Satellites

Advantages of Satellites:

Greater altitude than Aircraft
Greater platform speed - covers more territory
Greater field of view --> greater swath width
Fewer Perturbations --> less "Attitude Problems"
Global coverage
Longer duration --> homogeneous data, repeat observations

Disadvantages of Satellites:

Greater field of view --> lower resolution
Limited data storage --> constrained by locations of downlink sites
Difficult to correct instrument malfunctions

One Possible Compromise: The Space Shuttle

Satellite Orbits

Satellites move in elliptical paths about the object they orbit.

The ellipticity (e) describes how "non-circular" the orbit is; for a circular orbit e=0.

The point at which the satellite is closest to the earth is the Perigee and the point at which it is furthest away is the Apogee.

The geometry of satellite orbits results in both Ascending and Descending nodes.

If the satellite orbits the earth in the direction of the earth's rotation then the orbit is called Prograde; if it orbits in the opposite direction it is called Retrograde

Satellite orbits are described by Kepler's Laws

Law of Orbits - All planets (satellites) move in elliptical orbits with the sun (Earth) at one focus.
Law ofAreas - A line joining the planet(satellite) to the sun (Earth) sweeps out equal areas in equal times.

Law of Periods - The square of the period of any planet (satellite) is proportional to the cube of the semi-major axis of its orbit. Higher Orbit --> longer period

The period of a satellite is described by:

\[ p = \frac{2 \pi \sqrt[3]{a^3}}{\sqrt{(GM)}} \]

where

- \( P \) = period of orbit (days to complete an orbit)
- \( a \) = semi-major axis of orbit (distance from the earth)
- \( G \) = Gravitational Constant
- \( M \) = Mass of the earth

Special Orbits

Geostationary

- Satellite does not move relative to the rotating earth
- Field of view doesn't change with time.
- Equatorial at elevation of ~36000 km
- Limited to ± 55° north/south
- Weather & communication satellites

Sun-Synchronous

- Satellite crosses a given latitude at the same time every day
- Results in standardized light levels, solar heating, etc
- Necessarily Retrograde; Cannot have inclination < ~96°
- Most passive sensors that rely on sunlight use a Sun-Sync orbit

Exact Repeat

- Covers identical groundtracks at a given Repeat Cycle
- Tradeoff between duration of repeat cycle and track spacing

Orbital Decay

The reduction in the semimajor axis per orbit of a satellite in a circular orbit is given by:

\[ \delta a \sim \frac{4 \pi A \rho a^2}{M} \]

- \( A \) = cross sectional area of satellite
- \( \rho \) = atmospheric density at satellite altitude
- \( a \) = semimajor axis
- \( M \) = mass of satellite
This imposes a fundamental limit on the useful lifetime of a satellite in a low earth orbit.