Geosynchronous Orbits

A bit of Reality by Phillip Berrie

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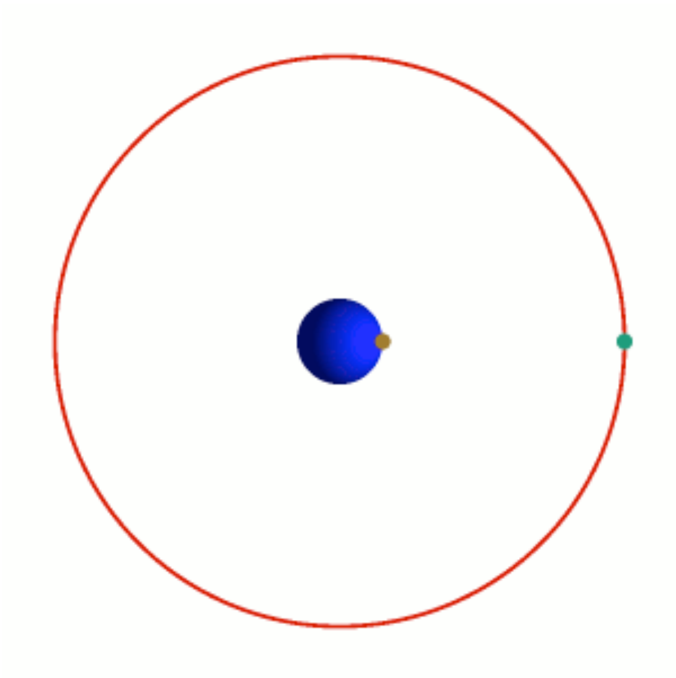
Geosynchronous Orbits - Geostationary:

Geosynchronous orbits are a much-abused term in science fiction and so I thought I should shed some light on them.

The most common use of this term is for the situation where a satellite sits motionless above the same point on the surface of the planet. This is a special case for a geosynchronous orbit and is called a 'Geostationary' or 'Clarke' orbit. And if that last name seems familiar, this orbit is indeed named after the famed science fiction author Arthur C. Clarke who passed away in 2008. Clarke was a space scientist before he became an author and he was the first to popularise this concept as a means for satellite-based radio communications.

Technically a geosynchronous orbit is one whose orbital period is in some ways synchronised with the rotation of the Earth such that the orbiting body will pass over the same point on the planet at the same time every day. The Geostationary orbit (something of a misnomer as the satellite is actually travelling very fast) is an extreme example of this.



For a satellite to be in a geostationary orbit it must orbit the Earth along the line of the equator at an altitude of approximately 35,786 kilometres (between 5 to 6 times the radius of the Earth which means its orbits circumference is correspondingly bigger). For the orbit to be stable and self sustaining (i.e. Requiring no energy to maintain) it must be travelling at about 11,000 kph or about 3 kilometres per second. If this is achieved, the satellite will stay directly above a particular spot on the equator as the planet spins on its axis. If either the orbital radius or velocity varies the satellite will lose this special synchronisation and its path will wander in the sky.

I think the most important thing to take away from this is the distance a satellite in geosynchronous orbit is away from the planet's surface. Considering that the International Space Station is in Low Earth Orbit (LEO) at an altitude of 350 kms, boosting any object to geosynchronous orbit is going to be very energy intensive. Similarly, travel times are going to be significant. I remember reading one story where someone bombarded a planet's surface with missiles from what was described as a geosynchronous orbit (yes, the distances will be different, but not by orders of magnitude). The missiles reached the surface within seconds. There is no way a normal missile is going to travel that far in seconds and, if you could accelerate something with mass that fast, there would be little need to put a warhead on it. The thermal shock of it entering the atmosphere at such speed would be like setting off a nuclear bomb high in the atmosphere.

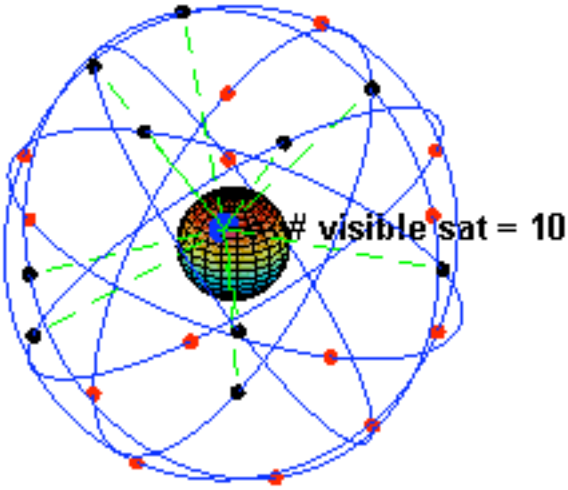
Geosynchronous Orbits - Communications Satellites:

This article follows on from my previous article about Geosynchronous and 'Clarke' (Geostationary) orbits and is a digression based on the distances involved in these highly specialised orbits and how they effect satellite communications. Hopefully, some of the information here will be useful to people who want to provide a more realistic communications environment for their science fiction stories.

As you may remember a Geostationary orbit means that the satellite appears to sit suspended over a specific point on the Earth's equator at an altitude of about 36,000 kms. This is quite a distance. Even light travelling at approximately 300,000 kms per second will take over a tenth of a second to cover this distance and you will have all seen this demonstrated in television satellite links where a remote interviewee's response will noticeably lag a question. In fact, with processing overheads and the travel time both ways this delay can be as much as a quarter of a second; a situation certainly not conducive to casual dialogue.

Geostationary satellites are good for certain types of communication - the mainly one-way type. This explains why a satellite television dish, once set up, doesn't move. It's pointing at a geostationary satellite orbiting in a particular spot above the equator. However, Geostationary satellites are not so good for telephony and locations at high latitude where the satellite is too close to the horizon to be practicable. Here's where the other type of geosynchronous orbit comes into play.

The definition of geosynchronous orbit tells us that a satellite in such an orbit will always be over a particular point on the surface at a particular time of the day; its orbit is synchronised to the rotation of the Earth. Networks (also commonly called 'constellations') of such geosynchronous satellites in lower orbits (so that the travel time for signals is much, much less) can work together to provide a better coverage of the Earth's surface with less communication's lag. Notable examples of these types of systems are the satellite telephone services: Iridium and Inmarsat and the Global Positioning System (GPS).



The 'visible sat' number is the number of GPS satellites
visible from the indicated point on the surface.
Image Courtesy of El Pak from the Wikimedia Commons.

However, having said all this, most telephony and other two-way communications systems (e.g. the Internet) use the vast network of cabling that has been laid both under the ground and sea to handle the world's long distance communications. These cables provide both a more secure (access to major cables is restricted) and more reliable (unaffected by sunspot activity, which plays havoc with radio) service.

References:

For a more complete discussion on Geosynchronous Orbits:

http://en.wikipedia.org/wiki/Geosynchronous_orbit

And for information about communications satellites:

http://en.wikipedia.org/wiki/Communications_satellite

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