Vegetation Obstruction Effects on Auspos and RTX

Trenton Lester
Peter Gibbings (corresponding author)
Peter.Gibbings@usq.edu.au
Faculty of Health, Engineering and Sciences, University of Southern Queensland
West Street, Toowoomba QLD 4350, Australia

Abstract
This paper reports an investigation into the horizontal accuracy of various static GNSS logging durations from two to 24 hours, at five sites with sky obstructions from 0% to 90%, using two online GNSS processing systems. It was found that in almost all situations, 12 hours of data would provide reliable results, and no appreciable difference was found between AUSPOS and Trimble CenterPoint RTX Post-Processing (RTX). Further refinement of the outcomes are presented in the form of a graph of suggested logging durations versus percentage of sky obstructions. These may be useful to the surveying profession, provided they are used as suggestions only and further redundancies are built into surveys based on normal good practice and relevant control survey requirements.

Keywords: GNSS, AUSPOS, RTX, Sky Obstructions.

Introduction
Particularly in remote areas of Australia, surveyors are often required to establish coordinates for survey control stations using data logged with static Global Navigation Satellite Systems (GNSS) and processed using online GNSS post-processing services. Often these survey control stations are obstructed by vegetation which may cause errors due to the reduced amount of data and noise in the data. These surveys need to comply with relevant standards with respect to accuracy and precision. For example: if the survey control is for the Queensland Government Department of Transport and Main Roads (TMR), then survey would have to comply with their GNSS Control Surveys Guideline (Queensland Government 2016); if the survey control was for a cadastral survey in Queensland, then the survey would have to comply with the Queensland Cadastral Survey Requirements (Department of Natural Resources and Mines 2015); and in all cases the control surveys need to comply with Special Publication 1 (Inter-Governmental Committee on Surveying and Mapping (ICSM) 2014).

In remote areas, it may be much more economical to simply log raw GNSS data at control stations, rather than establishing a control network. In these cases, Geoscience Australia's AUSPOS online GPS post processing service (Geoscience Australia 2018) or one of the other similar online GNSS post processing services such as Trimble CenterPoint RTX Post-Processing (Trimble CentrePoint TRX 2018) can be used to establish centimetre accurate coordinates on control stations by submitting a file of the logged data online. Note that AUSPOS is essentially a differential processing service that uses GPS alone, whereas RTX uses a multi-constellation Precise Point Positioning (PPP) technique, but from the users' perspective this is not important – all the end users require are the coordinates and some indication of the accuracy and precision.

There are many situations where the surveyor needs to establish survey control in vegetated areas which cannot be cleared because of environmental, economic or other reasons. For example, Surveyors are regularly faced with needing to establish survey control along vegetated road reserves where clearing has only ever been carried out for the road formation construction and in adjacent private property. This means that surveyors have to coordinate survey control marks in locations that have obstructed sky and do not conform to the preferred open-sky requirements for GNSS. In Australia the most common type of vegetation that will obstruct the sky in these situations are eucalyptus trees, so we restrict our testing to that type of obstruction.

Previous research testing online GNSS post-processing has focussed on ideal unobstructed mark selection and therefore it is unclear how much vegetation sky obstruction is acceptable and what observation durations are necessary to achieve results that meet the relevant surveying standards when obstructed marks are observed. This raises some questions:

- Can the Surveyor rely on the results provided by online GNSS post processing services such as AUSPOS when the control station has obstructed sky caused by vegetation?
- What is an acceptable level of sky obstruction for this process?
- What observation time is required, for various amounts of sky obstruction, to achieve acceptable results?
- Is there any difference in performance between AUSPOS and RTX for this type of work in Australia?

Research Aim

The aim of this research is to determine what duration of GNSS observations need to be logged in situations of eucalypt vegetation sky obstruction similar to that found on a variety of survey projects and along regional road reserves to produce accurate and repeatable results from AUSPOS and Trimble CenterPoint RTX Post-Processing.

Research Method and Data Collection

Varying amounts of vegetation sky obstruction (starting with an open sky situation) were tested in an attempt to clarify how much sky obstruction can be present and what observation duration is required with the different amounts of obstruction.

Observations were taken over three 24-hour periods on five survey control stations with different amounts of sky obstruction. The observation files were divided into eight shorter duration files and submitted to AUSPOS (which uses GPS satellites only) and Trimble CenterPoint RTX Post-Processing (which uses all five currently orbiting GNSS constellations) to test the uncertainty and repeatability of results.

Classification of Sky Obstruction

For the results to be useful to others, we needed a system to classify the various degrees of sky obstruction at each mark. Meyer (2002) conducted static network processing with sky obstructions and used a method of photographic processing to determine the percentage of sky obstruction. It was an elaborate method requiring specialised photographic hardware and software to take a 'fish-eye' photo looking vertically upwards, convert the photo to remove distortion and then use a software program to count the pixels of open sky vs obstructed sky. We used a less rigorous method though. In our research, the degree of sky obstruction was determined by sketching a sky plot diagram of the obstructions at each station using a compass and clinometer, drawing this in a CAD program, and then using polygonal area to calculate the percentage of obstructed sky. It is understood that this does not represent a full obstruction due to the fact that some GNSS signals will arrive at the antenna through the vegetation. However, this method does allow end users to judge similar cases and thereby make comparisons, and informed decisions, about their own scenarios.

Project Location

For logistical reasons and convenience, the Bundaberg Airport, Queensland, Australia, was chosen as the site of the field observations. The airport offers a secure area, and has sections of original bush which sit adjacent to the cleared areas alongside the main runway. This bush has a mixture of typical native eucalyptus vegetation consisting mainly of Bloodwood and Stringybark.

The ground marks were 1.65 metre star pickets driven to full length or to refusal. Amounts of sky obstruction were as follows:

- Station 901 – 90%
- Station 902 – 75%
- Station 903 – 45%
- Station 904 – 20%
- Station 905 – 0%

Equipment and Observations

The GNSS receivers were Trimble R10s set on normal wooden surveying tripods (except 905 which is on a more stable base). All legs were checked and tribrachs and optical plummets were in good adjustment. Data was logged at 30 second epochs (though the online processors filter this to their preferred rate) for three separate sessions of 24 hours on each mark. At the end of each 24 hour session, checks were made to ensure the receivers were still logging and the tribrachs were still level and centred over the survey marks. The 24 hour log files were subdivided into durations of 18, 12, 10, 8, 6, 4, and 2 hours for separate processing in both online processing services. The primary data used for comparisons was the resulting MGA94 coordinates. Note that AHD Derived elevations were also available for comparison, but they are beyond the scope of this paper.

Results and Discussion

Standard for Comparison - The resulting coordinates of the three 24 hour observations were averaged for each station and these average coordinates were used as the ‘fixed’ positions for comparison of the other results. A horizontal difference vector was calculated between the ‘fixed’ coordinates and each of the observations, with results analysed in spreadsheet tables.

The following series of graphs show the horizontal differences for each of the three 24 hour sessions along with the derived shorter durations.

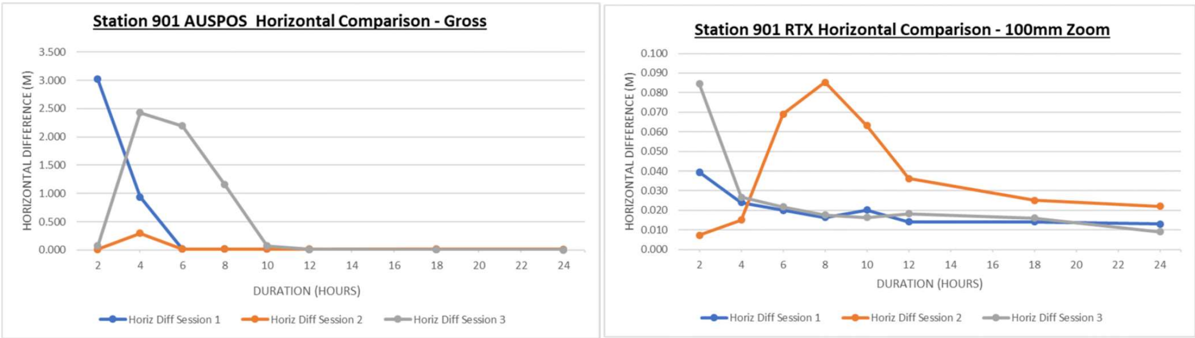

Figure 1 - AUSPOS and RTX for various logging times at 90% obstruction

Figure 1 indicates that at a site with 90% obstruction, AUSPOS gave repeatable results after 12 hours of observations and coordinate differences at 12 hours and after was always less than 20 mm. All RTX positions were within 90mm, and after 18 hours the coordinate differences was less than 30mm.

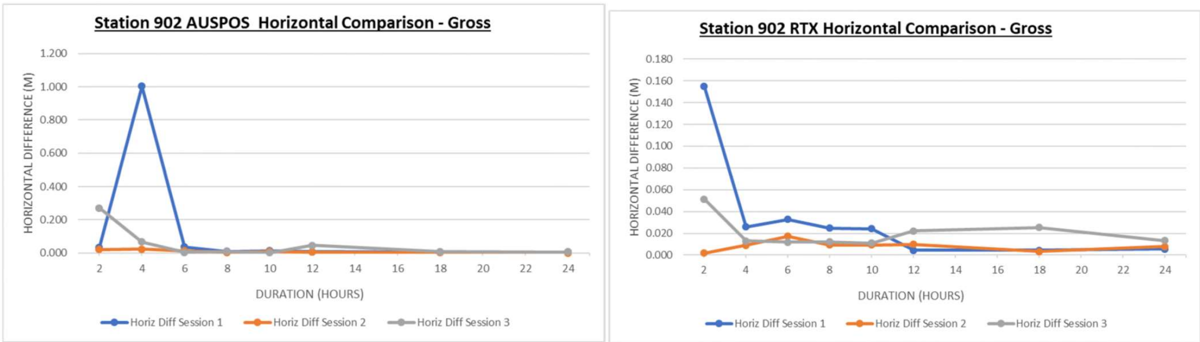

Figure 2 - AUSPOS and RTX for various logging times at 75% obstruction

Figure 2 indicates that at a site with 75% obstruction, AUSPOS gave repeatable results after 18 hours of observations and coordinate differences at 18 hours and after was always less than 10mm. After four hours of observations, RTX positions were less than 40 mm.

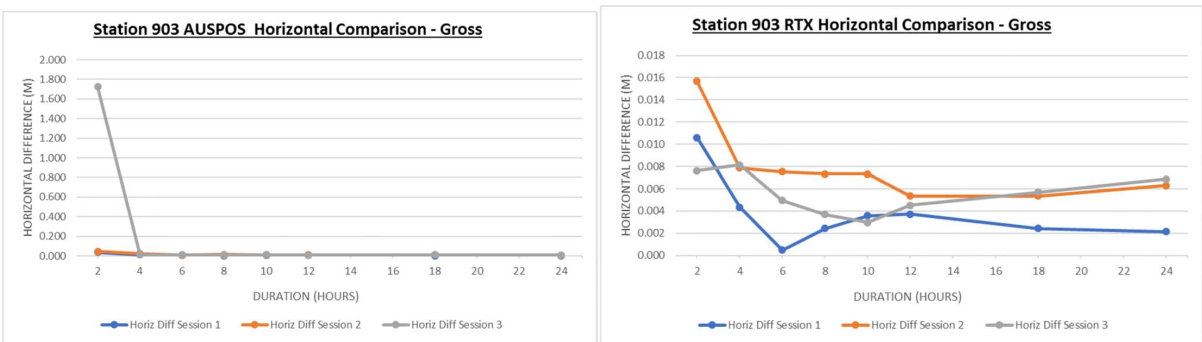

Figure 3 - AUSPOS and RTX for various logging times at 45% obstruction

Figure 3 indicates that at a site with 45% obstruction, AUSPOS gave repeatable results after 4 hours of observations and coordinate differences at 6 hours and after was always less than 20 mm. All RTX results were less than 16mm and after 4 hours were 8mm or less.

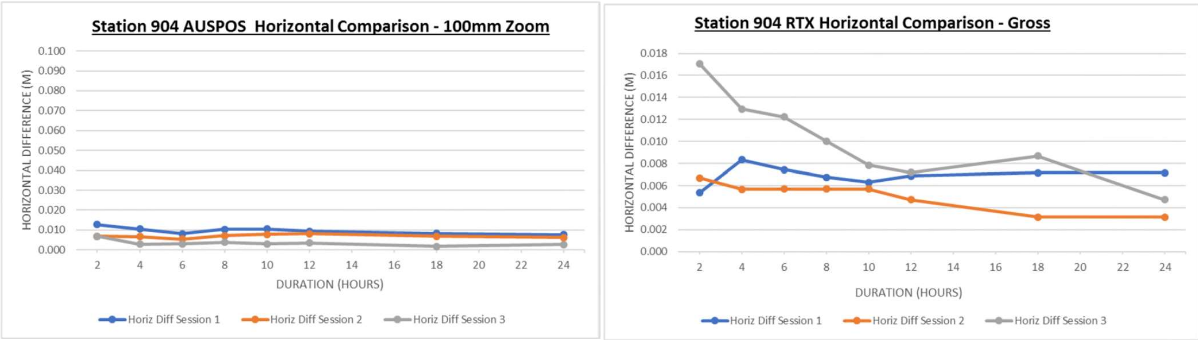

Figure 4 - AUSPOS and RTX for various logging times at 36% obstruction

Figure 4 indicates that at a site with 20% obstruction, AUSPOS gave repeatable results with 2 hours of observations and the coordinate differences was always less than 13 mm (always less than 10 mm after 12 hours). All RTX results were less than or equal to 17mm, and after 10 hours observations were less than 9 mm.

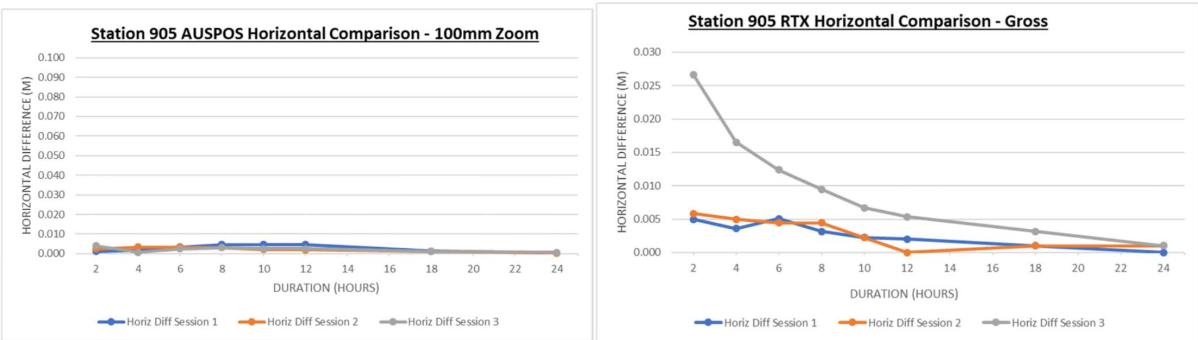

Figure 5 - AUSPOS and RTX for various logging times at 0% obstruction (clear sky)

Figure 5 indicates that at a clear site, AUSPOS gave repeatable results with 2 hours of observations with coordinate differences always less than 5mm. RTX provided results of less than 20 mm after four hours of observations.

Concluding Remarks

All stations tested were able to achieve acceptable results with sufficient observation duration and there was little difference between the two services tested even though the satellite constellations in use by each service are so different. With usual caution and independent checks, surveyors may use these results to influence control station site selection and to indicate required observation durations in similar situations. To provide some broad guidance on how long the observations should be as a function of the percentage of sky cover, we have produced the results shown in Figure 6.

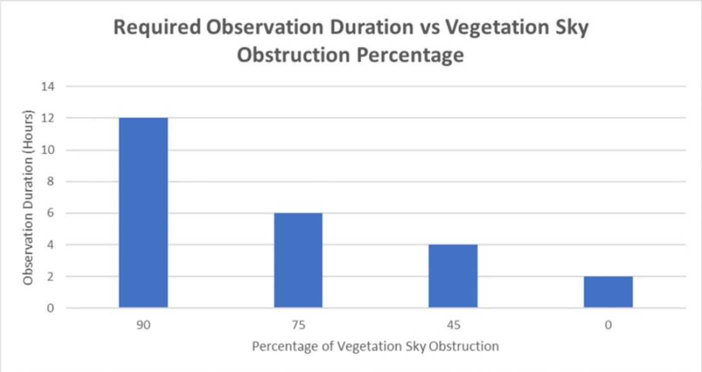

Figure 6 - Observation vs percentage sky cover

It is pointed out that this is just our suggestion based on our data. At other sites and at other times, you may get different results. If you want to be conservative (again based on our findings), a general rule of thumb would be to log at least 12 hours of data at heavily obstructed sites, and more if possible. And redundant observations or reoccupations are, of course, to be considered essential to provide necessary checks on setups, antenna heights, etc. And finally, in all cases, we recommend control surveys be carried out in accordance with SP1 (Inter-Governmental Committee on Surveying and Mapping (ICSM) 2014).

References

- Department of Natural Resources and Mines 2015, *Cadastral Survey Requirements (Version 7.0 - July 2015)*, viewed 22 July 2015, <https://www.dropbox.com/s/0aihfw06xr04xcf/Cadastral%20Survey%20Requirements%20Version%207.pdf?dl=0>.
- Geoscience Australia 2018, *AUSPOS - Online GPS Processing Service*, <http://www.ga.gov.au/scientific-topics/positioning-navigation/geodesy/auspos>.
- Inter-Governmental Committee on Surveying and Mapping (ICSM), *Guideline for Control Surveys - Special Publications 1 (SP1) - Version 2.1,* 2014, I-GCoSaM (ICSM), ICSM Publication No. 1, <http://www.icsm.gov.au/publications/standard-australian-survey-control-network-special-publication-1-sp1>.
- Meyer, TH, Bean, JE, Ferguson, CR & Naismith, JM 2002, 'The Effect of Broadleaf Canopies on Survey-grade Horizontal GPS/GLONASS Measurements', vol. 11, http://digitalcommons.uconn.edu/nrme_articles/11>.
- Queensland Government, *GNSS Control Surveys Guideline,* 2016, Department of Transport and Main Roads, <https://www.tmr.qld.gov.au/-/media/busind/techstdpubs/Surveying/Surveying-support-documents/GNSS/GNSSControlSurveys_Dec16.pdf?la=en>.
- Trimble CentrePoint TRX 2018, *CentrePoint Post Processing*, <https://www.trimble.com/Positioning-Services/CenterPoint-RTX-post-processing.aspx>.