National Astronomy and Ionosphere Center
Arecibo Gregorian Antenna Optics Series

Tertiary Frame Nodes' Coordinate Transformation

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1 Introduction

The node frame tables of the support backstructure of the tertiary mirror, as provided by Comsat RSI in the Final Design Review (FDR) of November 29 of 1995 in Sterling, VA, have a different coordinate system than the one used to describe the Arecibo optics, in which the origin of the coordinate system is at the apex of the spherical caustic as shown in Figure 1. This memo provides the coordinate transformations needed to convert the node frame tables to the Word Coordinate System (WCS) of the optics.

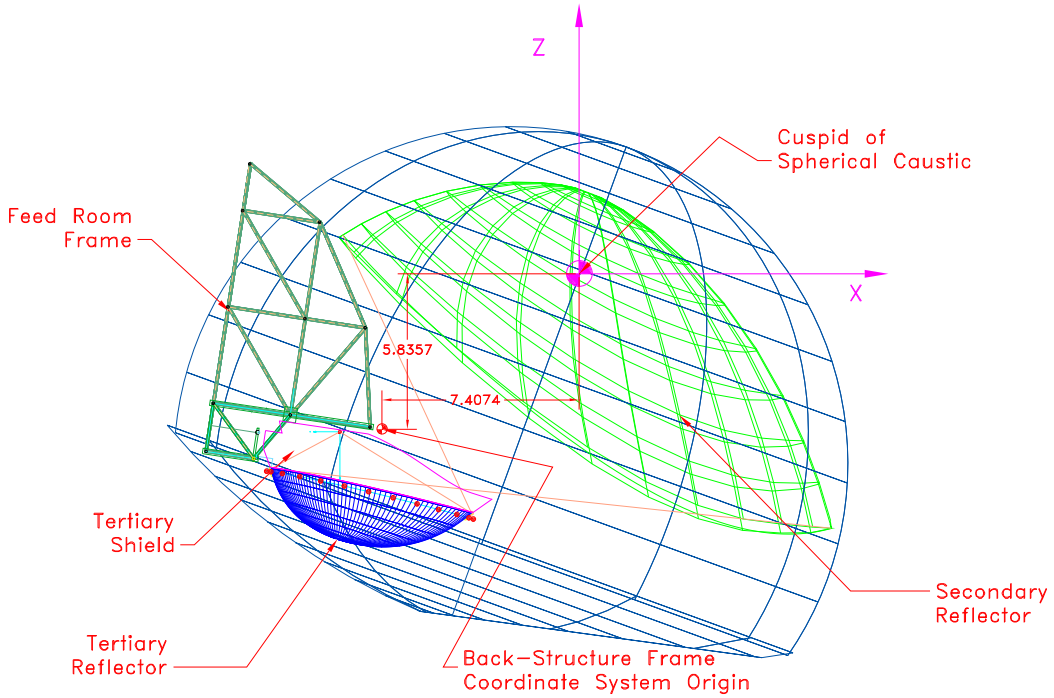

Figure 1. Arecibo Gregorian Geometry Detail

2 Transformation from Comsat LCS to Gregorian Optics WCS

Based on measurements of location of tertiary edge and Mero's node 77, performed on July 2001, in addition to the knowledge of the expected position of panel support fixtures we deduce a coordinate transformation of the node coordinates from Comsat LCS (Local Coordinate System) to the Gregorian Optics WCS. The coordinate transformation is given by,

$$\mathbf{x}_{WCS} = [\mathbf{R}] \cdot [\mathbf{T}] \cdot \mathbf{x}_{LCS} + \mathbf{x}_c, \tag{1}$$

with,

$$[\mathbf{R}] = \begin{bmatrix} \cos\theta_{cY} & 0 & -\sin\theta_{cY} \\ 0 & 1 & 0 \\ +\sin\theta_{cY} & 0 & \cos\theta_{cY} \end{bmatrix} \tag{2}$$

$$[\mathbf{T}] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

The origin of back-structure coordinate system with respect to the WCS is:

$$\mathbf{x}_c = (-7.4074, 0.0000, -5.8357)^T \quad [\text{m}] \tag{3}$$

The rotation angle around the Y-axis is given by,

$$\theta_{cY} = -12^o \tag{4}$$

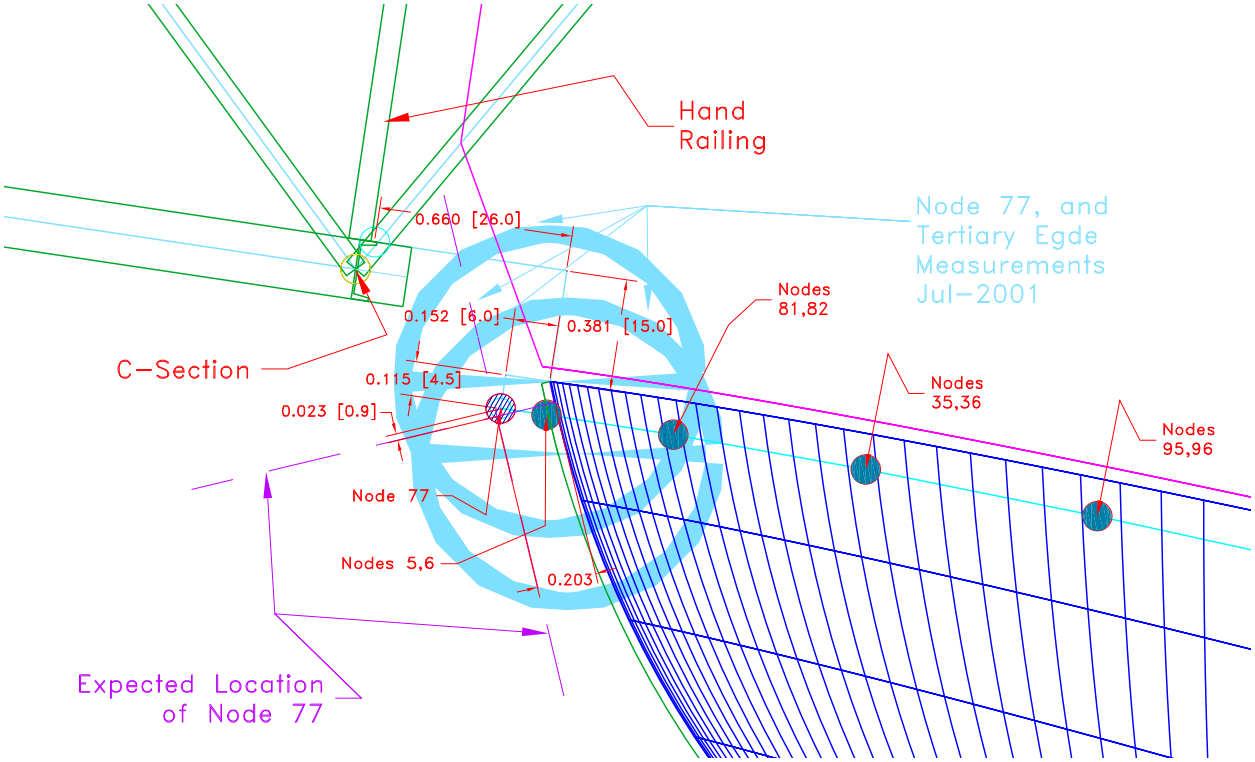

Figure 2. Measured location of Mero's Node 77 with respect to Tertiary Edge. (Dim. in m)

Based on July-2001 measurements we obtained the location of Mero's node 77 with respect to the WCS,

$$\mathbf{x}_{N77} \quad = \quad (-11.7399,\, 0.0000,\, -7.4219)^T \qquad [\text{m}] \tag{5}$$

3 Comments

- The rotation angle was deduced from symmetry considerations and the expected location of the panel support fixture. The uncertainty in the rotation angle is about $\pm 0.2^o$.
- There is a change in Mero's node number labeling from November 29 1995, Final Design Review tables to the set of drawings dated Jan 31, 1996.
- A series of measurements were carried out in Sep-04-2001 to verify the confiability of the FDR Node tables. The nodes used in the verification measurements are reproduced in Table 1. along with the equivalent node nomenclature as per drawings of Jan-31-96.

Table 1. Node Data Used in Measurements

Node Nov-29-95	Node Jan-31-96	X [in]	Y [in]	Z [in]
1	77	-153.860	-96.550	0.000
13	78	159.610	-102.290	0.000
7	98	-0.180	-95.000	-140.100
19	97	-0.180	-95.000	-140.100
121	90	-43.890	-85.900	-170.990
127	89	-43.890	-85.900	170.990

The comparison produced the following results shown in Table 2.

Table 2. Node-to-Node Distance Verification

Nodes (Jan-31-96)	Calculated Distance [m]	Measured Distance [m]	Difference [m]
77-78	7.963	8.039	0.076
77-98	5.282	5.321	0.039
78-98	5.401	5.436	0.035
89-90	8.686	8.680	-0.006

- Therefore, there are some changes in the node position that are not contained in the FDR of Nov-29-95.

4 Noise Shield Upper Edge Sections I and II (in Cone's LCS)

Label	ϕ [deg]	X [m]	Y [m]	Z [m]	Label	ϕ [deg]	X [m]	Y [m]	Z [m]
0	-180.000	-4.852208	0.000000	6.323497	64	0.000	4.660878	0.000000	6.074151
1	-178.008	-4.848820	-0.168612	6.324039	65	3.458	4.649870	0.280995	6.074151
2	-176.016	-4.838661	-0.337021	6.325665	66	6.919	4.616968	0.560237	6.074151
3	-174.021	-4.821742	-0.505027	6.328373	67	10.383	4.562524	0.836001	6.074151
4	-172.022	-4.798080	-0.672434	6.332159	68	13.854	4.487122	1.106624	6.074151
5	-170.019	-4.767699	-0.839052	6.337021	69	17.332	4.391553	1.370528	6.074151
6	-168.010	-4.730627	-1.004697	6.342954	70	20.819	4.276804	1.626249	6.074151
7	-165.993	-4.686895	-1.169193	6.349952	71	24.316	4.144026	1.872459	6.074151
8	-163.967	-4.636535	-1.332372	6.358011	72	27.822	3.994509	2.107986	6.074151
9	-161.931	-4.579577	-1.494073	6.367126	73	31.337	3.830134	2.332119	6.074924
10	-159.883	-4.516052	-1.654141	6.377292	74	34.860	3.657031	2.547397	6.084339
11	-157.821	-4.445986	-1.812428	6.388505	75	38.390	3.476976	2.754863	6.104308
12	-155.744	-4.369401	-1.968791	6.400761	76	41.925	3.290177	2.954729	6.134433
13	-153.650	-4.286314	-2.123090	6.414058	77	45.462	3.096664	3.147045	6.174062
14	-151.536	-4.196735	-2.275188	6.428393	78	48.998	2.896351	3.331669	6.222296
15	-149.402	-4.100666	-2.424949	6.443767	79	52.530	2.689098	3.508247	6.278010
16	-147.244	-3.998103	-2.572237	6.460180	80	56.052	2.474783	3.676222	6.339887
17	-145.061	-3.889030	-2.716915	6.477635	81	59.562	2.253356	3.834853	6.406454
18	-142.852	-3.773425	-2.858841	6.496136	82	63.053	2.024900	3.983257	6.476137
19	-140.612	-3.651254	-2.997868	6.515687	83	66.523	1.789669	4.120452	6.547311
20	-138.341	-3.522475	-3.133844	6.536295	84	69.965	1.548114	4.245420	6.618355
21	-136.037	-3.387034	-3.266607	6.557970	85	73.376	1.300888	4.357163	6.687711
22	-133.696	-3.244868	-3.395983	6.580721	86	76.751	1.048846	4.454764	6.753931
23	-131.318	-3.095907	-3.521787	6.604559	87	80.086	0.793014	4.537431	6.815717
24	-128.899	-2.940069	-3.643816	6.629498	88	83.378	0.534563	4.604545	6.871958
25	-126.437	-2.777265	-3.761851	6.655552	89	86.622	0.274764	4.655681	6.921747
26	-123.931	-2.607401	-3.875653	6.682735	90	89.817	0.014946	4.690629	6.964395
27	-121.378	-2.430375	-3.984959	6.711065	91	92.960	-0.243551	4.709393	6.999427
28	-118.777	-2.246083	-4.089480	6.740557	92	96.050	-0.498960	4.707874	7.020151
29	-116.125	-2.054420	-4.188899	6.771229	93	99.084	-0.744481	4.656106	6.980860
30	-113.422	-1.855283	-4.282866	6.803098	94	102.063	-0.982195	4.595957	6.942818
31	-110.665	-1.648572	-4.370998	6.836178	95	104.986	-1.212092	4.528028	6.906028
32	-107.853	-1.434200	-4.452873	6.870484	96	107.853	-1.434200	4.452873	6.870484
33	-104.986	-1.212092	-4.528028	6.906028	97	110.665	-1.648572	4.370998	6.836178
34	-102.063	-0.982195	-4.595957	6.942818	98	113.422	-1.855283	4.282866	6.803098
35	-99.084	-0.744481	-4.656106	6.980860	99	116.125	-2.054420	4.188899	6.771229
36	-96.050	-0.498960	-4.707874	7.020151	100	118.777	-2.246083	4.089480	6.740557
37	-92.960	-0.243551	-4.709393	6.999427	101	121.378	-2.430375	3.984959	6.711065
38	-89.817	0.014946	-4.690629	6.964395	102	123.931	-2.607401	3.875653	6.682735
39	-86.622	0.274764	-4.655681	6.921747	103	126.437	-2.777265	3.761851	6.655552
40	-83.378	0.534563	-4.604545	6.871958	104	128.899	-2.940069	3.643816	6.629498
41	-80.086	0.793014	-4.537431	6.815717	105	131.318	-3.095907	3.521787	6.604559
42	-76.751	1.048846	-4.454764	6.753931	106	133.696	-3.244868	3.395983	6.580721
43	-73.376	1.300888	-4.357163	6.687711	107	136.037	-3.387034	3.266607	6.557970
44	-69.965	1.548114	-4.245420	6.618355	108	138.341	-3.522475	3.133844	6.536295
45	-66.523	1.789669	-4.120452	6.547311	109	140.612	-3.651254	2.997868	6.515687
46	-63.053	2.024900	-3.983257	6.476137	110	142.852	-3.773425	2.858841	6.496136
47	-59.562	2.253356	-3.834853	6.406454	111	145.061	-3.889030	2.716915	6.477635
48	-56.052	2.474783	-3.676222	6.339887	112	147.244	-3.998103	2.572237	6.460180
49	-52.530	2.689098	-3.508247	6.278010	113	149.402	-4.100666	2.424949	6.443767
50	-48.998	2.896351	-3.331669	6.222296	114	151.536	-4.196735	2.275188	6.428393
51	-45.462	3.096664	-3.147045	6.174062	115	153.650	-4.286314	2.123090	6.414058
52	-41.925	3.290177	-2.954729	6.134433	116	155.744	-4.369401	1.968791	6.400761
53	-38.390	3.476976	-2.754863	6.104308	117	157.821	-4.445986	1.812428	6.388505
54	-34.860	3.657031	-2.547397	6.084339	118	159.883	-4.516052	1.654141	6.377292
55	-31.337	3.830134	-2.332119	6.074924	119	161.931	-4.579577	1.494073	6.367126
56	-27.822	3.994509	-2.107986	6.074151	120	163.967	-4.636535	1.332372	6.358011
57	-24.316	4.144026	-1.872459	6.074151	121	165.993	-4.686895	1.169193	6.349952
58	-20.819	4.276804	-1.626249	6.074151	122	168.010	-4.730627	1.004697	6.342954
59	-17.332	4.391553	-1.370528	6.074151	123	170.019	-4.767699	0.839052	6.337021
60	-13.854	4.487122	-1.106624	6.074151	124	172.022	-4.798080	0.672434	6.332159
61	-10.383	4.562524	-0.836001	6.074151	125	174.021	-4.821742	0.505027	6.328373
62	-6.919	4.616968	-0.560237	6.074151	126	176.016	-4.838661	0.337021	6.325665
63	-3.458	4.649870	-0.280995	6.074151	127	178.008	-4.848820	0.168612	6.324039

These coordinates are with respect to the elliptical cone's local coordinate system. There are 128 points in total[1]. **Note**: The data points with $|\phi| > 143.95^o$ are a mathematical continuation.

[1] Data stored in XYZ format in file: "*shield_upper_edge_I_II_xyz.dat*"