PERFORMANCE OF GPS FOR ROAD NETWORK MAPPING AND ANALYZING VEHICLE POSITION

By

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Nizar Alwi b. Mohamad Tajudin

ABSTRACT

The main objective object of this project is to determine the performance of Global Positioning System (GPS) in road network mapping and to analyze the vehicle position. The road network near the USM Engineering campus has been chosen as a study location. Today GPS is a very popular and useful in the field of surveying and navigation. Many GIS software can be used in GPS measurement technique and it also can be integrated with GPS data, whereby giving useful information. GIS also can be use to created a dynamic map where, the map that being create can be filled with any information or attribute data. GIS map (dynamic) also can be updated and also correction can be made to the map. ArcView GIS version 3.1 can be used to visualize, explore, query and analyze data spatially. In this project the Omnilite Reciever 132 and Psion Workabout Data logger is used to collect the road network data. ArcView GIS version 3.1 is used to analyze the data and also in mapping the road network of the study area. Coordinate and time data can be obtained from GPS instrument. Vehicle speed can be computed using this GPS data, so an analysis of vehicle speed on the area can be made.

ABSTRAK

Tujuan utama kajian ini dijalankan adalah untuk menilai prestasi alat System penentududukan sejagat atau GPS dalam menghasilkan peta jaringnan jalan raya dan juga untuk menganalisa kedudukan kenderaan. Jaringan jalan raya berhampiran kampus Kejuruteraan USM telah di pilih sebagai kawasan kajian. Pada masa kini GPS telah digunakan secara meluas dan amat berguna di dalam bidang ukur dan navigasi. Perisian Sistem Maklumat Geografi (GIS) juga dapat berintegrasi dengan data. Perisian GIS juga dapat digunakan dalam penghasilan peta yang bersifat dinamik dimana, atribut-atribut dan apa saja maklumat boleh disimpan dan diperbaharui dari masa ke semasa. Perisian ArcView GIS versi 3.1 yang digunakan dalam kajian ini boleh digunakan untuk memapar dan memberi informasi serta menganalisis data sesuatu peta.. Penerima isyarat GPS “Omnilite 132” dan Penyimpan data “Psion Workabout” digunakan di dalam kajian ini. Manakala perisian GIS (ArchView versi 3.1) digunakan untuk menganalisa data dan menghasilkan peta jaringan jalan raya di kawasan kajian. Data koordinat dan masa dapat direkod melalui alat GPS yang telah dinyatakan sebelum ini. Melalui data ini kelajuan kenderaan dapat dikira, maka analisis kelajuan kenderaan yang digunakan dapat dibuat.

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INTRODUCTION

1.0) GLOBAL POSITIONING SYSTEM

Global Positioning System or 'Navigation System With Aiming And Ranging global Positioning System is a system developed by United State Department of Defense (DoD) in 1973.This system was developed by U.S Navy's TIMATION program and U.S Air Force's 612B project under Joint Program Office (JPO) responsibility. This system was developed with the main objective to get the real time positioning in the air, sea and land. In the early 1990 this system was fully operated and it could be used 24 hours a day in any weather condition.

The Global Positioning System (GPS) was developed an operated to support military navigation. GPS represent an almost ideal dual-use technology and enjoys in creased attention by civilian to explore its suitability for civil applications. The complete GPS system consists of 24 operational satellites and is available 24 hours.

As a by-product, GPS has the potential of replacing leveling in many applications. The primary result of a GPS survey is a polyhedron of station with precisely known relative locations. This geometry can be expressed in terms of ellipsoidal (geodetic) coordinates that is latitude, longitude, and elevation.

GPS instrument manufacturers typically provide the software for phase processing, datum transformation, conformal mapping computation and even geoid undulation computation.

1.1) Problem Description

Global Positioning System (GPS) has been widely used in Vehicle Navigation Systems. It helps the users to determine the vehicle position or provides users with proper maneuver instruction. Because of some biases, such as selective availability (SA) effect, buildings canyon around cities affect and block GPS signals. These cause vehicle position not to locate precisely on the road network of the digital map.

From GPS data, road network map can be developed using the ArcView Version 3.1 GIS Software. The GPS road network map can be compared to the another GIS road map (in our case Seberang Perai GIS map). By comparing these two types of maps, the accuracy of the GPS data in mapping a road network can be determined.

GPS is an efficient tool in recording vehicle position and speed values and it can provide detailed information on traffic characteristics. GPS instrument can record the coordinates such as latitude, longitude, elevation and time data. From the coordinates, the distance between two points can be calculated. By using the time and distance data, the speed value can be computed. Finally, with these parameters vehicle speed that is effected by some construction/repair work or traffic signal can be analyzed.

1.2) Project Objective

The main objectives of this project are:

- To compare the effectiveness of GPS instrument (OmniSTAR Scout 12) performance in making a map of road network.
- To learn and improve the skill and knowledge in using the GPS Psion data Collector in collecting data and ArcView GIS software.
- To determine traffic characteristics on the road by analyzing the GPS data

1.3) Study Scope

The following is the scope of study:

i. Learning the concept and theory of GPS in collecting data.

ii. Understanding and learning how to operate the GPS instrument (Omnilite 132) receiver and data collector (Psion Workabout).

iii. Learning the technique to process the data in GIS for preparing a road network map.

iv. Analyze the performance and effectiveness of the GPS instrument in:

  - Mapping a road network.
  - Analyze the data in term of vehicle position on the road network.

CHAPTER II

LITERATURE REVIEW

Establishment of local control points is very important for carrying out surveying and mapping of the area for any engineering project (Ghosh and Goyal, 2003). GPS has already been used as an important tool for establishment of control point accurately, quickly and economically in a versatile way. The coordinates of the terrestrial sites thus obtained can be in the WGS 84 (World Geodetic System) reference frame. Surveyors are not, usually, interested in coordinates of terrestrial points referring to a global frame; rather the results are preferred to be in a local coordinate frame. Since the WGS 84 is a geocentric system and the local system usually is not, transformations from global coordinates to local level coordinates are required.

Ghosh and Rao (2001) in the research "Control point positioning using GPS" described that control establishment is an important exercise in mapping process. The mapping accuracy is directly based on the accuracy of control network. The control network is formed by a group of points whose position (x,y,z) are known to a high degree of accuracy. Accuracy defines the quality of a control network. The positions of other features of interest are determined with respect to these control points for mapping. To achieve such a high degree of accuracy a reliable and accurate method of surveying is required. Though several techniques are used to properly establish and provide accurate horizontal and vertical control networks, meeting the requirements of the user community, the best technique will be one that provides the control networks with required mapping accuracy at the least cost in time and money. GPS technique has been well established as a means for establishment of control points in surveying and mapping. In carrying out this, the absolute coordinates of at least one site have to be known accurately in WGS84 coordinate system. As WGS84 coordinates for a particular site was not known neither it could be derived, in order to establish a reference station, Single Point Positioning technique of GPS has been applied for several hours of observation spanning in three consecutive days and night. The observed value shows precise planimetric position but grossly imprecise in height. However, the study provides some insight on the influence of some variables like a-priori value of parameters, time of observation etc. on result. The paper also discusses the probable sources of errors, precautions to be taken and direction of further study.

The GPS is one of the viable systems which meets the requirements of the surveying fraternity all over the globe. It is a space-based all weather radio navigation system. It broadcasts precise, synchronized timing signals to provide precise estimates of position, velocity and time of the antenna location of the system receiver. There are several methods of measurement based on GPS that make possible to take survey measurements from space. The numerous limitations of the terrestrial surveying like requirement of inter-visibility of survey stations, dependability on weather, difficulties in night observations, 3D position parameters etc could be overcome using GPS techniques. These advantages over the conventional techniques coupled with economy in time and cost, accuracy, speed and versatility in operation make GPS the most promising surveying tool of the future. Thus, a great technological revolution is taking place at the development of GPS as it can be used in any conceivable problem under the sky, where the exact position of any object or phenomena involved.

GPS surveying is a relative technique with baseline being “observed” and computed from the reference to rover. As many baselines will often be measured from the same reference station, the choice and reliability of reference station are of particular importance. Thus, the absolute WGS84 coordinates of at least one site have to be known accurately as all measurements in GPS system are depicted in WGS84 coordinate system.

For any precise GPS survey the absolute coordinates of one site in a network have to be known in WGS84 to about 10 meters. There are three possibilities for obtaining reliable WGS84 coordinates for one site and these are:

- WGS84 coordinates may be available.
- WGS84 coordinates can be derived from local coordinates using appropriate transform function.
- WGS84 coordinates can be computed by GPS point positioning.

Since control point have to meet some specific requirements with special emphasis of its suitability for GPS observation, the choice and reliability of reference station is of particular importance. Location of control point is important in taking care of a good site characteristics for GPS observation such as

- A clear view of the sky;
- No obstructions above the cut-off angle (say 15°);
- No reflecting surfaces that could cause multi-path;

- Safe, away from traffic and passers-by;
- Possibility to leave the receiver unattended;
- No powerful transmitters (radio, TV antennas etc.) in the vicinity, a point on the top of a building (the Remote Sensing and Photogrammetric Engineering Section) of Civil Engineering department at IIT Roorkee is found suitable and thus considered as reference station for GPS receiver and subsequently, serves as the control point for this study.

Generally, the position indicated by the GPS at a given time does not coincide with the exact position of the apparatus. In fact, the difference between the coordinate readings and the true values are caused by two types of errors:

- systematic error due to the GPS system itself (receiver noise and resolution offset, receiver hardware offset etc.), which remains the same irrespective of the measurement date and point measured; and
- random error that differs with each measurement, due to atmospheric conditions, muti-path and shadowing effect, presence of water vapor etc.

To obtain accurate geodetic height, single point positioning can not be applied directly. Rather, some other better method may be tried. GPS system can be used reliably for establishing precise planimetric position of a control point.

Thus, planimetric change in position of any object or phenomena can be studied very precisely by single point pointing of GPS receiver. For this no previous information is necessary other than very approximate location of the station point. Since ionosphere is activated by solar radiation, its disturbances are much more severe on+ GPS observation during the day time than at night. So, GPS data should be preferably be collected at night than during day time, in single point positioning.

A further study can be done on the accuracy of single point positioning by using the precise ephemeredes (in calculating the position of satellites). However, other methods like relative positioning etc may be adopted which minimises the different errors. Moreover, post processing of relative positioning data takes into consideration the phase data of GPS observation and thus, may improve the accuracy of control point location. Local atmospheric models may be adopted to keep atmospheric errors least.

According to Pen -Shan Hung, Tsui -Chuan Su (ACRS 1998) in their research titled "Map-Matching Algorithm of GPS Vehicle Navigation System) inform that generally, Global Positioning System (GPS) has been widely used in Vehicle Navigation Systems. It helps the users to determine the vehicle position or provides users with proper maneuver instruction .Because of some biases, such as SA effect, buildings canyon around cities , thus those affect and block GPS signals .In addition , the road network of the digital Map is not accurate enough. These cause vehicle position not to locate precisely on the road network of the digital map. Therefore a map-matching algorithm is necessary. An optimal algorithm is developed through the analysis of some driving conditions (such as turning. U- turn or drive to parking lots). In vehicle Navigation System, Map- Matching approach plays an important role (Cring and Drane, 1994; Zhao, 1997). It is a method of using digital map data and GPS satellite signal to locate the vehicle on proper poison relative to digital map. In general, the vehicle location is not necessarily on the road of digital map. The unreasonable GPS signals tried to be filtered and to remove the biases of GPS signals by using map- matching system .It was expected to find the stability of GPS signals from many tests for different receivers. Sometimes the vehicle location is compatible with the road network and it is not sometimes. Therefore, it is possible to display vehicle location on the wrong road.

Yi Jiang & Shuo Li (2001) in their research(*Measuring and Analyzing Vehicle Position and Speed Data at Work Zones Using Global Positioning System)* expressed that GPS is an efficient tool in recording vehicle position and speed values and it can provide accurate and detailed information on traffic characteristics at work zones. A GPS device was configured to record the vehicle positions and speeds at one-second time intervals. An interface program was written to control the operations of the GPS device and to mark the landmark points. To perform the data collection two persons, a driver and a GPS recorder, were needed. The GPS device's error range is within one meter for distance measurements and is less than 0.16 km/h for speed measurements. This accuracy of
the GPS device is considered very high for the purpose of traffic analysis. The important thing in their research is:

- From the dynamic feature of the GPS collected data enables the traffic engineers to obtain the precise profile of vehicle speed along roadway section.
- The geometric layout can also be drawn using the GPS positioning data.
- Vehicle speed profile at a work zone can be obtained by analyzing vehicle position and speed data from GPS instruments.

- With the GPS data, the average travel speed on a given roadway section (freeway or work zone) can be calculated through Equation 1 or Equation 2. Which is :

- *Equation 1*

$$V = \frac{\sum V_i}{N} \tag{2.1}$$

where, V = average speed at work zone

V_i = the ith speed value within work zone

N = total number of speed values or total number of data points within work zone.

- *Equation 2*

$$U = \frac{D}{T} = \frac{d_1 - d_0}{t_1 - t_0} \tag{2.2}$$

where, U = average travel speed at work zone

D = distance traversed

T = travel time

d_1 = distance at the end of work zone

d_0 = distance at the beginning of work zone

t_1 = time at the end of work zone

t_0 = time at the beginning of work zone

And, $d_1 - d_0$ is the work zone distance and $t_1 - t_0$ is the total time that the vehicle spent to traverse the work zone.

- The two equations would yield the same results because the GPS position and speed
- values are recorded at equal time intervals.
- It is also presented that the vehicle deceleration and acceleration rates, which could only be roughly estimated in an earlier study, can be readily calculated with high accuracy using the GPS data.
- Traffic delay at a work zone can be obtained by comparing the GPS recorded actual travel time through a roadway section with the work zone and the travel time needed to traverse the same section at the freeway speed.
- In addition, under traffic congestion condition at a work zone, the GPS data provides the precise values of time, position and speed of the test vehicle's movement to identify the exact queue length in front of the work zone.
- The GPS device's error range is within one meter for distance measurements and is less than 0.16 km/h for speed measurements.

CHAPTER III

METHODOLOGY

The Global Navigation Satellite System (GNSS) is a satellite system that provides a world-wide position determination, time and velocity capability for multi-modal use. It includes user receivers, one or more satellite constellations and ground segment to monitor and control the world-wide conformity of the signals processed by the user receivers to pre-determined operational performance standards.

3.1) Major Component of GPS

There are three major component of a GPS:

- Space Segment
- Control Segment
- User Segment

3.1.1) Space Segment

This segment consist of the GPS satellites which all of it being placed in the spaced on the specific orbit. The Space Segment consists of the Constellation of NAVASTAR earth orbiting satellites. The current Defense Department plan calls for a full constellation of 24 Block II satellites (21 operational and 3 in-orbit spares). The satellites are arrayed in 6 orbital planes, inclined 55 degrees to the equator. They orbit at altitudes of about 12000, miles each, with orbital periods of 12 sidereal hours (i.e. determined by or from the stars),

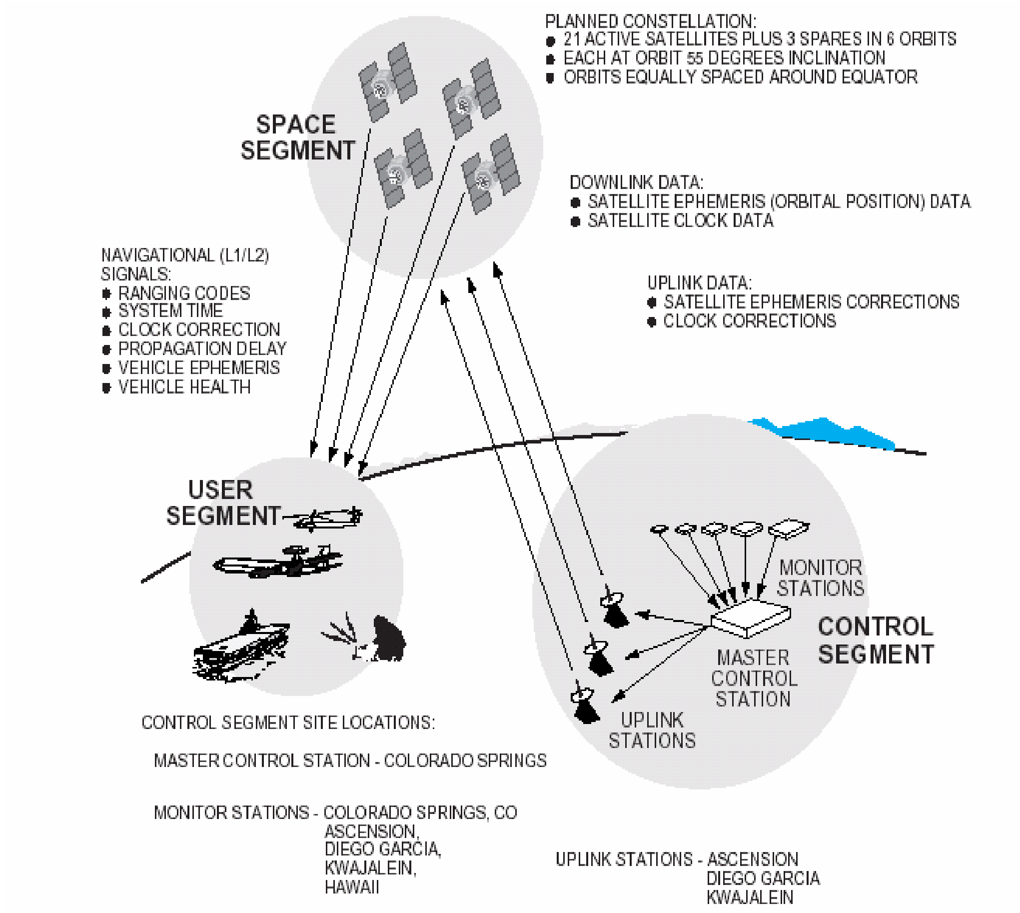

Figure 3.1. NAVSTAR GPS Segments

or approximately one half of the earth's periods, approximately 12 hours of 3-D position fixes.

The next block of satellites is called Block IIR, and they will provide improved reliability and have a capacity of ranging between satellites, which will increase the orbital accuracy. Each satellite contains four precise atomic clocks (Rubidium and Cesium standards) and has a microprocessor on board for limited self-monitoring and data processing. The satellites are equipped with thrusters which can be used to maintain or modify their orbits.

3.1.2) Control Segment

The control segment is responsible for operating the GPS system. From the user's point of view, the primary mission of the control segment is to update the navigation message transmitted by the satellites. To accomplish this, the Operational Control System (OCS) consist of 5 monitoring stations distributed around the world which is:-

i. Colorado Springs, United State of America (Master Control Station)
ii. Hawaii
iii. Ascension Island, South Atlantic Ocean
iv. Diego Garcia, Indian Ocean
v. Kwajalien

The main functions of this segment are:

i. Detect or tracking the Satellites
ii. Make the correction of atom and GPS orbit
iii. To make sure the time is consistent between all of the GPS satellites
iv. Transmit the navigation messages and the ephemeris calculation result to the GPS satellites.

It is important to note that the control segment is required only to monitor the satellites and to provide navigation message.

3.1.3) User Segment

User Segment consists of component such as user, receiver and GPS equipment or tools. User Component can be divided into two categories, which are:

i. Civil User
ii. Military User

It also includes the tools that are used for tracking the signal and GPS measurement, software (positioning algorithms and connection between the user) and operation procedure (influenced by accuracy, functions and others factor).

The user segment is a total user and supplier community, both civilian and military. The User Segment consists of all earth-based GPS receivers. Receivers vary greatly in size and complexity, though the basic design is rather simple. The typical receiver is composed of an antenna and preamplifier, radio signal microprocessor, control and display device, data-recording unit, and power supply. The GPS receiver decodes the timing signals from the 'visible' satellites (four or more) and, having calculated their distances, computes its own latitude, longitude, elevation, and time. This is a continuous process and generally the position is updated on a second-by-second basis, output to the receiver display device and, if the receiver display device and, if the receiver provides data capture capabilities, stored by the receiver-logging unit.

3.2) GPS Signal

All GPS satellites transmission are coherently derived from the fundamental frequency of 10.23 MHz (f_0). This signal are made available by the set of onboard cesium and rubidium atomic clocks which had been installed in the satellites. This atomic clocks also control the signal. By multiplying this fundamental frequency with the integer factor to get two electromagnet carrier L1 and L2. GPS satellites broadcast on three different frequencies, and each frequency (or carrier wave) has some information or codes on it. The Table 1 below lists the signals and the contents:

Table1. List of Signals carrier

L1 Carrier	L2 Carrier	L3 Carrier
19 cm wavelength	24 cm wavelength	Data not available
1575.42 M Hz	1227.6 M Hz	
C/A Code	P Code	
Navigation	Navigation Message	

The GPS navigation message is the data supplied to the user from a satellite. Signals are transmitted at two L-band frequencies, L1 and L2, to permit corrections to be made for ionospheric delays in signal propagation time in dual frequency receivers.

The L1 carrier is modulated with a 10.23 MHz precise (P-code) ranging signal and a 1.023 MHz clear acquisition (C/A code) ranging signal. These are pseudo random noise (PRN) codes in phase quadrature. The L2 signal is modulated with the P-code only. Both the L1 and L2 signals are also continuously modulated with a data stream at 50 bits per second. The P-code is a PRN sequence with a period of 38(+) weeks. The C/A code is a shorter PRN sequence of 1023 bits having a period of one millisecond. The P-code is intended for military use and is only available to authorized users. Access to GPS by civilian users is provided through the C/A coded signals.

The navigation message consists of a 50 bit per second data stream containing information enabling the receiver to perform the computations required for successful navigation. Each satellite has its own unique C/A code that provides satellite identification for acquisition and tracking by the user.

- *P Code :* Reserved for direct use only by the military
- *C/A Code :* Used for rougher positioning

- For Single frequency use only L1 career is used
- For Double frequency, L1/L2/L3 career is used

The navigation message (usually referred to as the ephemeris) tells us where the satellites are located, in a special coordinate system called WGS-84. If we know where the satellites are at any given time, then our location here on earth can be calculated.

3.3) Accuracy of GPS

There are four basic levels of accuracy - or types of solutions - can be obtain with real-time GPS mining system listed below,

- Autonomous Accuracy : 15 – 100 meters
- Differential GPS (DGPS) : Accuracy 0.5 – 5 meters
- Real-Time Kinematic Float :Accuracy 20cm – 1 meters
- Real-Time Kinematic Fixed (RTK Fixed) : Accuracy 1 cm – 5 cm

3.4) Factors that effect GPS

There are a number of potential error sources that affect either the GPS signal directly or your ability to produce optimal results:

- Number of satellites-minimum number required:

  You must track at least four common satellites - the same four satellites - at both the reference receiver and rover for either DGPS or RTK (real time cinematic) solutions. Also, to achieve centimeter -level accuracy, remember you must have a fifth satellite for on-the fly RTK initialization. This extra satellite adds a check on the internal calculation. Any additional satellites beyond five provide even more checks, which is always useful.

- Multipath - reflection of GPS signals near the antennae:
  Multipath is simply reflection of signals similar to the phenomenon of ghosting on our television screen. GPS signals may be reflected by surfaces near the antennae, causing error in the travel time and therefore error in the GPS positions.

- Ionosphere - change in the travel time of the signal:

- Before GPS signals reach your antenna on the earth, they pass through a zone of charged particles called the ionosphere, which changes the speed of the signal. If your reference and rover receivers are relatively close together, the effect of ionosphere tends to be minimal. And if you are working with the lower range of GPS precisions, the ionosphere is not a major consideration. However if your rover is working too far from the reference station, you may experience problems, particularly with initializing your RTK fixed solution.

- Troposphere - change in the travel time of the signal:

- Troposphere is essentially the weather zone of our atmosphere, and droplets of water vapour in it can effect the speed of the signals. The vertical component of GPS answer (your elevation) is particularly sensitive to the troposphere.

- Satellite Geometry - general distribution of the satellites:
  Satellite Geometry - or the distribution of satellites in the sky - effects the

computation of your position. This is often referred to as Position Dilution of Precision (PDOP).

- PDOP is expressed as a number, where lower numbers are preferable to higher numbers. The best results are obtained when PDOP is less than about 7. PDOP is determined by your geographic location, the time of day you are working, and any site obstruction, which might block satellites. Planning software can be used to help us determine when we will have the most satellites in a particular area.

- When satellites are spread out, PDOP is Low (good).

- When satellites are closer together, PDOP is High (weak).

- Satellite Health - Availability of Signal: While the satellite system is robust and dependable, it is possible for the satellites to occasionally be unhealthy. A satellite broadcasts its health status, based on information from the U.S. Department of Defense. Your receivers have safeguards to protect against using data from unhealthy satellites.

- Signal Strength - Quality of Signal: The strength of the satellite signal depends on obstructions and the elevation of the satellites above the horizon. To the extent it is possible, obstructions between your GPS antennae and the sky should be avoided. Also watch out for satellites which are close to the horizon, because the signals are weaker.

- Distance from the Reference Receiver: The effective range of a rover from a reference station depends primarily on the type of accuracy you area trying to achieve. For the highest real time accuracy (RTK fixed), rovers should be within about 10-15 Km (about 6-9 miles) of the reference station. As the range exceeds this recommended limit, you may fail to initialize and be restricted to RTK float solutions (decimeter accuracy).

- Radio Frequency (RF) Interference:
- RF interference may sometimes be a problem both for your GPS reception and your radio system. Some sources of RF interference include:
    - Radio towers
    - Transmitters
    - Satellite dishes
    - Generators

One should be particularly careful of sources which transmit either near the GPS frequencies (1227 and 1575 MHz) or near harmonics (multiples) of these frequencies. One should also be aware of the RF generated by his own machines.

- Loss of Radio Transmission from Base: If, for any reason, there is an interruption in the radio link between a reference receiver and a rover, then your rover is left with an autonomous position. It is very important to set up a network of radios and repeaters, which can provide the uninterrupted radio link needed for the best GPS results.

3.5) Working Procedure

The methodology in this project can be divide in a certain section which is: -

i. Project start with understanding the concepts and theory related to the project, mostly about GPS. It can was made by making a literature review about any topic that related to the GPS.
ii. OmniSTAR Scout 12 GPS system, receiver and Psion data logger and collector are used to collect the data for this project. This instrument had certain function, specification and method to operate. By study and learning about this instrument using the Scout 12 user manual this instrument can be well operated and systematically. The PsiWin software also used for downloading the data from the Psion data logger to the computer so this software also had been learn.
iii. Learn and study the software that used, ArcView Version 3.1 for mapping section.
iv. Taking Data. GPS instrument in the backpack carried on a motorcycle. Data are taken using a Track record option or function in the Psion data Logger. To perform the data collection two persons, a driver and a GPS recorder, were needed which, one person drive the motorcycle and the other monitor the instrument (Psion Data Logger). This make sure safety and data can be taken smoothly during taking the data because sometime the receiver will lost the signal so the data logger need to be monitor and operated back by the other person. Signal can be lost sometime because an obstruction by some big and high things such as buildings and trees.

v. Make an editing to the data. This editing is needed because some of the data can not be used because of an error due to lost of the signal during taking the data.

vi. Mapping using ArcView software and compare the map. Using the software the road network map can be make.

vii. Analyze the result.

3.6) Instrument used

Omnistar Scout 12 System

The Omnistar scout 12 is a complete package for all GIS and data collection applications. The scout software provides in the capability of outputting real-time sub-meter positions, to enable accurate recording and navigation functions.

The system consists of an Omnilite receiver, antenna and sealed portable battery, complete with all interconnecting cables, contained within backpack. User interface provide by Psion Workabout hand-held computer. The workabout connects to the Omnilite 132 receiver in the backpack via extension cable.

The Psion Workabout has a LCD screen that provides a graphical user interface and alphanumeric & and function keyboard. The Workabout is powered by its own internal batteries.

Data can be downloaded from the Psion Workabout to an external PC at the end of a working session, using a transfer Utility. Figure 3.2 below show the main component of this Omnistar Scout 12 System.

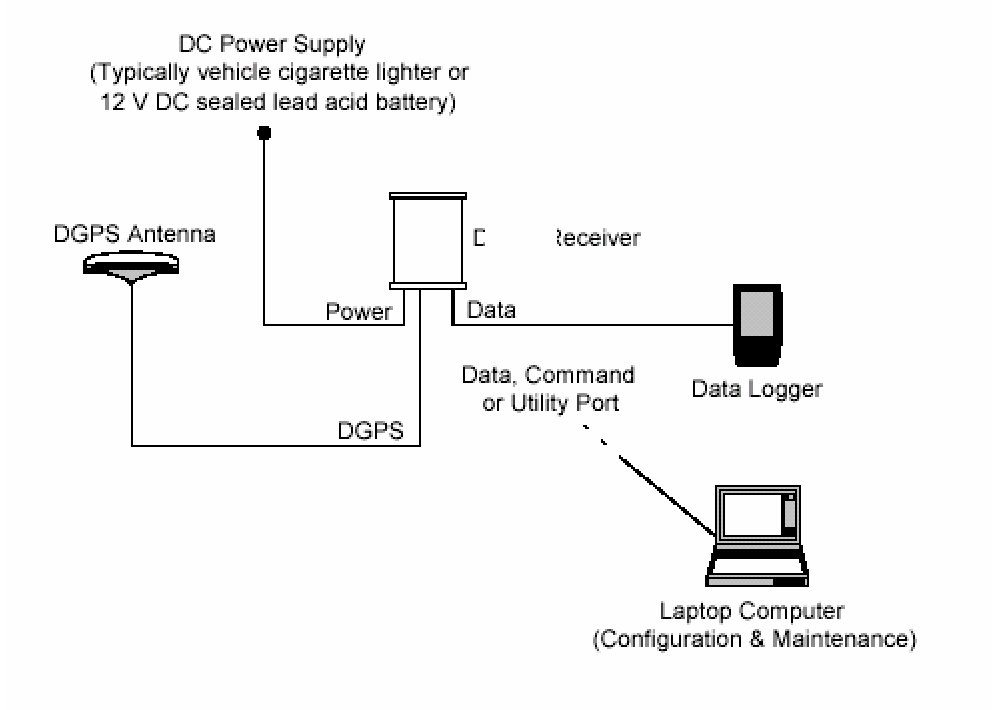

Figure 3.2. System component in OmniSTAR Scout 12

3.6.1) Instrument Specification

There were three component in the OmniSTAR Scout 12 system which is : -

- Omnilite 132 Receiver
- Psion Workabout MX data collector (Data Logger0
- Internal Software (Scout 12)

3.6.2) The 3100LR12 General Description

The 3100LR12 (shown in Figure 3.3) is the main part of a portable system. It contains the satellite RF receiving and signal processing components. All ancillary equipment is plugged into the appropriate sockets on the receiver rear panel.

A typical 3100LR12 package will consist of the following items:

- 3100LR12 (receiver)
- Data cable
- Power cable
- RF cable
- Antenna
- 3100LR12 users' 'Toolkit' diskette

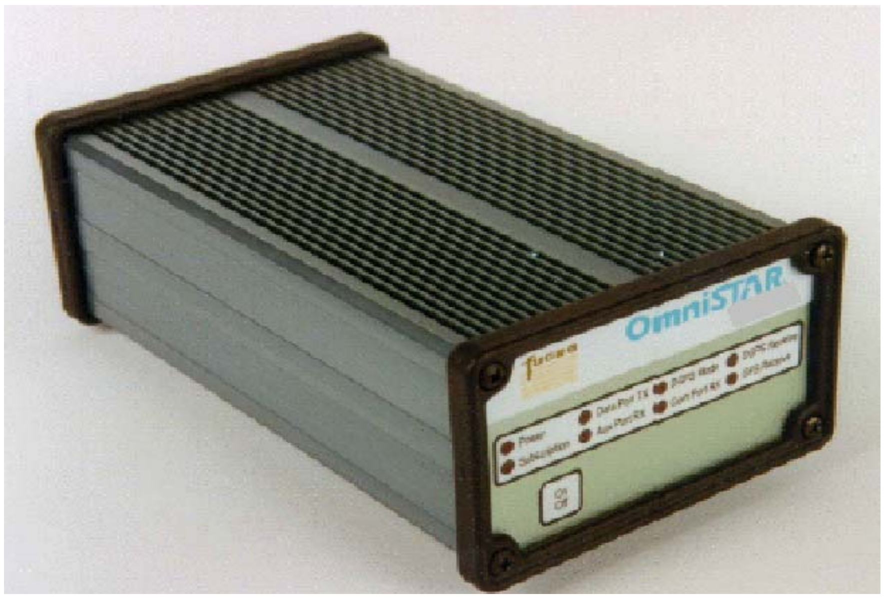

Figure 3.3 Omnilite 132 Receiver

3.6.3) Scout 12 Software

The Scout software provides the graphical user interface for the Omnistar Scout 12 GPS receiver. The software advanced features enable GPS information to be displayed on the Psion Workabout handheld computer. Rugged in design the Psion Workabout provides differentially corrected GPS coordinates on the backlite screen in real time.

Key features of the Scout software are:

- Graphical user interface