

NRAO ORBITING VLBI EARTH STATION COORDINATES

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17 March 1997

This memo describes the recent survey measurements of NRAO Orbiting VLBI Earth Station in Green Bank, West Virginia. The survey reference point for 45 foot diameter antenna (called the 45ft) is the azimuth-elevation crossing point. The determination of the coordinates of this point were determined based on laser ranging survey techniques.

The method of obtaining survey data is summarized, and the new results are compared with previous. The new surveyed position differs from the previous measurements by 0.49m. In addition to updating the surveyed position, the coordinates have been transformed from NAD83 to the ITRF93 frame.

Below is a summary of the ITRF 93 coordinates of the 45ft tracking station:

X -	884084.2636	LAT -	38 25 59.89692 North
Y -	-4924578.7481	LON -	79 49 20.63331 West
Z -	3943734.3354	EHT -	807.0868 meters

The surveyed position of the 45ft antenna is believed to be measured with an accuracy of better than 0.10m. The error in the coordinate transformation from the surveyed coordinate position to the required ITRF93 coordinate position should be better than 0.02m.

LASER RANGING SURVEY DATA

The precise measurement of a position on the antenna required 1) good knowledge of the location of a reference point, 2) a set of laser range and angle measurements, 3) conversion of the measurement data to a standard coordinate system and 4) measurement of the translation from the laser retro-reflector to the point of interest, based on conventional use of rulers.

John Shelton of the Green Bank staff, kindly made laser ranging measurements from a precisely known Green Bank Reference point (known as T007, described below) to a retro-reflector mounted on the 45ft near the azimuth-elevation crossing point.

David Parker of the Green Bank staff, kindly converted the raw laser ranging data to NAD83 West Virginia State Plane coordinates and into the NAD 83 coordinate system. The results of these calculations yield in state plane:

159734.0928 N (meters)
702810.4952 E
839.0380 elevation

and

38-25-59.87334 north
79-49-20.64139 west
839.0380 elevation

in NAD83. The position of the reference point is believed to be known to better than 0.003m, and the laser ranging system should also allow measurement of laser retro-reflector positions to better than 0.003m. The conditions on 97 Jan 29, when the measurements were made, were not

ideal, but the measurement accuracy should be no worse than 0.01m.

AZIMUTH ELEVATION POINT

The laser retro-reflector was mounted on a special fixture which allowed placement of the retro reflector very near the azimuth-elevation crossing point (az-el-point) on the antenna. The actual distance from the retro-reflector to the required location was 0.48m. There is no actual component of the antenna at the location of the az-el-point, but components of the antenna nearby allowed estimation this point to better than 0.03m.

My measurements indicated that the az-el-point was 0.038m above the retro-reflector. The az-el-point was 0.46m east of the retro-reflector and 0.13m south.

The x,y offset can be converted to seconds of arc using the radius of the earth 6,378,137m plus, for antenna elevation (808.380m) and latitude 38.4332980 degrees.

Addition of the corrections for the location of the retro-reflector yield:

latitude N38d25'59.86891"
longitude W79d49'20.62226"

in the NAD 83 coordinate system.

The NAD 83 surveyed elevation is the "GEOID" position, but the model ITRF position require ELLIPSOID, which is higher by 30.69553m at T007, in Green Bank. Subtracting this offsets yields an ellipsoid elevation for the az-el-point of $839.0380 - 30.69553 + 0.038 = 808.380\text{m}$.

COMPARISON WITH PREVIOUS SURVEYS

Several previous surveys were made to determine the location of the 45ft antenna and other locations nearby. The previous determination of the 45ft az-el-point was based on survey work relative to T007 by a different surveyor, in order to lay the foundation for the Jansky Lab Addition. The surveyor placed a temporary marker about 100m from the 45ft antenna. From this marker, the elevation of the 45ft antenna was surveyed to a different location. Previous coordinate transformations yielded an Ellipsoid elevation of 808.605m (in NAD 83).

The location of latitude and longitude of the az-el-point was calculated from measurements done in the early 1990's. In these surveys, the coordinates of 4 locations symmetrically placed around the antenna were measured. The az-el-point of the antenna was assumed to be the average of these points. The average of these points was:

latitude -N38 25 59.87929
longitude -W79 49 20.63408

in the NAD 83 system.

In the NAD 83 coordinate system, the new position offset relative to the old (new - old) is -0.01182 seconds of longitude, -0.01038 seconds of latitude, and -0.224m in elevation. At Green Bank, 0.01" of latitude corresponds to 0.30926m. The total magnitude of the surveyed position change was 0.485m.

CONVERSION TO ITRF93

The previously reported positions were in the NAD83 coordinate frame. The coordinate system required by JPL/NAV is ITRF 93 system. A program, called "transf", was kindly provided by Steve Franks at the U.S. NOAA. This program transforms between NAD83 and ITRF93 coordinates with an accuracy of about 0.02m. Conversion from the az-el-point NAD83 coordinates to the ITRF93 coordinates yields the following ITRF93 values:

```
X =      884084.2636    LAT =  38 25 59.89692 North
Y =     -4924578.7481    LON =  79 49 20.63331 West
Z =      3943734.3354    EHT =   807.0868
```

The survey reference point for these surveys at Green Bank is a point called T007, "designated" GREEN BANK T007 DMATC, with "pid" HW3152. It is on the NRAO site at WV/POCAHONTAS County. Based on Nation Geodetic Survey data, retrieved May 6, 1996, the location of T007 is:

```
LAT = 38 26 14.08357 North
LON = 79 49 54.55937 West
EL  = 791.593m          Ellip. height.
```

Using the same program "transf" to convert the coordinates yields ITRF 93 coordinates:

```
X =      883223.5982    LAT =  38 26 14.11158 North
Y =     -4924442.9766    LON =  79 49 54.56944 West
Z =      3944067.2713    EHT =   790.2995
```

The ITRF 93 and NAD 83 coordinate systems have different coordinate values for the same location. The magnitude of the coordinate value difference is 1.58m.

NAVY VLBI 20M ANTENNA COMPARISON

Frank Ghigo, an astronomer in Green Bank, supports the US Navy's geodetic VLBI observations. The geodetic VLBI observations use a 20m antenna, located approximately 200m from the 45ft antenna. The VLBI IERS coordinates system is reported to be "nearly identical" to the ITRF 93 coordinate system (Ghigo, private communication). Frank reports that the VLBI IERS position for the 20-meter is:

```
      X           Y           Z
883772.79740 -4924385.59750 3944042.49910
```

This coordinate was converted to the NAD83 coordinate system used for surveying in Green Bank. His conversion yields the following NAD83 coordinates:

```
      longitude          latitude          height(m)
W 79d49'31.865", N 38d26'12.666", 806.63
```

The surveyed position was:

```
W 79d49'31.865", N 38d26'12.661", 851.40
```

The latitude and longitude agree pretty well. The latitude difference is about 0.005 x 30.48m = 0.15m. But there is some uncertainty in in the 20m latitude VLBI reference location, which is offset about 0.50m, south of the location surveyed. The total discrepancy was 0.65m in latitude.

The conversion from measured position to az-el-point and from GEOID to ellipsoid given below:

```
height of retro-reflector = 851.40 (T007 GEOID + 29.11)
ellipsoid - GEOID height  =  30.69553
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```

	820.70	
minus		
height difference		
between retro-reflector		
and az-el-point	13.9 m	(assuming retro-reflector was 5ft above structure)

surveyed NAD83 height	806.80	(of az-el crossing point)
survey - VLBI difference	0.17m	(survey above VLBI)

SUMMARY

New surveyed measurements for the 45ft tracking station are reported which differ in position by 0.48m from previous measurements. In addition, these new coordinates are transformed from NAD83 to ITRF 93, which results in a further coordinate change by 1.58m.

A test of the survey and coordinate transformation process was performed by surveying the azimuth-elevation coordinate location of Navy 20m VLBI antenna. The difference between the VLBI and surveyed coordinates was 0.67m. This difference may be explained by some uncertainty in the location of the azimuth-elevation crossing point on the 20m antenna. A second, more careful, set of survey measurements will be carried out on both the 45ft and 20m. The 20m survey will be done to check the 0.67m difference between the survey and VLBI coordinates. The 45ft survey data will be used to check the repeatability of the survey measurements.