Satellite Basics

Satellite Components

- Satellite Subsystems
  - Telemetry, Tracking, and Control
  - Electrical Power and Thermal Control
  - Attitude Control
  - Communications Subsystem

Satellite Orbits

- Equatorial
- Inclined
- Polar

Orbital Mechanics
Here’s the Math...

- Gravity depends on the mass of the earth, the mass of the satellite, and the distance between the center of the earth and the satellite.
- For a satellite traveling in a circle, the speed of the satellite and the radius of the circle determine the force (of gravity) needed to maintain the orbit.

But...

- The radius of the orbit is also the distance from the center of the earth.
- For each orbit the amount of gravity available is therefore fixed.
- That in turn means that the speed at which the satellite travels is determined by the orbit.

Let’s look in a Physics Book...

- From what we have deduced so far, there has to be an equation that relates the orbit and the speed of the satellite:

\[ T = 2\pi \sqrt{\frac{r^3}{GM}} \]

\( T \) is the time for one full revolution around the orbit, in seconds.
\( r \) is the radius of the orbit, in meters, including the radius of the earth (6.38x10^6m).

The Most Common Example

- “Height” of the orbit = 22,300 mile
- That is 36,000km = 3.6x10^7m
- The radius of the orbit is 3.6x10^7m + 6.38x10^6m = 4.2x10^7m
- Put that into the formula and …
The Geosynchronous Orbit

- The answer is $T = 86,000$ sec (rounded)
- $86,000$ sec $= 1,433$ min $= 24$ hours (rounded)
- The satellite needs 1 day to complete an orbit
- Since the earth turns once per day, the satellite moves with the surface of the earth.

Try it...

- How long does a Low Earth Orbit Satellite need for one orbit at a height of 200 miles $= 322$ km $= 3.22 \times 10^5$ m
- Do this:
  - Add the radius of the earth, $6.38 \times 10^6$ m
  - Compute $T$ from the formula
  - Change $T$ to minutes or hours

$T = \sqrt[3]{\frac{r^3}{4\pi G M}}$

GEO Coverage

- Altitude is about 6 times the earth’s radius
- Three satellites can cover the surface of the earth

Orbit Examples

- Geostationary
  - Equatorial and Geosynchronous
- Inclined Geosynchronous
  - Satellite moves north/south relative to the earth station
- Polar LEO
  - Satellite group covers the entire earth
LEOS Coverage

• Altitude is 1/6 of the earth's radius

Communication Frequencies

• Uplink (Earth to Satellite)
  - C Band: around 6 GHz
  - Ku Band: around 14 GHz
  - Ka Band: around 30 GHz

• Downlink (Satellite to Earth)
  - C Band: around 4 GHz
  - Ku Band: around 12 GHz
  - Ka Band: around 20 GHz