

Remote Vehicle Monitoring and Tracking System

By

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Dissertation submitted in partial fulfillment of
The requirement for the
Bachelor of Technology (Hons)
(Business Information System)

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Business Information System Programme
Universiti Teknologi PETRONAS
in partial fulfillment of the requirements for the
BACHELOR OF TECHNOLOGY (Hons)
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Approved by,



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Tronoh, PERAK

June 2006

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.



RAUF LAHAB

ABSTRACT

Remote vehicle tracking and monitoring system has become one of the great systems in today industry. Many companies and institute are doing their research to enhance this system to another new level. Chapter one in this report gives a brief idea about the background of the study on what and why this system is develop. The problem statement and the scope of study are clearly stated in this section to indicate the main area of the system. Chapter two is the literature review which is a finding or study about the system that already develop by other developer. It consists of various area of system that has relation with the basic idea which is meant for tracking and monitoring purposes. Chapter three is the section where the methodology use in developing the system and how the project works for the system is presented. The methodology is a step-by-step guide to develop the system in an organize way. The project works show how the system works using the diagram and its basic framework. The framework developed is base on research being done and the best framework that suitable with the system that being develop is chose. Chapter four shows the result and discussion about the system development. The result is show in an illustrated figure. The discussion will give the basic idea on what is needed to be done and what should be improving for the system. Chapter five is the last section where in give the conclusion of the system development. It also gives the recommendation for any future upgrade or development on what need to be stressed out to build a sound system.

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LIST OF ABBREVIATION

AFB	- Air force base
AGV	- Automated Guided Vehicle
DGPS	- Differential GPS
GDOP	- Geometric Dilution of Precision Controlling
GPS	- Global positioning system
IVU	- In-vehicle unit
MAC	- Message authentication code
NMEA	- National Marine Electronics Association
PPS	- Precise Positioning Service
PRC	- Pseudo-Random Code
SDLC	- System development life cycle
SNR	- Signal-to-noise ratio
STT	- Set top terminal
SV	- Space vehicle
UTP	- Universiti Teknologi PETRONAS
VMS	- Vehicle monitoring system
VTIS	- Vehicle Tracking and Information System

CHAPTER 1

INTRODUCTION

1.1 Background

The use of remote vehicle tracking and monitoring system has become a common device for today's world. Most of the big transportation companies already implemented the system to monitor their vehicles from their office or head quarter. There are many kind of intervention to improve the performance of the system as well as trying to provide more additional feature that might useful for their usage.

The system that is planned to be developed is also a vehicle monitoring base system and it is specially build for the usage within Universiti Teknologi PETRONAS (UTP). The system will use a GPS system as it intermediate to transmit and receive data for the monitoring system. The in-vehicle unit will be installed with a customize circuit board to suit it purpose to be placed in the vehicle. A base station where the application is install to receive data and display the data will be placed somewhere in the UTP area to make sure that the system can be use efficiently. The location of the receiver of the spatial data will be placed at a strategic place in UTP area.

The system will be used firstly by security department as to monitor UTP's vehicle such as busses and pickup. This is to monitor their location inside UTP and also will become a work monitoring tools. Another issue that may need the system to be implemented is regarding the parking lot. Probably all of the car that registered in UTP will be installed with the vehicle monitoring system to monitor the vehicle movement. The purpose is to monitor where they parked they car, either they parked it at the right place. Student, lecturer and management will have their own identification and have their own lot to park their car, therefore using the system will be easy to monitor the situation and can also be a proved document if any argument arise.

The system should archive its objective by assisting humans to make a right decision as well as for recording purposes for future analysis. It should become a great tool to increase working efficiency and effectiveness.

1.2 Problem Statement

The system is built meant for monitoring vehicles inside the UTP area. The system can be used for UTP management to monitor their vehicle to know exactly the location of their vehicle. Besides that, the system also can be implemented for each car that registered in UTP such as students', lecturers' and managements' car. This can help UTP solving certain issues such as parking space problem. Security office can easily monitor if any of those cars is using the wrong parking lot to park their car. The real challenge for the system development is to develop the system application based on Visual Basic.NET.

1.3 Objectives

The objective of the system is to develop a vehicle monitoring system inside UTP that can be used by various departments to assist their daily work as well as to increase working efficiency. The system focuses on the development of the GPS application which will be developed using Visual Basic.NET and integrated with the transmitter. The challenge is to make sure this application can perform at the expected level. The application should be able to display the movement of the vehicle on the map as well as other information such as vehicle speed and the location. Another thing that needs to be looked in depth is how to use the map in the Visual Basic.NET application as a base map.

The system also can be used to scan if any of the vehicle is reported missing within the university area. Since there were several cases where motorcycle is reported missing in the university, by using this system, it can help security department to track back the vehicle. Therefore, each vehicle that wants to be brought into the university must be registered first to make sure the record of the vehicle already there for the future purpose.

1.4 Scope of Study

1.4.1 To improve the design of the board to place the GPS receiver

The GPS receiver and transmitter that want to be used in the system need to be attached to a circuit board in order to make the receiver link with a power supply. Currently, there is already an invention on this device, but the design of the board need to be improved to make it more compact and suitable to be put at the vehicles. Furthermore, the places where this device will be placed at the vehicle also need to be taken into account in designing the circuit board. The place where the device wants to be put at the vehicles need to be determined first before the designing process can be proceeds.

1.4.2 Find the place where to receive spatial data within the UTP's map.

The study on the mapping also needs to be done thoroughly in order to make sure the system can be implemented without any problem. The place where to receive spatial data using the GPS receiver device need to be determined by analyzing the UTP map to choose the best location where the basic station of the system will be located. There are several criteria that need to be count in choosing the location. The most important criteria, it should be free from any obstruction and noise to make sure the integrity of the data transfer. The base station needs to have ample applications and tools to make sure the system can run at it desired performance.

1.4.3 How GPS data transferal wirelessly.

Remote vehicle tracking and monitoring system combine a number of well-developed technologies. Irrespective of the technology being used, VMS consist of three subsystems: a) In-vehicle unit (IVU), b) Base station and c) Communication link.

The IVU includes a suitable position sensor and an intelligent controller together with an appropriate interface to the communication link. Embedded GPS receivers provide absolute position co-ordinates at any point, without any area restrictions. The controller interacts with the GPS receiver, collects co-ordinates at predefined intervals, processes it and sends out to the communication link.

The base station consists of a high-speed system running VMS application software that will receive the position data from the vehicles and display on a digital map. The data link, together with a suitable communication protocol, has to be selected after a thorough study of various parameters such as the bandwidth requirement, number of vehicles to be tracked, expandability, terrain, area of coverage etc. Sophisticated VMS are linked to data bases that can support information about the vehicles. Suitable communication protocols need to be established to avoid collision of radio signal. The simple technique is TDMA, where each IVU communicates during predefined time slots. This synchronization is easy in a GPS based IVU as the GPS receiver provides very precise time reference signal.

1.4.4 How to use the .jpeg file map

This is one of the challenge that need to solve in the first place before the process of the development can be proceed to the application development. The question arise is either the map can still be used as a jpeg file or need to be converted into a digital map. From the talk and discussion with some people who are working in this area, the jpeg file still can be used but it need more effort because the map should be plotted with the real coordinate taken from the GPS transmitter. The coordinate then should be store as a static database and embedded into the application to work along with the GPS transmitter later.

1.4.5 How to integrate the GPS transmitter with the Visual Basic.NET application

Since the development of the main application of the system will use Visual Basic.NET, then a problem may arise when the integration between the application and the GPS transmitter wan to be implemented. To solve this problem, a research needs to be conduct to source out how to integrate both of these things. Usually an online forum would discuss more about this thing and there is a chance that a portion or the full coding will be there for academic purposes. Furthermore, there are a lot of books discussing about this technology lately, therefore a serious effort need to be done to source out the coding.

CHAPTER 2

LITARETURE REVIEW AND/OR THEORY

Of all the applications of GPS, vehicle tracking and navigational systems have brought this technology to the day-to-day life of the common man. Today GPS fitted cars; ambulances, fleets and police vehicles are common sights on the roads of developed countries. Known by many names such as:

2.1 Vehicle Tracking and Information System (VTIS)

These systems offer an effective tool for improving the operational efficiency and utilization of vehicles.

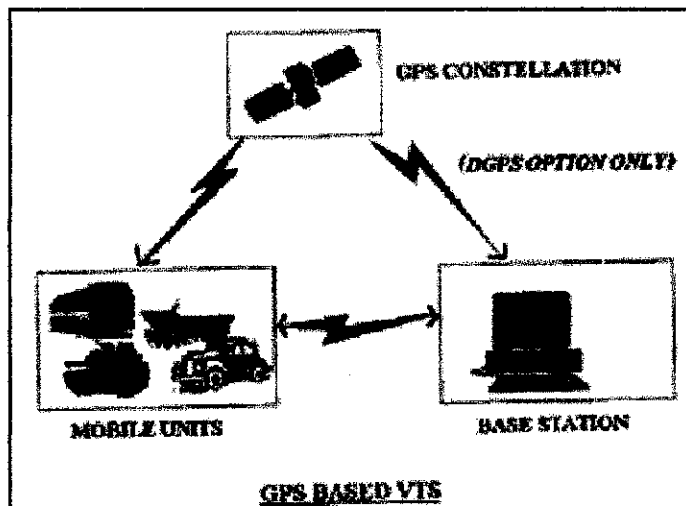


Figure 2.1: Block diagram of a DGPS based VTIS

GPS is used in vehicles for both tracking and navigation. Tracking systems enable a base station to keep track of the vehicles without the intervention of the driver where, as navigation system helps the driver to reach the destination [3]. Whether navigation system or tracking system, the architecture is more or less similar. The navigation system will have convenient, usually a graphic, display for the driver which is not needed for a

tracking system. Vehicle Tracking Systems combine a number of well-developed technologies. Irrespective of the technology being used, VTS consist of three subsystems:

- In-vehicle unit (IVU)
- Base station
- Communication link.

The IVU includes a suitable position sensor and an intelligent controller together with an appropriate interface to the communication link.

Embedded GPS receivers provide absolute position co-ordinates at any point, without any area restrictions.

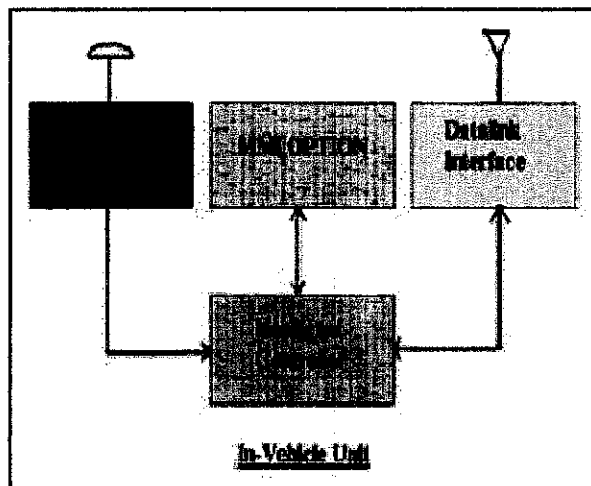


Figure 2.2: Block diagram of an In Vehicle Unit

The controller interacts with the GPS receiver, collects co-ordinates at predefined intervals, processes it and sends out to the communication link. Optionally in certain cases a man-machine- interface like a display with key board can be added for message communication between the driver and the base station [3].

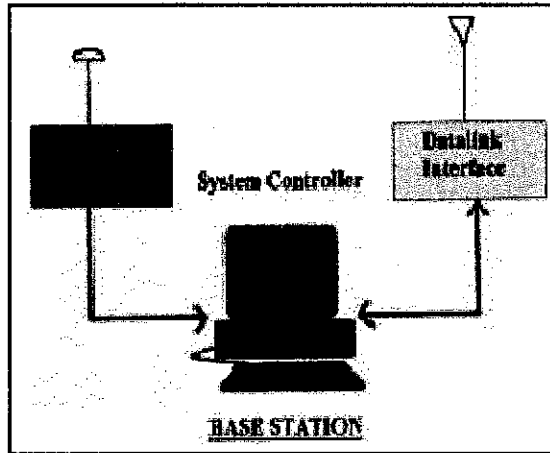


Figure 2.3: Block diagram of a Base station.

The base station consists of a high-speed system running VTIS application software that will receive the position data from the vehicles and display on a digital map. It too will have the interface to the communication link. Enhanced features include video features, trace mode, history track, vehicle database and network support.

The most costly part of a VTIS is the data link. The data link, together with a suitable communication protocol, has to be selected after a thorough study of various parameters such as the bandwidth requirement, number of vehicles to be tracked, expandability, terrain and area of coverage [3].

When multiple vehicles are being tracked, a suitable communication protocol needs to be established to avoid collision of radio signal. The simple technique is TDMA, where each In Vehicle Unit communicates during predefined time slots [3]. This synchronization is easy in a GPS based In Vehicle Unit as the GPS receiver provides very precise time reference signal. However, TDMA based systems have limited expandability, flexibility and are known for under-utilization of bandwidth.

The alternative is polling technique. Here each vehicle is addressed by the control station and in response the IVU sends the information. This arrangement enables variable

polling rate for different vehicles, non-polling of specific vehicles and expansion of polling list as new vehicles are added.

2.2 Automated Guided Vehicle (AGV)

AGV systems are particularly sensitive to the interactions among the vehicles on the track, and to the level of coordination between the AGV system and the rest of the manufacturing system. Because of the dynamic behavior of the AGV system, queuing theory-based analyses tend to give overly optimistic predictions [1]. Math programming procedures, many based on the transportation problem, have been presented as solutions to some AGV design problems [1].

Control of AGV's within most manufacturing systems is accomplished by means of a link to a central computer. The central computer often contains system-wide information, and directs the vehicle where to go to pick up a load, where to take the load, and might even redirect the vehicle while it is in transit to perform another task. Depending upon the type of system, communication may occur only at specified locations, or in more advanced systems, at any vehicle position.

Simulation modeling is used in many phases of the design process. AGV system characteristics include three for which simulation is commonly used: track layout, vehicle fleet size, and system control logic [1]. When various track layouts are being compared, a simulation model can assist in identifying bottlenecks and areas of high congestion. Once the layout is established, more detailed simulation models are used to compare various control schemes, and to evaluate the impact of the number of vehicles on system performance.

In many material handling systems, including AGV systems, individual transport devices share the areas of space on which they move. If an AGV is stopped, other vehicles which are moving on that track must wait until the halted unit moves. Likewise, if sections of track intersect, only one AGV may pass through the intersection at a time.

In a simulation model, resources are used to avoid collisions between AGV units while they move within the system. Resources are fixed-capacity facilities which may be allocated to one or more simulation entities (jobs) [1]. If the AGV track is separated into a number of consecutive resources, and then allowing only one entity at a time to have a resource manages AGV movement. Physical AGV systems often resemble this “zoning” very closely. Segments of track are divided into non-overlapping zones, in which no more than one vehicle is permitted at a time to avoid collisions.

The system map can be defined in at least two ways. Since the from-to table already contains the sequence of stations a vehicle must visit to go from anywhere in the system to any other location, a table which contains only the distance between adjacent stations would completely define the system. When moving an AGV, using this table would not add any modeling burden, since vehicles only travel between adjacent stations. However, when comparing the length of travel of various vehicles from their locations to the part station, use of this table would require the model to trace through the sequence of stations to get from “there” to “here,” summing the distances along the way. The alternate mapping table contains a complete from-to distance matrix, listing the total travel distance from any station in the system to any other station. For non-adjacent stations, the table entry is the sum of the distances between the stations which must be traversed to get from the vehicle location to the part station [1]. This method simplifies functions within the simulation model, but increases the amount of data required to fully describe the system.

2.3 Tracking the Location of Customer Equipment

Monitoring the location of customer equipment is an important problem in the direct broadcasting satellite industry [2]. This is because the service providers would like to prevent unauthorized movement of a customer’s set top terminal (STT) from a home to a public venue, or across an international border, due to various financial, copyright and political issues.

This paper study four schema for detecting the movement of the STT using the existing (or emerging) communication infrastructure. Start with the currently used scheme which is based on the telephone network's ANI or CND (caller-ID) features, and show how it can be undermined. Then suggest three new schemas which are more robust than the caller ID scheme: one that that uses the Global Positioning System (GPS), one that uses the cellular phone's enhanced 911 (E911) service, and one that measures the time-differences-of-arrival of the satellite's broadcast. Then discuss the accuracy, features and vulnerabilities of each scheme. It also presents possible attacks that allow pirates to conceal their movement when these schemas are employed.

2.3.1 Using the Global Positioning System

The Global Positioning System (GPS) allows relatively cheap commercial devices (< \$100) to determine their position with 100m accuracy, and with 10m accuracy using Differential GPS (DGPS). The GPS system uses a constellation of 24 satellites with synchronized clocks that broadcast a specific bit stream. GPS receivers compute their position horn the phase shift between the signals received from 4 or more satellites. In addition to accurate positioning, GPS also provides a fairly accurate clock (340 nanosecond accuracy). An accessible introduction to GPS is [Dan98].

- **The *locGPS* Scheme**

In order to use *locGPS*, the STT would need to contain a GPS receiver in addition to the secure module [2]. The GPS receiver requires an additional external antenna, which should be packaged with the satellite receiving dish. If the down-lead from the antenna to the STT is short, there is no need for amplification, and the added cost is negligible. Standard installation should include both antennas, so customers need not be aware of the added complexity. Callbacks would still be performed over the phone network as before. Prior to the callback, the STT would query the GPS receiver to get its current position [2]. This location information would then be sent to the service provider, who would math it against the STT's legitimate location recorded in the database.

Figure 3 depicts two possible configurations of the STT h configuration (a), the STT consists of a tamper resistant secure module (S), and an off-the-shelf GPS receiver (G). S deals with unscrambling the broadcast information and communicating with the service provider, and queries G for position information using G's data interface. In configuration (b), the STT consists of a single tamper-resistant mode (S+ G), which combines the functions of S and G of configuration (a). Configuration (b) would be more expensive to design and build, since it would require incorporating part or all of the GPS functionality into the secure module.

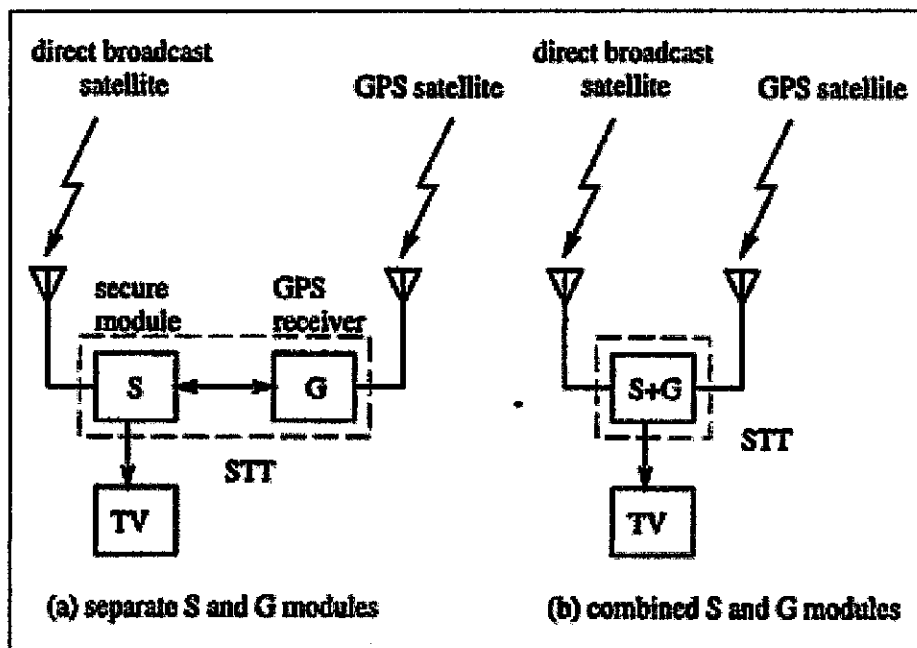


Figure 2.4: Configurations of an STT design using GPS.

- **locGPS Vulnerability**

The main problem with the *locGPS* scheme is that it is completely terminal-centric. The service provider relies on the STT to measure its position and report this information correctly. Therefore a pirate has several options of attacking the STT which would cause it to always report its expected legitimate position regardless of its true whereabouts.

The cheaper configuration (a) can be defeated by various forms of a man-in-the-middle attack. If the communication between S and G is in the clear, and then the pirate can

substitute the expected position for the actual position. An obvious counter-measure is to have S and G use a secure protocol between them (with the side effect that G is no longer completely “off-the-shelf”). This protocol would require at least the following properties:

- The protocol must mutually authenticate S and G, otherwise the pirate can disconnect G and replace it by a module that always reports a legitimate location.
- The GPS reports must contain freshness information such as time-stamps or some random bits, otherwise the pirate can record the encrypted report at the legitimate location and replay it at the new location.
- The GPS reports must be signed or have a message authentication code (MAC) attached to prevent pirate tampering.

Even if a secure protocol is used in configuration (a), or if the STT is designed using configuration (b), a sophisticated pirate can still defeat the scheme without tampering with its internal at all. The pirate can generate fake signals from the GPS satellite and feed them into the GPS antenna. Since the trajectory of the GPS satellite is known with great accuracy, the pirate can compute the signal that would be received on any point on the Earth at any given time. Of course, we are assuming here that the GPS receiver uses the Standard Positioning Service (SPS), which is the civilian (non-military) broadcast. If the GPS receiver uses the Precise Positioning Service (PPS), which is currently available only to the US and allied military, the pirate would not be able to generate the signals since they are encrypted. Another weakness of *locGPS* is that GPS signals may be jammed with a low-power transmitter.

CHAPTER 3

METHODOLOGY/PROJECT WORK

3.1 System development methodology.

System development methodologies are designed and use as a control method in the system development process. By providing the right methodology for the system development, the developer can easily monitor the progress work as well as controlling the quality of the develop system to make sure the best delivery will be made. The quality is achieved through standardization in many areas such as naming convention, abbreviation, structures and processes. System methodology also will ensure that each phase of the development will follow the specific time frame specify during the planning phase. This is to make sure the system delivery can be made at the anticipated time. Adjustment and alteration in the system specification and development also can be included in the system development process because it is common for any system development process to face a problem and alteration is needed. Using the system methodology, this adjustment and alteration will still be under control to make it is still in the system objective and scope.

For the development of remote vehicle tracking and monitoring system, SDLC is used as methodology. Since this methodology is widely used in various area of system development, therefore it should represent a great efficiency in controlling and monitoring any system development. Five phase in the SDLC ensure that the system development will be in control and the progress can be easily monitor time by time.

3.2 System model

System model occupied the SDLC phases in several ways. There are several popular system models that have been used by many developers such as waterfall model, evolutionary development, formal system development and reused-base development. In

developing remote vehicle tracking and monitoring system, waterfall model is chose to develop the system. The reason behind it is waterfall model usually use in the system development where the requirement is well-understood, therefore it is suitable for this system as well as providing a great control in each development phases. This can help to lead to a quality system development. The system develop using waterfall model should be really organize because the model have some difficulty to compromise with a change of requirement in the later phases.

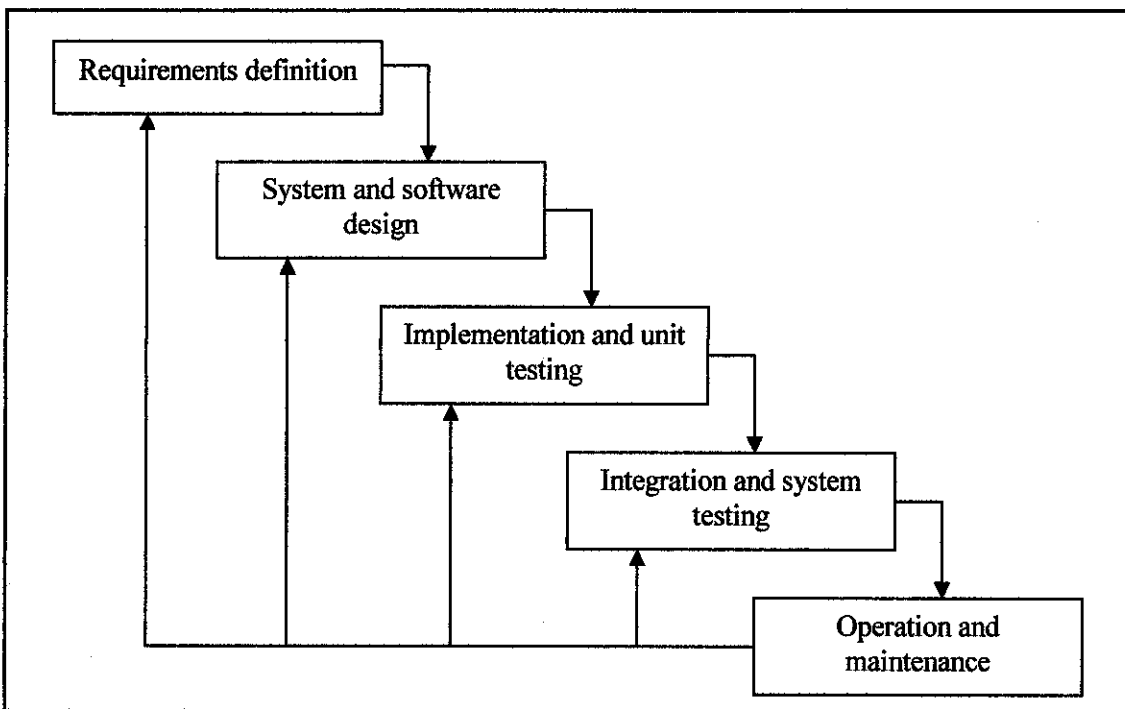


Figure 3.1: Waterfall model.

Each phase of waterfall model has its own specific purpose for the system development:

3.2.1 Requirement definition.

In this phase, the requirement of the project is specify based on the needs of the system usage. Requirement of the system included the system functions, timeframe, tools use, and the system framework. After the requirement has being specified, the information gathering process needs to be done to gather as much data as possible regarding the

system. The information gathered will consist of data from various area of study related to the system itself.

3.2.2 System and software design.

This phase is the transformation from the system requirement to the real system. The system framework and flow are converted to a real product which is perform as the propose system. This phase will consume most of the system development processes time, and usually will use many tools to produce the desired end product. For remote vehicle tracking and monitoring system, this phase will involve developing the application software, configuring the map server, converting the map into digital map, attaching the GPS transmitter and receiver to the vehicle and the base station.

3.2.3 Implementation and unit testing.

Implementation and unit testing phase is where each device and function is test separately. This testing phase is performed to make sure each function and component can perform at its specification. The main reason why each function and component need to be tested first before any integration of component and sub-system is done is to ensure each component is free from an error that may cause harm to the system and to ensure system performance is at a high level. Any error detected at this phase still can easily correct without need to extract back the whole system. For this system, the software application, GPS receiver and transmitter and the map server will be tested separately first to make sure all these component perform as required.

3.2.4 Integration and system testing.

This phase is where the components and sub-systems are integrated with each other. At this phase, the main objective is to make sure all components and sub-system can perform accordingly as one system. Usually the integration will be done in step-by-step where two components are integrated first until there is no error then will be followed by another component or sub-system. After the system is fully integrated, then a black-box testing and white-box testing will be perform to test the system as an end product.

3.2.5 Operation and maintenance.

This is the final phase where the system is ready to be deployed and use in the real environment. Before that, the end users need to be trained to make sure they understand the system functionality and process flow. They also will be trained how to perform a simple maintenance task for the system. Other complex maintenance still needs to be done by the expert. The system will be monitored from time to time.

3.3 System function

The system main issue is how to use the GPS technology and integrate it with the application built to complete the system. GPS provides specially coded satellite signals that can be processed in a GPS receiver, enabling the receiver to compute position, velocity and time. Four GPS satellite signals are used to compute positions in three dimensions and the time offset in the receiver clock.

The Space Segment of the system consists of the GPS satellites. These space vehicles (SVs) send radio signals from space. The nominal GPS Operational Constellation consists of 24 satellites that orbit the earth in 12 hours. There are often more than 24 operational satellites as new ones are launched to replace older satellites. The satellite orbits repeat almost the same ground track (as the earth turns beneath them) once each day. The orbit altitude is such that the satellites repeat the same track and configuration over any point approximately each 24 hours (4 minutes earlier each day). There are six orbital planes (with nominally four SVs in each), equally spaced (60 degrees apart), and inclined at about fifty-five degrees with respect to the equatorial plane. This constellation provides the user with between five and eight SVs visible from any point on the earth.

The Control Segment consists of a system of tracking stations located around the world. The Master Control facility is located at Schriever Air Force Base (formerly Falcon AFB) in Colorado. These monitor stations measure signals from the SVs which are incorporated into orbital models for each satellites. The models compute precise orbital data (ephemeris) and SV clock corrections for each satellite. The Master Control

station uploads ephemeris and clock data to the SVs. The SVs then send subsets of the orbital ephemeris data to GPS receivers over radio signals.

The GPS User Segment consists of the GPS receivers and the user community. GPS receivers convert SV signals into position, velocity, and time estimates. Four satellites are required to compute the four dimensions of X, Y, Z (position) and Time.

This system consists of three major components:

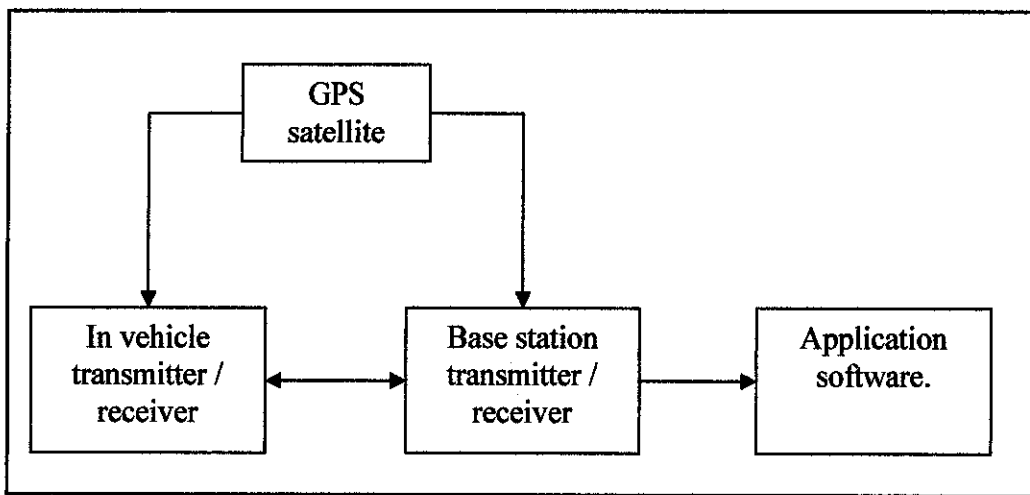


Figure 3.2: System Framework.

3.3.1 In-vehicle GPS transmitter/receiver

This unit will receive and transmit the location of the vehicle to and from the satellites. It may use four or more satellite and the reading between all the satellite will be intersect to determine the location of the vehicle. It will also communicate with the base station unit in order to determine the distance from the base station.

3.3.2 Base station GPS transmitter/receiver

Base station unit will receive and transmit data to and from satellite to navigate the location of the vehicle. Communication between this unit and in vehicle unit also will determine the vehicle distance from the base station. This unit will send all the gathered information to the application software. This unit is the unit which will send a request to

satellite to locate the intended vehicle then this unit also will receive back the signal from satellite that contain data about the vehicle. The raw GPS data is using the National Marine Electronics Association (NMEA) standard. This raw data will be use by the application to produce the output.

3.3.3 Application software

The application software has a lot of function to display the vehicle location on the map as well as giving other extra information such as vehicle distance from the base station and current speed. The application software will also able to give the detail about the location to the end user.

The GPS sentence which is in NMEA format will be capture by the application. NMEA data is sent as comma-delimited “sentences” which contain information based on the first word of the sentence. There are over fifty kinds of sentences, yet an interpreter really only needs to handle a few to get the job done. The most common NMEA sentence of all is the “Recommended Minimum” sentence, which begins with “\$GPRMC”. Here is an example:

```
$GPRMC,040302.663,A,3939.7,N,10506.6,W,0.27,358.86,200804,,*1A
```

This one sentence contains nearly everything a GPS application needs: latitude, longitude, speed, bearing, satellite-derived time, fix status and magnetic variation.

For the map use in the application, it use jpeg file map with a raster image. The coordinate for the map obtained using geo-coding.

CHAPTER 4

RESULT AND DISCUSSION

In this chapter, the result or the outcome of the system built we be show and discuss. The system flow will be discussed in detail and each main event will be illustrated using diagram or framework. The final output of the system will be show using a screen capture from the system.

The system starts from user requesting a location of certain vehicle. Then from the application, the GPS transmitter will then send a signal to satellite to locate the vehicle. Once the vehicle has been identified, then the satellite will send back the signal together with the data needs to be manipulated by the application. As discuss in the previous chapter, the data sent is in the National Marine Electronics Association (NMEA) format. This sentence then will go through several steps of manipulation by the application coding to produce the output that the system should able to display such as coordinate, location and current speed. Below is the flow diagram of the system:

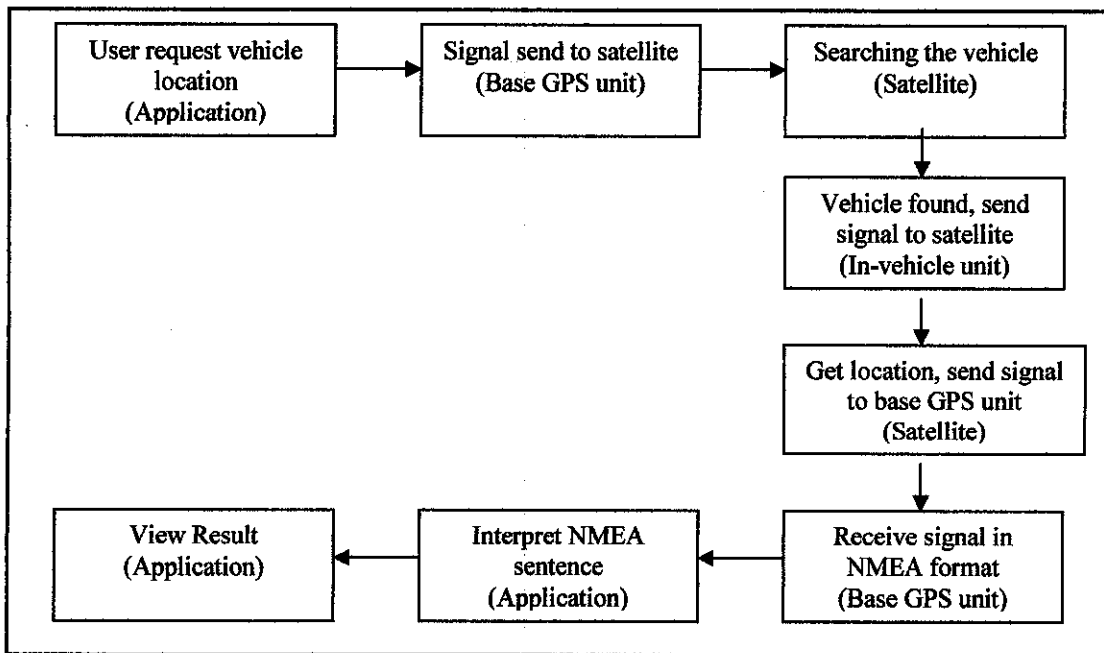


Figure 4.1: Flow diagram of the system

4.1 Request Vehicle Location

The system cycle start when user requesting a location or position of certain vehicle. From the application, a request will be sent to the base GPS unit to communicate with satellite to locate the vehicle.

4.2 Signal Send To Satellite

The signal from base GPS unit will reach one of those 24 satellites and then the satellites itself will communicate to locate the in-vehicle GPS unit.

4.3 Searching the Vehicle

From the 24 satellites on the space, at least three will be able to communicate with the in-vehicle GPS unit to get the location.

4.4 Vehicle Found, Send Signal to Satellite

The in-vehicle GPS unit will respond to each satellite that communicates with it. The in-vehicle GPS unit will send the data needed to calculate the location, distance, and current speed to each satellite.

4.5 Get Location, Send Signal to Base GPS Unit

After each satellite get the data from the in-vehicle GPS unit, it then will calculate the position, location, distance and current speed of that vehicle. This calculation is done by the satellite station. Then this data will be sent to the base GPS unit for further use by the application.

4.6 Receive Signal in NMEA Format

The data receive from the satellite is in the format of NMEA. This standard format was introduced by National Marine Electronics Association into the industry. Then from the base GPS unit, the NMEA sentence is send to the application. Here the process of the interpretation will begin.

4.7 Interpret NMEA Sentence

Here is the main concern of the application where a faulty coding or wrong interpretation will lead to wrong information that will be presented later. After the application receives the NMEA sentence then the process of interpreting it will begin. The Interpreter is the coding built in application. It consists of two steps in the beginning, separating each sentence into its individual words and examining the first word to figure out what information is available to extract. Below is the example of NMEA sentence:

```
$GPRMC,040302.663,A,3939.7,N,10506.6,W,0.27,358.86,200804, *1A
```

The next step is to perform actual extraction of information, starting with latitude and longitude. Latitude and longitude are stored in the form “DDD°MM’SS.S”, where D represents hours (also called “degrees”), M represents minutes, and S represents seconds. Coordinates can be displayed in shorthand, such as “DD°MM.M” or even “DD°”. The fourth word in the sentence, “3939.7”, shows the current latitude as hours and minutes (39°39.7’), except the numbers are squished together. The first two characters (39) represent hours and the remainder of the word (39.7) represents minutes. Longitude is structured the same way, except that the first three characters represent hours (105°06.6’). Words five and seven indicate the “hemisphere”, where “N” means “North”, “W” means “West”, “E” means “East” and “S” means “South”. The hemisphere is appended to the end of the numeric portion to make a complete measurement. The NMEA interpreters are much easier to work with as they are event-driven. This is because data arrives in no particular order. An event-driven class gives the interpreter the most flexibility and

responsiveness to an application. The interpreter has been designed to report information using events. There will be an event arise whenever the current latitude and longitude are received. One thing to watch out for here is that some GPS devices will report blank values when no information is known. Therefore, it's a good idea to test each word for a value before parsing.

The interpreter then will check for a validation of the sentence where any error or repetition will be discarded. Time is the cornerstone of GPS technology because distances are measured at the speed of light. Each GPS satellite contains four atomic clocks which it uses to time its radio transmissions within a few nanoseconds. One fascinating feature is that with just a few lines of code, these atomic clocks can be used to synchronize a computer's clock with millisecond accuracy. The second word of the \$GPRMC sentence, "040302.663", contains satellite-derived time in a compressed format. The first two characters represent hours, the next two represent minutes, the next two represent seconds, and everything after the decimal place is milliseconds. So, the time is 4:03:02.663 AM. However, satellites report time in universal time (GMT+0), so the time must be adjusted to the local time zone.

GPS devices analyze position over time to calculate speed and bearing. The \$GPRMC sentence also includes these readings. Speed is always reported in knots, and bearing is reported as an "azimuth", a measurement around the horizon measured clockwise from 0° to 360° where 0° represents north, 90° means east, 180° means south and 270° means west. A little math is applied to convert knots into miles per hour. The \$GPRMC sentence includes a value which indicates whether or not a "fix" has been obtained. A fix is possible when the signal strength of at least three satellites is strong enough to be involved in calculating your location. If at least four satellites are involved, altitude also becomes known. The third word of the \$GPRMC sentence is one of two letters: "A" for "active", where a fix is obtained, or "V" for "invalid" where no fix is present.

After the \$GPRMC sentence has been fully interpreted, the interpreter can be expanded to support a second sentence: \$GPGSV. This sentence describes the configuration of satellites overhead, in real-time. There are twenty-four operational satellites in orbit. Satellites are spaced in orbit so that at any time a minimum of six satellites will be in view to users anywhere in the world. Satellites are constantly in motion, which is good because it prevents the existence of “blind spots” in the world with little or no satellite visibility. Just like finding stars in the sky, satellite locations are described as the combination of an azimuth and an elevation. As mentioned above, azimuth measures a direction around the horizon. Elevation measures a degree value up from the horizon between 0° and 90°, where 0° represents the horizon and 90° represents “zenith”, directly overhead. So, if the device says a satellite’s azimuth is 45° and its elevation is 45°, the satellite is located halfway up from the horizon towards the northeast. In addition to location, devices report each satellite’s “Pseudo-Random Code” (or PRC) which is a number used to uniquely identify one satellite from another. Here’s an example of a \$GPGSV sentence:

```
$GPGSV,3,1,10,24,82,023,40,05,62,285,32,01,62,123,00,17,59,229,28*70
```

Each sentence contains up to four blocks of satellite information, comprised of four words. For example, the first block is “24,82,023,40” and the second block is “05,62,285,32” and so on. The first word of each block gives the satellite’s PRC. The second word gives each satellite’s elevation, followed by azimuth and signal strength. If this satellite information were to be shown graphically, it would look like Figure 8:

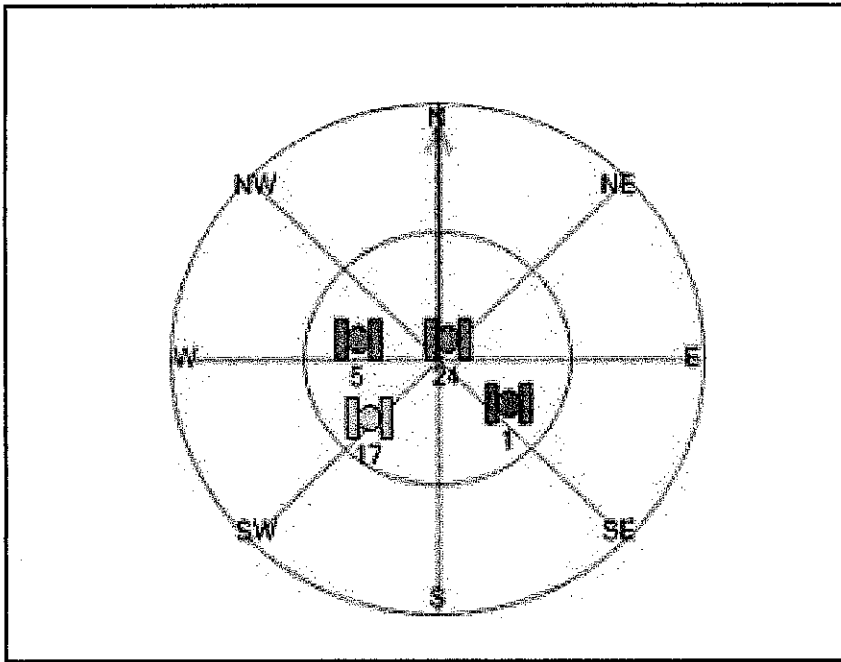


Figure 4.2: Graphical representation of a \$GPGSV sentence, where the center of the circle marks the current position and the edge of the circle

Perhaps, the most important number in this sentence is the “signal-to-noise ratio” (or SNR for short). This number indicates how strongly a satellite’s radio signal is being received. Satellites transmit signals at the same strength, but things like trees and walls can obscure a signal beyond recognition. Typical SNR values are between zero and fifty, where fifty means an excellent signal. In Figure 8, the green satellites indicate a strong signal, whereas the yellow satellite signifies a moderate signal. Satellite #1’s signal is completely obscured. The .NET framework includes built-in support for converting numbers between different cultures, so the changes to the interpreter required are straightforward. In the interpreter, the only fractional value is speed, so only one change is necessary.

All the necessary information has been extracted from the NMEA sentence and now the information obtain can be used to be presented in the application.

4.8 View Result

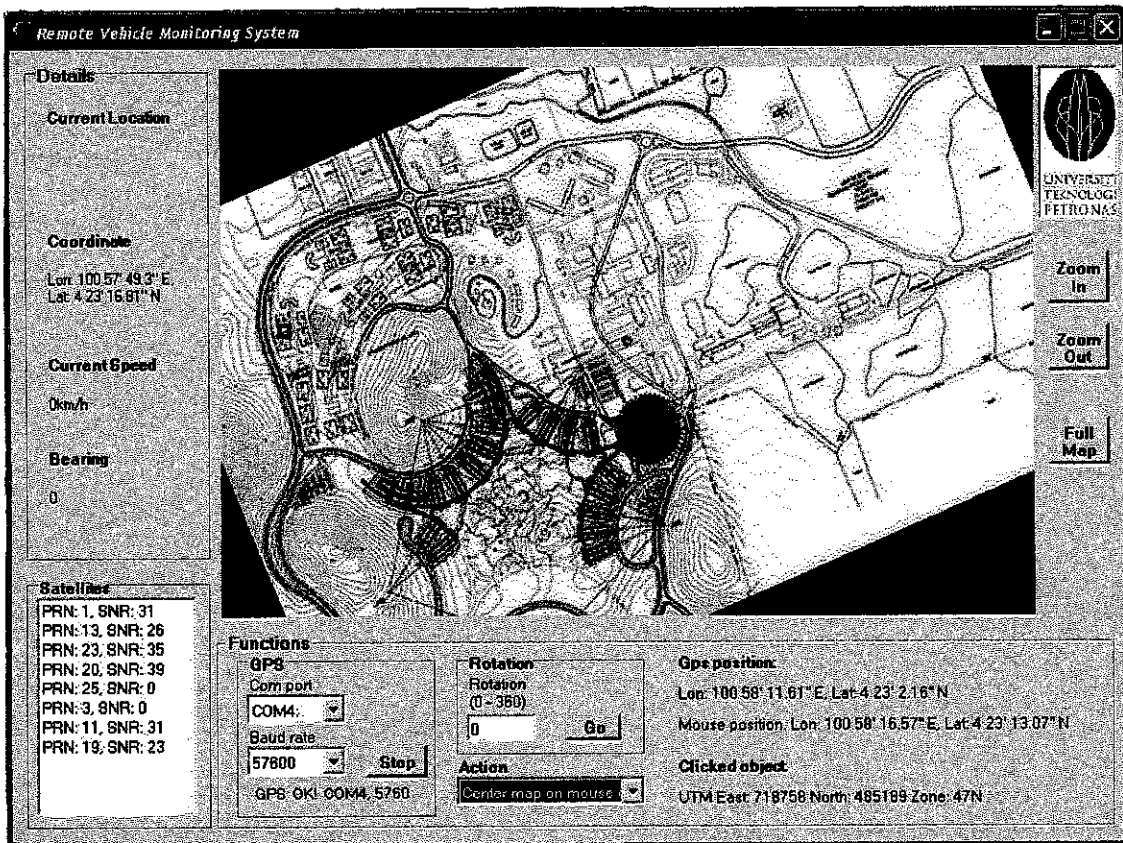


Figure 4.3: Application Screen

The output of the application is in figure 9. On the application screen, there are several information displayed base on the data gather from the communication process between the GPS receiver and satellites. The information was interpreted by the application using a set o interpreter (coding). There are two main information shows on the application, one is the vehicle information and the other one is the satellite information.

4.8.1 Vehicle Detail

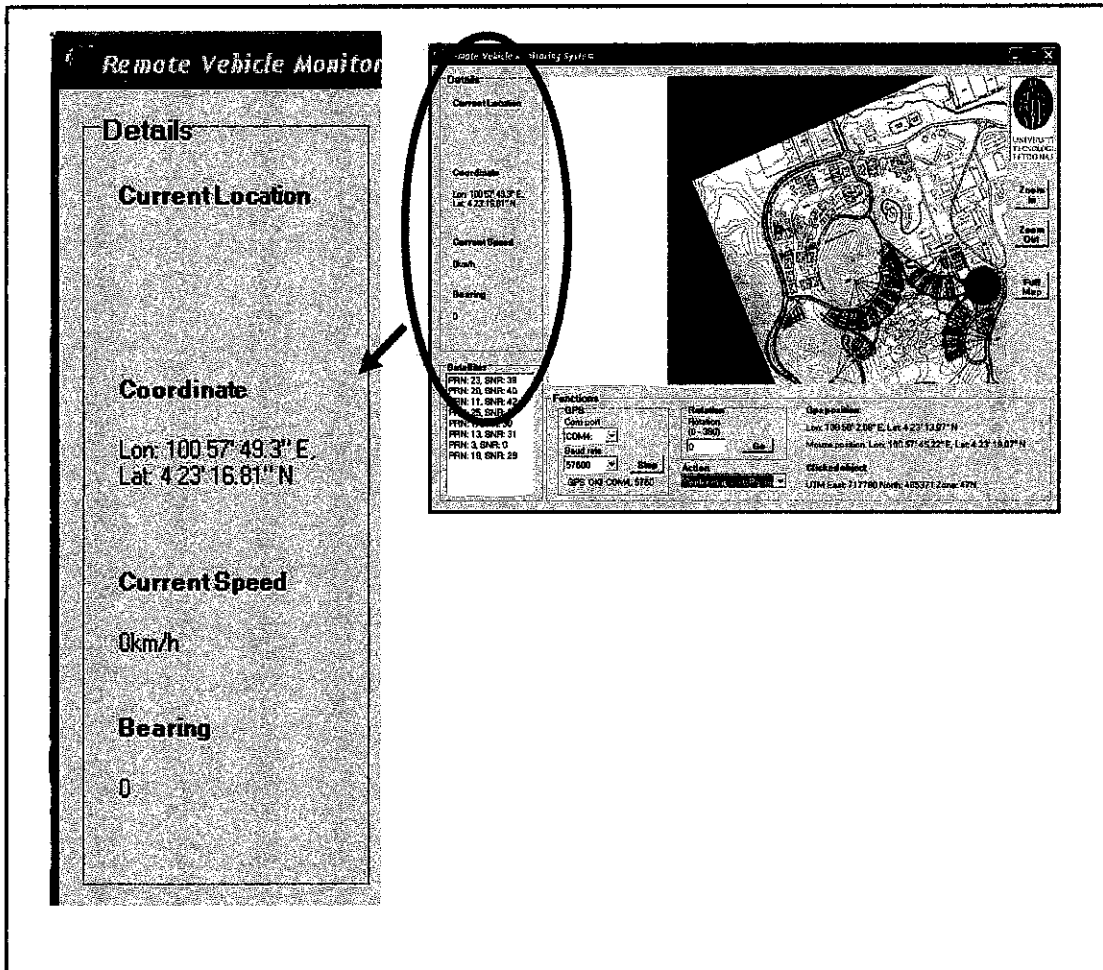


Figure 4.4: Vehicle Details

The information viewed for the vehicle details is obtained from the \$GPRSC sentence. After the interpreter extracting the information then the result is displayed on the left-hand side column of the application.

There are four information items shown on the column which are vehicle current location, vehicle current speed, vehicle coordinate and vehicle bearing. The vehicle current location is obtained when we match the coordinate received with the application map data to get the exact location of the vehicle. This event must work together with the application database. The database was built locally in the application and synchronizes with the map to enable the application to give the location base on the main place inside UTP. The current speed of the vehicle is obtained to show the movement of the car. This

information will work together with the map to show the movement. Hence it still displayed on the detail column to give a clear understanding of what happen on the map.

Vehicle's coordinate actually the raw information from the extracted data. This information will not give any understanding to user if it is just display alone, therefore this information must work together with the local database to give the location of the vehicle. Vehicle's bearing use to show the direction of the vehicle from certain place as the mark. This is just for reference purpose as to help user quickly screen through the map to see where the vehicle is.

4.8.2 Satellite Information

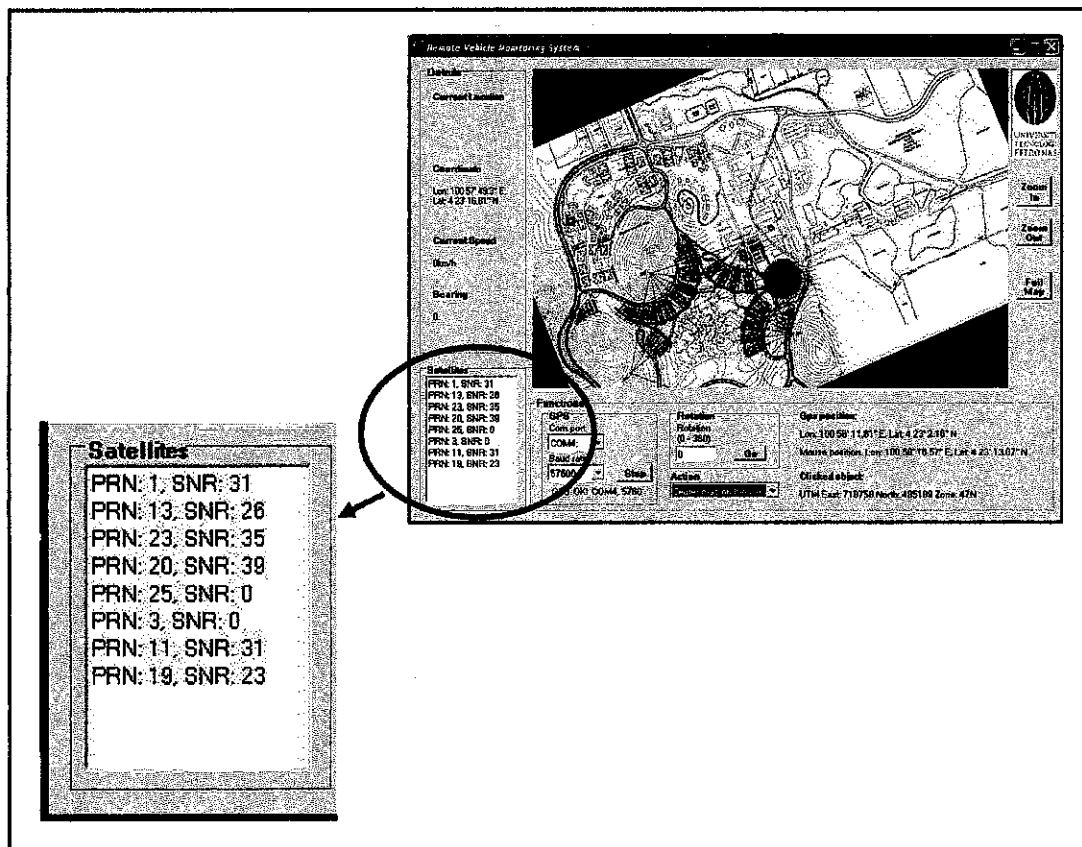


Figure 4.5: Satellite Information

The satellite information is obtained from the NMEA \$GPRSV sentence. There are four main things that need to be shown as the satellite information which are pseudo random code, azimuth, elevation and signal-to-noise ratio.

The pseudo random code (or PRC) which is a number used to uniquely identify one satellite from another. Azimuth measures a direction around the horizon. Elevation measures a degree value up from the horizon between 0° and 90°, where 0° represents the horizon and 90° represents “zenith”, directly overhead. The most important number is signal-to-noise ratio (or SNR for short). This number indicates how strongly a satellite’s radio signal is being received. Typical SNR values are between zero and fifty, where fifty means an excellent signal.

4.9 Discussion

GPS devices are designed to report any information they find, even if the information is inaccurate. In fact, information about the current location can be off as much as half a football field, even when devices are equipped with the latest DGPS and WAAS correction technologies. Unfortunately, several developers are not aware of this problem. There are some third-party components out there which are not suitable for commercial applications that require enforcing a minimum level of precision. The interpreter was really not suitable for commercial use because it did not monitor precision. Without precision, an application could end up making unintelligent business decisions.

The system built was not really taking a concern on coordinate precession since the limited time and source give a barrier to go further on that research. There are several phenomena which can cause poor precision. For example, when satellite radio signals are transmitted, they are distorted by the troposphere and especially the ionosphere. In fact, satellites very low on the horizon are not good for getting a fix because the signals travel through so much of the atmosphere. Some GPS devices may even exclude these satellites from a fix to avoid the precision problems they would cause.

Fortunately, atmospheric distortion can be measured and corrected for the most part. This is achieved by the use of GPS ground stations, fixed locations which constantly measure distortions in satellite radio signals. Calculated corrections are then broadcasted by radio which, when combined with the actual satellite signal, gives a GPS receiver the ability to correct distortions in real-time. But this feature cannot be implemented in this system.

There are several ways to distort a GPS satellite signal. Some are corrected by the Department of Defense and others can be corrected in GPS receiver using real-time ground station correction signals. The only precision problem which is left to control is Geometric Dilution of Precision. Controlling GDOP is the key to writing commercial-grade GPS applications. A small mathematical formula can be applied to determine the maximum allowable DOP for a particular application. The maximum allowable error should be the greatest possible value which minimizes accuracy problems while maximizing operational conditions.

Another factor which helps developers is time itself. Advances in GPS receiver technology are pushing precision to new levels. While precision can be questionable with any consumer GPS device, there will soon be a time when precision to a centimeter is possible. Most believe that this level of precision will cause a revolution in industry and pave the way for some truly amazing things; automated construction machines, tracking for every shipping container in the world and traffic control systems.

Therefore the enhancement of this system would be discussed in the next chapter. The current performance of the system should already give a big chance or opportunity for other to explore and do more research on how to improve the system especially in term of coordinate precession and noise.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The system is built for the purpose of assisting UTP's management in term of monitoring and tracking vehicle inside UTP area. The major scopes of study are to improve the design of the board to place the GPS receiver, Find the place where to receive spatial data within the UTP's map, how GPS data transferal wirelessly, how to use the .jpeg file map and how to integrate the GPS transmitter with the Visual Basic.NET application. After working on building the system, there are certain challenges identified as being the barrier. The first biggest challenge is on how to use the .jpeg file as a map on the application. Even though there are many tools that can be chose to use as an assistant to make the .jpeg file, still the difficulty can clearly be seen when the map is integrate inside the application. There is still missing information from the map and the spatial database which store the location name base on the coordinate obtain through plotting the coordinate manually during the development of the map conversion.

The second challenge is when to coordinate the GPS device with the application. The GPS device has several types and the trial with a few of the devices show that some device are working differently. Therefore, working on synchronizing the device with the application really takes time to make sure the data and signal can be transferred freely with less error possible. The third challenge faced is on the coding part where how to interpret the data receive from GPS receiver. At first this thing looks just a bit easy, but then after the data is transferred into the application and the application need to recognize the need and unneeded data which one it need to process. This part of development take long time to be succeeded because of lack of understanding in term of how the data work and which data is which.

Fortunately, most of the challenge and barrier can be counter just rightly by the assistant of several tool and people who are more expert in this field. The help of many

tools really give a great and various view on how to built and work with certain problem and how to properly choose the best solution. There are many opportunity but to recognize the most valuable one is the difficult part. Hence, the experience working on this system development gave a good advantage to learn for future work.

As for the system itself, the ability of the system to deliver the objective can already seen as a success work. Even though there are still a few weaknesses that can be detected on the system, the overall performance still can be classified as good.

5.2 Recommendation

As for the recommendation on the system itself, there two main things that need to be look in deep. The first thing is the use of map. The use of .jpeg file is a bit unsuitable because it cannot give or present detail information. It also lack of detail view because of the resolution and scaling limitation. For future enhancement, it is highly recommended that a use of digital map that built using any more sophisticated tools is need as it will give more option on how to design the select what is the details or outcome that can be show in the system that suit the use of the system itself.

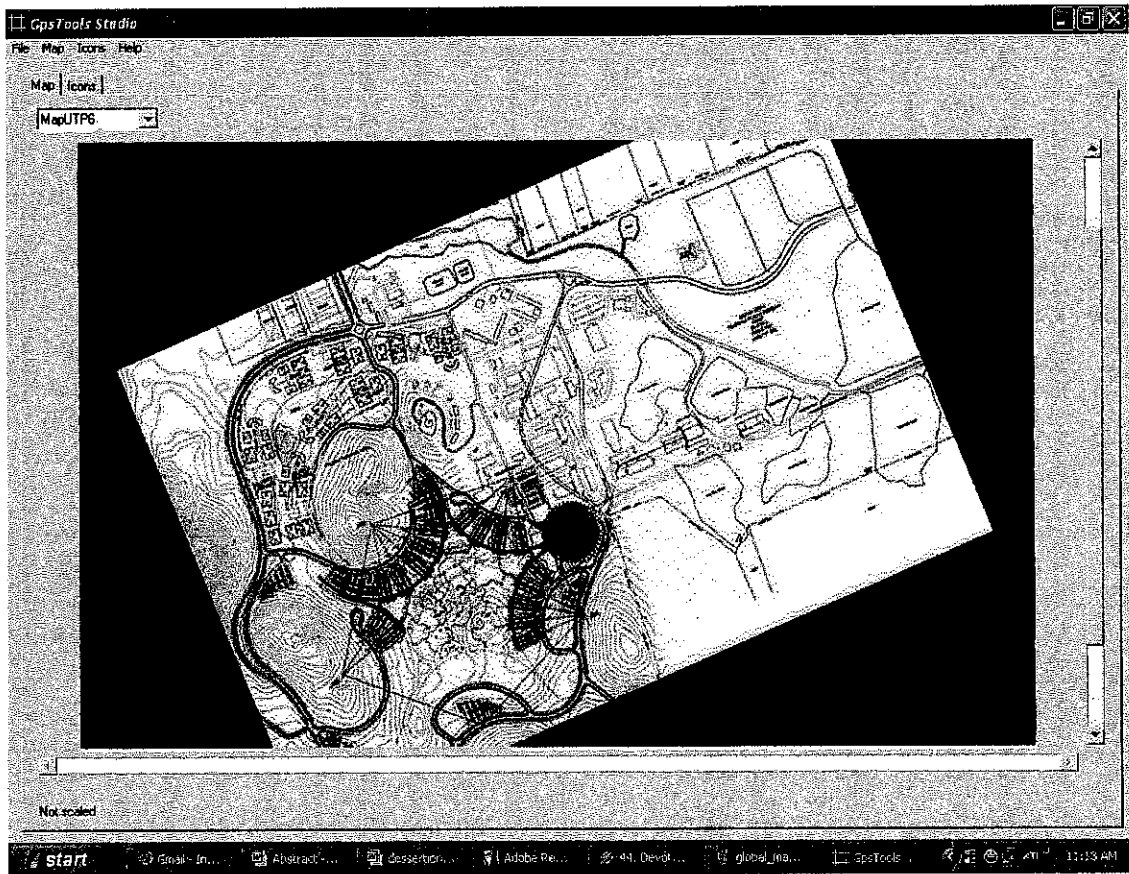
Second thing that need to be take into concern in future is regarding the precession calculation for the data. Since in this built application, the data precession was not really take into serious development. But for a more accurate and advance system that may be built later, the precession on interpreting the GPS sentence which is the NMEA sentence need a depth research. In today industry, the help of the GPS device itself can help giving the more accurate data, but as the system is built from beginning, it should have consider to develop a system that can deliver as accurate data as possible to user.

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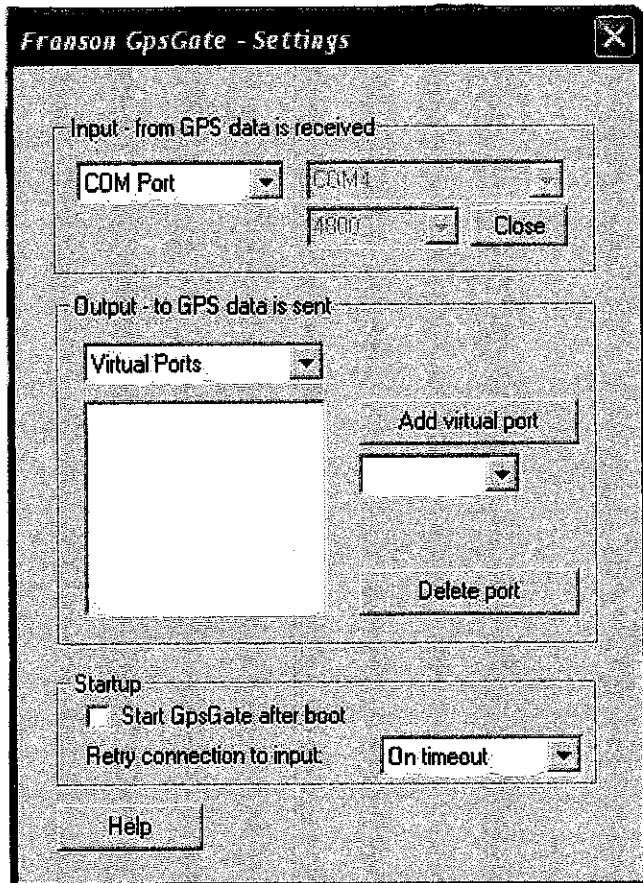
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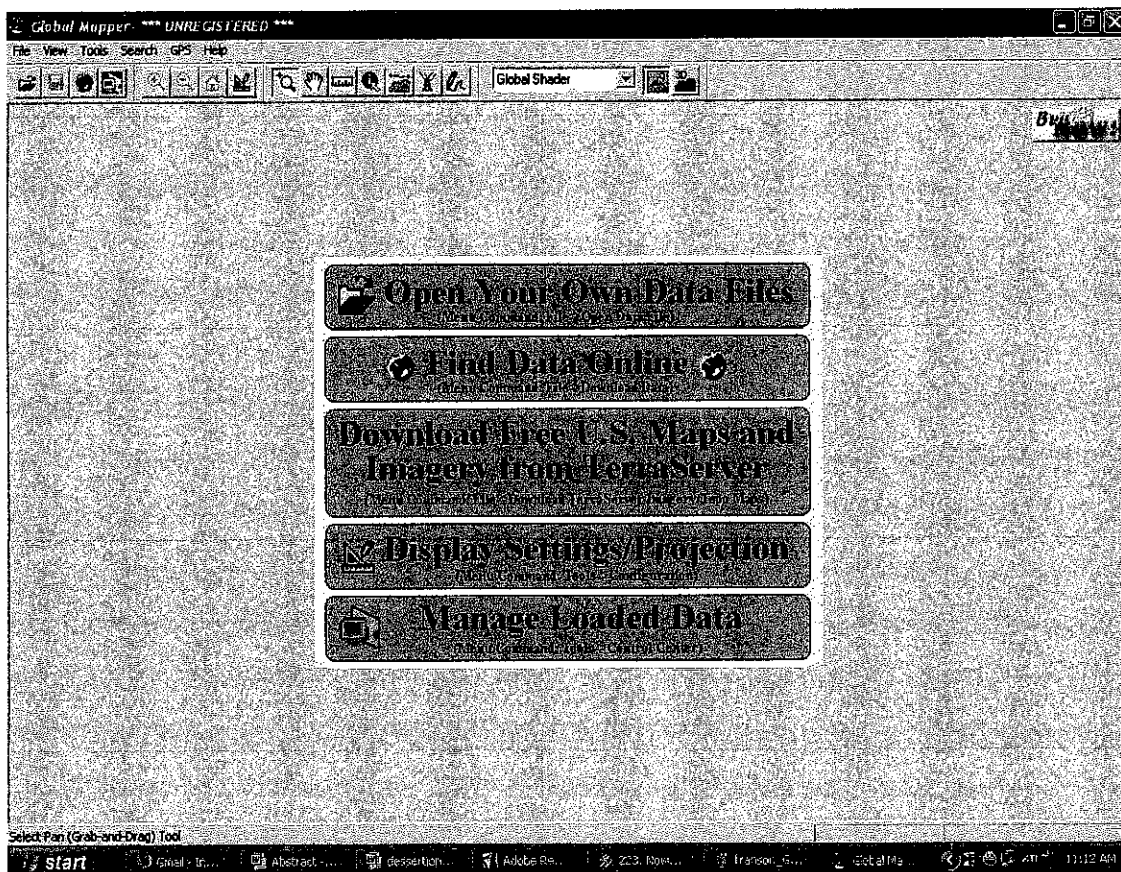
APPENDICES



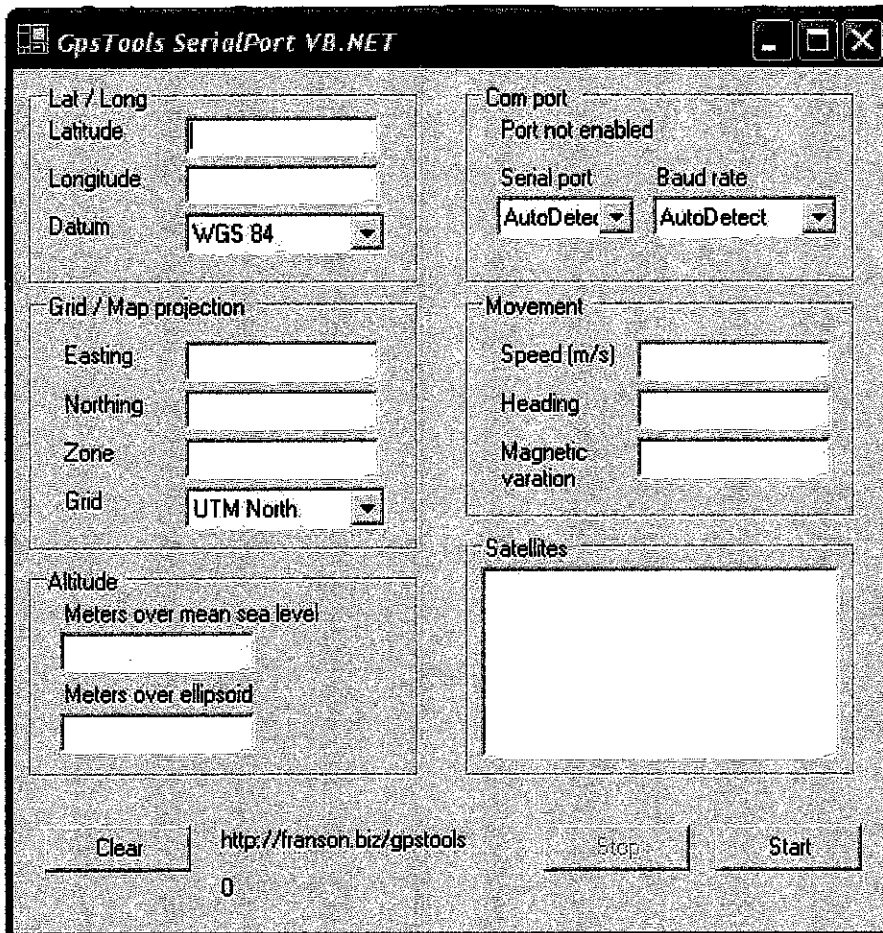
Franson GPS Tools SDK (GPS Tools Studio)



Franson GPS Gate



Global Mapper 7



Franson GPS Tools Serial Port

```

' **** A high-precision NMEA interpreter
' **** Written by Jon Person, author of "GPS.NET" (www.gpsdotnet.com)
' ****

Imports System
Imports System.Globalization

Public Class NmeaInterpreter

    ' Represents the EN-US culture, used for numbers in NMEA sentences
    Public Shared NmeaCultureInfo As New CultureInfo("en-US")
    ' Used to convert knots into miles per hour
    Public Shared MPHPerKnot As Double = Double.Parse("1.150779", _
        NmeaCultureInfo)

    ' Raised when the current location has changed
    Public Event PositionReceived(ByVal latitude As String, _
        ByVal longitude As String)
    Public Event DateTimeChanged(ByVal dateTime As DateTime)
    Public Event BearingReceived(ByVal bearing As Double)
    Public Event SpeedReceived(ByVal speed As Double)
    Public Event SpeedLimitReached()
    Public Event FixObtained()
    Public Event FixLost()
    Public Event SatelliteReceived(ByVal pseudoRandomCode As Integer, _
        ByVal azimuth As Integer, _
        ByVal elevation As Integer, _
        ByVal signalToNoiseRatio As Integer)
    Public Event HDOPReceived(ByVal value As Double)
    Public Event VDOPReceived(ByVal value As Double)
    Public Event PDOPReceived(ByVal value As Double)

    ' Processes information from the GPS receiver
    Public Function Parse(ByVal sentence As String) As Boolean
        ' Discard the sentence if its checksum does not match our
        ' calculated checksum
        If Not IsValid(sentence) Then Return False
        ' Look at the first word to decide where to go next
        Select Case GetWords(sentence)(0)
            Case "SGPRMC"
                ' A "Recommended Minimum" sentence was found!
                Return ParseGPRMC(sentence)
            Case "$GPGSV"
                ' A "Satellites in View" sentence was recieved
                Return ParseGPGSV(sentence)
            Case "SGPGSA"
                Return ParseGPGSA(sentence)
            Case Else
                ' Indicate that the sentence was not recognized
                Return False
        End Select
    End Function

    ' Divides a sentence into individual words
    Public Function GetWords(ByVal sentence As String) As String()
        Return sentence.Split(",","c")
    End Function

    ' Interprets a SGPRMC message
    Public Function ParseGPRMC(ByVal sentence As String) As Boolean
        ' Divide the sentence into words

```



```

Dim Words() As String = GetWords(sentence)
' Do we have enough values to describe our location?
If Words(3) <> "" And Words(4) <> ""
And Words(5) <> "" And Words(6) <> "" Then
' Yes. Extract latitude and longitude
' Append hours
Dim Latitude As String = Words(3).Substring(0, 2) & "°"
' Append minutes
Latitude = Latitude & Words(3).Substring(2) & ""
' Append the hemisphere
Latitude = Latitude & Words(4)
' Append hours
Dim Longitude As String = Words(5).Substring(0, 3) & "°"
' Append minutes
Longitude = Longitude & Words(5).Substring(3) & ""
' Append the hemisphere
Longitude = Longitude & Words(6)
' Notify the calling application of the change
RaiseEvent PositionReceived(Latitude, Longitude)
End If
' Do we have enough values to parse satellite-derived time?
If Words(1) <> "" Then
' Yes. Extract hours, minutes, seconds and milliseconds
Dim UtcHours As Integer = CType(Words(1).Substring(0, 2), Integer)
Dim UtcMinutes As Integer = CType(Words(1).Substring(2, 2), Integer)
Dim UtcSeconds As Integer = CType(Words(1).Substring(4, 2), Integer)
Dim UtcMilliseconds As Integer
' Extract milliseconds if it is available
If Words(1).Length > 7 Then UtcMilliseconds =
    CType(Words(1).Substring(7), Integer)
' Now build a DateTime object with all values
Dim Today As DateTime = System.DateTime.Now.ToUniversalTime
Dim SatelliteTime As New System.DateTime(Today.Year, Today.Month,
    Today.Day, UtcHours, UtcMinutes, UtcSeconds,
    UtcMilliseconds)
' Notify of the new time, adjusted to the local time zone
RaiseEvent DateTimeChanged(SatelliteTime.ToLocalTime)
End If
' Do we have enough information to extract the current speed?
If Words(7) <> "" Then
' Yes. Parse the speed and convert it to MPH
Dim Speed As Double = Double.Parse(Words(7), NmeaCultureInfo)
    * MPHPerKnot
' Notify of the new speed
RaiseEvent SpeedReceived(Speed)
' Are we over the highway speed limit?
If Speed > 55 Then RaiseEvent SpeedLimitReached()
End If
' Do we have enough information to extract bearing?
If Words(8) <> "" Then
' Indicate that the sentence was recognized
Dim Bearing As Double = Double.Parse(Words(8), NmeaCultureInfo)
RaiseEvent BearingReceived(Bearing)
End If
' Does the device currently have a satellite fix?
If Words(2) <> "" Then
Select Case Words(2)
Case "A"
    RaiseEvent FixObtained()
Case "V"
    RaiseEvent FixLost()
End Select
End If

```

```

' Indicate that the sentence was recognized
Return True
End Function

' Interprets a "Satellites in View" NMEA sentence
Public Function ParseGPGSV(ByVal sentence As String) As Boolean
Dim PseudoRandomCode As Integer
Dim Azimuth As Integer
Dim Elevation As Integer
Dim SignalToNoiseRatio As Integer
' Divide the sentence into words
Dim Words() As String = GetWords(sentence)
' Each sentence contains four blocks of satellite information.
' Read each block and report each satellite's information
Dim Count As Integer
For Count = 1 To 4
' Does the sentence have enough words to analyze?
If (Words.Length - 1) >= (Count * 4 + 3) Then
' Yes. Proceed with analyzing the block.
' Does it contain any information?
If Words(Count * 4) <> "" And Words(Count * 4 + 1) <> ""
And Words(Count * 4 + 2) <> "" And Words(Count * 4 + 3) <> "" Then
' Yes. Extract satellite information and report it
PseudoRandomCode = CType(Words(Count * 4), Integer)
Elevation = CType(Words(Count * 4 + 1), Integer)
Azimuth = CType(Words(Count * 4 + 2), Integer)
SignalToNoiseRatio = CType(Words(Count * 4 + 3), Integer)
' Notify of this satellite's information
RaiseEvent SatelliteReceived(PseudoRandomCode, Azimuth, _
Elevation, SignalToNoiseRatio)
End If
End If
Next
' Indicate that the sentence was recognized
Return True
End Function

' Interprets a "Fixed Satellites and DOP" NMEA sentence
Public Function ParseGPGSA(ByVal sentence As String) As Boolean
' Divide the sentence into words
Dim Words() As String = GetWords(sentence)
' Update the DOP values
If Words(15) <> "" Then
RaiseEvent PDOPReceived(Double.Parse(Words(15)), NmeaCultureInfo)
End If
If Words(16) <> "" Then
RaiseEvent HDOPReceived(Double.Parse(Words(16)), NmeaCultureInfo)
End If
If Words(17) <> "" Then
RaiseEvent VDOPReceived(Double.Parse(Words(17)), NmeaCultureInfo)
End If
Return True
End Function

' Returns True if a sentence's checksum matches the calculated checksum
Public Function IsValid(ByVal sentence As String) As Boolean
' Compare the characters after the asterisk to the calculation
Return sentence.Substring(sentence.IndexOf("*") + 1) = _
GetChecksum(sentence)
End Function

' Calculates the checksum for a sentence
Public Function GetChecksum(ByVal sentence As String) As String

```

```

' Loop through all chars to get a checksum
Dim Character As Char
Dim Checksum As Integer
For Each Character In sentence
    Select Case Character
        Case "$"c
            ' Ignore the dollar sign
        Case "*"c
            ' Stop processing before the asterisk
            Exit For
        Case Else
            ' Is this the first value for the checksum?
            If Checksum = 0 Then
                ' Yes. Set the checksum to the value
                Checksum = Convert.ToByte(Character)
            Else
                ' No. XOR the checksum with this character's value
                Checksum = Checksum Xor Convert.ToByte(Character)
            End If
        End Select
    Next
    ' Return the checksum formatted as a two-character hexadecimal
    Return Checksum.ToString("X2")
End Function
End Class

```

```

Public Class HighPrecisionTest

    Private WithEvents MyInterpreter As New NmeaInterpreter
    Private MaximumDOPAllowed As Integer = 6
    Private CurrentHDOP As Double

    Public Sub Test()
        ' Parse satellite information (HDOP is 50.0)
        MyInterpreter.Parse("$GPGSA,A,1,,,,,,,,,,,,,50.0,50.0,50.0*05")
        ' Parse the current position
        MyInterpreter.Parse("$GPRMC,225233.990,V,3939.4000,N," &
            "10506.4000,W,0.00,51.40,280804,,*35")
        ' Parse satellite information (HDOP is 1.2)
        MyInterpreter.Parse("$GPGSA,A,3,11,29,07,08,19,28,26,,,,,,,,,2.3,1.2,2.0*30")
        ' Parse the current position again
        MyInterpreter.Parse("$GPRMC,012558.584,A,3939.7000,N," &
            "10506.7000,W,0.00,198.07,290804,,*11")
    End Sub

    Private Sub OnHDOPReceived(ByVal value As Double) _
        Handles MyInterpreter.HDOPReceived
        ' Remember the current HDOP value
        CurrentHDOP = value
    End Sub

    Private Sub OnPositionReceived(ByVal latitude As String, _
        ByVal longitude As String) Handles MyInterpreter.PositionReceived
        ' Is the HDOP at least six?
        If CurrentHDOP <= MaximumDOPAllowed Then
            ' Yes. Display the current position
            Debug.WriteLine("You are here: " & latitude & ", " & longitude)
        Else
            ' No. Discard this positional measurement
            Debug.WriteLine("The received location is not precise enough to use.")
        End If
    End Sub
End Class

```