SLADE MEMORIAL LECTURE PAPER

SATELLITE COMMUNICATIONS

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Dr Franklin was born December 9, 1927 in Hastings, New Zealand. He received his MSc in Physics from Auckland University in 1953 and a PhD in Electrical Engineering from the Imperial College of Science and Technology, London in 1957. He was a Physics Lecturer at Auckland University in 1952 and a member of the Defence Science Corps, Royal New Zealand Air Force, from 1953 to 1959.

In 1957 he was posted to the Defence Research Telecommunications Establishment (DRTE) in Ottawa, Canada where he worked on the design of an airborne transistor Doppler navigation system.

In January 1959 he was assigned to a team at DRTE assembled to design and build Canada's first satellite, the Aloutte topside sounder. He was successively Chief Electrical Engineer for Alouette I and II, Chief Engineer and Program Manager for the ISIS-I and II Scientific Earth Satellites. He was also head of the Space Electronics Laboratory at DRTE for over eight years.

In January 1987 on the occasion of the 100th anniversary of Professional Engineering in Canada the Prime Minister of Canada announced the ten most outstanding achievements of Canadian Engineering of the past 100 years. The Alouette satellite was one of the ten selected.

In 1969 he joined the newly created Department of Communications in Ottawa. At its Communications Research Centre (CRC) he was Project Manager for the Communications Technology Satellite Hermes from 1970 to 1975. From August 1976 to September 1977 he was posted to the European Space Agency (ESA) HQ in Paris, where he worked in the Department of Future Programs and Plans. In September 1977 he was appointed Director-General of Space Programs in the Department of Communications HQ Ottawa and in 1983 Director-General of Space and Information Programs. In August 1985 he was appointed Senior Advisor for Space policy at the Ministry of State for Science and Technology in Ottawa. He retired from the Public Service of Canada at the beginning of 1987 to take up an appointment as Visiting Professor in the Electrical and Electronics Engineering Department at Auckland University.

Dr Franklin is the author on numerous technical Papers, Reports and presentations to international conferences on electronics and space system and sub-system design, and holds Canadian patents on spacecraft power supplies and transmit-receive switches. He is a Fellow of the Royal Society of Canada and a Fellow of the City and Guilds of London Institute.

1. ABSTRACT

Communication satellites are the first and so far the only really successful commercial application of space technology, with over 180 commercial satellites launched to date, generating some $5 billion in revenues each year. This paper reviews the history, current status and future developments in satellite communications and, because of its particular relevance to New Zealand, the related area of satellite-aided search end rescue.

Although much of the early promise of satellite technology has been achieved there have been setbacks as well as successes and the full potential of the technology has yet to be realised. This is because the obstacles to be overcome are not simply technological but also political, economic and institutional.

The implications for New Zealand are briefly discussed.

2. INTRODUCTION

The term satellite communications refers to the transmission end reception of TV, voice, and data vie orbiting radio relay stations. It is the first and so far the only application of space technology to become truly commercial, at least in the traditional business sense. This is not to deny the importance and value of the "public good" services provided by search and rescue satellites, navigation satellites and meteorological satellites nor the emerging commercial applications of remote sensing from space. It is simply to state that these "public good" services, with the possible future exception of remote sensing, cannot be delivered solely on a user pay basis and should not be expected to.

Satellite communications systems possess a number of advantages that have allowed them to very quickly establish their place in the telecommunications infrastructure of most countries. Often their role has been complementary rather than competing. The advantages are:

Cost of a satellite link is distance insensitive:

Wide area coverage and rapid establishment, with full interconnectivity, of high quality communication links for voice, data and television traffic between any two points within its ground coverage area. This capability led to the early use of satellites by the INTELSAT global system for the trans-mission of television programs live across the oceans and for telephony. It has also been the driving force behind the establishment of many domestic satellite systems, particularly in countries with dispersed populations end difficult terrain such as Australia, Canada, Indonesia, India and Brazil.

Multiple Access: capacity can be shared by many earth stations through-out its coverage area end immediately reassigned on demand to meet changing needs; Point to multi-point and multi-point to multi-point capability combined with the fact that most earth stations can now be moved relatively easily allows for rapid network reconfiguration. Terrestrial system capacity e.g. a fibre optic network, is tied to specific routes, not available for use anywhere except on those routes. For systems, such as private or corporate networks, designed to capitalize on this flexible universal availability of satellite capacity, very real cost and performance benefits can be captured; and

Provision of back up and overflow capacity for terrestrial networks.

3. HISTORY

It is not clear who first thought of using an artificial earth satellite for communications. Certainly there were prophetic publications long before there were launch vehicles powerful enough to make space flight a practical possibility. Everett Hale in 1869 ("The Brick Moon" serialized in the Atlantic Monthly) described a manned satellite to serve as a navigational aid. In 1897 Kurd Lasswitz ("AuP Zwei Pleneten") proposed a space station and orbital rendezvous. In 1928 an Austrian army officer Hermann Noordung (real name Potocnic), in his book "Das Problem der Befahrung des Wetraums" (Problem of Spaceflight), appears to have been the first to propose a geostationary satellite. Noordung's proposal was for a manned satellite for military surveillance i.e. a space station. It is generally agreed however that the geostationary satellite as we now know it was first proposed by Arthur C. Clarke in 1945 in his seminal article "Extraterrestrial Relays" in Wireless World. Clarke, who referenced Noordung, showed that three geostationary satellites powered by solar energy could provide a worldwide communications system. Clarke recognized the potential of the V-2 rocket and the conspicuous advantage of the geostationary orbit. Despite the Clarke paper and the understanding of the advantages of the geostationary orbit the translation of the concept into e practical operational system was a lengthy process end required many years of further development of launch vehicles, component technologies and system concepts.

The first demonstration of communications by satellite was in 1954 with voice transmissions by the US Navy over the earth-moon path. In 1958 a US Navy moon relay service was established between Hawaii and Washington and provided reliable long distance communications, as long as the moon was available. The circuit operated until 1962. The first passive artificial satellite was ECHO-1; a 100 ft diameter aluminium coated plastic balloon launched in 1960 by the US. The first trans-Atlantic satellite communications were by ECHO-1. The orbit height was 1000 miles and the operating frequencies 960 MHz end 2290 MHz. The concept was not a success. The balloons did not retain their shape, received signals were extremely weak, large earth stations were required, and because of the low earth orbit the earth terminals had to track the satellite.

The first active satellite was Telstar-developed by Bell Telephone Laboratories. The satellite received and transmitted simultaneously using on-board transponders or repeaters. Launched in 1962 into a 680 x 4030 miles high orbit, it operated at 4/6 GHz and was the first to transmit TV across the Atlantic. It experienced radiation damage to its semiconductors. A second Telstar, more radiation resistant, was launched in 1963. Relay was a similar satellite. Developed by RCA and NASA it carried wideband transponders at 4/6 GHz and was launched in 1962, shortly after the first Telstar, into a 940 x 5300 mile orbit. Syncom III was the first geostationary satellite and a landmark in the history of satellite communications. Launched by NASA in 1963 and designed end built by Hughes Aircraft it was an engineering tour de force, derivatives of which dominated the satellite market for the next twenty years.

In the early 1960s NASA undertook the ATS (Advanced Technology Satellite) program culminating in the launch of ATS-6 in 1974; TV broadcasts to Indian villages etc. In 1976 Canada end the US launched and operated for three years the CTS communications technology satellite. Communications trials included the first demonstration of high power direct broadcasting at 12/14 GHz. CTS also showed that rain attenuation was less serious then forecast and that much lower channel powers end therefore smaller end less expensive satellites could be used for direct to home TV.

The European Space Agency's heavy communications satellite Olympus, to be launched in 1989, has been designed to demonstrate technology and new communications services at 12/14 GHz and 20/30 GHz.

NASA's Advanced Communications Technology Satellite (ACTS) program is e major undertaking to advance the state of the art in satellite communications at 20/30 GHz in both the space and ground segments. One satellite is under construction for launch in 1990.

International Satellite Communications

Syncom III was followed by INTEL-SAT-I (known as Early Bird) and the subsequent series of INTELSAT satellites, of increasing size and complexity through to INTELSAT VII. The International Telecommunications Satellite Organization (INTELSAT) created in 1964 with headquarters in Washington D.C. now has 114 member countries. Through a network of 14 satellites in geostationary orbit over the Pacific, Indian and Atlantic oceans it links more than 165 countries, territories and dependencies around the globe. INTELSAT provides communications services in both international and domestic markets and currently provides most of the world's international satellite communications capacity. This may change as the result of competition from fibre optic cables and regulatory changes allowing, new entrants into international satellite communications markets. The Inter-national Maritime Satellite Organization (INMARSAT), with headquarters in London, was established 1n 1979 and began operations in 1982. It has a growing membership of over 54 countries and owns or leases communications capacity on nine geostationary satellites located over the Pacific, Indian and Atlantic oceans. INTER-SPUTNIK, an east bloc open inter-national system was established in 1971, leases two geostationary satellites from the USSR and numbers 14 countries.

Domestic satellite Communications

The USSR initiated domestic communications 1n 1965 with its non-geostationary Molniya system. Since 1975 the USSR has also placed e number of geostationary satellites in orbit. In 1972 Canada established the first domestic geostationary system with the launch of the first of Its ANIK series of satellites. In 1974 the first US domestic geostationary system was established. In October 1985 the Australian National Satellite System became operational with the launch of the first of its three AUSSAT geostationary satellites. Milestones in the history of satellite communications are given In Fig.l.

4. UNIQUE FEATURES OF SATELLITE COMMUNICATIONS SYSTEMS

Orbits Except for certain military and USSR domestic systems virtually all communications satellites are launched into the geostationary orbit. The latter is a circular equatorial orbit, et a height of 35,700 km above sea level, in which the period of revolution of the satellite is the same as that of the earth, and the direction of movement of the satellite is in the direction of rotation of the earth i.e. West to east. Hence the satellite appears stationery when viewed from any point on earth; e major advantage since it permits the use of non -tracking ground stations. In other words what we have is the equivalent of a microwave radio relay tower 35,700 km high. This permits coverage by a single satellite of up to 30 per cent of the earth's surface as far north and south as latitude 81.3 °.

The only non-geostationary orbit of serious interest, for civil communications, is the Molniya orbit; highly elliptical, inclined et 63.4° to the equator and with a period of 12 hours. Its advantages and disadvantages are given in Fig.2. The USSR has operated a Molniya regional and domestic communications satellite system since March 1965 firstly because it has no near-equatorial launch site, a major disadvantage when launching geo-stationary satellites, and secondly because the system provides coverage to the North Pole and high ground station elevation angles al high latitudes.

Delay and echo

The path length between two ground stations via a satellite varies between 83,400 km and 71,600 km. Hence the one-way propagation time or time delay varies between 0.24 and 0.28 seconds, Since some degree of mismatch will occur at both the receiving and transmitting ends an echo will be generated and the echo becomes increasingly objectionable as the delay increases. Furthermore, echo is not the only problem associated with delay. Excessive delay will by itself make communications difficult. A substantial amount of work has been done in evaluating customer reaction to delay under various conditions. In summary, results in Canada and the United States indicate that a 560 millisecond round trip delay corresponding to a single-hop circuit is acceptable for telephony Provided echo cancellers are used end that approximately the same level of customer satisfaction can be maintained using satellite circuits with echo cancellers as with terrestrial circuits using echo suppressors.

Sun transit outage

For a geostationary satellite there are two periods in the year, around the spring and autumn equinoxes (21 September and 21 March), when u ground station points at the sun (Fig.3) The conjunction occurs each day over a period of several days in the spring and autumn; the number of days and the duration of each day depending on the beamwidth of the earth station antenna; typically 4-5 days and 6-8 minutes respectively for beamwidths less than 0.5°. Each conjunction is accompanied by an increase in receiver noise level that may be unacceptable particularly for digital circuits. Because the outages occur only in daylight hours, are of short duration, and can be accurately predicted, they are not a significant operational problem. In Canada traffic is directed away from satellite circuits during these periods and, in the US, AT&T switch traffic from one satellite to another.

5. SERVICES AND FREQUENCIES

For New Zealand and the South Pacific the must important frequency bands are at 4 and 6 GHz (INTELSAT), 12 and 14 GHz (AUSSAT) and 1.5 GHZ (INMARSAT).

The principal services recognised by the 1TU are:

Fixed Satellite Service (FSS)
Communications between ground stations, located tit fixed points, via one or more satellites. Prime example is INTELSAT.

Broadcast Satellite Service (BSS)
TV and radio programs for direct reception by individual home receivers. Can also be used by community receivers for cable distribution to homes or within buildings.

Mobile Satellite Service (MSS)
Communications to and from mobile ground stations via one or more satellites. Depending on whether the mobile terminals are located on the ground, in aircraft or on ships there is the maritime mobile satellite service (MMSS), aeronautical mobile satellite service (AMSS) end land mobile satellite service (LMSS).

Radio Navigation Satellite Service
Position determination using signals received from one or more satellites. Examples are US Transit and GPS/Navstar systems.

Search and Rescue Satellite Service
Position determination of emergency locator beacon signals transmitted via satellite to a central ground station.

6. PRESENT STATE OF SATELLITE COMMUNICATIONS

Launch Vehicles: Europe with its Ariane family of rockets and near-equatorial launch site In French Guiana is now the major supplier of launch services for commercial communications satellites. The US launch vehicle industry is still recovering from the effects of the Challenger disaster and the earlier US government decision, since reversed, to phase out expendable launch vehicles in favour of the Shuttle. China is emerging as e small but significant player offering launch services at much lower prices than Europe end the US end has recently been cleared by the US Congress to launch the new AUSSAT-B satellites (US built). The USSR also offers low price launches but has been unsuccessful In marketing Its vehicles because of US and European concerns regarding transfer of satellite technology to e communist nation. Japan is expected to enter the launch vehicle market in the early 1990s with its H-II. For geo stationary satellites the closer the launch site is to the equator the heavier the satellite that can be put into orbit by a given launch vehicle. This is one of the reasons why Australia is currently exploring the possibility of building a multi-billion dollar launch complex on Cape York, Queensland for foreign vehicle manufacturers. Summaries of launch vehicle performance end existing and proposed launch sites are given in Figs. 4,5.

Launch vehicle reliability is still a problem, which makes for an uneven launch schedule as problems are identified and corrected, and insurance rates, when they can be obtained, are therefore high.

Launch and Satellite Costs
The cost of e satellite, In the West, is roughly equal to the cost of launching it; a ratio which has remained surprisingly constant over the past fifteen years. At present a communications satellite with a lift-off weight of 2500 - 2800 Kg, corresponding to an Ariane-4 class vehicle, costs around NZE130 million to launch end about the same amount to procure. In addition there is the cost of insurance which has risen steeply due to a series of failures over the pest few years in both NASA and Ariane launch vehicles. Insurance if taken out, and if available, can add 20-30 per cent to overall launch and procurement costs.

Satellite Systems
By mid-1988 over 150 communications satellites were in geostationary orbit and either operational or capable of operating (FIg.6). Since 1963 some 180 geostationary communications satellites have been launched with INTEL-SAT accounting for about 40 of the total.

A summary of the international, regional, domestic, and military systems now in place is given in Figs. 7-10. The terms international, regional and domestic should not be taken too literally. Regional systems in Europe (EUTELSAT) find the middle east (ARABSAT) are really international and domestic systems in for example Australia (AUSSAT) and Indonesia (PALAPA) become regional as they expand to serve neighbouring countries. Furthermore, INTELSAT provides domestic satellite communications to a number of countries and can be expected to become more aggressive in this area as the international market becomes increasingly deregulated. The major commercial markets are the international and North American domestic ones.

Extreme reliability has been one of the reel advantages of satellite systems. For example, since 1977 the INTELSAT system has had satellite continuity of service exceeding 99.9% and a maximum length of satellite outage of less than one hour. During the last decade only two operating communications satellites of western nations have experienced sudden failure in orbit. In-orbit lifetimes have been typically 7 years. They are currently nearer 10 years and new systems e.g. AUSSAT-B are being designed for a 15-year lifetime. Scrambling allows the secure distribution of satellite TV signals. Users can be authorised to receive scrambled channels offered by a single control centre. Encryption is the choice of most critical business transactions as well as those involving national security. Encryption equipment is available in many forms and for different data rates. The privacy of satellite transmissions is also related to the size of their footprints or coverage areas, the smaller the better; an aspect which has been exploited by military communications satellites using spot beams.

7. APPLICATIONS

A summery of the more Important satellite applications is given in Fig. 11. For users to buy communications capacity via satellite the system must be either:

- More cost effective - more reliable

- More flexible in network configuration and start-up times or - do things which cannot be done by other means.

Satellite systems are best suited to medium and thin-route networks, television and radio program broadcasting, private networks, end mobile communications for land, sea and air vehicles. They are unlikely to be competitive with terrestrial systems on heavy route point-to-point telecommunications which will be best served in many cases by fibre optic cables.

Satellite broadcasting: Because of their point to multi-point capability geostationary satellites are particularly suited to the distribution of radio and TV programs to many receivers over large geographical areas. This has led In the United States to the explosive growth in distribution by satellite of TV programs to cable TV headends; mostly by low-power fixed service 4/6 GHz satellites. It has also led to around two million back-yard earth stations receiving signals without the permission of program originators. This widespread unauthorised reception by private individuals of low power signals from fixed service satellites was not foreseen because it was thought that the required ground stations would be too expensive and the antenna diameters (3-5 meters) too large for domestic users. This did not happen. Instead, there was a dramatic improvement in performance end price of earth stations, brought about largely by extraordinary progress in the manufacture of low cost low noise GaAs field effect transistors.

The first operational high power DBS services are likely to start in France in 1989 using the French TDF-1 satellite (62 dBW) which was launched in November 1988. High power DBS services should start in the UK In late 1989 using IBA's British Satellite Broadcasting (BSB) spacecraft (59 dBW). TV reception will be possible with 30 cm dishes or equivalent area panel antennas. Cost of the receiving terminals is expected to be about 250 pounds. BSB is to operate a subscription service in a D-MAC format to allow later extension to high definition television. Medium power (50 dBW) DBS services are to be introduced In Europe by the Luxembourg Astra satellite, to be launched in December 1988. In the UK, Astra will deliver three channels of TV. They will be advertiser supported with no user fee, end the format is to be standard PAL. Antenna diameters will be about 80 cm end overall terminal cost about 300 pounds installed.

Medium power DBS service will be possible in New Zealand starting early 1992 with the launch of the first AUSSAT-B spacecraft. Reception will be possible with 70-80 cm diameter dishes or equivalent area panel antennas.

DBS may prove the most practical means of delivering high definition television. Starting with Japan in 1990, HDTV is expected to come into regular use in a number of countries in the early 1990s.

Finally, DBS has the potential to provide additional services such as distance learning, rebroadcasting of programs, stereo FM, programs to special interest groups, and electronic mail (BSB data service).

Private networks

Availability of higher power satellites operating in Ku-band and recent technological developments have reduced the size end cost of ground stations. These small ground stations and In particular the VSAT- very small aperture terminal, will bring very significant direct cost reductions to satellite communications. Also their small size and ability to share master stations will allow them to be located almost anywhere for business or even residential service applications so that private networks can be readily set up. As a result earth terminals can be located on user premises thus eliminating the need for "lest mile" interconnect or local access circuits; a problem which has competitively disadvantaged satellite operators until now. VSATs represents one of the most important developments in communications satellite technology in this decade. Because satellites do not have to share the Ku-band with terrestrial systems interference from the latter can be neglected, permitting operation of small terminals in urban end down town city areas; a key consideration for private networks. Initially the greatest opportunity for private network development Is in data transfer using VSATs. This will be followed by voice services using small single and multi-channel terminals. Specialized video services for training, information dissemination and meetings will also be part of the market but data and voice will be the dominant services.

Thin route services

Communications satellites are ideally suited to providing first time communications services to remote or sparsely populated regions, an application usually referred to as thin-route service or communications; mainly telephony and date involving moderate to low bandwidths. An example in New Zealand would be the Chatham Islands. More generally, the Pacific Basin comprising 40% of the earth's surface, some 40 countries and 23,000 islands, and some exceptionally difficult terrain Is a prime example of a region where medium and thin-route services can often best be provided by satellites. As communications develop and economics permit the satellite links can be replaced by terrestrial links.

Mobile satellite service

Satellites are particularly suited to provide mobile services for ships, aircraft and land vehicles. A lend mobile satellite provides both voice and data services and is primarily designed to augment terrestrial mobile systems in low-density traffic areas where service is either unavailable or inadequate. It is also designed to be complementary to fixed service satellites. Over the next 20 years mobile satellite services may prove one of the most important growth areas in satellite communications. The first operational land mobile satellites are expected to come into service in the early 1990s; first in Australia with the launching of AUSSAT-B in late 1991 end then in Canada and the United States with MSAT.

Search and rescue
Since the mid -1970s a number of countries have been interested in the concept of using satellites equipped with a suitable receiver to detect and locate emergency transmission: from aircraft and ships in distress. This mutual interest led to the formation in 1979 of the COSPAS-SARSAT project, an international joint venture In satellite aided search and rescue by the United States, USSR, Canada and France. Simply stated the concept involves the use of multiple satellites in low, near-polar orbits listening for distress transmissions. The signals are relayed to a network of dedicated -ground stations, known as local user terminals or LUTs, where the location of the emergency is determined by measuring the Doppler shift induced by the satellite motion relative to the distress signal. The location data is relayed to a Mission Control Centre which alerts the appropriate Rescue Coordination Centre. The space segment comprises two USSR and two US spacecraft. There is no charge for the service and the original signatories have agreed to maintain the service until an alternative global international system can be put in place (n the 1990s. The service is provided at 121.5 and 406 MHz on USSR COSPAS satellites and at 121.5, 243 and 406 MHz on US NOAA satellites. Accuracy of location is typically better than 20 km for 121.5 MHz beacon signals and better than 3 km for 406 MHz beacons. The latter are a new type designed specifically for satellite detection. The 121.5 MHz emergency locator transmitters (ELTS) for aircraft and the emergency position indicating radio beacons (EPIRBs) for ships were never designed for satellites and have non-optimum characteristics.

The system has been e great inter-national success story. It has already provided alert and location data for incidents involving over e thousand persons and has saved hundreds of Lives and tens of millions of dollars in search and rescue costs. The only southern hemisphere ground station is in Brazil. Australia is installing a ground station at Alice Springs to be operational in mid 1989 end in New Zealand the procurement of a ground station is under review.

Fig.12 illustrates the system concept and Fig.l3 the coverage that would be available to New Zealand if a local user terminal was installed. The average time between successive satellite passes is 60 -90 minutes within 1000 km of New Zealand. This is the maximum time delay in detecting distress beacon signals.

8. THE PROMISE

The commercial realisation of the geostationary satellite in the early 1960s produced a great deal of enthusiasm for satellite communications. That enthusiasm was generated by the following five promises of the technology:

Ability to communicate throughout the world with reliable, broadband communications using only three satellites; Communications independent of terrain whether it be oceans, deserts, jungle, ice and snow or built up areas; Communications capability free of routing constraints with total communications capacity available to be shared or transferred instantaneously to meet dynamic changing needs.

Communications cost independent of distance

Freedom to quickly locate terminals where needed and to salvage much of their costs when moved.

A good deal of the promise has been captured, internationally by INTELSAT and INMARSAT, by numerous domestic and regional systems, end by the COSPAS/SARSAT satellite-aided search and rescue system. Much of the promise has however not been realised for the following reasons:

High cost of satellites and launch vehicles

Between large population centres with no adverse geography satellites are only competitive at long distances between centres;

While one satellite can "see" about thirty per cent of the earth's surface the cost of providing transmitter power in satellite means that received signal powers are small end ground stations expensive.

User communications needs have not evolved to point where they can use all of the capability that satellites can provide. Capacity sharing between network nodes through TDMA, automatic network remapping, variable transmission rates, mixes of voice, date, facsimile and video or image services etc. are all very interesting but few user systems until recently have been able to use them.

The main reason, however, for the gap between promise and reality lies not in the technology but in the institutional structures of the telecommunications world. Most telecommunications systems are owned, operated end regulated as monopolies, often government owned, in institutional structures which tend to change very slowly and which always resist change when imposed from without. This has forced satellite operators into areas where access to telecommunications traffic is not controlled by others. This is why saLe11i1es have been so successful for international telecommunications, TV broadcasting where access has not been restricted by traditional carrier groups) and why satellites have generally not been successful when applied to voice and low speed data services where local access has been constrained by the local telephone collector and distribution networks.

9. IMPLICATIONS FOR NZ

New Zealand is currently provided with International and domestic fixed satellite services at 4/6 GHz by INTELSAT and maritime mobile satellite services by INMARSAT. In audition Telecom has leased Ku band capacity for pilot / trial use on AUSSAT-3; one 30 watt transponder and half a 12 watt transponder. Received signal levels from INTELSAT and AUSSAT spacecraft are fairly low requiring antenna diameters of 5-metres and ground stations costing $6000 for home TV reception. Clearly too high a price to pay for the average viewer. These signal levels also imply relatively expensive terminals for business services.

This scene is almost certainly about to change as a result of o number of recent developments which are creating new opportunities for satellite broadcasting and telecommunications in New Zealand and the Pacific Basin. The four main agents of change are:

The advent of the Australian National Satellite System and its AUSSAT series of satellites AUSSAT-B to be launched in late 1991 will deliver a signal to New Zealand 25-30 times more powerful than AUSSAT-3. It will also have six transponders with switchable trans - Tasman end New Zealand capability. These changes will dramatically reduce the size and cost of ground stations and allow TV reception with 70-80 cm dishes or flat panel antennas. It will also allow low cost rooftop terminals for trans-Tasman and domestic business services

Reduced size and cost of ground stations. Mainly driven by extra-ordinary improvements in recent years in the performance and price of GaAs field effect transistors for low noise receiver front-ends

Deregulation. By 1 April 1989 New Zealand will have one of the most deregulated telecommunications systems in the world; and

More TV programmes on INTELSAT Pacific Ocean spacecraft.

Deregulation is undoubtedly the single most Important change. The new environment will almost certainly see the growth of satellite business services, mainly voice and data, based on rooftop terminals and VSAT networks. Teleports will likely appear in some of the main population centres to provide users with alternative and less expensive access to C-bend (4/6 GHz) and Ku band (12/14 GHz) services via AUSSAT, and INTELSAT and any other satellites that may become available. There will be more TV, delivered either directly to the home or terrestrially via over the air broadcasting at UHF. Contrary to what is sometimes reported the program material exists and many New Zealanders will almost certainly welcome and be prepared to pay for greater choice in their viewing.

Other new services which may develop are videoconferencing and for the island nations of the South Pacific, teleeducation and telehealth. High definition television, when it comes to New Zealand, will probably be delivered by satellite because of radio spectrum constraints. Finally there will be major opportunities for New Zealand broadcasters end educational and health agencies to provide satellite delivered services in the South pacific basin.

These developments will not be without their social, cultural and sovereignty impacts. There will be New Zealand content problems due to increased competition affecting local writers, artists and producers. There are also bound to be cultural sovereignty concerns due to greater awareness and involvement of New Zealanders in Australian political, social and cultural issues. In the words of a recent TVNZ broadcast on satellite communications, "the Australians are coming".

HISTORY: COMMUNICATIONS SATELLITES

UNIVERSITY OF AUCKLAND

1869 Everett Hale, Atlantic Monthly, "Brick Moon"

1897 Kurd Lasswitz, "Auf Zwei Planeten"

1929 Hermann Noordung (Potocnic), "Problem of Spaceflight"

1945 Arthur Clarke Wireless World, "Extraterrestrial relays"

1960 EchO-1 100 ft Balloon: Trans-Atlantic Communications

1962 Telstar 4/6 GHz, low earth orbit, Trans-Atlantic TV

1963 Syncom III 4/6 GHz, first geostationary satellite

1964 Molniya first domestic system: non-geostationary

1965 INTELSAT: first international system

1972 Telesat Canada: first domestic geostationary system

1976 CTS (Communications Technology Satellite): first direct broadcast satellite

1982 INMARSAT: first international maritime system

1982 SARSAT/COSPAS Search and Rescue (USSR/USA/Canada/France)

MOLNIYA ORBIT

UNIVERSITY OF AUCKLAND

DISADVANTAGES

- FOUR SATELLITES NEEDED FOR 24-HOUR COVERAGE
- TRACKING ANTENNAS NEEDED ON THE GROUND
- TWO GROUND STATIONS PER SITE TO AVOID HAND-OVER OUTAGES
- DOPPLER SHIFT
- LOW ELEVATION ANGLES IN ALL EQUATORIAL REGIONS
- ATMOSPHERIC DRAG PERTURBATIONS

ADVANTAGES

- COVERS POLAR REGIONS
- NOT SUBJECT TO ECLIPSE OPERATION
- SINGLE SATELLITE FAILURE LESS SERIOUS THAN FOR GEO SYSTEM
- POSSIBLE TO ESTABLISH TRANSPARENT STATIONARY SERVICE

EXPOSURE TO VAN ALLEN BELT RADIATION IS OF SHORT DURATION

Fig.2 Molniya orbit advantages and disadvantages

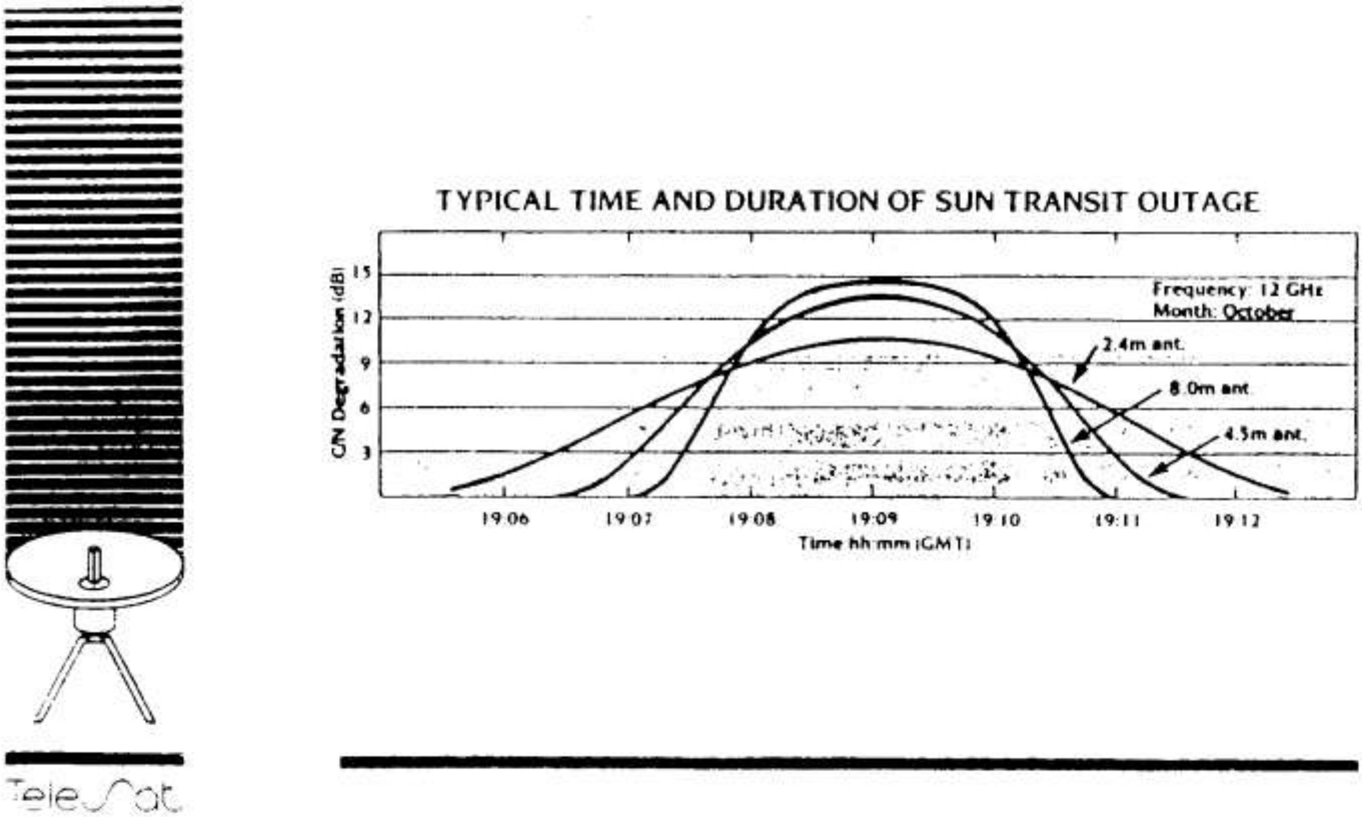

Fig.3 Sun transit outage

LAUNCH VEHICLE PERFORMANCE		UNIVERSITY OF AUCKLAND
Requirements: 2000 – 3000 kg at launch; 1100 – 1700 kg on orbit (GEO)		
Europe:	**GTO(kg)**	**GEO(kg)**
Ariane-4	1900-4200	1140-2510
USSR:		
Proton	N/A	2200
USA:		
Delta 2	1823	970
Atlas-Centaur	2360	1250
*Atlas-Cent 2 (MLV)	2730	1450
Titan 34D	3600	1910
China:		
* Long March -3	2500	1330
Japan:		
* H-2	3800	2000

* *Under Development*

Fig.4 Launch vehicle performance

LAUNCH SITES	UNIVERSITY OF AUCKLAND
	Lat (deg)
■ ***Cape Canaveral***	28.5 N
■ ***Kourou, French Guiana***	5.5 N
■ Baikonur	45.0 N
■ Xichang, China	28.5 N
■ Tanegashima, Japan	30.5 N
Proposed New Launch Sites	
■ ***Cape York, Queensland***	12.5 S
■ Palau Bay, Indonesia	1.0 S
■ Kiribati (proposed by Japan)	2.0 S
■ Hawaii	19.5 N

Fig.5 Launch sites

IN-ORBIT GEOSTATIONARY COMMUNICATION SATELLITES TO MID – 1988

TOTAL SATELLITES	NORTH AMERICAN DOMESTIC	NON-SOVIET OTHER	INTELSAT INMARSAT	USSR	NON-SOVIET MILITARY
159	65	30	19	26	19

COMSAT SYSTEMS — UNIVERSITY OF AUCKLAND

INTERNATIONAL

INTELSAT
INMARSAT
INTERSPUTNIK

REGIONAL

AUSSAT
ARABSAT
EUTELSAT
PALAPA
LUXEMBOURG – ASTRA
SCANDINAVIA TELE-X
PANAMSAT
PACSTAR (PLANNED – FOR PACIFIC BASIN)
PACIFIC STAR (PLANNED)

DOMESTIC

CANADA	TELESAT ANIK -C,-D,-E
USA	GE – RCA SATCOM COMSAT – COMSTAR SATELLITE BUSINESS SYSTEMS -SBS WESTERN UNION -WESTAR AT&T – TELSTAR HUGHES -GALAXY ALASCOM – AURORA GTE – GSTAR – SPACENET AMERICAN SATELLITE CO. – ASC1

Fig.7

COMSAT SYSTEMS — UNIVERSITY OF AUCKLAND

DOMESTIC

AUSTRALIA	AUSSAT
JAPAN	CS BS (DBS)
BRAZIL	SBTS
INDIA	INSAT
MEXICO	MORELOS
FRANCE	TDF (DBS)
WEST GERMANY	TVSAT (DBS)
UK	BSB (DBS)

Fig.8

COMSAT SYSTEMS — UNIVERSITY OF AUCKLAND

USSR: SATELLITES

MOLNIYA	EKRAN (6/0.7 GHZ) GORIZONT RADUGA KOSMOS (DATA RELAY) LOUTCH GALS VOLNA TOR

USSR: SYSTEM NAMES

GALS	-FIXED
LOUTCH	-FIXED
STATSIONAR	-FIXED
VOLNA	-MOBILE
TOR	-MOBILE (20/40 GHZ) FIXED
FOTON	-DATA RELAY
POTOK	-DATA RELAY

Fig.9

COMSAT SYSTEMS — UNIVERSITY OF AUCKLAND

MILITARY

UK	SKYNET
FRANCE	TELECOM
NATO	NATO
USA	FLTSATCOM LEASAT DSCS MILSTAR (FUTURE)
USSR	VOLNA GALS RADUGA *MOLNIYA*

LOW ALTITUDE CONSTELLATION

- 800 and 1500 km CIRCULAR
- THREE ORBITAL PLANES

Fig.10

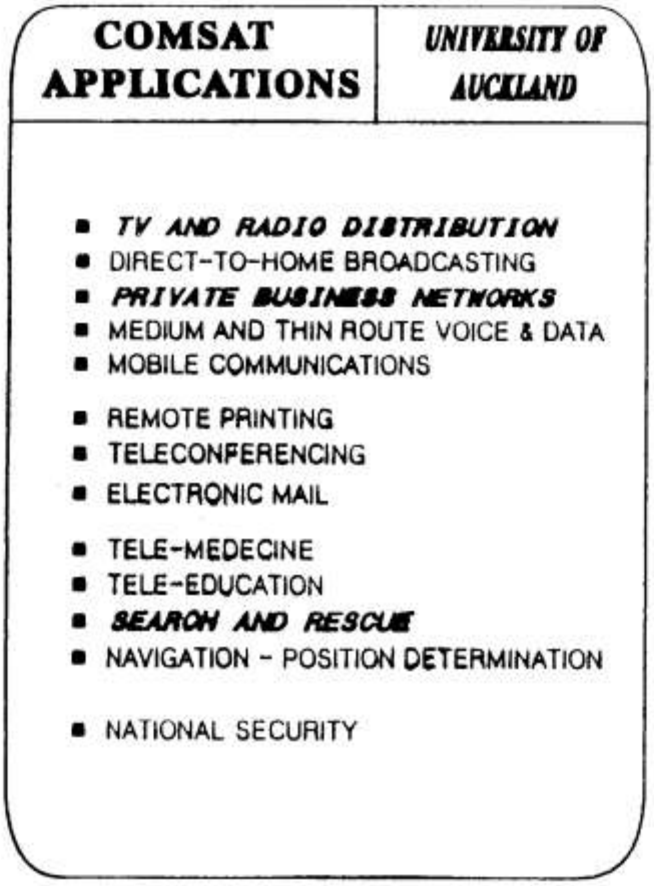

Fig.11 Applications

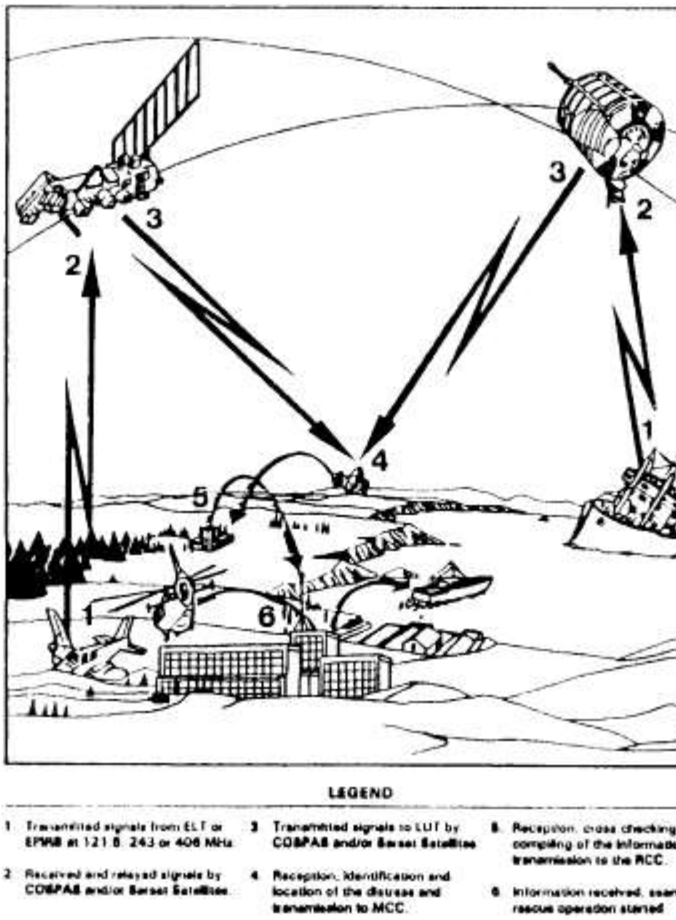

Fig.12 Search and Rescue System

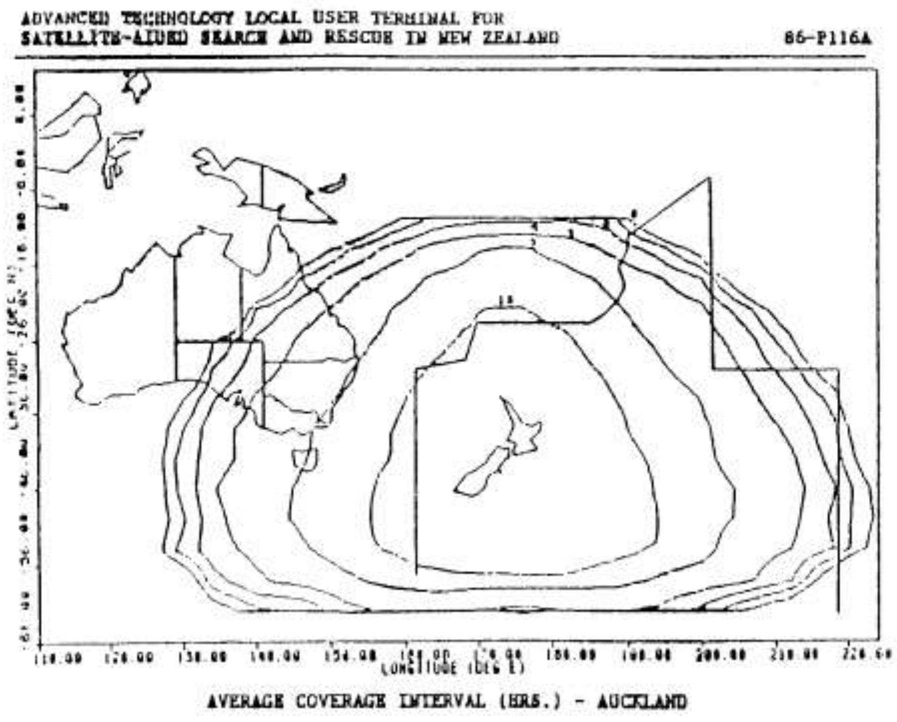

Fig.13 COSPAS/SARSAT coverage for New Zealand ground station