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Status of Surveying and Mapping in Malaysia

Submitted By Malaysia *

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COUNTRY REPORT
DEPARTMENT OF SURVEY AND MAPPING MALAYSIA

Abstract

This paper enumerates the developments that have occurred within the Department of Survey and Mapping Malaysia (JUPEM) for both the main activities of the Department viz. the cadastral survey and the mapping survey. These developments, not only brought about a new work pattern right across the top management to the supporting staff but also the more important element in the chain is the benefit felt by the client and the general public.

Introduction

Malaysia covers a land area of about 329,758 sq. km, consisting of 11 states in Peninsular Malaysia, 2 states in the island of Borneo (Sabah and Sarawak) and 3 Federal Territories, and with a population of approximately 29 millions.

JUPEM, established in 1885, is one of the oldest government departments in the country. It has experienced the tide of technological advancement for more than two decades now, since the widespread use of Global Navigation Satellite System technology and the availability of accurate satellite imagery for the field of surveying and mapping. The Department has continuously been transformed from carrying out survey to provide cadastral survey plans for issuing land titles and topographic maps for the military operations and some other civil use to include the management of digital spatial databases as well as the dissemination of geographical information to end-users.

To achieve these objectives and to fulfil the requirements of national development, JUPEM has taken various steps to modernise both its field and office operations. The rapid development of Information and Communication Technologies have resulted in widespread reforms in the surveying and mapping industry. Capitalising on this wave-of-change and the government's commitment to the national IT Agenda, JUPEM has initiated its computerisation programme in the early 1980's.

The e-Cadastre Project

Since 1995 JUPEM has embarked on a modernization program that saw the dramatic computerization of both its office and field processes of its cadastral survey division. The Digital Cadastral Database (DCDB), which is the crown jewel of the Department, was created by capturing the survey accurate information of all land parcels.

In 2006 the Government approved the e-Cadastre project, to be implemented by JUPEM under the 9th Malaysian Development Plan, which span over a five year period from 2006 till 2010. The primary objective of e-Cadastre is to expedite the delivery system for land title survey. This would entail the creation of a survey accurate database at the national level and usage of Coordinated Cadastral Systems (CCS). The main objective of CCS is to develop a homogeneous cadastral database based on the geocentric datum with a spatial accuracy of better than 5 centimetres in urban area and better than 10 centimetres in semi-urban and rural areas. In order to achieve the above objective a dense cadastral control infrastructure grid of 0.5km spacing in urban area and 2.5km spacing in semi-urban and

rural areas was established. The underlying technologies needed included GPS positioning based on GDM2000 geocentric datum, and least squares adjustment. Once the dense cadastral control infrastructure has been established the readjustment of the cadastral network is carried out and this adjusted National Digital Cadastral Database (NDCDB) will then form the base layer for all future title surveys. The readjustment uses least square methodology will distribute the residues homogeneously in the large cadastral network. Consequently, cadastral survey practices is being revamp to accommodate the use of least square adjustment. Under the e-Cadastre project, JUPEM has envisaged a significant reduction of time taken in any cadastral survey process from the existing average of 2 years to within 2 months.

The Computerised Mapping System (CAMS)

CAMS, a computerised mapping system that expedites mapping processes and also creates digital databases was introduced in JUPEM under the 5th Malaysian Development Plan and was fully operational in 1990. In 2008 and 2012, JUPEM acquired two digital aerial mapping cameras to compliment its aerial mapping activities. The use of a digital aerial camera for mapping will expedite the geospatial data extraction processes for map updating as well as provide the Department a raster image database. The introduction of this automated system has significantly impacted activities such as data acquisition, storage and retrieval, manipulation and generation of output (maps), which were efficiently and accurately managed. In essence, the main objectives of CAMS, besides expediting the production of digital and hard copy topographic map series are the creation and maintenance of National Topographic and Cartographic Databases and to disseminate digital spatial information from these databases to all government agencies including the military. The national coverage for digital topographic maps compiled at 1:25,000 and consisting of 1,048 map sheets was completed in 2006. These maps are updated according to a revision cycle of three, five and ten years depending on the extent of changes on the ground.

In this regard, the Digital Topographic Database is collected on a national basis, thus making use of a common data model throughout the country. Originally, data acquisition is based on CAD data model, more for the purpose of expediting mapping work through automated processes of a computerised system. Eventually, the needs of GIS users necessitates the data model to be restructured through the use of object oriented data-basing and data made to be GIS ready, and at the same time effort has been undertaken to restructure them to conform to the Malaysian Standard 1759 (MS 1759) – Features and Attribute Codes, beginning 2004.

Moving forward, JUPEM started producing new topographical and thematic maps named MY series since 2006 to replace the various map series currently in use. This new map series is based on Geocentric Datum of Malaysia also known as GDM2000 to replace the old Kertau/Timbalai Datum. The new topographical map series at scale 1:50,000 consist of 718 map sheets is targeted to be completed by 2014. The mapping for the whole country was put under a single coordinate reference system; effectively combining the previous differing system made use of for the mapping of Peninsular Malaysia as well as Sabah and Sarawak.

JUPEM has replaced the manual procedures of generalization with an automated generalization solution. This will increase the productivity of map update through automation. JUPEM recognize that the existing topographic and cartographic databases

will require enhancement to comply with the requirements of an automated generalization system. The generalisation module is developed to establish a seamless cartographic database at various scales at both scales of 1:25,000 and 1:50,000 and this data will be used to produce cartographic hardcopy products at the same scales.

The Computer Assisted Topographic Mapping System (CATMAPS)

The importance of integration of office-to-field solutions for data collection, remote data access and mobile management of geospatial databases incorporating field data collection has been realised by the Department. With the availability of mobile mapping solutions and new field survey instrumentations, the Department acquired the Computer Assisted Topographic Mapping System in 2002. The system was fully integrated with GNSS technology together with customised software aim to expedite the field process in depicting all the changes of the topographical features and attributes in line with the current demand of digital evolution. The system was upgraded in 2007 to expand its usability to all field survey parties. Further upgrading is anticipated during 2012 – 2014 to enhance the system functionalities, amongst others capable of performing on-line and real-time topographic database updating from the field surveys. With the advent of such system JUPEM would be able to establish a fully digital flow line for its topographic mapping in a real-time environment.

Utility Mapping

Noting the seriousness of having precise utility location information to avoid service disruptions, the Malaysian Government in 1994, directed JUPEM to compile utility location data from individual utility agencies and manage the information on underground facilities for the country.

In 2007, JUPEM acquired a Utility Mapping System and developed a national underground utility database called PADU with the main purpose of populating it with information from utility agencies in a systematic GIS approach. These information comprising gas and water pipelines, electric cables, telecommunication cables and sewerage pipes are however, subjected to various checks and verification processes in the field before they are accepted into PADU.

In order to maintain a reliable underground utility database, JUPEM in 2006 published a standard guideline for underground utility mapping to be used by those involved in various capacities in underground utility mapping. This guideline amongst others addresses issues related with:

- The role and responsibility of the stakeholders;
- Quality levels of underground utility data;
- Format for Utility Map; and
- Design and Development of the Underground Utility Database (PADU).

Utility mapping presents a new challenge to JUPEM, with the incorporation of geophysical elements to the established positioning aspects in JUPEMs' work practices. Advanced geophysical tools such as ground penetrating radar (GPR) and pipe and cable locator (PCL) are largely use to verify the position of underground facilities. Detection using GPR is done by pushing or towing the RADAR transmitter cum receiver across or along the facilities. Any buried utilities can be viewed in the form of GPR profiles or tomography images and interpreted. PCL on the other hand allows the detection of metal pipes by detecting electromagnetic field created or inherently present in the facility.

In materializing the full potential of the available techniques, JUPEM's personnel have to undergo specific training and specialized courses. This helps the field work force to efficiently and safely carry out their jobs. The underground utility information and other geo-spatial data which form the core component of PADU are kept in a seamless geo-database format for efficient access, analysis and sharing purposes.

The final products of the whole mapping process are maps presenting all the utility and geospatial information in a logical and easy to understand manner. These products are available on a print-on-demand basis allowing sharing of information amongst the relevant parties to be less hassle and more cost effective.

Having up to date information of all underground facilities will empower the government and local authorities in making informed decision to carry out planning and executing excavation projects with greater confidence, thus ensuring high productivity with safety in mind.

Malaysia Real-Time Kinematic GNSS Network (MyRTKnet)

In line with the Malaysian government's efforts to enhance its public delivery system, JUPEM through the use of real-time GNSS survey technology embark on a project aim at providing centimeter accuracy real-time positioning service through GNSS network to the whole of Peninsular Malaysia, Kuching, Miri and West Coast of Sabah and sub-meter accuracy throughout the whole nation.

This project, the Malaysia Real-Time Kinematic GNSS Network was implemented under the 8^{th} and 9^{th} Malaysian Development Plans, i.e. from 2002 to 2003 and from 2006 to 2008, respectively.

The MyRTKnet concept is based on having a network of seventy-eight (78) GNSS reference stations at a spacing of 30 to 150 km, continuously connected via telecommunication lines to a Control Centre situated at the JUPEM headquarters in Kuala Lumpur. The computer processor at the Control Centre continuously gathers the information from GNSS receivers located at all MyRTKnet reference stations and creates a living database of regional area corrections. These corrections can be disseminated to any users equipped with mobile GNSS receivers that are capable of connecting to GSM/GPRS/3G modem.

The geographical area in which the MyRTKnet network serves is depicted in **Figure 1**.

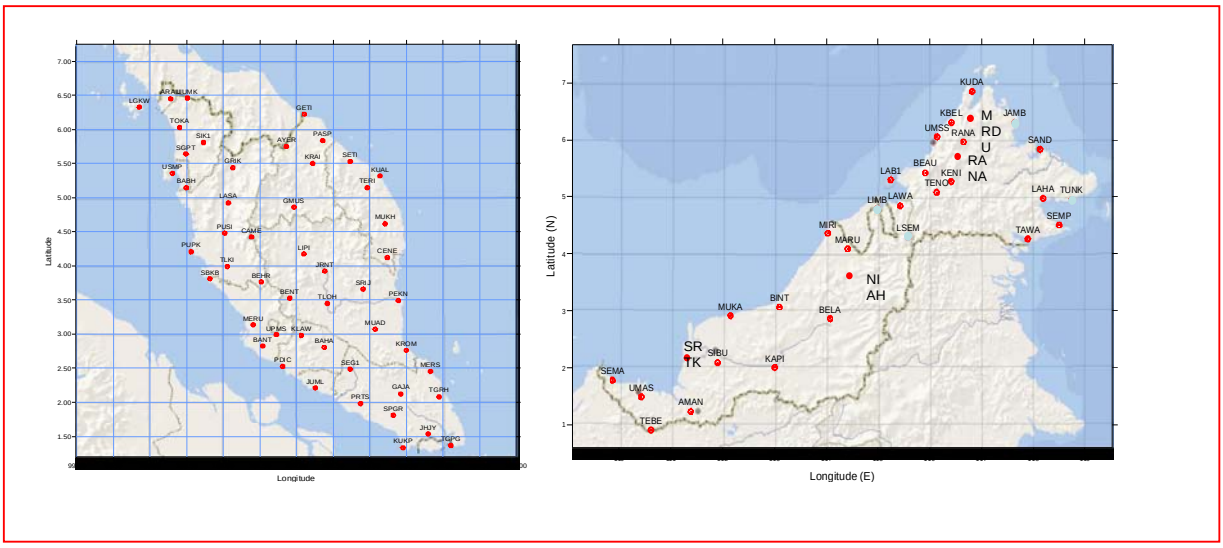

Figure 1 - The distribution of GNSS reference stations

MyRTKnet services can be used for various surveying applications ranging from setting up of control to the detailing of project sites; its usage will benefit not only the surveyors, but also many other GPS users who rely on these utilities to locate their positions and for navigation. Number of users that have utilized the MyRTKnet services until July 2012 as tracked from the Control Centre are 805. From this figure, the number of utilization of the real-time and post-processed coordinate corrections in July 2012 alone is 835 and 805 respectively. Accumulatively, the numbers of utilization of these services till July from January 2012 is 2942 for real time and 1830 for post-process corrections giving a total utilization number of the services to 4772.

MyRTKnet also has the capability for centimeter accuracy application that is suitable for cadastral survey and large scale mapping. The e-Cadastre Project, CATMAP System, utility mapping and the aerial photo missions carried out in JUPEM uses MyRTKnet services as their main control reference and are able to increase their productivity almost three to four times consistently. The Network DGPS has been proven to be useful for mobile platform application such as the continuous route surveying and navigation. With the increasing reception coverage of the mobile telco, MyRTKnet should be able to tap into this resource to expand the circle of users for multi discipline applications.

Tidal Network

The main objective of the setting-up of tide gauge stations is to enable a continuous time series of sea level be determined. JUPEM is among the few agencies responsible for the overall coordination of the data acquisition, verification, storage and publication of sea level data. The installation of twenty one tide gauges in Malaysia has been completed since 1984 to form what is referred to as the Tidal Observation Network (TON) (Refer to Figure 2) All the tide gauges are connected to each other through a network of precise leveling lines, the Precise Leveling Network (PLN).

JUPEM manages the TON of 21 continuously operating sea level observation stations or tide gauge stations along the coastal areas of Malaysia. It remains the sole government

agency that is given the mandate to acquire process, archive and disseminate sea level data. The choice for the sites was so arranged such that they are evenly distributed along the coastline. The main objective of the establishment of the network is to enable a continuous time series of sea level heights be obtained for the purpose of establishing a vertical datum for the nation.

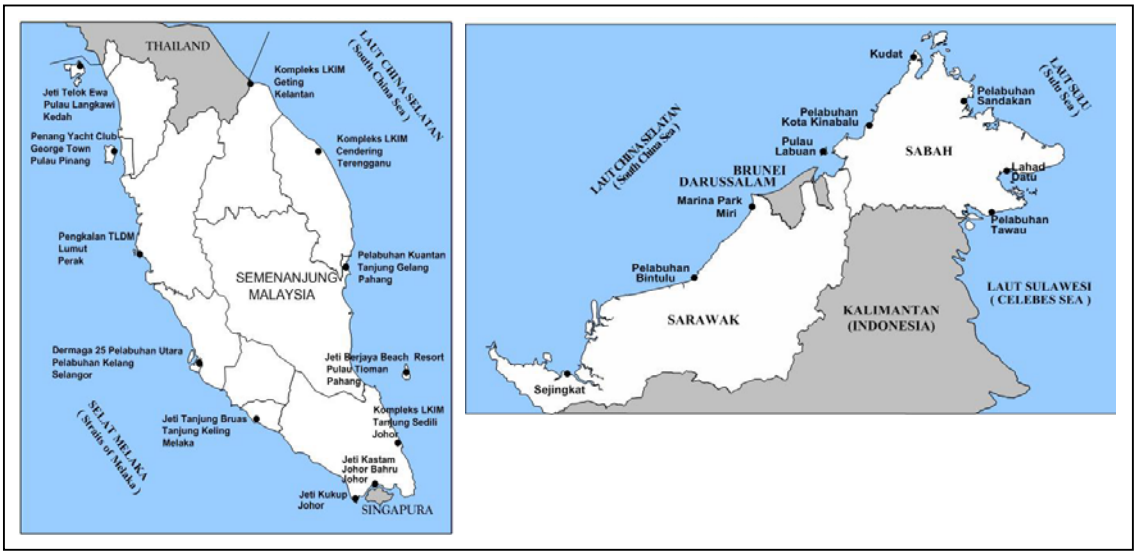

Figure 2 – Tide gauge stations locations

A tide gauge station in Malaysia consists of a tide gauge protective house, stilling or tide well, tide staff and several reference bench marks, one of which is referred to as the tide gauge bench mark. The tide gauge measures water-level heights with respect to the zero mark on a tide staff. The well and float gauge is the standard instrument at all tide gauge stations in Peninsular Malaysia.

The sea level data processing at JUPEM is a fully computerised operation and commences once the collected data on the storage device are transferred to the computer. The process can be split into three stages: observation data processing, data analysis and tidal prediction. The output from each tide gauge station is as follows:

- Hourly heights of sea level;
- Daily, monthly and yearly mean sea level values;
- Time and heights of high water and low water;
- Tidal marigram; and
- 29-day tidal analysis.

JUPEM produces two annual publications for all tide gauge stations:
- Record of Tidal Observations for previous year; and
- Tidal Prediction Tables for the following year.

Precise Leveling Network (PLN)

The establishment of a height network provides a system of vertical control whereby a height value of a point may be defined. Like most countries around the world, a nation-wide leveling network in Peninsular Malaysia was established at the turn of the last century. This network is referred to as the PLN.

In 1983, JUPEM began to determine the precise MSL value in conjunction with the establishment of the new Precise Leveling Network for Peninsular Malaysia. This was carried out by the setting-up of a Tidal Observation Network that consists of 21 tidal stations. Subsequently, Port Kelang was selected for the adoption as a reference level for the new vertical datum origin, based upon a 10-year tidal observation (1984-93). This new datum is known as the Peninsular Malaysia Geodetic Vertical Datum (PMGVD). The new mean sea level is adopted as 3.624 m above the zero tide gauge.

PLN consists of 113 first order leveling lines with 5443 bench marks, involving a total distance of 5004 km. Twenty-two main loops make up the network that covers a geographical area of about 131, 598 km^2. There also exists within the network itself an array of second class leveling lines. The precise leveling routes are shown in Figure 3.

Figure 3 – Precise Leveling Network

Gravity Network

The recorded gravity survey in Malaysia began in 1954 by a France Geophysicist by linking gravity network between Paris and Antarctica. It was continued by the Japanese and American experts in 1960's and was then adjusted to the International Gravity Standardization Net 1971 (IGSN71) in 1971. In 1989, JUPEM have produced a Peninsular Malaysia Gravity Standardization Net (PMGSN 89) aiming to get orthometric corrections for precise levelling measurement. The network was also used to establish the National Geodesy Vertical Datum (NGVD) as well as the study of geoid undulation. Gravity survey was also carried out in East Malaysia (Sabah and Sarawak). Currently, there are nearly

5000 gravity points throughout Malaysia. The maps showing the distribution of gravity points in Malaysia is depicted in Figure 4.

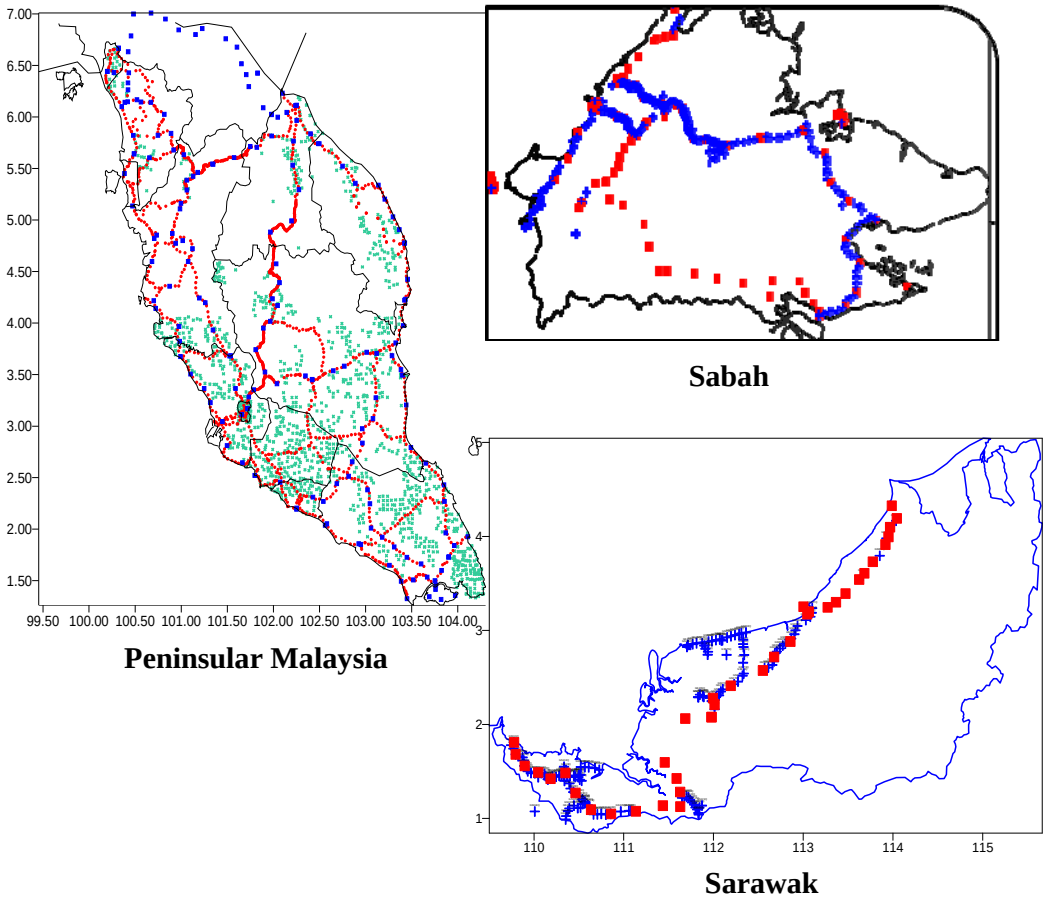

Figure 4: The distribution of gravity points in Malaysia

MyGeoid

Under the 8th Malaysia plan (2001-2005), DSMM has undertaken the **Airborne Gravity and Geoid Determination Project** for the whole of the Sabah-Sarawak and Peninsular Malaysia area. The purpose of implementing Airborne Gravity mode of gravimetric survey is to complement the existing terrestrial gravity data and computing with other relevant geodetic data to ultimately release a 5 centimetres accuracy geoid model applicable to the practicing surveyors and developers throughout the nation. This technology development is important to Malaysia because many inaccessible areas especially in Sabah, Sarawak and central part of Peninsular Malaysia where gravity data is very much lacking or not available at all. Consequently, the determination of a precise geoid at cm level accuracy for the Malaysian region has been hampered due to lacking of the gravity data.

The total area to be covered by the airborne gravity survey is approximately 350,000 square kilometers. The implementation of the airborne gravity survey and geoid determination for the Malaysian region will certainly complement and strengthen the existing geodetic infrastructure. Cross-over analysis indicates that the derived gravity anomalies are better

than 2 mgal accuracy while the computed geoid indicate that the relative accuracy is better than 2-5 cm. The geoid model for Malaysia is shown in Figure 5.

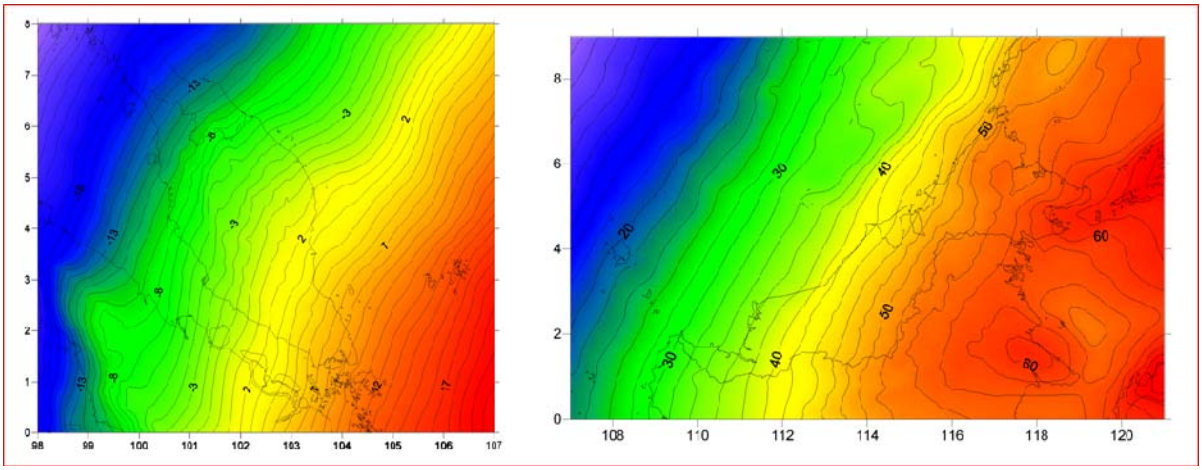

Figure 5: The Geoid Model (MyGeoid) for Malaysia

Height Modernisation System (HMS)

A modern height system in a modern survey and mapping community requires the ability to easily measure elevations relative to mean sea level, accurately, and at the lowest possible cost. Therefore, based on information and the needs to support modern height system, the implementation of HMS in Malaysia has to be realized. The ultimate goal of this project is to obtain the best possible geoid, at centimetre precision for relative geoid heights. This precision is needed for the definition of a homogeneous vertical datum for Malaysian region and also for various applications in GPS.

Although high precision positioning is already attainable, the height component does not have desired accuracy when we speak in a more geodetic environment. Therefore, JUPEM has again taken the initiative to enhance the achievable height accuracy and subsequently increase the synergy of land surveying activities throughout the country. The Kelang Valley has been chosen for this project due to its drastic development activities and once the desired accuracy has been achieved, further projects of the same mode will follow suit to the rest of the country. In addition, these gravity data can be utilised by other agencies for various purposes such as geological studies and geophysical exploration. The implementation of the height modernization is based on the above objective of providing a precise geoid model with centimetre accuracy for the whole country by using the acquired airborne gravity data with combination of the terrestrial gravity data, other derived gravity data and digital terrain model, levelling data and also GPS data. The fitted geoid model for HMS is depicted below in Figure 6.

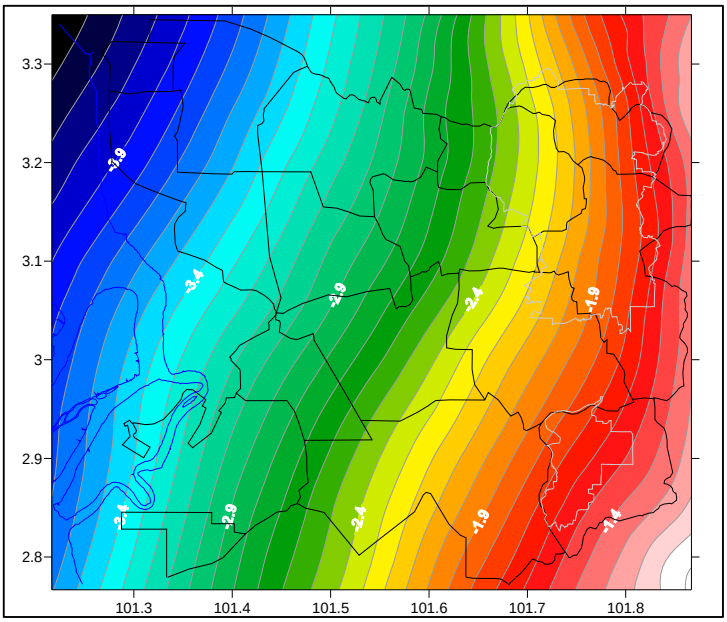

Figure 6: The Fitted Geoid model for Kelang Valley

National Atlas

The Department has formed a national committees consisting of twenty three (23) agencies to develop digital national atlas to be called eAtlas. This atlas will portray information on selected themes of history, climate, political, physical, land use, natural resources, infrastructure, socio-economy statistics and tourism. For this purpose, five (5) working groups have been established to populate and prepare data and descriptive information for their respective themes. The first edition of this atlas is expected to be completed in 2013.

Data Standards

At the national level, JUPEM as the chairman of the Technical Committee 2 (TC2) of Standards and Industrial Research Institute (SIRIM) of Malaysia played an important role in the development of Malaysian Standard for geographic information/geomatics. As such, at the international level, the members of this committee have been actively participating in the International Organisation for Standardisation Technical Committee 211 (ISO/TC 211) activities. The majority of the ISO/TC 211 suite of standards for geographic information, which comprises of more than 20 standards, are expected to be adopted for use by Malaysia.

In order to allow GIS users to get the maximum benefits from the geospatial data in the country that provided by all the data suppliers through the national intelligent access of SDI, JUPEM takes lead the activity of Standard Technical Committee of Malaysian Geospatial Data Infrastructure (MyGDI). This is to ensure that the spirit of geospatial data sharing and dissemination amongst government agencies, private sectors and the general public at common standards platform will be achieved.

At the regional level, the "Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP)" was formed in July 1995, to provide a forum for countries from the Asia Pacific region to discuss and agree on, inter alia, GIS standards, GIS infrastructure and institutional development. Malaysia, being a founding member is actively involved in the works of the Permanent Committee and the formulation of policies on the sharing of spatial data within the region. The latest initiative afford was the launching of the Kuala Lumpur Declaration on Spatially Enabled Government and Society held on 16th February 2012 during the PCGIAP International Symposium in Kuala Lumpur.

JUPEM Geoportal

In 2006 JUPEM launch geoportal services to deliver its digital geospatial products through the internet. This was a bold initiative in support of the government's objective to provide a more efficient and customer-oriented public delivery system. The JUPEM Geoportal leverages the power of geography through an intelligent mapping and web services interface against which JUPEM delivers smart, user-friendly technology with the best available spatial data available on demand to meet user's geospatial information needs. The system will help users find and do business with JUPEM online or in person. Through an online map-based interface, the user may search and find exactly what he or she needs. For example, from the computer, the user can identify a location on an on-screen map, and subsequently discover what data exist for that specific location. The user is then able to purchase the selected data or place an order for the data online. Alternatively, the user may choose to do business in person at any of JUPEM's State sales counter or JUPEM One-Stop-Centre at JUPEM's headquarter. Currently the Geoportal is being upgraded in consonance with the latest technology in the market and to include more products and services.

Sales of Digital Data

It is the government’s policy to provide an open system, which enables anyone to obtain up-to-date survey and mapping information from the JUPEM. However the rights over possession and use of digital data are a matter of concern due to the enormous amount of data in digital form that can be easily made available to users. As such, in order to prevent illegal transmission of digital data by users to third party and to protect the interest of the Department, the Fees and Royalties (Survey Data and Digital Mapping) Order 1997 has been approved in February 1997 and revised in December 2010. The Order provided copyright protection for all forms of digital survey and mapping data as well as regulating the fees and royalties chargeable by the Department. In addition, it includes fees for utilisation of survey and mapping data, and services provided by the Department.

JUPEM’s digital data are currently sold at a highly subsidised price. This is due to the service-oriented policy of the Department as well as its inclination to promote the use of digital data and development of spatial data related activities. It is expected that in future, in line with the Malaysia Incorporated Concept, there will be a change to a higher cost recovery policy. In consonance with the government’s drive to increase productivity and recover costs, the Department has made recommendations towards the formulation of a national charging policy regarding the sale of digital data, copyright and other related issues.

Human Resource Development

The rapid change and modernisation introduced into the Department would not be meaningful if they are not supported by an equally up-to-date dynamic workforce. In meeting with the challenges of this daunting task, JUPEM has designed and implemented a Human Resource Development (HRD) Blueprint, to provide its staff with concurrent training to enable them to keep abreast with the advancements not only in the field of surveying and mapping but also in the Information and Communication Technology (ICT). The HRD Blueprint has been devised as a long term strategy to systematically and continuously train and update the Department's staff with an ultimate aim of achieving full and complete computer literacy within the Department and to prepare them for new challenges that the Department will face in this new millennium.

In addition to this, training is also sought at counterpart organisations overseas and at institutions of higher learning. A Continuous Professional Development (CPD) Programme has also been organised to ensure that personnel at the managerial level remain up-to-date technically and professionally.

Conclusion

With the implementation of the various modernisation programmes, JUPEM has been transformed into a modern ICT-oriented organisation to better serve its ever increasingly sophisticated clientele. The training provided under its Human Resource Development Programme will also change the Department's staff into a computer literate workforce in line with the Government's aspiration of achieving a knowledgeable society.

It is indeed fortunate that with a somewhat generous budgetary allocation given to it, and backed by a core of hardworking and dedicated staff, the Department has been able to harness recent advancements in ICT to implement its strategic modernisation plans. In so doing, the Department has been able to fulfil its mission of providing digital spatial data as well as the geodetic referencing framework in support of the development of geographic and land information systems in the country.

As can be seen, the Department's move to venture into the digital arena some 20 years ago spearheaded a wave of change that is felt by the survey and mapping profession in the country. With the government vigorously supporting the growth of the spatial information industry, the challenge is for JUPEM to evolve strategies and structures such that it is well poised to continue to serve the needs of the nation.

Department of Survey and Mapping
Malaysia
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