CCSDS NAVIGATION STANDARDS NORMATIVE ANNEXES

ORBITAL ELEMENTS REGISTRY

**Policy:**  Expert Review

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**OID:**  1.3.112.4.57.5

**References:**

* [[ccsds-502.0-B-2]](https://public.ccsds.org/Pubs/502x0b2c1.pdf)

| **Name** | **Description and Reference** | **Nomenclature** | **Default Units/Type** |
| --- | --- | --- | --- |
| ADBARV | Spherical 6-element set comprised of: right ascension +E°, declination +N°, inertial flight path angle measured from the radial direction to inertial velocity direction (e.g. 90° for circular orbit), inertial azimuth angle measured from local North to projection of inertial velocity in local horizontal plane, radius magnitude, and velocity magnitude. | $$α, δ, β, A, r, v$$ | $$4×degrees, $$$1×km$, $1×\frac{km}{s}$ |
| CARTP | Cartesian 3-element position (only) orbit state | X, Y, Z | $$3×km$$ |
| CARTPV | Cartesian 6-element position and velocity orbit state | X, Y, Z, XD, YD, ZD | $3×km$, $3×\frac{km}{s}$ |
| CARTPVA | Cartesian 9-element position, velocity, and acceleration orbit state | X, Y, Z, XD, YD, ZD, XDD, YDD, ZDD | $3×km$, $3×\frac{km}{s}$, $$3×\frac{km}{s^{2}}$$ |
| DELAUNAY | Delaunay elements employ a set of canonical action-angle variables, which are commonly used in general perturbation theories. The element set consists of three conjugate action-angle pairs. Lower case letters represent the angles while upper case letters represent the conjugate actions. Delaunay variables coordinate type is not available if a fixed coordinate system is selected. Elements L, G, and H are expressed in terms of distance squared divided by time, where distance is measured in standard units and time is measured in seconds, where “L” is related to the two-body orbital energy, “G” is the magnitude of the orbital angular momentum, “H” is the Z component of the orbital angular momentum. The elements l, g, and h are angles, where l is the mean anomaly, g is the argument of perigee, and h is the right ascension of the ascending node.  | L, G, H, l, g, h | $3×\frac{km^{2}}{s}$, $$3×degrees$$ |
| DELAUNAYMOD | Modified Delaunay variables, where the L, G, and H “action” variables of the Delaunay element set defined above are divided by the square root of the central-body gravitational constant, yielding a geometric version of the Delaunay set that is independent of the central body. | Lm, Gm, Hm, lm, gm, hm | $3×\sqrt{km}$, $$3×degrees$$ |
| EIGVAL3EIGVEC3 | 12-element eigenvalue/eigenvector representation time history corresponding to the 3x3 position covariance time history. The set consists of the three (major, medium, and minor) eigenvalues in descending order, and the corresponding three eigenvectors matching the major, medium, and minor eigenvalues. | EigMaj, EigMed, EigMin,EigVecMaj,EigVecMed,EigVecMin | $3×km$, $9×NonDim$, |
| EQUINOCTIAL | Equinoctial elements (Broucke and Cefola, 1972) are popular because they do not suffer from the singularity problems that classical and other elements do. This standardized equinoctial seven-element set is adopted from the definition contained in David A. Vallado, Fundamentals of Astrodynamics and Applications, 4th Ed., Microcosm Press and Springer, ISBN 978-1881883180. The first six equinoctial elements have a singularity for exact 180º inclinations, which is overcome by the addition of a seventh element which specifies the retrograde factor [fr = ±1, where fr = 1 denotes direct orbits (inclination<=90°), -1 for retrograde orbits (inclination>90°)]. Note that some centers switch the retrograde factor (-1) only for exact retrograde orbits (switching the singularity for that case to an inclination of 0º), while others switch this retrograde factor to (-1) for any/all retrograde orbits. | [a, af, ag, L=$(M+ω+f\_{r} Ω)$, χ, ψ, $f\_{r}$ | $1×km$, $2×NonDim$,$1×degrees$,$2×NonDim$, $$1×(\pm 1)$$ |
| EQUINOCTIALMOD | Modified equinoctial seven-element set, where semi-major axis has been replaced by semi-latus rectum “p” = a (1-e2), and where Mean Anomaly has been replaced by True Anomaly in the “L” term. The seventh element specifies the retrograde factor [fr = ±1] as defined in David A. Vallado, Fundamentals of Astrodynamics and Applications, 4th Ed., Microcosm Press and Springer, ISBN 978-1881883180. | [p = a(1-e2)], af, ag, $\{L'=\left(ν+ω+f\_{r} Ω\right)\}$, χ, ψ, $f\_{r}$ | $1×km$, $2×NonDim$,$1×degrees$,$2×NonDim$, $$1×(\pm 1)$$ |
| GEODETIC | Geodetic elements (longitude, geodetic latitude, fixed frame flight path angle, fixed frame azimuth, altitude above oblate spheroid, and, velocity relative to the fixed frame. | $$λ, ϕ\_{GD}, β, Α ,h, v\_{rel}$$ | $$4×degrees, $$$1×km$, $1×\frac{km}{s}$ |
| KEPLERIAN | Keplerian 6-element classical set (semi-major axis, eccentricity, inclination, right ascension of the ascending node, argument of perigee, and true anomaly). | $$a, e, i, Ω, ω, ν$$ | $1×km$, $1×NonDim$,$$4×degrees$$ |
| KEPLERIANMEAN | Keplerian 6-element classical set (semi-major axis, eccentricity, inclination, right ascension of the ascending node, argument of perigee, and mean anomaly). | $$a, e, i, Ω, ω,M$$ | $1×km$, $1×NonDim$,$$4×degrees$$ |
| LDBARV | Modified spherical 6-element set (Earth longitude +E°, declination +N°, inertial flight path angle measured from the radial direction to inertial velocity direction (e.g. 90° for circular orbit), inertial azimuth angle measured from local North to projection of inertial velocity in local horizontal plane, radius magnitude, and velocity magnitude) | $$λ, δ, β, A, r, v$$ | $$4×degrees, $$$1×km$, $1×\frac{km}{s}$ |
| ONSTATION | A geosynchronous on-station-tailored set of orbital elements consisting of semi-major axis, x and y components of the eccentricity vector, x and y components of the inclination vector, and true longitude. | $$a, e\_{x}, e\_{y},i\_{x}, i\_{y}, λ$$ | $$km, $$$$4×NonDim,$$$$1×degrees$$ |
| POINCARE | Canonical counterpart of equinoctial 6-element set. See David A. Vallado, Fundamentals of Astrodynamics and Applications, 4th Ed., Microcosm Press and Springer, ISBN 978-1881883180. | $\left(λ\_{M}=M+ω+Ω\right), $gp, hp, Lp, Gp, Hp | $1×degrees$,$2×\frac{km}{s^{0.5}}$, $1×\frac{km^{2}}{s}$,$2×\frac{km}{s^{0.5}}$  |