DEVELOPMENT OF GIS BASED MAPPING SYSTEM FOR FUTURE MAIN CAMPUS INFRASTRUCTURE MANAGING SPATIAL INFORMATION

BY

MOHAMAD SHAMSUL NIZAM BIN SHAHROM

This dissertation is submitted to

UNIVERSITI SAINS MALAYSIA

As partial fulfillment of the requirement for the degree of

BACHELOR OF ENGINEERING (CIVIL ENGINEERING)

School of Civil Engineering
Universiti Sains Malaysia

April 2005

ACKNOWLEDGEMENT

For the last two semesters as a final year student, I have gained a new experience in civil engineering area. For the past three years, I thought that civil engineer just only do design and field work. But from this project, I knew there are much more than I ever thought. I am so grateful to God, Allah S.W.T. because He gave me this opportunity to learn, understand and finish this project successfully.

I want to thank to my supervisor, Dr. Mohd. Sanusi S. Ahamad for always being supportive and encourage me all the time. I also want to thanks Dr. Shamshad Ahmad and Mr. Azahari for helping me to solve problems with this project.

Last but not least, I want to express thanks to School of Civil Engineering staff for helping me in many way. I could not have finished my final year project without their support and help. Again, I am so grateful being here with these amazing people and I will carry on this sprit when I join the industry.

ABSTRAK

Projek intergerasi ArcView GIS dengan AutoCAD dan Idrisi32 ini adalah untuk merekabentuk pangkalan data untuk menjadi asas kepada pusat informasi Universiti Sains Malaysia pada akan datang. Projek ini juga dapat menjalankan analisis data menerusi intergrasi imej satelit dan pelan lukisan untuk kerja-kerja pembinaan yang dikenali sebagai "As built map". Segala maklumat dan analisis ini di satukan dan di jangka menjadi asas kepada pengurusan pembangunan kampus yang di kenali sebagai USM-Me iaitu 'Universiti Sains Malaysia Map Explorer'. Oleh itu, proses dimulakan dengan pengumpulan data melalui Pusat Pengajian Kejuruteraan Awam iaitu imej satelit dan pelan tapak kampus induk Universiti Sains Malaysia (USM). Imej satelit di ubahsuai menerusi pengunaan Idrisi32 manakala pelan tapak diubahsuai melalui perisian AutoCAD. Kedua-dua maklumat ini di eksport ke dalam perisian ArcView GIS menggunakan arahan-arahan tertentu di dalam ArcView GIS. Pelan tapak yang berbentuk format AutoCAD kemudian di ubah ke dalam format Arcview manakala imej satelit dalam format data raster di ubah ke dalam bentuk imej TIFF. Intergrasi antara 2 data ini di buat di dalam ArcView dan kemudiannya data maklumat di masukkan dan di olah mengikut keperluan. Secara keseluruhannya, satu pangkalan data yang mengikut keperluan pengguna dan keadaan semasa mengikut kepada data yang di perolehi telah terhasil.

ABSTRACT

The integration between ArcView GIS with AutoCAD and Idrisi32 is for designing and developing a database for Universiti Sains Malaysia information centre in the future. This project also practices a data analysis through the integration of satellite image and engineering drawing as known as 'As Built Map'. All the information and analysis are combined and assumed to be the basic tool for managing the campus development that is called Universiti Sains Malaysia Map Explorer or USM – Me. The project process begins with collecting data from School of Civil Engineering like satellite image and AutoCAD drawing of USM main campus. The satellite image was customized with Idrisi32 while the drawing edit in AutoCAD. The two data were brought into ArcView GIS using specialized command and tool. The drawing in DWG format was changed to ArcView GIS format while the raster image in Idrisi32 was changed into TIFF image format. These two data were changed in ArcView GIS and combined with the other data. Generally, one database designed for people demand and situation with all data that has collected in one system tool been created.

CONTENT

LIST OF FIGURE

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Geographic Information System (GIS) an accurate mapping tool for an urban development planning after a certain construction based on an engineering design plan has been completed. Huxhold and Levinshon (1995) defined GIS as “a collection of information technology, data and procedures for collecting, storing, manipulating, analyzing and presenting maps and descriptive information about features that can be presented on maps”. GIS maps can combine the infrastructure data with its information related to the properties of every location in the map. GIS today is the most reliable technology in achieving sustainable approaches for planning, management and information archive of urban planning. For the past two decades the concept of urban mapping has become more understood as a base for urban planning and management. The combination of mapping system with spatial data and information creating the best database archive as a common reference delivered in the map forms.

1.2 Problem Statement

The Main Campus of University Science Malaysia is located in Minden. With an area of 500 acqes, this campus has established from 1969 until now. Currently, there has never been a spatially accurate digital campus map available at the campus. There are collections of existing paper maps that contain important information that can converted into digital form. There are some digital maps and drawings of unreliable quality and not spatially

referenced and not link to any tabular databases. Although there are digital data available on the campus related directly to some amenities but currently there is no system available for linking this valuable information to maps. A GIS campus wide mapping can allow a systematic database management approach with wide range information displayed on map. These existing maps and database will represent valuable pieces of a potential campus wide GIS and should be incorporated as part on an overall campus wide GIS system.

There is no formal departmental coordination or process to manage the spatial data that should be shared by the university and public especially. The GIS system concept will be developed using the combination of office automation, CAD, GIS, multimedia and other software packages. The complete database GIS system will provide a range of information about campus with maps as the front page window. With this system application, the public can manage to get information about the campus using a 'user friendly' window interface.

1.3 Objective

The objective of this project is to develop a campus wide information system for USM main campus called USM Map Explorer using GIS spatial data management tool that can:

1. Store data about map features for infrastructure in a database along with the associated map graphics.

2. Managed information about the campus through user friendly specialized function and analysis.

1.4 The Database Development Process

The database development can be divided into:

1.4.1 Design

Identifying the spatial data needed for the analysis, determining the required feature attributes, setting the study area boundary, choosing a coordinate system. Information design must be based in the planning and development control process to be implemented. Based on conceptualized GIS application for managing data, there will be 6 layers within the database. They are meant for analysis and conform to technical requirements for any planning applications. The main layers are:

a. Building – condition, height, plinth, conservation, walkway and others information,
b. Road – present, proposed and dedicated,
c. Land usage – type of land usage, section, and district name
d. Contour – the height of land
e. Land boundary
f. Image – satellite and digital image

1.4.2 Automation

Digitizing or converting data from other systems or formats into a useable format, verifying data and correcting errors. Some data must be verified first before taking as useable and important information. Some existing digital maps must also must be confirmed that thesis no error in the information given on the maps. Selected

digital maps will only be taken as the information in the database. If the maps or others information are not in digital format, for topographic maps, it must be scanned and turned into the digital format. Data capture or acquisition for the area (campus) and subject (building, roads and etc) of interest must also be computerized. Many applications require the coverage of large areas in short periodic time intervals, so the most important part of this development as to gain the most up to date information..

1.4.3 Management

From the design and automation steps, the data must be managed and arranged so that it will be sufficient before doing the analysis. Some of the data like maps must be georeferenced to one and another (if we have more that one map) so we can differentiate between the main data and the support data. This process called verifying coordinate system, as if the data must be coordinated by the value and usage of the data. In design steps, there are four main layers. Joining adjacent layers and registration of coordinates among layers must be done. The validation of the data sets also must be up-to-date because there are many current activities in the campus. There for, managing the database for future analysis is a must.

1.5 Organization of The Research

This research consists of 5 chapters. All chapters are based on the format and guidelines that is required by School of Civil Engineering, Universiti Sains Malaysia.

In Chapter One, an introduction to the topic of study with the explanation of background, aim of the research and the scope of the study is presented. It contains the whole general information of the research. Chapter Two described the literature review of research that has been done in area of GIS application tool and spatial data management. In addition, Chapter Three explained the process to develop the database and create the 'As Built Map' gradually. The result is showed in Chapter Four in form of tables, graphics and maps. Finally the conclusions and recommendations are given in Chapter Five.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The development of Geographical Information System, or also known as GIS help process of development control management involves a technique like design, automation, analysis and data managing with GIS database include land information, structure, existing and developing project, utilities and socio-economy information (Ruslin Hassan, 2003). In addition, data like digital image, example digital map taken from satellite or aerials photos, combine into one GIS database development; present in map inter-face window. There are many ways to describe a Geographic Information System. Here are three working definitions:

1. The nominal definition*:* A GIS is a hardware/software system for the storage, management, and (with hardcopy or screen graphic) selective retrieval capabilities of geo referenced data. Definitions like this one are often used by vendors and users of vector-only GIS, whose objective is sophisticated management and output of cartographic data (James P. Hall, 2004).
2. A comparable definition*:* A GIS is a hardware/software system for managing and displaying spatial data. It is similar to a traditional Data Base Management System, where we now think in spatial rather than in tabular terms, and where the "report writer" now allows output of maps as well as of tables and numbers. Thus we can consider a GIS a "spatial DBMS" as opposed to traditional

"tabular DBMSs." Few people use this definition, but it might help to explain GIS to a DBMS user (James P. Hall, 2004).

3. A complete definition***:*** A GIS is a system of hardware, software, and data that facilitates the development, enhancement, modeling, and display of multivariate (e.g. multi layered) spatially referenced data. It performs some analytical functions itself, and by its analysis, selective retrieval and display capabilities, helps the user to further analyze and interpret the data. Properly configured, the GIS can model (e.g. synthetically recreate) a feature or phenomenon as a function of other features or phenomena which may be related - where all features or phenomena are represented (characterized) by spatial and related tabular data. The analytical objectives described here are sometimes controversial - and often given lip service by cartographic GIS specialists who have not yet seen what can be accomplished scientifically by a select few GIS that go beyond cartographic approaches (James P. Hall, 2004).

University Science Malaysia (USM) engineering campus is one of developing facilities. Managing campus that still is developing is a challenging task. The development of a local spatial data framework requires idea, capable man power and institutional relationships and lastly, spatial data (Jan, Nelly and Jose, 2002). The data can be archive in two types; in digital form and in base form. The digital form mostly comes from existing link of data in internet or campus database. There are also some digital maps that are not link to these tabular data. Even some maps that are available now do not correlate with the existing building or with the latest development can be analyzed in campus. With this wide range

data and digital maps, this information can be analyzed to get the most accurate data on site. However, these types of data are still not significant enough for some current changes in the campus. Normally the digital data, are verified by digital map that taken from satellite image or aerial photos. In addition, topographic maps and other relevant information from specific authority are required to make the database near perfection at the current state. The unique features that distinguish GIS from other type of information system one data of entities and relationships managed within a spatial framework; and the ability to perform spatial analysis (E. Lioubimtseva, 1999). With this features and ability, the concept of developing of GIS based mapping system for Engineering Campus Infrastructure to managing spatial information can be done.

2.2 Data Development

The development of control system for local authority in Malaysia is still small. However, the government has launched the 'e-planning' that enhanced local authority to develop GIS database to improve their managing system (James P. Hall, 2004). The same concept applies to this campus, as there was no as-build map that verified the campus construction has completed. The latest digital image from satellite was taken for this campus; as for the development of GIS database for this campus must proceed. The process of development control involves a systematic compilation of quantitative analysis and assessment of existing and developing project. There for an organizational structure must first establish (Ashild Ouvik Pederson, 2004). This organization responsible to prepare, gathering latest information and managing GIS database to the latest. As example, Kuala Lumpur City Hall act as the management and administration for GIS database for all local authority in Kuala

Lumpur district. There are 20 different departments or unit assisted by two Deputy Director Generals with power and authority over decision making (Baharom and Yusof, 2001). Some development control system integrates several sub-systems to complete certain functions. Like Kuala Lumpur City Hall as mentioned by Ahris Yaakup (2003), has integrates six main sub-systems:

2.2.1 Planning authorization sub-system

This sub-system operates to process planning applications. This sub-system allow user to gain spatial information while the planning applications evaluated and view the planning requirements (Figure 2.1). This method save a lot of time for user, paper-less, minimize workload and overlapping problem will minimize with data sharing concept plus increase the quality and productivity.

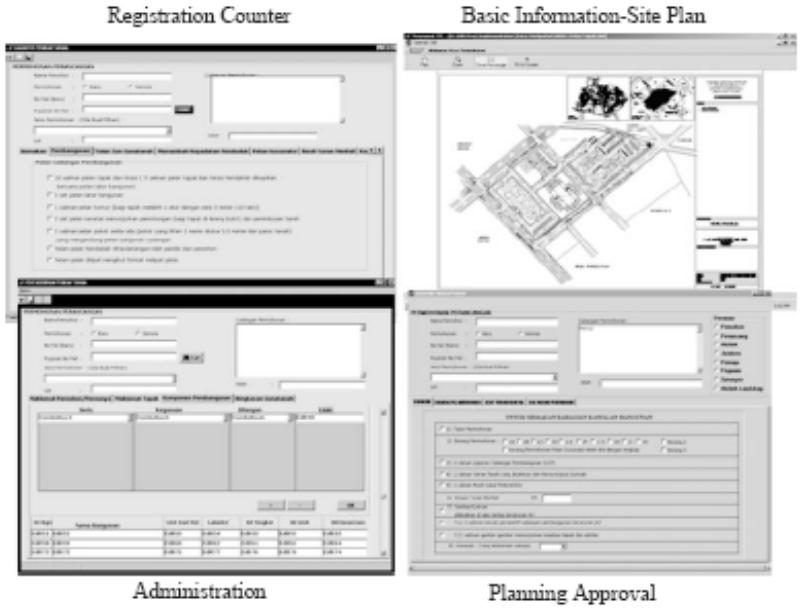

Figure 2.1 Planning authorization sub-system interface (Source: Kuala Lumpur City Hall, 2004)

2.2.2 Building control sub-system

The building control sub-system developed for building plan approval process. This system has the same features as the planning authorization sub-system which includes graphic and interactive interface and link between other sub-systems.

2.2.3 Enforcement sub-system

This sub-system serves for enforcement actions like reports on site investigation, warning notices, control actions and reports. Users also can make reports and get feedbacks from local authorities faster, systematic and effectively.

2.2.4 Geo-spatial and planning information system

To produce a complete spatial database along with attribute data, the geospatial and planning information sub-system has been created. The advantages of this system that users can choose the type of information that want to retrieve. This system combine GIS database design, data collection, data analysis and updating spatial data for others sub-system. With the provided interface, allows other division can retrieve any information (Figure 2.2).

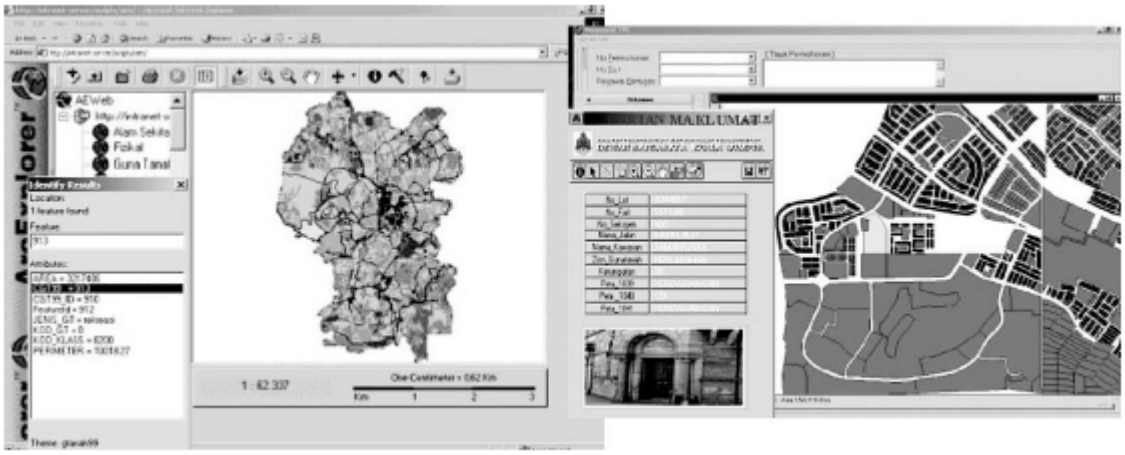

Figure 2.2 Planning information system interface (Source: Kuala Lumpur City Hall, 2004)

2.2.5 Information kiosk sub-system

The concept that apply to this system is user can retrieve information related to Kuala Lumpur City Hall as well as to obtain some forms also allows the City Hall to announce any issues to the public.

2.2.6 Meeting presentation sub-system

This sub-system developed for ensuring the smooth progress of a carried out meeting through facilities for displaying information such as map, GIS related data and others information (Figure 2.3).

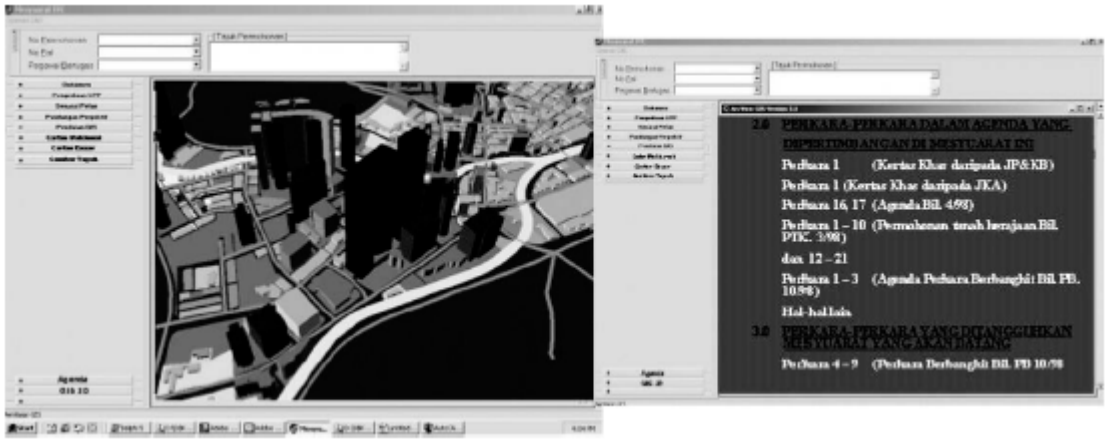

Figure 2.3 Meeting presentation sub-system (Source: Kuala Lumpur City Hall, 2004)

A combining approach to GIS and interactive map maintain the interactivity between users and the information. The capacity provided by GIS; create a interface program written in standard program language with libraries of user callable routine such as analysis routine (P. H. Martin, 2004). J.P. Hall (2004) also has mentioned the same concepts as A. Yaakub described but added one more sub-system that called GIS investigation summary. This sub-system contained identification of application, project rating and implementation options.

The usage of GIS application just not for certain development control system or analysis tools but also has been used as building safety management in Kolej Universiti Teknologi Tun Hussien Onn (KUiTTHO). The main objective of developing the system was for give information about safety, position of all safety equipment in the building, the nearest escape door if emergency happen and many more (Munzilah and Shifaa', 2004). GIS just not only for 'big event' management tool but also just for simple usage as safety precaution.

2.3 Data Analysis

As mention by A. Yaakup (2003), the data obtained must be analyzed to show the complexity in displaying geographic distribution or relationships to complex spatial modeling. Level of GIS analysis:

2.3.1 Showing the geographic distribution of features

The inter-face window must contain a menu, map and some basic data with a search bar to gain information in the database. The graphic must use an image of campus (map or satellite image) as an inter-face besides some menu. This interface must be 'user-friendly' to pleasure the user when surfing (A.O. Pesedersen et al., 2004).

2.3.2 Geospatial system

The geospatial information sub system is developed to produce a complete spatial database along with the attribute data. The advantage of this system is that users can choose the type that they want to retrieve. The query operation is based on four layers that have mention. The implementation of this system involves the GIS database design, data collection and data updating of spatial and attribute data (A. Yaakup et. al., 2003). Therefore, the interface program will link to each other.

2.3.3 Data link

Some of the information can be obtain from other database (using local area network or internet) to support the existing data in the framework.

But for A.O. Pedersen (2004), all agencies in Oslo Norway introduce the so called Demings-Circle for data analysis. This concept is widely used for environment analysis; to elaborate plans, explain dues, check and finally act according to the analysis that the system made (Figure 2.4).

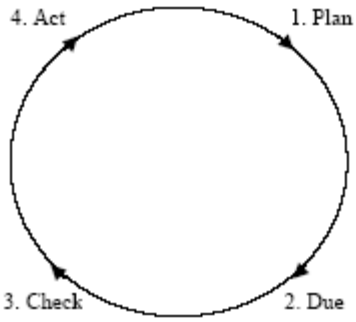

Figure 2.4 Demings-Circle (Source: Department of Transport and Environmental Affair, Norway, 1999)

It is also useful for site selection in other purposes such as incineration site location. The analytical technique of analyzing information will help professionals such as engineers, town planners and others to properly zone an area for a specific use. Decisions made by using some criteria can then be analyzed using Constraint Mapping Technique to evaluate and to seek the potential location for level one location analysis for which to identify the potential incineration site.

The use of GIS in selection process will reduce the time and enhance the accuracy. Their paper highlight a user interface developed under ArcView 3.0 using a combination of avenue and dialogs to help in the process of selection. The most important conclusion is that non-GIS users can select interactively their site in a short time. If the user is not satisfied with the output, they can iterate again and again (M. M. Yagoub and Taher Buyong, 2000).

2.4 Future Development

GIS is an information, communication and analytical tool for managing spatial data for wide range applications especially for environmental modeling. But for urban planning, the practice is still very different (J. Turkstra et. al., 2003). For Europe continent, their research among the use of GIS in urban area (Graafland Graafland, 1989) has shown that GIS mainly proposed for information, communication or routine operation for efficiency achieves. But for developing nation as example Peru, the most common spatial tool is AutoCAD and GIS tools or software is just recently introduce to the local department and NGO such as ArcView.

Now days, with the help of the newly system or application in GIS such as Global Positioning System (GPS) combined with GIS, make the urban development more persist to their objective in development planning and control. As mentioned by C.A. Quirroga and D. Bullock (1998) described GPS is the beginning of spatial mathematical model for future development. With GPS, the latest information can easily be transfer to database for user information. There lots of improvement for GIS tools today as we know for the past two decades and it will grow more and more in the future. The ability and functions of GIS

in managing developing urbanization will expand and be used not only for develop nation but also in developed country especially in Malaysia.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

Managing wide campus information like Universiti Sains Malaysia (USM) incorporating two other major campuses is not a simple problem. Each campus having different kind of management will complicate the collection of data of each campus. To overcome the problem of database management, spatial data tool like Geographical Information System (GIS) can be very useful. In spite of having spatial data tool, it capability can also do some data analysis that can be very useful in managing information.

3.2 Geographical Information System (GIS) software

GIS software like ArcView 3.1 and IDRISI32 provided the functions and tools needed to store, analyze, and display information about places. The key components of GIS software are:

1. Tools for entering and manipulating geographic information such as addresses or political boundaries
2. A database management system (DBMS)
3. Tools that create intelligent digital maps you can analyze, query for more information, or print for presentation
4. An easy-to-use graphical user interface (GUI)

3.2.1 Raster image

Technically, a raster is a pattern of horizontal scan lines, as traced by an electron beam in a CRT. It is commonly used as a term to describe a system of representing images, where the image is composed of small, internally uniform cells (pixels) arranged in a grid. The order of image storage is typically by scan lines, progressing from left to right along scan lines, and then from top to bottom from one scans line to the next. The image will provide x and y coordinate according to the setting or data input. Raster Group Files are used with the extended cursor inquiry mode in the display, to zoom in and out and pan simultaneously across multiple images, and to enter a group of file names into certain dialog boxes. Extended cursor inquiry mode is possible when the Feature Properties icon is enabled. Extended cursor inquiry mode produces a listing of the values occurring at a pixel across a set of images listed in the Raster Group File. With extended cursor inquiry mode enabled, it also is possible to simultaneously view a graphic histogram of the values listed for the pixel as it is selected. Zooming in and out and panning is possible across multiple images when these images are displayed as part of a raster collection. The example is shown in Figure 3.1 below.

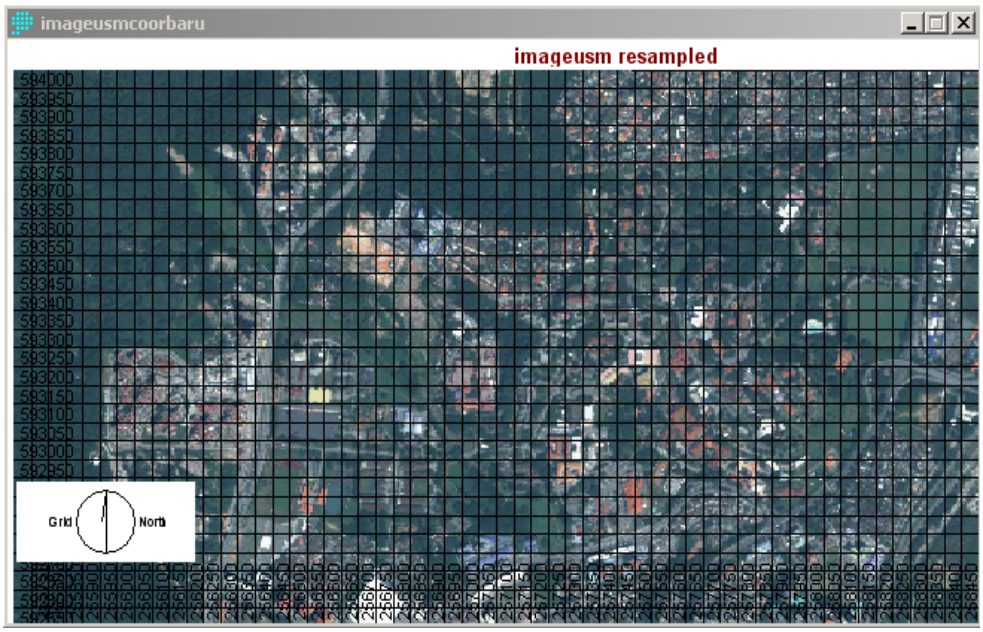

Figure 3.1 Example Raster image with x and y coordinate in Idrisi32

3.2.2 Feature Data Source

ArcView coverage is a topological data structure for geographic features. The coverage format is suitable for spatial analysis and large geographic data management applications. Defining spatial features topologically in coverage can optimize data storage by reducing coordinate redundancy, and facilitate a number of key spatial operations such as polygon overlay, path finding through connectivity of arcs and contiguity analysis that can be performed in ArcView. Figure 3.2 showed the Feature Data Source image. ArcView coverage format is a common spatial data formats found in digital mapping and GIS applications. In ArcView coverage, features are stored as vector data and their attributes are stored in tables known as attribute tables. Each class of features stored in coverage has its own attribute table. Attribute tables contain one record for each feature of that class in the coverage.

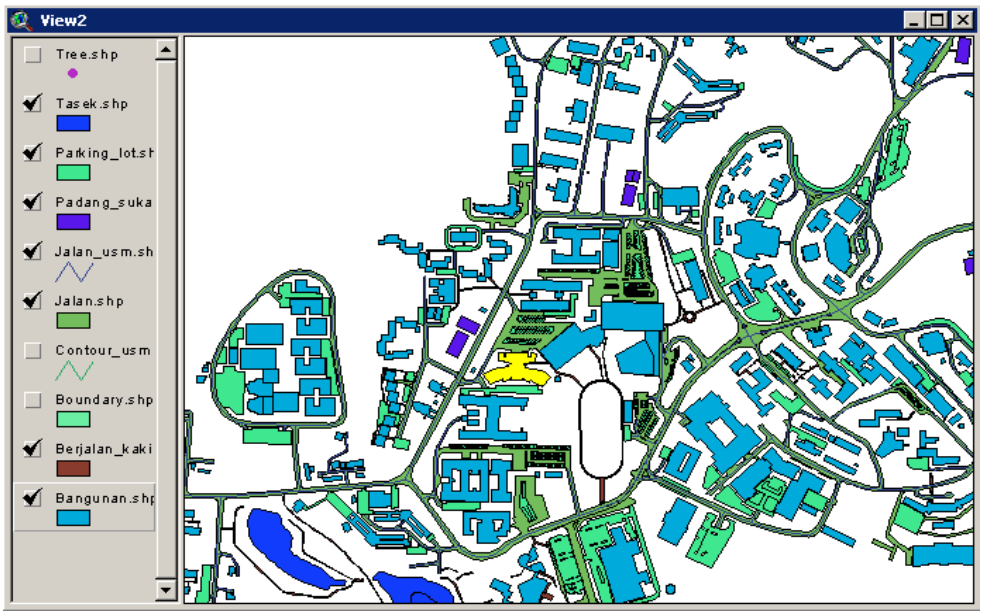

Figure 3.2 Feature Data Source image

3.2.3 Satellite image

Satellite image of USM main campus is the main data in this project. This image will help in spatial analyst for georeferencing. With this image, a process RESAMPLE will occur. This process registers the data in one grid system to a different grid system covering the same area. With the ArcView Spatial Analyst extension (Version 1.1) can create, view, query, and analyze map cell-based raster data and perform integrated vector-raster analysis using feature themes and grid themes. It can also convert feature themes to grid themes, create buffer distance and proximity surfaces from feature or grid themes, do contouring and density mapping from themes containing point features, map slope and aspect, analyze cell-based maps, do Boolean queries on multiple grid themes, analyze neighborhoods and zones, classify and display grids, among other things. The extension includes an Avenue programming interface for developing spatial analysis applications. Warp

environment sample extension extends the spatial analyst user interface for georeferencing or warping grid data sets. Other extensions are also available for transferring image to ArcView like in JPG file format or TIFF file format.

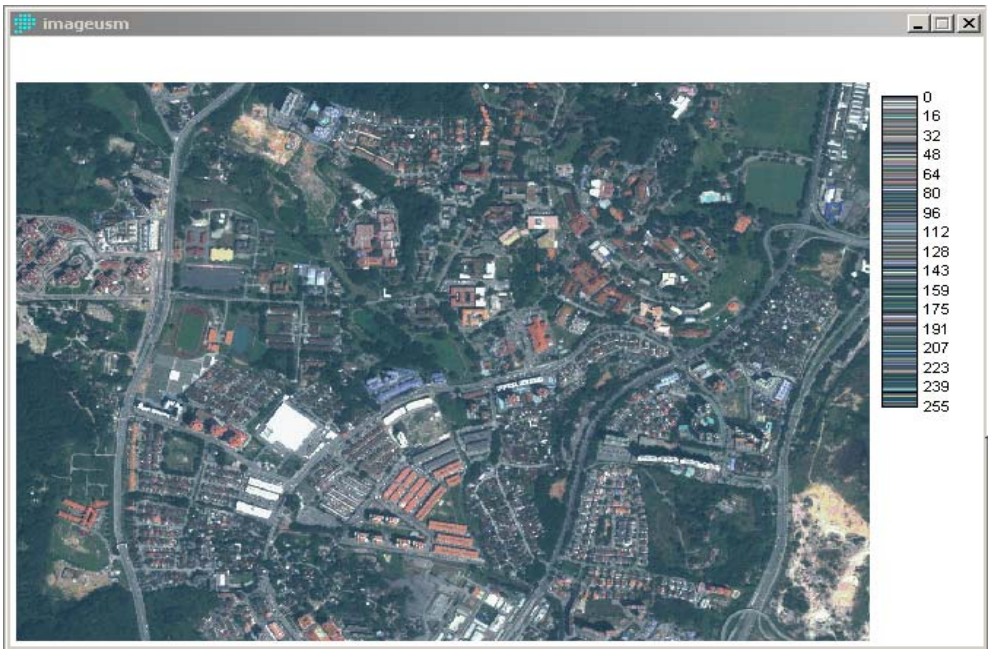

Figure 3.3 Satellite image of USM main campus

3.3 Hardware Requirement

There are some requirements for the software to run properly. Even though the minimum requirements are provided but for more efficient result, the hardware that been used for this project was the MSI V-P4 motherboard, 2.4 GHz Intel Pentium Chipset and 512 MB RAM. The minimum requirements are 32 MB RAM, 200 MB Chipset and 10 MB of hard disk space.

3.4 Site Location Description

USM was founded after an agreement made on a resolution approved by the Penang State Legislative Council in 1962, which suggested that a university college be established in the state. An area in Sungai Ara was identified and later the foundation stone was placed by the then Prime Minister, Y.T.M Tunku Abdul Rahman Putra Al-Haj on the 7th of August 1967. In 1969, the University of Penang was established in response to the need for a larger campus with a more conducive environment, appropriate to the needs of the future of the country. In April 1969, Professor Hamzah Sendut was elected the first Vice-Chancellor. Two months later, a group of 57 students was envoled. Since the area of Sungai Ara could not be developed as fast as anticipated, the group of the student was placed at the Malayan Teachers' Training College at Bukit Gelugor on loan from the Education Ministry. In 1971, the campus, which was originally planned to be situated in Sungai Ara, moved to its present site, Minden, which is a beautiful location with an area 500 acres. The green and hilly scenery facing the sea is truly captivating.

3.5 Project Development Procedure

The project started based on the procedure in the flow chart shown below.

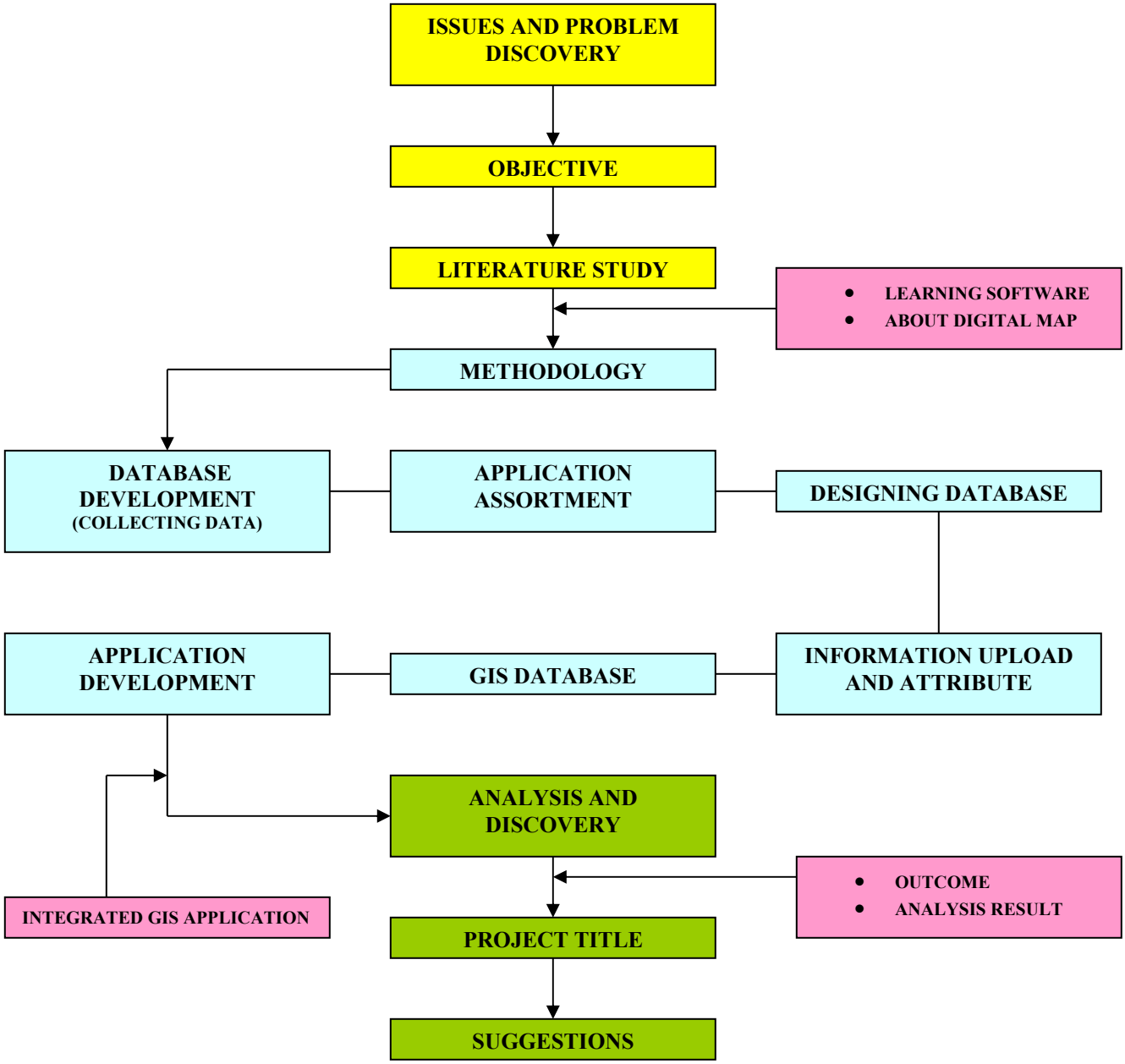

Figure 3.4 Methodology flow chart

3.5.1 Database development (collecting data)

For designing or creating a database, the collecting data is the first step to gain information. The collection of data for database design is necessary as a main platform to gain any information about USM main campus. The project meant for spatial analysis alone but also for the benefit of the USM staff and public to have access any information about USM. With this main database, all information can be shared in one big file and can access able freely throughout internet or local network. The database also can be updated if necessary. There are many types of information that shared in the database but most of them are digital images. These images may come from satellite, CAD drawing and digital camera. The interface for this project is from Feature data source image. The image come with database containing the information related to the image. Other information that is found necessary was collected from USM management authority such as the Development Office, Library and websites. If any changes on the creation of the database, it can easily be changed. As a conclusion, the data collection was made from two sources digital and formal data.

3.5.2 Application assortment

After collecting all the data needed, application assortment was performed before designing the database. These applications must be done orderly because the result can effect the other application there after. Some application must be done first before the result can be used in other platform or application. Basically, learning to handle the software ArcView 3.1 and IDRISI32 was also in this part of the project