GENERAL INFORMATION ARTICLE

MAN-MADE SATELLITES AND THE CHANGING WORLD OF COMMUNICATIONS

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What is a Satellite?

Astronomers define satellite as a celestial body that reflects light from the sun and rotates around a planet. Therefore, two types of satelites can now be recognised: natural and artificial or man-made.

Since the 1950's with the launching of Sputniks by the Russians, we have man-made satellites rotating around our planet Earth. they are actually "electronic systems" with high technology equipment on board, circling the Earth and obtaining data for establishing "electronic links" among different geographic points.

Positioning of Satellites

Since an artificial satellite is an object rotating around the Earth, it must be positioned in an orbit around the planet. To do this, it has to be carried into an orbit either by the "space shuttle" or a rocket. Rockets are propelled by the thrust generated by gasses produced during a "combustion process".

The necessary elements to produce the combustion are loaded and stored in the rocket's "deposits" at very low temperatures. The upward thrust in the rocket depends on two main factors:

i) Velocity at which the gases are expelled from the nozzle (from the "burning chamber").
ii) The amount of "fuel" that "burns".

Figure 1, shows a sketch of a propulsion system of a rocket. The oxidant agent and the "fuel" are mixed and placed in the combustion chamber, where the mixture is burned. At high temperature gases expand and are expelled through a nozzle generating characteristic clouds of vapour and smoke during a rocket lift off.

The first satellites were placed in orbits near the Earth. For example the Score experimental satellite placed in orbit around earth by United States in 1958, was in an elliptic orbit, with a minimum distance to Earth of 185 km and a maximum distance of 1470 km.

Since the satellite, rotates around Earth, in order to "capture" its radio-electric signals, the rquired antennae have to follow its path in the sky. To do that, it is required to point a large antenna capable of following the trajectory of the satellite, located far away from it, and therefore not visible on the horizon. This is a complicated matter.

The above problem has been solved by using the concept of geo-stationary orbits allowing a satellite to remain in a fixed position relative to Earth. As a result of this, the antennae that required to send or receive radio-electric signals to or from a geo-

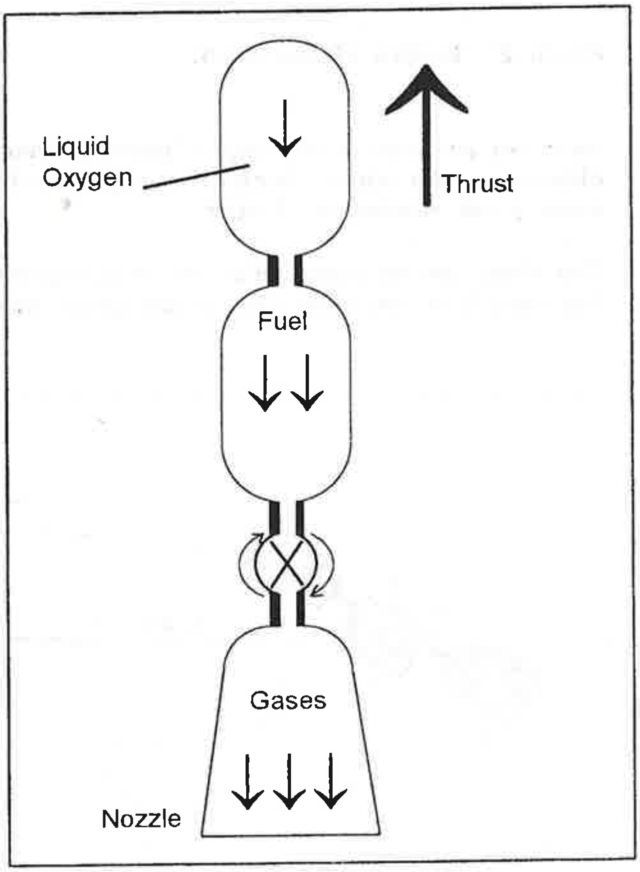

Figure 1. **Rocket's Propulsion system.**

stationary satellite can remain in a fixed position without the need for corrections or adjustments unless we change to a different satellite. If this is required, then we need to modify its "direction" toward the sky.

Now, the Earth has an elliptic orbit around the Sun and rotates on its own axis as shown in Figure 2.

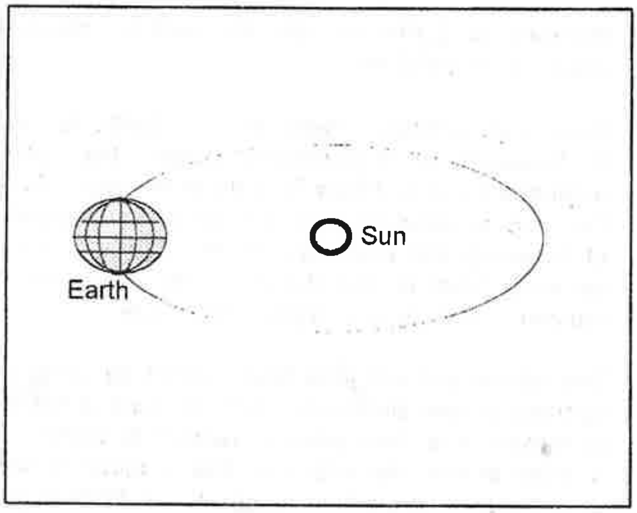

Figure 2. **Earth's elliptic orbit.**

How can we have in the sky a "geo-stationary" object, i.e. An object located always on the same point relative to Earth?

This effect can be achieved as shown in Figure 3. The satellite is not really fixed in the space (sky), but travels with a very high speed, about 11000 km/hour and at an altitude of about 36000 km. With this velocity the satellite follows and completes a circular orbit once every 24 hours. This is the time in which the Earth rotates on its axis, therefore, it seems that the satellite is fixed in the sky relative to a point on Earth, even-though an observer on Earth and the satellite are moving with a high speed.

Since this is not a scientific paper, we will not discuss any mathemathics involved. We can only say that when an object is moving around Earth there are two forces acting on it: a repulsion force and an attraction force exerted by Earth on the object.

When both forces are equal there is a stable orbit with a specific radius and specific time period. For the specific case we are interested in, we could prove that for a satellite to rotate around our planet once every 23 hours, 56 minutes, and 4 seconds (time needed for Earth to rotate on its own axis), it is necessary to place it at an altitude of 36 000 Km and to have a velocity of 11000 km/hour. Knowing this the next question to ask is:

On what geographic points are the Geo-stationary satellites placed?

In principle, we could answer this question by saying that any geographic point is good, or that a location directly above the country that will be using that satellite is ideal. However, the answer is very different indeed: all geo-stationary satellites are placed over the Earth's Equator, (the equator is the maximum circle that "divides the Earth in two equal

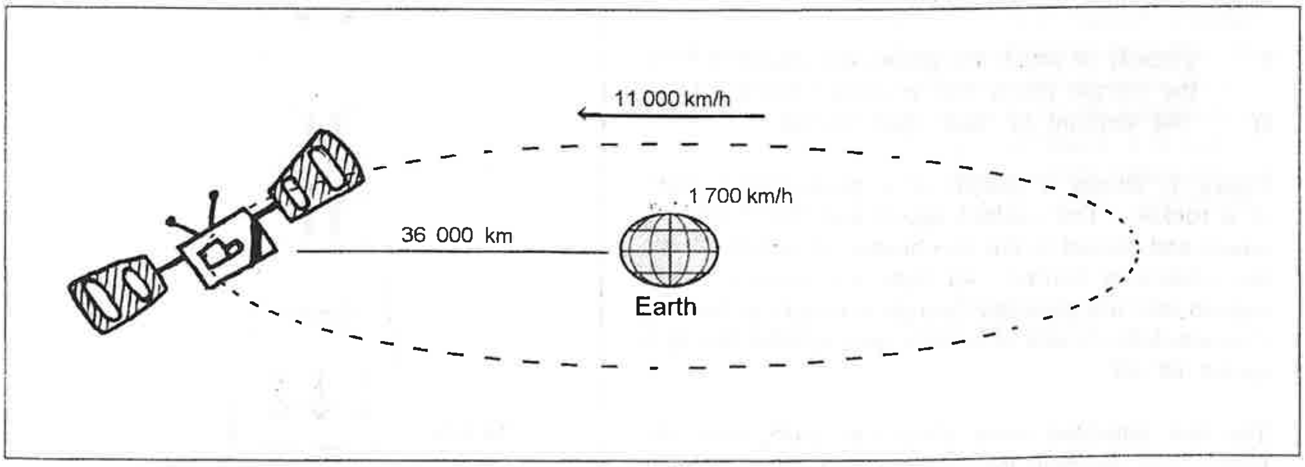

Figure 3. **Geo-stationary Satellite.**

parts" and is located at the same distance from both geographic poles).

If the satellite's orbit is **not over the equator**, the direction of the satellite would be different from the Earth's rotation (and from an observer on Earth), as it can be seen in figure 4, therefore the satellite

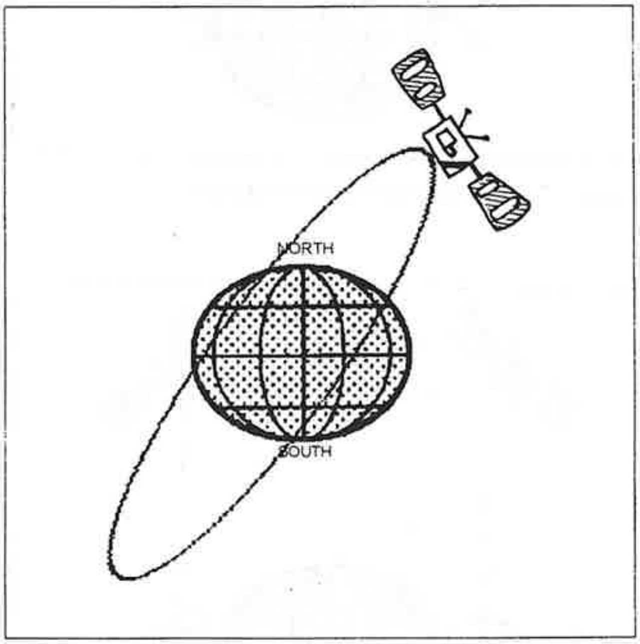

Figure 4. **Non-geo-satationary satellite.**

would not remain stationary; it would even disappear sometimes from the observer's line of sight. In order for that not to happen, the satellite would have to be placed at a different altitude and rotating at a different velocity which in reality would be almost impossible.
Therefore, the only possible location for an orbit of 24 hours duration is about Earth's equator, because in that orbit the satellite will be travelling from East to West, in exact synchrony with Earth's motion. It will therefore remain geo-stationary (fixed with respect any point on the planet).

The Geo-stationary orbit is also called **Clarke's Belt** since in 1945 Arthur C. Clarke pointed out that all points on Earth could be covered by using only three geo-stationary satellites. Due to this fact we could say that the satellites are basically TV receivers tuned to signals sent from Earth via big parabolic antennae.

The signal received by the satellite is amplified to increase its power and then re-transmitted back to Earth to be received by parabolic entennae located in big cities and that we can also find in some places in PNG. The number of these antennae is decreasing due to the cable TV increase in popularity during the 1990s.

A transmission from a satellite is somewhat similar to a "shadow" from a light source in the theather when the scene is in darkness and the actor is followed with a light ("torch"). Where here with a "plate" (satellite's parabolic antenna) a specific area of the surface on Earth is "illuminated" (radio waves and light waves have a lot in common). This area covered by the "plate" (satellite's antenna) is called the shadow of the satellite. Satellites used for TV broadcasting are powerful enough, for their signals to be received by using only small parabolic antennae.

What is a Satellite used for ? or Why do we need satellites?

Is it not possible to send/transmit TV signals in a straight line from the transmitter's antenna to the receiver's antenna instead of sending them up to the sky (satellite) and then back to Earth? What is it that we cannot have in conventional TV system where we can use a simple radio-TV transmitter with all the world's antennae pointing towards it?

The first question would make sense if the Earth was a flat surface, and since this is not the case, there are some transmission problems associated with its spherical shape. The high frequency waves travel in a straight line, and they can not be bent, so, they can not follow the shape of the planet.

As it can be seen in figure 5, a signal that is transmitted by antenna A can reach another antenna B, but since our planet is spherical, it cannot reach

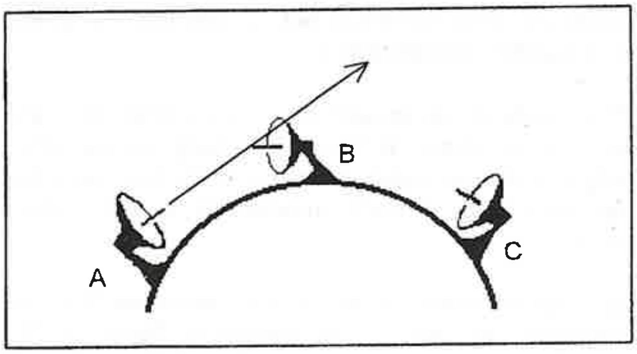

Figure 5. **Ground transmission among several points.**

antenna C. In other words, if antenna A is a transmitter, its signals follow a straight line. Antenna B and C are receivers, and even-though antenna B receives the signal without any difficulty, this does not happen to antenna C, since it is "hidden" from the line of sight of antenna A.

Therefore, the major requirement for ground transmissions, is that both antennae, transmitter and receiver, must "see each other", since signals that have been transmitted 'beyond" the line of sight (beyond the horizon), of a receiver antenna, can not be received. Due to this restriction, receiver antennae are usually placed in high mountains or high towers built to increase the "line of sight" of the antenna.

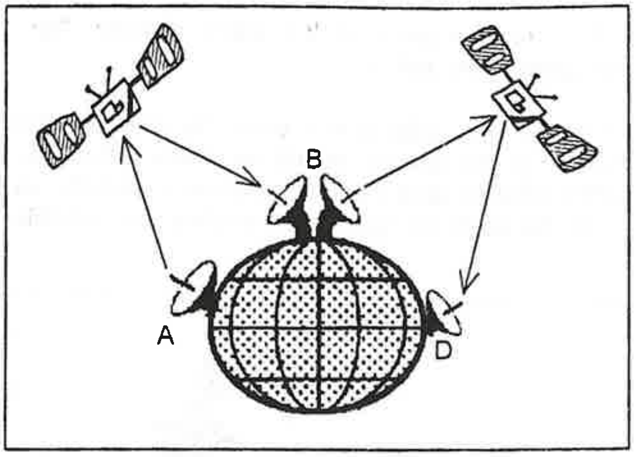

Figure 7. **Two satellite transmission.**

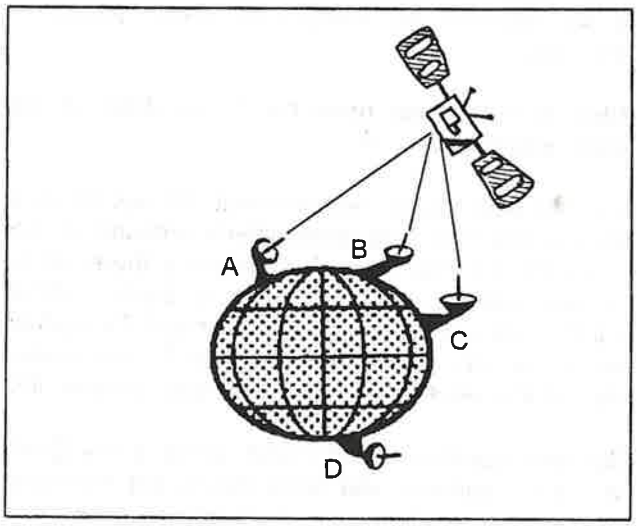

Figure 6. **Transmission via a satellite.**

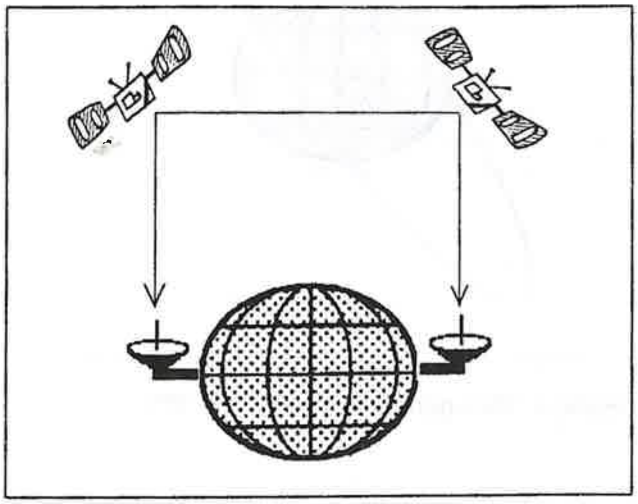

Figure 8. **Direct link between two satellites.**

Figure 6 shows how this distance limitation problem can be overcome. Antenna A can now communicate with antennas B and C via a satellite. However, antenna D can not receive any signal with this satellite configuration.

This problem is solved by using more than one satellite, as shown in figure 7. Using two satellites, antenna A can reach antenna D in two satellites, Antenna A can reach antenna D in two "single jumps".

We would have a direct link between the two satellites, of course, as shown in figure 8; this would decrease the total signal path from A to D, but this would bring other problems, such as;

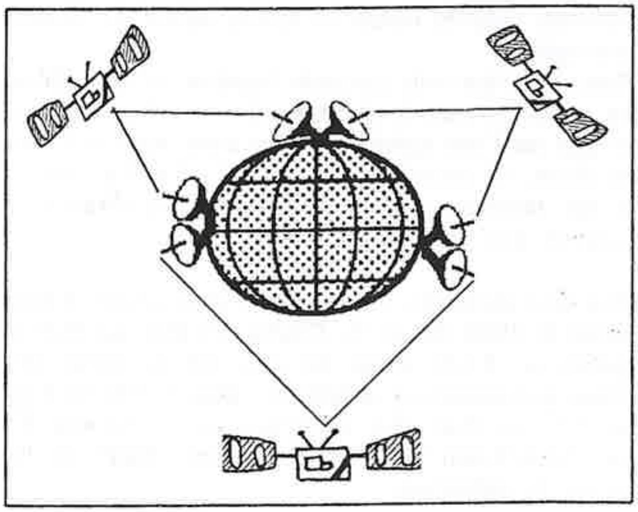

Figure 9. **Three satellite configuration.**

difficulty to achieve a very good accuracy in the orientation between the two satellites.

After many studies, it has been found that three geo-stationary satellites are necessary, (located at 120° apart), to cover the entire surface of the planet, as it was predicted by Arthur C. Clarke in 1945. This satellite configuration is shown in figure 9. One of the problems with the RF signals from the TV Channels is that they are absorbed by the Earth and other solid objects, therefore, when we are dealing with long distances,the signal is usually "weak" when it reaches its destination. Thus, re-transmitters are usually needed to "repeat' transmissions from point to point.

So, the advantage in using a satellite is that only one -re-transmission (performed in the satellite), is needed to cover long distances. Moreover, it is always possible to re-adjust (change the orientation), the receiver antennae, to receive different satellites" signals.

Since the first commercial model was launched in 1965, the communications satellite has become a linchpin of global communications. Satellites now carry about one third of the voice traffic between countries and essentially all the television signals between countries. Much of the voice traffic handled by satellites, is to countries that have no access to fiber-optic cables, which are the preferred medium for carrying telephone calls.

At the present time, large communications satellites put into geosynchronous orbits are used to carry voice traffic, therefore, a time delay of a quarter of a second is created when the signals travel to and from the satellite, during a phone conversation. Although not everybody finds this delay irritating, communications satellites are increasingly being used to carry TV signals and data rather than voice traffic.

All of this is about to change. A completely new type of satellite communications system will begin operations very soon. Basically these new networks will provide cellular phone service via satellite. Among other unique characteristics, these new personal communications satellite systems will be based on a relatively large number of satellites in orbits considerably lower than geosynchronous ones; they will therefore introduce less delay into telephone conversations. A second type of system will be used primarily for handling data, such as connections to the Internet. A few years ago cumbersome dish antennae were needed to obtain a satellite connection faste than simple telephone service cost was high. Those limitations are disappearing. The coming torrent of high-speed data "from space" should soon be a colossal boom for everybody around the world. it will be specially important in developing countries such as India, Brazil, China, Pacific Countries, which do not have extensive fiber-optic networks.

During the past six years, wireless services and satellites have been experiencing record growth. Today they can provide a telephone-line transmissin at a very low cost. Moreover, the most rapidly growing type of telecommunications service is direct broadcasting satellite (DBS) television, which uses geosynchronous orbiters to beam signals to more than 20 million people worldwide.

Specially in developing countries, space-based telecommunications systems will change our lives during the next two decades, providing rapid access to information of all types. Of special interest, are applications int he areas of medicine and education, as "tele-health", and tele-education services and video tele-conferencing that could be provided to remote areas in those countries.

CONCLUSION

Over the next five to six years, four to five of the new voice-type satellite systems (personal comm-unications ystems) and possible upward of a dozen of the data-oriented satellite systems will go into operation. In addtion, some of the already proposed systems will operate at very high frequencies in radio bands not previously used for satellite communications. The technical challenges and risks are significant.

The new personal communications satellite systems are trying to combine some of the attributes of cellular telephone systems with those of traditional satellite communications into a single global network. Traditional cellular systems uses a band of radio waves with frequencies between 800 and 900 Megahertz, and the new personal communications systems will operate at about twice this frequency, but both systems function in the same manner. In the new systems the satellites will be, orbiting cellular base stations, with which the mobile phones will communicate directly.

One advantage of these personal communications satellite systems will be an unobstructed path between the satellite and the subscribers, allowing operations at lower power levels. Recent studies show that systems operating at higher, intermediate-circular-orbit will enjoy an advantage, as the satellites are visible at higher elevations and cross the sky slowly.

Many different systems are proposed, but only five appear to have some promise of being developed. Four of them are U.S. based and have already received licenses from the U.S. Federal Communications Commission; the fifth is an enterprise spun off from the International Mobile Satellite Organisation (Inmarsat), a treaty organisation similar to Intelsat.

The development of those new fleets of satellites will affect some of us profoundly. By the year 2000 it will be possible to call home from essentially anywhere on this planet by using a handheld terminal similar to today's cellular phones. We would never be out of touch, no matter where we are. Universal service will become possible, for those who can afford it, even in places where none now exists. This planet will soon be a place where not just communications, but all kinds of information will be available for everyone, everywhere.

FURTHER READING

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