**Coordinate System Information**

**Definitions**

**X** unit vector in the direction of the x-axis

**Y** unit vector in the direction of the y-axis

**Z** unit vector in the direction of the z-axis

**K** unit vector in the direction of the rotation axis

**M** unit vector in the direction of the magnetic dipole

**S** unit vector pointing from Saturn to the Sun

**V** unit vector pointing along Saturn's orbital motion

**G** unit vector pointing along the Saturn Prime Meridian as defined in the SPICE/NAIF

**R** unit vector pointing from the Sun to the spacecraft

**W**  unit vector pointing in the direction of the Sun's rotation axis

**KSM - Kronocentric Solar Magnetospheric**

This coordinate system is similar to the GSM (Geocentric Solar Magnetospheric) coordinate system used at Earth. Because Saturn's rotation axis and magnetic dipole axis are closely aligned, we will do not differentiate them when defining this coordinate system. For the Earth, this system would be based on the magnetic dipole axis. Here we will define the system in terms of the rotation axis instead, with the understanding that this is nearly the same as defining it in terms of the dipole axis. The formal definition follows.

**X** = **S** Points from Saturn to the Sun

**Y** = **K** x**X** Perpendicular to the rotation axis towards dusk

**Z** = **X** x**Y** Chosen so that the rotation axis lies in the X-Z plane

**KSO - Kronocentric Solar Orbital**

This coordinate system is similar to the GSE (Geocentric Solar Ecliptic) coordinate system used at Earth. At the Earth the y-axis is chosen to lie in the ecliptic plane (the Earth's orbital plane). At Saturn, Saturn's orbital plane is used as the natural plane by which to define this vector. Note that in this system neither the dipole axis nor the rotation axis necessarily lie along a cardinal direction or in a special plane.

**X** = **S** Points from Saturn to the Sun

**Y** = **-V** In Saturn's orbital plane, points opposite Saturn's motion (towards dusk)

**Z** = **X** x**Y** Perpendicular to the plane of Saturn's motion in the *Northward* sense

**KG - Kronographic**

This coordinate system is equivalent to the IAU-Saturn coordinate system that is defined in the SPICE/NAIF kernels and by the IAU. This system is analogous to the geographic (longitude and latitude) system used at the Earth. The KG system is therefore a system that rotates with Saturn at the official IAU rotation period. This coordinate system should always be used with respect to the official epoch and rotation rate (as defined by the IAU).

**X** = **G** Points along the Saturn Prime Meridian as defined by the IAU

**Y** = **K** x **X** Lies in the rotational equatorial plane

**Z** = **K** Lies along the rotation axis

**SC - Spacecraft**

This coordinate system is fixed relative to the Cassini spacecraft. It is therefore in constant motion as Cassini adjusts its pointing. The coordinate system is useful when comparing measurements between different instruments, especially when studying the pitch angle distributions of particles (relative to the local magnetic field vector). This should not be used for spacecraft trajectory, only for referencing vector field directions.

**X** -X is along the MIMI CHEMS, INMS and RPWS Langmuir Probe Field Of View (FOV)

**Y** -Y is along the FOV of the ORS instruments

**Z** -Z points in the look direction of the High Gain Antenna

**RTN - Radial, Tangential, Normal**

This coordinate system is based on the location of the spacecraft relative to the Sun and the Sun's rotation axis. It is a spacecraft centered coordinate system. It is most useful for periods when the spacecraft is in interplanetary space.

**R** = **R** Points from the Sun to the spacecraft

**T** = **W** x**R** The Sun's rotation vector crossed into R

**V** = **X** x**Y** Completes the right-handed triad

(This information was extracted from MAPSVIEW website at University of Michigan: <http://mapsview.engin.umich.edu>)

Additional information on commonly used magnetospheric coordinate systems can be found in Appendix A.3 of

Russell, C.T. Luhmann, J.G. and R.J. Strangeway, Space Physics: An Introduction, Cambridge University Press, 2016.