The History and Development of Surveying & Measurement in Malaysia

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SUMMARY

In Malaysia, records show that the earliest survey department was established in the state of Johore in 1885, but surveying works were already carried out a few years prior to that. Most of the early surveys appeared to be in scattered parcels and measurements were of boundary length without bearings. A general survey of those lands under occupation was started by J.O. Moniot in 1851 using plane table and chain but this survey was found unreliable due to its low technical specification and subsequently land administration continued in a state of confusion.

The first known cadastral plan was dated 1885 and appertained to a plot of land in Gunong Pulai area. When Mohd Salleh was transferred to Muar and Batu Pahat, he prepared a map of those two districts which is still preserved. A further edition of the state map was prepared in 1907 possibly based on the first one. A copy of this map is still preserved today in the Royal Palace of the Johore Sultan.

As in the case of the establishment of the early geodetic infrastructure for the basis of surveying and mapping in Peninsular Malaysia, known as the Repsold Triangulation network, JUPEM obtained the initial position of a point in Taiping in 1885 by directly observing the stars. The principle of triangulation was based on simple trigonometric procedures and basically it consisted of the measurement of the angles of a series of triangles. With the longitude, latitude, and azimuth of the initial points obtained by astronomical observation, similar data was computed for each vertex of the triangles thereby establishing triangulation stations or geodetic control stations. Nowadays, the operational use of satellite techniques in geodesy, geodynamics and surveying started. The United States Department of Defence began to develop the new NAVSTAR GPS and it was in 1987 that this new technology was introduced to JUPEM.

This paper shall describe the brief history of survey and mapping in Malaysia, including current trend and some latest development.

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1.0 INTRODUCTION

Since time immemorial surveying has impinged particularly on astronomy and mathematics. It is under these headings that many of the historical references to surveying and related measurement instruments and techniques will be found although several other major areas of study also have relevant references.

The term 'surveying and measurement' encompasses aspects of mathematics, astronomy, geography, physics, mechanics, metrology, statistics, geophysics and other scientific disciplines. Within these disciplines, it includes reading devices - such as verniers, micrometers and circles; standard units of measurement and their inter-relationship; temperature devices and scales; trigonometric and other tables; logarithms; angle and distance measuring devices from earliest times; calculating devices; barometric devices and use of their readings; the determination of gravity values; the determination and depiction of elevation and all the other sundry instruments and methods associated with these areas of interest. In addition to the practical construction and operation of the instruments the mathematical theories related to all the instruments and their use are of prime importance.

The history of surveying started with plane surveying when the first line was measured. Today the land surveying basics are the same but the instruments and technology has changed. The surveying equipments used today are much more different than the simple surveying instruments in the past. The land surveying methods too have changed and the surveyor uses more advanced tools and techniques in land survey.

2.0 BRIEF HISTORY OF SURVEY AND MEASUREMENT IN MALAYSIA

Records show the earliest survey department was established in the state of Johore in 1885, but surveying works were already carried-out a few years prior to that. Quinton was appointed the first surveyor in 1858, and started his plane table survey which covered about a third of Malacca and included most of the town and thickly settled coastal areas but omitted the congested centre of the town in 1860. No permanent marks were emplaced but Quinton directed the planting of lines of areca palms to mark boundaries. Quinton left Malacca in 1867 and the records remained obscure until 1884 when Major McCallum initiated the compilation of a series of sheets. Under Major McCallum, boundary marks were emplaced and a trigonometrical survey was carried out between 1886 and 1888.

Most of the early surveys appeared to be in scattered parcels and measurements were of boundary length without bearings. A general survey of those lands under occupation was started by J.O. Moniot in 1851 using plane table and chain but this survey was found unreliable due to its low technical specification and subsequently land administration continued in a state of confusion. As a remedy the Boundaries Ordinance of 1884 was enacted and a resurvey was started and eventually finished by F.W. Kelly who directed this work from 1890 to 1894.

The earliest survey work in Perak dates back to the 1880's. Some were performed by the Land Office and licensed surveyors contracted from Australia and carrying out surveys with plane table, prismatic compasses and theodolites. H.L. Pemberton produced a series of 16-chain scale lithographed sheets of Kurau and Krian districts during the years 1881 - 1883 which were printed in Dehra Dun, India, in 1885. The first systematic work was carried out by plane table with control provided by theodolite circuits, the earliest being done in 1894 and this approach prevailed for small rural holdings until 1915.

Surveys were only introduced when the Administrator wanted to make a state map showing the rivers, mountains and coastal areas. Two officers, Mohamed Salleh bin Prang and Yahya bin Awal-ed-din, were sent to Singapore to be trained by Major McCallum in 1868. Mohamed Salleh bin Prang prepared a map of the Johore State between 1868 and 1877. The first known cadastral plan was dated 1885 and appertained to a plot of land in Gunong Pulai area. When Mohd Salleh was transferred to Muar and Batu Pahat, he prepared a map of those two districts which is still preserved. A further edition of the state map was prepared in 1907 possibly based on the first one. A copy of this map is still preserved today in the Royal Palace of the Johore Sultan.

The first attempt at triangulation was made in Penang in 1832 by Lieutenant Woore of the Royal Navy and the earliest determination of geographical position was that of Fort Cornwalls in Penang by Captain Home Popham in 1791. This was followed by the subsequent Penang and Province Wellesley Triangulation which commenced in 1885 by J.W. Mac Dougal, assisted by P.A.Peters and H.Greene and completed in 1887 by P.A. Peters.

In 1885, H.G. Deanne, a contract surveyor from Ceylon, was appointed by the Public Works Department, Perak to carry out the Trigonometrical survey of Perak. He measured the 4.6 mile Larut baseline and carried out astronomical determinations for latitude and azimuth near Taiping. This Trigonometrical Survey in Perak together with the Penang and Province Wellesley triangulations and Malacca Triangulation (1886-1888), laid the foundation of the existing control framework. These foundations were still primitive, progress was frequently sporadic and much of the work was found to be substandard but by the end of 1901, the Major Triangulation of Perak and Selangor had been completed and work had been in progress in Negeri Sembilan since 1899.

As in the case of the establishment of the early geodetic infrastructure for the basis of surveying and mapping in Peninsular Malaysia, known as the Repsold Triangulation network, Department of Survey and Mapping Malaysia (JUPEM) obtained the initial position of a point in Taiping in 1885 by directly observing the stars. The principle of triangulation was based on simple trigonometric procedures and basically it consisted of the measurement of the angles of a series of triangles. With the longitude, latitude, and azimuth of the initial points obtained by astronomical observation, similar data was computed for each vertex of the triangles thereby establishing triangulation stations or geodetic control stations. The locations of each station at the vertex of the triangles were connected by a series of adjoining triangles forming quadrilaterals extending from each end. Triangulation extends over large areas by connecting and extending series of arcs and forming a network or triangulation system. A denser distribution of geodetic control is achieved in a system by subdividing or filling in with other surveys.

The primary instrument for measuring angles is the theodolite. The technology for measuring the angles has changed very little since JUPEM inception in 1885, although the instruments are now smaller and more accurate. On the other hand, the technology for measuring distances has changed several times, from chains, to bars, to invar tapes, to today’s electronic distance measuring instruments. Electronic distance measuring instruments provided dramatic improvements over previous technologies. Then, a major change in surveying and mapping occurred for JUPEM in 1987. Positioning changed from line-of-sight surveys for measuring angles and distances to using global positioning satellite technology, which only requires clear lines of sight to GPS satellites in the sky.

Before GPS, Doppler TRANSIT was the first satellite positioning system that was used by JUPEM in the 1978 to tie the old geodetic networks to a global coordinate reference frame. TRANSIT consisted of seven satellites orbiting at heights of about 1100 km. From 1980 onwards, the operational use of satellite techniques in geodesy, geodynamics and surveying started. The United States Department of Defence began to develop the new NAVSTAR GPS and it was in 1987 that this new technology was introduced to JUPEM.

Coordinate reference systems have been established in many regions around the world by national mapping authorities since the 19th century, using conventional surveying techniques and procedures. Most of them used local datums that are confined to small areas of the globe, fit to limited areas to satisfy national mapping requirements. This is also the case with Malaysia where it has in place two old/ classical triangulation networks, namely the Malayan Revised Triangulation 1968 (MRT68) for Peninsular Malaysia and the Borneo Triangulation 1968 (BT68) for Sabah and Sarawak.

The MRT68 consists of 77 geodetic, 240 primary, 837 secondary and 51 tertiary stations with the station at Kertau as the origin. It is based on conventional observations with many of the triangulation points dated as far back as 1885. The MRT68 has been adopted as a result of the recomputations of the earlier network together with the Primary or Repsold Trianngulation carried out between 1913 and 1916. The map projection used for mapping in Peninsular Malaysia is Rectified Skew Orthomorphic (RSO) and Cassini Soldner for cadastral surveying. Sabah started its primary triangulation work between 1930 and 1942. In around 1935, Sarawak and Brunei also began their primary triangulation projects. EDM traversings were also carried out in 1961 to 1968 to supplement the work. The combined geodetic networks in Sabah and

Sarawak, known as the Borneo Triangulation 1968 (BT68) was established with the station at Bukit Timbalai as the origin.

In 1994, JUPEM established a GPS network of 238 stations in Peninsular Malaysia as an effort to harness the full prowess of the space-based technology, called the Peninsular Malaysia Geodetic Scientific Network 1994 (PMSGN94). The main objectives of setting up PMSGN94 are to establish a new geodetic network based on GPS observations and to analyse the existing geodetic network. The network has been observed using four Ashtech LXII dual frequency GPS receivers and the acquired data was processed and adjusted in 1994. Following the successful completion of PMSGN94 in Peninsular Malaysia, JUPEM began making plans to establish a similar type of GPS-derived geodetic network in Sabah and Sarawak. For this purpose, GPS observations were made using Trimble 4000SSE L1/L2 receivers to establish the East Malaysia Geodetic Scientific Network 1997 (EMGSN97) that comprises a total of 171 GPS stations.

JUPEM established the permanent GPS tracking stations known as Malaysia Active GPS System (MASS) at the end of 1998, with eighteen (18) stations making up the whole MASS infrastructure. Coupled with the GPS data obtained from the International Global Navigational Satellite System (GNSS) Service (IGS) stations, the coordinates of MASS stations were derived from four years of continuous GPS data (1999-2002). Collectively, these coordinates represent the basis for the determination of the Geocentric Datum of Malaysia (GDM2000), which was launched on 26 August 2003.

Between 2002 and 2008, JUPEM further developed a modern active GNSS network with the latest state-of-the-art technology to establish the Malaysia Real-Time Kinematic GNSS Network or MyRTKnet, which is meant to provide real-time positioning services at centimetre-level accuracy to users in the field. By the end of 2008, Malaysia has seventy-eight (78) RTK reference stations for the network with fifty (50) stations covering the whole Peninsular Malaysia, while fourteen (14) stations each covering Sabah and Sarawak.

3.0 CURRENT TREND AND LATEST DEVELOPMENT

The advance in surveying instruments and measurement technology has contribute significantly to the availability of geospatial information. In Malaysia, geospatial information is becoming part of our daily life and is growing remarkably. Major advances in Information and Communication Technologies (ICT) in the last decade combined with the rapid growth of global information networks such as the Internet have exponentially expanded both the need for geospatial information and the access to this information.

Geospatial information is now recognised by the government of Malaysia as an essential resource that supports the economic, social and environmental interests of the nation. Demand for accurate, up-to-date, relevant and accessible geospatial information at the various levels of government in Malaysia is critical to the delivery of many government services. The incorporation of accurate geospatial information and technologies in research activities and operations can empower seamless innovative spatial solutions.

3.1 Cadastre

There are mainly two core surveying activities in Malaysia, namely cadastral survey and mapping. In Malaysia its cadastral survey has undergone dramatic changes technically, operationally, structurally and institutionally over the past decades. The introduction of a computerised system introduce the concept of digital databases. JUPEM has undertaken the initiative to create and maintain the National Digital Cadastral Database (NDCDB) which is survey-accurate and seamless; the base layer for enhanced GIS. In order to produce NDCDB, a Cadastral Coordinated System (CCS) is implemented through the eKadaster project.

eKadaster is a system that optimized current ICT, GIS and survey technologies, implicating modification in cadastral survey manner from the traditional Bowditch and Transit methods to a Survey Accurate Coordinate using Least Square Adjustment with the establishment of an NDCDB and Strata/Stratum/Marin Survey Database (SSMSD), aiming to expedite and strengthen the nations cadastral survey delivery system via an efficient integrated system. In other words, eKadaster is developed in order to transform current regiment cadastral system to a coordinated cadastral system. The main philosophy of applying CCS is to use a geocentric datum to have a single projection system for the whole country and the application of least square adjustment procedure in the distribution of survey errors. With CCS, Global Navigation Satellite System (GNSS) will be the natural tool for cadastral surveys, hence enabling absolute and real time positioning, with coordinates being given legal significance. The prominence of measured bearing and distances are reduced whereby they are considered as only a means by which the final adjusted coordinates are derived.

3.2 Mapping

Meanwhile, mapping in Malaysia has also taken a huge leap from conventional methods in acquiring and producing maps for various purposes. In 1988, Computer Assisted Mapping System (CAMS) was introduced in Malaysia to facilitate the establishment of the Topographic and Cartographic National Databases for production of topographical and thematic maps throughout the country. In order to support the field work process in the digital environment, Computer Assisted Topographic Mapping System (CATMAPS) was developed to replace the conventional method of data collection.

Under the 10th Malaysia Development Plan, Malaysia will continue to accelerate topographic data production and this will be undertaken under the recently approved e-Mapping project. This project aims, among other things, to further expedite mapping activities such as topographic data collection, production and data base updating by decentralising the said activities to the regional branches, and the outcome will certainly benefit the GIS community.

3.3 Geodetic Infrastructure

In 2003, Malaysia launched its single referenced geocentric datum, the Geocentric Datum of Malaysia 2000 (GDM2000), to convert the state-based localise Cassini-Soldner system into the Geocentric Cassini Coordinate Projection System. The GDM2000 which has been established with respect to a geocentric reference frame defined in ITRF system at ITRF2000 epoch 2 January 2000 at an accuracy of 1 cm supersedes the classical geodetic datums in Malaysia. A newer version of GDM2000 parameters has been published in 2009 following the displacement and movement due to the Sumatran earthquakes in 2004, 2005 and 2007.

The new generation of Real Time Kinematic (RTK) process known as “Virtual Reference Station” is based on having a network of GNSS reference stations continuously connected via tele-communication network to the control centre. A computer at the control centre continuously gathers the information from all receivers, and creates a living database of Regional Area Corrections. With VRS system, one can establish a virtual reference station at any point and broadcast the data from the reference station to roving receivers.

3.4 Geospatial Data Infrastructure (MyGDI)

The 21^{st} century is an age of information technology. With the development of modern information technology, a great deal of geospatial data from different sources is produced almost continuously. Thus, to integrate data from various sources for analysis, and realize heterogeneous spatial data interoperability in a distributed environment, Malaysia established the Malaysian Centre for Geospatial Data Infrastructure (MaCGDI) in 2002. MaCGDI is responsible for the development of the Malaysia Geospatial Data Infrastructure (MyGDI) as the National Spatial Data Infrastructure (NSDI).

MyGDI is an initiative by the government to develop a geospatial data infrastructure to enhance the awareness about data availability and improve access to geospatial information. MyGDI is a geospatial data infrastructure that comprises of policies, standards, technology research and development and skilled human resources. MyGDI facilitates online access to geospatial information, avoid duplication of effort in the collection of data and to ensure the accuracy, timeliness, correctness and consistency of data to be used in planning, development and management of land resources.

4.0 CONCLUSION

Surveying & Measurement in Malaysia has undergone tremendous change as the technology, method and survey environment evolved to better suit the challenging demand of a modern age of information. Malaysia is currently gearing toward a multi-purpose cadastre system and also studying the feasibility of implementing a marine cadastre system. The future of surveying & measurement in Malaysia is bright and indeed full of exciting development in the pipeline. As Malaysia gear toward a developed country by 2020, its survey profession continue to play an important role to help achieve this goal.

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