SECTION TWO

ADVANCED SPACE TECHNOLOGY

2.0 INTRODUCTION

The Department of Survey and Mapping Malaysia is responsible for the establishment and maintenance of horizontal and vertical control points for geodetic applications. Originally, this was achieved with the use of traditional surveying equipment such as theodolites and chains, followed by total stations and EDMs. Nowadays, the advent of Global Positioning System or GPS has prompted DSMM to explore the possibilities of using this new technology in order to keep abreast with the latest development in surveying.

GPS had been introduced at DSMM in 1987. To date, it has been used in the establishment of GPS networks in the Peninsular Malaysia, Sabah and Sarawak. The presence of these 'passive' networks served their purpose relatively well, especially in mapping and engineering applications. However, nowadays most precise applications of GPS make use of 'active' GPS networks.

2.1 MALAYSIAN ACTIVE GPS SYSTEM (MASS) NETWORK

Originally, the concept of having a network of unstaffed, permanently configured GPS facilities that collect GPS data in an automatic manner has been evolving at the DSMM since 1996 (Abu & Mohamed, 1996). MASS is the latest venture of DSMM in providing 24 hours GPS data for GPS users in Malaysia. This network was completed two years later under the 'Sea Level Monitoring Using GPS' project.

One of the primary objectives of the MASS is to act as the provider of GPS observational data and its related products (Abu & Mohamed, 1997; Abu *et. al.*, 1998). The MASS data are made available to the public by DSMM either through the Internet or on request. The data are available in daily observation batches (i.e. from 0000 to 24 hours) and in compressed form to save disk space and transfer time.

2.1.1 Objectives of MASS

MASS is established with the following objectives:

- To monitor sites which are determined to cm-accuracy and provide local users ties to the global and national spatial reference systems
- To allow JUPEM to perform its survey more efficiently
- To permit maintenance of the National Coordinate System at the cm-level
- To monitor vertical and horizontal crustal motion
- To standardise aspects of reference station operation
- To provide observational data and corrections to users

- For non-positioning applications such as ionospheric and atmospheric water vapour determination
- Geodynamic and other scientific studies

2.1.2 MASS Data Products

The core products of the MASS is the data collected from the permanent GPS stations:

- Daily 24 hours GPS carrier phase and code observations, on both frequencies, for all satellites in view
- GPS navigation messages and status information

Products to be generated by MASS include:

- MASS station GPS observation data
- GPS satellite ephemerides
- MASS station coordinates and velocities
- Earth rotation parameters
- GPS satellite and MASS station clock information
- Inospheric and atmospheric information

2.1.3 Network Configuration

The whole system consists of 18 permanent GPS tracking stations situated at strategic locations across the nation as shown in Figure 2.1. Two of the stations are located at tide gauges.

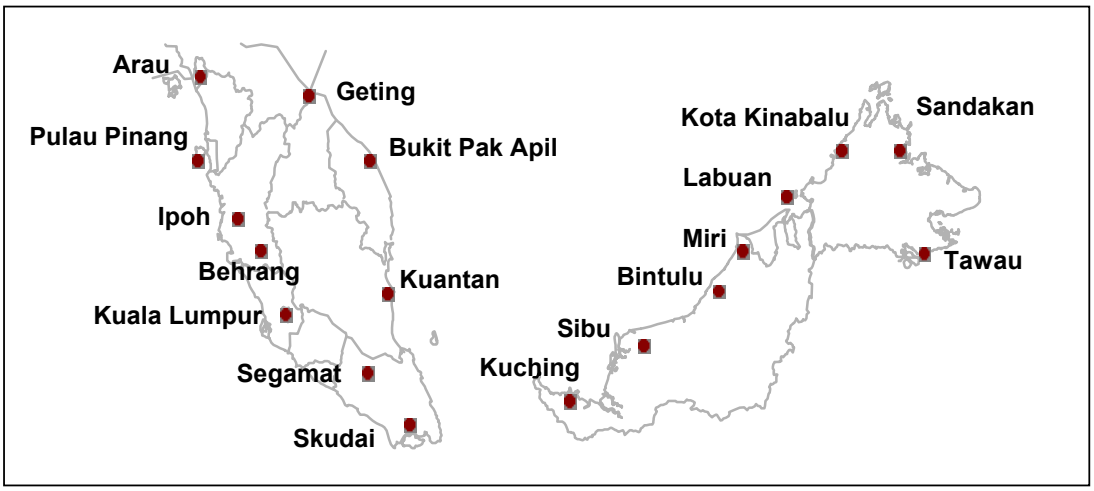

Figure 2.1 Distribution of MASS stations

2.1.4 Hardware Configuration

Figure 2.2 shows the hardware configuration of the network and the processing centre. Connected via telephone lines, all MASS stations are in direct link-up to the Kuala Lumpur Processing Centre (KLPC), situated at Geodesy Section of DSMM. All functions of the MASS stations such as receiver control, tracking schedules, data acquisition and uploading times are accomplished by the software residing in the PC. The system is also capable of alerting and engaging onsite personnel of any abnormal conditions occurring at each MASS station such as power failure, system breakdown etc. The current design of the MASS system allows external interrogation by the System Manager in Kuala Lumpur for status reports and if the need arises, override certain functions at any MASS station.

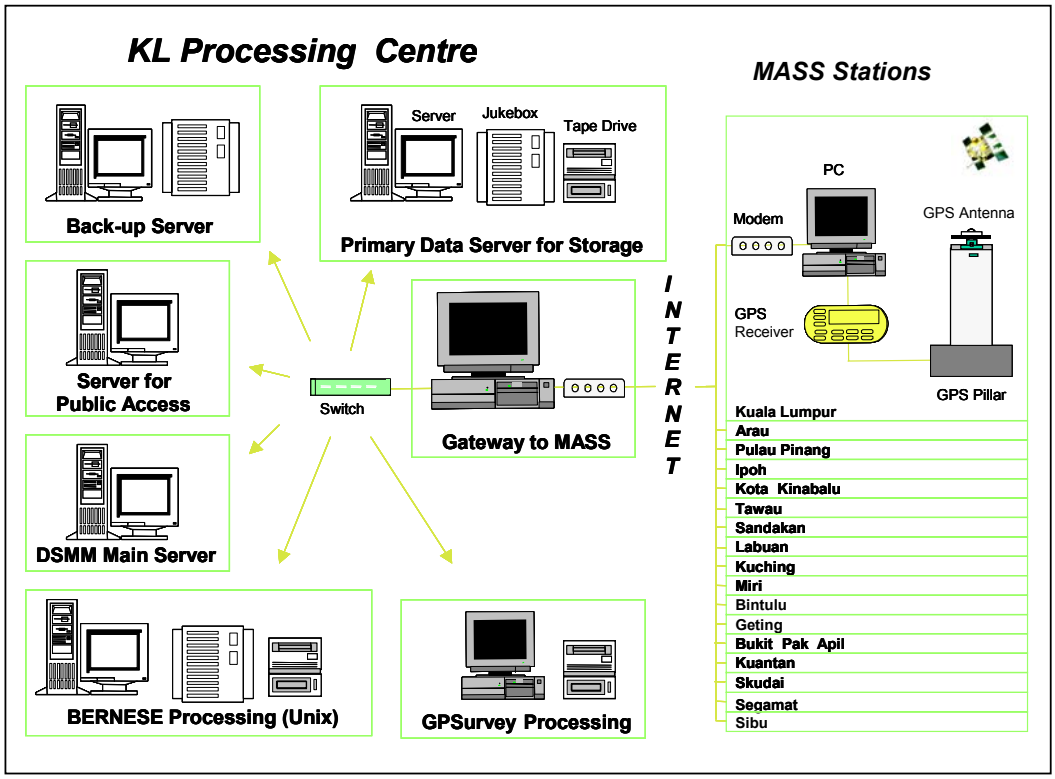

Figure 2.2 The hardware configuration of the Malaysian Active GPS System and the Processing Centre

At the heart of the system are the GPS receivers, which are dual frequency Trimble 4000 of either SSI or SSE geodetic models. The receivers have 24 channels, which are set to record GPS signals at a 15 seconds recording interval. The receivers are also equipped with either geodetic antennas with ground plane or choke ring antennas. To ensure that the system operates continuously, an uninterrupted power supply (UPS) will maintain power for at least three hours in the event of any power failure. The software is also designed to have an auto-start capability once the power is resumed.

The stations track GPS data 24 hours a day continuously. The data are stored and archived at an hourly interval in the site computers. The GPS data at each MASS site

are then suitably compressed into an hourly batches before they are uploaded automatically twice daily to the central processing facility (KLPC) in Kuala Lumpur.

The processing centre is situated at the DSMM headquarters. Its function is to monitor the 18 remote stations, to download the data on a daily basis and to provide all the information to users. At the KLPC, the GPS data are prepared in daily (24 hours) RINEX files, both for observations and broadcast navigation messages. The daily observation files from each MASS station contain the observations collected between 00:00:00 and 23:59:30 GPS time.

The data editing and validation process is performed using a quality check program, UNAVCO's QC program which was obtained from the IGS Central Bureau Information System. The GPS data are validated and edited for quality control by checking:

- the header-file information (station name, receiver/antenna information, antenna height);
- the number of GPS observations;
- the number of observed satellites; and
- the date and times of first and last observation record.

Figure 2.3 A typical MASS station (Arau, Perlis)

Next the data are archived in the RINEX format before it is made available to registered users via on-line on the Internet the following day. (*http:www.geodesi.jupem.gov.my/mass.htm*). The data will remain on the departmental Internet server for a period of 30 days. After this period has passed, the data will be archived inside the Primary Data Server CD jukebox and would only be made available on user's request. Presently, the MASS data products are available to users without charge.

2.1.5 Some Potential Applications

The main concern in establishing the network is in the determination and maintenance of precise local reference frame and at the same providing a three dimensional surveying system for geodetic control. Although the primary concern is in the field of geodetic survey, the products from this project will find its way into many other applications. These include:

- **Products**

  As the MASS system matures, KLPC is expected to be able to meet all levels of users by:
  - producing a highly precise reference frame connected to the International Terrestrial Reference Frame (ITRF),
  - monitoring deformations of the solid earth, earth rotation and variations in the sea-level, and
  - determining GPS satellite orbits

- **Single receiver positioning**

  In this concept, a user can carry out a survey with only one receiver for the purpose of survey and mapping work such as GIS systems Integration, Map completion etc. Here, the user can avoid the setting-up of a base station, thus saving time, money and energy. The MASS Station will act as a reference point and will provide data for measurements in the differential and relative mode.

- **Establishing a Global Reference Frame**

  The MASS Station GPS data will be contributed to IGS so as to realise a precise reference frame for the country. Through this continuous observations, the reference frame could be constantly refined, yearly coordinates by epoch and velocities could be produced, and thus a consistent and stable national reference frame of international standard is maintained.

- **Transportation and Recreation**

With an active reference system, one can think of many applications where the GPS data could be used to provide reference for various kind of transportation and recreation activities. With the ultimate goal of providing data in real time, transportation monitoring is of great potential by providing real time positioning, vehicle tracking and reporting and setting up of the intelligent transport system. Fishing, boating, bike touring and hiking could be more enjoying just by knowing that you are constantly on course.

- **Navigation**

It is envisaged that MASS will also support users in areas of navigation. These users are quite unique in their needs as they are particularly interested in knowing their positions in real time. In order to meet their demands, MASS is expected to be able to broadcast both the differential corrections (for DGPS applications) and raw GPS data (for RTK applications) to registered users.

- **Environmental and Deformation Monitoring**

Sea level could be monitored over the years to provide environmental assessment so as to allow our coast and marine activities to be protected and preserved. Deformation monitoring will contribute to a better maintenance of our infrastructure and land use.

- **Support for Regional GPS Campaigns**

With the availability of MASS data combined with that of the region, a time series of the dynamics can be produced for geodynamical studies.

- **Aerial Photography Surveys**

Currently DSMM is conducting a study into the use of GPS as control in aerial photography. One of the components of the project is the use of reference GPS station for post-mission DGPS relative to the on-board GPS. MASS data can be used to achieve this by supplying post-mission GPS data in RINEX format. As such, aircraft conducting aerial photography work will be able to fly at any specified time without having to initiate the ground reference station.

2.1.6 Conclusion

DSMM has proposed the establishment of MASS which comprises of 15 permanent GPS stations throughout Malaysia. Thce station5(co-2)5.ackio nang,ch lleductingnanmieminatoring