# Site Survey - NRARAO

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*Abstract* – ***As a precursor to assembling an antenna for observations it is necessary to determine the areas of the celestial sphere that is visible from the observatory site. For professional observatories this essentially simplifies down to limits determined by the observatory latitude as the site is chosen based on the ease of observation (i.e. not in the middle of a forest) to which certain levels of personal accommodation is added. For the amateur observatory the site is almost always chosen solely on the basis of accommodation purposes for a family to which observatory facilities are added. Under these circumstances the view of the sky is often limited not only by latitude, by trees and adjacent buildings. Sometimes this limited view excludes certain types of observations. Evaluation of various locations within the site can identify the best location for the type of observations desired.***

## I. INTRODUCTION

The limits to the view of the celestial sphere are fundamentally determined by the latitude of the observatory.

An observatory placed at the north or south poles could only observe one hemisphere of the celestial sphere (mutually exclusive between north and south poles), but can observe that hemisphere continuously. An observatory placed on the equator has access to *all* of the celestial sphere over a period of 24 hours, but only a hemisphere of that celestial sphere at any one time. At latitudes between these two cases the visible area is a hybrid of the two views. Naturally the extent of these views is further limited by the need to avoid observations near the horizon due to ground noise, mountains or local terrain.

Here at NRARAO, which is located at about 33.5°S, excluding local obstructions, a cone section of the celestial sphere extending from the South Celestial Pole (SCP at 90°S) to a declination of about 56.5°S is visible 24 hours a day.

Also a band of the celestial sphere between 56.5°S and 56.5°N is visible for some fraction of the day determined by declination, ranging from almost 24 hours at 56.5°S to a very short period at 56.5°N.

Finally, that part of the celestial sphere at declinations north of 56.5°N are not visible at any time at NRARAO. Other observatories at different locations have their own set of areas of the celestial sphere which is visible all the time, visible some of the time, or not at all. Of course, these visibilities are pared down by local obstructions which, in the case of NRARAO, are numerous – consisting of many tall trees.

## II. DETERMINATION OF TRUE NORTH

Reasonably the first task required in a site survey should be the determination of True North. The equatorial coordinate system used to locate objects on the celestial sphere requires a reference direction which is aligned in azimuth with TN. That is, an equatorial mount has its axis aligned to TN in azimuth (its elevation is determined by observatory latitude).

True North is not the same as Magnetic North, the difference between the two changes with the location on Earth and, more slowly, over time. The offset of MN from TN at NRARAO is currently 12.62º E, decreasing by 0.01°/year. That is, currently, a magnetic compass at NRARAO points 12.62º east of TN.

A magnetic compass could be used to determine TN here at NRARAO and the appropriate correction (12.62º) made, but as such a device of sufficient accuracy was not available, three other methods were used.

Determining the alignment of the residential building at NRARAO as a local reference is a useful guide when walking around surveying possible observatory locations on the block. By the way, the walking around and looking up at the sky and waving your arms about to simulate antenna beam directions is best done whilst your neighbours are out – unless they already know you are a bit 'unusual'.

The first method used for this exercise is the least accurate and utilises the compass app on an iPhone which can be switched between indicating TN or MN if location services are activated. This was used to crudely determine the alignment of the western wall of the residence as shown in Figure 1. Unfortunately there is a large amount of hysteresis in the readings where the readings obtained by rotating the phone from western azimuths differ by more than 5 degrees from the readings obtained by rotating from eastern azimuths.


*Figure 1: Using an iPhone to Determine Building Alignment*

A rough averaging of the two sets of readings gave an estimate of alignment of about 340º for the western wall – or about 20º W of TN.

The second method used was to observe the time when the shadow of the Sun just touches the surface of the western wall. The point in time sought is when, because of the slight unevenness of the brick wall face, some sections (the valleys) are in shade, whilst some sections (the peaks) are in sunlight.

The determination of the alignment of the residence is a key point because, as seen below, the position and alignment of any radio astronomy antenna will have to be associated with that

structure.

As shown in Figure 2 the Sun just touched the western wall on the 17th March, 2014 at 13:55 local time. This corresponds to the Sun being at an azimuth of about 338º as reported by Radio-Eyes (337.86º) and GJTracker (337.6º). A value of 338º is sufficiently accurate enough for the purpose here.

This value is mapped onto a plan view of the NRARAO site as well as True North as shown in Figure 3.


*Figure 2: Date and Time When Sun Just Touched the Western Wall*

## III. VIEW OF THE SKY AT NRARAO

The layout of the site at NRARAO is shown in Figure 3. It can be seen that the site is almost completely covered in trees, severely restricting the view of the sky. The view in Figure 3 taken from Google Earth is dated 2009 – since that date more gardens have been added as shown by the red cross-hatched areas – further restricting the positioning of a radio astronomy antenna.

Virtually the only position available for a radio astronomy antenna is on the roof of the residence – posing problems of size and mechanical stability.


*Figure 3: Plan View of Site at NRARAO*

As an alternative to on-roof mounting there are two sites (marked with yellow ellipses in Figure 3) at each end of the residence where a mounting pole could be attached. Unfortunately, while affording more mechanical stability, both of these locations are significantly more restricted, in terms of sky view, by overhanging trees, than a location on the roof itself.

The light-coloured area next to the left-hand bottom corner of the residence is not usable as this is part of the front drive area.

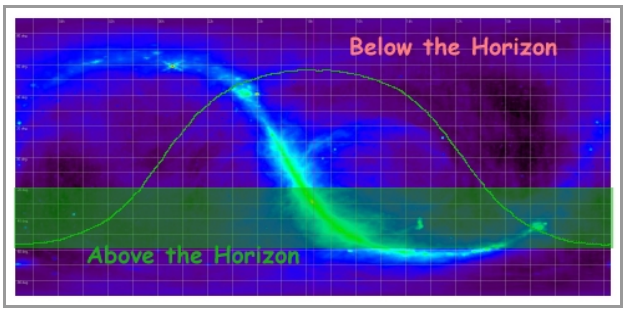


*Figure 4: View of Sky at NRARAO*

Although theoretically the horizon at NRARAO is as shown in Figure 4 - where the geological horizon is shown by the thin green line (in an example when the the centre of the Galaxy is on the local meridian), in actual fact the parts of the sky accessible is restricted by trees. The broad green band shows that part of the sky that would be accessible during a spin-scan, where the antenna is pointed at an unobstructed location in between the trees and the Earth's rotation sweeps the antenna beam across a portion of the celestial sphere. Even so, the band as shown is optimistic as it assumes a very narrow beamwidth antenna – in practice using a more representative, wider, antenna beamwidth, the allowable pointing area is much narrower in order to prevent the thermal noise from the trees from entering the beam pattern.

Such severe restrictions on available sky view, in turn, place a significant restriction on the types of observations that can be undertaken at the NRARAO site.

## IV. CONCLUSION

The severe restrictions on the available portion of the celestial sphere which can be viewed free from local obstructions (almost exclusively trees) limits the type of observational projects which can be undertaken. Such projects as wholesale mapping of the sky cannot be done.

Careful selection of one out of the limited number of antenna locations needs to be done on a project-by-project basis, with the types of projects limited to one or two.

In the future it may be possible to operate a radio astronomy antenna further away from the residence in the small space a little over halfway down the site (near the red cross-hatched area in Figure 3) where the overhanging trees in the near vicinity are of lower height. This will entail considerable effort in running signal and power cables across the intervening space of about 40m. That intervening space is filled with mature landscaping and so will require some measure of ingenuity in order not to compromise the aesthetics.