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Effect of Time Interval Variations on Network RTK in a High Multipath Environment

James McDonnell – 0061011923

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Abstract

The research aim for this project was to investigate the effect of time interval variations on Network RTK in a high multipath environment. Meaning does the time in between observing each point at the end of a line using Network RTK GNSS effect the accuracy of the calculated distance between the two points. And how is the relationship of time and accuracy affected when introduced to a high multipath environment. Finally, how can these determined accuracies for horizontal distance measurement be applied to survey regulation accuracy for cadastral surveys of 10mm + 50ppm stated in the CSR.

The analysis looked at two different datasets. First a dataset captured over a 12-hour period free from the effects of multipath. And secondly a dataset captured over a 12-hour period with the effect of multipath present. The analysis calculations used the Zero Distance Method and utilized two different time intervals firstly a 30-minute window and second a 5-minute window.

The key findings from the research found that using the shorter time lapse window of 5-minutes produced a calculated distance with high accuracy over the 30-minute time lapse window. The was found for both the multipath free and multipath present datasets. These results successfully achieved the research aim and aligned with previous research.

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Name: **James Peter McDonnell**

Student Number: **0061011923**

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Table of Contents

List of Figures

Chapter 1 – Introduction

Real-Time Kinematic (RTK) Global Navigation Satellite Systems (GNSS) has been a tool used by surveyors for over 20 years. Since its inception the technology and applied uses have changed dramatically over time. In recent years the introduction of more satellites to the GNSS constellations and a more reliable and increased availability of Continuously Operating Reference Stations (CORS) in Australia has made RTK GNSS a tool surveyors choose to use more often over traditional survey methods. Most populated areas in Australia are now serviced by a Global System for Mobile Communication (GSM) and coverage by CORS Networks for survey grade RTK GNSS solutions has made GNSS based surveying even more appealing. For a surveyor to simply turn on their GNSS receiver connect to a CORS Network via a GSM connection and begin taking measurements and achieve the required accuracy improves field efficiencies and removes technical problems when a RTK Base needs to be established on site. With this RTK surveying system becoming a common tool for surveyors undertaking many tasks such as Engineering and Construction Surveying, residential allotment staking and measuring distances in some Cadastral Surveying applications greater understanding is needed of the environmental errors that can adhere to this ease of use measuring system.

RTK GNSS is a complex system with numerous variables that can affect the calculated position of the rover. Receiving a network solution from a CORS Network can remove many possible site specific errors from one half of the RTK system. However, site specific errors surrounding the rover end of the system will still have substantial impacts on the calculated rover position. Multipath being one of the common site specific errors affecting both Single Base and Network RTK GNSS systems it is important to understand this form of error before undertaking any type of survey-level GNSS operations. Multipath occurs when the signal read by the GNSS receiver is reflected off something around the receiver such as a building or vehicle before it reaches the receiver. Because this reflected signal has travelled further than it really should have to reach the receiver a miscalculation of the observed position may occur.

The current Queensland Cadastral Survey Requirements (CSR) states that when taking RTK GNSS observations a minimum of 30 minutes should elapse before re-observing the same point for the purpose of deriving a distance (Spatial Policy of Department of Natural Resources and Mines 2015). With this requirement being a blanket requirement over all RTK GNSS surveying systems e.g. Single Base, Single Base via CORS and Network RTK via CORS it is not taking into account error reductions when using a Network RTK system. Greater understanding of the nature of Network RTK systems by the surveyor is needed to clearly identify the error budget for observations when Multipath is present and when is not and how this error budget evolves when lapse in time between observations also known as temporal change is introduced. With this type of analysis using temporal change as the variable, the survey requirements mentioned above will determine if necessary when using a Network RTK system. Of course the CSR is in place for real world survey conditions meaning a true laboratory style scientific test where all other variables are removed cannot be used as a comparative analysis of the CSR purpose.

With numerous research already conducted into the world of RTK GNSS Surveying and Cadastral Surveying involving RTK GNSS in Australia, a gap has been identified in the literature review below where further research is needed on how Network RTK surveying systems fits into that world and if it can be treated differently to the other more traditional RTK systems. The main questions that do arise are that is it affected by temporal change and multipath in the same way as other RTK systems and do the survey requirements established for RTK GNSS surveying really apply to the Network RTK Surveying System.

1.2 Problem Statement

This research directly follows on from (Bein 2015) research which only looked at temporal change with no site specific errors introduced by creating almost laboratory type conditions to analyse the variable of time on RTK GNSS observations. With (Bein 2015) conclusions restricted to these laboratory, non real-world conditions, further research is needed to extend this research to include real-world site-specific errors.

Multipath is one of the major potential site specific errors associated with RTK GNSS observations and detection of this observational error is difficult without redundant observations. Relying on temporal change to detect the error if the Multipath source is still present at the time of the second occupation is where the problem has developed. Using a Network RTK GNSS system to capture the Multipath affected observations removes some potential environmental and systematic errors by introducing redundancy into the calculated correction solution. Therefore, more onus is put back onto the GNSS receiver being used where the observation is taking place.

The RTK GNSS system is a passive system and can only calculate its position using the information it receives from the continuously changing satellite constellations. Using the algorithms on board the receiver it does its best to calculate its position using only that information and estimates its accuracy from that information as well. The algorithms estimating position and accuracy are calculated and the dataset and statistical information is continuously recalculating and can be record at set time interval for instance recorded every second known as an Epoch. Averaging these epochs together over a certain period of time depending on the required accuracy of the observation will greatly improve the accuracy of the calculated position and remove any prominent outliers from the calculation. The on-board algorithms calculate the best fit solution no matter what the data set contains. Meaning if multiple Epochs in the data set have been affect by site specific error they may not be deemed as outliers and not removed from the positional calculation. This solution of removing outliers and having the possibility of including data with error when grouping epochs is the best method for when actually conducting a RTK GNSS survey because the whole point of the system is needing no post processing.

For the application of data analysis when Multipath is present each epoch needs to be considered in its entirety when averaging the observations. Therefore averaging and analysing the single epochs collected post capture rather than relying on the data collector to find its own best fit and manipulating the raw data in the process will affect the results of the analysis. Even though this is not what would happen when conducting a real RTK GNSS survey it will better map the effect of multipath for this research.

It is widely known that to detect if an observation has been affected by the site specific error of Multipath additional observations must be taken after a certain time period so that the constellation of the satellites has changed creating a redundancy in the observation system because not all errors can be detected at the time of first observation which is why the variable of time is introduced.

With Network RTK becoming the common type of RTK system used by surveyors over single base setup it only makes sense to apply the multipath research to the Network RTK system. Therefore, the key problem being addressed in this research is as follows. Does time interval variations effect Network RTK observations in a high multipath environment?

The broad objectives from the research when trying to address the problem statement are as follows.

- Are there any affects to Network RTK GNSS observations when analysed against temporal change?
- Are there any affects to Network RTK GNSS observations when analysed against temporal change when Multipath is introduced?
- How will the well-documented expected accuracies differ when Multipath is introduced?
- Will the analysis align with current recommended RTK GNSS Survey methods?

1.3 Research Aim

To investigate the effect time interval variations have on Network RTK in a high multipath environment.

1.4 Research Justification & Motivation

There is a gap in research surrounding Network RTK GNSS and Multipath analysis. With Network RTK GNSS being one of the latest technological advances in the GNSS surveying industry and having a high adoption rate due to low upfront costs and improved efficiencies any further research surrounding this technology would be of great interest to the surveying community. With Multipath being the most common error occurring when conducting GNSS surveying tasks, any further research to analyse and map its occurrence when using Network RTK GNSS would give a better understanding of the random type of error to the surveying community.

My own motivation for this research beyond being a mandatory requirement for me to successfully complete my Bachelor Degree in Spatial Science Honours first came about after being in the audience of an undergraduate research project presentation at the University of Southern Queensland in September 2015. Their research on the "Effect of Time Interval Variations on RTK Derived Distances" and their suggestions of further research interested myself to explore this topic of time variations when conductions RTK GNSS surveys which has evolved to my research topic of this dissertation.

1.5 Research Method

To address both the aim and objectives of the research project the methodology of the data capture and analysis must take into account a few GNSS surveying factors such as satellite constellation orbits as well as a well-considered out data management plan. The following is a broad outline of how the research will be undertaken, a more in depth description of the methodology can be found in Chapter 3.

- Conduct 12 hours of observations with no Multipath present.

- Conduct 12 hours of observations with Multipath present setup over same mark used in Multipath-free observations.
- Export observed data as a text format that includes X, Y, Z, Time, Number of Satellites, Horizontal Accuracy and Dilution of Precision and which can be imported into Microsoft Excel for data analysis.
- Using the data set with no Multipath a mean of all those observations will determine the true position of the observed point.
- Split data up into 60 second observations and average each set into one dataset which aligns with minimum survey standards.
- Compare and analyse individual datasets against each other at varied time intervals.

1.6 Summary

Chapter 1 gave a brief outline of the background information for this research topic thus setting the reader up for a better understanding of the problem statement of this research. It gave background information on Network RTK, multipath and survey regulations. And touched on where this research follows on from previous research in the subject area of time interval variations when observing and calculating distances using RTK GNSS. From that the research aim was established, and the justification and motivation was outlined. Following that a brief outline of the methodology was described.

Chapter 2 will consist of a literature review and further background information to give the reader a better understanding of the research topic. It will give an in depth review of Network RTK and Multipath as well as an outline of previous research and survey regulations. And finally describe to the audience the gap in research and then need for the chosen topic.

Chapter 2 – Literature Review

2.1 Introduction

The following literature review and analysis is necessary to gain a broader understanding of the research topic, fulfilling the research objectives and identifies the current gap of knowledge surrounding Network RTK and Multipath. The literature will review the principles of Network RTK GNSS and outline a brief history. The principles and occurrence of Multipath in relation to RTK GNSS systems will be explored. The survey standards and guidelines will be discussed to give a further insight and how they relate to this research project. And finally a review of previous research project from 2015 will be conducted to discuss his findings and how his research was conducted. It also must be noted that after completing the literature review it has been determined that numerous studies have been completed surround the accuracy and precision of RTK GNSS but little equivalent research can be found in relation to Multipath and its effects of Network RTK GNSS therefore reducing the literature review into the exact research topic and identifying the gap of recorded knowledge.

2.2 Network RTK GNSS

The principle of Real-Time Kinematic (RTK) Global Navigation Satellite System (GNSS) is very similar to conventional GNSS. A conventional GNSS calculates the position of the receiver purely from the signals received from the satellites. The receiver receives as many satellite signals it can from the available satellite constellation above and calculates its position using algorithms pre-set in the receiver. This method has an accuracy of approximately 10m (Kaplan & Hegarty 2006) and is widely used around the world for navigation. The reason the receiver can only calculate a positional accuracy to only 10m is due to the errors in the satellite signals which are created from satellite clock errors and the signal traveling through the atmosphere which can distort the signal.

To improve the accuracy to a centimetre accuracy, survey grade GNSS receivers use the phase observable component of the satellite signal. The signal is still affected by errors created from the atmosphere thus a correction from this error must be included in the receiver's algorithms. The method of using the phase observable signal and calculating the error and transferring that correction to the receiver is known as Real-Time Kinematic (RTK). The correction is calculated from a single base receiver or multiple base stations know as a network correction. The base receiver is stationary and is usually setup over a known geodetic coordinated point. The base receiver receives the satellite signals just like the rover but because the true position of the base receiver is known the signal correction can be calculated. This calculated correction must now be transferred to the mobile receiver also known as a rover in real time for its accuracy to improve. The two most common ways for the correction to be transferred to the rover is by radio link or via the internet. However, the accuracy does begin to fade once the rover is further than 20km away from the base station, this is one major limitation of using a single base for corrections rather than a network solution. Figure 1 below demonstrates the basic system of RTK GNSS.

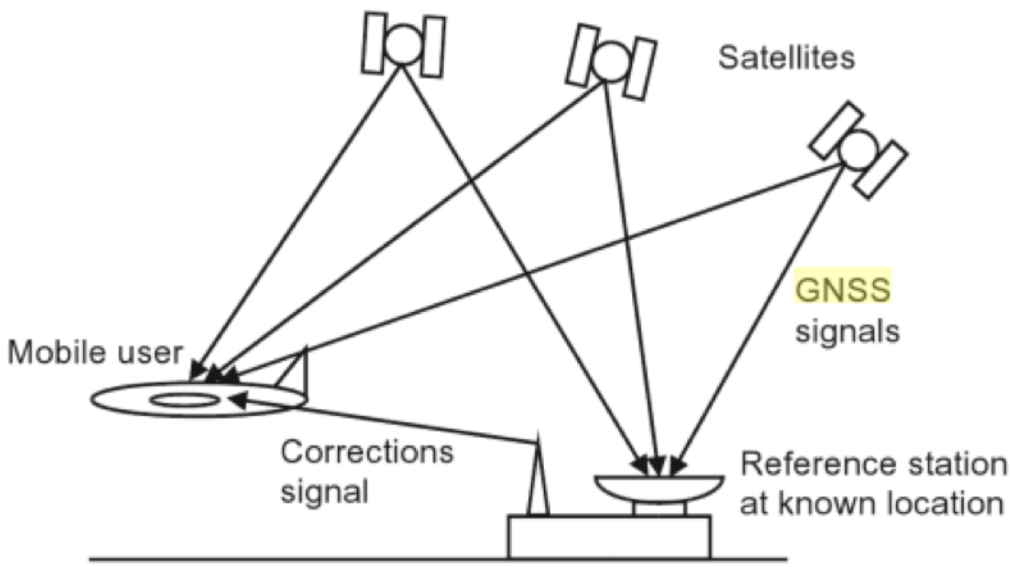

Figure 1: RTK GNSS Diagram
Source: (Groves 2013)

Network RTK is similar in many ways to Single Base RTK however the correction solution is calculated from multiple Continuously Operating Reference Stations (CORS) creating redundancy in the correction solution. A CORS system is comprised of four major elements including the reference stations themselves, a data processing centre, data communication system and the user connected to the system via the communication system (Wang & Hu 2013). When a rover is connected to a CORS system usually via an internet connection to the networks computer server which manages all of the CORS in its service. The server receives real time data from all the reference stations and calculates the best correction solution depending on where the rover is located to the nearby reference stations. Figure 2 below is a diagram of how all the Reference Stations, Server, Satellites and Rover all interact in a Network RTK system.

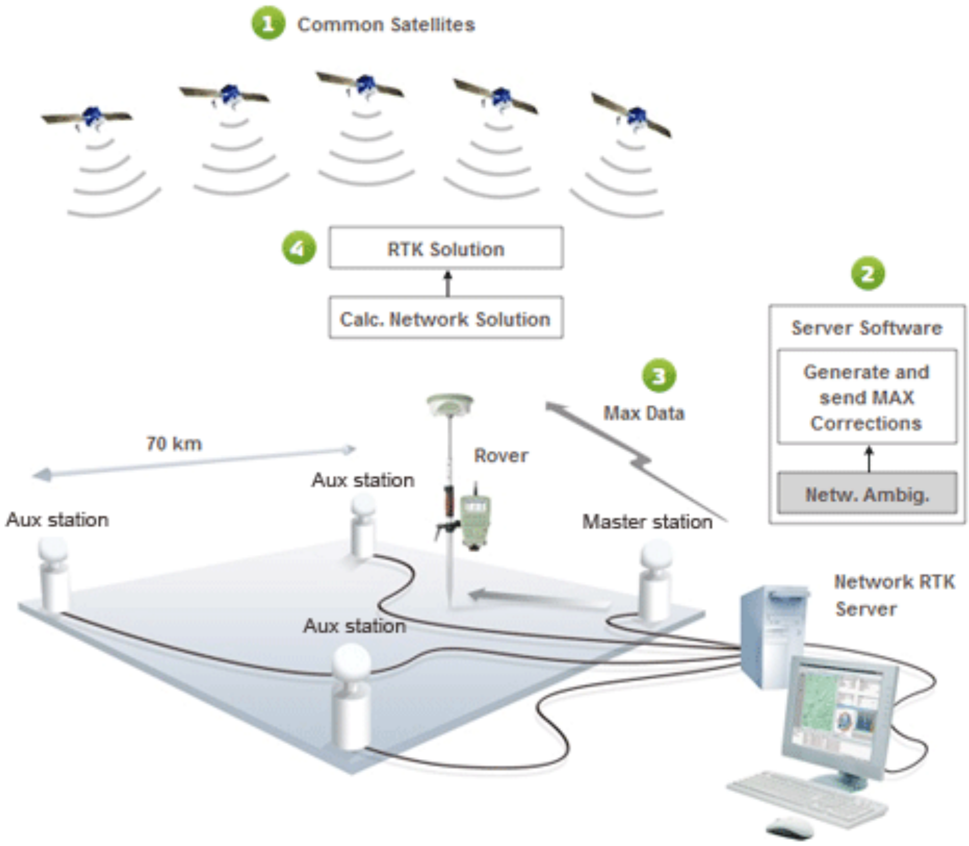

Figure 2: Network RTK Diagram
Source: (SmartNet Aus 2016d)

Depending on the rover being used there are different options of how the Network RTK solution is received and used in the position calculation. The main two are i-MAX and Virtual Reference Station (VRS). The main difference between the two is that i-MAX uses a real reference station and therefor has a traceable baseline and VRS uses a virtual point (SmartNet Aus 2016c). Both of these methods are compatible with the RTCM (Radio Technical Commission for Maritime Services) format and is usually transported via NTRIP (Networked Transport of RTCM via Internet Protocol) (Garrido et al. 2011).

The main advantages of using a Network RTK solution are not only because it is cost effective and efficient it also creates a more reliable observation in the field. By using the network solution, it provides a more consistent result and reduces distance dependant errors (SmartNet Aus 2016b). It improves rover coverage, greater reliability, more homogenous accuracy and faster times to fix ambiguities (Garrido et al. 2011)

In Australia there are numerous CORS Networks offering Network RTK solutions for GNSS receiver, either being run by government or private entities. Some notable government run CORS Networks are CORSnet-NSW, AuScope Geospatial and Vicmap Position – GPSnet which its dense network spans the entire state of Victoria (Gowans 2010). The major private offerings are Checkpoint, Trimble VRS and SmartNet Aus which now has a presence in most populated areas in Australia. SmartNet Aus have been able to cover a majority of these areas which are continually growing by not owning the Reference Station infrastructure but collect data from infrastructure owned by government and private owners (Gowans 2010). Figure 3 below is SmartNet Aus' coverage map in South East Queensland.

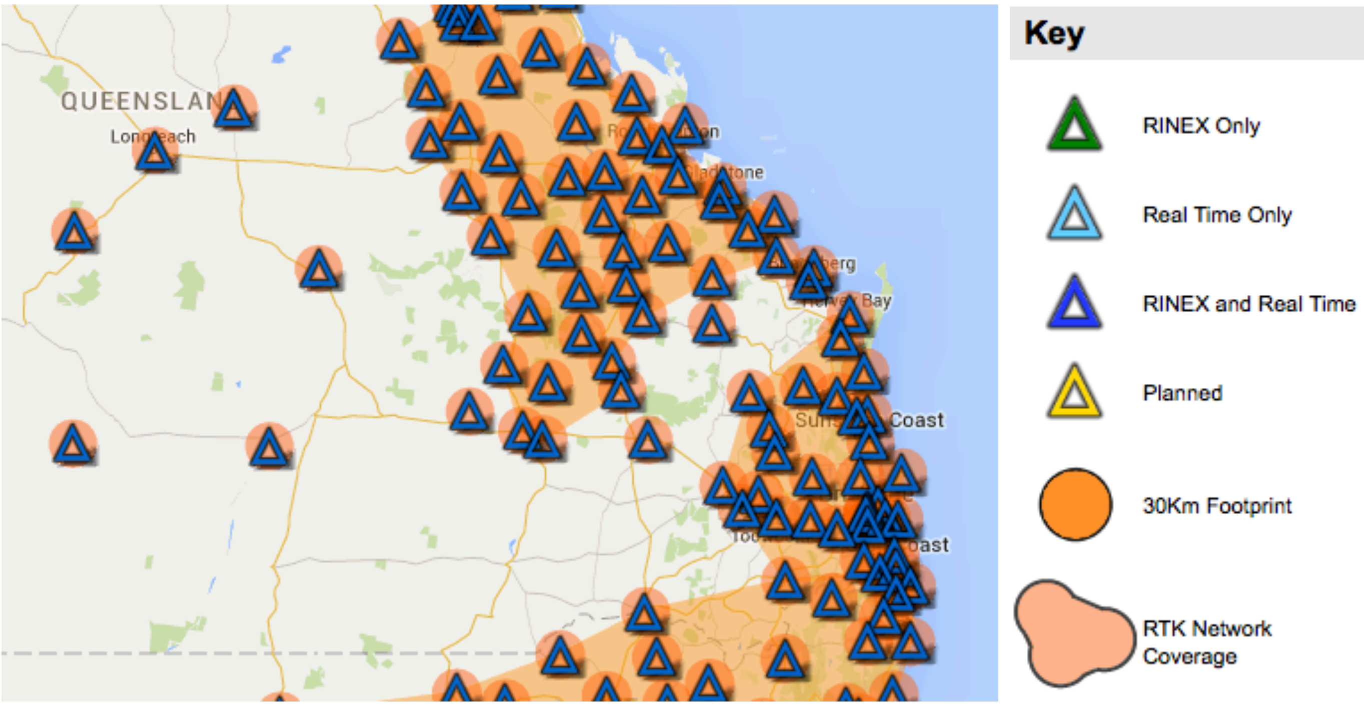

Figure 3: SmartNet Aus SEQ Coverage Map
Source: (SmartNet Aus 2016a)

2.3 Multipath

Multipath is a transmission error that is not only found in GNSS. It is defined as one or more signals arriving at the antenna by indirect paths (Bilich & Larson 2007). In GNSS the signal sent from the satellite which is received by the antenna on the rover can be reflected or distorted by something on the earth's surface before it reaches the rovers antenna. By the signal taking an indirect path to the rover creating a miscalculation and an error in the true position of the rover. The signal from the satellite can be reflected or distorted off a range of things in the environment around the rover such as buildings, vehicles, trees, water, traffic signs and topography. There are two main types of Multipath which are Specular and Diffuse. Specular Multipath occurs when the signal reflects off a smooth surface before reaching the antenna, while the signals message is maintained the time of flight has increased creating a miscalculation in position. Diffuse Multipath occurs when the satellite signal reflects off a rough surface and scatters the signal in multiple directions. This type of Multipath if scattered enough can make the signal unreadable by the antenna and therefor the rover is unable to calculate a position.

Multipath is one of the major errors involved with RTK GNSS and it is difficult to control, predict, detect and remove. Therefore, a surveyors best practice is avoidance of high multipath environments and make redundant observations to help detect if Multipath is present. In newer receivers the algorithms and hardware have become more advanced to try to avoid and remove Multipath affected signals in real time. However, these features are not fool proof and are only there to help minimize the occurrence. It should also be noted that Multipath can not only affect the rover in RTK GNSS but it can also affect the base receiver used to calculate signal corrections if placed in the wrong environment, meaning if the base has been affected by Multipath it can create an incorrect signal correction for the rover. Figure 4 demonstrates the difference between reflected signals (Multipath) and unreflected signals. The reflected signals taking an indirect path to the receiver and creating an error in the calculated position of the receiver.

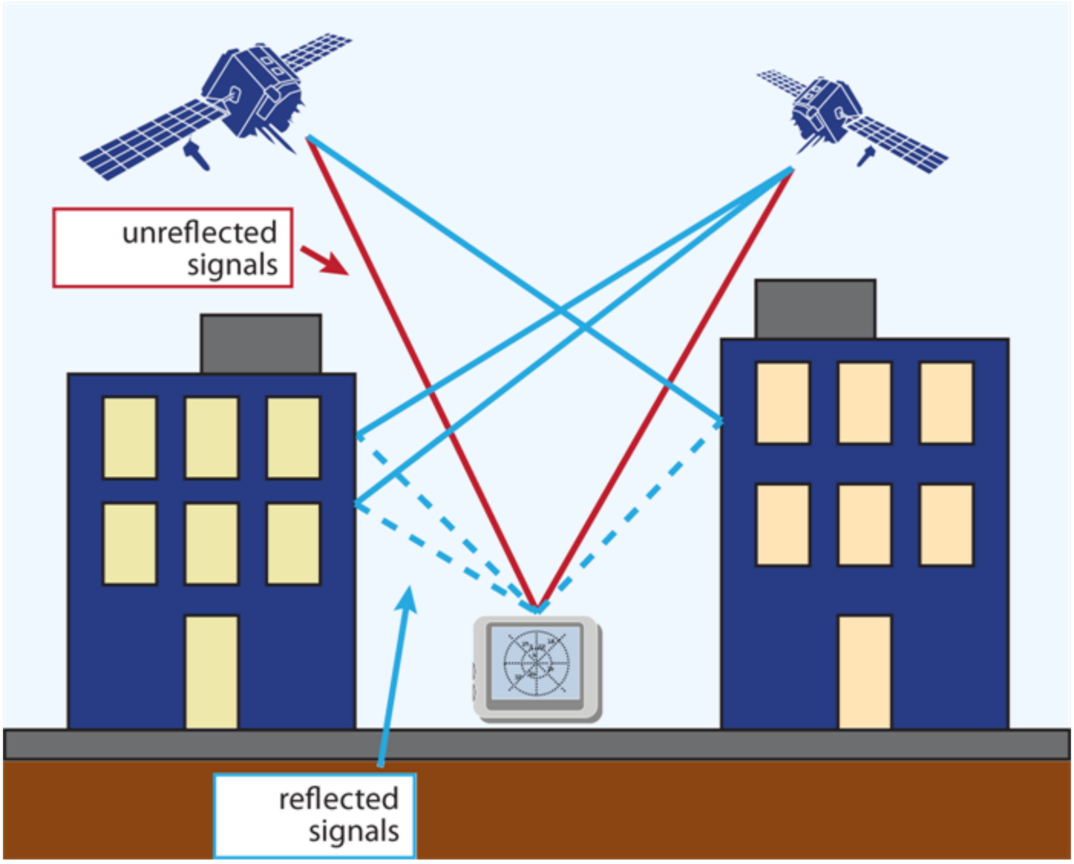

Figure 4: Multipath Diagram
Source: (Spectracom 2015)

As mentioned earlier GNSS manufactures are continually improving their software and algorithms to detect and remove multipath affected signals from the calculated position. As well has hardware improvements such as choke rings and base plates attached to the antenna to potentially stop the affected signals reaching the antenna. However, for surveying purposes when a constant accuracy is required for all observations the best mitigation technique is avoidance. Meaning being aware of your immediate environment, materials such as glass and metallic materials are highly reflective (Yi, Li & Gu 2012) and should always be avoided.

Creating a high multipath environment for the entirety of the data capture phase is important and a chosen environment must not be relied upon. This approach has been taken by numerous other researchers when multipath has been a focus of the study and an instrument has been chosen to create multipath affected signals rather than relying on a chosen environment. The instrument chosen by (McCabe 2002) and (Mylne 2007a) for their research in Multipath and GNSS receivers was that of an aluminium disc which is mounted beneath the GNSS receiver. Both (McCabe 2002) and (Mylne 2007a) concluded in their research that the multipath instrument did affect the GNSS receivers performance thus creating the desired effect. Figure 5 below shows (Mylne 2007a) aluminium disc detached and attached to the GNSS receiver during his research.

Figure 5: Aluminium Multipath Disc
Source:(Mylne 2007b)

2.4 Survey Standards & Guidelines

Surveying standards and regulations in Australia differ from state to state however all suggested surveying practices and guidelines to maintain accurate GNSS observations are based from the Intergovernmental Committee on Surveying and Mapping (ICSM) Special Publication 1 (SP1). In relation to RTK GNSS and Network RTK GNSS observational techniques, SP1 outlines minimum practice when establishing survey control. The recommend observation time for a single survey control point is an average of recorded positions for at least 1 minute after the rover has successfully initialised (Intergovernmental Committee on Surveying and Mapping 2014). It is also a guideline of SP1 that survey control must be observed at least twice with at least 30 minutes between the two observations. The time window of 30 minutes is necessary noted in the Cadastral Survey Requirements (CSR) for detecting outliers if the mark is subject to multipath and / or obstructions to allow sufficient change in the satellite constellations (Spatial Policy of Department of Natural Resources and Mines 2015). The Queensland Surveyors regulatory body the Surveyors Board of Queensland (SBQ) also mirror these observational techniques in their guidelines for Cadastral Surveys when a lack of understanding was identified in the profession (Gibbings 2012).

2.5 (Bein 2015) Research Project Review

(Bein 2015) completed a research dissertation last year as part of his completion of Bachelor of Spatial Science Degree at the University of Southern Queensland in 2015. His research was on the effect of time interval variations on RTK derived distances. His method of data capture is similar to the method used in the research project however Bein used an environment free of multipath and conducted the data capture in what is described in his dissertation as laboratory conditions and does not reflect the real world surveying environment. His observations were taken using a single base RTK GNSS for over a 24-hour period recording an epoch every second.

His data analysis was extensive and analysed numerous time windows and related his findings back to other previous research. Bein also used the method used in this research project to validate the captured data by determining the true absolute position of the recorded point by calculating and average of all the epochs over the 12-hour period. His analysis of each epoch compared to the calculated mean showed a random results with no noticeable trend or pattern present (Bein 2015).

His time lapse analysis method used the Zero Distance method to calculate distance because all the recorded observations were taken at the same physical position. The Zero Distance Method was also used in (Gibbings & Zahl 2014a) research on when to consider RTK GNSS for cadastral surveys. This method of analysis is perfect for this type of research it removes the need to physically observe both ends of a line in two different positions thus creating greater possibility for error to be introduced. The methods works under the assumption that in the absence of any measurement error the calculation of a distance between two records observed at the same location should produce a calculated value of zero (Gibbings & Zahl 2014a). This type of distance accuracy analysis will be used in the research project as well.

(Bein 2015) analysis found that using a shorter time window in between measuring both ends of a line proved to of higher accuracy. Thus his key finding was that a practitioner can observe either points of a line, in quick succession using the 1-minute observation time, for which a cadastral distance is to be derived when using RTK and comply with the CSR by not re-observing within the 30-minute window (Bein 2015).

However, it is noted in the research that further extensive research is still required before a definitive outcome can be concluded. There were also certain limitations noted in the research that may affect this research to be considered by governmental agencies when reviewing RTK GNSS standards and guidelines. Such as observations were taken in laboratory conditions with no setup errors which cannot reflect the real world, observations were taken in an environment free of multipath and no observations were taken using a Network RTK system. With this research focusing on a high multipath environment it is expected that the results will differ in some ways.

2.6 Conclusion

This chapter introduced the principals of Network RTK and CORS systems and multipath occurrence and past applications where multipath has been artificially created by attaching instruments to the GNSS receivers. A brief outline where of where Australian regulatory surveying bodies stand on GNSS practices to detect and mitigate site specific errors when conducting RTK GNSS surveys. And finally a review of (Bein 2015) research where his research looked at these surveying practices outlined by the regulatory bodies.

The review has given an understanding to the reader how the RTK GNSS system works and why site specific errors such as multipath can greatly affect the desired accuracy of GNSS surveys. While there has been research aligning temporal change and GNSS measurements most recent (Bein 2015) there has been little aligning the effects of multipath with temporal change rather past research has always been of mitigation and detection. (Bein 2015) also noted this in his research and put it forward as a pathway for further research into the area of temporal change in GNSS measurements. To further expand on his findings and introduce Network RTK and multipath when analysed over time is where this gap in research has evolved.

Chapter 3 – Method

3.1 Introduction

The literature review in Chapter 2 explored Network RTK and Multipath principles, surveying standards and guidelines and a review of (Bein 2015) research. This chapter will include a detailed description of the method of the data capture location, equipment utilised and the process of the data collection and analysis. This chapter will not only detail the methodology but why those steps were taken to give a better understanding of what is to be achieved from the research.

3.2 Site Selection

The location of the data capture must always be considered when using GNSS. For this research the receiver must be in a position with a wide unrestricted sky view and clear of any obstacles that could potentially create Multipath. It is important that the chosen environment is suitable for a multipath free data capture. This captured data set will be used to calculate a true position of the observed point, be used in checking if multipath is in fact present in the Multipath present observations, analyse any patterns and of course compare against the multipath data set.

The site chosen is a residential acreage property with a large cleared area near the southern property boundary as shown in Figure 6. This large vacant area is a perfect location to conduct the data capture because being a secure site there is no interference from members of the community interfering with the data capture periods. Which is important because if any unexpected interference did occur it could compromise the whole data set and may possibly have to be started all over again. This low interference site is also good because the mark used as the observed point has less chance of becoming disturbed when not in use. Meaning it can be used for all site visits during the testing and data capture phases.

Figure 6: Selected Site (Acreage Property)
Source: (Nearmap 2015)

The site is located in the suburb of Sheldon which is on Brisbane's south side along Mt Cotton Road. As shown in Figure 7, the receiver is positioned with an unrestricted sky view and with almost no objects or structures in its immediate vicinity. The location of the site is located within the SmartNet Network RTK coverage area and has 6 CORS within a 20km radius which can be seen in Figure 8. The mark used in the ground as the observed point for all the data capture is a deep driven star picket that sits 100mm below natural surface with a centre punch mark on the top to create a precises setup location.

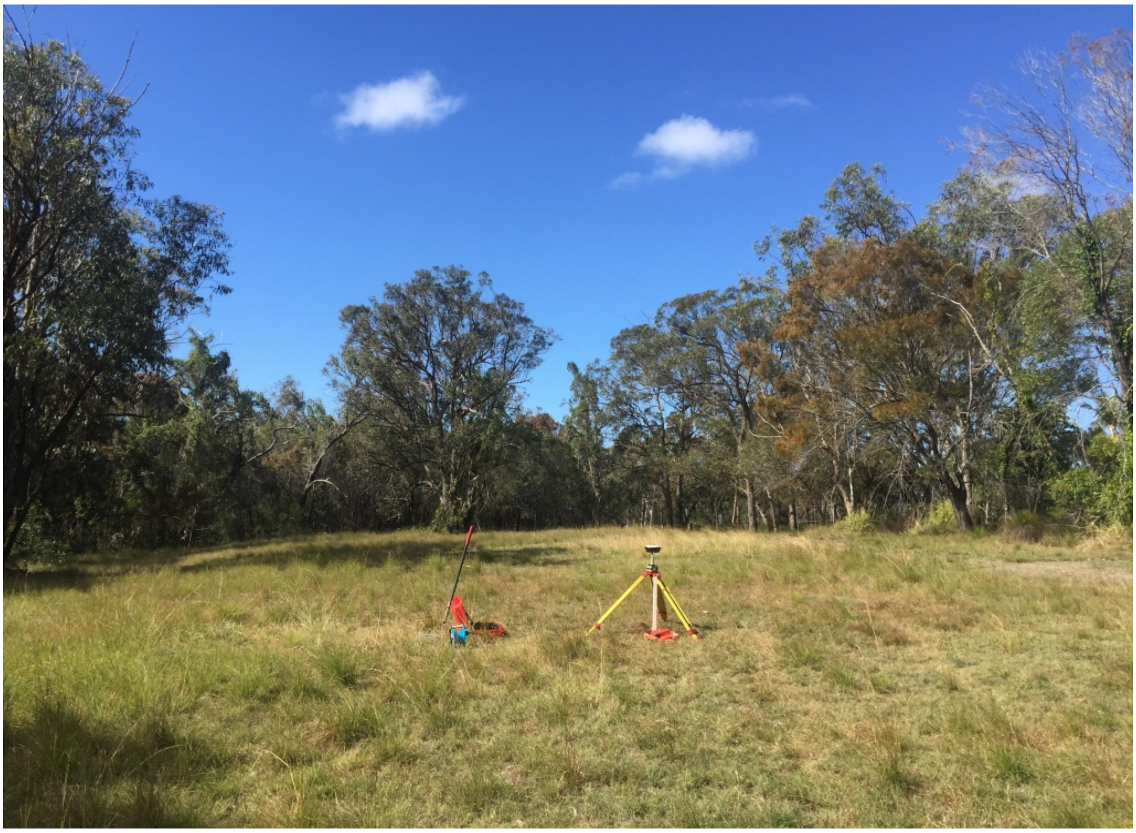

Figure 7: Receiver Setup – Multipath Free Environment

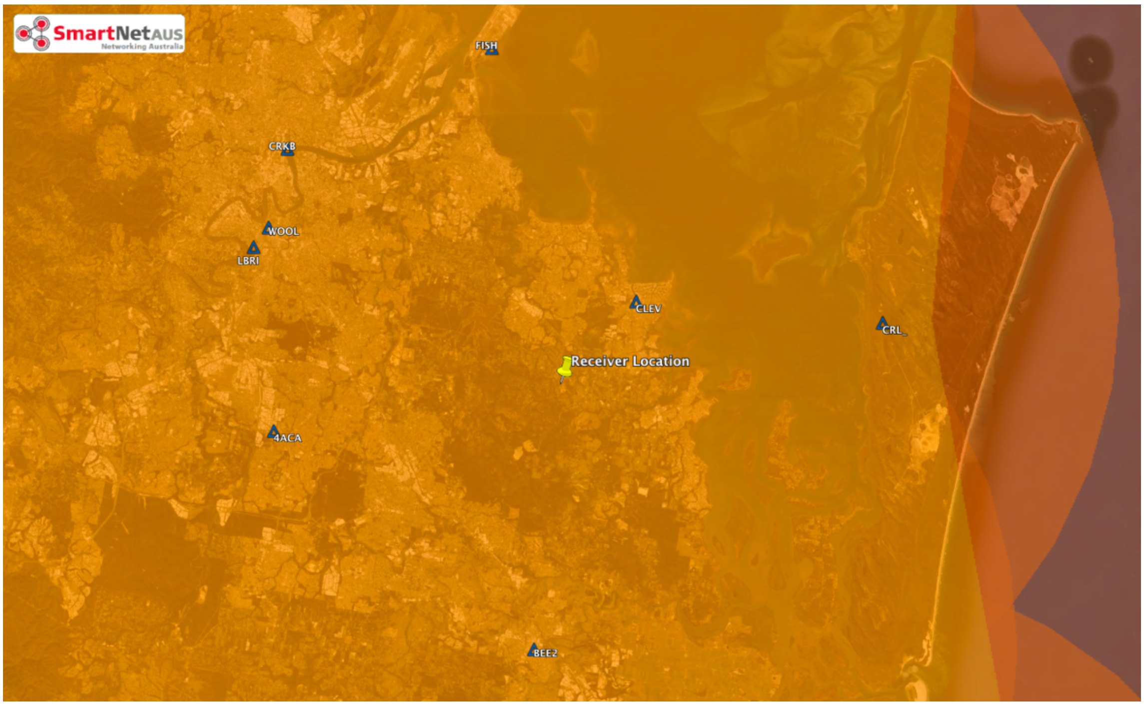

Figure 8: SmartNet Aus CORS Locality
Source: (SmartNet Aus 2016)

3.3 Equipment Details

The GNSS setup for the data capture is as follows:

GNSS Receiver

Model: Leica Viva GS16 GNSS Smart Receiver

Signal tracking: GPS (L1, L2, L2cC), Glonass (L1, L2), BeiDou (B1, B2), Galileo, QZSS and SBAS. Number channels 555.

Connections: Cable (USB & RS2320 and Bluetooth (V2.0)

Power: External 12v Battery

Data Links: 3.75g GSM Antenna & Radio Modem

Network RTK: VRS, FKP, iMAX, MAC (RTCM SC 104)

Data Recorder:

Model: Leica CS35 Tuff Tablet

Software: Leica Captivate V2.0

Internal Storage: 128GB

Connections: Cable (USB & RS2320) & Bluetooth (V2.0)

Network RTK Service:

Network: Smart Net Aus

Connection Method: GSM Antenna Internet Connection

Solution Method: iMAX

The receiver is setup over the mark using a tripod and tribrach with optical plummet. The receiver is then connected to the external 12V battery to last entire 12-hour data capture session. The receiver is then connected to the Data Recorder via Bluetooth link. Setup of receiver can be seen in Figure 9. Once receiver setup is complete a connection can be made to the Network RTK service using the Leica Captivate Software on the Data Recorder.

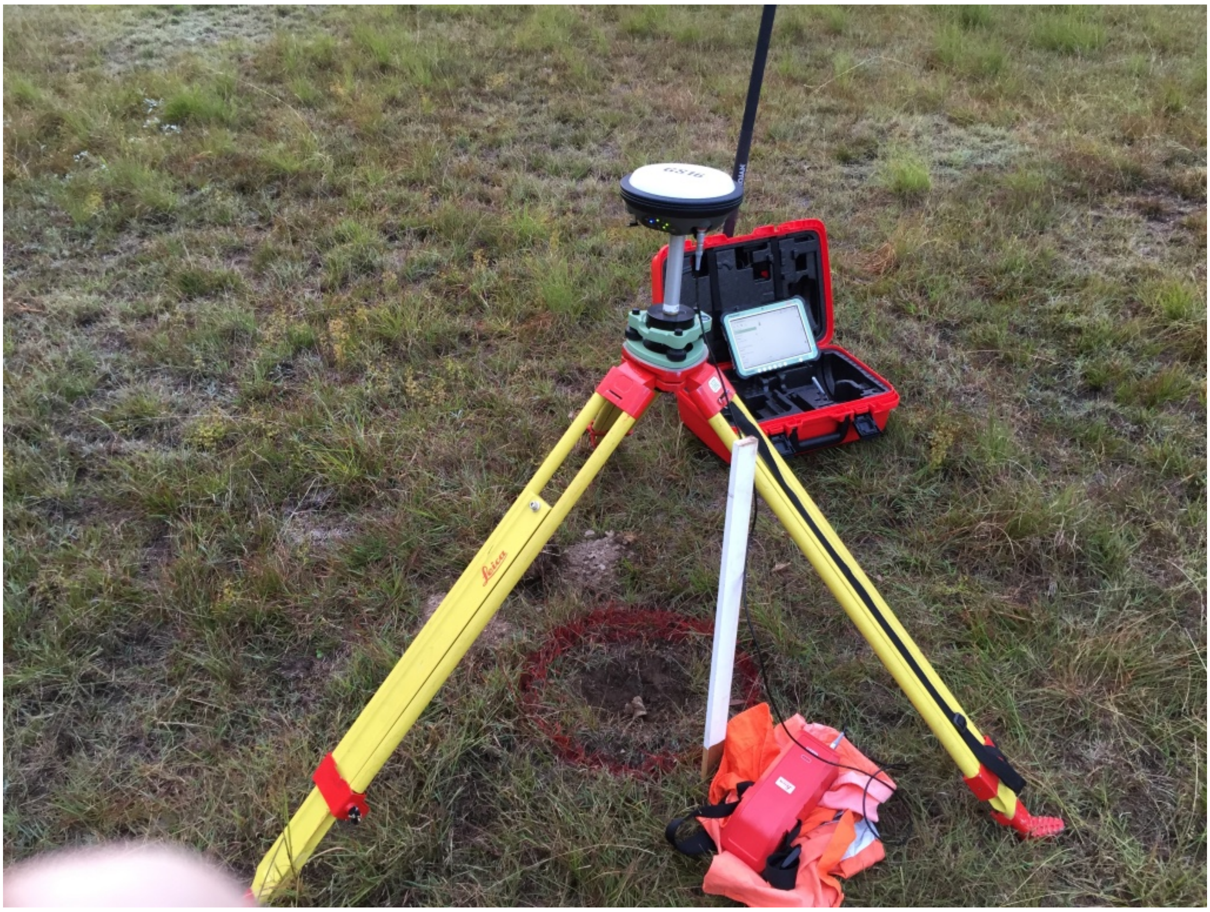

Figure 9: RTK GNSS Equipment Setup

3.4 Data Collection Process

No Multipath Present Collection

The data controller is set to continually record an epoch every second. This collection will be conducted for a 12-hour period as mentioned early to allow for satellite constellation orbits. The data is stored on the data controller during the capture process then backed up onto an external drive once complete. The equipment and recording process is monitored for the entirety of the capture to ensure the equipment is not interfered with and there are no problems with the data recorder.

Multipath Present Collection

The same collection method is repeated from the no multipath present collection for the multipath present collection however the removable multipath instruments will be setup around the receiver to create a multipath environment.

Removable Multipath Instruments

The original intention was to just use the one reflective material similar to what McCabe and Mylne had used in their research however after some initial testing to create a multipath environment it was determined that this one reflective disc would not be enough to create the desired environment. After further testing using additional reflective surfaces the desired environment was achieved. The determination that the multipath environment was achieved is noted the results chapter. With the reflective disc still in place underneath the receiver three more reflective surfaces were placed around the receiver in the east, west and south positions. Leaving the receiver with a clear sky view to the north gives the receiver the best possible chance to obtain the most satellite signals. In figure 10 and 11 the reflective instruments in place around the receiver are shown which were kept in the same position for the duration of the 12-hour capture period. The disc underneath and the instruments to the east and west were constructed from aluminium sheeting and a dual cab ute was parked to the south. In the testing stage it was determined that all four surfaces were required to create a noticeable multipath environment which proves how robust the latest GNSS RTK software and hardware are against the effects of multipath.

Figure 10: Multipath Instruments in Place

Figure 11: Multipath Instruments in Place

3.5 Data Analysis Process

Once all the data is captured from both of the scenarios totalling 86,400 epochs it is then exported from the data controller in a useable format for Microsoft Excel.

Data Format

The data format used to be imported into Microsoft Excel is a Comma-Separated Values (CSV) file. With the following data columns:

- X
- Y
- Z
- Time
- Number of Satellites
- Horizontal Accuracy
- Dilution of Precision (PDOP)

This custom output specific to this research has been created using Leica Geo Office software. The software enables the user to create a custom output template for Leica data recorders meaning only the relevant information is handled and analysed for the research which is important due to the large size of the captured data. Figure 12 shows an extract of the captured data in its raw form using the export template. The data exported had an arbitrary coordinate system applied to make the data more useable during the analysis. The arbitrary system used is a planar grid system which was calculated by using the quick grid function on Leica's Captivate software on board the data recorder. The X, Y, Z coordinates (X = 100.2… Y = 500.7… Z = 10.5…) were chosen because they will have smaller and more unique values compared to a MGA system. The planar system was chosen over MGA because ground distances need to be calculated in the analysis stage so they can be compared to previous research and survey requirements and guidelines.

	A	B	C	D	E	F	G	H	I
1	Point ID	Easting	Northing	Height	No. Satellites	Horizontal Accuracy	Vertical Accuracy	PDOP	Time
2	103601	100.21	500.698	10.492	13	0.006	0.013	1.70	7:29:30
3	103602	100.211	500.698	10.496	13	0.006	0.012	1.70	7:29:31
4	103603	100.209	500.696	10.497	13	0.006	0.012	1.70	7:29:32
5	103604	100.214	500.695	10.498	13	0.006	0.013	1.70	7:29:33
6	103605	100.214	500.696	10.495	13	0.006	0.012	1.70	7:29:34
7	103606	100.21	500.694	10.499	13	0.005	0.012	1.70	7:29:35
8	103607	100.211	500.698	10.497	13	0.006	0.013	1.70	7:29:36
9	103608	100.211	500.699	10.497	13	0.006	0.014	1.70	7:29:37
10	103609	100.209	500.695	10.492	13	0.006	0.013	1.70	7:29:38
11	103610	100.211	500.696	10.482	13	0.006	0.012	1.70	7:29:39
12	103611	100.211	500.698	10.49	13	0.006	0.013	1.70	7:29:40
13	103612	100.212	500.698	10.485	13	0.006	0.013	1.70	7:29:41
14	103613	100.211	500.696	10.494	13	0.006	0.013	1.70	7:29:42
15	103614	100.211	500.695	10.494	13	0.006	0.013	1.70	7:29:43
16	103615	100.211	500.695	10.491	13	0.005	0.011	1.70	7:29:44
17	103616	100.212	500.694	10.488	13	0.006	0.013	1.70	7:29:45
18	103617	100.212	500.696	10.488	13	0.006	0.012	1.70	7:29:46
19	103618	100.21	500.697	10.487	13	0.006	0.013	1.70	7:29:47
20	103619	100.21	500.699	10.488	13	0.006	0.013	1.70	7:29:48
21	103620	100.211	500.697	10.485	13	0.005	0.012	1.70	7:29:49

Figure 12: Example Raw Export from Data Recorder using Custom Output

Data Processing Strategy

Firstly, the entire no multipath present data set will be used to calculate true position of the observed point by mathematical mean. This calculated mean will be used as the control or baseline for the data validation and analysis.

For both data sets the individual Epochs will be grouped into 1 minute intervals and the mean will be calculated for each 1-minute subset. The 1-minute interval has been chosen as this is the minimum time recommended in the SP1 document when establishing survey control and also used in (Bein 2015) research. Thus creating 720 values for both the multipath free and multipath present data sets, 1,440 in total.

Both data sets can then be compared against the true value position. The X and Y values for each minute subset will have the difference (delta) calculated and graphed. This will show the error budget for each scenario, indicate if multipath has in fact been created and what differences if make to the point positions.

Once the data has been validated and determined that multipath is in fact present in the multipath present captured data. The zero distance method for calculating distances will be used with two different time lapse windows. The zero distance method calculates a distance between two points. The true distance will equal to zero as both observations used were recorded at the exact same position. This is the same method used in (Bein 2015) and (Gibbings & Zahl 2014a) research. With the true distance value of zero known a comparison against this value can be made and the analysis against the different time lapse windows can be made.

The first time lapse window chosen to analyse is a 30-minute window as this aligns with survey guidelines. The windowing strategy is as follows:

- Starting at minute 1 subset and calculating distance between minute subset 31.
- Next calculating a distance between minute subset 2 and 32.
- Next calculating a distance between minute subset 3 and 33.

- And follow that same pattern until all possible distances that can be calculated from the available 720 are complete.
- Use this window lapse strategy for both the multipath free and multipath present data sets.
- The calculated distance can then be graphed any analysed.

This same time lapse strategy will be used for the smaller time window of 5 minutes as well. A shorter time window was chosen because if results find no noticeable difference or if results are improved compared against the 30-minute time lapse it will help put further weight behind (Bein 2015) research which found that that there is a noticeable difference when analysing calculated distances over shorter time lapse windows.

3.6 Conclusion

Chapter 3 detailed the site selection, equipment used, the capture methodology. As well as including the data validation and analysis steps of the research to best answer the project aim.

Chapter 4 will validate all the captured data in both the multipath free and multipath present datasets. Then the zero distance method calculations will be displayed for further analysis and discussion in chapter 5.

Chapter 4 – Data Validation & Analysis

4.1 Introduction

The first aim of chapter 4 is to validate both the multipath free and the multipath present datasets by analysing against the true calculated positional value of the receiver in the field capture. Once the multipath free data has been validated to prove that it has no effects of multipath and fits in with the expected accuracies in can therefore be used in further analysis. This is also the case for the multipath present dataset, once it has been validated to prove that in fact the dataset has been affected by a multipath environment for the entire 12-hour period it too can be used for further analysis.

Then the data can be analysed using the Zero Distance Method for the four different scenarios. 30-minute time lapse with and without multipath and 5-minute lapse with and without multipath. The calculated distances and analysis will then be graphed and accuracies calculated for the results to be discussed in chapter 5.

4.2 Multipath Free Data Validation

From the 12-hour multipath free data capture period which totalled to 43,200 individual records. The data needed to be first validated to make sure it came within expected RTK GNSS accuracies and could confidently confirm that the data was free of multipath interference for the entire 12-hour period. For this validation process a true point value of the observed point location needed to be determined to calculate point positional accuracies against.

The true value was determined by calculating the mathematical mean of all the multipath free records. The calculated true position value is stated below.

True Positional Value:

Easting: 100.210 **Northing: 500.696**

The multipath free dataset was then grouped into 1-minute subsets totalling 720 averaged records that would be easier to manage during the validation and analysis processes. Note that a full tabulated list of all 720 records for the multipath free dataset can be found in Appendix C attached to this document. These subsets would then be compared against the true value calculating the difference (delta) for both the Easting and Northing values. Figure 13 and 14 below graph the delta values of the multipath free 1-minute subsets against the true value in both horizontal axis.

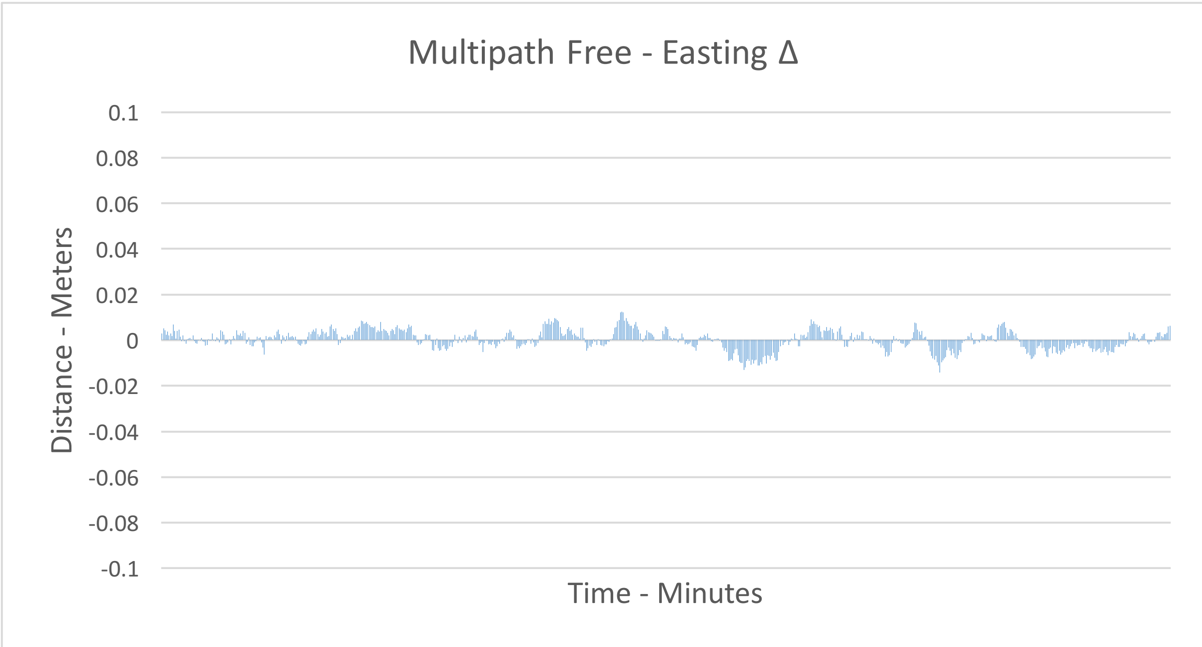

Figure 13: Multipath Free – Easting Delta's

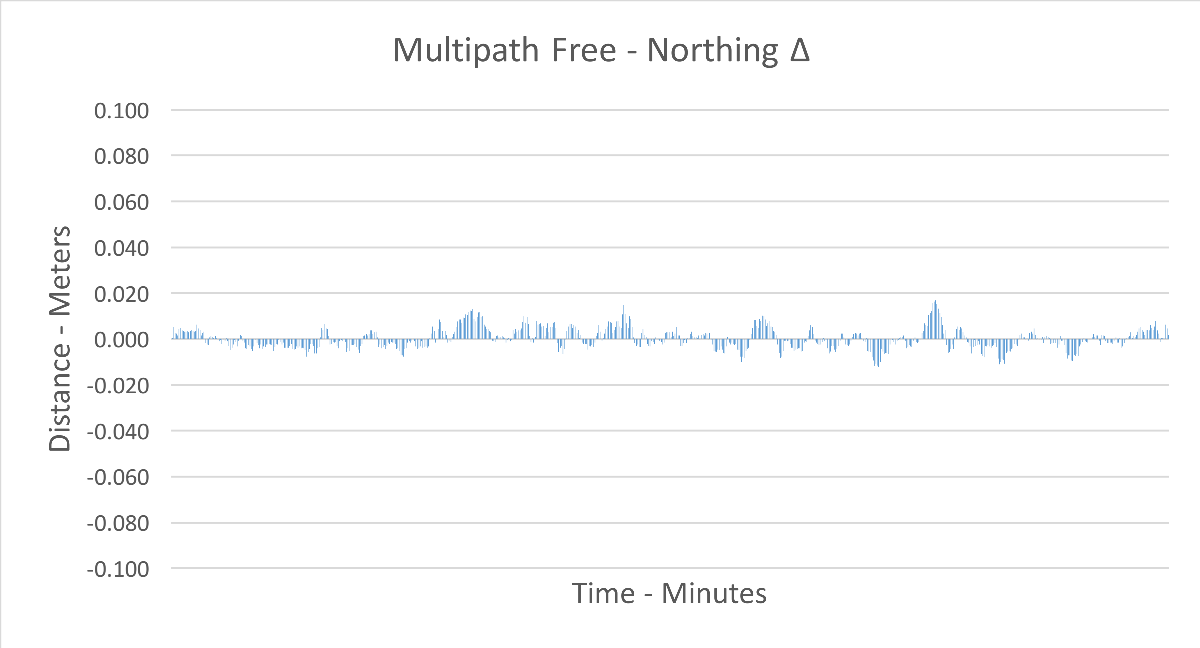

Figure 14: Multipath Free – Northing Delta's

The graphs above show no distinctive outliers or noticeable trends. All the values fit within +- 20mm, which is generally the expected accuracy of horizontal values using RTK GNSS. The 95% Confidence Interval of each dataset can also be compared against the manufactures horizontal accuracy specification of +- 8mm. From the descriptive statistics below (Table 1 and 2) and the graphs above (Figure 13 and 14) it can be stated that the multipath free data conforms to expected accuracies and has no indication of multipath interference for the entire 12-hour period.

Table 1 - Descriptive Statistics – Easting Multipath Free	
Mean	100.20982
Standard Error	0.000158145
Median	100.2096917
Mode	100.2084
Standard Deviation	0.004243485
Sample Variance	1.80072E-05
Range	0.026633333
Minimum	100.1974333
Maximum	100.2240667
Sum	72151.0704
Count	720
95% C.I	0.00831723

Table 2 – Descriptive Statistics – Northing Multipath Free	
Mean	500.6959072
Standard Error	0.000171941
Median	500.6965583
Mode	500.6985667
Standard Deviation	0.004613648
Sample Variance	2.12857E-05
Range	0.0289
Minimum	500.67925
Maximum	500.70815
Sum	360501.0532
Count	720
95% C.I	0.0090427

4.3 Multipath Present Data Validation

From the 12-hour multipath present data capture period which also totalled to 43,200 individual records. This dataset also needed to be validated to confirm that a multipath environment had in fact been created and was maintained for the entire 12-hour period. The same validation process conducted for the multipath free dataset would be used for the multipath present dataset. Grouping the data into 1-minute subsets totalling 720 records and calculating the difference (delta) from the True Positional Value used in the multipath free validation. Note that a full tabulated list of all 720 records for the multipath present dataset can be found in Appendix C attached to this document. Figure 15 and 16 below graph the delta values of the multipath present 1-minute subsets against the true value in bot horizontal axis. Note that the vertical scale of the graphs has been chosen to best represent the detail of the data, however some large outlier values cannot be determined from these graphs. These large values will be discussed further in the following chapter.

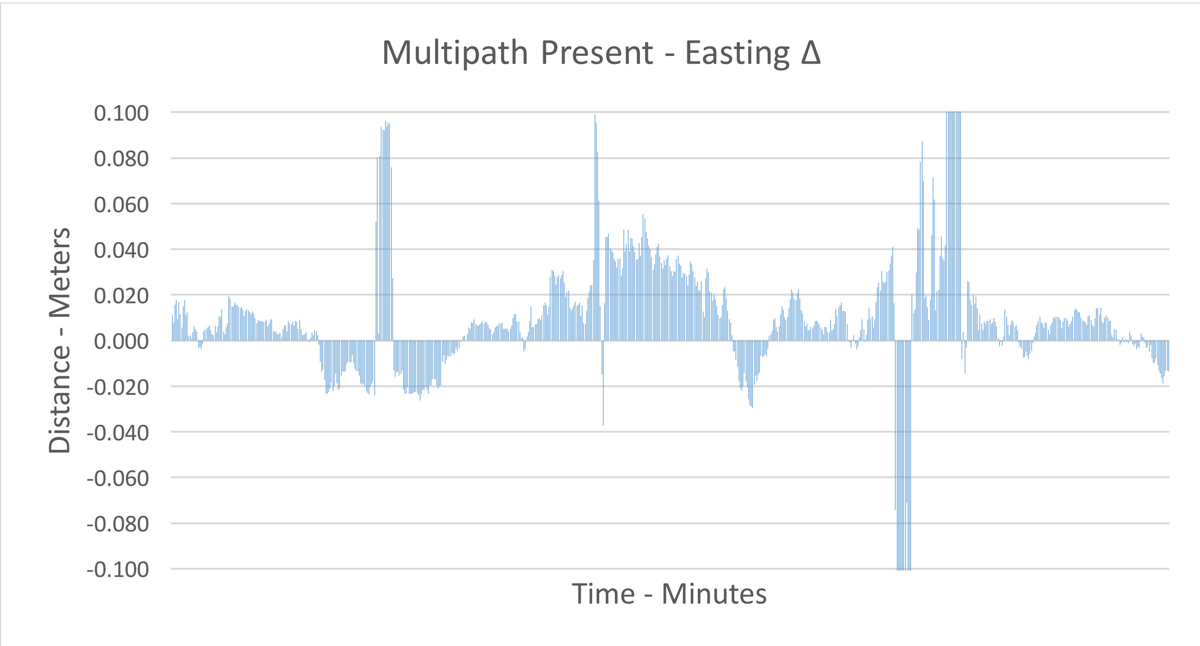

Figure 15: Multipath Present – Easting Delta's

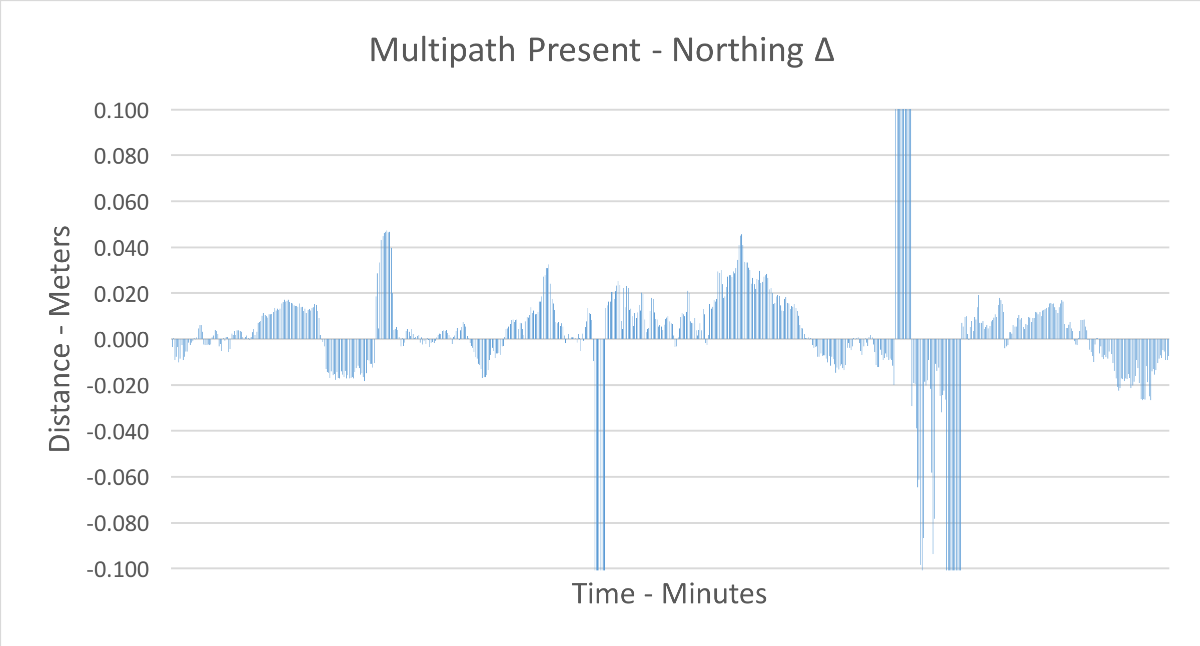

Figure 16: Multipath Present – Northing Delta's

Comparing the multipath free graphs (Figure 13 and 14) against the multipath present graphs (Figure 15 and 16) there is a definite difference between the two datasets. The multipath present deltas have increased and the average accuracy is +- 40mm with some large outliers throughout the 12-hour period. By looking at the 95% Confidence Interval values below (Table 3 and 4) the values have increased over 10 times the multipath free values. With these noticeable differences it can be stated that an effective multipath environment has been created for the entire 12-hour period.

Table 3 – Descriptive Statistics – Easting Multipath Present	
Mean	100.2014618
Standard Error	0.001512532
Median	100.2024333
Mode	100.1614667
Standard Deviation	0.040585493
Sample Variance	0.001647182
Range	0.441933333
Minimum	100.0257333
Maximum	100.4676667
Sum	72145.05252
Count	720
95% C.I	0.079547566

Table 4 – Descriptive Statistics – Northing Multipath Present	
Mean	500.6959501
Standard Error	0.002511722
Median	500.6927583
Mode	500.6959167
Standard Deviation	0.06739658
Sample Variance	0.004542299
Range	0.942583333
Minimum	500.3207167
Maximum	501.2633
Sum	360501.0841
Count	720
95% C.I	0.132097297

4.4 Zero Distance Method 30 Minute Window

With both datasets validated the data analysis can take place using the Zero Distance Method. Note further data validation analysis for both datasets can be found in Appendix B attached to this document. The Zero Distance Method calculates a horizontal distance between two points but because both of the points have been measured in the exact same position the true distance value will equal zero. For this research the variable of time will be introduced between the two points and their accuracy analysed.

The first time lapse window applied to the two datasets will be 30 minutes. Figure 17 and Table 5 will show the calculated horizontal distances graphed and the descriptive statistics tabulated respectively for the multipath free dataset. Figure 18 and Table 6 will show the calculated horizontal distances graphed and the descriptive statistics tabulated respectively for the multipath present dataset.

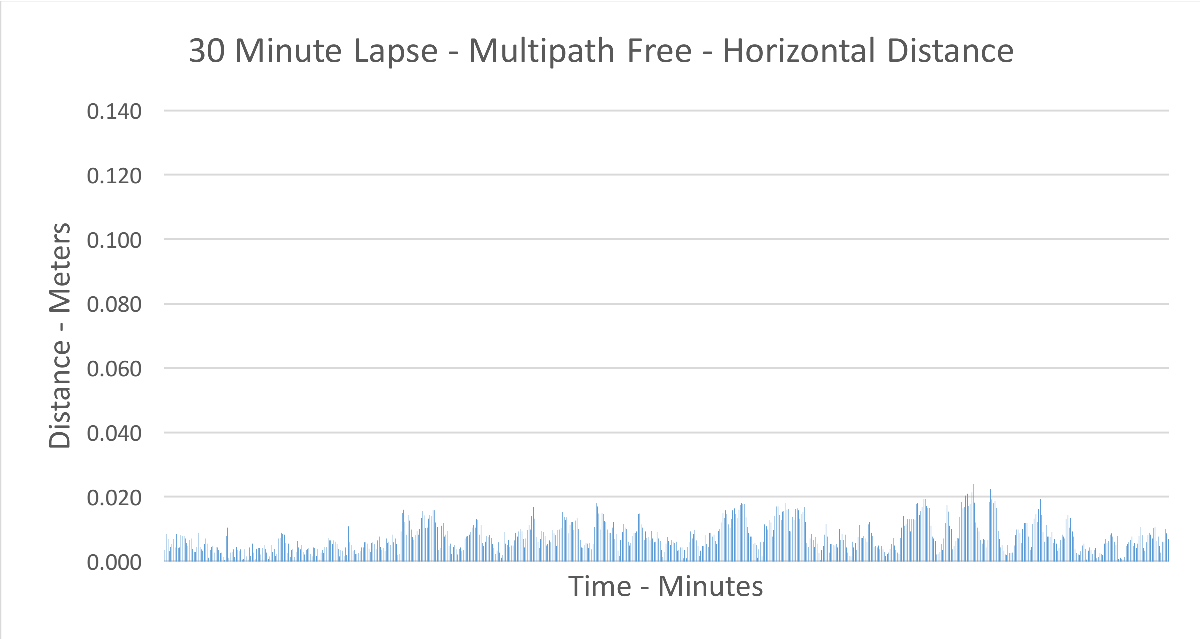

Figure 17: Multipath Free – 30-Minute Window – Horizontal Distance

Table 5 – Descriptive Statistics – 30 Min Window – Multipath Free - Horizontal Distance	
Mean	0.007488303
Standard Error	0.000172356
Median	0.006588173
Standard Deviation	0.004527413
Sample Variance	2.04975E-05
Range	0.023600992
Minimum	0.000405518
Maximum	0.02400651
Sum	5.166929343
Count	690
95% C.I	0.011092162

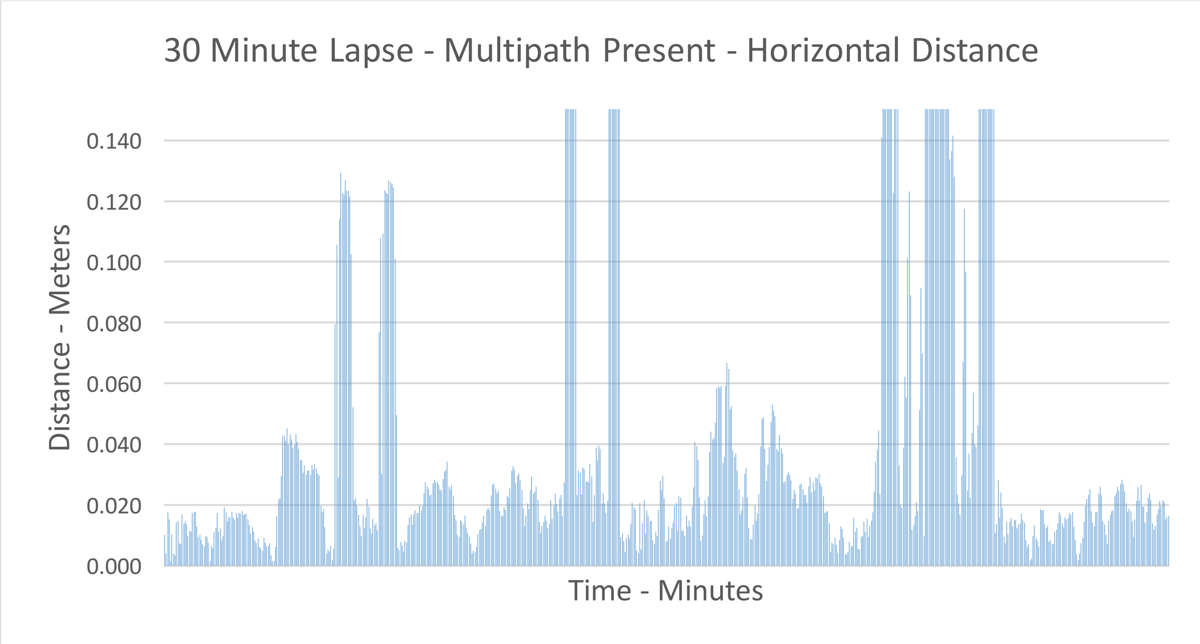

Figure 18: Multipath Present – 30-Minute Window – Horizontal Distance

Table 6 – Descriptive Statistics – 30 Min Window – Multipath Present - Horizontal Distance	
Mean	0.053436945
Standard Error	0.004050006
Median	0.019372696
Standard Deviation	0.106384954
Sample Variance	0.011317758
Range	0.681463198
Minimum	0.001463728
Maximum	0.682926927
Sum	36.87149226
Count	690
95% C.I	0.260643138

4.5 Zero Distance Method 5 Minute Window

The same Zero Distance Analysis Method used for the 30-minute window is applied to the 5-minute time lapse window. Figure 19 and Table 7 will show the calculated horizontal distances graphed and the descriptive statistics tabulated respectively for the multipath free dataset. Figure 20 and Table 8 will show the calculated horizontal distances graphed and the descriptive statistics tabulated respectively for the multipath present dataset.

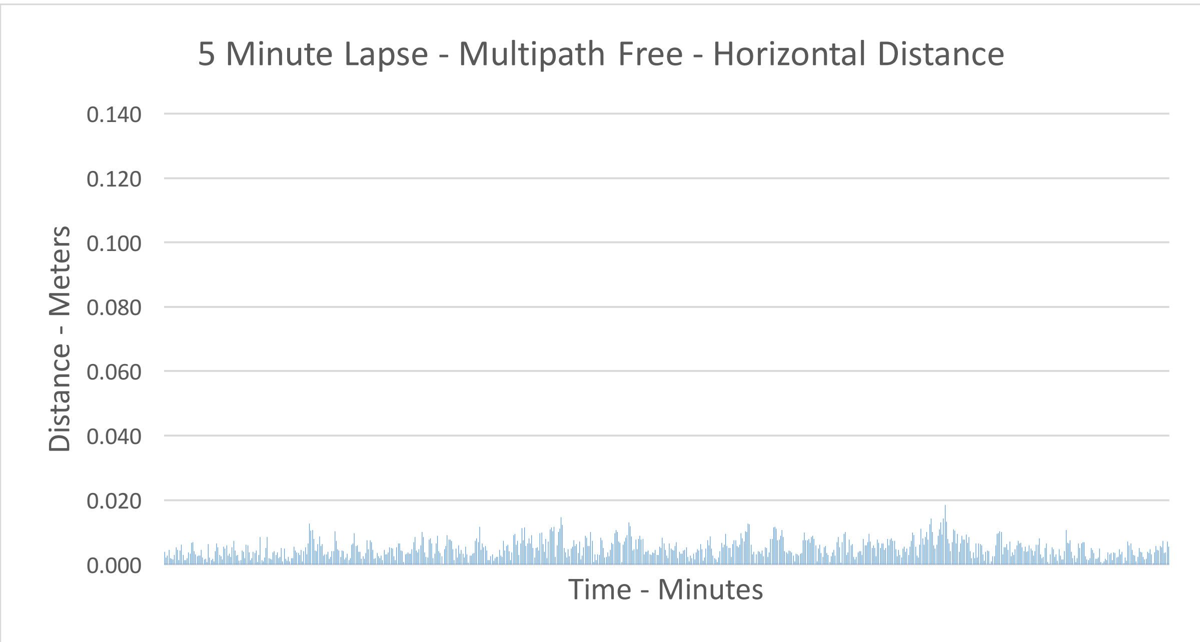

Figure 19: Multipath Free – 5-Minute Window – Horizontal Distance

Table 7 – Descriptive Statistics – 5 Min Window – Multipath Free - Horizontal Distance	
Mean	0.004942123
Standard Error	0.000105459
Median	0.004469185
Standard Deviation	0.002819912
Sample Variance	7.9519E-06
Range	0.018333069
Minimum	3.33333E-05
Maximum	0.018366402
Sum	3.533618094
Count	715
95% C.I	0.006908783

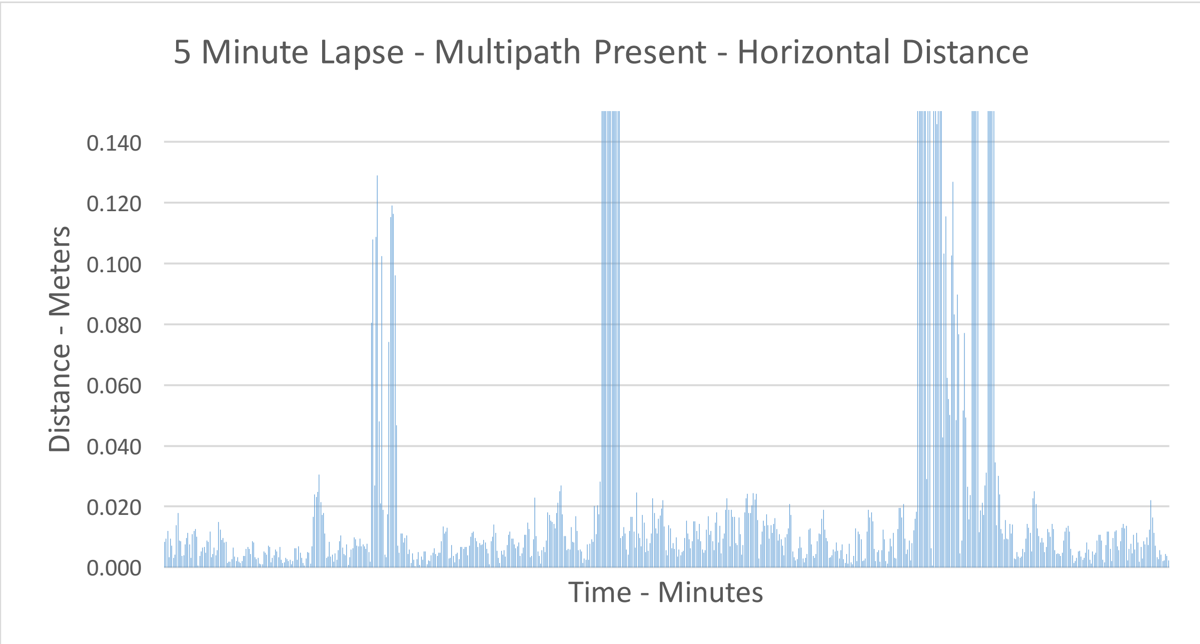

Figure 20: Multipath Present – 5-Minute Window – Horizontal Distance

Table 8 – Descriptive Statistics – 5 Min Window – Multipath Present - Horizontal Distance	
Mean	0.028199635
Standard Error	0.002922187
Median	0.008273687
Standard Deviation	0.078137773
Sample Variance	0.006105512
Range	0.5884597
Minimum	0.000271314
Maximum	0.588731014
Sum	20.16273871
Count	715
95% C.I	0.191437543

4.6 Conclusion

Chapter 4 successfully validated both datasets for further analysis using the Zero Distance Method. With all 4 scenarios graphed and statistics tabulated it is easy to see that there is a definite difference between the difference time interval variations have when calculating a distance. Focusing on the 95% Confidence Interval values it can be seen that the shorter 5-minute time window proved to be of higher accuracy. These data calculations and results will be discussed further in chapter 5.

Chapter 5 – Results & Discussions

5.1 Introduction

Chapter 5 directly follows on from the data validation and analysis in chapter 4. It will discuss in more detail how the time windows performed against each scenario. It will also discuss these findings in relation to the real world uses of calculating distances for the professional practitioner. By analysing the calculated accuracies against the survey standards for line measurement in the CSR. And finally the key findings will be discussed in regards to the implications this research may have on the surveying community and further research surrounding this subject.

5.2 Time Windows

With the data now validated and the zero distance calculations complete, the results of the Zero Distance Method can now be reviewed. The aim of the research was to consider Time Interval Variations in a high multipath environment. However, having the multipath free dataset as well the analysis can also be compared against previous research.

The multipath free dataset can be directly compared against (Bein 2015) research. He too conducted analysis with observation time at 1-minute. With time lapse windows of 5-minute and 30-minute also aligning with this research. A comparison of this research and (Bein 2015) of 95% Confidence Interval values is stated below.

1-Minute Observation Time with 30-Minute Window (Multipath Free)

95% C.I = 0.0111m 95% C.I (Bein 2015) = 0.0069m

1-Minute Observation Time with 5-Minute Window (Multipath Free)

95% C.I = 0.0069m 95% C.I (Bein 2015) = 0.0057m

From the comparative results above it can be seen that there is some correlation between the research. In both studies it was found that the smaller time window of 5-minutes proved to be of higher accuracy when calculating a distance by RTK GNSS. Thus also validating the multipath free dataset and the zero distance analysis method. It must be noted that (Bein 2015) data capture was considered to be laboratory conditions there for higher accuracy results would be expected compared to this research.

When applying this analysis to the multipath present dataset it too follows the same trend of the smaller time window producing higher accuracy which can be seen stated below. Meaning that even in a multipath environment the accuracy trend surrounding time windows is maintained.

1-Minute Observation Time with 30-Minute Window (Multipath Present)
95% C.I = 0.2606m

1-Minute Observation Time with 5-Minute Window (Multipath Present)
95% C.I = 0.1914m

5.3 Results Applied to CSR

Having gained this further knowledge on how both multipath free and multipath present datasets behave when calculating a distance using Network RTK. This can now be applied to use for surveyors. Just like (Bein 2015) and (Gibbings & Zahl 2014a) did in their research the accuracies determined above can be applied to the required accuracy stated in the CSR (Spatial Policy of Department of Natural Resources and Mines 2015) of +- 10mm + 50ppm for measuring a distance for use in a cadastral survey. Meaning determining which distances can be adequately measured by Network RTK in the four different scenarios.

First the multipath free time windows will be analysed against the CSR's +- 10mm +50ppm. In figure 21 below the 95% Confidence Interval values of the 30-minute and 5-minute scenarios have been plotted as a horizontal line. With the function of the CSR accuracy of +- 10mm + 50ppm plotted as the green line. Where the horizontal lines fall below the green line it is considered adequate to be measured by RTK GNSS using the time lapse scenario. The results shown in Figure 21 indicate that measurements using the 5-minute time lapse would be adequate for all distance while the 30-minute time lapse method would be suitable for distances over 30 meters. These results are similar to what (Bein 2015) found in his research however would not be considered as realistic measurement method for these short distance. Considering (Gibbings & Zahl 2014a) research which gave a detailed investigation into this question, the key finding was to consider distances over 378 meters adequate to be measured by RTK GNSS which is a more realistic value when RTK GNSS is consider as a whole full of potential environmental and systematic errors.

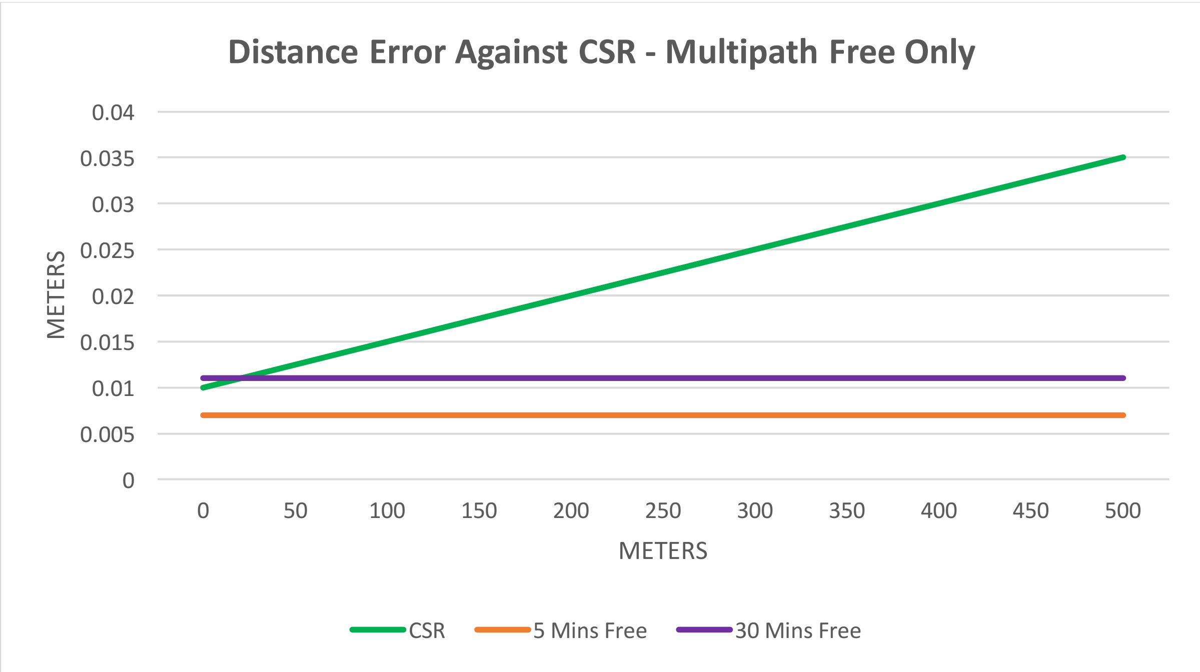

Figure 21: Distance Error Against CSR – Multipath Free Only

When the multipath present scenarios are introduced to this analysis the magnitude of the effects of multipath can be truly seen. In Figure 22 below which is set out similar to Figure 21 with the green line representing the function of +- 10mm + 50ppm. The results indicate that measurements using the 5-minute time lapse would be adequate for distance over 3.6km in a multipath environment. While measurements using the 30-minute time lapse would be adequate for distances over 5km in a multipath environment.

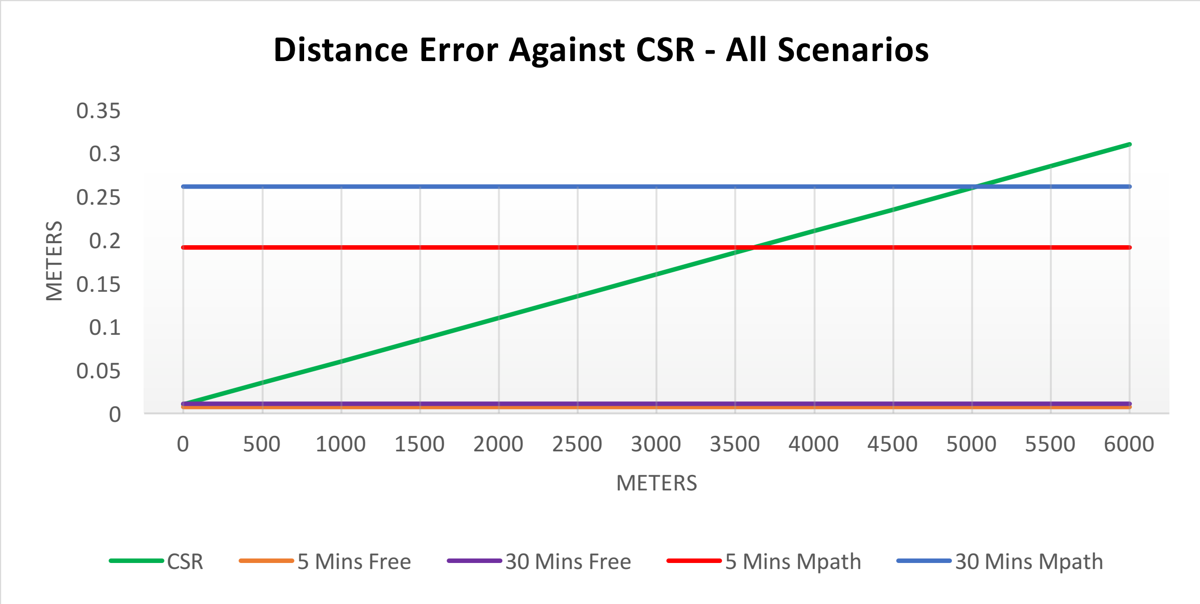

Figure 22: Distance Error Against CSR – All Scenarios

5.4 Implications

This research follows on from previous research by (Bein 2015) and (Gibbings & Zahl 2014a) to gain greater knowledge surrounding using RTK GNSS in cadastral surveys. From this research there are no major implications in which will immediately affect the tried and tested procedures and guidelines already in place for when conducting cadastral surveys using RTK GNSS.

This research has just added to the knowledge base to which further improvements to procedures and guidelines can be made in the future after further research has been completed. This research has added further knowledge to the behaviour of Network RTK which aligns with (Bein 2015) research. And begins to add a starting point for further research of calculated distances in a multipath environment.

With the key findings in this research and past research indicating that measuring both ends of a line in quick succession using 1-minute observation time and will comply with the CSR. Proves possibilities for procedural and efficiencies improvements for the survey practitioner. Of course it must be remembered that if using this procedure for calculating distances, sufficient checks and re-observation must be conducted to eliminate any outliers which has been well researched and documented.

5.5 Conclusion

Chapter 5 looked in depth into the results of the effects of time interval variations in both the multipath free and multipath present datasets. Focusing on the 95% Confidence Interval values which is commonly used as an indicator for accuracy. With the findings aligning with previous research even in the multipath environment it just adds further to the subject knowledge base.

The application of the calculated accuracies against the CSR requirements was an interesting point. If a practitioner is considering using RTK GNSS to calculate a distance in a multipath environment for cadastral purposes the line lengths necessary are enormous to align with CSR. It would be a very challenging task for an operator of a RTK GNSS system to measure both ends of a 3.6km line in under 7 minutes.

Chapter 6 – Conclusion

6.1 Introduction

This research paper investigated the effects of time interval variations on Network RTK in a high multipath environment. The research successfully utilised a Network RTK solution in both a multipath free and a multipath present environment created by removable instruments. This artificial multipath environment proved to be a success and results in both scenarios aligned with previous research.

6.2 Meeting the Aims and Objectives

The research aim for this project was to investigate the effect time interval variations have on Network RTK in a high multipath environment. Which has been successfully achieved. The broad objectives derived from the problem statement have been addressed below.

Are there any affects to Network RTK GNSS observations when analysed against temporal change?

Yes, temporal change did affect the accuracy when using Network RTK to calculate a distance. Shorter time windows have found to be more accurate which align with previous research.

Are there any affects to Network RTK GNSS observations when analysed against temporal change when Multipath is introduced?

Yes, temporal change did affect the accuracy of the calculated distances when observed in a multipath environment. The accuracy of the temporal change aligned with the multipath free environment.

How will the well-documented expected accuracies differ when Multipath is introduced?

The expected accuracies of RTK GNSS is well documented and aligns with the data captured in the multipath free environment. Showing no noticeable trends or patterns, the random values fit within the expected error budget. With the multipath present data this too had no noticeable trends or patterns to the dataset but of course with a much larger error budget. However, one thing that could be noted is that the multipath environment created, did manage to create some very large errors over a meter in position in some instances. These large errors were created even though the received had maintained initialisation.

Will the analysis align with current recommended RTK GNSS Survey methods?

The research did differ from recommended RTK GNSS survey methods in a way. The research found that observing both ends of a line in quick succession proved to be more accurate than using observations with a 30-minte lapse in time as recommended in the CSR. With sufficient checks this alternate method could be used to calculate distance in both a multipath free and multipath present environment. Which just shows that it is up to the professional judgement, experience and instrumentation knowledge of the surveyor when using RTK GNSS. One cannot only rely on the standards and guidelines when conducting a RTK GNSS survey especially in a multipath environment.

6.3 Further Research

The intention of this research was to add to the findings by (Bein 2015) and (Gibbings & Zahl 2014a). The variations in this research follow on from the limitations in the past research. With still so many limitations surrounding this research topic there is still a large need for further research which are listed below.

- Using a different Network RTK service in Australia or Internationally.
- Create a different unique multipath environment using different reflective surfaces and distance from receiver.

- Conduct research using different satellite constellations especially with new GNSS services planned for the near future.
- Conduct research using different brand and model RTK GNSS instruments.
- Conduct research in high multipath environment using a single base RTK system.
- Conduct the same research but apply different time interval variations to the analysis.

With the knowledge base growing in this research topic there is a greater need for the research to continue. This further research must be undertaken to be considered and accepted in the RTK GNSS community and therefore make it a valid technique for the professional practitioner in the future.

6.4 Conclusion

The aim of this research was to investigate the effect of time interval variations on Network RTK in a high multipath environment which has been successfully achieved at the completion of this research. Whilst there is still need for further research in the subject of achieving accurate and efficient calculated distances using RTK GNSS there are some key findings that have come from this research which are stated below.

- Results achieved from Network RTK in a multipath free environment aligned with previous research using a single base RTK system. That is using observation times of 1-minute higher accuracy is achieved using a smaller time lapse window of 5-minutes to observe both ends of a line to calculate a distance rather than increasing the time window to 30-minutes.
- Results achieved from Network RTK in a high multipath environment aligned with the dataset with a multipath free environment however with a larger error budget as expected. Meaning if using this measurement technique, the observation procedure does not need to be altered when measuring in different environments. However, it must be remembered that the suitable line lengths

dramatically increase to meet standard measurement accuracies when in a multipath environment.

From these findings an alternative practice for calculating distances using RTK has been reaffirmed again which differs from survey regulations and guidelines but does meet the CSR measurement standard of 10mm + 50ppm. Meaning being a professional practitioner using RTK GNSS instrumentation one cannot solely rely on the standards and guidelines when conducting a RTK GNSS survey especially in a multipath environment. The understanding of the RTK GNSS system coming from experience, professional judgement and instrumentation knowledge is what will help achieve the most accurate results than any guidelines especially in a multipath environment.

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Appendix A – Project Specification

For: James McDonnell

Title: Effect of Time Interval Variations on Network RTK in a High Multipath Environment.

Major: Surveying
Supervisor: Peter Gibbings
Enrolment: ENG4111 – EXT S1, 2016
ENG4112 – EXT S2, 2016
Project Aim: To investigate the effect time interval variations have on Network RTK in a high multipath environment when in real world survey conditions.

Programme: Issue C, 15th March 2016

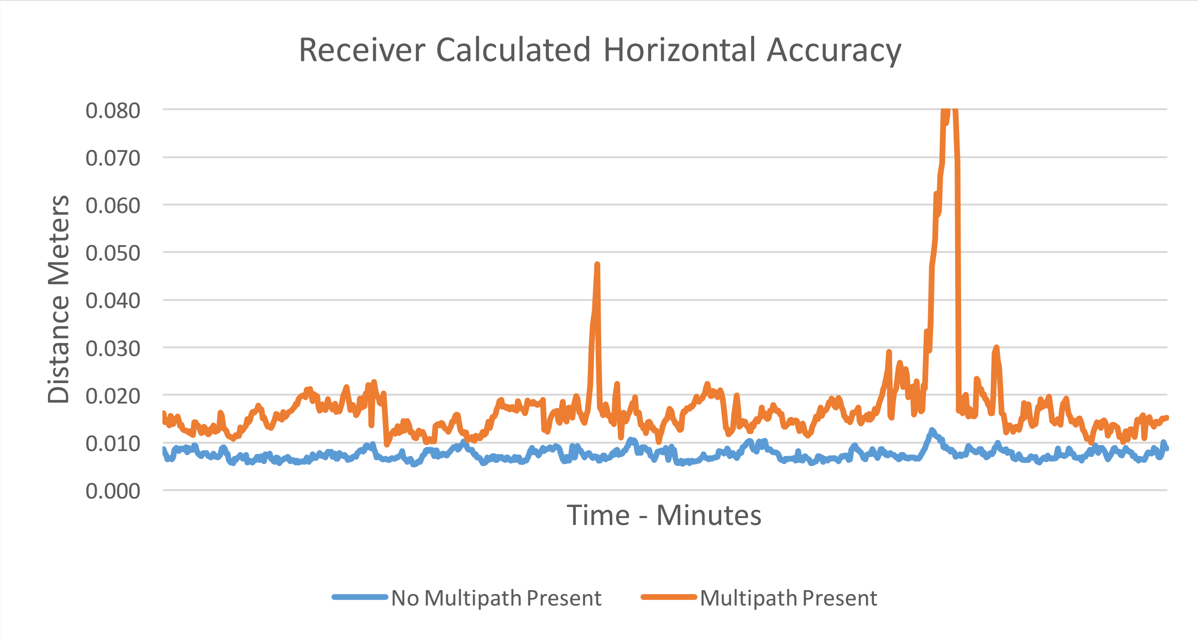
1. Research related background literature into RTK GNSS focusing on CORS / Network RTK, Multipath and why the survey requirements determined a time lapse between observations as best practice. Review V.Bein Research Project from last year from where this current research has evolved from and conduct similar data capture but with Network RTK and Multipath introduced which is suggest in his further research notes to answer our similar project aim.

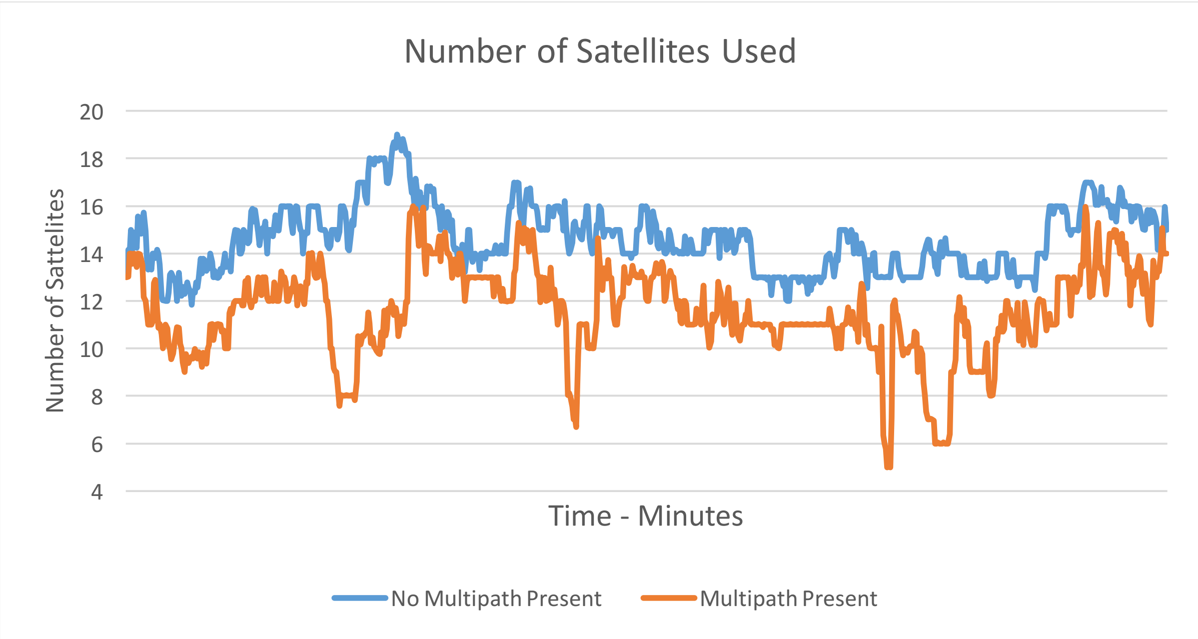
2. Using Network RTK GNSS system, capture data in a real world environment with multipath present and not present. Conduct 12 hours of observation in each of the 2 scenarios to account for satellite constellation orbits. The use of a removable instrument to create multipath will help improve the comparable accuracy against the non-multipath observations as well as be sure that multipath is taking place.

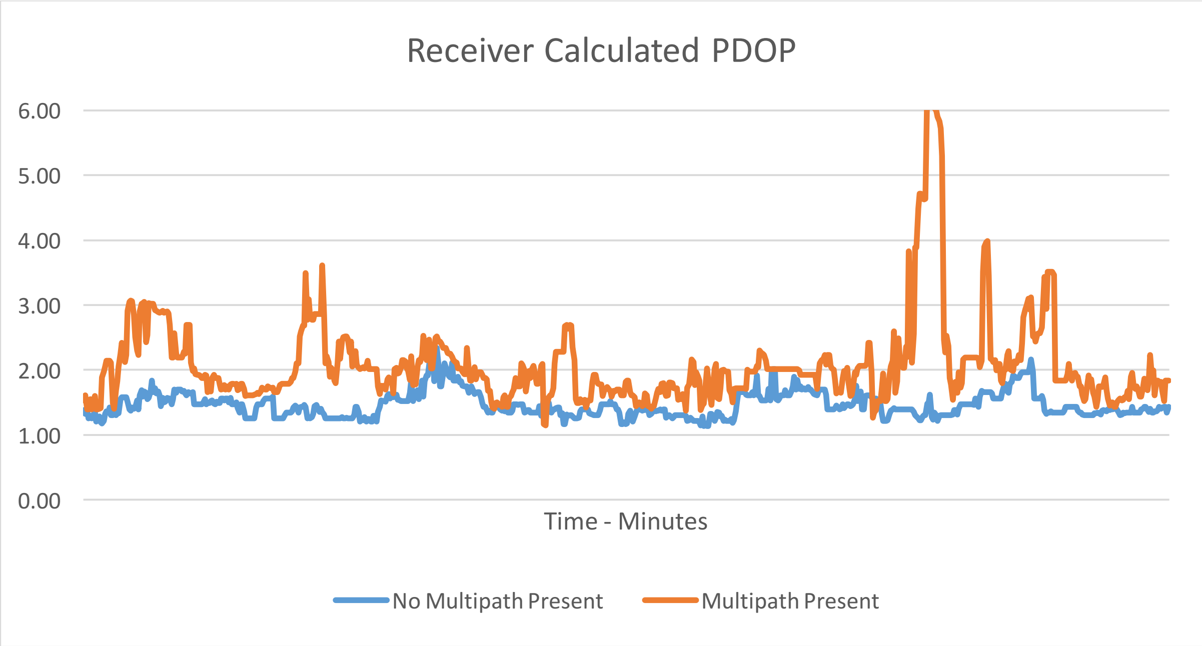
3. Once the data has been collected it will be exported in a format of X, Y, Z Time, Number of Satellites, horizontal accuracy and Dilution of Precision and be imported into Microsoft excel for data analysis. Using the data set with no multipath a mean of all those measurements will determine the true position of the observed point. The data will then be spilt up into 60 second observations and averaged which is the minimum observation time recommended in the QLD CSR when using GNSS. These averaged observations will then be compared to each other at varied time intervals and differences calculated.

4. The data will then be analysed and graphed to determine any arising patterns. The main aim of the analysis is to determine if re-observing the point with a time lapse in between observations improves the quality of the observation compared to re observing straight after the first. The accuracies and precisions will be compared against the acceptable levels in the survey requirements and results from V.Bein research to come up with a conclusion.

Appendix B – Further Data Validation






Receiver Calculated PDOP
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Time - Minutes
No Multipath Present
Multipath Present

Appendix C – Tabulated 1-Minute Subsets

Multipath Free 1-Minute Subsets

Point ID	Easting	Northing	No. Satellites	Horizontal Accuracy	PDOP	Time
1	100.207	500.696	13	0.009	1.38	6:29:00
2	100.205	500.691	14	0.008	1.32	6:30:00
3	100.206	500.693	14	0.007	1.38	6:31:00
4	100.208	500.694	15	0.007	1.25	6:32:00
5	100.206	500.695	14	0.007	1.30	6:33:00
6	100.208	500.692	15	0.007	1.26	6:34:00
7	100.207	500.691	15	0.007	1.29	6:35:00
8	100.208	500.692	14	0.007	1.37	6:36:00
9	100.203	500.693	16	0.009	1.20	6:37:00
10	100.206	500.693	15	0.009	1.27	6:38:00
11	100.209	500.693	15	0.008	1.28	6:39:00
12	100.206	500.693	15	0.008	1.20	6:40:00
13	100.205	500.693	16	0.009	1.18	6:41:00
14	100.209	500.692	15	0.009	1.21	6:42:00
15	100.211	500.692	14	0.009	1.32	6:43:00
16	100.208	500.692	13	0.009	1.36	6:44:00
17	100.210	500.693	14	0.009	1.34	6:45:00
18	100.212	500.693	13	0.008	1.42	6:46:00
19	100.210	500.690	14	0.009	1.30	6:47:00
20	100.209	500.691	14	0.008	1.30	6:48:00
21	100.209	500.692	14	0.009	1.32	6:49:00
22	100.210	500.695	14	0.009	1.30	6:50:00
23	100.208	500.693	14	0.010	1.34	6:51:00
24	100.210	500.693	14	0.009	1.34	6:52:00
25	100.211	500.698	12	0.008	1.55	6:53:00
26	100.212	500.698	12	0.008	1.58	6:54:00
27	100.210	500.699	12	0.007	1.58	6:55:00
28	100.210	500.695	12	0.007	1.58	6:56:00
29	100.209	500.695	12	0.008	1.58	6:57:00
30	100.210	500.695	12	0.008	1.51	6:58:00
31	100.211	500.696	13	0.008	1.39	6:59:00
32	100.212	500.695	13	0.008	1.37	7:00:00
33	100.212	500.696	13	0.007	1.42	7:01:00
34	100.210	500.696	13	0.007	1.41	7:02:00
35	100.210	500.697	13	0.007	1.42	7:03:00
36	100.210	500.696	12	0.007	1.53	7:04:00

37	100.207	500.698	13	0.008	1.40	7:05:00
38	100.210	500.696	12	0.007	1.61	7:06:00
39	100.210	500.697	12	0.007	1.69	7:07:00
40	100.209	500.696	13	0.007	1.59	7:08:00
41	100.209	500.697	12	0.007	1.67	7:09:00
42	100.211	500.699	13	0.008	1.65	7:10:00
43	100.206	500.701	13	0.009	1.55	7:11:00
44	100.206	500.700	13	0.009	1.57	7:12:00
45	100.208	500.698	12	0.009	1.67	7:13:00
46	100.212	500.697	12	0.008	1.84	7:14:00
47	100.211	500.697	12	0.008	1.66	7:15:00
48	100.211	500.699	12	0.006	1.72	7:16:00
49	100.210	500.697	13	0.006	1.64	7:17:00
50	100.212	500.694	13	0.006	1.67	7:18:00
51	100.210	500.695	13	0.006	1.61	7:19:00
52	100.208	500.697	14	0.007	1.44	7:20:00
53	100.209	500.698	13	0.006	1.58	7:21:00
54	100.206	500.700	14	0.007	1.50	7:22:00
55	100.208	500.700	14	0.007	1.51	7:23:00
56	100.208	500.699	13	0.007	1.57	7:24:00
57	100.207	500.699	13	0.007	1.56	7:25:00
58	100.208	500.700	13	0.007	1.56	7:26:00
59	100.206	500.701	14	0.007	1.48	7:27:00
60	100.207	500.699	14	0.007	1.55	7:28:00
61	100.211	500.697	13	0.006	1.70	7:29:00
62	100.211	500.698	13	0.006	1.65	7:30:00
63	100.209	500.699	13	0.006	1.70	7:31:00
64	100.212	500.700	13	0.006	1.70	7:32:00
65	100.213	500.698	13	0.006	1.70	7:33:00
66	100.213	500.700	13	0.006	1.67	7:34:00
67	100.211	500.699	13	0.006	1.68	7:35:00
68	100.210	500.700	14	0.007	1.64	7:36:00
69	100.208	500.698	14	0.007	1.61	7:37:00
70	100.209	500.698	13	0.006	1.66	7:38:00
71	100.209	500.698	14	0.007	1.64	7:39:00
72	100.211	500.699	14	0.007	1.64	7:40:00
73	100.213	500.699	13	0.006	1.65	7:41:00
74	100.216	500.701	14	0.007	1.47	7:42:00
75	100.208	500.700	15	0.007	1.48	7:43:00
76	100.210	500.698	15	0.007	1.48	7:44:00
77	100.209	500.698	15	0.008	1.48	7:45:00

78	100.208	500.697	15	0.007	1.48	7:46:00
79	100.209	500.697	14	0.006	1.48	7:47:00
80	100.210	500.698	14	0.006	1.49	7:48:00
81	100.208	500.698	14	0.006	1.55	7:49:00
82	100.209	500.700	15	0.007	1.48	7:50:00
83	100.206	500.700	15	0.007	1.49	7:51:00
84	100.205	500.700	15	0.006	1.49	7:52:00
85	100.207	500.700	14	0.006	1.52	7:53:00
86	100.212	500.699	15	0.006	1.53	7:54:00
87	100.208	500.698	16	0.006	1.48	7:55:00
88	100.209	500.700	16	0.007	1.48	7:56:00
89	100.210	500.701	15	0.007	1.51	7:57:00
90	100.208	500.700	16	0.007	1.49	7:58:00
91	100.207	500.699	15	0.007	1.49	7:59:00
92	100.209	500.700	15	0.006	1.56	8:00:00
93	100.208	500.699	14	0.006	1.57	8:01:00
94	100.208	500.700	15	0.006	1.53	8:02:00
95	100.209	500.700	15	0.006	1.56	8:03:00
96	100.209	500.700	15	0.006	1.56	8:04:00
97	100.210	500.701	15	0.006	1.50	8:05:00
98	100.212	500.704	14	0.006	1.57	8:06:00
99	100.212	500.702	15	0.006	1.48	8:07:00
100	100.212	500.700	15	0.006	1.48	8:08:00
101	100.212	500.698	15	0.006	1.48	8:09:00
102	100.210	500.698	15	0.006	1.50	8:10:00
103	100.212	500.699	15	0.006	1.41	8:11:00
104	100.212	500.702	16	0.007	1.34	8:12:00
105	100.209	500.702	15	0.006	1.48	8:13:00
106	100.206	500.700	15	0.006	1.48	8:14:00
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108	100.206	500.695	16	0.008	1.26	8:16:00
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111	100.205	500.689	16	0.007	1.25	8:19:00
112	100.207	500.692	16	0.007	1.25	8:20:00
113	100.208	500.692	16	0.008	1.25	8:21:00
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116	100.206	500.698	15	0.007	1.48	8:24:00
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118	100.207	500.698	16	0.008	1.48	8:26:00

119	100.208	500.697	16	0.008	1.48	8:27:00
120	100.208	500.699	15	0.008	1.53	8:28:00
121	100.204	500.700	15	0.008	1.57	8:29:00
122	100.203	500.697	15	0.007	1.57	8:30:00
123	100.205	500.696	14	0.007	1.57	8:31:00
124	100.206	500.697	15	0.008	1.57	8:32:00
125	100.205	500.696	15	0.007	1.57	8:33:00
126	100.207	500.697	15	0.007	1.59	8:34:00
127	100.212	500.702	16	0.008	1.25	8:35:00
128	100.211	500.700	16	0.007	1.25	8:36:00
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131	100.209	500.699	16	0.007	1.25	8:39:00
132	100.209	500.699	16	0.007	1.25	8:40:00
133	100.208	500.698	16	0.006	1.25	8:41:00
134	100.208	500.700	16	0.007	1.30	8:42:00
135	100.208	500.701	15	0.006	1.34	8:43:00
136	100.210	500.702	15	0.007	1.34	8:44:00
137	100.208	500.699	15	0.007	1.34	8:45:00
138	100.206	500.698	15	0.007	1.34	8:46:00
139	100.205	500.695	15	0.007	1.36	8:47:00
140	100.206	500.695	14	0.008	1.43	8:48:00
141	100.204	500.694	14	0.008	1.45	8:49:00
142	100.204	500.695	14	0.008	1.43	8:50:00
143	100.202	500.694	15	0.009	1.34	8:51:00
144	100.202	500.692	15	0.008	1.42	8:52:00
145	100.203	500.692	15	0.008	1.43	8:53:00
146	100.203	500.694	15	0.009	1.43	8:54:00
147	100.202	500.693	15	0.009	1.47	8:55:00
148	100.203	500.693	15	0.009	1.43	8:56:00
149	100.203	500.695	16	0.009	1.25	8:57:00
150	100.204	500.700	16	0.009	1.27	8:58:00
151	100.204	500.698	16	0.010	1.25	8:59:00
152	100.205	500.700	16	0.009	1.28	9:00:00
153	100.204	500.700	15	0.008	1.32	9:01:00
154	100.207	500.699	14	0.007	1.45	9:02:00
155	100.206	500.700	14	0.007	1.46	9:03:00
156	100.206	500.699	15	0.007	1.41	9:04:00
157	100.202	500.698	15	0.007	1.35	9:05:00
158	100.206	500.698	15	0.006	1.40	9:06:00
159	100.205	500.697	16	0.007	1.35	9:07:00

160	100.206	500.698	16	0.007	1.31	9:08:00
161	100.206	500.697	17	0.006	1.25	9:09:00
162	100.207	500.698	17	0.006	1.25	9:10:00
163	100.208	500.700	17	0.006	1.25	9:11:00
164	100.206	500.700	17	0.007	1.25	9:12:00
165	100.205	500.701	17	0.007	1.25	9:13:00
166	100.206	500.703	16	0.007	1.25	9:14:00
167	100.207	500.703	16	0.007	1.25	9:15:00
168	100.204	500.704	17	0.007	1.25	9:16:00
169	100.203	500.700	18	0.007	1.25	9:17:00
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172	100.205	500.697	18	0.008	1.28	9:20:00
173	100.206	500.697	18	0.007	1.25	9:21:00
174	100.205	500.697	18	0.007	1.25	9:22:00
175	100.206	500.696	18	0.006	1.27	9:23:00
176	100.205	500.697	18	0.006	1.25	9:24:00
177	100.203	500.699	18	0.006	1.25	9:25:00
178	100.204	500.700	18	0.007	1.25	9:26:00
179	100.204	500.700	18	0.006	1.25	9:27:00
180	100.208	500.699	18	0.005	1.30	9:28:00
181	100.208	500.697	17	0.005	1.43	9:29:00
182	100.208	500.700	17	0.006	1.43	9:30:00
183	100.211	500.699	17	0.006	1.36	9:31:00
184	100.212	500.699	18	0.006	1.21	9:32:00
185	100.212	500.700	18	0.006	1.25	9:33:00
186	100.211	500.699	19	0.007	1.23	9:34:00
187	100.210	500.696	18	0.007	1.27	9:35:00
188	100.210	500.694	19	0.008	1.21	9:36:00
189	100.207	500.690	19	0.008	1.25	9:37:00
190	100.208	500.693	19	0.008	1.25	9:38:00
191	100.208	500.697	18	0.008	1.21	9:39:00
192	100.208	500.696	19	0.009	1.21	9:40:00
193	100.210	500.692	19	0.009	1.30	9:41:00
194	100.214	500.688	18	0.008	1.30	9:42:00
195	100.215	500.689	18	0.007	1.21	9:43:00
196	100.212	500.692	18	0.008	1.35	9:44:00
197	100.209	500.695	17	0.008	1.43	9:45:00
198	100.213	500.693	17	0.007	1.53	9:46:00
199	100.215	500.694	17	0.008	1.52	9:47:00
200	100.214	500.697	16	0.007	1.52	9:48:00

201	100.213	500.697	17	0.008	1.51	9:49:00
202	100.212	500.697	16	0.008	1.61	9:50:00
203	100.214	500.695	16	0.007	1.63	9:51:00
204	100.215	500.694	17	0.007	1.56	9:52:00
205	100.214	500.693	16	0.008	1.62	9:53:00
206	100.213	500.691	16	0.008	1.58	9:54:00
207	100.211	500.688	16	0.008	1.59	9:55:00
208	100.213	500.687	16	0.009	1.62	9:56:00
209	100.211	500.687	17	0.009	1.54	9:57:00
210	100.208	500.689	17	0.009	1.54	9:58:00
211	100.210	500.687	17	0.009	1.52	9:59:00
212	100.211	500.687	17	0.009	1.52	10:00:00
213	100.208	500.685	17	0.009	1.52	10:01:00
214	100.210	500.685	16	0.009	1.52	10:02:00
215	100.211	500.684	16	0.010	1.52	10:03:00
216	100.209	500.684	16	0.010	1.52	10:04:00
217	100.208	500.684	16	0.010	1.65	10:05:00
218	100.211	500.683	15	0.010	1.84	10:06:00
219	100.209	500.687	16	0.009	1.52	10:07:00
220	100.208	500.688	15	0.008	1.63	10:08:00
221	100.208	500.686	15	0.008	1.61	10:09:00
222	100.208	500.684	15	0.008	1.69	10:10:00
223	100.208	500.684	16	0.008	1.55	10:11:00
224	100.206	500.686	16	0.007	1.62	10:12:00
225	100.205	500.686	15	0.008	1.84	10:13:00
226	100.208	500.690	15	0.007	1.59	10:14:00
227	100.212	500.690	14	0.007	1.83	10:15:00
228	100.211	500.692	14	0.007	1.92	10:16:00
229	100.211	500.692	14	0.006	1.92	10:17:00
230	100.215	500.692	14	0.006	2.07	10:18:00
231	100.211	500.693	13	0.006	2.37	10:19:00
232	100.210	500.697	13	0.006	2.39	10:20:00
233	100.210	500.697	14	0.007	1.83	10:21:00
234	100.212	500.697	13	0.006	2.20	10:22:00
235	100.212	500.695	13	0.007	2.34	10:23:00
236	100.212	500.694	14	0.007	2.04	10:24:00
237	100.211	500.695	15	0.007	1.75	10:25:00
238	100.212	500.695	15	0.007	1.75	10:26:00
239	100.214	500.695	14	0.006	1.95	10:27:00
240	100.213	500.695	14	0.006	2.11	10:28:00
241	100.211	500.696	14	0.007	2.04	10:29:00

242	100.212	500.697	14	0.007	1.94	10:30:00
243	100.210	500.696	14	0.007	1.91	10:31:00
244	100.209	500.696	14	0.007	1.89	10:32:00
245	100.211	500.697	13	0.007	2.11	10:33:00
246	100.208	500.696	14	0.006	1.84	10:34:00
247	100.207	500.692	14	0.007	1.84	10:35:00
248	100.207	500.694	14	0.007	1.84	10:36:00
249	100.205	500.692	14	0.006	1.90	10:37:00
250	100.206	500.693	14	0.006	1.81	10:38:00
251	100.209	500.692	14	0.006	1.83	10:39:00
252	100.208	500.692	14	0.006	1.75	10:40:00
253	100.210	500.691	14	0.007	1.75	10:41:00
254	100.214	500.689	14	0.006	1.75	10:42:00
255	100.213	500.686	14	0.007	1.75	10:43:00
256	100.214	500.689	14	0.007	1.65	10:44:00
257	100.213	500.686	14	0.006	1.70	10:45:00
258	100.212	500.690	14	0.006	1.75	10:46:00
259	100.211	500.695	14	0.006	1.68	10:47:00
260	100.212	500.697	14	0.006	1.63	10:48:00
261	100.211	500.696	14	0.006	1.65	10:49:00
262	100.210	500.697	14	0.007	1.66	10:50:00
263	100.210	500.695	14	0.007	1.66	10:51:00
264	100.212	500.688	15	0.008	1.58	10:52:00
265	100.209	500.690	16	0.009	1.50	10:53:00
266	100.211	500.689	16	0.008	1.43	10:54:00
267	100.213	500.689	16	0.008	1.43	10:55:00
268	100.212	500.690	17	0.008	1.39	10:56:00
269	100.211	500.690	17	0.008	1.34	10:57:00
270	100.208	500.695	17	0.007	1.37	10:58:00
271	100.206	500.691	17	0.008	1.34	10:59:00
272	100.209	500.689	17	0.008	1.34	11:00:00
273	100.203	500.693	16	0.009	1.43	11:01:00
274	100.202	500.691	16	0.008	1.45	11:02:00
275	100.203	500.691	15	0.009	1.47	11:03:00
276	100.203	500.689	16	0.009	1.42	11:04:00
277	100.201	500.689	16	0.009	1.40	11:05:00
278	100.203	500.691	17	0.009	1.37	11:06:00
279	100.202	500.698	16	0.009	1.39	11:07:00
280	100.202	500.702	17	0.009	1.36	11:08:00
281	100.200	500.700	16	0.009	1.42	11:09:00
282	100.201	500.699	16	0.009	1.34	11:10:00

283	100.201	500.702	16	0.009	1.34	11:11:00
284	100.202	500.700	16	0.009	1.34	11:12:00
285	100.204	500.696	16	0.009	1.37	11:13:00
286	100.207	500.692	15	0.008	1.47	11:14:00
287	100.208	500.690	15	0.007	1.48	11:15:00
288	100.208	500.689	15	0.006	1.48	11:16:00
289	100.207	500.689	15	0.006	1.47	11:17:00
290	100.205	500.691	15	0.007	1.48	11:18:00
291	100.204	500.690	15	0.006	1.47	11:19:00
292	100.206	500.691	15	0.006	1.48	11:20:00
293	100.205	500.693	16	0.007	1.35	11:21:00
294	100.208	500.692	16	0.009	1.36	11:22:00
295	100.207	500.696	16	0.007	1.38	11:23:00
296	100.208	500.694	16	0.007	1.38	11:24:00
297	100.208	500.698	16	0.008	1.34	11:25:00
298	100.208	500.698	16	0.009	1.34	11:26:00
299	100.209	500.698	16	0.008	1.34	11:27:00
300	100.205	500.698	16	0.008	1.34	11:28:00
301	100.205	500.701	16	0.008	1.34	11:29:00
302	100.209	500.699	16	0.007	1.34	11:30:00
303	100.211	500.699	15	0.007	1.44	11:31:00
304	100.215	500.699	16	0.008	1.29	11:32:00
305	100.213	500.700	15	0.008	1.45	11:33:00
306	100.212	500.698	14	0.008	1.53	11:34:00
307	100.213	500.695	14	0.007	1.57	11:35:00
308	100.212	500.693	14	0.007	1.54	11:36:00
309	100.210	500.690	14	0.007	1.49	11:37:00
310	100.211	500.693	15	0.007	1.36	11:38:00
311	100.212	500.697	15	0.007	1.34	11:39:00
312	100.210	500.696	15	0.007	1.39	11:40:00
313	100.210	500.694	15	0.006	1.39	11:41:00
314	100.212	500.692	15	0.006	1.41	11:42:00
315	100.212	500.690	15	0.007	1.42	11:43:00
316	100.213	500.688	15	0.007	1.42	11:44:00
317	100.212	500.689	15	0.007	1.30	11:45:00
318	100.212	500.689	15	0.006	1.33	11:46:00
319	100.210	500.693	16	0.007	1.17	11:47:00
320	100.211	500.692	16	0.007	1.17	11:48:00
321	100.210	500.691	15	0.007	1.31	11:49:00
322	100.209	500.688	14	0.007	1.29	11:50:00
323	100.207	500.688	14	0.008	1.30	11:51:00

324	100.204	500.690	14	0.007	1.30	11:52:00
325	100.204	500.691	14	0.008	1.28	11:53:00
326	100.202	500.685	15	0.008	1.25	11:54:00
327	100.201	500.681	15	0.007	1.25	11:55:00
328	100.198	500.685	16	0.008	1.25	11:56:00
329	100.197	500.689	16	0.008	1.27	11:57:00
330	100.198	500.691	15	0.008	1.36	11:58:00
331	100.201	500.686	15	0.008	1.39	11:59:00
332	100.200	500.687	15	0.008	1.39	12:00:00
333	100.202	500.691	15	0.009	1.39	12:01:00
334	100.203	500.695	15	0.009	1.39	12:02:00
335	100.204	500.698	15	0.010	1.39	12:03:00
336	100.204	500.699	15	0.011	1.33	12:04:00
337	100.205	500.698	15	0.010	1.33	12:05:00
338	100.203	500.700	15	0.010	1.32	12:06:00
339	100.202	500.700	15	0.010	1.30	12:07:00
340	100.204	500.693	15	0.009	1.30	12:08:00
341	100.205	500.692	15	0.008	1.30	12:09:00
342	100.207	500.694	15	0.008	1.30	12:10:00
343	100.210	500.695	15	0.008	1.38	12:11:00
344	100.211	500.698	14	0.009	1.48	12:12:00
345	100.209	500.699	14	0.009	1.48	12:13:00
346	100.208	500.699	14	0.009	1.48	12:14:00
347	100.206	500.697	14	0.009	1.48	12:15:00
348	100.206	500.697	14	0.008	1.48	12:16:00
349	100.207	500.698	14	0.009	1.48	12:17:00
350	100.207	500.695	14	0.007	1.52	12:18:00
351	100.208	500.696	14	0.007	1.48	12:19:00
352	100.208	500.696	14	0.007	1.48	12:20:00
353	100.210	500.697	14	0.006	1.48	12:21:00
354	100.210	500.697	15	0.007	1.39	12:22:00
355	100.210	500.698	15	0.008	1.39	12:23:00
356	100.210	500.697	15	0.008	1.35	12:24:00
357	100.210	500.693	16	0.008	1.17	12:25:00
358	100.206	500.693	16	0.008	1.17	12:26:00
359	100.207	500.693	16	0.008	1.20	12:27:00
360	100.204	500.693	16	0.008	1.17	12:28:00
361	100.204	500.695	16	0.009	1.18	12:29:00
362	100.205	500.693	15	0.008	1.33	12:30:00
363	100.208	500.695	14	0.006	1.37	12:31:00
364	100.209	500.694	15	0.007	1.30	12:32:00

365	100.210	500.691	16	0.009	1.21	12:33:00
366	100.209	500.695	15	0.008	1.29	12:34:00
367	100.209	500.695	15	0.009	1.34	12:35:00
368	100.209	500.699	14	0.007	1.39	12:36:00
369	100.211	500.699	14	0.006	1.39	12:37:00
370	100.209	500.698	15	0.006	1.39	12:38:00
371	100.209	500.696	14	0.006	1.38	12:39:00
372	100.207	500.698	14	0.006	1.39	12:40:00
373	100.209	500.696	14	0.006	1.39	12:41:00
374	100.212	500.696	14	0.006	1.39	12:42:00
375	100.211	500.694	14	0.006	1.38	12:43:00
376	100.212	500.693	15	0.006	1.30	12:44:00
377	100.211	500.695	15	0.006	1.32	12:45:00
378	100.211	500.695	14	0.006	1.36	12:46:00
379	100.213	500.695	14	0.006	1.39	12:47:00
380	100.213	500.696	14	0.006	1.36	12:48:00
381	100.213	500.694	14	0.006	1.38	12:49:00
382	100.215	500.696	14	0.006	1.38	12:50:00
383	100.212	500.694	14	0.006	1.39	12:51:00
384	100.209	500.694	14	0.006	1.38	12:52:00
385	100.208	500.694	14	0.006	1.39	12:53:00
386	100.209	500.693	14	0.007	1.39	12:54:00
387	100.209	500.694	15	0.007	1.27	12:55:00
388	100.208	500.696	15	0.008	1.29	12:56:00
389	100.208	500.693	14	0.007	1.30	12:57:00
390	100.207	500.696	14	0.007	1.28	12:58:00
391	100.209	500.698	15	0.007	1.25	12:59:00
392	100.209	500.701	14	0.006	1.28	13:00:00
393	100.211	500.701	14	0.007	1.30	13:01:00
394	100.211	500.702	14	0.007	1.30	13:02:00
395	100.210	500.701	14	0.007	1.30	13:03:00
396	100.210	500.701	14	0.007	1.30	13:04:00
397	100.209	500.699	14	0.007	1.30	13:05:00
398	100.209	500.701	14	0.007	1.30	13:06:00
399	100.210	500.702	14	0.008	1.30	13:07:00
400	100.211	500.702	14	0.008	1.30	13:08:00
401	100.213	500.699	15	0.008	1.22	13:09:00
402	100.215	500.695	15	0.008	1.23	13:10:00
403	100.214	500.698	14	0.008	1.27	13:11:00
404	100.215	500.698	15	0.008	1.24	13:12:00
405	100.219	500.698	15	0.009	1.22	13:13:00

406	100.219	500.698	15	0.008	1.22	13:14:00
407	100.218	500.699	15	0.007	1.22	13:15:00
408	100.219	500.698	15	0.007	1.22	13:16:00
409	100.216	500.701	15	0.008	1.20	13:17:00
410	100.214	500.701	15	0.007	1.15	13:18:00
411	100.214	500.704	14	0.007	1.29	13:19:00
412	100.217	500.706	15	0.007	1.14	13:20:00
413	100.219	500.704	15	0.007	1.18	13:21:00
414	100.220	500.704	15	0.008	1.14	13:22:00
415	100.220	500.701	15	0.008	1.14	13:23:00
416	100.223	500.700	14	0.009	1.32	13:24:00
417	100.222	500.700	14	0.009	1.33	13:25:00
418	100.219	500.697	15	0.009	1.31	13:26:00
419	100.218	500.694	15	0.010	1.22	13:27:00
420	100.219	500.691	15	0.010	1.27	13:28:00
421	100.221	500.688	14	0.010	1.36	13:29:00
422	100.219	500.688	14	0.010	1.34	13:30:00
423	100.220	500.690	15	0.009	1.28	13:31:00
424	100.219	500.691	15	0.009	1.29	13:32:00
425	100.218	500.687	15	0.008	1.22	13:33:00
426	100.221	500.688	15	0.008	1.23	13:34:00
427	100.221	500.686	15	0.010	1.22	13:35:00
428	100.220	500.686	15	0.010	1.22	13:36:00
429	100.221	500.688	15	0.010	1.22	13:37:00
430	100.217	500.690	15	0.009	1.25	13:38:00
431	100.217	500.689	15	0.010	1.18	13:39:00
432	100.220	500.688	15	0.010	1.22	13:40:00
433	100.217	500.691	14	0.009	1.36	13:41:00
434	100.217	500.691	13	0.009	1.52	13:42:00
435	100.218	500.692	13	0.009	1.66	13:43:00
436	100.217	500.693	13	0.009	1.66	13:44:00
437	100.215	500.694	13	0.008	1.66	13:45:00
438	100.218	500.698	13	0.008	1.66	13:46:00
439	100.219	500.702	13	0.008	1.66	13:47:00
440	100.219	500.704	13	0.008	1.62	13:48:00
441	100.215	500.704	13	0.008	1.61	13:49:00
442	100.213	500.701	13	0.008	1.61	13:50:00
443	100.210	500.697	13	0.006	1.61	13:51:00
444	100.212	500.697	13	0.006	1.66	13:52:00
445	100.211	500.697	13	0.006	1.61	13:53:00
446	100.211	500.697	13	0.006	1.66	13:54:00

447	100.210	500.698	12	0.007	1.91	13:55:00
448	100.212	500.700	13	0.007	1.61	13:56:00
449	100.211	500.700	13	0.007	1.60	13:57:00
450	100.209	500.701	13	0.007	1.53	13:58:00
451	100.210	500.701	13	0.007	1.53	13:59:00
452	100.207	500.700	13	0.007	1.53	14:00:00
453	100.209	500.700	13	0.007	1.53	14:01:00
454	100.210	500.700	13	0.006	1.55	14:02:00
455	100.213	500.701	13	0.007	1.71	14:03:00
456	100.213	500.701	13	0.008	1.53	14:04:00
457	100.207	500.698	12	0.006	1.99	14:05:00
458	100.208	500.697	12	0.006	2.01	14:06:00
459	100.208	500.697	12	0.006	2.01	14:07:00
460	100.209	500.695	13	0.007	1.55	14:08:00
461	100.208	500.692	13	0.007	1.53	14:09:00
462	100.207	500.690	13	0.007	1.56	14:10:00
463	100.204	500.691	13	0.007	1.61	14:11:00
464	100.201	500.694	13	0.006	1.61	14:12:00
465	100.203	500.697	13	0.006	1.61	14:13:00
466	100.202	500.698	13	0.006	1.69	14:14:00
467	100.203	500.698	13	0.006	1.61	14:15:00
468	100.203	500.699	13	0.006	1.61	14:16:00
469	100.204	500.698	13	0.006	1.61	14:17:00
470	100.204	500.697	13	0.007	1.68	14:18:00
471	100.206	500.696	13	0.007	1.75	14:19:00
472	100.209	500.697	12	0.007	1.89	14:20:00
473	100.206	500.696	13	0.007	1.70	14:21:00
474	100.206	500.700	12	0.006	1.84	14:22:00
475	100.204	500.702	13	0.007	1.71	14:23:00
476	100.206	500.701	13	0.007	1.75	14:24:00
477	100.206	500.699	13	0.006	1.70	14:25:00
478	100.205	500.699	13	0.007	1.72	14:26:00
479	100.205	500.701	13	0.007	1.70	14:27:00
480	100.207	500.702	13	0.007	1.70	14:28:00
481	100.210	500.700	13	0.007	1.74	14:29:00
482	100.210	500.699	13	0.007	1.70	14:30:00
483	100.206	500.697	13	0.006	1.70	14:31:00
484	100.205	500.694	13	0.006	1.66	14:32:00
485	100.204	500.694	14	0.006	1.63	14:33:00
486	100.208	500.695	14	0.007	1.62	14:34:00
487	100.210	500.698	14	0.007	1.61	14:35:00

488	100.213	500.699	14	0.007	1.67	14:36:00
489	100.213	500.699	14	0.007	1.70	14:37:00
490	100.213	500.698	13	0.007	1.70	14:38:00
491	100.210	500.697	13	0.007	1.70	14:39:00
492	100.208	500.695	14	0.006	1.70	14:40:00
493	100.207	500.694	14	0.007	1.62	14:41:00
494	100.211	500.693	15	0.008	1.39	14:42:00
495	100.209	500.694	15	0.009	1.39	14:43:00
496	100.210	500.695	15	0.009	1.39	14:44:00
497	100.208	500.694	15	0.009	1.39	14:45:00
498	100.209	500.693	15	0.008	1.39	14:46:00
499	100.208	500.696	15	0.009	1.41	14:47:00
500	100.206	500.697	14	0.008	1.45	14:48:00
501	100.207	500.697	15	0.008	1.42	14:49:00
502	100.210	500.696	15	0.007	1.39	14:50:00
503	100.209	500.701	15	0.007	1.41	14:51:00
504	100.210	500.702	14	0.007	1.48	14:52:00
505	100.210	500.702	15	0.007	1.41	14:53:00
506	100.208	500.704	14	0.008	1.46	14:54:00
507	100.209	500.705	14	0.008	1.48	14:55:00
508	100.212	500.708	14	0.008	1.48	14:56:00
509	100.209	500.707	14	0.009	1.44	14:57:00
510	100.211	500.708	14	0.008	1.46	14:58:00
511	100.211	500.708	14	0.007	1.48	14:59:00
512	100.212	500.706	13	0.007	1.55	15:00:00
513	100.211	500.700	13	0.007	1.76	15:01:00
514	100.213	500.701	14	0.007	1.52	15:02:00
515	100.212	500.703	14	0.009	1.58	15:03:00
516	100.214	500.702	13	0.009	1.67	15:04:00
517	100.217	500.702	14	0.008	1.39	15:05:00
518	100.215	500.702	14	0.008	1.39	15:06:00
519	100.217	500.698	13	0.007	1.60	15:07:00
520	100.217	500.696	13	0.007	1.61	15:08:00
521	100.215	500.696	13	0.008	1.61	15:09:00
522	100.211	500.697	13	0.008	1.61	15:10:00
523	100.208	500.698	13	0.008	1.58	15:11:00
524	100.210	500.697	13	0.007	1.57	15:12:00
525	100.209	500.696	13	0.007	1.57	15:13:00
526	100.211	500.696	13	0.007	1.57	15:14:00
527	100.210	500.695	13	0.007	1.50	15:15:00
528	100.211	500.695	13	0.007	1.48	15:16:00

529	100.211	500.694	13	0.007	1.48	15:17:00
530	100.211	500.697	14	0.007	1.32	15:18:00
531	100.213	500.700	14	0.007	1.22	15:19:00
532	100.213	500.700	14	0.007	1.22	15:20:00
533	100.212	500.699	14	0.007	1.22	15:21:00
534	100.211	500.699	14	0.007	1.22	15:22:00
535	100.211	500.700	13	0.007	1.33	15:23:00
536	100.209	500.697	13	0.007	1.38	15:24:00
537	100.207	500.695	13	0.007	1.39	15:25:00
538	100.202	500.697	13	0.007	1.41	15:26:00
539	100.203	500.698	13	0.007	1.39	15:27:00
540	100.205	500.697	13	0.007	1.39	15:28:00
541	100.206	500.696	13	0.007	1.39	15:29:00
542	100.208	500.693	13	0.007	1.39	15:30:00
543	100.206	500.693	13	0.007	1.39	15:31:00
544	100.209	500.689	13	0.007	1.39	15:32:00
545	100.209	500.690	13	0.008	1.39	15:33:00
546	100.209	500.690	13	0.008	1.39	15:34:00
547	100.211	500.685	13	0.009	1.39	15:35:00
548	100.212	500.685	13	0.010	1.39	15:36:00
549	100.215	500.684	13	0.010	1.39	15:37:00
550	100.217	500.680	13	0.011	1.39	15:38:00
551	100.218	500.680	13	0.012	1.35	15:39:00
552	100.219	500.679	14	0.013	1.30	15:40:00
553	100.217	500.681	14	0.012	1.29	15:41:00
554	100.220	500.683	14	0.012	1.26	15:42:00
555	100.221	500.685	15	0.011	1.22	15:43:00
556	100.224	500.686	15	0.011	1.23	15:44:00
557	100.220	500.690	14	0.011	1.29	15:45:00
558	100.219	500.694	14	0.010	1.30	15:46:00
559	100.218	500.692	14	0.011	1.30	15:47:00
560	100.217	500.699	13	0.009	1.48	15:48:00
561	100.214	500.702	13	0.009	1.49	15:49:00
562	100.213	500.702	13	0.009	1.62	15:50:00
563	100.215	500.700	14	0.009	1.28	15:51:00
564	100.217	500.698	14	0.009	1.24	15:52:00
565	100.214	500.700	14	0.008	1.35	15:53:00
566	100.216	500.695	14	0.009	1.30	15:54:00
567	100.218	500.692	15	0.008	1.21	15:55:00
568	100.218	500.691	14	0.008	1.29	15:56:00
569	100.217	500.692	14	0.007	1.30	15:57:00

570	100.214	500.691	14	0.007	1.30	15:58:00
571	100.215	500.691	14	0.007	1.30	15:59:00
572	100.211	500.693	14	0.008	1.30	16:00:00
573	100.210	500.695	14	0.007	1.30	16:01:00
574	100.210	500.695	14	0.007	1.30	16:02:00
575	100.210	500.697	14	0.007	1.30	16:03:00
576	100.208	500.697	14	0.007	1.30	16:04:00
577	100.208	500.699	14	0.008	1.32	16:05:00
578	100.207	500.702	13	0.009	1.38	16:06:00
579	100.209	500.699	13	0.009	1.38	16:07:00
580	100.212	500.696	14	0.009	1.31	16:08:00
581	100.212	500.699	13	0.008	1.40	16:09:00
582	100.210	500.699	13	0.008	1.48	16:10:00
583	100.211	500.697	13	0.008	1.48	16:11:00
584	100.211	500.698	13	0.008	1.48	16:12:00
585	100.209	500.703	13	0.008	1.48	16:13:00
586	100.207	500.703	13	0.009	1.48	16:14:00
587	100.208	500.704	13	0.009	1.48	16:15:00
588	100.208	500.699	13	0.008	1.48	16:16:00
589	100.210	500.699	13	0.008	1.48	16:17:00
590	100.208	500.699	13	0.007	1.48	16:18:00
591	100.208	500.699	14	0.007	1.46	16:19:00
592	100.208	500.700	13	0.007	1.56	16:20:00
593	100.208	500.699	13	0.008	1.55	16:21:00
594	100.210	500.699	14	0.008	1.43	16:22:00
595	100.210	500.698	13	0.008	1.59	16:23:00
596	100.211	500.700	13	0.008	1.68	16:24:00
597	100.204	500.705	13	0.009	1.66	16:25:00
598	100.203	500.707	13	0.009	1.66	16:26:00
599	100.204	500.706	13	0.010	1.66	16:27:00
600	100.203	500.705	13	0.009	1.66	16:28:00
601	100.202	500.705	13	0.009	1.66	16:29:00
602	100.202	500.707	13	0.008	1.66	16:30:00
603	100.205	500.702	13	0.008	1.64	16:31:00
604	100.207	500.702	14	0.008	1.57	16:32:00
605	100.208	500.701	14	0.009	1.57	16:33:00
606	100.205	500.702	14	0.008	1.57	16:34:00
607	100.205	500.700	14	0.008	1.57	16:35:00
608	100.206	500.700	14	0.008	1.57	16:36:00
609	100.208	500.698	14	0.008	1.57	16:37:00
610	100.207	500.698	13	0.007	1.66	16:38:00

611	100.209	500.699	13	0.007	1.76	16:39:00
612	100.210	500.696	13	0.006	1.79	16:40:00
613	100.211	500.694	14	0.007	1.67	16:41:00
614	100.213	500.694	14	0.007	1.65	16:42:00
615	100.213	500.695	13	0.007	1.79	16:43:00
616	100.213	500.695	13	0.006	1.81	16:44:00
617	100.214	500.696	13	0.006	1.91	16:45:00
618	100.216	500.696	13	0.006	1.91	16:46:00
619	100.216	500.697	13	0.006	1.88	16:47:00
620	100.217	500.693	13	0.006	1.88	16:48:00
621	100.218	500.693	13	0.006	1.88	16:49:00
622	100.218	500.694	13	0.007	1.95	16:50:00
623	100.217	500.692	13	0.007	1.97	16:51:00
624	100.216	500.694	13	0.007	1.97	16:52:00
625	100.213	500.696	13	0.007	1.97	16:53:00
626	100.213	500.695	13	0.007	1.97	16:54:00
627	100.212	500.696	13	0.006	1.97	16:55:00
628	100.211	500.697	13	0.006	2.04	16:56:00
629	100.213	500.695	12	0.006	2.16	16:57:00
630	100.213	500.698	13	0.006	1.97	16:58:00
631	100.215	500.695	14	0.007	1.56	16:59:00
632	100.217	500.695	14	0.007	1.57	17:00:00
633	100.217	500.695	14	0.007	1.57	17:01:00
634	100.214	500.696	14	0.007	1.57	17:02:00
635	100.213	500.698	14	0.007	1.57	17:03:00
636	100.216	500.698	14	0.007	1.60	17:04:00
637	100.213	500.698	14	0.007	1.55	17:05:00
638	100.213	500.696	15	0.007	1.38	17:06:00
639	100.215	500.698	16	0.007	1.33	17:07:00
640	100.216	500.700	16	0.007	1.34	17:08:00
641	100.215	500.698	16	0.007	1.34	17:09:00
642	100.216	500.695	16	0.009	1.37	17:10:00
643	100.216	500.697	16	0.007	1.34	17:11:00
644	100.214	500.697	16	0.007	1.34	17:12:00
645	100.215	500.699	16	0.007	1.34	17:13:00
646	100.213	500.702	16	0.007	1.34	17:14:00
647	100.212	500.704	16	0.007	1.34	17:15:00
648	100.214	500.703	16	0.007	1.34	17:16:00
649	100.213	500.703	16	0.008	1.34	17:17:00
650	100.212	500.705	16	0.009	1.34	17:18:00
651	100.211	500.706	16	0.009	1.37	17:19:00

652	100.214	500.703	15	0.008	1.43	17:20:00
653	100.211	500.703	15	0.008	1.43	17:21:00
654	100.212	500.703	15	0.007	1.43	17:22:00
655	100.212	500.704	15	0.007	1.43	17:23:00
656	100.212	500.699	15	0.007	1.43	17:24:00
657	100.211	500.698	15	0.007	1.43	17:25:00
658	100.213	500.697	15	0.007	1.43	17:26:00
659	100.212	500.696	15	0.006	1.43	17:27:00
660	100.210	500.697	16	0.007	1.37	17:28:00
661	100.211	500.697	16	0.007	1.34	17:29:00
662	100.213	500.698	17	0.007	1.35	17:30:00
663	100.214	500.696	17	0.008	1.32	17:31:00
664	100.214	500.696	17	0.008	1.30	17:32:00
665	100.215	500.695	17	0.009	1.30	17:33:00
666	100.214	500.694	17	0.008	1.30	17:34:00
667	100.215	500.695	17	0.008	1.30	17:35:00
668	100.214	500.694	17	0.008	1.30	17:36:00
669	100.214	500.695	17	0.009	1.31	17:37:00
670	100.213	500.697	17	0.009	1.30	17:38:00
671	100.215	500.699	16	0.008	1.33	17:39:00
672	100.215	500.694	16	0.009	1.33	17:40:00
673	100.214	500.695	16	0.009	1.34	17:41:00
674	100.213	500.695	16	0.009	1.33	17:42:00
675	100.215	500.697	17	0.008	1.32	17:43:00
676	100.216	500.698	16	0.008	1.38	17:44:00
677	100.215	500.698	16	0.007	1.38	17:45:00
678	100.215	500.698	16	0.007	1.38	17:46:00
679	100.215	500.697	16	0.007	1.37	17:47:00
680	100.215	500.698	16	0.007	1.39	17:48:00
681	100.213	500.697	16	0.008	1.39	17:49:00
682	100.212	500.695	16	0.009	1.41	17:50:00
683	100.213	500.698	16	0.009	1.39	17:51:00
684	100.213	500.698	16	0.008	1.41	17:52:00
685	100.211	500.696	15	0.008	1.42	17:53:00
686	100.212	500.700	16	0.008	1.39	17:54:00
687	100.212	500.699	16	0.007	1.34	17:55:00
688	100.213	500.698	17	0.007	1.31	17:56:00
689	100.211	500.696	17	0.008	1.32	17:57:00
690	100.210	500.696	16	0.008	1.34	17:58:00
691	100.207	500.695	16	0.009	1.33	17:59:00
692	100.208	500.695	16	0.008	1.34	18:00:00

693	100.208	500.693	16	0.008	1.34	18:01:00
694	100.207	500.696	16	0.008	1.34	18:02:00
695	100.207	500.695	16	0.008	1.34	18:03:00
696	100.209	500.695	15	0.007	1.44	18:04:00
697	100.209	500.694	16	0.007	1.34	18:05:00
698	100.211	500.693	16	0.007	1.34	18:06:00
699	100.209	500.691	16	0.007	1.34	18:07:00
700	100.208	500.691	16	0.006	1.34	18:08:00
701	100.207	500.692	16	0.007	1.34	18:09:00
702	100.207	500.693	16	0.006	1.39	18:10:00
703	100.210	500.694	15	0.006	1.41	18:11:00
704	100.211	500.692	15	0.006	1.43	18:12:00
705	100.212	500.692	15	0.007	1.43	18:13:00
706	100.211	500.692	16	0.008	1.38	18:14:00
707	100.211	500.690	16	0.008	1.36	18:15:00
708	100.210	500.691	15	0.008	1.41	18:16:00
709	100.211	500.692	16	0.008	1.34	18:17:00
710	100.208	500.691	15	0.008	1.34	18:18:00
711	100.207	500.688	16	0.009	1.36	18:19:00
712	100.207	500.692	16	0.008	1.36	18:20:00
713	100.207	500.694	15	0.009	1.39	18:21:00
714	100.208	500.697	14	0.007	1.43	18:22:00
715	100.209	500.696	15	0.007	1.40	18:23:00
716	100.207	500.696	15	0.007	1.42	18:24:00
717	100.207	500.696	14	0.008	1.43	18:25:00
718	100.207	500.690	15	0.010	1.43	18:26:00
719	100.204	500.691	16	0.009	1.34	18:27:00
720	100.204	500.694	15	0.009	1.43	18:28:00

Multipath Present 1-Minute Subsets

Point ID	Easting	Northing	No. Satellites	Horizontal Accuracy	PDOP	Time
1	100.199	500.699	13	0.016	1.53	6:27:00
2	100.202	500.696	13	0.014	1.61	6:28:00
3	100.194	500.705	14	0.015	1.39	6:29:00
4	100.192	500.704	14	0.015	1.39	6:30:00
5	100.201	500.700	14	0.014	1.55	6:31:00
6	100.193	500.706	14	0.016	1.39	6:32:00
7	100.198	500.704	14	0.015	1.49	6:33:00
8	100.204	500.699	13	0.014	1.60	6:34:00
9	100.195	500.705	14	0.015	1.39	6:35:00
10	100.192	500.704	14	0.015	1.39	6:36:00
11	100.199	500.701	14	0.015	1.40	6:37:00
12	100.198	500.701	14	0.015	1.42	6:38:00
13	100.208	500.698	12	0.013	1.88	6:39:00
14	100.208	500.699	12	0.014	1.97	6:40:00
15	100.209	500.698	12	0.013	2.06	6:41:00
16	100.206	500.697	11	0.013	2.15	6:42:00
17	100.204	500.695	11	0.013	2.15	6:43:00
18	100.205	500.696	11	0.012	2.15	6:44:00
19	100.206	500.695	11	0.012	2.12	6:45:00
20	100.213	500.691	13	0.012	1.49	6:46:00
21	100.213	500.690	13	0.012	1.41	6:47:00
22	100.214	500.690	12	0.012	1.69	6:48:00
23	100.212	500.693	11	0.014	1.82	6:49:00
24	100.206	500.698	11	0.014	2.05	6:50:00
25	100.205	500.699	11	0.014	2.25	6:51:00
26	100.205	500.699	10	0.014	2.42	6:52:00
27	100.204	500.698	11	0.013	2.22	6:53:00
28	100.204	500.699	11	0.012	2.13	6:54:00
29	100.206	500.698	11	0.012	2.23	6:55:00
30	100.207	500.695	10	0.013	2.91	6:56:00
31	100.208	500.695	10	0.013	3.05	6:57:00
32	100.204	500.692	10	0.012	3.07	6:58:00
33	100.206	500.693	10	0.012	3.05	6:59:00
34	100.204	500.694	10	0.012	2.84	7:00:00
35	100.199	500.699	11	0.013	2.51	7:01:00
36	100.200	500.698	11	0.013	2.30	7:02:00
37	100.196	500.701	11	0.014	2.23	7:03:00
38	100.206	500.696	10	0.012	2.90	7:04:00

39	100.207	500.697	10	0.013	3.02	7:05:00
40	100.204	500.695	9	0.013	3.03	7:06:00
41	100.203	500.695	9	0.013	3.05	7:07:00
42	100.191	500.702	10	0.016	2.43	7:08:00
43	100.192	500.700	10	0.016	2.54	7:09:00
44	100.195	500.694	9	0.013	3.03	7:10:00
45	100.195	500.694	10	0.013	3.02	7:11:00
46	100.193	500.693	10	0.013	3.02	7:12:00
47	100.194	500.694	10	0.012	3.02	7:13:00
48	100.194	500.692	10	0.011	2.92	7:14:00
49	100.195	500.692	10	0.011	2.91	7:15:00
50	100.196	500.693	10	0.011	2.89	7:16:00
51	100.195	500.693	10	0.011	2.89	7:17:00
52	100.197	500.695	10	0.011	2.89	7:18:00
53	100.199	500.696	9	0.012	2.91	7:19:00
54	100.197	500.695	10	0.011	2.89	7:20:00
55	100.196	500.695	10	0.011	2.90	7:21:00
56	100.197	500.696	9	0.013	2.90	7:22:00
57	100.198	500.697	10	0.012	2.87	7:23:00
58	100.199	500.695	10	0.013	2.70	7:24:00
59	100.197	500.693	11	0.013	2.19	7:25:00
60	100.198	500.692	11	0.014	2.19	7:26:00
61	100.200	500.694	10	0.015	2.57	7:27:00
62	100.202	500.693	11	0.014	2.25	7:28:00
63	100.201	500.689	11	0.015	2.19	7:29:00
64	100.201	500.689	11	0.016	2.19	7:30:00
65	100.201	500.688	11	0.016	2.19	7:31:00
66	100.202	500.686	11	0.016	2.19	7:32:00
67	100.202	500.685	11	0.017	2.28	7:33:00
68	100.201	500.686	11	0.017	2.25	7:34:00
69	100.201	500.686	10	0.018	2.69	7:35:00
70	100.204	500.687	10	0.017	2.69	7:36:00
71	100.203	500.685	10	0.017	2.69	7:37:00
72	100.201	500.685	12	0.015	2.12	7:38:00
73	100.201	500.685	12	0.015	1.98	7:39:00
74	100.206	500.684	11	0.015	2.02	7:40:00
75	100.206	500.683	12	0.014	1.94	7:41:00
76	100.206	500.684	12	0.013	1.92	7:42:00
77	100.207	500.683	12	0.013	1.92	7:43:00
78	100.207	500.683	12	0.013	1.91	7:44:00
79	100.207	500.683	12	0.014	1.88	7:45:00

80	100.208	500.680	12	0.014	1.88	7:46:00
81	100.205	500.680	12	0.015	1.92	7:47:00
82	100.203	500.679	12	0.016	1.92	7:48:00
83	100.203	500.680	13	0.016	1.66	7:49:00
84	100.206	500.680	13	0.015	1.75	7:50:00
85	100.202	500.679	13	0.016	1.67	7:51:00
86	100.203	500.680	12	0.015	1.88	7:52:00
87	100.203	500.680	12	0.016	1.92	7:53:00
88	100.202	500.680	12	0.015	1.88	7:54:00
89	100.203	500.681	12	0.016	1.88	7:55:00
90	100.201	500.682	12	0.016	1.88	7:56:00
91	100.202	500.682	13	0.016	1.77	7:57:00
92	100.205	500.682	13	0.017	1.70	7:58:00
93	100.201	500.681	13	0.017	1.70	7:59:00
94	100.205	500.682	12	0.017	1.77	8:00:00
95	100.208	500.682	13	0.018	1.70	8:01:00
96	100.208	500.684	12	0.018	1.75	8:02:00
97	100.207	500.683	13	0.018	1.70	8:03:00
98	100.206	500.685	12	0.019	1.78	8:04:00
99	100.210	500.683	12	0.020	1.79	8:05:00
100	100.210	500.683	12	0.020	1.79	8:06:00
101	100.209	500.684	12	0.020	1.78	8:07:00
102	100.207	500.683	12	0.020	1.79	8:08:00
103	100.208	500.682	13	0.020	1.68	8:09:00
104	100.205	500.681	13	0.021	1.71	8:10:00
105	100.206	500.681	12	0.021	1.79	8:11:00
106	100.208	500.684	12	0.021	1.79	8:12:00
107	100.212	500.687	12	0.020	1.71	8:13:00
108	100.219	500.694	13	0.019	1.60	8:14:00
109	100.224	500.696	13	0.020	1.61	8:15:00
110	100.223	500.697	13	0.020	1.61	8:16:00
111	100.227	500.699	13	0.020	1.61	8:17:00
112	100.233	500.709	12	0.018	1.61	8:18:00
113	100.233	500.711	12	0.017	1.61	8:19:00
114	100.233	500.711	12	0.017	1.62	8:20:00
115	100.231	500.713	13	0.018	1.63	8:21:00
116	100.229	500.710	12	0.018	1.65	8:22:00
117	100.232	500.712	13	0.017	1.63	8:23:00
118	100.230	500.711	13	0.018	1.67	8:24:00
119	100.225	500.714	12	0.019	1.73	8:25:00
120	100.229	500.710	12	0.018	1.71	8:26:00

121	100.232	500.713	13	0.018	1.70	8:27:00
122	100.231	500.713	12	0.017	1.70	8:28:00
123	100.225	500.710	12	0.017	1.75	8:29:00
124	100.224	500.712	12	0.018	1.73	8:30:00
125	100.224	500.713	13	0.016	1.72	8:31:00
126	100.224	500.710	13	0.017	1.73	8:32:00
127	100.220	500.713	14	0.017	1.66	8:33:00
128	100.219	500.712	14	0.018	1.66	8:34:00
129	100.220	500.713	14	0.019	1.66	8:35:00
130	100.220	500.713	14	0.020	1.71	8:36:00
131	100.216	500.713	13	0.020	1.77	8:37:00
132	100.220	500.713	13	0.022	1.79	8:38:00
133	100.222	500.710	13	0.020	1.79	8:39:00
134	100.223	500.709	14	0.019	1.79	8:40:00
135	100.223	500.708	14	0.017	1.79	8:41:00
136	100.226	500.709	14	0.018	1.79	8:42:00
137	100.229	500.711	13	0.018	1.79	8:43:00
138	100.229	500.711	13	0.017	1.81	8:44:00
139	100.229	500.713	12	0.016	1.88	8:45:00
140	100.230	500.714	12	0.016	1.88	8:46:00
141	100.232	500.711	11	0.017	1.97	8:47:00
142	100.233	500.705	10	0.019	2.10	8:48:00
143	100.233	500.705	10	0.017	2.10	8:49:00
144	100.230	500.707	9	0.019	2.51	8:50:00
145	100.229	500.707	9	0.018	2.59	8:51:00
146	100.228	500.708	9	0.020	2.68	8:52:00
147	100.234	500.707	9	0.020	2.68	8:53:00
148	100.158	500.677	8	0.022	3.50	8:54:00
149	100.130	500.667	8	0.022	2.77	8:55:00
150	100.207	500.691	8	0.014	3.09	8:56:00
151	100.129	500.663	8	0.021	2.83	8:57:00
152	100.117	500.653	8	0.023	2.77	8:58:00
153	100.118	500.651	8	0.021	2.77	8:59:00
154	100.118	500.650	8	0.020	2.86	9:00:00
155	100.114	500.649	8	0.019	2.86	9:01:00
156	100.116	500.649	8	0.018	2.86	9:02:00
157	100.115	500.649	8	0.018	2.86	9:03:00
158	100.115	500.649	8	0.018	2.86	9:04:00
159	100.134	500.656	8	0.020	3.61	9:05:00
160	100.183	500.676	9	0.014	2.84	9:06:00
161	100.223	500.692	11	0.010	2.10	9:07:00

162	100.226	500.692	10	0.010	2.21	9:08:00
163	100.224	500.691	10	0.011	2.12	9:09:00
164	100.224	500.692	11	0.012	1.89	9:10:00
165	100.225	500.695	11	0.012	2.03	9:11:00
166	100.225	500.699	11	0.012	1.99	9:12:00
167	100.223	500.696	11	0.012	1.84	9:13:00
168	100.232	500.699	12	0.012	1.80	9:14:00
169	100.233	500.698	11	0.014	2.10	9:15:00
170	100.233	500.693	10	0.012	2.44	9:16:00
171	100.230	500.692	10	0.012	2.17	9:17:00
172	100.233	500.693	10	0.012	2.45	9:18:00
173	100.233	500.695	10	0.015	2.51	9:19:00
174	100.233	500.692	10	0.013	2.51	9:20:00
175	100.233	500.694	10	0.014	2.52	9:21:00
176	100.233	500.696	10	0.015	2.48	9:22:00
177	100.232	500.695	11	0.014	2.27	9:23:00
178	100.233	500.695	10	0.012	2.44	9:24:00
179	100.234	500.694	12	0.012	2.05	9:25:00
180	100.236	500.698	11	0.012	2.15	9:26:00
181	100.233	500.695	11	0.011	2.29	9:27:00
182	100.232	500.698	12	0.011	2.07	9:28:00
183	100.232	500.697	12	0.012	2.04	9:29:00
184	100.231	500.698	12	0.013	2.01	9:30:00
185	100.231	500.696	12	0.012	2.02	9:31:00
186	100.233	500.696	11	0.012	2.04	9:32:00
187	100.230	500.700	12	0.012	2.03	9:33:00
188	100.230	500.698	11	0.011	2.06	9:34:00
189	100.227	500.697	11	0.010	2.14	9:35:00
190	100.227	500.698	11	0.010	2.01	9:36:00
191	100.227	500.697	11	0.010	2.01	9:37:00
192	100.230	500.695	11	0.011	2.01	9:38:00
193	100.231	500.694	11	0.010	2.01	9:39:00
194	100.230	500.694	12	0.011	2.01	9:40:00
195	100.230	500.694	12	0.010	2.01	9:41:00
196	100.219	500.693	15	0.013	1.75	9:42:00
197	100.216	500.692	16	0.014	1.63	9:43:00
198	100.220	500.692	16	0.014	1.76	9:44:00
199	100.218	500.692	16	0.014	1.75	9:45:00
200	100.217	500.693	16	0.014	1.76	9:46:00
201	100.217	500.694	16	0.014	1.70	9:47:00
202	100.217	500.695	15	0.013	1.86	9:48:00

203	100.215	500.698	14	0.013	1.89	9:49:00
204	100.216	500.695	15	0.013	1.81	9:50:00
205	100.216	500.694	16	0.012	1.82	9:51:00
206	100.213	500.693	16	0.013	1.64	9:52:00
207	100.215	500.691	14	0.013	2.01	9:53:00
208	100.213	500.696	13	0.014	2.03	9:54:00
209	100.210	500.692	14	0.014	1.95	9:55:00
210	100.210	500.691	14	0.016	1.96	9:56:00
211	100.208	500.689	14	0.016	2.04	9:57:00
212	100.208	500.689	14	0.016	2.15	9:58:00
213	100.210	500.691	14	0.014	2.15	9:59:00
214	100.207	500.695	14	0.013	2.13	10:00:00
215	100.204	500.696	14	0.012	2.02	10:01:00
216	100.205	500.698	14	0.012	1.99	10:02:00
217	100.202	500.699	15	0.012	1.85	10:03:00
218	100.202	500.700	14	0.012	2.21	10:04:00
219	100.201	500.702	15	0.010	1.77	10:05:00
220	100.203	500.704	15	0.011	1.89	10:06:00
221	100.204	500.705	15	0.011	1.78	10:07:00
222	100.204	500.707	14	0.011	2.05	10:08:00
223	100.203	500.707	14	0.011	2.15	10:09:00
224	100.202	500.709	14	0.010	2.12	10:10:00
225	100.201	500.713	14	0.011	2.24	10:11:00
226	100.203	500.713	13	0.011	2.53	10:12:00
227	100.202	500.713	13	0.011	2.37	10:13:00
228	100.202	500.712	14	0.011	2.15	10:14:00
229	100.203	500.709	13	0.012	2.44	10:15:00
230	100.205	500.705	13	0.012	2.47	10:16:00
231	100.205	500.703	14	0.012	2.02	10:17:00
232	100.207	500.700	14	0.012	2.02	10:18:00
233	100.206	500.701	13	0.013	2.29	10:19:00
234	100.204	500.704	13	0.014	2.50	10:20:00
235	100.204	500.702	12	0.013	2.52	10:21:00
236	100.204	500.702	13	0.014	2.44	10:22:00
237	100.203	500.702	13	0.015	2.44	10:23:00
238	100.203	500.703	13	0.016	2.41	10:24:00
239	100.202	500.699	13	0.016	2.34	10:25:00
240	100.205	500.699	13	0.017	2.34	10:26:00
241	100.205	500.695	13	0.018	2.34	10:27:00
242	100.205	500.692	13	0.019	2.26	10:28:00
243	100.205	500.691	13	0.019	2.25	10:29:00

244	100.206	500.691	13	0.018	2.25	10:30:00
245	100.205	500.689	13	0.018	2.20	10:31:00
246	100.203	500.688	13	0.018	2.15	10:32:00
247	100.200	500.688	13	0.017	2.12	10:33:00
248	100.198	500.689	13	0.017	2.11	10:34:00
249	100.198	500.688	13	0.017	2.02	10:35:00
250	100.202	500.688	13	0.017	2.02	10:36:00
251	100.201	500.692	13	0.017	2.02	10:37:00
252	100.206	500.689	13	0.017	1.97	10:38:00
253	100.209	500.689	13	0.017	1.93	10:39:00
254	100.208	500.692	13	0.017	1.93	10:40:00
255	100.215	500.694	12	0.019	2.34	10:41:00
256	100.214	500.688	13	0.018	2.00	10:42:00
257	100.208	500.686	13	0.017	1.84	10:43:00
258	100.206	500.687	13	0.017	1.84	10:44:00
259	100.202	500.686	12	0.017	1.95	10:45:00
260	100.195	500.682	12	0.016	2.04	10:46:00
261	100.204	500.685	13	0.017	1.85	10:47:00
262	100.204	500.683	12	0.019	1.97	10:48:00
263	100.203	500.685	12	0.018	1.97	10:49:00
264	100.203	500.685	12	0.018	1.97	10:50:00
265	100.201	500.684	12	0.018	1.92	10:51:00
266	100.200	500.680	12	0.019	1.88	10:52:00
267	100.201	500.680	12	0.018	1.88	10:53:00
268	100.199	500.677	12	0.018	1.85	10:54:00
269	100.195	500.669	13	0.018	1.68	10:55:00
270	100.194	500.668	13	0.018	1.68	10:56:00
271	100.194	500.665	15	0.018	1.51	10:57:00
272	100.199	500.665	15	0.018	1.42	10:58:00
273	100.195	500.664	15	0.019	1.41	10:59:00
274	100.182	500.672	15	0.013	1.49	11:00:00
275	100.179	500.679	14	0.013	1.50	11:01:00
276	100.180	500.680	15	0.012	1.46	11:02:00
277	100.182	500.683	14	0.013	1.47	11:03:00
278	100.185	500.689	15	0.015	1.43	11:04:00
279	100.182	500.689	14	0.015	1.58	11:05:00
280	100.181	500.689	14	0.016	1.61	11:06:00
281	100.183	500.690	15	0.016	1.44	11:07:00
282	100.181	500.689	15	0.017	1.43	11:08:00
283	100.180	500.691	14	0.017	1.57	11:09:00
284	100.185	500.695	14	0.015	1.60	11:10:00

285	100.191	500.698	13	0.014	1.66	11:11:00
286	100.189	500.696	13	0.016	1.70	11:12:00
287	100.188	500.694	12	0.019	1.87	11:13:00
288	100.196	500.696	13	0.015	1.75	11:14:00
289	100.197	500.695	13	0.015	1.75	11:15:00
290	100.196	500.695	13	0.014	1.75	11:16:00
291	100.194	500.695	12	0.017	2.10	11:17:00
292	100.193	500.696	12	0.017	2.07	11:18:00
293	100.195	500.697	12	0.017	2.00	11:19:00
294	100.194	500.694	13	0.015	1.67	11:20:00
295	100.194	500.696	13	0.018	1.87	11:21:00
296	100.199	500.701	12	0.019	1.98	11:22:00
297	100.195	500.694	12	0.020	1.88	11:23:00
298	100.203	500.697	12	0.019	2.02	11:24:00
299	100.203	500.691	11	0.016	2.06	11:25:00
300	100.197	500.688	11	0.016	1.97	11:26:00
301	100.191	500.683	12	0.015	1.79	11:27:00
302	100.189	500.685	12	0.015	1.79	11:28:00
303	100.186	500.685	12	0.014	1.84	11:29:00
304	100.186	500.688	12	0.016	2.07	11:30:00
305	100.175	500.706	11	0.017	2.10	11:31:00
306	100.111	501.078	8	0.019	1.16	11:32:00
307	100.115	501.089	8	0.022	1.15	11:33:00
308	100.127	501.106	8	0.030	1.48	11:34:00
309	100.149	501.139	8	0.035	1.58	11:35:00
310	100.195	501.195	7	0.038	1.61	11:36:00
311	100.225	501.227	7	0.043	1.61	11:37:00
312	100.247	501.263	7	0.048	1.72	11:38:00
313	100.194	500.880	10	0.028	2.10	11:39:00
314	100.165	500.682	11	0.017	2.28	11:40:00
315	100.164	500.681	11	0.017	2.28	11:41:00
316	100.163	500.680	11	0.016	2.28	11:42:00
317	100.169	500.680	11	0.017	2.28	11:43:00
318	100.171	500.676	11	0.018	2.28	11:44:00
319	100.172	500.676	11	0.017	2.28	11:45:00
320	100.174	500.678	10	0.016	2.68	11:46:00
321	100.176	500.675	10	0.016	2.69	11:47:00
322	100.178	500.673	10	0.014	2.63	11:48:00
323	100.174	500.671	10	0.015	2.69	11:49:00
324	100.174	500.672	10	0.014	2.69	11:50:00
325	100.182	500.688	11	0.019	2.35	11:51:00

326	100.178	500.692	11	0.022	2.15	11:52:00
327	100.161	500.674	15	0.015	1.55	11:53:00
328	100.171	500.682	14	0.016	1.49	11:54:00
329	100.168	500.673	13	0.011	1.49	11:55:00
330	100.161	500.674	12	0.015	1.55	11:56:00
331	100.171	500.683	13	0.016	1.50	11:57:00
332	100.165	500.683	13	0.014	1.51	11:58:00
333	100.165	500.686	13	0.015	1.54	11:59:00
334	100.169	500.690	14	0.016	1.43	12:00:00
335	100.171	500.685	13	0.016	1.53	12:01:00
336	100.175	500.687	13	0.017	1.53	12:02:00
337	100.174	500.685	12	0.018	1.53	12:03:00
338	100.167	500.681	11	0.018	1.82	12:04:00
339	100.173	500.684	11	0.019	1.92	12:05:00
340	100.165	500.676	11	0.016	1.92	12:06:00
341	100.155	500.676	12	0.016	1.83	12:07:00
342	100.157	500.687	12	0.016	1.79	12:08:00
343	100.162	500.693	12	0.014	1.78	12:09:00
344	100.165	500.692	12	0.014	1.78	12:10:00
345	100.168	500.691	13	0.013	1.60	12:11:00
346	100.170	500.684	13	0.013	1.70	12:12:00
347	100.174	500.678	13	0.012	1.71	12:13:00
348	100.179	500.679	13	0.014	1.74	12:14:00
349	100.176	500.685	13	0.014	1.70	12:15:00
350	100.172	500.687	13	0.014	1.68	12:16:00
351	100.169	500.688	13	0.013	1.59	12:17:00
352	100.168	500.691	13	0.013	1.68	12:18:00
353	100.173	500.690	13	0.013	1.67	12:19:00
354	100.176	500.691	13	0.012	1.70	12:20:00
355	100.178	500.692	13	0.012	1.70	12:21:00
356	100.175	500.690	13	0.010	1.70	12:22:00
357	100.177	500.687	13	0.011	1.61	12:23:00
358	100.174	500.687	13	0.012	1.61	12:24:00
359	100.173	500.686	13	0.013	1.61	12:25:00
360	100.177	500.688	12	0.014	1.81	12:26:00
361	100.180	500.689	12	0.015	1.84	12:27:00
362	100.182	500.689	12	0.015	1.84	12:28:00
363	100.180	500.694	13	0.016	1.66	12:29:00
364	100.180	500.700	13	0.017	1.61	12:30:00
365	100.174	500.699	13	0.017	1.61	12:31:00
366	100.173	500.695	13	0.015	1.58	12:32:00

367	100.176	500.691	14	0.015	1.44	12:33:00
368	100.177	500.686	13	0.014	1.46	12:34:00
369	100.183	500.685	13	0.014	1.51	12:35:00
370	100.180	500.685	13	0.013	1.49	12:36:00
371	100.181	500.686	14	0.013	1.44	12:37:00
372	100.182	500.684	13	0.013	1.46	12:38:00
373	100.186	500.675	12	0.016	1.64	12:39:00
374	100.181	500.676	12	0.017	1.61	12:40:00
375	100.175	500.688	13	0.016	1.44	12:41:00
376	100.177	500.689	13	0.017	1.44	12:42:00
377	100.180	500.689	13	0.017	1.41	12:43:00
378	100.182	500.687	13	0.017	1.44	12:44:00
379	100.186	500.692	13	0.018	1.44	12:45:00
380	100.184	500.694	12	0.018	1.56	12:46:00
381	100.188	500.692	12	0.018	1.65	12:47:00
382	100.188	500.689	12	0.019	1.71	12:48:00
383	100.184	500.692	12	0.020	1.66	12:49:00
384	100.197	500.683	11	0.019	1.78	12:50:00
385	100.200	500.685	11	0.019	1.79	12:51:00
386	100.183	500.698	12	0.019	1.66	12:52:00
387	100.178	500.699	12	0.019	1.60	12:53:00
388	100.180	500.694	12	0.020	1.61	12:54:00
389	100.188	500.681	11	0.020	1.80	12:55:00
390	100.189	500.683	11	0.022	1.80	12:56:00
391	100.193	500.682	11	0.022	1.80	12:57:00
392	100.190	500.679	11	0.021	1.72	12:58:00
393	100.192	500.680	11	0.020	1.72	12:59:00
394	100.195	500.679	11	0.020	1.72	13:00:00
395	100.199	500.666	12	0.021	1.54	13:01:00
396	100.200	500.667	11	0.020	1.56	13:02:00
397	100.200	500.666	11	0.021	1.55	13:03:00
398	100.194	500.672	11	0.020	1.63	13:04:00
399	100.187	500.678	12	0.020	1.52	13:05:00
400	100.187	500.677	13	0.021	1.37	13:06:00
401	100.191	500.673	11	0.020	1.72	13:07:00
402	100.197	500.669	11	0.019	1.78	13:08:00
403	100.201	500.668	11	0.017	1.95	13:09:00
404	100.202	500.668	10	0.013	2.16	13:10:00
405	100.208	500.669	10	0.013	2.12	13:11:00
406	100.215	500.666	11	0.012	1.77	13:12:00
407	100.215	500.667	11	0.012	1.97	13:13:00

408	100.218	500.665	11	0.012	1.90	13:14:00
409	100.222	500.661	11	0.013	1.84	13:15:00
410	100.228	500.655	13	0.016	1.39	13:16:00
411	100.231	500.651	13	0.018	1.47	13:17:00
412	100.232	500.650	12	0.020	1.49	13:18:00
413	100.230	500.655	12	0.017	1.70	13:19:00
414	100.224	500.662	11	0.013	2.02	13:20:00
415	100.228	500.663	11	0.014	1.83	13:21:00
416	100.231	500.663	12	0.015	1.58	13:22:00
417	100.236	500.665	13	0.014	1.46	13:23:00
418	100.238	500.666	12	0.014	1.74	13:24:00
419	100.239	500.672	11	0.014	2.02	13:25:00
420	100.240	500.669	11	0.013	2.10	13:26:00
421	100.229	500.672	12	0.012	1.57	13:27:00
422	100.225	500.674	12	0.012	1.55	13:28:00
423	100.228	500.670	11	0.014	1.71	13:29:00
424	100.225	500.670	11	0.013	2.00	13:30:00
425	100.224	500.666	10	0.014	2.01	13:31:00
426	100.217	500.672	11	0.015	1.99	13:32:00
427	100.217	500.671	11	0.014	1.97	13:33:00
428	100.217	500.669	11	0.015	1.97	13:34:00
429	100.216	500.668	11	0.015	1.69	13:35:00
430	100.217	500.668	11	0.017	1.63	13:36:00
431	100.213	500.669	12	0.016	1.50	13:37:00
432	100.208	500.674	11	0.016	1.71	13:38:00
433	100.207	500.674	11	0.015	1.72	13:39:00
434	100.206	500.676	11	0.015	1.72	13:40:00
435	100.201	500.681	11	0.015	1.72	13:41:00
436	100.200	500.680	11	0.017	1.72	13:42:00
437	100.204	500.677	11	0.017	1.72	13:43:00
438	100.206	500.677	11	0.018	1.72	13:44:00
439	100.204	500.677	11	0.017	1.72	13:45:00
440	100.198	500.681	11	0.017	1.71	13:46:00
441	100.195	500.684	11	0.017	2.01	13:47:00
442	100.196	500.684	11	0.017	1.97	13:48:00
443	100.200	500.679	11	0.016	1.97	13:49:00
444	100.201	500.678	11	0.016	1.97	13:50:00
445	100.200	500.680	11	0.014	1.97	13:51:00
446	100.196	500.681	11	0.013	1.97	13:52:00
447	100.192	500.683	11	0.013	2.07	13:53:00
448	100.188	500.682	11	0.014	2.04	13:54:00

449	100.189	500.682	10	0.014	2.30	13:55:00
450	100.192	500.681	10	0.015	2.26	13:56:00
451	100.192	500.682	10	0.015	2.25	13:57:00
452	100.189	500.684	10	0.014	2.24	13:58:00
453	100.188	500.686	10	0.015	2.15	13:59:00
454	100.192	500.690	11	0.015	2.01	14:00:00
455	100.197	500.691	11	0.015	2.01	14:01:00
456	100.198	500.692	11	0.013	2.01	14:02:00
457	100.202	500.694	11	0.012	2.01	14:03:00
458	100.204	500.695	11	0.014	2.01	14:04:00
459	100.203	500.696	11	0.014	2.01	14:05:00
460	100.205	500.695	11	0.013	2.01	14:06:00
461	100.205	500.696	11	0.012	2.01	14:07:00
462	100.204	500.696	11	0.012	2.01	14:08:00
463	100.205	500.699	11	0.011	2.01	14:09:00
464	100.204	500.700	11	0.012	2.01	14:10:00
465	100.202	500.700	11	0.012	2.01	14:11:00
466	100.201	500.699	11	0.013	2.01	14:12:00
467	100.202	500.704	11	0.014	2.01	14:13:00
468	100.203	500.704	11	0.015	2.01	14:14:00
469	100.204	500.702	11	0.016	2.01	14:15:00
470	100.205	500.704	11	0.015	2.01	14:16:00
471	100.208	500.703	11	0.016	2.01	14:17:00
472	100.204	500.703	11	0.017	2.01	14:18:00
473	100.204	500.704	11	0.016	2.01	14:19:00
474	100.206	500.706	11	0.017	2.01	14:20:00
475	100.207	500.703	11	0.017	2.00	14:21:00
476	100.201	500.708	11	0.017	1.92	14:22:00
477	100.206	500.704	11	0.018	1.92	14:23:00
478	100.205	500.705	11	0.018	1.92	14:24:00
479	100.203	500.707	11	0.018	1.92	14:25:00
480	100.196	500.711	11	0.019	1.92	14:26:00
481	100.199	500.709	11	0.019	1.92	14:27:00
482	100.195	500.709	11	0.018	1.92	14:28:00
483	100.194	500.708	11	0.017	1.92	14:29:00
484	100.193	500.707	11	0.018	1.92	14:30:00
485	100.197	500.709	11	0.019	1.92	14:31:00
486	100.197	500.709	11	0.019	1.92	14:32:00
487	100.197	500.707	12	0.017	1.71	14:33:00
488	100.203	500.700	11	0.017	1.92	14:34:00
489	100.210	500.698	11	0.015	2.10	14:35:00

490	100.211	500.700	11	0.015	2.15	14:36:00
491	100.213	500.701	11	0.015	2.15	14:37:00
492	100.210	500.699	10	0.015	2.24	14:38:00
493	100.208	500.696	11	0.014	2.08	14:39:00
494	100.211	500.696	10	0.015	2.23	14:40:00
495	100.214	500.696	10	0.016	2.24	14:41:00
496	100.213	500.695	11	0.016	2.06	14:42:00
497	100.209	500.698	11	0.016	2.02	14:43:00
498	100.206	500.701	11	0.017	2.00	14:44:00
499	100.201	500.703	11	0.017	1.84	14:45:00
500	100.205	500.699	12	0.014	1.64	14:46:00
501	100.211	500.696	11	0.014	1.69	14:47:00
502	100.207	500.698	11	0.014	1.70	14:48:00
503	100.201	500.699	12	0.015	1.65	14:49:00
504	100.196	500.695	11	0.015	1.88	14:50:00
505	100.200	500.694	11	0.016	1.99	14:51:00
506	100.199	500.695	11	0.015	1.98	14:52:00
507	100.204	500.698	10	0.016	2.03	14:53:00
508	100.201	500.702	12	0.015	1.81	14:54:00
509	100.193	500.707	13	0.015	1.60	14:55:00
510	100.187	500.708	13	0.016	1.62	14:56:00
511	100.185	500.708	12	0.017	1.74	14:57:00
512	100.188	500.701	11	0.016	1.97	14:58:00
513	100.180	500.703	11	0.017	1.92	14:59:00
514	100.184	500.705	10	0.018	2.02	15:00:00
515	100.185	500.704	10	0.019	2.06	15:01:00
516	100.184	500.702	10	0.020	2.06	15:02:00
517	100.180	500.704	10	0.021	2.06	15:03:00
518	100.179	500.705	10	0.022	2.06	15:04:00
519	100.176	500.705	10	0.023	2.06	15:05:00
520	100.173	500.705	10	0.025	2.11	15:06:00
521	100.169	500.708	9	0.029	2.42	15:07:00
522	100.194	500.716	9	0.016	2.42	15:08:00
523	100.284	500.578	11	0.015	1.96	15:09:00
524	100.449	500.321	6	0.019	1.27	15:10:00
525	100.450	500.323	6	0.021	1.34	15:11:00
526	100.454	500.326	6	0.021	1.38	15:12:00
527	100.462	500.333	5	0.023	1.52	15:13:00
528	100.464	500.338	5	0.026	1.52	15:14:00
529	100.468	500.343	5	0.027	1.52	15:15:00
530	100.382	500.467	7	0.025	1.72	15:16:00

531	100.281	500.595	12	0.022	1.95	15:17:00
532	100.466	500.338	12	0.025	1.52	15:18:00
533	100.464	500.337	11	0.026	1.52	15:19:00
534	100.370	500.479	11	0.024	1.55	15:20:00
535	100.190	500.725	11	0.020	1.91	15:21:00
536	100.198	500.715	11	0.020	2.06	15:22:00
537	100.196	500.716	10	0.020	2.15	15:23:00
538	100.180	500.735	10	0.022	2.59	15:24:00
539	100.161	500.761	10	0.016	1.65	15:25:00
540	100.161	500.757	10	0.017	1.83	15:26:00
541	100.132	500.794	10	0.023	2.48	15:27:00
542	100.123	500.805	10	0.018	2.20	15:28:00
543	100.140	500.783	10	0.019	2.15	15:29:00
544	100.191	500.715	10	0.017	2.04	15:30:00
545	100.190	500.716	10	0.017	2.03	15:31:00
546	100.195	500.714	11	0.022	2.36	15:32:00
547	100.201	500.705	11	0.021	2.20	15:33:00
548	100.192	500.718	9	0.033	3.83	15:34:00
549	100.164	500.754	9	0.031	3.05	15:35:00
550	100.138	500.790	10	0.029	2.11	15:36:00
551	100.148	500.774	10	0.035	2.55	15:37:00
552	100.197	500.707	9	0.047	3.88	15:38:00
553	100.188	500.710	8	0.050	3.88	15:39:00
554	100.188	500.709	7	0.053	4.48	15:40:00
555	100.173	500.721	7	0.062	4.72	15:41:00
556	100.165	500.728	7	0.058	4.72	15:42:00
557	100.174	500.720	7	0.059	4.64	15:43:00
558	100.175	500.718	7	0.066	4.63	15:44:00
559	100.168	500.722	7	0.069	4.64	15:45:00
560	100.042	500.882	6	0.079	6.39	15:46:00
561	100.054	500.865	6	0.083	6.34	15:47:00
562	100.044	500.875	6	0.077	6.28	15:48:00
563	100.044	500.875	6	0.079	6.22	15:49:00
564	100.051	500.863	6	0.086	6.14	15:50:00
565	100.043	500.871	6	0.094	6.04	15:51:00
566	100.038	500.874	6	0.093	5.99	15:52:00
567	100.026	500.886	6	0.082	5.90	15:53:00
568	100.028	500.881	6	0.082	5.82	15:54:00
569	100.027	500.876	6	0.079	5.72	15:55:00
570	100.060	500.844	6	0.069	5.29	15:56:00
571	100.218	500.689	9	0.017	2.47	15:57:00

572	100.206	500.690	9	0.019	2.27	15:58:00
573	100.225	500.686	9	0.017	2.52	15:59:00
574	100.213	500.686	10	0.016	2.37	16:00:00
575	100.184	500.694	11	0.019	1.87	16:01:00
576	100.184	500.697	12	0.020	1.77	16:02:00
577	100.192	500.691	12	0.017	1.54	16:03:00
578	100.194	500.688	11	0.015	1.78	16:04:00
579	100.190	500.692	11	0.017	1.82	16:05:00
580	100.194	500.686	12	0.016	1.65	16:06:00
581	100.191	500.687	11	0.016	1.96	16:07:00
582	100.196	500.682	11	0.015	1.73	16:08:00
583	100.205	500.677	11	0.016	1.80	16:09:00
584	100.199	500.689	9	0.023	2.17	16:10:00
585	100.203	500.689	9	0.023	2.20	16:11:00
586	100.205	500.688	9	0.021	2.20	16:12:00
587	100.202	500.692	9	0.021	2.20	16:13:00
588	100.203	500.691	9	0.020	2.20	16:14:00
589	100.201	500.690	9	0.020	2.20	16:15:00
590	100.202	500.691	9	0.019	2.20	16:16:00
591	100.201	500.690	9	0.019	2.20	16:17:00
592	100.203	500.688	9	0.018	2.20	16:18:00
593	100.202	500.688	9	0.018	2.20	16:19:00
594	100.200	500.687	9	0.016	2.18	16:20:00
595	100.202	500.685	10	0.016	2.04	16:21:00
596	100.204	500.686	10	0.020	2.14	16:22:00
597	100.209	500.681	8	0.029	3.52	16:23:00
598	100.213	500.678	8	0.030	3.89	16:24:00
599	100.211	500.679	8	0.027	3.97	16:25:00
600	100.212	500.681	8	0.026	3.98	16:26:00
601	100.208	500.684	9	0.022	3.46	16:27:00
602	100.197	500.700	10	0.016	2.17	16:28:00
603	100.199	500.699	10	0.016	2.16	16:29:00
604	100.203	500.699	11	0.014	2.13	16:30:00
605	100.208	500.693	11	0.012	2.15	16:31:00
606	100.203	500.693	11	0.013	1.99	16:32:00
607	100.201	500.694	11	0.014	2.10	16:33:00
608	100.202	500.690	11	0.014	2.09	16:34:00
609	100.204	500.691	12	0.013	1.84	16:35:00
610	100.203	500.691	12	0.012	1.80	16:36:00
611	100.205	500.687	12	0.013	2.01	16:37:00
612	100.211	500.686	12	0.013	2.01	16:38:00

613	100.213	500.687	11	0.013	2.23	16:39:00
614	100.214	500.687	11	0.013	2.29	16:40:00
615	100.218	500.691	11	0.014	2.01	16:41:00
616	100.217	500.692	11	0.015	2.00	16:42:00
617	100.215	500.690	12	0.015	1.98	16:43:00
618	100.217	500.690	10	0.018	2.13	16:44:00
619	100.218	500.686	11	0.015	2.10	16:45:00
620	100.216	500.687	11	0.017	2.14	16:46:00
621	100.215	500.689	10	0.018	2.23	16:47:00
622	100.211	500.687	12	0.016	2.16	16:48:00
623	100.208	500.687	12	0.014	2.41	16:49:00
624	100.207	500.684	11	0.014	2.82	16:50:00
625	100.203	500.684	11	0.014	2.93	16:51:00
626	100.202	500.685	10	0.014	2.99	16:52:00
627	100.200	500.684	10	0.016	3.10	16:53:00
628	100.202	500.686	10	0.018	2.93	16:54:00
629	100.203	500.684	10	0.017	3.11	16:55:00
630	100.204	500.683	11	0.019	2.52	16:56:00
631	100.202	500.683	12	0.017	2.55	16:57:00
632	100.202	500.682	12	0.018	2.44	16:58:00
633	100.205	500.682	12	0.019	2.56	16:59:00
634	100.207	500.681	12	0.018	2.56	17:00:00
635	100.203	500.680	12	0.019	2.57	17:01:00
636	100.202	500.681	11	0.020	2.66	17:02:00
637	100.200	500.681	11	0.017	3.05	17:03:00
638	100.200	500.682	11	0.015	3.43	17:04:00
639	100.200	500.683	11	0.015	2.95	17:05:00
640	100.199	500.685	11	0.014	3.52	17:06:00
641	100.200	500.682	11	0.014	3.52	17:07:00
642	100.201	500.680	11	0.015	3.52	17:08:00
643	100.205	500.679	11	0.015	3.52	17:09:00
644	100.202	500.680	11	0.014	3.46	17:10:00
645	100.200	500.689	13	0.017	1.84	17:11:00
646	100.200	500.691	13	0.018	1.84	17:12:00
647	100.201	500.691	13	0.018	1.84	17:13:00
648	100.204	500.690	13	0.019	1.84	17:14:00
649	100.203	500.689	13	0.017	1.84	17:15:00
650	100.202	500.691	13	0.016	1.84	17:16:00
651	100.200	500.692	13	0.016	1.84	17:17:00
652	100.197	500.697	13	0.014	1.84	17:18:00
653	100.196	500.698	12	0.015	1.94	17:19:00

654	100.197	500.699	11	0.014	2.10	17:20:00
655	100.198	500.696	13	0.014	1.89	17:21:00
656	100.198	500.693	13	0.014	1.84	17:22:00
657	100.200	500.688	12	0.015	1.94	17:23:00
658	100.201	500.688	12	0.015	1.96	17:24:00
659	100.201	500.687	13	0.014	1.90	17:25:00
660	100.202	500.691	13	0.013	1.89	17:26:00
661	100.203	500.692	14	0.012	1.74	17:27:00
662	100.199	500.697	13	0.012	1.75	17:28:00
663	100.199	500.701	15	0.011	1.62	17:29:00
664	100.201	500.702	16	0.011	1.52	17:30:00
665	100.203	500.703	16	0.011	1.56	17:31:00
666	100.204	500.706	14	0.010	1.71	17:32:00
667	100.200	500.699	12	0.011	1.91	17:33:00
668	100.196	500.696	13	0.013	1.78	17:34:00
669	100.196	500.696	12	0.013	1.86	17:35:00
670	100.199	500.702	13	0.014	1.65	17:36:00
671	100.196	500.699	14	0.014	1.59	17:37:00
672	100.202	500.704	15	0.014	1.43	17:38:00
673	100.203	500.705	15	0.013	1.54	17:39:00
674	100.200	500.703	13	0.014	1.75	17:40:00
675	100.199	500.704	13	0.015	1.75	17:41:00
676	100.200	500.704	13	0.014	1.74	17:42:00
677	100.202	500.701	13	0.014	1.77	17:43:00
678	100.201	500.696	12	0.011	1.89	17:44:00
679	100.208	500.702	13	0.012	1.69	17:45:00
680	100.209	500.707	14	0.012	1.57	17:46:00
681	100.205	500.710	15	0.014	1.45	17:47:00
682	100.205	500.713	15	0.014	1.47	17:48:00
683	100.210	500.717	15	0.014	1.50	17:49:00
684	100.210	500.719	15	0.013	1.43	17:50:00
685	100.212	500.717	15	0.013	1.43	17:51:00
686	100.211	500.713	14	0.011	1.51	17:52:00
687	100.209	500.713	15	0.011	1.54	17:53:00
688	100.211	500.714	14	0.011	1.57	17:54:00
689	100.209	500.713	15	0.010	1.53	17:55:00
690	100.210	500.714	14	0.012	1.54	17:56:00
691	100.211	500.711	14	0.012	1.58	17:57:00
692	100.206	500.713	14	0.011	1.59	17:58:00
693	100.208	500.717	13	0.012	1.68	17:59:00
694	100.212	500.716	13	0.013	1.55	18:00:00

695	100.212	500.714	12	0.013	1.90	18:01:00
696	100.211	500.712	13	0.012	1.96	18:02:00
697	100.214	500.705	13	0.011	1.78	18:03:00
698	100.213	500.709	13	0.013	1.71	18:04:00
699	100.213	500.715	13	0.015	1.75	18:05:00
700	100.207	500.722	13	0.015	1.70	18:06:00
701	100.208	500.723	14	0.014	1.59	18:07:00
702	100.209	500.722	14	0.015	1.59	18:08:00
703	100.211	500.722	13	0.016	1.73	18:09:00
704	100.213	500.708	12	0.011	1.86	18:10:00
705	100.213	500.715	13	0.014	1.73	18:11:00
706	100.215	500.721	13	0.015	1.69	18:12:00
707	100.212	500.723	12	0.015	1.86	18:13:00
708	100.218	500.710	11	0.015	2.23	18:14:00
709	100.220	500.709	11	0.014	1.88	18:15:00
710	100.219	500.711	12	0.014	1.99	18:16:00
711	100.218	500.709	14	0.013	1.61	18:17:00
712	100.221	500.706	13	0.014	1.84	18:18:00
713	100.223	500.705	13	0.014	1.84	18:19:00
714	100.224	500.703	13	0.014	1.81	18:20:00
715	100.227	500.704	13	0.014	1.81	18:21:00
716	100.229	500.701	14	0.015	1.68	18:22:00
717	100.226	500.702	15	0.015	1.52	18:23:00
718	100.223	500.705	14	0.015	1.84	18:24:00
719	100.223	500.705	14	0.015	1.84	18:25:00
720	100.223	500.703	14	0.015	1.84	18:26:00