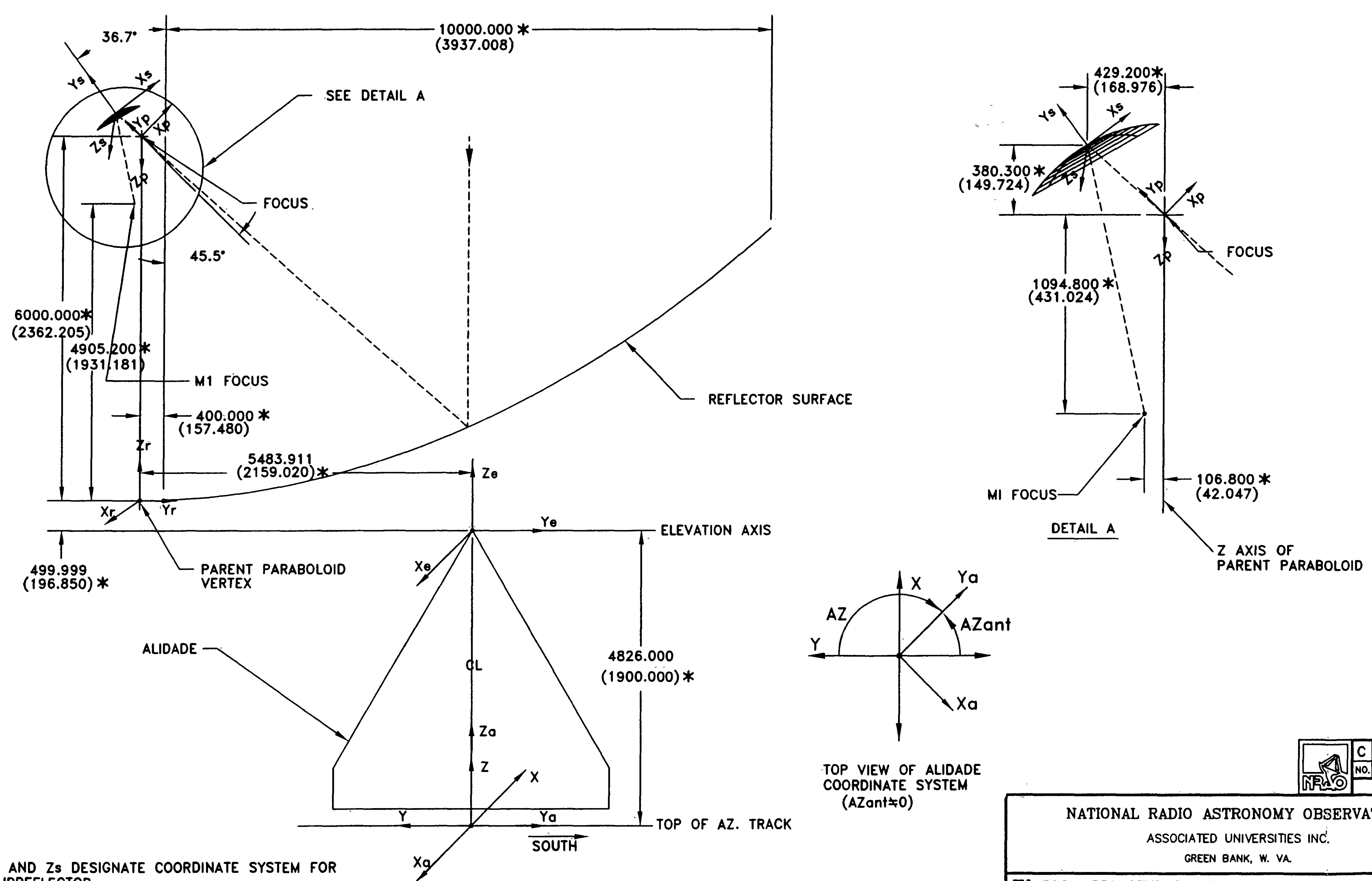
* INDICATES DIMENSIONAL DESIGN

CENTIMETERS
(INCHES)



COORDINATE SYSTEMS
(AZant=0°
ELant=90°)

)TES:
Xs, Ys AND Zs DESIGNATE COORDINATE SYSTEM FOR THE SUBREFLECTOR.
Xp, Yp AND Zp DESIGNATE COORDINATE SYSTEM FOR THE PRIME FOCUS.
Xr, Yr AND Zr DESIGNATE COORDINATE SYSTEM FOR THE REFLECTOR STRUCTURE.
Xe, Ye AND Ze DESIGNATE COORDINATE SYSTEM FOR THE ELEVATION STRUCTURE.
Xa, Ya AND Za DESIGNATE COORDINATE SYSTEM FOR THE ALIDADE.
X, Y AND Z DESIGNATE THE BASE COORDINATE SYSTEM.
SEE SHEETS 2 THRU 5 FOR COORDINATE TRANSFORMATION EQUATIONS.

C	RT	4/02
NO.	DATE	BY
REVISIONS		

NATIONAL RADIO ASTRONOMY OBSERVATORY
ASSOCIATED UNIVERSITIES INC.
GREEN BANK, W. VA.

TITLE FOCI ARRANGEMENT AND COORDINATE SYSTEMS FOR THE GBT

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES
ANGLES ±
3 PLACE DECIMALS (.xxx): ±
2 PLACE DECIMALS (.xx): ±
1 PLACE DECIMALS (.x): ±
FRACTIONS: ±
MATERIAL:
FINISH:

	NAME	DATE		SIGNATURE	DATE
DESIGN			RECOMMENDED BY		
DRAWN	GMORRIS	12/93	ENGINEER	L.KING	12/93
CHECKED			APPROVED		

SCALE	SHEET		REVISION
1:500	1 OF 5	NO. C35102M081	C

Definition of Coordinate Systems:

The Base Coordinate System, (X, Y, Z).

The base coordinate system is fixed to the ground. Its origin is at the intersection of the antenna azimuth axis and the top of the azimuth track. The positive directions of the axes are defined as follows:

X–axis towards East
Y–axis towards North
Z–axis points up

The azimuth angle (AZ) is measured from the Y–axis and is positive in the clockwise direction looking from the positive Z side.

The Alidade Coordinate System, (Xa, Ya, Za).

The alidade coordinate system is attached to the alidade structure. It rotates about the antenna azimuth axis. Its position is defined by the azimuth antenna angle. The positive azimuth antenna angle (AZant) is measured from the negative Y axis in the counter–clockwise direction. When AZant is zero, the orientations of the axes are:

Xa–axis towards West
Ya–axis towards South
Za–axis points up

Therefore, AZ = 180 degrees – AZant. The transformation between the two coordinate systems, (1) and (2), are:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = R_{12} \begin{bmatrix} Xa \\ Ya \\ Za \end{bmatrix}$$

where

$$R_{12} = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos(AZant) & -\sin(AZant) & 0 \\ \sin(AZant) & \cos(AZant) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

NO.	DATE	BY
C	RT	4/02

REVISIONS

NATIONAL RADIO ASTRONOMY OBSERVATORY
ASSOCIATED UNIVERSITIES INC.
GREEN BANK, W. VA.

TITLE: FOCI ARRANGEMENT AND COORDINATE SYSTEMS FOR THE GBT

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES
ANGLES ±
3 PLACE DECIMALS (.xxx): ±
2 PLACE DECIMALS (.xx): ±
1 PLACE DECIMALS (.x): ±
FRACTIONS: ±
MATERIAL:
FINISH:

	NAME	DATE		SIGNATURE	DATE
DESIGN			RECOMMENDED BY		
DRAWN	GMORRIS	1/94	ENGINEER	L.KING	1/94
CHECKED			APPROVED		

SCALE: | SHEET: 2 of 5 | NO. C35102M081 | REVISION: C

3. The Elevation Coordinate System, (Xe, Ye, Ze).

The elevation coordinate system is attached to the elevation structure. It rotates with the elevation structure defined by the elevation and the azimuth antenna angles. When the elevation antenna is 90°, ELant = 90°, its axes are positioned in the same directions as that of the alidade coordinate system. The relation between the Elevation and Alidade coordinate systems is given as follows:

$$\begin{bmatrix} Xa \\ Ya \\ Za \end{bmatrix} = R23 \begin{bmatrix} Xe \\ Ye \\ Ze \end{bmatrix} + T23$$

where

$$R_{23} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \sin(ELant) & \cos(ELant) \\ 0 & -\cos(ELant) & \sin(ELant) \end{bmatrix}$$

$$T_{23} = \begin{bmatrix} 0 \\ 0 \\ +1900.000 \end{bmatrix}$$

1900.00 is the height in inches of the elevation axis about the top of the track.

C	RT	4/02
NO.	DATE	BY
REVISIONS		

NATIONAL RADIO ASTRONOMY OBSERVATORY
ASSOCIATED UNIVERSITIES INC.
GREEN BANK, W. VA.

TITLE FOCI ARRANGEMENT AND COORDINATE SYSTEMS FOR THE GBT

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES
ANGLES ±
3 PLACE DECIMALS (.xxx): ±
2 PLACE DECIMALS (.xx): ±
1 PLACE DECIMALS (.x): ±
FRACTIONS: ±
MATERIAL:
FINISH:

	NAME	DATE		SIGNATURE	DATE
DESIGN			RECOMMENDED BY		
DRAWN	GMORRIS	1/94	ENGINEER	L.KING	1/94
CHECKED			APPROVED		

SCALE | SHEET 3 OF 5 | NO. C35102M081 | REVISION C

4. The Reflector Coordinate System, (Xr, Yr, Zr).

The reflector coordinate system is obtained by translations of the elevation coordinate system. This is shown in the following equation:

$$\begin{bmatrix} Xe \\ Ye \\ Ze \end{bmatrix} = \begin{bmatrix} Xr \\ Yr \\ Zr \end{bmatrix} + T34$$

where

$$T34 = \begin{bmatrix} 0 \\ -2159.020 \\ 196.850 \end{bmatrix}$$

The offsets of the reflector paraboloid vertex from the elevation axis is given in inches by T34.

5. The Prime Focus Coordinate System, (Xp, Yp, Zp).

The origin of this coordinate system is at the focus of the dish paraboloid, 2362.205 inches from vertex of the paraboloid on the Zr–axis.
Yp–axis is 45.5° from Zr–axis on the ZrYr plane, and the Zp–axis is parallel to the Xr–axis. The transformation is as follows:

$$\begin{bmatrix} Xr \\ Yr \\ Zr \end{bmatrix} = R45 \begin{bmatrix} Xp \\ Yp \\ Zp \end{bmatrix} + T45$$

where

$$R45 = \begin{bmatrix} 0 & 0 & 1 \\ \cos(45.5^\circ) & -\sin(45.5^\circ) & 0 \\ \sin(45.5^\circ) & \cos(45.5^\circ) & 0 \end{bmatrix}$$

$$T45 = \begin{bmatrix} 0 \\ 0 \\ 2362.205 \end{bmatrix}$$

NO.	DATE	BY
C	RT	4/02
REVISIONS		

NATIONAL RADIO ASTRONOMY OBSERVATORY
ASSOCIATED UNIVERSITIES INC.
GREEN BANK, W. VA.

TITLE FOCI ARRANGEMENT AND COORDINATE SYSTEMS FOR THE GBT

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES
ANGLES ±
3 PLACE DECIMALS (.xxx): ±
2 PLACE DECIMALS (.xx): ±
1 PLACE DECIMALS (.x): ±
FRACTIONS: ±
MATERIAL:
FINISH:

	NAME	DATE		SIGNATURE	DATE
DESIGN			RECOMMENDED BY		
DRAWN	GMORRIS	1/94	ENGINEER	L.KING	1/94
CHECKED			APPROVED		

SCALE	SHEET	NO.	REVISION
	4 of 5	C35102M081	C

6. The Subreflector Coordinate System, (Xs, Ys, Zs).

The axes of this coordinate system are orientated similarly as that of the prime focus coordinate system. The angle between Ys–axis and Zr–axis is 36.7°. By the same token, we have:

$$\begin{bmatrix} Xr \\ Yr \\ Zr \end{bmatrix} = R_{46} \begin{bmatrix} Xs \\ Ys \\ Zs \end{bmatrix} + T_{46}$$

where

$$R_{46} = \begin{bmatrix} 0 & 0 & 1 \\ \cos(36.7°) & -\sin(36.7°) & 0 \\ \sin(36.7°) & \cos(36.7°) & 0 \end{bmatrix}$$

$$T_{46} = \begin{bmatrix} 0 \\ -168.976 \\ 2511.929 \end{bmatrix}$$

7. Examples:

a. For a point L from the reflector coordinates to the base coordinates.

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_L = R_{12} \left[R_{23} \left[\begin{bmatrix} Xr \\ Yr \\ Zr \end{bmatrix}_L + T_{34} \right] + T_{23} \right]$$

b. For a point M from the base coordinates to the reflector coordinates.

$$\begin{bmatrix} Xr \\ Yr \\ Zr \end{bmatrix}_M = R_{23}^{-1} \left[R_{12}^{-1} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_M - T_{23} \right] - T_{34}$$

C	RT	4/02
NO.	DATE	BY
REVISIONS		

NATIONAL RADIO ASTRONOMY OBSERVATORY
ASSOCIATED UNIVERSITIES INC.
GREEN BANK, W. VA.

TITLE FOCI ARRANGEMENT AND COORDINATE SYSTEMS FOR THE GBT

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES
ANGLES ±
3 PLACE DECIMALS (.xxx): ±
2 PLACE DECIMALS (.xx): ±
1 PLACE DECIMALS (.x): ±
FRACTIONS: ±
MATERIAL:
FINISH:

	NAME	DATE		SIGNATURE	DATE
DESIGN			RECOMMENDED BY		
DRAWN	GMORRIS	1/94	ENGINEER	L.KING	1/94
CHECKED			APPROVED		

SCALE | SHEET 5 OF 5 | NO. C35102M081 | REVISION C