RTK GPS Performance Assessment for Long Baseline Deformation Monitoring

by

Muhammad Azfar Bin Mohd Zuber

Dissertation submitted in partial fulfillment of

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Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Civil Engineering Department Programme
Universiti Teknologi PETRONAS
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Approved by,

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(AP Dr. Abdul Nassir Bin Matori)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

May 2013

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.

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MUHAMMAD AZFAR BIN MOHD ZUBER

ABSTRACT

An offshore platform or correctly is a large structure with facilities to drill wells, to extract and process oil and natural gas, and to temporarily store product until it can be brought to shore for refining and marketing. For a normal GPS, after we obtained the coordinates of certain point, we have to process them and this will take time. For RTK GPS, it is real time process. It means that the data obtained can be processed on time and this can reduce time and occupation load. When a platform is hit by external forces, it will move a little bit from its original position, maybe just about 10cm. How can we measure the movement of the platform at the middle of the sea? This project work will be using the knowledge that author had learnt during the period of study. It is a method to test for the practicality of the knowledge that had been learned. In conducting this project, the author has to study about RTK GPS performance, understand the concept and the functions of RTK GPS. Next, some tests are going to be conducted, which is distance, accuracy, precision, and performance of RTK GPS single-based test.

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First and foremost, I would like to thank God the Almighty, for without His consent, it would be impossible to achieve what had been done in this work. I would like also to thank my parents, Mohd Zuber bin Ali and Mustakizah bt Abd Halim and all my family members for their love and support me from distance to achieve my goals in this work.

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ABBREVIATIONS AND NOMENCLATURES

CORS	Continuously Operating Reference Station.
DoD	Department of Defence.
DSMM	The Department of Survey and Mapping Malaysia.
GNSS	Global Navigation Satellite System.
GPS	Global Positioning System.
MyRTKnet	Malaysia Real-Time Kinematic GNSS Network.
PUK	Pulau Pangkor.
PUSI	Pusing.
RINEX	Receiver Independent Exchange Format.
RTK	Real Time Kinematic.
SVs	Satellite vehicle.
UTP	Universiti Teknologi PETRONAS.
UTPB	UTP Base Station.
VRS	Virtual Reference Station.

CHAPTER 1

INTRODUCTION

1.0 CLEAR AND COINSCISE BACKGROUND OF STUDY

An offshore platform or correctly, oil rig, is a large structure with facilities to drill wells, to extract and process oil and natural gas, and to temporarily store product until it can be brought to shore for refining and marketing. There are usually located at ocean at particular depth. It is subordinate to near shore and offshore projects, selected here to mean projects for seabed supported facilities in water depths between about 20 m and about 200 m. (Peuchen, J, 2013). There are various types of offshore platform, for example semi-submersible platform, SPARR platform, fixed platform, Jack-up platform, Tension Leg Platform, and Gravity Based Platform. These offshore platforms are usually located hundreds kilometers away from land.

Figure 1.0.1: A fixed offshore platform.

Meanwhile, GPS is a tool that can detect direction and locate places in very high accuracy because it received signal from many satellites. GPS is funded by and controlled by the U. S. Department of Defense (DOD). While there are many thousands of civil users of GPS world-wide, the system was designed for and is operated by the U. S. military. 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. (Peter H. Dana, 1999).

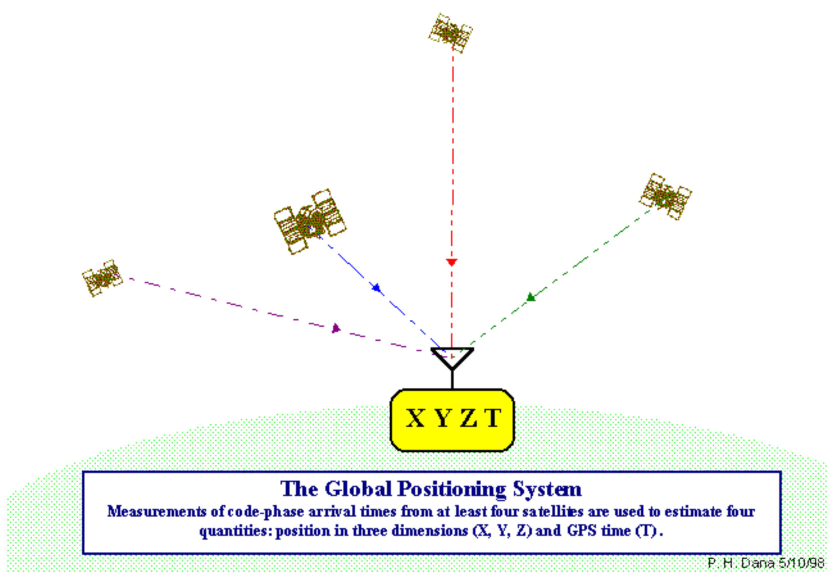

Figure 1.0.2: Position and time from four GPS satellite signals. (Peter H. Dana, 1999).

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, 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. (Peter H. Dana, 1999).

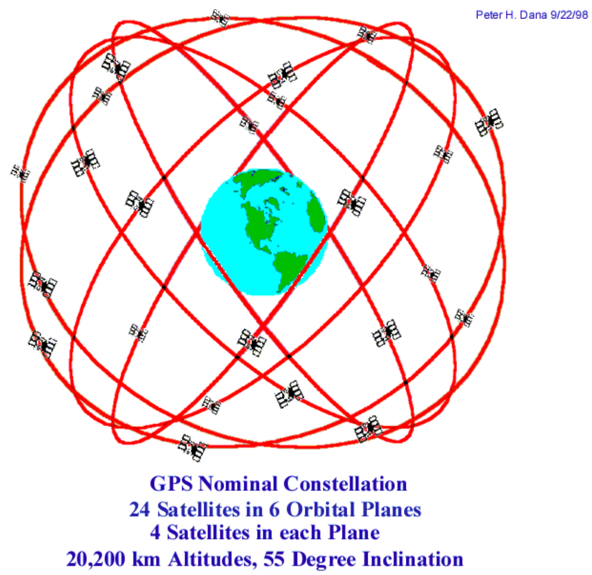

Figure 1.0.3: GPS constellation. (Peter H. Dana, 1999).

RTK GPS is different from normal GPS in term of work processes. For a normal GPS, after we obtained the coordinates of certain point, we have to process them and this will take time. For RTK GPS, it is real time process. It means that the data obtained can be processed on time and this can reduce time and occupation load. Most of these offshore platforms are located 120– 250 km from shore and they require very high precision, reliable and highly available positioning tool for the monitoring of subsidence at these offshore platforms. (Halim Setan, Rusli Othman, 2006). Besides, RTK GPS provide more accurate and precise data from normal GPS. Conventional RTK GPS positioning is a technique that allows centimetre level accuracy positioning in real time through effectively differencing away similar errors and biases that are caused by atmospheric effects and GNSS satellite orbit errors (distance dependent errors) and clock bias in carrier phase observations of the receivers at both ends of a baseline (a reference station and a rover). (Jose Aponte, Xiaolin Meng, Chris Hill, et al, 2009). The use of reference station networks has become the ubiquitous solution for high precision satellite positioning applications.

Figure 1.0.4: RTK GPS Receiver.

The main systematic errors affecting the RTK rover performance are multipath, atmospheric and ephemeris errors. Whereas single base RTK is limited with respect to the distance between reference and rover the network RTK approach offers the possibility to increase the coverage area. It ideally leads to a situation in which the positioning error is independent of the rover position in the area of the network. (Ulrich Vollath, Herbert Landau, Xiaoming Chen, et al, 2002).

Figure 1.0.5: RTK GPS Receiver with its battery and memory card.

Basically, a single baseline solution uses one base station to obtain correction data. This single base station can be a personal base station setup on-farm or a CORS station. For radio transmitted data, it is recommended that the rover unit be within 6 miles or line-of-sight to ensure adequate signal integrity. The distance in this scenario is a function of satellite commonality. In other words, the rover and the base station must be able to see the same constellation of satellites (minimum of 5) for accurate correction data and to achieve RTK quality. (Daniel Mullenix, , John Fulton, Anora Brooke, 2011).

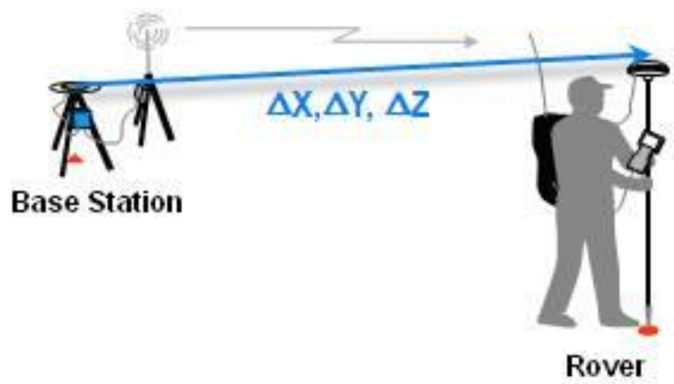

Figure 1.0.6: Single- based RTK GPS.

1.1 PROBLEM STATEMENT

1.1.1 Problem Identification

When a platform is hit by external forces, it will move a little bit from its original position, maybe just about 10cm. How can we measure the movement of the platform at the middle of the sea? Can we just look from our naked eye from onshore? Or we must go to the platform and measure using some ruler or tape? The author's suggestion is using RTK GPS method. But, a problem arises because RTK GPS can only transmit data from reference station to the rover of maximum 20km only. Meanwhile the minimum distance between offshore platform and onshore is 100km. How can the problem be solved?

One of a major problem with offshore platform is the occurrence of deformation which can have serious and potentially fatal consequences. The implementing of a deformation monitoring system to maintain regular surveillance of the stability is a means to address both human safety and company profitability. The approach developed in this study uses a precise relative Global Positioning System (GPS) which is advantageous for deformation monitoring in terms of long-baseline data as offshore platforms are located hundreds of kilometers from shore. (Widjajanti, Nurrohmat, 2010). Since these offshore platforms are located hundreds of kilometers from shore, the GPS technique is seemed the only possible method that is able to carry out subsidence monitoring for geodetic method. (Othman, Rusli and Setan, Halim, 2005)

1.1.2 Significant of the project.

"There are nearly 4,000 offshore oil and gas facility platforms in the Gulf of Mexico. On average**, at least 10 platform facilities are lost or destroyed** each year due to storms and/or hurricanes. The 2005 hurricane season had an extraordinary impact on the offshore oil and gas industry in the Gulf of Mexico. The combination of Hurricanes Katrina and Rita had a direct effect on 3050 of the 4000 platforms in the Gulf, and 22,000 of the 33,000 miles of pipelines were in the direct path of both of these storms. The magnitude of the damage was immense **46 platforms were destroyed and 20 others damaged by Hurricane Katrina.** Hurricane Rita **destroyed 69 platforms and damaged an additional 32.** Some **457 pipelines were damaged** by the storms. **100 percent of Gulf oil production was shut in during both storms and 94 percent of Gulf natural gas production was shut in during Katrina.** By the end of the 2008 storm season approximately **1,450 oil and gas production platforms in the Gulf of Mexico had been exposed to hurricane** conditions. As a result of these storms**, 54 of the almost 4000 offshore oil and gas production platforms were destroyed**, 35 platforms suffered extensive damage, and more than 60 platforms received moderate damage." (CRADDOCK INTERNATIONAL PETROLEUM ENGINEERING & TECHNICAL SERVICES, 2010)

Above case study shows that the danger of massive destructive wave in the sea that can bring catastrophic disaster to the workers working at the oil rig. Thus, monitoring the movement and the impact of the offshore platform is vital to design stronger platform so that it can prevent the disaster from happen.

1.2 OBJECTIVE AND SCOPE OF STUDY

The main objective of this project is to study the performance of RTK GPS in al long baseline, which is the distance between the base and the rover. To assess the performance of this RTK GPS, the author had divided the main objective to three other objectives. Which is first is to determine the maximum distance the base and the rover can receive the signal. For example, a base is going to be set up at onshore, while a rover is going to be set up at the platform at offshore. So, what is the maximum distance the base can receive the data from the rover at offshore? In this project, the author can only is 1 Hz of frequency of RTK GPS, because if the frequency is higher, it might disturb the wave such as radio wave at the project area. Besides, higher frequency can cause bad health impact to local residents. So, what is the maximum distance the base can receive the data from the rover using frequency of 1Hz only?

Second, is to determine the accuracy and precision the data taken in a further baseline. Third, is to determine the time taken for the rover to be fixed and has 100% radio signal to take the data. And finally, to determine other factor that can affect the performance of this RTK GPS

1.3 THE RELEVANCY OF THE PROJECT.

This project work will be using the knowledge that author had learnt during the period of study. It is a method to test for the practicality of the knowledge that had been learned. Furthermore the author taking major in offshore and coastal engineering. The author thinks the subject will help me a lot completing this project. The authors know the type of water waves, types of oil rig, and many others that related to offshore structure. By doing this project, the author can help my supervisor to complete this project and to increase the quality if offshore platform in the future which are stronger, more reliable, and more stable. Technology is getting more advances day by day. If this project succeeds, the result will be proposed to oil and gas company, such as PETRONAS. The company can built their offshore platform better in quality. So the author proud to be a little contributor to this oil and gas company, thus to the nation.

This study also has been conducted inside and outside UTP about 3 kilometers radius due to the lack of manpower. All the instrument need to be secured and well monitored by several persons at one time for safety purposes.

1.4 FEASIBILITY OF THE PROJECT WITHIN THE SCOPE AND TIME FRAME

The duration of the project is about four months which is a whole semester. The usage of the Gantt chart also will help to manage the time wisely in realization of the project work.

CHAPTER 2

LITERATURE REVIEW

2.0 CRITICAL ANALYSIS OF LITERATURE

2.0.1 RTK GPS

With the increase of available GLONASS satellites during its revitalization, GLONASS observations were increasingly integrated into GPS-based PPP. (Cai,C, 1 February 2013). This technique introduces significant improvements compared to other techniques for monitoring small areas such as better repeatability, accuracy, reliability, etc. (Garrido, M.S, 2013). - Real Time Kinematic (RTK) satellite navigation is a technique used to enhance the precision of position data derived from satellite-based positioning systems, being usable in conjunction with GPS, GLONASS and/or Galileo. They come out with better accuracy and precision.

Canopy and terrain interference reduce accuracies and efficiencies because the optimal set of satellites may not be visible even though they are above the planar horizon. (Christopher Deckert, Paul V. Bolstad, 1996). High-accuracy RTK-GPS was used to first assess the accuracy of the conventional and image-derived survey methods. (Harley, M.D, February 2011). Losing the RTK fix solution is a common occurrence when operating near trees, tall landforms, and large structures that can cause significant sky blockage. (Freeland, R.S., Buschermohle, M.J., Wilkerson, J.B., et al, 2012). Moreover, in order to cope with the fact that GPS systems sometimes lose their signal and receive inaccurate position data, the self-tuning filter estimates the covariance matrix associated with the GPS measurement noise. (Aghili, F., Salerno, A., 2013). - RTK GPS is a high accuracy GPS which are used for surveying providing up to centimeter-level accuracy. The position on RTK GPS also must be considered to achieve high level accuracy data gathering. It must not be stationed under roofing area or else signals from satellite wouldn't send to receivers. Selections of terrain also vital to ensure accurate data are received. This is because minor displacement such as 1cm runaway can cause major error data and can affect the final result.

Multi-reference station is a well-known approach in RTK GPS. Using multi-reference points is an effective way to achieve consistent accuracy in the whole net by making errors less distance dependent on the reference stations. It is possible to achieve high reliability and availability by using multi-reference stations. If one station goes down or starts to provide suspicious values, it is possible to compensate the situation with other stations, while this is not possible when a single reference station fails. (Pirti, A., 2012). - This literature reviews proves that using multi-references for the base for RTK GPS can enhance the accuracy and lengthen the distance from base to rover. But, the references point must be identified first.

2.0.2 Dynamic loading

Effect of water level variation acting on the jacket structure and illustrates subsequent results of the stress utilization within the structure elements. The results of time history analysis show that the initial design water depth (before water level rise) has a basic role on the subsequent behavior of structural elements. (Lotfollahi-Yanghin, M.A, 2013). Only physical load had significant effects on local dynamic stability. (Qu, X, 2013). - Dynamic loading is mainly concerned with finding out the behavior of a structure when subjected to some action. This action can be in the form of load due to the weight of things such as people, furniture, wind, snow, or some other kind of excitation such as an earthquake, shaking of the ground, and waves.

Dynamic Loads can result in fatigue phenomena within the material concrete which are not totally explored even in their beginnings. (Urban, S., Strauss, A., Reiterer, M, et al, 2013). However, an uncertainty was the extension and distribution of the damaged region which affected the prediction of the load capacity. (Hanjari, K.Z., Kettil, P., Lundgren, K., 2013). - The conclusion is structural dynamics is a type of structural analysis which covers the behavior of structures subjected to dynamic actions having high acceleration loading. Dynamic loads for examples are people, wind, waves, traffic, earthquakes, and blasts.

2.1 CITATION AND CROSS REFERENCING

However, this differential positioning technique is valid only for short baseline lengths (<20km). (Jose Aponte, Xiaolin Meng, Chris Hill, et al, 2009). Additionally, the recommended maximum baseline length for conventional RTK is about 10km due to the constraint of a radio modem that transmits the data from the reference station to the rover (Wegener and Wanninger 2005).

These two statements show that a single base RTK GPS cannot receive the signal from rover more than 10km distance. These limitations have constrained the application scope of RTK GPS positioning, for instance, in precise vehicle tracking where mobility is a priority.

Dynamic Loads can result in fatigue phenomena within the material concrete which are not totally explored even in their beginnings. Especially in the fields of Foundations for wind energy plants on- and offshore fatigue is a big problem. The Fatigue associated load combinations are mostly the decisive ones for design and dimensioning of the structure. (Urban, S., Strauss, A., Reiterer, M., 2013). The Norwegian offshore employees indicate higher subjective risk perception both with regards to personal injuries and process accidents compared to Danish offshore employees. (Rasmussen, H.B., 2012).

Based on above two citations above, the author can conclude that structures of oil rig can easily broke because of the fatigue failure. This can happen if the structures are being exposed to heavy load such as strong waves frequently. The oil rig can move and it brings risk to the workers up there because of the unbalance condition.

"The influence of floating ice on the dynamic behavior of ships and offshore structures depends on many factors such as ice thickness and its relative speed with respect to the floating structure." (Ibrahim, R.A., Chalhoub, N.G.,Falzarano, J., Interaction of ships and ocean structures with ice loads and stochastic ocean waves, Volume 60, Issue 1-6, 2007, Pages 246-290). It is concerned that the stability of the platform besides the safety requirement when the platform is being used as a facility for public staying. However, to avoid the vibration induced from waves or wind loading is always a challenging task due to the difficulties of accurately monitoring the platform motion and applying the appropriate mitigation device to the system. (Lee, H.H., Lee, R-S., 2003). An offshore wind farm situated sufficiently far away from the coast can generate more wind power and will have a longer operation life since the winds are stronger and more consistent than those on or near the coast. (Luo, NMay 2012).

What the author can conclude from two citations above is stability of the platform is important to make sure all processes and workers up there safe to work. Besides, in the ocean, strong wind can happen and it can cause the platform to move. Not only about wind forces, but from the force created by melting of iceberg. In North Sea, there are a lot of offshore platforms and there are also a lot of massive ice bergs that are melting and collapsing. If the platforms located near to the ice berg, the fallen of the ice can create big wave and force that can affect the platform. Thus, monitoring the platform is vital to prevent more catastrophic disaster from happen.

2.2 RELEVANCY AND RECENTNESS OF THE LITERATURE

Literature review is very important in making sure the information gathering and all the data obtained is correct. The information given in the literature also can help in giving guidance to its reader about the topic. For this project, the information from all the articles, books, and journals had given the author some information about the RTK GPS, and dynamic loading of offshore platform. Besides, some experiment had been done by the author about performance of RTK GPS. Some results have been taken and analyzed. All the information will be used until the final stage of the project.

CHAPTER 3

METHODOLOGY

3.0 RESEARCH METHODOLOGY

In conducting this project, the author has to study about RTK GPS performance from varies of books related to this RTK GPS. The author must understand the concept and the functions of RTK GPS. Next, a test is going to be conducted, which is distance versus accuracy and precision test. The distance is from base to rover. In conducting this test, varies distances has been used for example 2km, 5km, 10km, 20km, 40km, until the data no longer receive by the base from the rover. The hypothesis is the longer the distance base from rover, the lesser the chance the data will be received by the base from the rover. The apparatus needed for conducting this experiment are:

i) A set of RTK GPS

Figure 3.0.1: A set of RTK GPS

ii) A pole to put rover on top of it.

Figure 3.0.2: A pole

iii) A tripod to put base on top of it.

Figure 3.0.3: Tripod with rover attached on top of it.

iv) A measuring tape to measure the height of the base to the ground.

Figure 3.0.4: A measuring tape.

v) Surveying nail to mark the point where the rover is put on the ground.

Figure 3.0.4: A surveying nail.

Next page are the pictures how the test is going to be conducted.

The UTPB station has been established by using GPS Static Post Processing mode and located at Car Park, Pocket C inside UTP. First, the rover is set up at main entrance UTP. The distance from the car park at Pocket C to the main entrance UTP is about 1.8 kilometers. Then, the distance will be increase until the base no longer receives data from the rover, which means the rover must be set up outside the UTP.

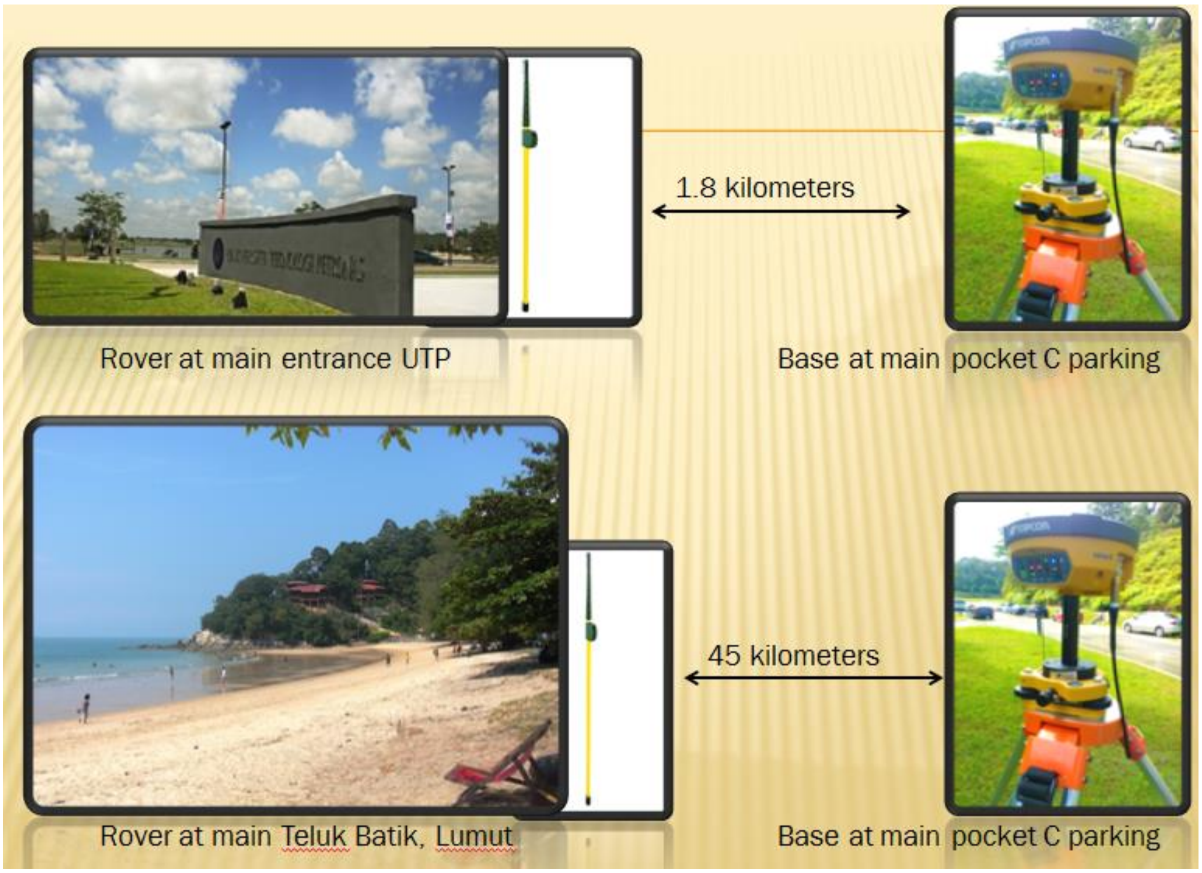

Figure 3.0.6: Distance of base and rover.

The other detail project procedures are explained on next page.

The project procedures as below:

1) Establishment of UTPB Control Station by using baseline and network processing. This step has been done by Fauzi in October 2012, who is the person who had done Final Year Project using RTK GPS about monitoring building movement. For clearer steps how the establishment of UTPB has been made by him, the steps are below:
   - Two sessions of GPS observation were carried at UTPB control station in way to form the GPS network with provided data from PUSI CORS and PUPK CORS. Each of the observation was carried out with 10 second data interval.
   - The observation was conducted on 30th October 2013 from 11.00 am to 01.00 pm for the first session and the second session observation continued at 01.15 pm until 03.15 pm with same data interval.
   - The Receiver Independent Exchange Format (RINEX) is a data gathered from the both CORS is used to process with UTPB data by using Static Topcon v.8 Software to establish the precise coordinate of UTPB control point. Besides that, the actual coordinate of PUSI CORS and PUPK CORS supplied by DSMM located at Kuala Lumpur are also needed before start the processing work.
   - The data is processed by using Topcon Tools v.8 (Static Software) started with individual baseline and followed by network adjustment process. The baseline with green color determines the successful baselines that have been processed. On the other hand, the red baseline color determines the failure of baseline processing. This failure indicated by symbol “NO” as shown in figure 3.0.7 next page.

(Fauzi, 2009)

2) After the establishment of UTPB at car park Pocket C inside UTP, a base is set up at the point. The establishment of the base is referred from the manual. There are a lot of steps need to be done to set up the base. About 15 to 20 minutes need to set up the base. Below is the location where the base is set up. The base is set up at the high ground at Pocket C car park. Next page shows the base which has been set up at the place.

Figure 3.0.8: Establishment of base at car park, Pocket C.

Figure 3.0.9: Base at car park, Pocket C.

3) After the setup of the base, the rover needs to be setup. After the rover has been setup by attaching it to the pole and some steps to get signal from satellite, the rover first is brought at the main entrance of UTP. This is to test the objective of the project which is to study how far the maximum length the base can receive the data from the rover.
4) After the rover has been tested at the main entrance UTP, and the wave signal is 100% and fix, which means the data can be received by the base. Then, the rover is brought further from the base until the wave signal is no longer achieve 100% and the it is in float condition, which means the data no longer can be received by the base. Next page shows some locations where the rover has been brought to test the maximum distance the base can receive the signal.

Figure 3.0.10: At bushes behind Pocket C car park.

Figure 3.0.11: At field behind Block 5.

Figure 3.0.12: At UTP Main Gate.

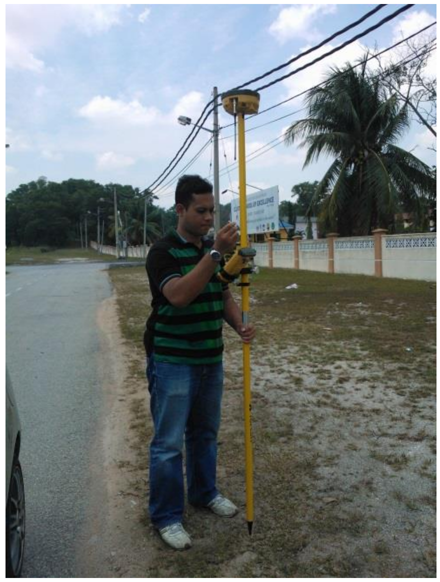

Figure 3.0.13: At SMKA Sultan Azlan Shah.

Figure 3.0.14: At Al-Ikhsan Jalan Parit.

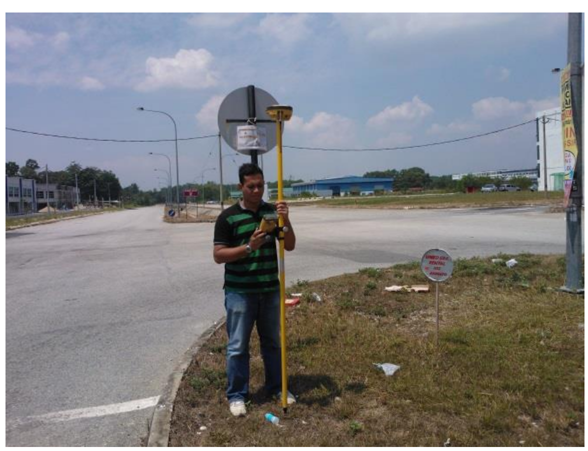

Figure 3.0.15: At UiTM Perak Main Gate.

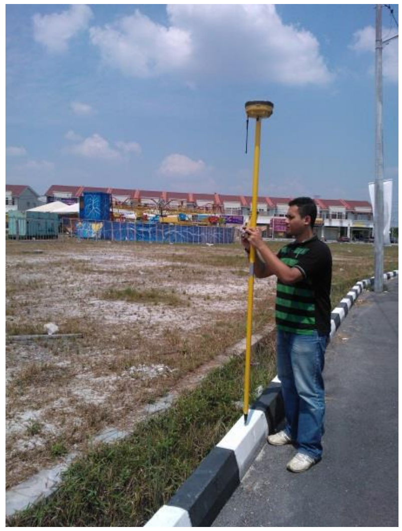

Figure 3.0.16: At Petronas Taman Maju.

Below shows a table of the locations and their respective distance from the base.

point	distance from base (m)
Point 1 (parking at Pocket C)	57
Point 2 (bushes at Pocket C)	303
Point 3 (lake at front UTP)	1870
Point 4 (Balai Polis Daerah)	2330
Point 5 (Tesco Bandar Universiti)	2500
Point 6 (Petronas Taman Maju)	2760
Point 7 (Al-Ikhsan Jalan Parit)	2800
Point 8 (Uitm Perak main gate)	3300
Point 9 (SMKA Sultan Azlan Shah)	3970

Table 3.0.17: Distance rover from base.

So, this is to find the maximum distance from base to rover where the radio signal is strong and data can be collected. At the results, the author will show where the maximum distance the rover can go is and the radio signal is strong and the rover is in fixed condition.

5) Then, some data is collected at the locations which has stable and has strong radio signal. The data timing also is recorded which mean how long the rover can take the data if it is further from the base. The data is collected to analyze the accuracy and precision of this RTK GPS, which is to full fill second and third objective. The data is processed using software named Topcon Tools.

Figure 3.0.18 below shows the concept how the data is received by the base from the rover.

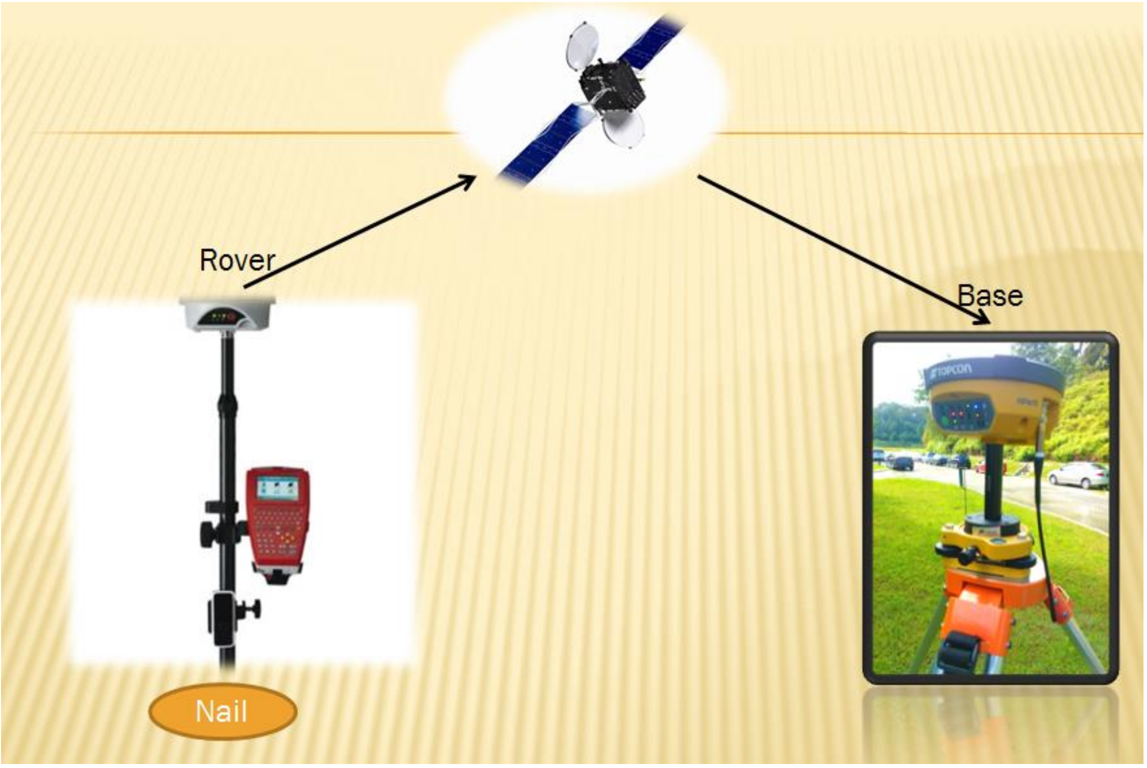

Figure 3.0.18: Conceptual how data is transmitted.

The satellite is like a medium to transfer data from rover to base. Without satellite, data cannot be transferred. During the setup of the base, the base first must identify at least four satellites before it is completely setup. Next page shows the condition of the satellites.

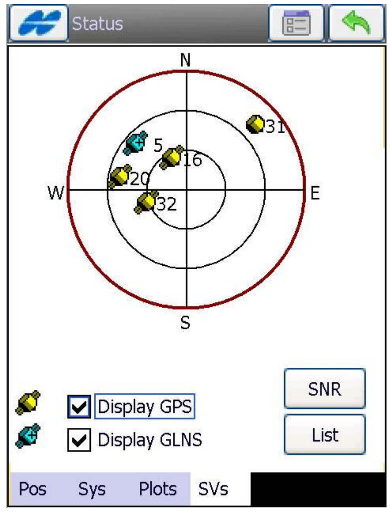

Figure 3.0.19: Satellite detected during set up of base and rover.

After it had identified four satellites, than the rover can be setup. At a point, the rover is placed vertically to the ground with a pole. It must be not moved for a certain minutes. This is to stabilize the signal and connection between the base and the rover. If the wave signal at the rover shows 100% and it is fixed, that's mean the connection is perfect, otherwise it is not connected.

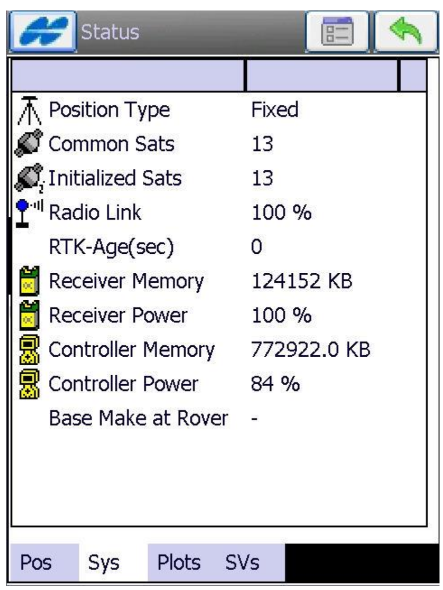

Figure 3.0.20: Condition of rover which fixed and has 100% radio signal.

This test is going to be conducted at open space far away from tall structures such as buildings and trees. The RTK GPS also is using only 1 Hz radio transmitter. The author cannot increase the frequency more than 1 Hz because of the law of Malaysia, which might impact the health of people nearby and also might disturb some other waves such as cellular wave. But, this only applies on onshore not offshore. On offshore, there is no limit frequency is going to be used. The hypothesis is the smaller the frequency; the shorter the distance base can detect the rover.

However, long-term exposure that does not lead to immediate symptoms can still result in cumulative physiological effects that may ultimately cause serious disease. Every person is affected by electrical pollution, but some people are more sensitive, less resilient and therefore more susceptible to health problems associated with high frequency radio waves (this is known in the medical literature as ”radio wave sickness"). (Dr. Hayas, Dr. William Rae, Dr. Adiel Tel Oren (Founder), 2013).

Symptoms of Radio Wave Sickness:

- Neurological: headaches, dizziness, nausea, difficulty concentrating, memory loss, irritability, depression, anxiety, insomnia, fatigue, weakness, tremors, muscle spasms, numbness, tingling, altered reflexes, muscle and joint paint, leg/foot pain, "Flu-like" symptoms, fever.
- Cardiac: palpitations, arrhythmias, pain or pressure in the chest, low or high blood pressure, slow or fast heart rate, shortness of breath.
- Respiratory: sinusitis, bronchitis, pneumonia, asthma.
- Dermatological: skin rash, itching, burning, facial flushing
- Ophthalmologic: pain or burning in the eyes, pressure in/behind the eyes, deteriorating vision, floaters, cataracts.
- Others: digestive problems; abdominal pain; enlarged thyroid, testicular/ovarian pain; dryness of lips, tongue, mouth, eyes; great thirst; dehydration; nosebleeds; internal bleeding; altered sugar metabolism; immune abnormalities; redistribution of metals within the body; hair loss; pain in the teeth; deteriorating fillings; impaired sense of smell; ringing in the ears.

(Excerpted from: No Place To Hide April 2001.)

3.1 PROJECT ACTIVITIES

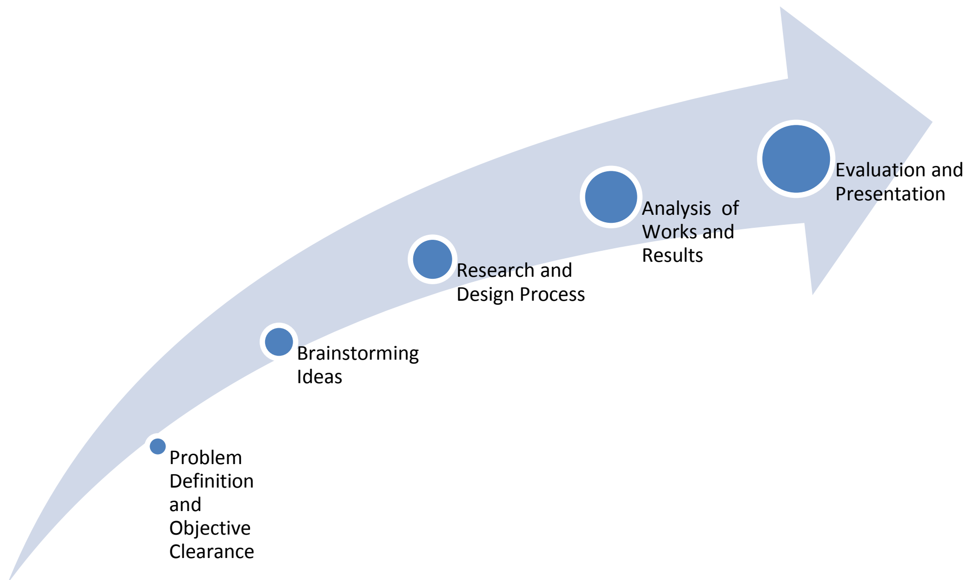

Figure 3.1.1

Figure above shows the flow for the progress of my project work. All the process will take quite some time but hopefully the target for the project work will be achieved within the time specified. As this report is written, it is already in week 12 in the author's final year second semester. So the rest of weeks until the end, the author hope and will learn more about RTK GPS and involved actively in this project. The author will try to gain as much experienced before going finishing this semester.

3.2 KEY MILESTONE

Table 3.2.1 and table 3.2.2 below and in the next page show the project deliverables and target date for the project work throughout final year first and second semester.

Event or Deliverable	Target Date	Responsibility
Submission of project title and project synopsis.	Week 1-2	Students must submit the project title to FYP coordinator.
Approval on project proposal and supervisor	Week 1-2	FYP coordinator approves the project title along with the supervisor.
Doing research on the project and completing extended proposal defense.	Week 2-6	Find the related data regarding the project and start doing extended proposal defense.
Submission extended proposal defense.	Week 6	Complete the extended proposal defense and hand it to supervisor.
Preparation for proposal defense.	Week 7-9	Prepare for the question and answer about the project during this period.
Project works continues.	Week 10-12	Continue searching and produces results and conclusion for the project.
Submission of interim draft report.	Week 13	Students must submit the draft to the supervisor.
Submission of interim report.	Week 14	Students must submit the final report to the supervisor.

Table 3.2.1: Key milestone for FYP I in final year first semester.

Event or Deliverable	Target Date	Responsibility
Project works continues.	Week 1-7	Continue searching and produces results and conclusion for the project.
Preparation for the progress report.	Week 7-8	Preparing the progress reported with progress works and results for the time being.
Submission of progress report.	Week 8	Students must submit the progress report to the supervisor.
Project works continues.	Week 8-12	Continue searching and produces results and conclusion for the project.
Preparation for Pre-SEDEX	Week 10	Prepare for the presentation of the report for competition named Science and Design Exhibition (SEDEX).
Pre-SEDEX	Week 11	Presentation of the report for Pre-SEDEX. If selected, student can go to the SEDEX.
Preparation of draft report.	Week 11-12	Students must prepare the project draft complete with results to the supervisor and internal examiner.
Submission of draft report.	Week 12	Students must submit the project draft to the supervisor and internal examiner.
Preparation of project dissertation	Week 12-13	Students must update the draft report with new things and upgrade it to dissertation report.
Submission of project dissertation (soft bound) and technical paper.	Week 13	Students must submit the dissertation report and technical paper according to ASCE format to the supervisor.

Submission of project technical paper.	Week 13	Students must submit the project technical paper according to ASCE format to the supervisor.
Oral presentation (Viva)	Week 14	Students must present the whole project complete with results to the supervisor and internal examiner.
Submission of project dissertation (hard bound)	Week 15	Students must submit the project dissertation report with hard bounded to the supervisor and internal examiner.

Table 3.2.2: Key milestone for FYP II in final year second semester.

3.3 GANTT CHART

Table 3.3.1 and table 3.3.2 below and in the next page show the Gantt chart of the project throughout the final year first and second semester.

NO.	DETAIL/WEEK	1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Selection of Project Topic								M							
									i							
2	Preliminary Research Work								d							
3	Submission of Extended Proposal Defence								s							
									e							
4	Proposal Defence								m							
5	Project work continues								b							
									r							
6	Submission of Interim Draft Report								e							
									a							
7	Submission of Interim Report								k							

Table 3.3.1: Gantt chart for FYP I in final year first semester.

NO.	DETAIL/WEEK	1	2	3	4	5	6	7	Mid sem break	8	9	10	11	12	13	14	15
1	Project works continue																
2	Submission of Progress report																
3	Project works continue																
4	Pre-SEDEX																
5	Submission of project draft report																
6	Submission of project dissertation (soft bound)																
7	Submission of proejct technical paper																
8	Oral presentation (Viva)																
9	Submission of project dissertation (hard bound)																

Table 3.3.2: Gantt chart for FYP II in final year second semester.

3.4 TOOLS

Table below shows the lists of software that will be going to use in doing the monitoring offshore platform dynamic loading.

No	Software	Description
1	Microsoft Office -Microsoft Word -Microsoft Excel	 Documentation of the project work Producing the flood report and data gathering.
2	RTK GPS	Monitoring the movement of the offshore platform.
3	Google Earth	Find the distance of base and rower of RTK GPS
4	Topcon Tools	Process of data to determine accuracy and precision of RTK GPS.

Figure 3.5: Tools.

CHAPTER 4

RESULTS AND DISCUSSION

4.0 SINGLE BASED RTK GPS

As stated at the objective part, the objective is to find the maximum distance the base can receive the data from the rover. Figure below shows the distances tested by the author. The frequency used in this test is only 1 Hz.

Base in the figure 4.0.0 next page is the UTPB. The base of RTK GPS is set up at the base. After that, the rover is brought to UTP main entrance first which is about 1.80 kilometers from the base. At this distance, the rover shows 100% radio wave frequency and the condition is fixed, which means the base can clearly receive the data from the rover. Then, the rover is brought to Balai Polis Daerah. The distance from this place to the base is about 2.3 kilometers. The rover still shows 100% radio wave frequency and the condition are fixed.

After that, the rover is taken to the longer distance which is about 2.76 kilometers away from the base. At this distance, the base still can receive the signal from the rover. After that, the rover is taken to longer distance which is about 2.80 kilometers away from the base. But at this distance, the base cannot longer receive signal from the rover. The radio wave is not 100% and the condition is float. This happened because of the low frequency of radio wave which is only 1 Hz. The author also tries testing the distance at longer distance, which are 3.30 kilometers at SMKA Sultan Azlan Shah and 3.97 kilometers away at FELCRA Nasaruddin, yet the same thing happens. Table next page also shows summary of the distance tested against signal of the base and rover RTK GPS. Based on the figure next page, the green line shows the fixed condition, which mean the radio signal is strong, while the red line shows the autonomys condition which means the radio signal is weak, the data cannot be taken.

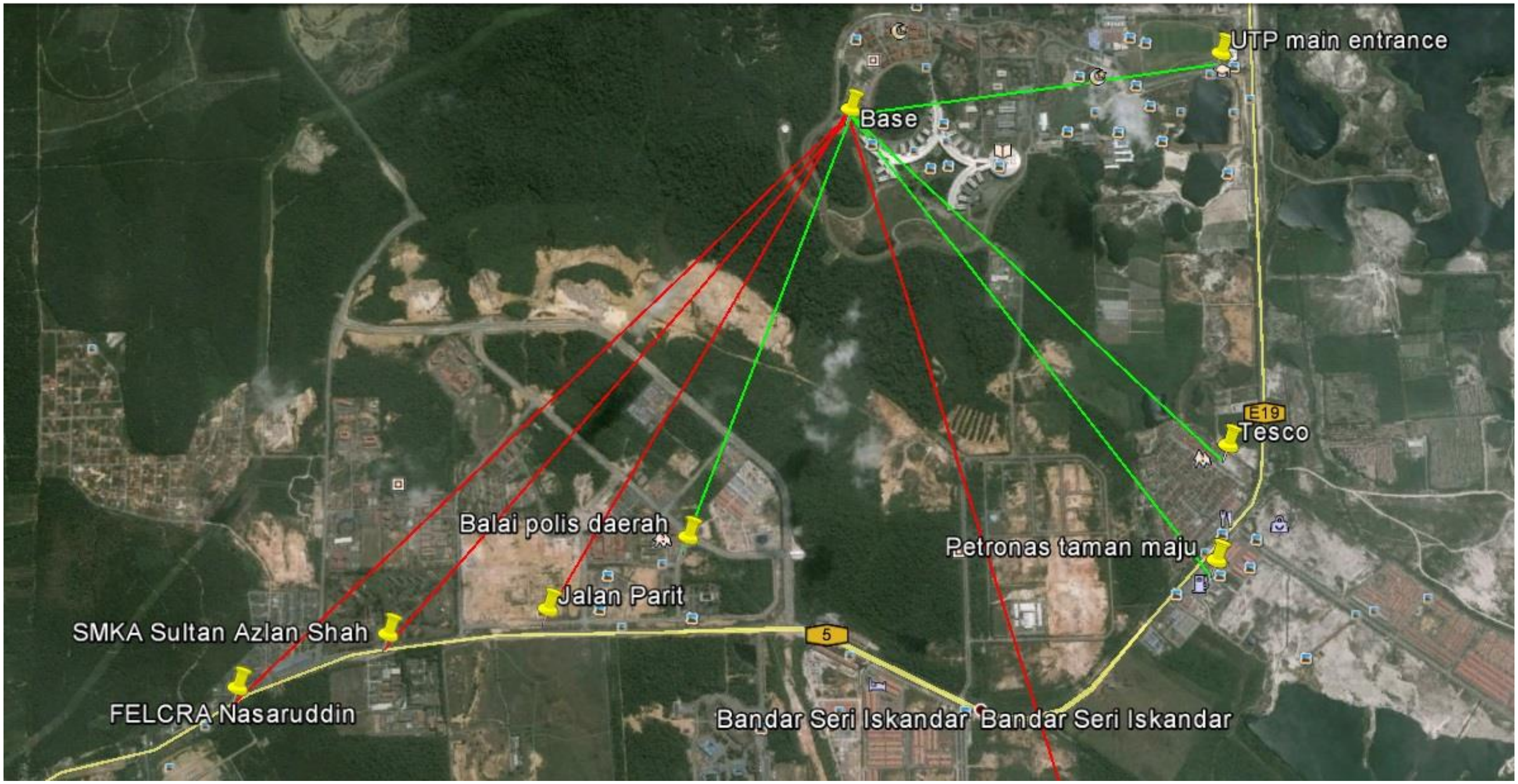

Figure 4.0.0: Distance test of single base RTK GPS.

point	distance from base (m)	radio signal (%)	condition
Point 1 (parking at Pocket C)	57	100	fixed
Point 2 (bushes at Pocket C)	303	100	fixed
Point 3 (lake at front UTP)	1870	100	fixed
Point 4 (Balai Polis Daerah)	2330	100	fixed
Point 5 (Tesco Bandar Universiti)	2500	98	fixed
Point 6 (Petronas Taman Maju)	2760	95	fixed
Point 7 (Al-Ikhsan Jalan Parit)	2800	0	autonomys
Point 8 (Uitm Perak main gate)	3300	0	autonomys
Point 9 (SMKA Sultan Azlan Shah)	3970	0	autonomys

Table 4.0.1: Distance test of single base RTK GPS.

So, the conclusion after the author had tested the points, the author can determine the final maximum distance the base can receive the signal from the rover which is 2.76 kilometers approximately. This test is only for distance test. The coordinate for the 2.76 km distance of rover from the base is 4°21'48.13"N, 100°58'37.41"E, which is ate Petronas Taman Maju.

The data link is an essential component of the RTK GPS system. RTK positioning requires regular transmission of data from the reference station to the rover. The rate of transmission is on the order of 0.5-2 Hz. (RTCM, 1998). Currently available data links in commercial RTK GPS survey systems take the form of a digital radio modem operating in the VHF or UHF frequency range. (Trimble Navigation Limited, 1997; Pacific Crest Corporation, 1999; Magellan Corporation, 2000).

Next page is the figure 4.0.2 shows the location of maximum distance the base can receive the signal from the rover which is 2.76 kilometers.

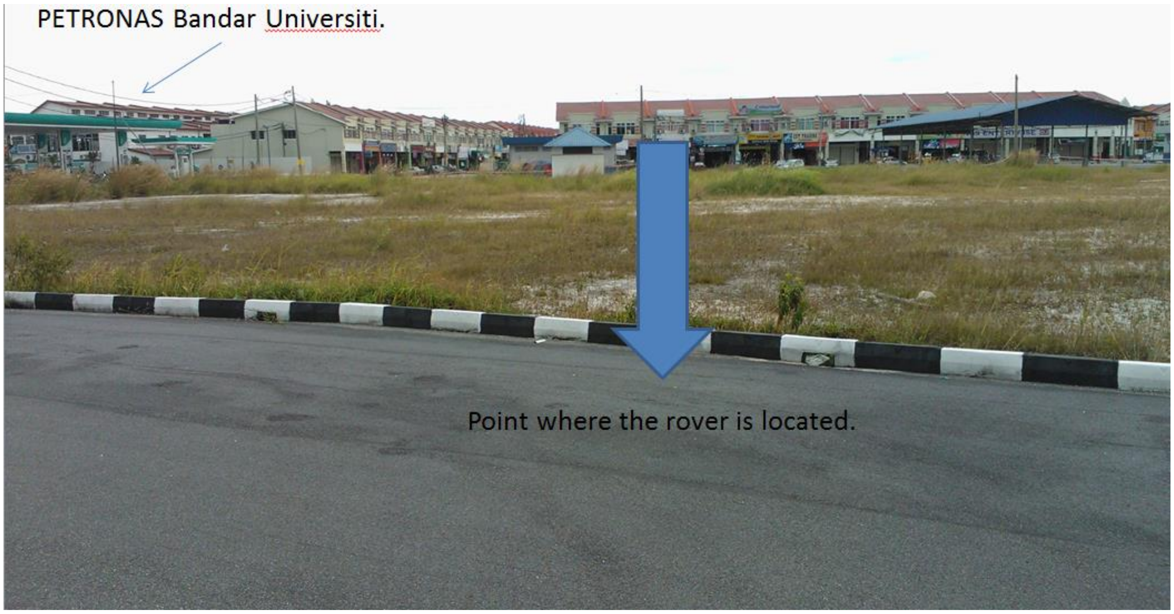

Figure 4.0.2: Point of maximum distance of rover from the base.

The author had taken some data at three different locations to determine the accuracy and precision of RTK GPS, which distance versus accuracy and precision. Figure below shows locations of the data taken. The initial inference is the longer the distance, the less accuracy and precision. Each point, the author had taken about twelve data. Figures in next page show the distribution of data taken in each point.

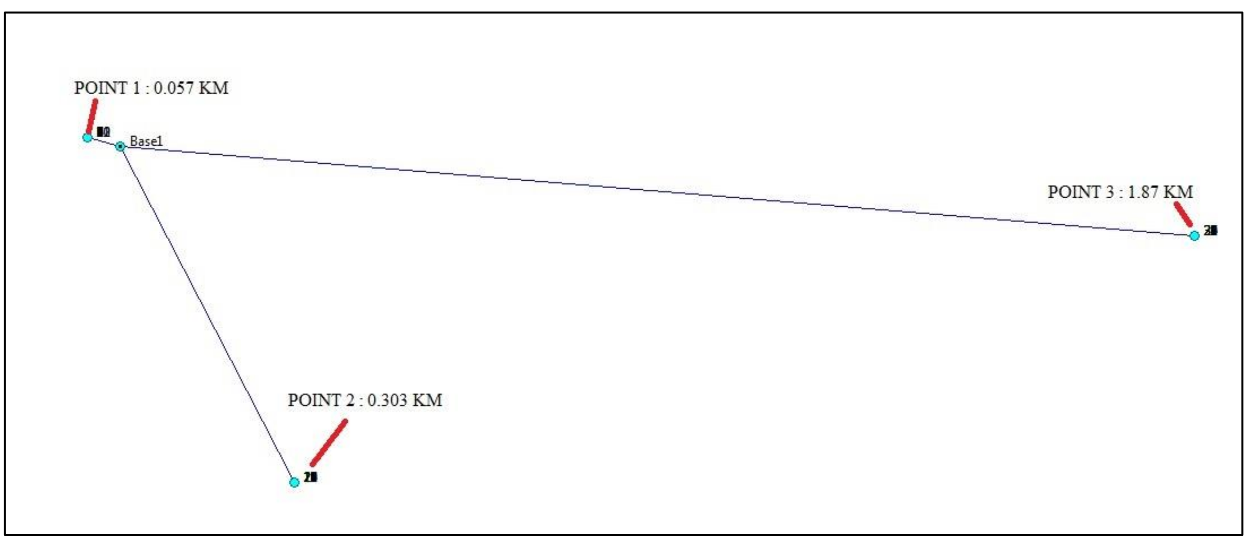

Figure 4.0.3: Point of locations where data are taken.

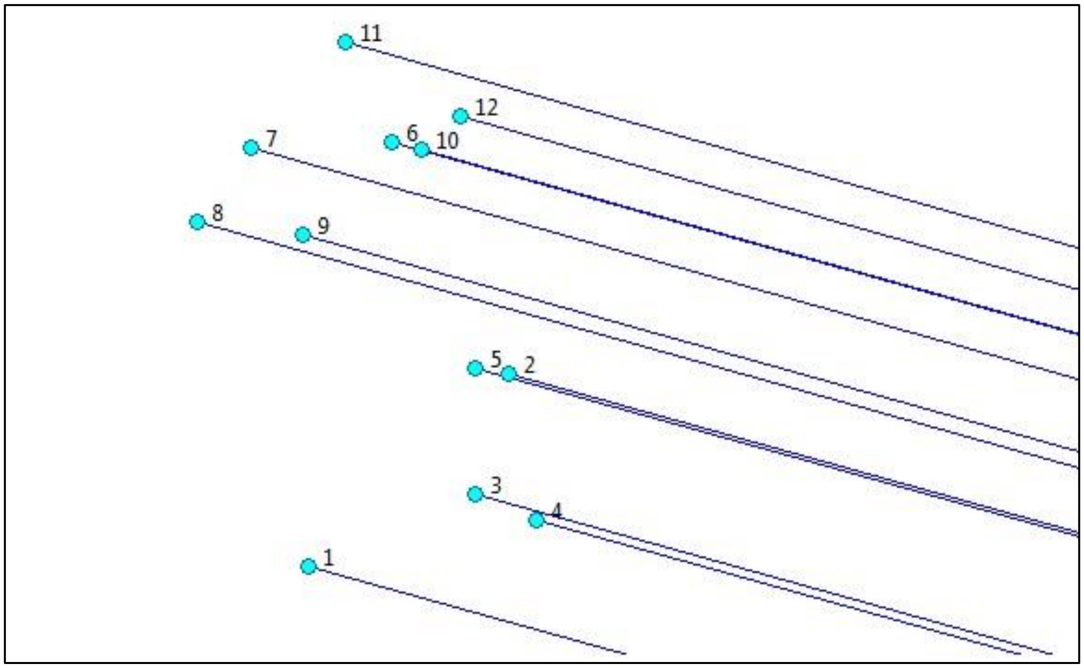

Figure 4.0.4: Data taken at point 1.

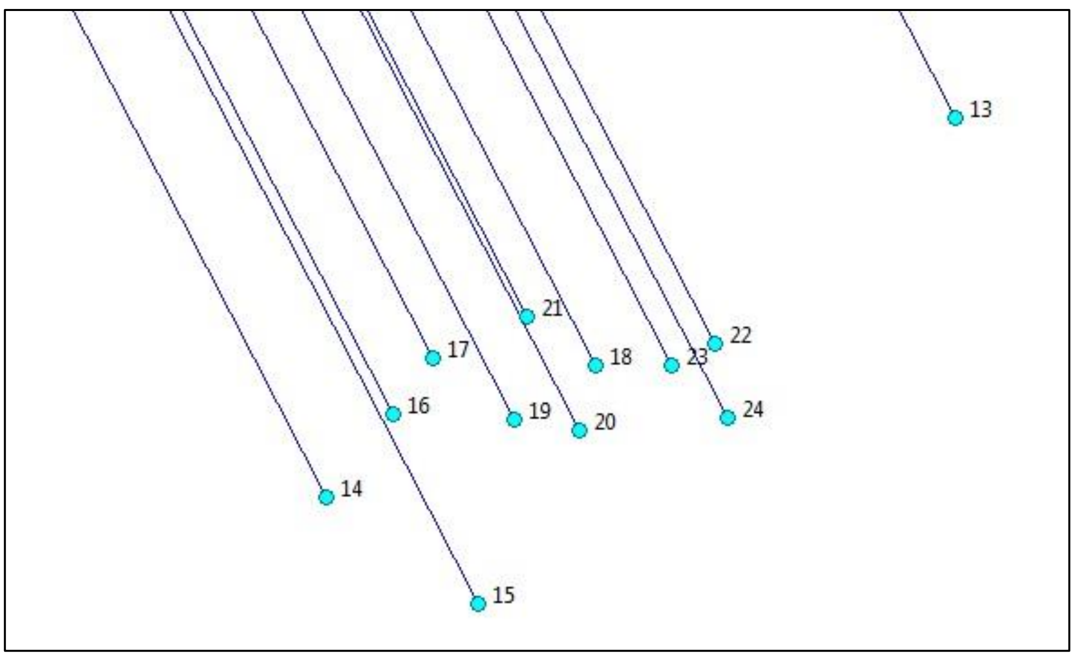

Figure 4.0.5: Data taken at point 2.

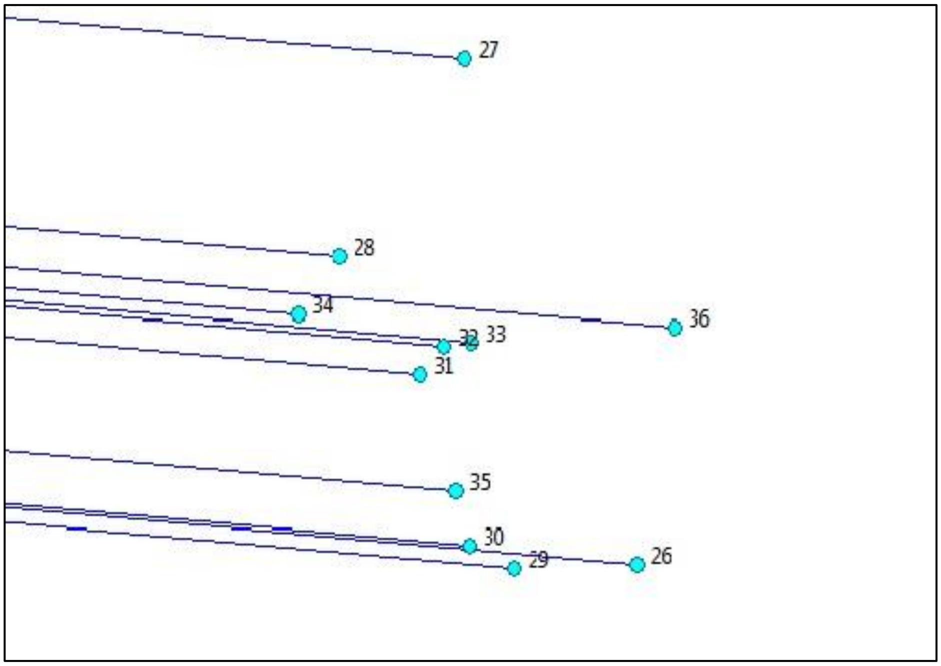

Figure 4.0.6: Data taken at point 3.

Below show the details of the data taken for all these three locations. The details include coordinate, northing, easting, and elevation.

	Point	North	East	Elevation					
Base		**485278.937**	**330248.482**	**46.288**		**Std Dev n (m)**	**Std Dev e (m)**	**Std Dev u (m)**	**Std Dev Hz (m)**
Point 1	1	485294.637	330191.764	46.141		0.003	0.005	0.006	0.008
57m	2	485294.72	330191.85	46.138		0.003	0.003	0.006	0.005
	3	485294.668	330191.835	46.143		0.003	0.003	0.007	0.004
	4	485294.658	330191.862	46.146		0.003	0.003	0.007	0.004
	5	485294.723	330191.835	46.14		0.004	0.003	0.006	0.005
	6	485294.821	330191.799	46.124		0.003	0.004	0.011	0.006
	7	485294.818	330191.738	46.119		0.003	0.005	0.008	0.006
	8	485294.786	330191.715	46.126		0.004	0.004	0.007	0.006
	9	485294.781	330191.761	46.145		0.003	0.005	0.006	0.005
	10	485294.817	330191.812	46.132		0.003	0.006	0.008	0.007
	11	485294.864	330191.779	46.114		0.003	0.004	0.007	0.005
	12	485294.832	330191.829	46.123		0.003	0.003	0.008	0.005
					average	0.003166667	0.004	0.00725	0.0055

Table 4.0.7: Details of data taken at point 1.

	Point	North	East	Elevation					
Base		**485278.937**	**330248.482**	**46.288**		**Std Dev n (m)**	**Std Dev e (m)**	**Std Dev u (m)**	**Std Dev Hz (m)**
Point 2	13	484695.376	330551.88	46.765		0.003	0.004	0.007	0.005
303m	14	484695.295	330551.745	46.766		0.003	0.003	0.007	0.005
	15	484695.272	330551.777	46.767		0.003	0.003	0.007	0.005
	16	484695.313	330551.759	46.768		0.004	0.003	0.007	0.005
	17	484695.325	330551.767	46.767		0.003	0.003	0.008	0.005
	18	484695.323	330551.802	46.768		0.005	0.004	0.007	0.006
	19	484695.311	330551.785	46.766		0.004	0.004	0.007	0.006
	20	484695.309	330551.799	46.771		0.003	0.003	0.007	0.005
	21	484695.334	330551.788	46.764		0.003	0.003	0.007	0.005
	22	484695.328	330551.828	46.766		0.003	0.004	0.008	0.005
	23	484695.323	330551.819	46.765		0.003	0.003	0.008	0.005
	24	484695.312	330551.831	46.766		0.003	0.004	0.008	0.005
					average	0.003333333	0.003416667	0.007333333	0.005166667

Table 4.0.8: Details of data taken at point 2.

	Point	North	East	Elevation					
Base		**485278.937**	**330248.482**	**46.288**		**Std Dev n (m)**	**Std Dev e (m)**	**Std Dev u (m)**	**Std Dev Hz (m)**
Point 3	25	485124.671	332116.859	32.24		0.004	0.005	0.009	0.006
1870m	26	485124.726	332117.18	32.238		0.005	0.006	0.01	0.008
	27	485124.828	332117.143	32.241		0.005	0.006	0.011	0.008
	28	485124.788	332117.115	32.246		0.004	0.006	0.011	0.007
	29	485124.725	332117.153	32.253		0.004	0.006	0.012	0.007
	30	485124.73	332117.144	32.248		0.005	0.006	0.013	0.008
	31	485124.764	332117.133	32.253		0.005	0.007	0.013	0.008
	32	485124.77	332117.138	32.244		0.004	0.005	0.013	0.006
	33	485124.771	332117.144	32.247		0.003	0.005	0.011	0.006
	34	485124.776	332117.106	32.241		0.004	0.006	0.014	0.007
	35	485124.74	332117.141	32.25		0.004	0.006	0.014	0.007
	36	485124.774	332117.188	32.248		0.004	0.006	0.015	0.007
					average	0.00425	0.005833333	0.012166667	0.007083333

Table 4.0.9: Details of data taken at point 3.

After these data are collected, accuracy and precision graph can be produced. Next page shows the graph of tabulation of data for each point. Also shows the accuracy and precision versus distance graph.

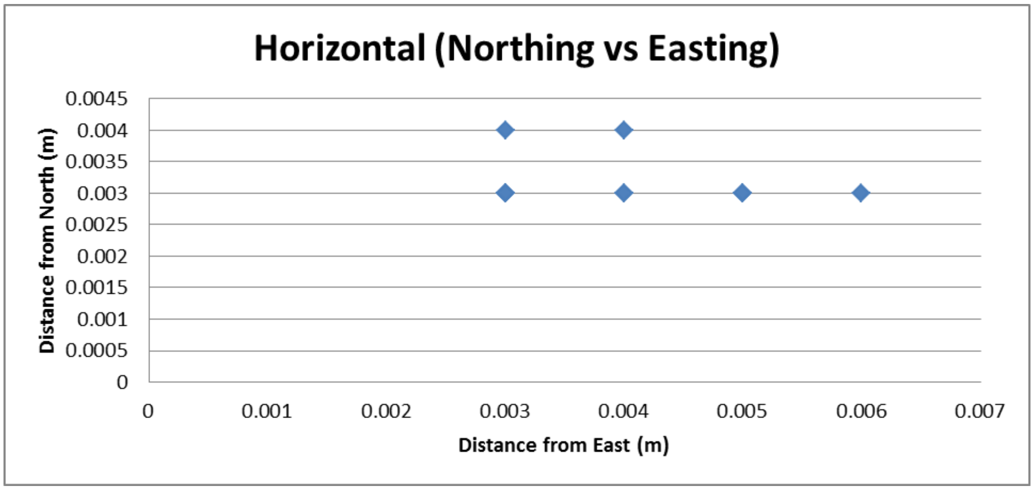

Figure 4.0.10(a): RTK GPS precision (Horizontal) at Point 1.

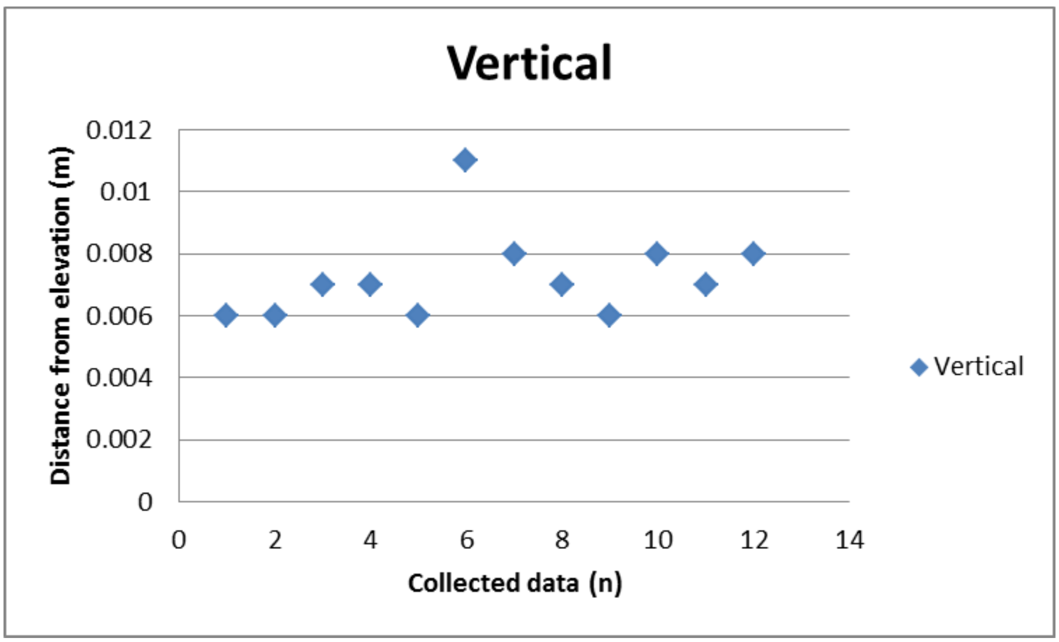

Figure 4.0.10(b): RTK GPS precision (Vertical) at Point 1.

Based on the figure 4.0.10(a), the maximum value for horizontal position drift is about 4mm for Northing and 6mm for Easting with an average drift 3.17mm for Northing and 4mm for Easting respectively. Besides that, the maximum value for height drift is 11mm with an average drift 7.25mm at figure 4.0.10(b).

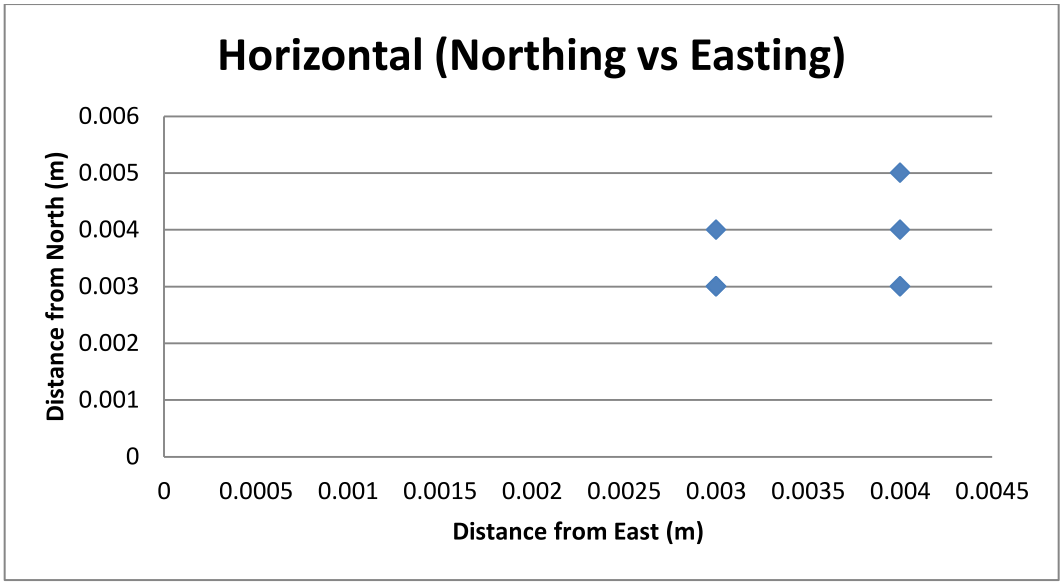

Figure 4.0.11(a): RTK GPS precision (Horizontal) at Point 2.

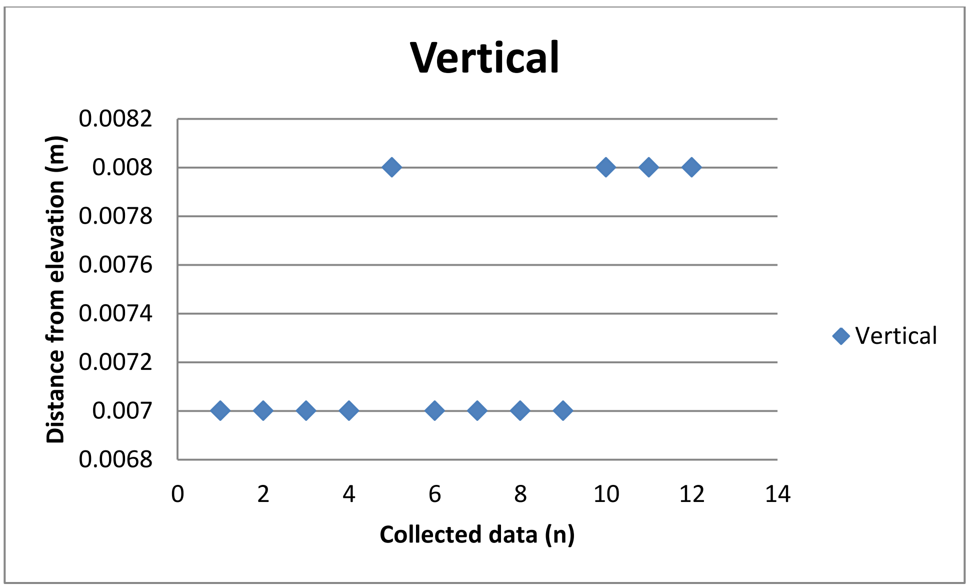

Figure 4.0.11(b): RTK GPS precision (Vertical) at Point 2.

Based on the figure 4.0.11(a), the maximum value for horizontal position drift is about 5mm for Northing and 4mm for Easting with an average drift 3.33mm for Northing and 3.42mm for Easting respectively. Besides that, the maximum value for height drift is 8mm with an average drift 7.33mm at figure 4.0.11(b).

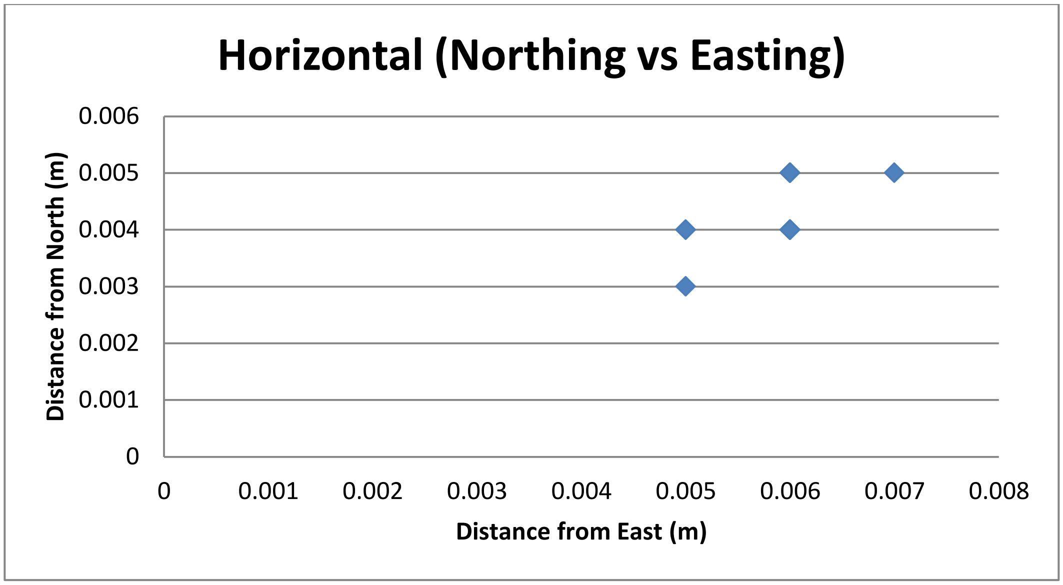

Figure 4.0.12(a): RTK GPS precision (Horizontal) at Point 3.

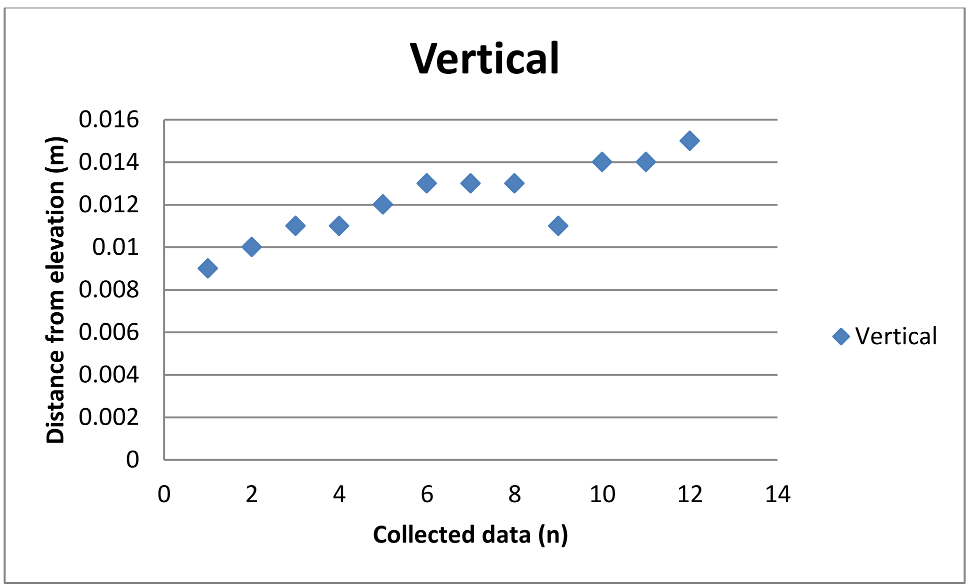

Figure 4.0.12(b): RTK GPS precision (Vertical) at Point 3.

Based on the figure 4.0.12(a), the maximum value for horizontal position drift is about 5mm for Northing and 7mm for Easting with an average drift 4.25mm for Northing and 5.83mm for Easting respectively. Besides that, the maximum value for height drift is 15mm with an average drift 12.17mm at figure 4.0.12(b). The overall results shows that the drift for height was big then the horizontal drift. The RTK GPS accuracy also determined where the accuracy was in centimeter level for every rover points.

Based on the results above, the accuracy of single-based RTK GPS is proved well fitted horizontally but not vertically with the manufacturer specification. Besides that, the expected distance- dependence biases are not produced as the distance between base and rover within 2.0km. This can be approved by analyzing the pattern of standard deviation graph as shown in figure below.

distance from base (m)	North	East	Elavation
57	0.003167	0.004	0.00725
303	0.003333	0.003417	0.007333
1870	0.00425	0.005833	0.012167

Table 4.0.13: Results reliability.

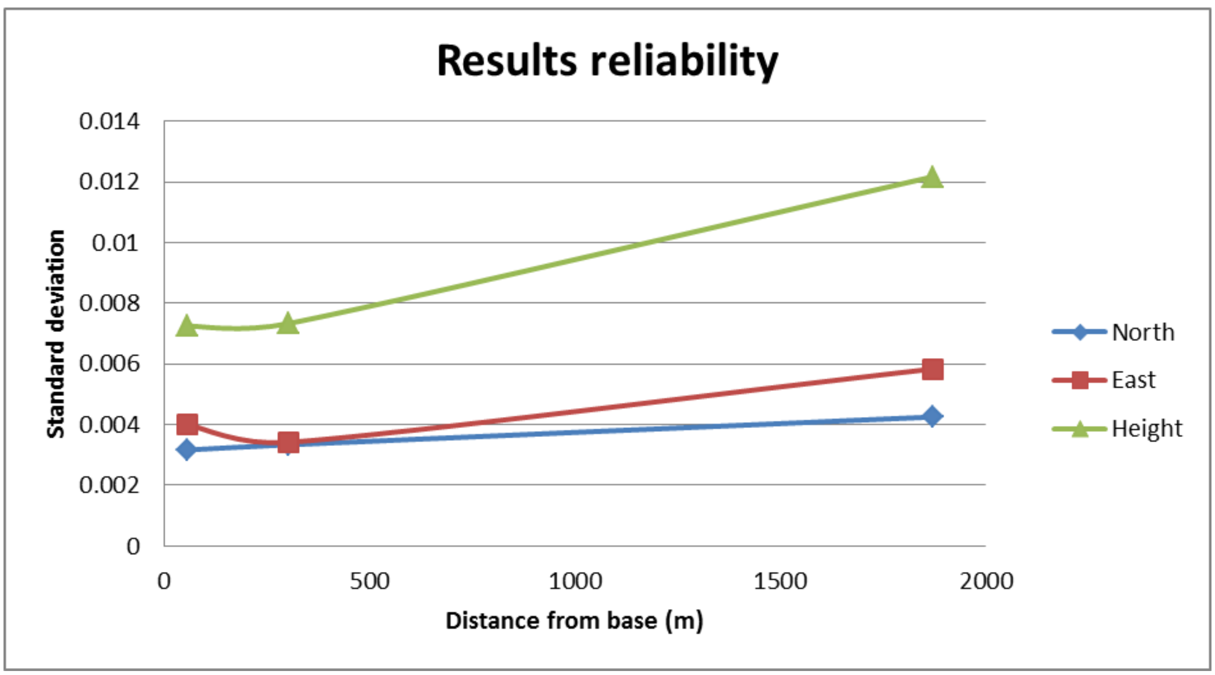

Figure 4.0.13: Results reliability of rover points.

The graph has shown uniformly increase as the distance of base station and rover point increase. This proved that the single-based RTK GPS is not affected by the distance-dependence biases as the range of baseline within 2km. Besides that, the possible random error expected has been occurred during the setup of the GPS instrument at the respective base station and rover points that result the uncertainty of reliable result of RTK GPS.

Figure below shows a graph of average precision for horizontal and vertical versus distance from base to rover.

distance from base (m)	Horizontal Precision (m)	Vertical Precision (m)
57	0.0055	0.00725
303	0.005166667	0.007333333
1870	0.007083333	0.012166667

Table 4.0.14(a): Precision versus distance.

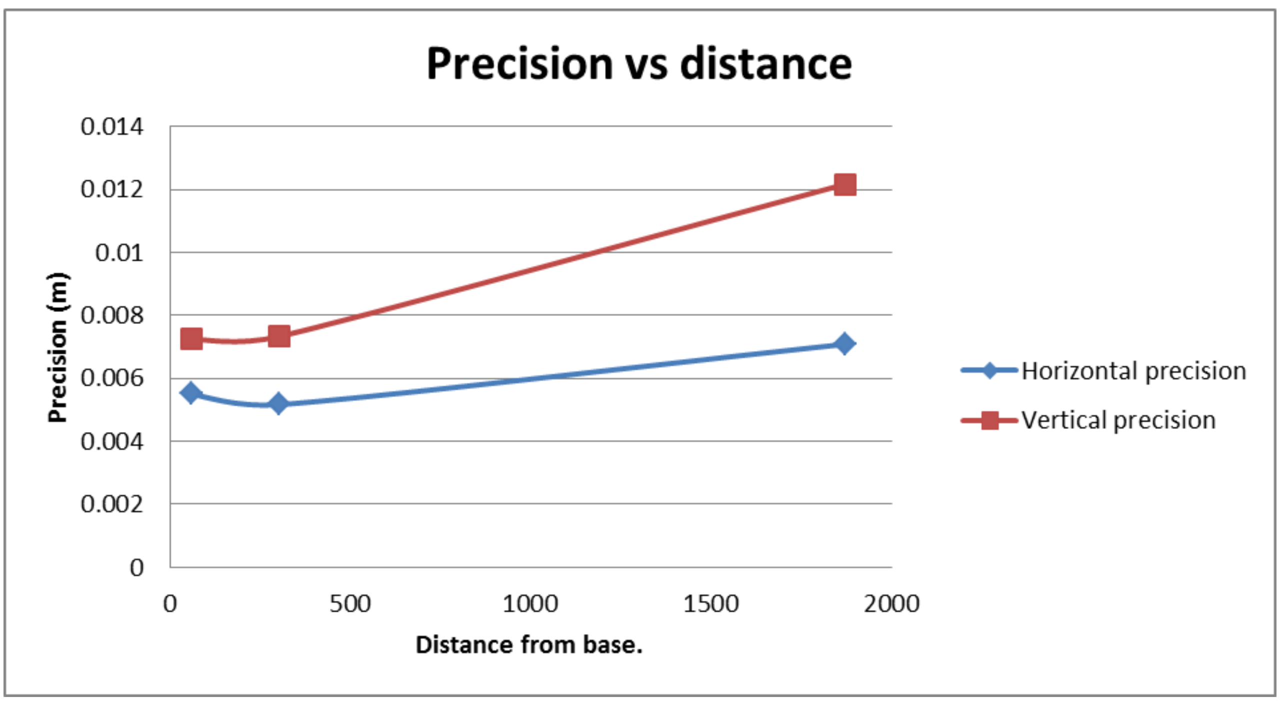

Figure 4.0.14(b): Graph of precision versus distance.

As stated earlier, RTK GPS RTK GPS is not affected by the distance-dependence biases as the range of baseline within 2km. so the precision of data taken is fully on the author's works. Data taken at third point has higher precision than data taken at first point. This may be due to hot weather and the author cannot fully concentrate taking the data to make them more precise.

As the distance from base to rover is further, the time taken for rover to be fixed is longer. This is because the low frequency used which is only 1Hz limits the distance. The longer the distance, the higher the resistance of the frequency, thus the longer the time rover needs to be fixed and has strong radio signal. Table and graph below show the proved of the hypothesis.

distance from base (m)	time rover to be fixed (s)
57	5
303	20
1870	240
2760	300

Table 4.0.14(a): Distance versus time rover need to be fixed.

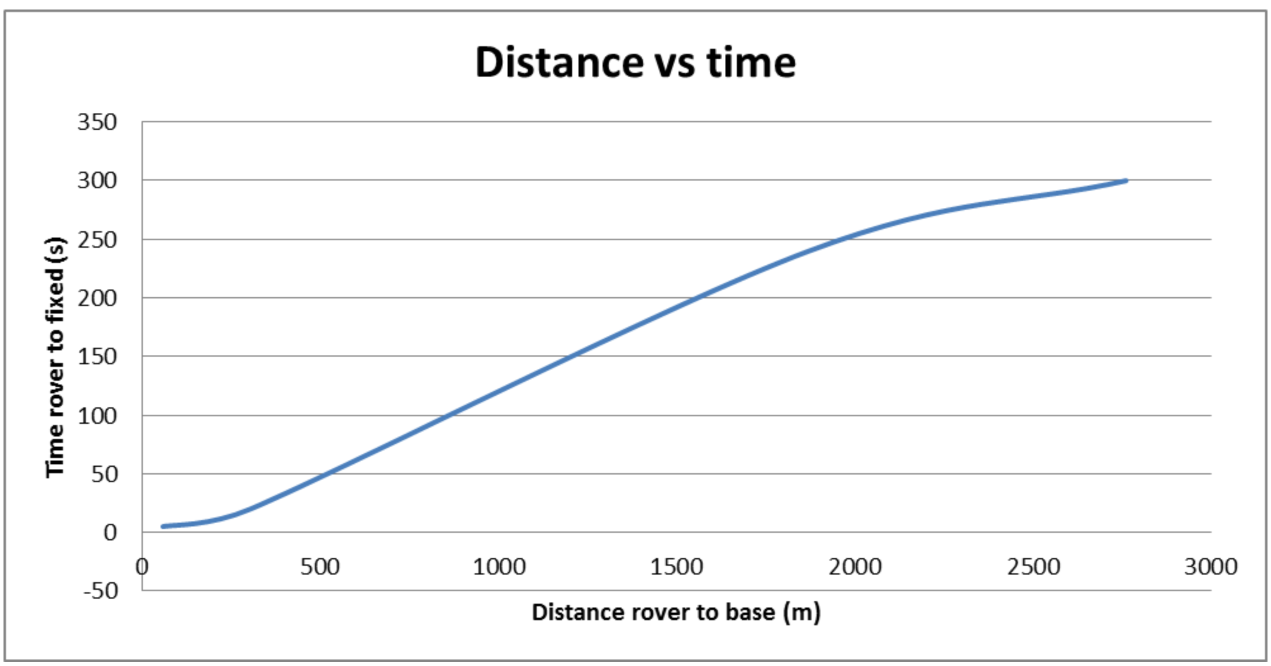

Figure 4.0.14(b): Graph of time rover need to be fixed versus distance.

Same also to the radio signal of the rover. The further the distance from base to the rover, the lower the radio signal. If the distance is much further until radio signal become 0%, the condition of the rover is not fixed anymore. Thus, data cannot be taken. Table and graph below show prove that the further the distance between base and rover, the lower the radio signal.

point	distance from base (m)	radio signal (%)	condition
Point 1 (parking at Pocket C)	57	100	fixed
Point 2 (bushes at Pocket C)	303	100	fixed
Point 3 (lake at front UTP)	1870	100	fixed
Point 4 (Balai Polis Daerah)	2330	100	fixed
Point 5 (Tesco Bandar Universiti)	2500	98	fixed
Point 6 (Petronas Taman Maju)	2760	95	fixed
Point 7 (Al-Ikhsan Jalan Parit)	2800	0	autonomys
Point 8 (Uitm Perak main gate)	3300	0	autonomys
Point 9 (SMKA Sultan Azlan Shah)	3970	0	autonomys

Table 4.0.15(a): Distance versus radio signal.

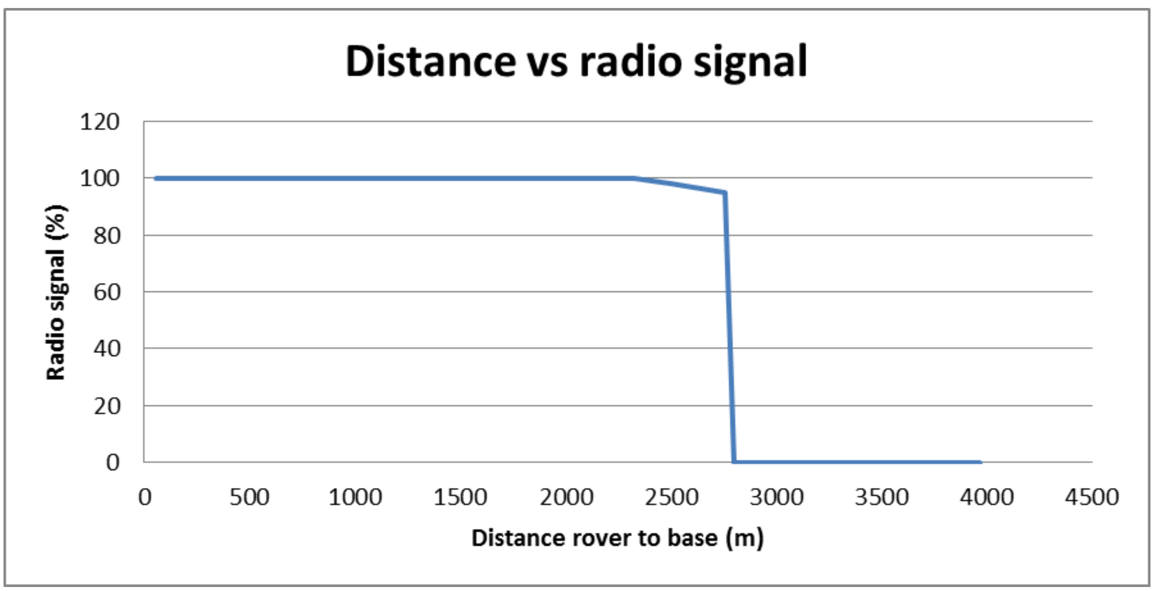

Figure 4.0.15(b): Radio signal versus distance.

During the completion of this project, the author found one major factor that can affect the performance of this RTK GPS, which is haze. During 20th July 2013, author was doing this project. The skies are clear. No haze at all. The air is good. The rover can go to maximum distance from the base which is 2.76km. Radio signal is easy to get strong and the condition of the rover is fixed at 2.76km from the base.

Then, author was doing the project again in 24th July 2013. During this day, there was haze. The air pollution index (API) showed high reading of haze. The maximum distance the rover can goes in the day is only 1.87km. The rover also needs a lot of time to be stable and get fixed. Figure below shows the API for 20th July and 24th July 2013.

20-07-2013 (Saturday) - 12:00PM - 05:00PM

» Bacaan Terkumpul Indeks Pencemaran Udara Accumulated Air Pollutant Index
» Maklumat Umum Indeks Pencemaran Udara General Info of Air Pollutant Index
» Guidelines for the Protection of Employees Against the Effects of Haze at Workplaces

Tarikh Lain / Other Date : | 06-08-2013 | 05-08-2013 | 04-08-2013 | 03-08-2013 | 02-08-2013 | 01-08-2013 | 31-07-2013 |

Julat Masa / Time Range : **[12:00AM - 05:00AM]** | **[06:00AM - 11:00AM]** | **[12:00PM - 05:00PM]** | **[06:00PM - 11:00PM]**

Paparan IPU dari **12:00PM hingga 05:00PM** pada 20-07-2013
Hourly API from **12:00PM to 05:00PM** on 20-07-2013

NEGERI / STATE	KAWASAN/AREA	MASA/TIME 12:00PM	MASA/TIME 01:00PM	MASA/TIME 02:00PM	MASA/TIME 03:00PM	MASA/TIME 04:00PM	MASA/TIME 05:00PM
Perak	Seri Manjung	60*	60*	61*	#	#	#

Figure 4.0.16: API for 20th July 2013.

24-07-2013 (Wednesday) - 12:00PM - 05:00PM

» Bacaan Terkumpul Indeks Pencemaran Udara Accumulated Air Pollutant Index
» Maklumat Umum Indeks Pencemaran Udara General Info of Air Pollutant Index
» Guidelines for the Protection of Employees Against the Effects of Haze at Workplaces

Tarikh Lain / Other Date : | 06-08-2013 | 05-08-2013 | 04-08-2013 | 03-08-2013 | 02-08-2013 | 01-08-2013 | 31-07-2013 |

Julat Masa / Time Range : **[12:00AM - 05:00AM]** | **[06:00AM - 11:00AM]** | **[12:00PM - 05:00PM]** | **[06:00PM - 11:00PM]**

Paparan IPU dari **12:00PM hingga 05:00PM** pada 24-07-2013
Hourly API from **12:00PM to 05:00PM** on 24-07-2013

NEGERI / STATE	KAWASAN/AREA	MASA/TIME 12:00PM	MASA/TIME 01:00PM	MASA/TIME 02:00PM	MASA/TIME 03:00PM	MASA/TIME 04:00PM	MASA/TIME 05:00PM
Perak	Seri Manjung	122*	122*	120*	119*	120*	120*

Figure 4.0.17: API for 24th July 2013.

The API shows unhealthy level for the area in 24th July 2013. Haze means the air is concentrated with unhealthy dust and particles. The low frequency used by RTK GPS showed that it is hard to penetrate through the haze air. The area of the project is at Seri Iskandar which is about 30km from Seri Manjung. The API shows the nearest location to Seri Iskandar. The author can conclude that the haze is major role for the performance of RTK GPS. The higher the API, the lower the performance of RTK GPS. Figure in next page showed the time taken by the author doing the project in 24th July 2013.

The green color shows time taken for the whole work. The time taken at base is about 2 hours. Usually, this work can be done within one hour and less. But during the 24th July 2013, there was haze. So the rover needs more time to be stable and fixed. Once it is stable and fixed, data can be taken. The short green color shows the time for the taken data. Each data taken is about 2 seconds. The gap between one location to another where the data are taken is the process of stabilizing and fixing the rover. The figure shows the long gap between second location and third location shows that the rover need a lot of time to be stable and fixed. This is because the distance rover from base is longer, compare with first and second point.

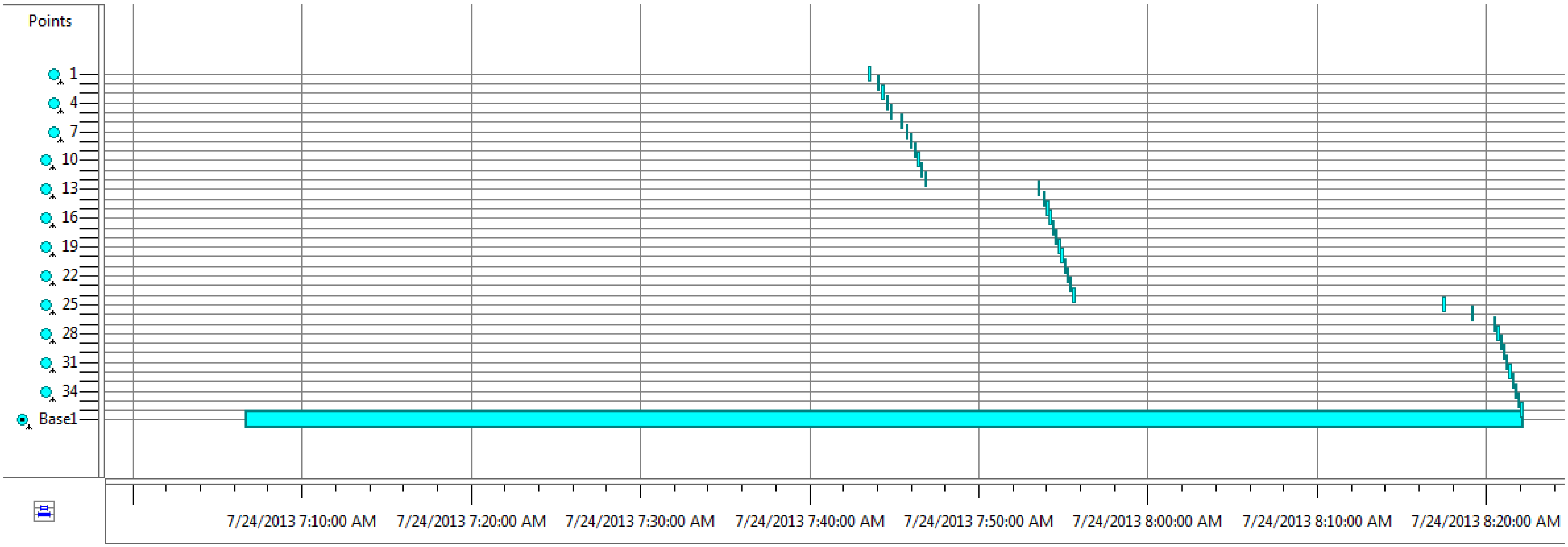

Figure 4.0.18: Time taken for the project work in 24th July 2013.

The other factor the author had discovered while doing this RTK GPS work, is the rover and the base need to be setup at a very open space. Which means the rover and the base must be clear and far away from tall building and trees. Or else the signal from satellite cannot penetrate through the building or trees to get to the rover and base. Thus, data cannot be taken. Figure 4.0.19 below shows the rover has been set up under a tree which is wrong place. The rover cannot achieve strong radio signal and it is not fixed. While figure 4.0.20 shows the rover has been set up at a field which is at a very open space. It is a wright place to set up the rover. The conclusion is rover needs to be set up at an open space so that the signal from satellite can get to the base and the rover, then data can be taken easily.

Figure 4.0.19: Rover under a tree.

Figure 4.0.20: Rover at a field.

The conclusion is RTK GPS single-based is not suitable for monitoring deformation of offshore platform or other buildings which are located more than 2km away from the base. So, how can we monitor the buildings but still using this RTK GPS?

4.1 INCREASING RADIO FREQUENCY

There are two other methods to solve the problem. The first solution is just by simply increasing the frequency of the radio wave. The higher the frequency, the longer distance base can receive signal from the rover.

Frequency allocations are governed by federal and international agencies such as Industry Canada in Canada, Federal Communications Commission (FCC) in the United States, and the International Telecommunication Union. (Michael K. Hogan, 2001). Frequencies available to be used for RTK applications include 150 to 174 MHz (VHF), 450 to 470 MHz (UHF), and Industrial, Scientific, and Medical (ISM) frequencies 902 to 928 MHz (Langley, 1998). In planning an RTK GPS survey, the user has little control over the frequency, but within the allocated frequency range a channel can be changed if there is interference. ((Michael K. Hogan, 2001).

Location variability has been shown to increase with frequency and terrain irregularity, but is not a function of T-R separation. (Parsons, 1992). Frequency and distribution of base points are essential to confirm suitability of Digital Terrain Model (DTM) to topography. (Ibrahim Yılmaz, Ibrahim Tiryakioglu, Fatih Taktak, et al, 2005).

4.2 USING NRTK GPS

What is NRTK GPS? NRTK GPS stands for Networking Real Time Kinematic Global Positioning System. It is a different way from single based RTK GPS. Network-based Real Time Kinematic (NRTK) GPS positioning is considered to be a superior solution compared to the conventional single reference station based Real Time Kinematic (RTK) GPS positioning technique whose accuracy is highly affected by the distance dependent errors such as satellite orbital and atmospheric biases. (Jose Aponte, Xiaolin Meng, Chris Hill, et al, 2009). From this quotation, NRTK GPS can be one of the best solutions to solve distance limitation for RTK GPS. NRTK GPS can be used for much longer distance from single based RTK GPS.

NRTK GPS positioning uses raw measurements gathered from a network of Continuously Operating Reference Stations (CORS) in order to generate more reliable error models that can mitigate the distance dependent errors within the area covered by the CORS. This technique has been developed and tested considerably during recent years and the overall performance in terms of achievable accuracies, reliability and mobility is as good as or even better than can be achieved using the conventional RTK GPS positioning technique. (Jose Aponte, Xiaolin Meng, Chris Hill, et al, 2009). NRTK GPS positioning overcomes the drawbacks of RTK GPS and increases the GPS positioning accuracy by accurately modelling the distance dependent errors at the rover position using the raw measurements of an array of CORS surrounding the rover site. (Wanninger 2004).

How this network RTK GPS works? In Malaysia, there are many references stations located in each state. This system is controlled by Jabatan Ukur Dan Pemetaan Malaysia (JUPEM). This system also used internet connection and multi references stations. That’s why the distance between base and receiver can be much longer that using single based RTK GPS which using only radio wave and single reference station.

N-RTK is a carrier phase-based positioning technique that combines measurements from multiple reference stations and thus generates “network corrections” that can be applied to extended baseline lengths. The implementation of N-RTK requires a network of permanent receiver stations, known as “Continuously Operating Reference Station” (CORS), communication links for data streaming and correction broadcast, and a processing center (i.e. control center). In summary, GPS measurements are recorded at the CORSs and streamed to the control center via Internet links. Data gathered at the control center are processed to model distance dependent errors, generate N-RTK corrections, which are then delivered to users. (N. S. M. Shariff, T. A. Musa, S. Ses, et al, 2008). The network-based RTK positioning technique can be realized by establishing at least three CORS. One of the reference stations can be treated as the 'master station', that is usually selected as the nearest to the roving user receiver (Musa, 2007).

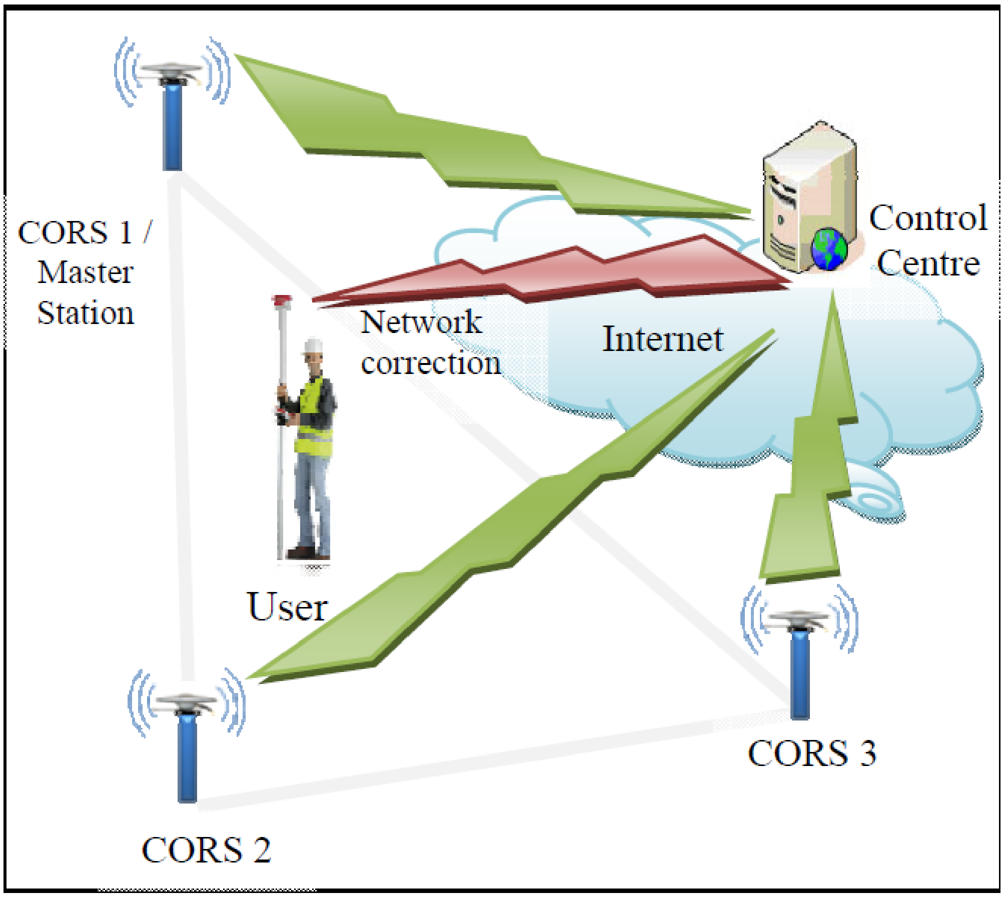

Figure 4.2.1: The architecture of NRTK GPS positioning. (N. S. M. Shariff, T. A. Musa, S. Ses, et al, 2008)

Since 1997, JUPEM has been developing the capability for real-time data streaming from a network of continuously operating reference stations. Currently there are 78 stations, with spacing of between 30 to 120 km, providing real-time corrections with a latency of less than one second using Virtual Reference Station (VRS) technique. Each station of the network is equipped with a high precision dual frequency GPS receiver that is operational 24 hours daily. The acquired GPS data is transferred on a daily basis to the Central Processing Centre at JUPEM's Headquarters in Kuala Lumpur via the internet. This network is known as the Malaysia Real-Time Kinematic GNSS Network or MyRTKnet. (Jamil. H, 2010).

JUPEM has implemented a real-time kinematic network project that is known as Malaysia Real-Time Kinematic GNSS Network (MyRTKnet) in 2003. The system then has total 29 RTK stations forming all over Malaysia. There are 27 RTK stations forming the network which covers the whole Peninsular Malaysia and two major cities in Sabah and Sarawak.

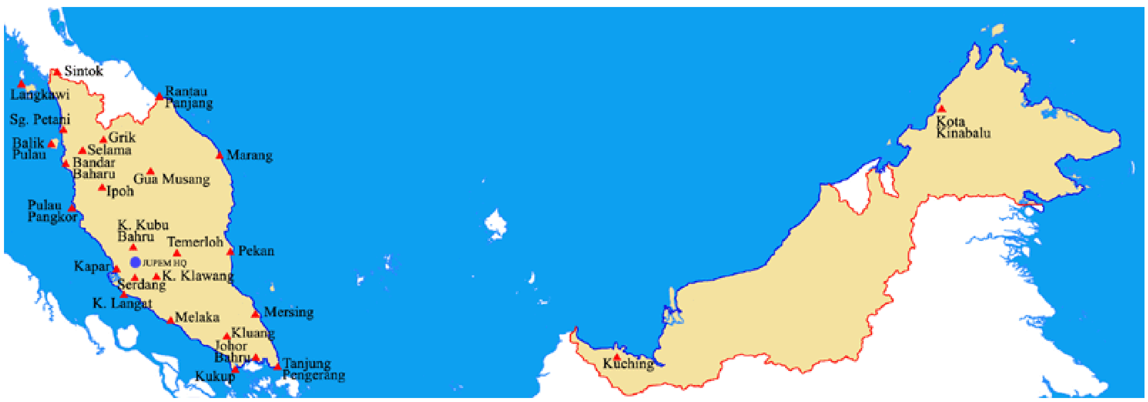

Figure 4.2.2: RTK stations. (Jamil. H, 2010).

CHAPTER 5

CONCLUSION AND RECOMMENDATION

The conclusion is the objectives of this project has been achieved which is to find the maximum distance of RTK GPS using single based, to study about the accuracy and precision of the RTK GPS data, to study time taken for collecting data in varies distance, and to find other factor that contribute to the performance of RTK GPS. So, to monitor the offshore platform which is located at the middle of the sea, using single based RTK GPS is not suitable. For the time being, the author find only two ways to extend the baseline, which is increasing the frequency of the single based RTK GPS and using Network RTK GPS (NRTK GPS) which has many base and it is using internet frequency. So, these two methods seem to be the solution of short baseline if using single based RTK GPS. In other word, if we want to monitor movement of the offshore platform, single based RTK GPS is not very suitable because it has very short baseline and the frequency used is not enough.

The communication signal between base station and rover is well works within 2 kilometers rage. This is very important aspect to be concern as the correction signal sent to the rover from base station to correct coordinate or value produced at rover point. Besides that, this project successfully determines the expected error such as distance dependent biases to be occurred within 2 kilometers by using single-based RTK GPS surveying method. At the end of the study, the distance-dependence biases such as ionosphere and tropospheric error conclude not governed as the error produced within 2 kilometers. Therefore, the surveying method could produce the precise and reliable coordinate as the correction value is the same.

As the conclusion, single-based RTK GPS is capable to provide a reliable and precise data up to centimeter level accuracy for deformation of any buildings within 2 kilometers baseline between base station and rover receiver.

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