PVO Spinning Spacecraft coordinates (PVO_SSCC):

Spacecraft coordinates (Xs, Ys, Zs) are used to describe the physical mounting locations of the Sun sensors, the star sensor, and the experiment sensors. The spacecraft coordinate system is centered at the spacecraft center of mass and rotates with the spacecraft. The Xs-Ys plane is parallel to the plane of the spacecraft equipment shelf. The positive Zs axis points out the top of the spacecraft. The positive Ys axis coincides with the split line of the equipment shelf. With no spacecraft wobble or nutation, the spacecraft positive Zs axis will coincide with the spin axis and the equipment shelf will thus be perpendicular to the spin axis.

PVO Inertial Spacecraft Coordinates (PVO_ISCC):

The inertial spacecraft coordinate system for the PVO spacecraft is same coordinate system as the spinning spacecraft coordinate system (SSCC) except that it does not spin with the spacecraft. Thus the Spin axis or positive Z axis direction is the same in both systems and it points out the top (toward the BAFTA assembly) of the spacecraft. The axes in the spin plane are defined as follows: The X-Z plane is defined to contain the spacecraft-Sun vector with the positive X direction being sunward, and the coordinate system is defined to be right-handed. The transformation from SSCC to ISCC is:

$$\begin{bmatrix} \cos(p) & -\sin(p) & 0 \\ \sin(p) & \cos(p) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

where p is the spin phase angle measured in ISSC coordinates.

Venus Solar Orbital Coordinates (VSO):

The VSO coordinate system is a Cartesian coordinate system centered on Venus. The components of this coordinate system are as follows: The X axis direction points from the center of Venus to the Sun, taken positive towards the Sun, the Z axis is parallel to the northward pole of the Venus orbital plane, the Y axis completes the right-handed set and points towards dusk. Locations of bodies (spacecraft) given in VSO coordinates are usually represented in units of Venus radii where Rv = 6052 km.

Equatorial Inertial Spherical Coordinates (ISC_EQTR):

The Equatorial Inertial Spherical Coordinate system is defined by the equatorial plane of the Earth for the reference epoch of 1950.0. The principal direction vectors of this system are the Earth's Equatorial Pole and the Vernal Equinox direction. The components of the coordinate system are:

1) Radius: Distance from the reference body to the spacecraft.
2) Declination: The angle between the reference body-spacecraft radius vector and the reference body equatorial plane, measured

positive north of the equatorial plane.
3) Right Ascension: The angle between the Vernal Equinox line and the projection of the reference body-spacecraft radius vector onto the Earth equatorial plane, measured eastward from the Vernal Equinox line.
4) Inertial Speed (V): The magnitude of the inertial velocity of the spacecraft.
5) Inertial Flight Path Angle (GAMMA): The angle between the spacecraft inertial velocity vector and the plane perpendicular to the reference-body-to-spacecraft (radius) vector; positive when measured away from the reference body.
6) Inertial Azimuth Angle (SIGMA): The angle, measured in the plane perpendicular to the reference-body-to-spacecraft (radius) vector, from the projection of true north into that plane eastward to the projection of the inertial velocity vector into that plane.

When the reference body is taken to be the Earth, this becomes the coordinate system EME-50 (FK-4).

Inertial Spherical Coordinates - Ecliptic (ISC_ECLP):

The Ecliptic Inertial Spherical Coordinate system is defined by the ecliptic plane of the Earth for the reference epoch of 1950.0. The principal direction vectors of this system are the Earth's Ecliptic Pole and the Vernal Equinox direction. The components of the coordinate system are:

1) Radius: Distance from the reference body to the spacecraft.
2) Celestial Latitude: The angle between the reference body-spacecraft radius vector and the reference body ecliptic plane, measured positive north of the ecliptic plane.
3) Celestial Longitude: The angle between the Vernal Equinox line and the projection of the reference body-spacecraft radius vector onto the Earth ecliptic plane, measured eastward from the Vernal Equinox line.
4) Inertial Speed (V): The magnitude of the inertial velocity of the spacecraft.
5) Inertial Flight Path Angle (GAMMA): The angle between the spacecraft inertial velocity vector and the plane perpendicular to the reference-body-to-spacecraft (radius) vector; positive when measured away from the reference body.
6) Inertial Azimuth Angle (SIGMA): The angle, measured in the plane perpendicular to the reference-body-to-spacecraft (radius) vector, from the projection of true north into that plane eastward to the projection of the inertial velocity vector into that plane.

When the reference body is taken to be the Earth, this becomes the coordinate system ECL-50.

Earth-Sun Line Cartesian Coordinates (ESL-CART):

The Earth-Sun Line Cartesian coordinate system is defined to have the X-Y plane be the instantaneous ecliptic plane with the positive Z direction taken to be the Sun-centered, northward ecliptic normal. The positive X direction is away from the Sun along the Sun-Earth line. Y completes the right-handed set and is positive away from the Sun.

Note: This system rotates with the Earth about the Sun.

Inertial Cartesian Coordinate System - Equatorial (ICC_EQTL):

The Equatorial Inertial Cartesian Coordinate System is defined for the reference epoch of 1950.0 The X-direction is positive away from the reference body towards the Vernal Equinox which is determined by the line of intersection between the mean Earth equatorial plane and the ecliptic plane of reference. The Y direction is measured outward from the center of the reference body, perpendicular to and east of the the X-axis, and lying in the equatorial plane of reference. The Z direction is positive toward the north equatorial pole of reference, from the center of the reference body.

Inertial Cartesian Coordinate System - Ecliptic (ICC_ECLP):

The Equatorial Inertial Cartesian Coordinate System is defined for the reference epoch of 1950.0 The X-direction lies in the Ecliptic Plane and is positive away from the reference body towards the Vernal Equinox which is determined by the line of intersection between the mean Earth equatorial plane and the ecliptic plane of reference. The Y direction is measured outward from the center of the reference body, perpendicular to and east of the the X-axis, and lying in the ecliptic plane of reference. The Z direction is positive toward the north ecliptic pole of reference, from the center of the reference body.

Body-Fixed Spherical Coordinate System (BFS_CRDS):

The body-fixed spherical coordinate system is the familiar Geographic coordinate system at Earth generalized to other planets. The system consists of the components Radius, Latitude, Longitude. The definition of the prime meridian varies for each planet as does the rotation period. It is crucial to know the exact definition of these variables when changing the reference body.

Note: This coordinate system rotates with the reference body.

Spacecraft Centered Ecliptic Coordinates (SCC_ECLP):

The Spacecraft Centered Ecliptic coordinates system (Xe, Ye, Ze) is used to describe the locations of the roll reference celestial objects (Sun or star) and the planet Venus. The coordinate system is centered at the spacecraft center of mass. The Xe-Ye plane is parallel to the Ecliptic Plane and the Ze axis points to the North Ecliptic Pole. The Xe axis points towards the Vernal Equinox. Directions in this coordinate system are described by Celestial Longitude and Celestial Latitude.

Non-Rotating Spin Coordinates (NRSC):

The roll angle of the roll reference object will be calculated in this coordinate system as well as the roll angles of the Fs, RIP, RAM, and NADIR signals. The non-rotating coordinate system (Wx, Wy, Wz) is centered at the spacecraft center of mass. The Wz-axis is parallel to the spacecraft spin axis. The Wx-Wy plane is perpendicular to the spacecraft spin axis. The Wx-Wz plane includes the Vernal Equinox of reference. Thus the Wx-axis is at the intersection of the plane perpendicular to

the spacecraft spin axis and the plane containing the spin axis and the Vernal Equinox. Roll angles in this coordinate system are measured in the Wx-Wy plane from the roll reference direction.