COMMUNICATIONS SATELLITES

By 1970 it is likely that Strategic Communications will be carrie out by Communications Satellites. A trial on a joint services basis i due to start in 1966.

There are two broad classifications of communications satellites Active and Passive.

Passive Satellites

Passive Satellites may be divided into two types "deliberate" and "accidental". Deliberate satellites such as the much critised "needles type" relied on creating, by the distribution of millions of dipoles in a shell about the earth, an artificial forward scattering medium at the frequency of the dipoles. As in all forward scatter systems very high powers are required. In addition there are the problems of ensuring an even distribution of the needles and the legitimate objection by other users, e.g. Radio Astronomers, to this distribution of litter in space. It is thought unlikely that this method will be pursued. The other type of Passive deliberate satellite is that type of large object put into space with a view to providing a reflector of Radio Waves. An example of this type is Echo. This type in common with all passive satellites (except the needles type) is subject to the radar equation, i.e. Received power is proportional to the Transmitted power multiplied by TX aerial gain multiplied by the area of the reflector in space and receiver aerial gain but divided by $(\text{distance})^4$. This means that large aerials, high powers and large satellites are required. Despite these objections work continues on this type of satellite, its future usefulness is, however, in doubt.

A further type of passive satellite is the accidental type. The prime example of this is, of course, the moon. This has a large echoing area but is a very long way away and powers and aerial sizes are very similar to those required for the Echo type. One more accidental type is "space junk" although echoing sizes are small it i estimated that by 1970 there will be enough "junk" in space to render this a usable system for low capacity military systems. Work continu and with ever increasing powers possible from Microwave devices it ma be a possible low cost solution for those who cannot afford their own Satellites.

Active Satellites

By far the greatest hope lies in the active satellite where the "up" signal is received amplified and retransmitted. The sole limitations to the use of this type of satellite is the amount of power available in the satellite for station keeping and retransmission. The life and weight of the satellite will depend on the method of generation of this power, and it is on these two factors that the costing of future systems depend. The power retransmitted is almost directly proportional to the required band-width and depends on the number and type of channels and to some extent on the modulation method used.

The most promising orbit is the Synchronous Equatorial. This orbit positions a Satellite over a fixed point on the Earth's equator. There are two main disadvantages of this type of orbit. The earth is unfortunately not truly spherical and gravitational forces drift the satellite slowly out of position. Power (compressed gas) or some other rocket fuel is required to keep this type of satellite on station. This means that the ground stations may be simplified as there are no tracking problems. A further difficulty with synchronous satellites arises from the great height at which they operate. The resultant radio path length is sufficient to cause a time delay of 0.3 seconds or more. This is of little significance in unidirectional 4 wire circuits such as Television and telegraphy but becomes very significant in two wire telephony where the delays and required echo sypressors may cause users to become tongue tied.

Other orbits are possible and reference should be made to N.E.R. July 1965. The other orbits all require computer control of the ground station aerials and more satellites to achieve a given coverage. At the same time however the satellites can be in lower orbits (less time delay and cheaper to launch) and do not require station keeping power.

With the use of modern microwave devices, Lasers, parametric amplifiers, tunnel diodes, etc., and very large receiving aerial dishes the overall noise factor of the receivers can now be made small relative to the noise received from the aerial, waveguides and from the sky. Further improvements must therefore be made by increasing the transmitted power from the satellite. This can be achieved in two ways

(a) Increasing the transmitter power (this requires a greater power supply in the satellite).

(b) Providing high gain aerials in the satellite. As these aerials would be highly directional, power will probably be required to stabilize them.

At the moment an active satellite system can only be used by about four stations at the same time and even under these conditions channel capacity is restricted compared with that possible when two stations work one satellite. This is due to cross modulation problems in a channel limiting f.m. system. Work is being continued on more sophisticated modulation methods and multiple access should become possible within the next decade.

Vehicle and Ship mounted equipments with reasonably sized dish aerials will also become possible as satellite powers increase and provided the number of channels required is not great.

<u>Data on the Main Communications Satellites</u>

	Telstar	Relay	Syncom	Early Bird
Transmitting Power (Watts)	$2\frac{1}{4}$	10	2	4.5
Transmitting Frequency (Mc/s)	4,170	4,170	1,815	4,100
Receiving Frequency (Mc/s)	6,390	1,725	7,360	6,350
Shape	Spherical	8 sided prism	Cylindrical	Cylindrical
Weight (lb)	170	172	150	85
Solar Cells	3,600	8,215	3,840	6,000
Power generation (watts)	14	45	25	45
Manufacturer	Bell Telephone	R.C.A.	Hughes	Hughes
Capacity	T.V. Signal or 60 Two way Telephone circuits	T.V. Signal or 12 Two way Telephone circuits	T.V. Signal or 1 Telephone circuit	T.V. Signal or 240 Two way Telephone circuits