Classification of satellite orbits

1. Centric classifications

1. Galactocentric orbit: An orbit about the center of a galaxy. The Sun follows this type of orbit about the galactic center of the Milky Way.

2. Heliocentric orbit: An orbit around the Sun. In the Solar System, all planets, comets, and asteroids are in such orbits, as are many artificial satellites and pieces of space debris. Moons by contrast are not in a heliocentric orbit but rather orbit their parent object.

3. Geocentric orbit: An orbit around the planet Earth, such as that of the Moon or of artificial satellites.

4. Areocentric orbit: An orbit around the planet Mars, such as that of its moons or artificial satellites.

5. Lunar orbit (also selenocentric orbit): An orbit around the Earth's moon.

6. Hermocentric orbit (also hermiocentric orbit): An orbit around the planet Mercury.

7. Aphrodiocentric orbit (also cytheriocentric orbit): An orbit around the planet Venus.

8. Jovicentric orbit (also zenocentric orbit): An orbit around the planet Jupiter.

9. Kronocentric orbit (also saturnocentric orbit): An orbit around the planet Saturn.

10. Oranocentric orbit: An orbit around the planet Uranus.

11. Poseidocentric orbit: An orbit around the planet Neptune.

2. Altitude classifications for geocentric orbits

1. Low Earth orbit (LEO): geocentric orbits with altitudes from 160 to 2,000 km (100–1,240 miles).

2.Medium Earth orbit (MEO): geocentric orbits ranging in altitude from 2,000 km (1,240 miles) to just below orbit at 35,786 kilometers (22,236 mi). Also known as an intermediate circular orbit. These are "most commonly at 20,200 kilometers (12,600 mi), or 20,650 kilometers (12,830 mi), with an orbital period of 12 hours."

3. Both geosynchronous orbit (GSO) and geostationary orbit (GEO) are orbits around Earth matching Earth's sidereal rotationperiod. All geosynchronous and geostationary orbits have a semi-major axis of 42,164 km (26,199 mi). This works out to an altitude of 35,786 km (22,236 mi). All geostationary orbits are also geosynchronous, but not all geosynchronous orbits are geostationary. A geostationary orbit stays exactly above the equator, whereas a geosynchronous orbit may swing north and south to cover more of the Earth's surface. Both complete one full orbit of Earth per sidereal day (relative to the stars, not the Sun).

4. High Earth orbit: geocentric orbits above the altitude of geosynchronous orbit 35,786 km (22,240 miles).

3. Inclination classifications

1.Inclined orbit: An orbit whose inclination in reference to the equatorial plane is not 0.

a) Polar orbit: An orbit that passes above or nearly above both poles of the planet on each revolution. Therefore, it has an inclination of (or very close to) either 90 degrees or −90 degrees.

b) Polar Sun-synchronous orbit (SSO): A nearly polar orbit that passes the equator at the same local solar time on every pass. Useful for image-taking satellites because shadows will be the same on every pass.

2. Non-inclined orbit: An orbit whose inclination is equal to zero with respect to some plane of reference.

a)Ecliptic orbit: A non-inclined orbit with respect to the ecliptic.

b)Equatorial orbit: A non-inclined orbit with respect to the equator.

3. Near equatorial orbit: An orbit whose inclination with respect to the equatorial plane is nearly zero. This orbit allows for rapid revisit times (for a single orbiting spacecraft) of near equatorial ground sites.

4.Eccentricity classifications

There are two types of orbits: closed (periodic) orbits, and open (escape) orbits. Circular and elliptical orbits are closed. Parabolic and hyperbolic orbits are open. Radial orbits can be either open or closed.

1.Circular orbit: An orbit that has an eccentricity of 0 and whose path traces a circle.

2.Elliptic orbit: An orbit with an eccentricity greater than 0 and less than 1 whose orbit traces the path of an ellipse.

a)Geostationary or geosynchronous transfer orbit (GTO): An elliptic orbit where the perigee is at the altitude of a low Earth orbit (LEO) and the apogee at the altitude of a geostationary orbit.

b)Hohmann transfer orbit: An orbital maneuver that moves a spacecraft from one circular orbit to another using two engine impulses. This maneuver was named after Walter Hohmann.

c)Ballistic capture orbit: a lower-energy orbit than a Hohmann transfer orbit, a spacecraft moving at a lower orbital velocity than the target celestial body is inserted into a similar orbit, allowing the planet or moon to move toward it and gravitationally snag it into orbit around the celestial body.

d) Coelliptic orbit: A relative reference for two spacecraft—or more generally, satellites—in orbit in the same plane. "Coelliptic orbits can be defined as

two orbits that are coplanar and confocal. A property of coelliptic orbits is that the difference in magnitude between aligned radius vectors is nearly the same, regardless of where within the orbits they are positioned. For this and other reasons, coelliptic orbits are useful in [spacecraft] rendezvous".

3.Parabolic orbit: An orbit with the eccentricity equal to 1. Such an orbit also has a velocity equal to the escape velocity and therefore will escape the gravitational pull of the planet. If the speed of a parabolic orbit is increased it will become a hyperbolic orbit.

a) Escape orbit: A parabolic orbit where the object has escape velocity and is moving directly away from the planet.

b) Capture orbit: A parabolic orbit where the object has escape velocity and is moving directly toward the planet.

4.Hyperbolic orbit: An orbit with the eccentricity greater than 1. Such an orbit also has a velocity in excess of the escape velocity and as such, will escape the gravitational pull of the planet and continue to travel infinitely until it is acted upon by another body with sufficient gravitational force.

a)Radial orbit: An orbit with zero angular momentum and eccentricity equal to 1. The two objects move directly towards or away from each other in a straight-line.

b) Radial elliptic orbit: A closed elliptic orbit where the object is moving at less than the escape velocity. This is an elliptic orbit with semi-minor axis = 0 and eccentricity = 1. Although the eccentricity is 1, this is not a parabolic orbit.

c) Radial parabolic orbit: An open parabolic orbit where the object is moving at the escape velocity.

d) Radial hyperbolic orbit: An open hyperbolic orbit where the object is moving at greater than the escape velocity. This is a hyperbolic orbit with semi-minor axis = 0 and eccentricity = 1. Although the eccentricity is 1, this is not a parabolic orbit.

5.Decaying orbit: A decaying orbit is one with a minimum distance between the two objects that decreases over time due to factors like atmospheric resistance. Often used to dispose of dying artificial satellites or to aerobrake an interplanetary spacecraft.

5. Synchronicity classifications

1.Synchronous orbit: An orbit whose period is a rational multiple of the average rotational period of the body being orbited and in the same direction of rotation as that body. This means the track of the satellite, as seen from the central body, will repeat exactly after a fixed number of orbits. In practice, only 1:1 ratio (geosynchronous) and 1:2 ratios (semi-synchronous) are common.

2.Geosynchronous orbit (GSO): An orbit around the Earth with a period equal to one sidereal day, which is Earth's average rotational period of 23 hours, 56 minutes, 4.091 seconds. For a nearly circular orbit, this implies an altitude of approximately 35,786 kilometers (22,236 mi). The orbit's inclination and eccentricity may not necessarily be zero. If both the inclination and eccentricity are zero, then the satellite will appear stationary from the ground. If not, then each day the satellite traces out an analemma (i.e. a "figure-eight") in the sky, as seen from the ground. When the orbit is circular and the rotational period has zero inclination, the orbit is considered to also be geostationary. Also known as a Clarke orbit after the writer Arthur C. Clarke.

a)Geostationary orbit (GEO): A circular geosynchronous orbit with an inclination of zero. To an observer on the ground this satellite appears as a fixed point in the sky. "All geostationary orbits must be geosynchronous, but not all geosynchronous orbits are geostationary."

b)Tundra orbit: A synchronous but highly elliptic orbit with significant inclination (typically close to 63.4°) and orbital period of one sidereal

day (23 hours, 56 minutes for the Earth). Such a satellite spends most of its time over a designated area of the planet. The particular inclination keeps the perigee shift small.

3.Semi-synchronous orbit: An orbit with an orbital period equal to half of the average rotational period of the body being orbited and in the same direction of rotation as that body. For Earth this means a period of just under 12 hours at an altitude of approximately 20,200 km (12,544.2 miles) if the orbit is circular.

Molniya orbit: A semi-synchronous variation of a Tundra orbit. For Earth this means an orbital period of just under 12 hours. Such a satellite spends most of its time over two designated areas of the planet. An inclination of 63.4° is normally used to keep the perigee shift small.

4.Supersynchronous orbit: Any orbit in which the orbital period of a satellite or celestial body is greater than the rotational period of the body which contains the barycenter of the orbit.

5.Subsynchronous orbit: A drift orbit close to but below GSO/GEO. Satellites will drift east.

6.Graveyard orbit: An orbit a few hundred kilometers above geosynchronous that satellites are moved into at the end of their operation.

a)Disposal orbit: A synonym for graveyard orbit.

b)Junk orbit: A synonym for graveyard orbit.

7.Areosynchronous orbit (ASO): A synchronous orbit around the planet Mars with an orbital period equal in length to Mars' sidereal day, 24.6229 hours.

8.Areostationary orbit (AEO): A circular areosynchronous orbit on the equatorial plane and about 17,000 km (10,557 miles) above the surface of Mars. To an observer on Mars this satellite would appear as a fixed point in the sky.

6. Special classifications

1.Sun-synchronous orbit: An orbit which combines altitude and inclination in such a way that the satellite passes over any given point of the planets's surface at the same local solar time. Such an orbit can place a satellite in constant sunlight and is useful for imaging, spy, and weather satellites.

2. Frozen orbit: An orbit in which natural drifting due to the central body's shape has been minimized by careful selection of the orbital parameters.

3. Orbit of the Moon: The orbital characteristics of the Moon. Average altitude of 384,403 kilometers (238,857 mi), elliptical-inclined orbit.

4.Beyond-low Earth orbit (BLEO) and beyond Earth orbit (BEO) are a broad class of orbits that are energetically farther out than low Earth orbit or require an insertion into a heliocentric orbit as part of a journey that may require multiple orbital insertions, respectively.

5. Gate orbit: an optimal circular departure orbit for transfer from one planet to another.

6. Near Rectilinear Halo Orbit (NRHO): an orbit currently planned in cislunar space that could serve as a staging area for future missions in a 2018 NASA concept.

7.Pseudo-orbit classifications

1.Horseshoe orbit: An orbit that appears to a ground observer to be orbiting a certain planet but is actually in co-orbit with the planet. See asteroids 3753 Cruithne and 2002 AA29.

2.Exo-orbit: A maneuver where a spacecraft achieves an orbit that is unstable due to atmospheric drag.

3.Lunar transfer orbit (LTO) (accomplished with trans-lunar injection, TLI)

4.Prograde orbit: An orbit with an inclination of less than 90°, or equivalently, an orbit that is in the same direction as the rotation of the primary.

5.Retrograde orbit: An orbit with an inclination of more than 90°, or equivalently, an orbit counter to the direction of rotation of the planet. Apart from those in Sun-synchronous orbit, few satellites are launched into retrograde orbit because the quantity of fuel required to launch them is much greater than for a prograde orbit. This is because when the rocket starts out on the ground, it already has an eastward component of velocity equal to the rotational velocity of the planet at its launch latitude. A gravity assist around the moon can reduce the fuel premium.

6.Distant retrograde orbit (DRO): A stable circular retrograde orbit. Stability means that satellites in DRO do not need to use station keeping propellant to stay in orbit. The lunar DRO is a high lunar orbit with a radius of approximately 61,500 km.

7.Mars transfer orbit (MTO) also known as trans-Mars injection (TMI) orbit

8.Halo orbits and Lissajous orbits: These are orbits around a Lagrangian point. Lagrange points are shown in the adjacent diagram, and orbits near these points allow a spacecraft to stay in constant relative position with very little use of fuel. Orbits around the L1 point are used by spacecraft that want a constant view of the Sun, such as the Solar and Heliospheric Observatory. Orbits around L2 are used by missions that always want both Earth and the Sun behind them. This enables a single shield to block radiation from both Earth and the Sun, allowing passive cooling of sensitive instruments. Examples include the Wilkinson Microwave Anisotropy Probe and the upcoming James Webb Space Telescope. L1, L2, and L3 are unstable orbits, meaning that small perturbations will cause the orbiting craft to drift out of the orbit without periodic corrections.

9.P/2 orbit, a highly-stable 2:1 lunar resonant orbit, that will be used for the first time with the spacecraft TESS (Transiting Exoplanet Survey Satellite) in 2018.