

ON THE ESTABLISHMENT OF THE LOWEST ASTRONOMICAL TIDE FOR
MARINE PARCEL COMMENCEMENT IN PENINSULAR MALAYSIA

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A thesis submitted in fulfilment of the
requirements for the award of the degree of
Master of Science (Geomatic Engineering)

Faculty of Geoinformation and Real Estate
Universiti Teknologi Malaysia

DECEMBER 2015

ALHAMDULILLAH...

Specially dedicated to;

Mak (Adilah) & Abah (Rahibulsadri)

My husband (Mohammad Shahir)...and my "baby bump"...

ACKNOWLEDGEMENT

I wish to thank my supervisor, Dr. Abdullah Hisam Omar, for giving me the opportunity to do this research and all his help and advice throughout my time at UTM. I also wish to thank the other members of my research team (Cadastre Modernization): Nazirah Mohamad Abdullah, Noor Anim Zanariah Yahaya, Wan Muhammad Azzat Wan Azhar, Ashraf Abdullah, Siti Zainun Mohamad and Mohd Farid Al Azmi Isahak for their support and help throughout my studies at UTM and through this process.

It is also worthy to mention Department of Survey and Mapping Malaysia (DSMM) especially to Dr Teng Chee Hua and Mr Chan Keat Lim. They have contributed significantly regarding data and knowledge sharing.

I would also like to express my gratitude to Hery Purwanto from Institut Teknologi Malang, for his informal discussion on Tidal Analysis.

In conclusion, I wish to extend my gratitude to all my family and friends for their support.

ABSTRACT

Tidal datum is a standard height defined by a certain phase of the tide. Tidal datum is also the beginning for establishing privately owned land, state owned land, Territorial Sea, Exclusive Economic Zone (EEZ), and high seas boundaries. A review of previous studies shows that technical aspect is one of the major problems in marine cadastre development because there is no reference datum to implement marine administration for marine cadastre. Thus, technical aspect is needed to support marine cadastre development. Foundational to this, marine parcel is a part of space in marine administration which included air space, water column, seabed profile and subsea. It is also consisting vertical and horizontal and water tidal datum elements in marine area. The objectives of this study are to determine the tidal datum, Lowest Astronomical Tide (LAT) for Peninsular Malaysia and to analyse the stability of LAT as a datum for marine cadastre commencement. Tide datasets were processed using Total Tide Solution (TOTIS) software for computing the LAT as the reference datum for marine cadastre. Tidal epoch is from year 1992 to year 2013. Based on the analysis, the range of stability value for LAT with respect to Mean Sea Level (MSL) is -0.002 metre to -0.500 metre. Therefore, LAT is potential to be used as a reference datum for marine parcel commencement in Malaysia due to its stability and consistency as a lowest water level.

ABSTRAK

Datum pasang surut adalah ketinggian piawai yang ditakrifkan oleh fasa air pasang surut tertentu. Datum pasang surut juga diaplikasikan sebagai permulaan bagi menentukan hakmilik tanah persendirian, hakmilik tanah negara, laut wilayah, zon ekonomi eksklusif (EEZ), dan sempadan laut. Kajian ke atas kajian-kajian sebelum ini menunjukkan bahawa aspek teknikal merupakan salah satu masalah utama dalam pembangunan kadaster marin kerana tiada lagi datum rujukan dalam pentadbiran marin bagi pembangunan kadaster marin. Secara asasnya, ruang petak marin merupakan sebahagian daripada ruang dalam pentadbiran marin termasuk ruang udara, ruang air, profil dasar laut dan dasar laut. Ia juga terdiri daripada elemen datum pasang surut air menegak dan mendatar bagi kawasan marin. Objektif kajian ini adalah bagi menentukan datum pasang surut, pasang surut astronomi terendah (LAT) di Semenanjung Malaysia dan bagi menganalisis kestabilan LAT sebagai datum permulaan kadaster marin. Dataset pasang surut telah diproses menggunakan perisian Total Tide Solution (TOTIS) bagi menghitung LAT sebagai datum rujukan kadaster marin. Tempoh data air pasang surut adalah dari tahun 1992 hingga ke tahun 2013. Berdasarkan kepada analisis, julat kestabilan nilai LAT terhadap aras laut min (MSL) adalah -0.002 meter hingga -0.500 meter. Oleh itu, LAT sangat berpotensi untuk digunakan sebagai datum rujukan bagi permulaan ruang petak marin di Malaysia disebabkan oleh tahap kestabilan dan juga konsisten sebagai paras air yang paling rendah.

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The rapid and disproportionate development of coastal areas in Malaysia for economic generation activities and public interests has brought about the demand of a good system of marine administration. The development happened not only on land, but it also happened at the coastal and offshore area.

Malaysia is a federal state with marine authority and administration responsibility split between the states and the federal government. Following the Emergency (Essential Powers) Ordinance, No.7 1969, now loosened and replaced by Territorial Water Act 2012, territorial water shall be constructed as a reference to such part of the sea that is adjacent to control the coast there of not exceeding 3 nautical miles measured from low water mark. In this situation, the states control up to 3 nautical miles from low water mark whilst the federal government has jurisdiction and management responsibility from the said 3 nautical miles limit to the outer edge of the EEZ and continental shelf. Through this specific jurisdiction by United Nations Convention on the Law of the Sea (UNCLOS), Malaysia enacted plentiful acts related to the sea zone.

The term cadastre has not often been used in the context of the marine environment (Fowler and Trembl, 2001). Cadastre is a system containing a record of interesting land such as right, restrictions and responsibility meanwhile marine cadastre is a cadastre system in the context of the marine administration. The prerequisite for initiate administration of marine environment in a country is to clearly identify the determination of low water mark, in order for it to define the commencement of marine cadastre. Moreover, marine cadastre is quite different situation as that on the land. The marine cadastre concept will be successful if supported by the right law and regulation on marine management and practice for marine parcel (Ashraf *et al.*, 2013). To certify that parcels are uniquely positioned and identified, datums and map projections used in marine spaces have to be recognized and harmonised (Ng'ang'a *et al.*, 2004). Thus both horizontal and vertical datum is important to be defined.

There are a number of vertical datum are used for surveying, mapping and charting activities in Malaysia. A vertical datum is a base measurement point to which all elevations are invoke (Baquer *et al.*, 2011). A precise vertical datum is required for all categories of surveys. It may have a different elevations point for the same position without a common datum. The vertical datum is always used as a reference level in the marine environment is called chart datum. A chart datum usually related to mean of low ocean surfaces, such as Mean Lower Low Water Spring (MLLWS), Mean Lower Low Water (MLLW), Mean Low Water (MLW), Low Water (LW), Mean Low Water Spring (MLWS) or Lowest Astronomical Tide (LAT) and not every country in the world is using the same level as chart datum for their marine administration.

Mean Sea Level (MSL) is normally used as a reference level for various land development application while low water level practically applied as the reference level for marine environment. A chart datum is commonly a tidal datum and usually used Lowest Astronomical Tide (LAT) as a reference point or level. LAT is defined as the lowest tide level to occur under average meteorological conditions and under any combination of astronomical circumstance and may be derived by the analysis of

a number of years of tidal data and prediction, normally it takes 18.6 years to account for the full nodal cycle (Turner and Iliffe, 2010).

Tides have been important for commerce and science for thousands of years (Vella, 2000). Historically, tides were measured only by coastal tide gauges along continental coastline and at islands and by base pressure recorders at a few hundred deep-sea sites. Along the coastlines, everyone is common with tides and how they affect the water level. However, in inland situations by the side of river systems and reservoirs, elevations are used to determine the water level or water surface. These elevations are usually referenced to a height (elevation) above mean sea level (MSL). Mean sea level, depending on positioned, is often the same as National Geodetic Vertical Datum (NGVD).

The intention towards marine cadastre is commonly concerned on three main components which are technical, legal and institutional. In technical issue, many researchers have intensively covered the technical requirements supported by legal and institutional aspects such as Sutherland (2005), Ng'ang'a (2004), Quadros (2008), Binns (2003) and many more. More recently, (Seet, 2013) from University of Glasgow has discussed the related issues, in his research entitled "Accurate low-water line determination: The Influence of Malaysia's Legislation and Coastal Policies on Maritime Baseline Integrity" has stated out on the location from where a marine cadastre should commence will affect the rights of marine parcels or marine activities.

Acknowledges from Todd and Martin (2004), The Lowest Astronomical Tide (LAT) is used as a delimiters in many spheres of activity along the inter-tidal zone and the accurate mapping is important to use for coastal and near shore land. Besides, tidal heights are known merely at tidal stations and tidal range varies from place to place. Equally important, the tidal datum modelling is generally well accepted by using mathematical interpolation/extrapolation of tidal datum heights derived from tide gauge observations.

1.2 Statement of the Problem

A cadastre is a system registering the right, interests and ownership of spatially determined land parcels and a marine cadastre is simply a cadastre system in the context of the marine environment. In Malaysia, the rapid development is not only taking place on the land but it also thrives into marine area. The research on marine cadastre system had been globally recognized the importance issues based on four main aspects of marine cadastre such as legal, technical, social and institutional. The development in marine area became more popular with highly demand from public especially from the construction resorts, marina residences, harbours, and recreational parks.

In this study, technical aspect is one of the major problems because there is no reference datum to implement in marine cadastre. As a result, it will be a huge problem to certain agencies such as Department of Survey and Mapping Malaysia (DSMM) and Jabatan Ketua Pengarah Tanah dan Galian (JKPTG) to administer, manage and identification of some particular area in marine environment.

According to Malaysia National Land Code (NLC), the limit of Land Cadastre administration is referred to the level of Highest Astronomical Tide (HAT). This description will create an uncertainty of jurisdiction of space between HAT to the shoreline. Based on the above mentioned acts, the determination of LAT as the reference level for marine cadastre is crucial.

This research investigates an efficient method to determine tidal datum and how the tidal model is presented. Lowest Astronomical Tide (LAT) is required in order to settle the marine cadastre commencement with particular interest relevance and application to the development of a marine cadastre and finally makes one of the recommendations regarding the management policy for the marine administration.

A rational approach is to initially use the Rayleigh criterion as a useful guide when carrying out a harmonic analysis. The rule of Rayleigh criterion is depending on the length of data series. The more tidal constituents that can be legitimately determined, the higher the accuracy that can be achieved in tidal predictions. Furthermore, Hou and Vanicek (2015) believe that the accuracies of assessed amplitude and the phases of these tidal constituents that we wished to select as many as possible are strictly related to the period of the time series used in the estimation with the least square method. Assuming that there are too many constituents chosen for the analysis, that is, if the time period over which observations are taken is too short, then either no solution would ensue, or an unstable solution would be obtained, in which the interference between and among tidal components with similar frequencies would be a detrimental factor. This happens when two or more frequencies are too close together, they cannot be resolved from the given period of the time series.

1.3 Objectives of the Study

This research has identified several objectives to fulfil its requirement. The objectives are as follow:

1. To determine the tidal datum, Lowest Astronomical Tide (LAT) for Peninsular Malaysia.
2. To analyze the stability of Lowest Astronomical Tide (LAT) as a datum for marine cadastre commencement.

1.4 Research Question

There have several specific research questions in this study;

- i. How to determine Lowest Astronomical Tide (LAT) in Peninsular Malaysia?
- ii. Where should marine cadastre begin?
- iii. What is marine cadastre datum?

1.5 Scope of the Study

In order to achieve the research objectives, the scope of work will involve all the procedures based on the objectives. There are:

1st Objective: To determine the tidal datum Lowest Astronomical Tide (LAT) for Peninsular Malaysia.

Scope :

- i. Review of the consistency of Lowest Astronomical Tide (LAT) from tidal data observation.
- ii. Review on current effort on current and related projects, worldwide.
- iii. Case Study: Peninsular Malaysia
- iv. Review on tidal datum modeling of LAT
- v. Planning of data acquisition such as: Tidal data, field work on tide stations and the software to process the tidal data.
- vi. Tides data from 12 tide gauge station (Peninsular Malaysia) of Department of Survey and Mapping Malaysia (DSMM). Tides data period was started from year 1993 to 2012.

- vii. Tides data from temporary tide gauge stations near Berjaya Resort, Langkawi and Pantai Minyak Beku, Batu Pahat. Minimum tides data is 1 month (30 days).

2nd Objective: To analyze the stability of Lowest Astronomical Tide (LAT) as a datum for marine cadastre commencement.

Scope :

- i. The stability of LAT will be analyzed by generate the modeling of tidal datum.
- ii. The difference level value of the series of the tidal datum
- iii. Comparison the difference zero value of Lowest Astronomical Tide (LAT) respect to the Mean Sea Level (MSL)

1.6 Significance of the Study

The significances of the study include:

- i. Lowest Astronomical Tide (LAT) as a reference datum for marine cadastre commencement will support Legal Framework of Marine Cadastre.
- ii. The technical aspect that will support the definition of marine parcel.
- iii. Recommendation regarding the reference datum for marine cadastre implementation.

1.7 Thesis Outline and Summary of Thesis

A brief overview of stability of the LAT and the process to create a tidal model will be further elucidated in further chapters which consist of the details analysed and processed regarding modelling of the LAT using interpolation method from tidal analysis. A compendium of data collecting and data arrangement technique will also be given in upcoming chapters along with the supporting analysis through the processing of tidal data. As seen in the background of the research, not many researchers have been involved in the examined of the stability of the Lowest Astronomical Tide (LAT) for the purpose of marine cadastre.

In Chapter 2, the definite tidal analysis and interpolation method used in this study was discussed along with its congruence such as location with a longer datasets. Basic processing also introduces measurement and outliers of the tidal analysis, as well the ways in which to define LAT value. Total Tide Solutions (TOTIS) which is tidal analysis software is capable to process tidal observation data at least 15 days of observation and achieved high accuracy result.

Chapter 3 considered the data used and the procedures involved in analysing the data. The methodology is provided as to how to process the tidal observation with a long period of observations. It also explained the steps done from the beginning of collecting data until how to create a tidal model. Some equations are provided to show the statistical accountability for the analysis and result.

Chapter 4 presented details of the result and analysis in the form of tables and figure. The way to study a tidal model, the stability of the Lowest Astronomical Tide (LAT) has been analysed first.

Chapter 5 evaluated and explained the factors which affect the stability of LAT and justified the range of LAT point as a datum for marine parcel commencement in Malaysia.

Subsequently, Chapter 6 provided the conclusion and the recommendations for the research perhaps to demonstrate how the research benefits towards marine cadastre implementation.

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