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Development of Transformation Equations for Remote Tracking

Robert T. Finnell

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DEVELOPMENT OF TRANSFORMATION EQUATIONS
FOR REMOTE TRACKING

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ABSTRACT

A method to accurately parallax-correct tracking data is needed at the Tonopah Test Range which can be executed by a minicomputer in a very short time. Spherical transformation equations were developed that give very accurate results when adapted to a given region on the earth's surface. These calculations will run very fast on a 16-bit minicomputer as no floating point and very little double-precision processing is required. Results show that calculated target locations are accurate to within one foot of those calculated with a geocentric formula.

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REQUIREMENTS

A method to accurately calculate tracking data which can be executed by a minicomputer in a very short time is needed at Tonopah Test Range (TTR). It will be used primarily to point cameras at a target that is being tracked by radar. The tracking stations are remotely located from the radar stations; as far as 40 miles in some cases.

An upgrading program is now underway at TTR. As a part of this program, an improved tracking system will be implemented. The new tracking system will improve greatly the capabilities of the present system. Figure 1 is a block diagram of the complete tracking station system.

Fixed program minicomputers will be used to provide tracking information for telescopes, radars, cinetheodolites, and telemetry antennas. Data from up to five radars will be processed at the individual radars to remove systematic errors, and reformatted for local display and transmission, via microwave, to the Range Control Point. This radar data will be combined in a time-multiplexed format at the Control Point and will be transmitted over a single RF link to all tracking stations. The multiplexed data format will contain the target location vectors referenced to the tracking radars and will be transmitted in 10 millisecond intervals. Data processed in the minicomputers at the using location will provide pointing and focus information referenced to that station. Filtering, smoothing, and look-ahead operations will be made on the data at the tracking mount location.

Each tracking station computer will be a fixed function processor. The computer programs will be stored in read-only memory so preloading or initialization will not be required at station start-up or when recovering from a momentary power failure. Station position will be entered with thumbwheel switches.

This system of distributed processing will make several improvements over the present system of doing all calculations and formatting in a central computer. These improvements are:

1. Enhance the tracking control characteristics of the raw radar data. The data will be enhanced by simple filtering and smoothing techniques. A look-ahead operation will compensate for the time involved in measurement, transmission, calculation, and utilization of the data.
2. Include corrections for the earth's curvature that are not being made with the present system. This is required as the radars and tracking stations are leveled with respect to the center of the earth and, if there is any distance

between them, they are not in the same data plane. These corrections are significant even if there are only a few miles between the radar and tracking station.

3. Increase the data rate by a factor of 10 to support a tracking mount slew rate of 10-20 degrees per second.
4. Permit use of an unlimited number of tracking stations as the target vector calculation is done at each station independent of the other stations. This technique does not depend on the I/O capabilities of a central processor as with the present system. Range operations reliability should increase through the use of this independent system.
5. Since individual tracking stations will be capable of performing their own parallax corrections, the capacity for off-range operations will be greatly expanded. With the present system, all tracking instruments must be in data communications with the Control Point computer to receive the parallax-corrected target vector, even if collocated with a radar. The new system can be easily adapted to allow direct communication from a radar to the tracking stations and thus establish "local ranges" where required.

Another report will be prepared to completely describe the new tracking system after its implementation at the Tonopah Test Range.

Figure 1. Block Diagram of Tracking System

DEVELOPMENT OF TRANSFORMATION EQUATIONS FOR REMOTE TRACKING

Derivation of Transformation Equations

The choice of a simple flat-plane solution for remote tracking was discarded because of the inherent errors introduced by the lack of corrections for the earth's curvature. The pointing errors are most noticeable when there are a few miles between the camera and radar station, and when the target is within a mile or so of the camera station. Also, the target position errors are quite large when tracking distant targets.

Geocentric solutions, which take into account the elliptical shape of the earth, are available for extremely accurate data transformations, but they require double-precision, floating-point arithmetic that cannot be processed fast enough in a minicomputer.

It was found that a spherical solution for data transformations was very accurate when limited to a region of about 200 miles on the earth's surface. The calculations developed in this report will run very fast on a minicomputer as no floating-point and very few double-precision calculations are required.

Coordinates at TTR are referenced to a flat-plane that is tangent to the earth at mean sea level directly below the Main Lake target. The x-direction is east, y-direction is true north and z-direction is up.

Transformation of data from one earth tangent plane to another is influenced by:

1. Translation in all three directions.
2. Rotation about the x-axis because of a north-south translation.
3. Rotation about the y-axis because of an east-west translation.
4. Rotation about the z-axis, also because of an east-west translation.

The above four factors of transformation can be developed as follows:

Translation

Transformation in the three directions are defined by the following:

$$x = \bar{x} - x' \quad (1)$$

$$y = \bar{y} - y'$$

$$z = \bar{z} - z'$$

where

(translated data) = (original data) - (translation).

Figure 2 is a graphical representation of data translation.

Figure 2. Translations

Rotation About the X-Axis

Rotation about the x-axis is due to the north-south translation. This rotation is shown in Figure 3 and defined by:

$$y = \bar{y} \cos \alpha - \bar{z} \sin \alpha \quad (2)$$

$$z = \bar{y} \sin \alpha + \bar{z} \cos \alpha$$

where

$$\alpha = \sin^{-1}(y' / d)$$

y' = translation distance in northerly direction

d = distance to center of earth.

Figure 3. Rotation About X-Axis

Rotation About the Y-Axis

Rotation about the y-axis is due to the east-west translation. This rotation is shown in Figure 4 and defined by:

$$x = \bar{x} \cos \beta - \bar{z} \sin \beta \quad (3)$$

$$z = \bar{x} \sin \beta + \bar{z} \cos \beta$$

where

$$\beta = \sin^{-1}(x'/d)$$

x' = translation distance in easterly direction

d = distance to center of earth

Figure 4. Rotation About Y-Axis

Rotation About the Z-Axis

Rotation about the z-axis is due to the east-west translation. This rotation is shown in Figure 5 and defined by:

$$x = \bar{x} \cos \gamma + \bar{y} \sin \gamma \quad (4)$$

$$y = \bar{y} \cos \gamma - \bar{x} \sin \gamma$$

where

$$\gamma = \sin^{-1}(x'/e)$$

x' = translation distance in easterly direction

e = distance from the tangent point at the region latitude
to the north-south pole axis

Figure 5. Rotation About Z-Axis

Figure 6 shows the relationship between distances d and e.

Figure 6. Spherical Constants

Translation and Rotation Equations

Simultaneous translation and rotation about the x-axis is described by:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos \alpha & -\sin \alpha \\ 0 & \sin \alpha & \cos \alpha \end{bmatrix} \begin{bmatrix} \bar{x} - x' \\ \bar{y} - y' \\ \bar{z} - z' \end{bmatrix} \quad (5)$$

Simultaneous translation and rotation about the y-axis is described by:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} \cos \beta & 0 & -\sin \beta \\ 0 & 1 & 0 \\ \sin \beta & 0 & \cos \beta \end{bmatrix} \begin{bmatrix} \bar{x} - x' \\ \bar{y} - y' \\ \bar{z} - z' \end{bmatrix} \quad (6)$$

Simultaneous translation and rotation about the z-axis is described by:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} \cos \gamma & \sin \gamma & 0 \\ -\sin \gamma & \cos \gamma & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \bar{x} - x' \\ \bar{y} - y' \\ \bar{z} - z' \end{bmatrix} \quad (7)$$

The matrix product of rotation about the x, y, and z axis is:

$\cos \gamma \cos \beta$	$\sin \gamma \cos \alpha$ $-\cos \gamma \sin \beta \sin \alpha$	$-\sin \gamma \sin \alpha$ $-\cos \gamma \sin \beta \cos \alpha$
$-\sin \gamma \cos \beta$	$\cos \gamma \cos \alpha$ $+\sin \gamma \sin \beta \sin \alpha$	$-\cos \gamma \sin \alpha$ $+\sin \gamma \sin \beta \cos \alpha$
$\sin \beta$	$\cos \beta \sin \alpha$	$\cos \beta \cos \alpha$

Fortunately, this can be simplified considerably because the angles are very small if the region of operation is not greater than 200 miles. The cosine of the angles round off to one, and the multiple sine terms become insignificant and drop out. The simplification of the rotation matrix leaves the combination of equations 5, 6, and 7 to become:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 1 & \sin \gamma & -\sin \beta \\ -\sin \gamma & 1 & -\sin \alpha \\ \sin \beta & \sin \alpha & 1 \end{bmatrix} \begin{bmatrix} \bar{x} - x' \\ \bar{y} - y' \\ \bar{z} - z' \end{bmatrix} \quad (8)$$

Equation (8), then, is the general equation for transferring data from one plane to another plane within a given region on the earth. It can be written in the following form:

$$x = (\bar{x} - x') + (\bar{y} - y') \sin \gamma - (\bar{z} - z') \sin \beta \quad (9)$$

$$y = (\bar{y} - y') - (\bar{x} - x') \sin \gamma - (\bar{z} - z') \sin \alpha$$

$$z = (\bar{z} - z') + (\bar{x} - x') \sin \beta + (\bar{y} - y') \sin \alpha$$

Application of the Spherical Transformation Equations

Two primary applications for the use of the spherical transformation equations (9) are for:

1. Pointing and focusing camera mounts to a target being tracked by radar, and
2. Pointing radars to a window for gun tests

Camera Tracking

The location of all radar and camera equipment on TTR is defined in terms of their relationship to a plane tangent to the earth at MSL directly below the "Main Lake Target" (MLT).

Two transformations are required to provide pointing data for a camera. First, the camera location must be rereferenced from the Main Lake plane (MLP) to the radar plane; then the radar data can be rereferenced to the camera plane.

To determine the camera location with respect to the radar, in equations 9 let:

$$x = x_o, \bar{x} = x_c, x' = x_r, \sin \alpha = y_r/d$$

$$y = y_o, \bar{y} = y_c, y' = y_r, \sin \beta = x_r/d$$

$$z = z_o, \bar{z} = z_c, z' = z_r, \sin \gamma = x_r/e$$

Subscript "c" refers to MLP camera location and subscript "r" refers to MLP radar location. Then substituting in equations (9), the camera location from the radar is:

$$x_o = (x_c - x_r) + (x_r/e) (y_c - y_r) - (x_r/d) (z_c - z_r) \quad (10)$$

$$y_o = (y_c - y_r) - (x_r/e) (x_c - x_r) - (y_r/d) (z_c - z_r)$$

$$z_o = (z_c - z_r) + (x_r/d) (x_c - x_r) + (y_r/d) (y_c - y_r)$$

These values can be precalculated.

To determine the target location with respect to the camera plane, let:

$$\bar{x} = R \cos E \sin A, x' = x_o, \sin \alpha = (y_o/d)$$

$$\bar{y} = R \cos E \cos A, y' = y_o, \sin \beta = (x_o/d)$$

$$\bar{z} = R \sin E, z' = z_o, \sin \gamma = (x_o/e)$$

where

R, E, A are radar measurements (range, elevation, azimuth) to the target,

x_o, y_o, z_o determined from equations (10)

Then, substituting again in equations (9), the target location is:

$$x = (\bar{x} - x_o) + (x_o/e) (\bar{y} - y_o) - (x_o/d) (\bar{z} - z_o) \quad (11)$$

$$y = (\bar{y} - y_o) - (x_o/e) (\bar{x} - x_o) - (y_o/d) (\bar{z} - z_o)$$

$$z = (\bar{z} - z_o) + (x_o/d) (\bar{x} - x_o) + (y_o/d) (\bar{y} - y_o)$$

Range, azimuth, and elevation from the camera to the target are obtained by:

$$R = (x^2 + y^2 + z^2)^{1/2} \quad (12)$$

$$A = \tan^{-1}(x/y)$$

$$E = \tan^{-1}(z/(x^2 + y^2)^{1/2})$$

Gun Window

Two transformations are also required to provide pointing data for a radar to a gun window. First, the radar location must be rereferenced from the Main Lake plane to the gun plane; then the gun data can be rereferenced to the radar plane.

To determine the radar location with respect to the gun, in equation 9 let:

$$x = x_o, \bar{x} = x_r, x' = x_g, \sin \alpha = y_g/d$$

$$y = y_o, \bar{y} = y_r, y' = y_g, \sin \beta = x_g/d$$

$$z = z_o, \bar{z} = z_r, z' = z_g, \sin \gamma = x_g/e$$

Subscript "r" refers to MLP radar location and subscript "g" refers to MLP gun location. Then, substituting in equations (9), the radar location from the gun is:

$$x_o = (x_r - x_g) + (x_g/e) (y_r - y_g) - (x_g/d) (z_r - z_g) \quad (13)$$

$$y_o = (y_r - y_g) - (x_g/e) (x_r - x_g) - (y_g/d) (z_r - z_g)$$

$$z_o = (z_r - z_g) + (x_g/d) (x_r - x_g) + (y_g/d) (y_r - y_g)$$

To determine the window location with respect to the radar plane, let:

$$\bar{x} = R \cos E \sin A, \quad x' = x_0, \quad \sin \alpha = (y_0/d)$$

$$\bar{y} = R \cos E \cos A, \quad y' = y_0, \quad \sin \beta = (x_0/d)$$

$$\bar{z} = R \sin E, \quad z' = z_0, \quad \sin \gamma = (x_0/e)$$

where

R, E, A are gun parameters (range, elevation, azimuth) to the target,

x_0, y_0, z_0 are determined from equations (13).

Then, the window location from the radar is found by again using equations (11) and (12).

Accuracy

Calculations were made to compare the results of the geocentric, flat plane, and spherical solutions. Camera pointing (AZ, EL, RANGE in degrees and yards) and position data (X, Y, Z, in feet) were calculated for various target locations about our range. Table 1 shows the results of calculations with a radar located at station 17 (see Figure 7 for TTR Map) and with a camera located at the MLT. Target locations are 100 feet above the identified stations. The comparison of methods shows that the spherical method is very accurate in that the positions are within 1 foot of the true positions. These results also show that flat plane calculations are not useful for pointing cameras if the target is within 1.5 miles of a camera station.

Table 2 shows the results for various locations of cameras with the radar located on Radar Hill. Target positions are given as 100 feet and 10,000 feet above various stations. Stations 201C (Pahute Mesa) and CABT (Stone Cabin) are not on TTR. 201C is 38 miles south of MLT, and CABT is 23 miles north of MLT. The results show that the flat plane position errors are very large at long ranges and would not be entirely satisfactory for plotting board or similar uses, while the spherical solution is still very accurate at these distances.

Figure 7. Map of Tonopah Test Range

TABLE I

THE RADAR LOCATION IS 175			THE CAMERA LOCATION IS MAIN									
STATION	AZ	DIFF	EL	DIFF	RANGE	DIFF	X	DIFF	Y	DIFF	Z	DIFF
GEOCENTRIC												
2010	160.0656		0.0303		66999.44		68519.19		-188958.75		5437.74	
FLAT PLANE												
2010	160.1393	0.0737	0.0743	0.0440	66984.77	-14.67	68271.00	-248.19	-189001.69	-42.94	5592.04	154.30
SPHERICAL												
2010	160.0634	-0.0001	0.0304	0.0000	66999.61	0.17	68520.19	1.00	-188959.00	-0.25	5438.12	0.38
GEOCENTRIC												
510	173.3119		0.3475		29550.71		10324.67		-28047.19		5869.08	
FLAT PLANE												
510	173.3779	0.0660	0.3432	-0.0043	29533.74	-16.97	10217.32	-107.35	-28008.52	38.67	5862.03	-7.05
SPHERICAL												
510	173.3115	-0.0003	0.3477	0.0002	29550.82	0.11	10325.24	0.57	-28047.47	-0.28	5869.29	0.21
GEOCENTRIC												
410	141.8147		0.2783		20793.58		38563.75		-49031.65		5634.29	
FLAT PLANE												
410	141.8531	0.0384	0.2788	0.0205	20785.08	-10.50	38511.34	-52.41	-49032.62	-0.98	5656.45	22.16
SPHERICAL												
410	141.8145	-0.0002	0.2783	0.0000	20793.70	0.12	38564.19	0.44	-49031.76	-0.11	5634.31	0.02
GEOCENTRIC												
140	135.8255		0.3018		12881.46		26928.80		-27716.15		5534.90	
FLAT PLANE												
140	135.8335	0.0081	0.2862	-0.0156	12872.60	-8.86	26906.41	-22.39	-27700.95	15.20	5524.24	-10.66
SPHERICAL												
140	135.8253	-0.0001	0.3019	0.0001	12881.55	0.08	26929.06	0.26	-27716.29	-0.14	5534.96	0.06
GEOCENTRIC												
510	166.9515		0.2006		7628.89		5167.04		-22245.45		5451.02	
FLAT PLANE												
510	166.9612	0.0097	0.1674	-0.1322	7612.93	-15.96	5152.15	-14.90	-22210.01	45.54	5398.08	-52.94
SPHERICAL												
510	166.9516	-0.0002	0.2009	0.0003	7628.99	0.10	5167.22	0.18	-22245.72	-0.27	5451.15	0.13

TABLE I (Cont)

THE RADAR LOCATION IS 17R				THE CAMERA LOCATION IS MAIN								
STATION	AZ	DIFF	EL	DIFF	RANGE	DIFF	X	DIFF	Y	DIFF	Z	DIFF
GEOCENTRIC												
31 DAME	302.7874		1.1562		1920.30		-4842.12		3119.03		5447.59	
FLAT PLANE												
31 DAME	303.3961	0.6087	0.3091	-0.8471	1924.90	4.60	-4821.13	20.99	3178.49	59.46	5362.49	-85.10
SPHERICAL												
31 DAME	302.7847	-0.0026	1.1579	0.0016	1920.24	-0.05	-4842.11	0.00	3118.71	-0.32	5447.75	0.16
GEOCENTRIC												
WILKES	218.5001		2.3367		830.72		-1550.11		-1948.75		5432.95	
FLAT PLANE												
WILKES	219.0466	0.5465	0.5935	-1.7432	812.91	-17.41	-1536.19	13.92	-1893.89	54.86	5356.60	-76.35
SPHERICAL												
WILKES	218.4948	-0.0053	2.3400	0.0032	830.79	0.06	-1550.06	0.05	-1949.06	-0.31	5433.10	0.15
GEOCENTRIC												
1M	314.4808		0.8497		3019.71		-6462.85		6346.78		5465.69	
FLAT PLANE												
1M	314.8713	0.3905	0.2810	-0.5687	3027.85	8.14	-6437.37	25.48	6408.54	61.76	5375.89	-89.80
SPHERICAL												
1M	314.4794	-0.0014	0.8509	0.0011	3019.65	-0.06	-6462.86	-0.00	6346.48	-0.30	5465.87	0.18
GEOCENTRIC												
19C	306.5244		0.3407		5787.38		-13941.21		10347.77		5434.57	
FLAT PLANE												
19C	306.8364	0.2520	-0.0076	-0.3483	5793.34	5.96	-13910.10	31.11	10410.89	72.12	5320.01	-105.56
SPHERICAL												
19C	306.5831	-0.0012	0.3412	0.0005	5787.33	-0.05	-13941.31	-0.09	10347.36	-0.41	5434.73	0.16
GEOCENTRIC												
ST CAS	18.8063		0.0392		40721.12		39381.84		115641.47		5415.05	
FLAT PLANE												
ST CAS	18.8859	0.0796	0.0074	-0.0318	40739.55	18.44	39560.41	173.57	115639.00	-2.47	5347.24	-67.81
SPHERICAL												
ST CAS	18.8062	-0.0000	0.0392	0.0000	40721.09	-0.02	39381.55	-0.29	115641.52	0.04	5414.97	-0.08

TABLE I (Cont)

THE RADAR LOCATION IS 172						THE CAMERA LOCATION IS MAIN						
STATION	AZ	DIFF	EL	DIFF	RANGE	DIFF	X	DIFF	Y	DIFF	Z	DIFF
GEOCENTRIC HAR	166.9547		1.6011		1232.71		834.42		-3601.29		5434.67	
FLAT PLANE HAR	166.5047	-1.3600	0.5047	-1.0954	1216.44	-16.27	846.02	11.60	-3540.76	51.53	5363.55	-71.12
SPHERICAL HAR	166.9547	0.0000	1.6034	0.0023	1232.82	0.11	834.49	0.07	-3601.59	-0.30	5434.83	0.16
GEOCENTRIC REB	164.4365		3.2188		592.55		476.20		-1709.76		5431.15	
FLAT PLANE REB	163.5198	-0.9167	0.2942	-2.3246	576.33	-16.22	490.42	14.22	-1657.75	52.01	5358.32	-72.83
SPHERICAL REB	164.4784	0.0019	3.2297	0.0039	592.65	0.10	476.23	0.03	-1710.07	-0.31	5431.29	0.14
GEOCENTRIC X STA	3.8133		33.6316		60.18		10.00		150.00		5431.34	
FLAT PLANE X STA	7.5415	3.7282	7.0485	-26.5831	65.67	8.49	26.83	16.83	202.68	52.68	5356.62	-74.72
SPHERICAL X STA	3.8295	0.0162	33.7152	0.0835	60.13	-0.05	10.02	0.02	140.71	-0.29	5431.46	0.12
GEOCENTRIC 1K 0.	359.9518		5.7059		334.99		-0.67		1010.00		5431.28	
FLAT PLANE 1K 0.	0.2460	-0.9847	1.3477	-4.3592	351.05	16.06	17.39	18.06	1052.73	52.73	5356.11	-75.17
SPHERICAL 1K 0.	359.9647	-0.0028	5.7180	0.0111	334.91	-0.08	-0.62	0.05	920.74	-0.26	5431.45	0.17
GEOCENTRIC 2K 0.	359.9618		2.8588		667.51		-1.33		2000.00		5431.20	
FLAT PLANE 2K 0.	1.5049	0.5431	0.6735	-2.1850	684.31	16.80	18.09	19.62	2032.69	52.69	5355.47	-75.73
SPHERICAL 2K 0.	359.9622	0.0007	2.8635	0.0050	667.41	-0.10	-1.32	0.01	1999.70	-0.30	5431.36	0.16

TABLE II

THE RADAR LOCATION IS MPS-25

THE CAMERA LOCATION IS 201C

STATION	AZ	DIFF	EL	DIFF	RANGE	DIFF	X	DIFF	Y	DIFF	Z	DIFF
GEOCENTRIC												
17T+100	350.3185		-0.4289		59999.37		-30269.25		177429.66		4965.14	
FLAT PLANE												
17T+100	350.1718	-0.1467	0.0881	0.5170	60008.83	9.52	-30729.53	-460.28	177384.34	-45.31	6589.55	1624.41
SPHERICAL												
17T+100	350.3207	0.0021	-0.4280	0.0008	60001.49	2.11	-30263.75	5.50	177437.00	7.34	4967.98	2.84
GEOCENTRIC												
CABT+100	354.6801		-0.5212		101996.61		-28368.75		304659.25		3529.31	
FLAT PLANE												
CABT+100	354.5212	-0.1589	-0.0451	0.4761	102008.11	11.50	-29218.26	-849.51	304626.25	-33.00	6071.18	2541.87
SPHERICAL												
CABT+100	354.6822	0.0021	-0.5203	0.0009	102000.02	3.41	-28358.89	9.86	304670.50	11.25	3534.11	4.80
GEOCENTRIC												
19T+100	337.6569		-0.5178		71896.91		-81957.11		199503.66		4363.47	
FLAT PLANE												
19T+100	337.5168	-0.1500	0.0103	0.5281	71899.83	2.92	-82485.69	-528.58	199304.78	-198.87	6351.54	1980.07
SPHERICAL												
19T+100	337.6594	0.0025	-0.5179	0.0008	71899.66	2.75	-81951.52	5.59	199515.00	11.34	4366.19	2.72
GEOCENTRIC												
12T+100	344.6575		-0.4902		69928.80		-55505.12		202302.50		4517.93	
FLAT PLANE												
12T+100	344.5074	-0.1501	0.0299	0.5201	69935.37	6.58	-56041.86	-536.74	202182.91	-119.59	6422.34	1904.41
SPHERICAL												
12T+100	344.6597	0.0021	-0.4893	0.0009	69931.37	2.53	-55499.11	6.01	202312.25	9.75	4520.91	2.98
GEOCENTRIC												
MANT+100	340.2214		-0.5271		66997.77		-68010.36		189128.25		4463.59	
FLAT PLANE												
MANT+100	340.0730	-0.1484	0.0025	0.5296	67002.05	4.28	-68507.41	-497.05	188971.44	-156.81	6321.44	1857.85
SPHERICAL												
MANT+100	340.2239	0.0025	-0.5263	0.0008	67000.33	2.56	-68004.91	5.45	189138.41	10.16	4466.31	2.72

TABLE II (Cont)

THE RADAR LOCATION IS MPS-25

THE CAMERA LOCATION IS 201C

STATION	AZ	DIFF	EL	DIFF	RANGE	DIFF	X	DIFF	Y	DIFF	Z	DIFF
GEOCENTRIC												
17T+10K	350.3135		2.7507		60095.69		-30283.70		177514.69		14964.76	
FLAT PLANE												
17T+10K	350.1892	-0.1383	3.2671	0.5164	60109.20	13.51	-30704.76	-421.06	177396.81	-117.87	16589.54	1624.78
SPHERICAL												
17T+10K	350.3206	0.0020	2.7517	0.0009	60097.80	2.11	-30278.55	5.15	177521.81	7.12	14967.98	3.22
GEOCENTRIC												
CABT+10K	354.6802		1.3503		102069.61		-28382.29		304805.25		13528.24	
FLAT PLANE												
CABT+10K	354.5273	-0.1529	1.8259	0.4756	102083.44	13.83	-29192.62	-810.33	304699.56	-105.69	16070.76	2542.52
SPHERICAL												
CABT+10K	354.6821	0.0018	1.3512	0.0009	102072.97	3.36	-28372.64	9.65	304816.19	10.94	13533.25	5.01
GEOCENTRIC												
19T+10K	337.6664		2.1366		71978.44		-81996.25		199599.25		14362.94	
FLAT PLANE												
19T+10K	337.5153	-0.1476	2.6644	0.5278	71984.72	6.28	-82485.55	-489.31	199327.75	-271.50	16351.45	1988.51
SPHERICAL												
19T+10K	337.6693	0.0023	2.1373	0.0006	71981.22	2.78	-81990.91	5.34	199610.31	11.06	14365.94	3.00
GEOCENTRIC												
12T+10K	344.6575		2.2387		70013.19		-55531.61		202399.44		14517.43	
FLAT PLANE												
12T+10K	344.5126	-0.1449	2.7584	0.5197	70023.19	10.00	-56029.05	-497.45	202207.22	-192.22	16422.28	1904.85
SPHERICAL												
12T+10K	344.6597	0.0021	2.2395	0.0007	70015.77	2.58	-55525.84	5.77	202408.91	9.47	14520.72	3.29
GEOCENTRIC												
MANT+10K	340.2214		2.3211		67032.08		-68042.60		189218.81		14463.12	
FLAT PLANE												
MANT+10K	340.0755	-0.1449	2.8504	0.5293	67089.61	7.83	-68500.58	-457.75	188989.41	-229.41	16321.39	1858.27
SPHERICAL												
MANT+10K	340.2238	0.0023	2.3219	0.0008	67084.61	2.53	-68037.62	5.17	189228.75	9.94	14466.15	3.03

TABLE II (Cont)

THE RADAR LOCATION IS MPS-25

THE CAMERA LOCATION IS 17C

STATION	AZ	DIFF	EL	DIFF	RANGE	DIFF	X	DIFF	Y	DIFF	Z	DIFF
GEOCENTRIC												
201T+100	170.2548		-0.0015		59999.62		30467.98		-177401.50		5636.44	
FLAT PLANE												
201T+100	170.1473	-0.1075	0.0157	0.0172	59990.02	-9.59	30795.75	327.77	-177315.69	85.81	5690.86	54.42
SPHERICAL												
201T+100	170.2552	0.0003	-0.0037	-0.0022	59999.77	0.16	30466.66	-1.32	-177402.22	-0.72	5629.59	-6.85
GEOCENTRIC												
CABT+100	0.7913		-0.1156		42417.22		1757.39		127239.27		5384.49	
FLAT PLANE												
CABT+100	0.6742	-0.1171	-0.2252	-0.1096	42426.13	8.91	1497.60	-259.79	127268.61	20.34	5141.03	-243.46
SPHERICAL												
CABT+100	0.7913	0.0004	-0.1157	-0.0001	42417.27	0.04	1758.49	1.10	127239.37	0.11	5384.29	-0.20
GEOCENTRIC												
19T+100	293.0651		-0.2440		18735.60		-51713.13		22020.37		5401.97	
FLAT PLANE												
19T+100	292.9739	-0.0911	-0.2241	0.0199	18743.42	7.82	-51769.84	-56.71	21947.17	-73.20	5421.39	19.42
SPHERICAL												
19T+100	293.0652	0.0001	-0.2443	-0.0002	18735.63	0.03	-51713.16	-0.03	22020.54	0.17	5401.61	-0.36
GEOCENTRIC												
12T+100	314.3236		-0.1605		11811.85		-25264.05		24847.44		5542.02	
FLAT PLANE												
12T+100	314.4279	-0.0957	-0.2409	-0.0804	11821.46	9.61	-25326.01	-61.96	24825.27	-22.17	5492.20	-49.82
SPHERICAL												
12T+100	314.5237	0.0001	-0.1609	-0.0004	11811.83	-0.02	-25263.96	0.08	24847.45	0.01	5541.77	-0.25
GEOCENTRIC												
MANT+100	237.1627		-0.3590		13171.69		-37754.73		11660.13		5393.73	
FLAT PLANE												
MANT+100	237.0829	-0.0798	-0.3623	-0.0033	13178.87	7.18	-37791.55	-36.82	11613.80	-46.33	5391.29	-2.44
SPHERICAL												
MANT+100	237.1627	0.0000	-0.3593	-0.0002	13171.71	0.01	-37754.79	-0.06	11660.20	0.07	5393.49	-0.24

TABLE II (Cont)

THE RADAR LOCATION IS 088-25				THE CAMERA LOCATION IS 170								
STATION	AZ	DIFF	EL	DIFF	RANGE	DIFF	X	DIFF	Y	DIFF	Z	DIFF
GEODESIC												
2011+10K	170.2855		3.1767		60120.76		30482.51		-177486.50		15636.07	
FLAT PLANE												
2011+10K	170.1350	-0.1150	3.1970	-0.0203	60140.70	-11.06	30435.15	352.64	-177388.41	98.09	15697.94	61.87
SPHERICAL												
2011+10K	170.2855	0.0004	3.1769	0.0002	60120.97	0.21	30481.02	-1.42	-177487.41	-0.91	15636.68	0.61
GEODESIC												
041+10K	0.7013		4.3762		42561.55		1758.23		127300.22		15384.30	
FLAT PLANE												
041+10K	0.6855	-0.1060	4.2859	-0.1103	42568.29	6.74	1523.24	-234.99	127341.97	41.75	15140.61	-243.69
SPHERICAL												
041+10K	0.7013	0.0004	4.3761	-0.0001	42561.56	-0.01	1759.40	1.17	127300.30	0.07	15384.02	-0.28
GEODESIC												
191+10K	293.0852		0.8470		19024.64		-51737.80		22030.93		15401.93	
FLAT PLANE												
191+10K	292.9854	-0.0898	0.8852	-0.0182	19027.57	2.93	-51769.70	-31.50	21970.11	-60.82	15421.30	19.37
SPHERICAL												
191+10K	293.0852	0.0000	0.8466	-0.0003	19024.66	0.01	-51737.88	-0.07	22031.09	0.16	15401.55	-0.38
GEODESIC												
121+10K	314.5237		15.6034		12269.62		-25276.11		24850.34		15542.00	
FLAT PLANE												
121+10K	314.4700	-0.0537	15.5204	-0.1830	12271.46	1.84	-25313.21	-37.10	24840.56	-0.78	15492.13	-40.87
SPHERICAL												
121+10K	314.5237	0.0000	15.6031	-0.0002	12269.57	-0.05	-25276.00	0.11	24850.33	-0.01	15541.77	-0.23
GEODESIC												
MAN1+10K	287.1427		13.8878		13572.77		-37772.76		11665.71		15393.71	
FLAT PLANE												
MAN1+10K	287.1100	-0.0521	13.9867	-0.0989	13573.04	0.27	-37784.73	-11.97	11651.77	-33.04	15391.24	-2.47
SPHERICAL												
MAN1+10K	287.1427	0.0000	13.8878	-0.0002	13572.77	0.00	-37772.90	-0.04	11665.76	0.05	15393.47	-0.24

TABLE II (Cont)

THE RADAR LOCATION IS MPS-25				THE CAMERA LOCATION IS MANC								
STATION	AZ	DIFF	ELEV	DIFF	RANGE	DIFF	X	DIFF	Y	DIFF	Z	DIFF

GEOCENTRIC												
2011+100	151.3212		-0.1106		57535.91		82834.08		-151432.56		5599.48	
FLAT PLANE												
2011+100	151.3212	0.0000	-0.1131	-0.0025	57535.91	0.00	82834.22	0.14	-151432.50	0.06	5592.06	-7.42
SPHERICAL												
2011+100	151.3212	0.0000	-0.1131	-0.0025	57535.91	0.00	82834.22	0.14	-151432.50	0.06	5592.06	-7.42

GEOCENTRIC												
171+100	63.5253		-0.3669		19373.65		52024.80		25909.95		5660.63	
FLAT PLANE												
171+100	63.5253	0.0000	-0.3669	0.0000	19373.64	-0.01	52024.80	0.00	25909.92	-0.03	5660.60	-0.03
SPHERICAL												
171+100	63.5253	0.0000	-0.3669	0.0000	19373.64	-0.01	52024.80	0.00	25909.92	-0.03	5660.60	-0.03

GEOCENTRIC												
CAB1+100	19.2677		-0.3145		54080.59		53536.20		153151.75		5142.11	
FLAT PLANE												
CAB1+100	19.2677	0.0000	-0.3145	0.0000	54080.56	-0.02	53536.06	-0.13	153151.75	0.00	5142.23	0.12
SPHERICAL												
CAB1+100	19.2677	0.0000	-0.3145	0.0000	54080.56	-0.02	53536.06	-0.13	153151.75	0.00	5142.23	0.12

GEOCENTRIC												
10T+100	0.3218		-0.7309		15045.01		268.66		47830.37		5422.57	
FLAT PLANE												
10T+100	0.3218	0.0000	-0.7309	0.0000	15045.00	-0.00	268.64	-0.02	47830.34	-0.03	5422.58	0.00
SPHERICAL												
10T+100	0.3218	0.0000	-0.7309	0.0000	15045.00	-0.00	268.64	-0.02	47830.34	-0.03	5422.58	0.00

GEOCENTRIC												
12T+100	43.3666		0.7354		6055.13		12472.48		13214.69		5564.15	
FLAT PLANE												
12T+100	43.2750	-0.0007	0.3911	-0.3443	6051.78	-3.35	12445.40	-27.08	13217.91	13.22	5454.00	-109.25
SPHERICAL												
12T+100	43.3669	0.0003	0.7350	-0.0004	6055.11	-0.02	12472.53	0.05	13214.60	-0.08	5564.00	-0.15

TABLE II (Cont)

THE RADAR LOCATION IS KPS-25				THE CAMERA LOCATION IS XANO								
STATION	AZ	DIFF	EL	DIFF	RANGE	DIFF	X	DIFF	Y	DIFF	Z	DIFF
GEOCENTRIC												
2011+10K	160.0779		2.8792		67114.91		68520.05		-149056.56		15444.71	
FLAT PLANE												
2011+10K	160.0484	-0.0290	2.9410	0.0618	67109.33	-5.58	68606.55	86.50	-138995.75	60.81	15660.65	215.94
SPHERICAL												
2011+10K	160.0780	0.0000	2.8794	0.0001	67114.02	0.11	68519.72	-0.33	-149057.06	-0.50	15445.39	0.68
GEOCENTRIC												
17T+10K	107.0826		14.7021		13623.95		37789.59		-11613.03		15704.00	
FLAT PLANE												
17T+10K	107.0234	-0.0592	14.5980	-0.1041	13610.64	-13.34	37782.50	-7.09	-11568.16	44.87	15622.10	-81.90
SPHERICAL												
17T+10K	107.0827	0.0000	14.7021	0.0000	13623.99	0.00	37789.59	0.00	-11613.11	-0.08	15704.02	0.01
GEOCENTRIC												
CABT+10K	18.7934		4.7172		40873.41		39369.15		115680.72		15414.98	
FLAT PLANE												
CABT+10K	18.7546	-0.0398	4.5713	-0.1459	40871.16	-2.25	39294.63	-74.52	115734.61	44.89	15103.32	-311.66
SPHERICAL												
CABT+10K	18.7935	0.0000	4.7170	-0.0002	40873.45	0.04	39369.45	0.30	115680.77	0.04	15414.55	-0.43
GEOCENTRIC												
19T+10K	306.5035		40.0422		6710.37		-13079.51		10345.65		15470.16	
FLAT PLANE												
19T+10K	306.5121	0.0086	39.9939	-0.0483	6704.25	-7.12	-13094.30	-12.72	10342.75	17.10	15384.01	-86.15
SPHERICAL												
19T+10K	306.5035	0.0000	40.0419	-0.0003	6710.32	-0.04	-13079.44	0.07	10345.63	-0.01	15469.27	-0.19
GEOCENTRIC												
12T+10K	43.3655		50.3043		6951.98		12478.44		13211.09		15564.14	
FLAT PLANE												
12T+10K	43.2557	-0.1098	50.1132	-0.1911	6936.65	-15.34	12454.20	-20.14	13242.20	31.18	15454.83	-109.31
SPHERICAL												
12T+10K	43.3656	0.0000	50.3039	-0.0003	6951.92	-0.06	12478.57	0.13	13210.98	-0.07	15563.99	-0.15

TABLE II (Cont)

THE BAKAR LOCATION IS MPS-25				THE CAPEWA LOCATION IS 24C								
STATION	AZ	DIFF	EL	DIFF	RANGE	DIFF	X	DIFF	Y	DIFF	Z	DIFF

GEOCENTRIC												
201T+100	160.0779		0.0325		66098.11		68487.38		-188966.00		5445.17	
FLAT PLANE												
201T+100	160.0523	-0.0256	0.0419	0.0594	66093.77	-4.34	68567.16	79.78	-188923.00	43.00	5453.57	208.40
SPHERICAL												
201T+100	160.0779	0.0000	0.0306	-0.0019	66098.10	0.02	68487.16	-0.22	-188956.41	-0.41	5438.42	-6.75

GEOCENTRIC												
17T+100	107.0826		0.5409		13172.21		37771.58		-11607.47		5704.02	
FLAT PLANE												
17T+100	107.0512	-0.0314	0.4223	-0.1186	13164.94	-7.27	37757.73	-13.35	-11580.62	26.85	5622.11	-81.91
SPHERICAL												
17T+100	107.0828	0.0001	0.5408	-0.0001	13172.24	0.02	37771.62	0.03	-11607.63	-0.16	5703.99	-0.03

GEOCENTRIC												
CABT+100	18.7934		0.0394		40715.48		39350.37		115634.30		5415.15	
FLAT PLANE												
CABT+100	18.7532	-0.0402	-0.1066	-0.1460	40715.30	-0.17	39269.00	-81.37	115661.25	26.95	5103.74	-311.41
SPHERICAL												
CABT+100	18.7935	0.0000	0.0393	-0.0001	40715.52	0.03	39350.59	0.22	115634.36	0.06	5414.83	-0.32

GEOCENTRIC												
19T+100	306.5035		0.4587		5794.53		-13972.84		10340.70		5470.16	
FLAT PLANE												
19T+100	306.4510	-0.0524	0.1748	-0.2839	5801.06	6.53	-13998.43	-25.59	10339.81	-0.89	5384.09	-86.07
SPHERICAL												
19T+100	306.5034	-0.0001	0.4582	-0.0004	5794.50	-0.02	-13972.77	0.07	10340.62	-0.08	5470.02	-0.14

GEOCENTRIC												
12T+100	27.7796		-0.5392		19105.55		26712.52		50708.48		5493.41	
FLAT PLANE												
12T+100	27.7796	0.0000	-0.5392	0.0000	19105.54	-0.00	26712.46	-0.06	50708.45	-0.03	5493.30	-0.01
SPHERICAL												
12T+100	27.7796	0.0000	-0.5392	0.0000	19105.54	-0.00	26712.46	-0.06	50708.45	-0.03	5493.30	-0.01

GEOCENTRIC												
MANI+100	20.8342		-0.0145		13372.40		14246.03		37407.01		5392.46	
FLAT PLANE												
MANI+100	20.8342	0.0000	-0.0145	0.0000	13372.46	-0.00	14246.02	-0.00	37406.08	-0.03	5392.40	0.02
SPHERICAL												
MANI+100	20.8342	0.0000	-0.0145	0.0000	13372.43	-0.00	14246.02	-0.00	37406.08	-0.03	5392.40	0.02

TABLE II (Cont)

THE RADAR LOCATION IS 838-25				THE CAMERA LOCATION IS 240								
STATION	AZ	DIFF	EL	DIFF	RANGE	DIFF	X	DIFF	Y	DIFF	Z	DIFF
GEOMETRIC												
2011+10K	151.3213		3.2038		57653.47		82873.61		-151505.06		15699.14	
FLAT PLANE												
2011+10K	151.3213	0.0000	3.2038	0.0000	57653.44	0.00	82873.61	0.00	-151505.22	-0.16	15699.14	0.00
SPHERICAL												
2011+10K	151.3213	0.0000	3.2038	0.0000	57653.48	0.00	82873.61	0.00	-151505.22	-0.16	15699.14	0.00
GEOMETRIC												
171+10K	63.5252		9.4015		19646.39		52049.56		25922.37		15660.59	
FLAT PLANE												
171+10K	63.5252	0.0000	9.4015	0.0000	19646.38	-0.00	52049.56	-0.05	25922.38	0.01	15660.59	0.00
SPHERICAL												
171+10K	63.5252	0.0000	9.4015	0.0000	19646.38	-0.00	52049.56	-0.05	25922.38	0.01	15660.59	0.00
GEOMETRIC												
CART+10K	19.2677		3.2120		54190.80		53561.75		153225.19		15141.81	
FLAT PLANE												
CART+10K	19.2677	0.0000	3.2120	0.0000	54190.79	-0.00	53561.70	-0.04	153225.16	-0.03	15141.81	0.00
SPHERICAL												
CART+10K	19.2677	0.0000	3.2120	0.0000	54190.79	-0.00	53561.70	-0.04	153225.16	-0.03	15141.81	0.00
GEOMETRIC												
191+10K	0.3213		11.1113		16255.53		269.79		47853.30		15422.54	
FLAT PLANE												
191+10K	0.3213	0.0000	11.1113	0.0000	16255.52	-0.00	269.77	-0.02	47853.30	0.00	15422.50	-0.03
SPHERICAL												
191+10K	0.3213	0.0000	11.1113	0.0000	16255.52	-0.00	269.77	-0.02	47853.30	0.00	15422.50	-0.03
GEOMETRIC												
121+10K	27.7756		0.3686		19372.25		26725.27		56732.79		15493.37	
FLAT PLANE												
121+10K	27.7756	0.0000	0.3686	0.0000	19372.21	-0.01	26725.27	0.01	56732.73	-0.05	15493.32	-0.05
SPHERICAL												
121+10K	27.7756	0.0000	0.3686	0.0000	19372.24	-0.01	26725.27	0.01	56732.73	-0.05	15493.32	-0.05
GEOMETRIC												
MAN1+10K	20.8042		13.1251		13736.12		14253.72		37514.08		15392.44	
FLAT PLANE												
MAN1+10K	20.8042	0.0000	13.1251	0.0000	13736.12	-0.00	14253.74	0.01	37514.05	-0.03	15392.43	-0.00
SPHERICAL												
MAN1+10K	20.8042	0.0000	13.1251	0.0000	13736.12	-0.00	14253.74	0.01	37514.05	-0.03	15392.43	-0.00

TABLE II (Cont)

THE RADAR LOCATION IS MRS-25

THE CAMERA LOCATION IS 120

STATION	AZ	DIFF	EL	DIFF	RANGE	DIFF	X	DIFF	Y	DIFF	Z	DIFF
GEOCENTRIC												
201+100	164.5402		-0.0310		69929.08		55921.44		-202196.50		5358.48	
FLAT PLANE												
201+100	164.4895	-0.0507	0.0517	0.0827	69922.38	-6.70	56094.75	173.31	-202127.69	68.81	5461.47	302.99
SPHERICAL												
201+100	164.5404	0.0001	-0.0327	-0.0016	69929.27	0.19	55920.95	-0.48	-202197.28	-0.78	5352.04	-6.44
GEOCENTRIC												
171+100	134.4700		0.3868		11812.16		25287.53		-24823.95		5711.27	
FLAT PLANE												
171+100	134.4278	-0.0421	0.2556	-0.1312	11802.46	-9.70	25285.32	-2.21	-24785.27	38.68	5630.01	-81.26
SPHERICAL												
171+100	134.4703	0.0003	0.3868	0.0000	11812.23	0.07	25287.54	0.01	-24824.22	-0.27	5711.29	0.01
GEOCENTRIC												
CAR1+100	14.7297		0.0172		35299.12		26925.35		102417.22		5503.84	
FLAT PLANE												
CAR1+100	14.6569	-0.0728	-0.1950	-0.2122	35301.15	2.02	26796.59	-128.76	102456.58	32.36	5111.64	-392.20
SPHERICAL												
CAR1+100	14.7298	0.0001	0.0169	-0.0002	35299.23	0.10	26925.74	0.39	102417.41	0.19	5503.43	-0.41
GEOCENTRIC												
191+100	263.8456		-0.0246		8866.63		-26446.58		-2851.70		5460.50	
FLAT PLANE												
191+100	263.8232	-0.0224	-0.1722	-0.1474	8875.18	8.55	-26470.84	-24.26	-2864.84	-13.14	5392.00	-68.50
SPHERICAL												
191+100	263.8453	-0.0003	-0.0252	-0.0003	8866.63	0.00	-26446.56	0.01	-2851.86	-0.16	5460.32	-0.18
GEOCENTRIC												
HAN1+100	223.3931		-0.1544		6054.61		-12478.51		-13198.83		5423.10	
FLAT PLANE												
HAN1+100	223.4267	0.0336	-0.3472	-0.1928	6057.77	3.16	-12492.56	-14.05	-13198.21	0.62	5361.91	-61.19
SPHERICAL												
HAN1+100	223.3927	-0.0004	-0.1546	-0.0002	6054.65	0.04	-12478.50	0.00	-13199.02	-0.19	5423.02	-0.08

TABLE II (Cont)

THE RADAR LOCATION IS 095-25				THE CAMERA LOCATION IS 190								
STATION	X	DIFF	Y	DIFF	RANGE	DIFF	X	DIFF	Y	DIFF	Z	DIFF
GEOMETRIC												
2011+100	157.4937		-0.0000		71897.19		52563.44		-109263.84		5298.66	
FLAT PLANE												
2011+100	157.4995	0.0057	0.1782	0.0961	71894.16	-3.03	52530.94	-23.50	-109263.69	0.16	5560.75	362.09
SPHERICAL												
2011+100	157.4937	0.0000	-0.0026	-0.0017	71897.36	0.17	52563.69	0.25	-109264.41	-0.56	5291.96	-6.70
GEOMETRIC												
171+100	112.9553		0.2441		13735.91		51755.93		-21921.45		5665.87	
FLAT PLANE												
171+100	112.9652	0.0099	0.2569	-0.6372	13728.03	-7.88	51730.52	-25.41	-21921.26	0.19	5629.29	-36.58
SPHERICAL												
171+100	112.9554	0.0001	0.2440	-0.0001	13735.96	0.05	51756.02	0.08	-21921.59	-0.14	5665.76	-0.11
GEOMETRIC												
CAB1+100	26.4290		0.0209		30341.97		53268.59		105321.27		5438.99	
FLAT PLANE												
CAB1+100	26.4175	-0.0115	-0.1294	-0.1593	30337.84	-4.13	53241.80	-26.79	105320.61	-0.66	5110.22	-328.07
SPHERICAL												
CAB1+100	26.4290	-0.0000	0.0208	-0.0003	30342.12	0.14	53268.56	-0.02	105321.44	0.17	5438.47	-0.52
GEOMETRIC												
121+100	83.7894		0.6129		8966.87		26443.89		2877.66		5555.15	
FLAT PLANE												
121+100	83.7843	-0.0051	0.1826	-0.2003	8966.19	-8.68	26419.20	-25.69	2877.27	-0.39	5462.08	-93.07
SPHERICAL												
121+100	83.7896	0.0001	0.6125	-0.0004	8966.88	0.00	26443.94	0.05	2877.58	-0.08	5554.95	-0.20
GEOMETRIC												
MAN1+100	126.4735		0.1509		5704.36		13279.17		-10333.43		5423.77	
FLAT PLANE												
MAN1+100	126.5260	0.1522	-0.0534	-0.2003	5707.65	-6.71	13052.60	-25.52	-10334.20	-0.77	5361.18	-62.50
SPHERICAL												
MAN1+100	126.4740	0.0002	0.1526	-0.0002	5704.10	0.04	13279.26	0.09	-10333.53	-0.00	5423.67	-0.00

TABLE II (Cont)

THE RADAR LOCATION IS MPS-25					THE CAMERA LOCATION IS 12C							
STATION	AZ	DIFF	EL	DIFF	RANGE	DIFF	X	DIFF	Y	DIFF	Z	DIFF

GEOCENTRIC												
2011+10K	164.5402		2.6967		70040.11		55948.12		-202233.34		15357.08	
FLAT PLANE												
2011+10K	164.4845	-0.0556	2.7818	0.0851	70031.75	-8.36	56134.15	186.03	-202200.41	92.04	15668.55	310.57
SPHERICAL												
2011+10K	164.5404	0.0001	2.6970	0.0002	70040.36	0.25	55947.50	-0.62	-202294.28	-0.94	15358.99	1.01

GEOCENTRIC												
171+10K	134.4700		16.1095		12300.54		25299.59		-24835.85		15711.25	
FLAT PLANE												
171+10K	134.3854	-0.0845	16.0039	-0.1056	12281.32	-19.22	25310.09	10.50	-24772.81	63.04	15630.01	-81.24
SPHERICAL												
171+10K	134.4703	0.0003	16.1096	0.0000	12300.59	0.05	25299.55	-0.04	-24836.04	-0.19	15711.35	0.09

GEOCENTRIC												
CAB1+10K	14.7296		5.4089		35474.00		26938.20		102466.30		15503.72	
FLAT PLANE												
CAB1+10K	14.6602	-0.0694	5.1969	-0.2120	35472.59	-1.41	26822.23	-115.97	102520.94	63.64	15111.22	-392.50
SPHERICAL												
CAB1+10K	14.7298	0.0002	5.4086	-0.0002	35474.09	0.08	26938.68	0.48	102466.47	0.17	15503.21	-0.51

GEOCENTRIC												
121+10K	263.8456		20.5725		9475.11		-26450.20		-2853.06		15460.49	
FLAT PLANE												
121+10K	263.8723	0.0266	20.4358	-0.1367	9470.30	-4.81	-26470.71	-11.51	-2841.90	11.16	15391.91	-68.58
SPHERICAL												
121+10K	263.8455	-0.0001	20.5722	-0.0003	9475.08	-0.03	-26450.18	0.01	-2853.17	-0.11	15460.29	-0.20

GEOCENTRIC												
MAN1+10K	223.3930		28.7047		6906.21		-12484.46		-13205.16		15423.10	
FLAT PLANE												
MAN1+10K	223.4300	0.0370	28.5787	-1.1260	6891.39	-14.82	-12485.73	-1.27	-13180.24	24.02	15361.85	-61.25
SPHERICAL												
MAN1+10K	223.3927	-0.0003	28.7044	-0.0002	6906.23	0.01	-12484.43	0.02	-13205.32	-0.16	15423.02	-0.08

TABLE II (Cont)

THE RADAR LOCATION IS 188-25			THE CAMERA LOCATION IS 190									
STATION	AZ	DIFF	EL	DIFF	RANGE	DIFF	X	DIFF	Y	DIFF	Z	DIFF

GEODETRIC												
2011+10K	157.4937		2.6520		72007.58		82602.83		-149359.34		15298.13	
FLAT PLANE												
2011+10K	157.4937	0.1035	2.7505	0.0983	72003.27	-4.31	82579.36	-23.47	-149356.41	22.94	15667.83	369.70
SPHERICAL												
2011+10K	157.4937	0.0000	2.6524	0.0001	72007.77	0.19	82602.94	0.11	-149360.00	-0.66	15298.87	0.74

GEODETRIC												
171+10K	112.9554		10.3551		19055.75		51780.62		-21931.05		15665.83	
FLAT PLANE												
171+10K	112.9437	-0.0115	10.3579	-0.0302	19042.96	-12.79	51755.30	-25.32	-21908.80	23.15	15629.29	-36.54
SPHERICAL												
171+10K	112.9554	0.0001	10.3550	-0.0001	19055.77	0.01	51780.66	0.03	-21932.00	-0.05	15665.78	-0.04

GEODETRIC												
CAB1+10K	26.8290		4.8702		39503.41		53294.02		105371.72		15438.83	
FLAT PLANE												
CAB1+10K	26.8126	-0.0164	4.7117	-0.1585	39496.88	-6.52	53267.45	-26.57	105393.07	22.25	15110.50	-328.33
SPHERICAL												
CAB1+10K	26.8290	0.0000	4.8709	-0.0002	39503.48	0.07	53294.09	0.07	105371.94	0.22	15438.21	-0.62

GEODETRIC												
121+10K	83.7894		29.0280		9497.50		26456.51		2870.04		15555.15	
FLAT PLANE												
121+10K	83.7352	-0.0541	29.7701	-0.1588	9479.31	-18.19	26431.00	-25.51	2901.56	22.52	15462.02	-93.13
SPHERICAL												
121+10K	83.7894	0.0000	29.0284	-0.0004	9497.51	0.00	26456.61	0.10	2870.00	-0.03	15554.94	-0.21

GEODETRIC												
MAN1+10K	126.4754		50.0136		6694.34		13904.83		-10339.78		15423.77	
FLAT PLANE												
MAN1+10K	126.4749	-0.0005	50.0136	-0.1072	6674.75	-20.12	13959.47	-25.36	-10316.23	22.15	15361.13	-62.64
SPHERICAL												
MAN1+10K	126.4754	0.0000	50.0131	-0.0004	6694.86	0.31	13904.96	0.13	-10339.44	-0.06	15423.66	-0.11

TABLE II (Cont)

THE RADAR LOCATION IS MP2-25												THE CAMERA LOCATION IS GARG											
STATION	AZ	DIFF	EL	DIFF	RANGE	DIFF	Y	DIFF	Y	DIFF	Z	DIFF											
GEOCENTRIC																							
2011+100	174.6192		-0.2114		101096.77		28690.65		-304638.50		4169.50												
FLAT PLANE																							
2011+100	174.5202	-0.0996	0.0633	0.3447	101085.08	-11.69	29217.13	526.48	-304556.75	81.75	6010.92	1841.42											
SPHERICAL																							
2011+100	174.6192	0.0000	-0.2621	-0.0006	101099.58	2.81	28691.18	0.53	-304642.00	-8.50	4166.05	-3.45											
GEOCENTRIC																							
171+100	180.7050		-0.1437		42417.20		-1765.74		-127238.87		5353.35												
FLAT PLANE																							
171+100	180.7171	-0.0770	0.1383	0.2820	42408.25	-8.95	-1592.30	173.44	-127214.41	24.47	5979.46	626.11											
SPHERICAL																							
171+100	180.7050	0.0000	-0.1431	0.0005	42418.56	1.37	-1765.49	0.25	-127243.05	-4.17	5354.62	1.27											
GEOCENTRIC																							
191+100	206.9431		-0.2566		39341.80		-53477.41		-105213.50		5143.95												
FLAT PLANE																							
191+100	206.8696	-0.0734	0.0334	0.2900	39345.88	4.08	-53348.45	128.95	-105293.97	-80.47	5741.44	597.49											
SPHERICAL																							
191+100	206.9422	-0.0008	-0.2562	0.0004	39343.12	1.32	-53477.45	-0.03	-105217.97	-4.47	5144.65	0.70											
GEOCENTRIC																							
121+100	194.7673		-0.1996		35299.02		-27028.15		-102380.00		5303.45												
FLAT PLANE																							
121+100	194.7190	-0.0682	0.0756	0.2752	35296.98	-2.04	-26904.63	123.52	-102415.86	-26.86	5812.25	508.80											
SPHERICAL																							
121+100	194.7869	-0.0005	-0.1992	0.0004	35300.26	1.24	-27028.08	0.07	-102392.97	-3.97	5304.24	0.79											
GEOCENTRIC																							
MAN1+100	198.8777		-0.2508		40715.29		-39510.69		-115574.37		5073.71												
FLAT PLANE																							
MAN1+100	198.8033	-0.0744	0.0182	0.2990	40715.40	0.11	-39370.18	149.51	-115627.33	-52.95	5711.35	637.64											
SPHERICAL																							
MAN1+100	198.8770	-0.0007	-0.2504	0.0004	40716.70	1.41	-39510.63	0.05	-115578.91	-4.53	5074.66	0.95											

TABLE II (Cont)

THE RADAR LOCATION IS MRS-25			THE CAMERA LOCATION IS CARO									
STATION	AZ	DIFF	EL	DIFF	RANGE	DIFF	X	DIFF	Y	DIFF	Z	DIFF

GEOCENTRIC												
2011+10K	174.6198		1.5597		102003.69		28704.34		-304734.50		14168.43	
FLAT PLANE												
2011+10K	174.5142	-0.1056	1.9362	0.3465	102068.66	-15.03	29256.53	552.19	-304629.50	155.00	16018.00	1849.57
SPHERICAL												
2011+10K	174.6199	0.0001	1.5595	0.0007	102006.58	2.89	28704.81	0.47	-304793.00	-8.50	14172.70	4.27

GEOCENTRIC												
171+10K	180.7950		4.3484		42550.90		-1766.58		-127290.97		15353.16	
FLAT PLANE												
171+10K	180.7061	-0.0889	4.6321	0.2837	42542.91	-17.00	-1567.53	190.05	-127201.04	97.94	15979.45	626.29
SPHERICAL												
171+10K	180.7949	-0.0001	4.3489	0.0005	42561.26	1.36	-1766.30	0.28	-127303.82	-4.00	15354.77	1.61

GEOCENTRIC												
191+10K	206.9430		4.5550		39486.66		-53502.03		-105263.87		15143.79	
FLAT PLANE												
191+10K	206.8746	-0.0684	4.8765	0.2906	39481.25	-4.71	-53348.33	154.60	-105271.02	-7.14	15741.36	597.57
SPHERICAL												
191+10K	206.9421	-0.0001	4.5562	0.0013	39487.05	1.30	-53502.27	0.06	-105268.27	-4.39	15144.74	0.05

GEOCENTRIC												
121+10K	194.7873		5.1941		35461.30		-27041.04		-102438.08		15303.32	
FLAT PLANE												
121+10K	194.7157	-0.0716	5.4711	0.2770	35449.52	-11.78	-26991.84	149.20	-102391.58	46.50	15812.18	508.86
SPHERICAL												
121+10K	194.7867	-0.0006	5.1945	0.0004	35462.55	1.24	-27040.84	0.20	-102441.04	-3.86	15304.39	1.07

GEOCENTRIC												
841+10K	198.8276		4.3921		40854.66		-30538.55		-115620.80		15073.54	
FLAT PLANE												
841+10K	198.8050	-0.0246	4.6692	0.2771	40846.30	-8.76	-30563.36	175.10	-115600.36	20.44	15711.29	637.75
SPHERICAL												
841+10K	198.8269	-0.0007	4.3925	0.0004	40857.05	1.39	-30532.37	0.17	-115634.19	-4.39	15074.76	1.22

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