB

1.7 Significance of Study

Current cadastre registration has shown limitations in providing insight in 3D location of 3D constructions such pipelines, tunnels, and building complexes as well as in the vertical dimension of depth and height which show the right for the establishment of three-dimensional constructions (Stoter and Ploeger, 2003). The implementation of 3D coordinates into land parcel data can solve some complications related to current 2D system such as the complexity of cadastral registration of 3D property situations. Sanecki et al. (2013) said a 3D cadastre with the additional height information will define objects by the reference to their physical boundaries without the creation of own geometry for legal.

JUPEM currently uses 2D-NDCDB for cadastre system and is trying to develop a 3D NDCDB (Looi, 2011) but must considering some important elements. One of the crucial elements is the method of data collection (Tan and Looi, 2013). Various methods can be used for the data collection. The crucial data needed is the height data as the existing NDCDB has not yet consists of orthometric height. The important of implementing the orthometric height is that further practical purposes can be performed in numerous engineering works.

A key driver to a sustainable development for more adequate and effective land administration processes needs an integrated way to managing land resources as depicted by Williamson et al. (2010). This can be expedited through spatially enabling land information. 3D-NDCDB is a new approach for modern cadastre systems. This approach is not only enhancing the government frameworks but is also providing more realistic and meaningful information in a format that will assure inclusivity through all levels of government and industry.

This study inspects some possible methods that can be used for data collection of 3D coordinates. Factors such as the accuracy and precision of height value, time taken for data collection, cost to imply method, and positional accuracy are taken into consideration. Through this research study, a suitable method for data acquisition can be proposed considering all the factors related and a 3D coordinates can be implemented into 3D-NDCDB of Malaysia later on. In the future, a cadastre will form an all-inclusive updated documentation of public and private rights, ownership, land use and real estate in various spaces.

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