Candidate VALUEs FOR SANA REGISTRY Pertaining to TIME SYSTEMs, reference frames, orbit elements and covariance-RELATED KEYWORDS

(Normative)

The values in this document represent the set of acceptable values for the TIME\_SYSTEM, REF\_FRAME, OEB\_FRAME, MAN\_REF\_FRAME, ORB\_REF\_FRAME, COV\_REF\_FRAME and STM\_REF\_FRAME keywords in the OPM, OMM, OEM and OCM. (For details and description of these time systems, see reference [L1]) If exchange partners wish to use different settings, the settings should be documented in the ICD.

* 1. Relative reference FRAME KEYWORDS

In addition to the above reference frames, maneuver and covariance data can be specified in the following relative frames:

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Description and reference** | **Nomenclature** | **Default Units/Type** |
| ACC\_i | Accelerometer |  |  |
| ACTUATOR\_i | Actuator reference frame (‘i’ = 0→9): could denote reaction wheels, solar arrays, thrusters, magnetic torque rods, etc. |   |  |
| AST\_i | Autonomous Star Tracker Reference Frame (‘i’ indicates the sensor number if there is more than one) |  |  |
| CSS\_ij | Coarse Sun Sensor (‘i’ = 0→9, ‘j’ = 0→9) |   |  |
| DSS\_i | Digital Sun Sensor (‘i’ = 0→9) |   |  |
| EQS | Equinoctial Coordinate System, with E aligned with the ascending node direction, W along the orbital angular momentum vector ($\overbar{ω} = \overbar{r} x \overbar{v}$) and Q completing the set ($\hat{Q} = \hat{W}x \hat{E}$) |   |  |
| ESA\_i | Earth Sensor Assembly Reference Frame (‘i’ indicates the sensor number if there is more than one) |  |  |
| ANGVEL\_FRAME\_i | Angular Velocity (Gyroscope) Reference Frame, Inertial Measurement Unit Reference Frame (‘i’ = 0→9) | GYRO, IMU  |  |
| INSTRUMENT\_i | Instrument ‘y’ reference frame (‘i’ =0→9) |   |  |
| MTA | Magnetic Torque Assembly |  |  |
| NSW | “NADIR, Sun, Normal” – This frame aligns the x-axis in the NADIR direction, the y-axis as much as possible toward the Sun while still being normal to the x-axis, and the z-axis completing the right-hand set |   |  |
| NTW or LVLH | A local orbital coordinate frame that has the x-axis along the Tangential (or velocity) vector, z-axis (“W”) along the orbital angular momentum vector ($\overbar{ω} = \overbar{r} x \overbar{v}$), and N completing the right handed system (i.e., for a circular orbit “N” generally points in the Nadir direction and for an eccentric orbit, “N” points as close to Nadir as possible while still being normal to the T-W plane). Note that while this frame has the same axes defined as in the TNW frame, the ordering of axes is different. |  |  |
| PQW | Perifocal Coordinate System, with P axis pointing to perigee, W along the orbital angular momentum vector ($\overbar{ω} = \overbar{r} x \overbar{v}$) and Q completing the set ($\hat{Q} = \hat{W}x \hat{P}$) |  |  |
| RATE\_FRAME | The frame of reference in which the Euler rates are specified. | REF\_FRAME\_AREF\_FRAME\_B |  |
| REF\_FRAME\_A | Name of the reference frame that defines the starting point of a transformation.  | SC\_BODY, ICRFyyyy |  |
| REF\_FRAME\_B | Name of the reference frame that defines the ending point of a transformation. | INSTRUMENT\_i,AST\_i |  |
| RSW | A Radial, Along track, Cross track, local orbital coordinate frame, where the R axis always points out from the satellite along the central body’s radius vector to the satellite as it moves through the orbit. The S axis is in the direction of (but not necessarily parallel to) the velocity vector and is perpendicular to the radius vector. The W axis is aligned with the orbit angular momentum vector.Note that this RSW frame is also referred to as:Gaussian Coordinate SystemLVLH ‘Radial, In-track, Cross-track” (**RIC**)‘Radial, Transverse, Normal’ (**RTN**)**UVW** (as employed in Conjunction Data Messages) |  |  |
| RWA | Reaction Wheel Assembly |  |  |
| SA\_i | Solar Array Coordinate Frame (‘i’ =0→9) |  |  |
| SC\_BODY\_i | Spacecraft Body Frame (‘i’ = 0→9); requires clear specification via ICD |   |  |
| SENSOR\_i | Sensor ‘x’ reference frame (‘i’ = 0→9) |   |  |
| TAM\_i | Three Axis Magnetometer Reference Frame |  |  |
| TOPOHORIZ | The SEZ system rotates with the observing site. The local horizon forms the fundamental plane, with the S axis pointing due south from the site (even in the Southern Hemisphere). The E axis points east from the site and is undefined at the North or South Poles. The Z axis (zenith) points radially outward from the site, along the site’s geodetic local vertical. | SEZ |  |
| STARTRACKER\_i | Star Tracker Reference Frame (‘i’ = 0→9) |   |  |
| TAM\_i | Three Axis Magnetometer Reference Frame (‘i’ = 0→9) |   |  |
| TNW | A local orbital coordinate Tangential, Normal, Cross track frame that has the x-axis along the Tangential (or velocity) vector, z-axis (“W”) along the orbital angular momentum vector ($\overbar{ω} = \overbar{r} x \overbar{v}$), and N completing the right handed system (i.e., for a circular orbit “N” generally points in the Nadir direction and for an eccentric orbit, “N” points as close to Nadir as possible while still being normal to the T-W plane). Note that while this frame has the same axes defined as in the NTW frame, the ordering of axes is different (TNW). |   |  |
| VNC | A local orbital coordinate Velocity, Normal, Co-normal frame that has the x-axis along the Velocity (or tangential) vector, y-axis Normal to the orbit along the orbital angular momentum vector ($\overbar{ω} = \overbar{r} x \overbar{v}$), and z-axis is the “Co-normal” direction completing the right handed system (i.e., for a circular orbit “C” points in the radius vector direction whereas for an eccentric orbit, “C” points as close to radial as possible while still being normal to the V-N plane). Note that while this frame has the same axes defined as in the NTW frame, the ordering of axes is different (i.e., TWN). |   |  |

**ATTITUDE AND SPACECRAFT DYNAMICS KEYWORDS**

|  |  |  |  |
| --- | --- | --- | --- |
| **Keyword** | **Description and reference** | **Nomenclature** | **Default Units/Type** |
| M\_BA  | Direction Cosine Matrix: Represents the orientation of a frame B with respect to a frame A, the coordinate transformation from frame A to frame B. | MB,A$ $ | N/A |
| Q1, Q2, Q3, Q4 | Quaternion: The first three elements form the vector part of the quaternion, the fourth is the scalar element. Defined as:$$Q=\left[\begin{matrix}Q1\\Q2\\\begin{matrix}Q3\\QC\end{matrix}\end{matrix}\right]=\left[\begin{matrix}e\_{1}sin⁡(\frac{∅}{2})\\e\_{2}sin⁡(\frac{∅}{2})\\\begin{matrix}e\_{3}sin⁡(\frac{∅}{2})\\cos(\frac{∅}{2})\end{matrix}\end{matrix}\right]$$where e1,e2,e3 are the three elements of the Euler rotation axis (unit vector) and  is the Euler rotation angle. The quaternion represents the coordinate transformation from frame A to frame B. | Q=[Q1,Q2,Q3,QC] | N/A, N/A, N/A, N/A |
| Q1\_dot, Q2\_dot, Q3\_dot, Q4\_dot | Quaternion Derivative: Rate of change of the quaternion.  | $$\dot{Q}=\left[\begin{matrix}\dot{Q1}\\\dot{Q2}\\\begin{matrix}\dot{Q3}\\\dot{QC}\end{matrix}\end{matrix}\right]$$ | second-1 |
| ANGVEL\_X, ANGVEL\_Y,ANGVEL\_Z  | Angular Velocity: The rotational rate of frame B with respect to frame A. The vector direction is the instantaneous axis of rotation of frame B with respect to frame A and the vector magnitude is the instantaneous rate of this rotation. The subscript indicates the frame in which the angular velocity is resolved. ‘SC’ refers to the spacecraft body frame. | $$ω\_{SC}=\left[\begin{matrix}ω\_{x}\\ω\_{y}\\ω\_{z}\end{matrix}\right]$$ | radians/second |
|  |  |  |  |
| ANGLE\_1\_DOT, ANGLE\_2\_DOT, ANGLE\_3\_DOT | Euler Rates: The time derivatives of the Euler angle representation. They represent the rotation rates of the individual transformations represented in the three angle Euler angle rotation sequence. The transformation between Euler rates and angular velocity is not orthogonal. The angles are written in the same order as the Euler angle sequence, with a dot to indicate differentiation. | $$\left[\begin{matrix}\dot{ϕ}&\dot{θ}&\dot{ψ}\end{matrix}\right]$$ | radians/second |
| IXX, IXY, IXZ, IYY, IYZ, IZZ | Inertia: The moment of inertia tensor, a symmetric 3x3 matrix. Expressed in a coordinate frame attached to the center of mass of a spacecraft body. The subscript indicates the frame in which the inertia is resolved and the superscript indicates the component.  | $$I\_{SC}=\left[\begin{matrix}I\_{XX}&-I\_{XY}&-I\_{XZ}\\-I\_{XY}&I\_{YY}&-I\_{YZ}\\-I\_{XZ}&-I\_{YZ}&I\_{ZZ}\end{matrix}\right]$$ | kilogram-meters2 |
| ANG\_MOM | Angular Momentum: Defined for a rigid body as the product of the inertia and the angular velocity. If a spacecraft contains devices which contribute angular momentum they are added to the momentum generated by the spacecraft body. The subscript indicates the coordinate frame in which the momentum is resolved. The superscript indicates what elements are included in the momentum. For example, ‘W’ indicates a reaction wheel, ‘B’ indicates just the spacecraft body, ‘C’ indicates the total system momentum, momentum about the system center of mass.$$H\_{SC}^{B}=I\_{SC}ω\_{SC}$$$$H\_{SC}^{C}=I\_{SC}ω\_{SC}+H\_{SC}^{W}$$$$H\_{SC}^{W}=M\_{SC,W}I\_{W}ω\_{W}$$Note that in the 2nd equation above the JSC includes the inertia of the wheels transverse to their spin axes, but not the inertia along the spin axes. The second term is the momentum contribution of the wheels along their spin axes only, the momentum along the transverse direction is included in the first term (see Markley and Crassidis).  | $$H\_{SC}^{B}$$ | Newton-meter-seconds |
| MAN\_TOR\_X, MAN\_TOR\_Y, MAN\_TOR\_Z | Torque Vector: Torque is the rate of change of angular momentum. For example, $T\_{SC}=\dot{H}\_{SC}^{C}+ω\_{SC}×H\_{SC}^{C}$ | **T**SC |  |
|  NUTATION | Nutation: The angle between a spacecraft principal moment of inertia axis and the angular momentum vector. |  | radians |
| SPIN\_ALPHA, SPIN\_DELTA | Spin Axis: The axis about which a spacecraft is spinning, often closely aligned with the major principal axis of inertia. | RA,DEC | radians |
| SPIN\_ANGLE\_VEL | Spin Rate: The rotation rate about the Spin Axis. |  | radians/second  |
| PHASE | Phase: Rotation angle about the Spin Axis |  |  |

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