Communication Satellites

Communication satellites get used all around the world for a variety of uses from marine rescues to home Internet. Each satellite falls around the earth at unimaginable speeds around the curvature of the earth; this is called an orbit. Each satellite contains delicate and expensive equipment. Some offer public services; others are private. I wondered how these satellites work. For this reason I have picked this topic to study, and I think you should be interested in it because it is part of your life without you thinking about it much, such as watching satellite TV or using the maps app on your phone.

One of the major benefits of using satellites is that they provide a higher coverage range than terrestrial alternatives. In the case of TV without satellites you would not be able to watch TV if there was no station in your area. Without satellites you would not be able to use GPS. The way GPS works is a GPS satellite sends down a signal to earth. where a device receives the signal, allowing the device to find the device's relative position to the satellite. Then with the information of the satellite’s relative position to the ground, the device can calculate the device's position on the ground. None of this would be possible without satellites.

The uplink of a communications satellite is the channel that heads up to the satellite. The downlink is the channel that a communications satellite uses to

send signals down to earth. A radio station on the ground can send data on the uplink frequency to the satellite and wait for a response on the downlink frequency.

Satellite communications and wireless communication rely on radio waves. Radio waves are part of the electromagnetic spectrum.The electromagnetic spectrum is composed of electromagnetic waves. Electromagnetic waves are composed of two parts: an electric field and a magnetic field, each constantly varying. Electromagnetic waves can be thought of as a wave in the ocean . The height that a wave reaches above the normal level is the amplitude of the wave. The wavelength of a wave is the distance between each of the peaks of the waves. The frequency of a wave is the number of times per second that the wave goes between one peak and the next. Radio waves have the longest wavelength of anything on the electromagnetic spectrum. These frequencies get used because they naturally produce an oscillating current at the same frequency as the radio wave and vice versa, allowing for the integration into electrical circuits.

There are two types of ways of conveying meaning using electromagnetic waves: amplitude modulation(AM) and frequency modulation(FM). AM changes the amplitude of a base radio wave and FM changes the frequency of it based on an input wave, for example a sound wave. For example, the sound waves produced by someone talking into a microphone would be turned into an electric wave. Using amplitude modulation the amplitude of the electric wave would become the amplitude of the AM radio wave. With frequency modulation the change in the amplitude of the electric wave would be turned into changes in a base wave's frequency. A receiver of these waves could run this process in reverse to obtain the original audio.

There are multiple types of ways a satellite can relay signals either by using a bent pipe transceiver, a linear transponder, or a digital transponder. A bent pipe transceiver takes a signal from one frequency and retransmits it on another like a

bent pipe does with water. This acts as a boost to the signal, allowing for more long range communication. A linear transponder takes data from a range of frequencies and retransmits it on a different frequency range, allowing it to retransmit multiple analog signals. A digital transponder takes digital data from one frequency and reads it either to send right away or saves it to send it later.

The way spacecraft and satellites get launched is currently by use of chemical driven rockets. During a rocket launch the main engines on the rocket fire until there is no fuel remaining in that stage. Then the stage falls away and the next engine fires and goes on. Once in space the satellite unfolds its solar panels if necessary. It uses solar panels to power itself. As of October 23, 2020 there were 2666 satellites in operation around the earth.

There are three different types of satellites: LEO, MEO, GEO. Low Earth Orbit (LEO) satellites orbit Earth 160-1500 km above the Earth's surface with an orbital period, or how long it takes to make an orbit, of 90-120 minutes. LEO satellites get used in situations which require high data transmission rates or high quality images, such as SpaceX Starlink satellites for satellite Internet access. LEO orbit comes with both benefits and drawbacks. Some of the benefits it offers include higher data rates and lower power requirements to communicate with them. Its major problem is that it takes far more satellites to get good coverage compared to higher orbits.

Medium Earth Orbit(MEO) satellites orbit 5000-20000 km above the Earth's surface with an orbital period of 2-12 hours. MEO satellites are useful for purposes that require a mix of the benefits from GEO and LEO satellites, such as GPS satellites. MEO satellites have both benefits and drawbacks. One of the major benefits of them is having both higher data speeds than GEO satellites and a wider range than LEO satellites. Some of their major drawbacks are lower data transfer speeds than LEO satellites and less coverage than GEO satellites.

Geostationary orbit (GEO) satellites orbit 35,786 km above the Earth's equator with an orbital period of one day. GEO satellites are useful in situations that require a wide coverage area with relatively few satellites. Due to geostationary satellites' specific altitude they stay still relative to the Earth's surface. This makes it ideal for things like TV satellites because it does not require the movement of ground based antennas. GEO satellites have both benefits and drawbacks. Some of their major benefits are that they have a large coverage and that ground antennas do not have to reorient themselves to face the satellite. Some of their major drawbacks are the higher delays communicating with them and the need for higher power transceivers to communicate with them.

In conclusion, satellites and wireless communication are very important to your day-to-day life. I hope you walk away from this with a new sense of how satellites and wireless communication work.

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