THE ADVENT OF COMMUNICATIONS VIA SATELLITE

Australia's Story

Cyril Vahtrick

Australia, through the Overseas Telecommunications Commission (OTC), was among those in the forefront steering the course of events towards establishing a viable practical public international telecommunications system through the use of satellites. This article provides a historical narrative of Australia's early involvement in these developments.

Firstly, going further back in history, British World War II boffin Arthur C. Clarke's "Wireless World" article published in October, 1945, foreshadowed the use of artificial earth satellites for relaying radio communication across oceans. Amongst other things, in the latter stages of the war, Clarke worked on the development of the magnetron for use in radar. The magnetron was capable of generating high power radio signals at microwave frequencies to provide much greater detail in radar images.

The gigahertz frequencies generated by magnetrons also provided the opportunity for very wideband modulation and it was quickly realised that such radio transmission systems could be used to relay large groups of telephone channels over distance. At these gigahertz frequencies, however, the radio signals could only be transmitted over "line of sight" distances and could not pass through or over obstacles such as buildings, hills or trees.

The idea of using microwave transmissions from hilltop to hilltop quickly took root as a significant cost saving in place of cabling for terrestrial trunk telephone routes. This is the point where Clarke's thinking turned on how to deal with trans–ocean situations.

He calculated that if a satellite could be placed in a special 24-hour orbit, travelling west to east above the equator so that it kept track with the earth's rotation, the satellite would appear stationary when viewed from the earth's surface. This could then be used as a radio relay station using these microwave frequencies to pass telecommunications traffic across oceans. While Clarke became better known later as a science fiction writer, his scientific credentials could not be disputed. Nevertheless, at that time there was still a long way to go in space technology development before anything like this could be achieved in practice.

During World War II the German V2 rocket development pointed the way towards the technology to launch an object into "orbit" and after the war, rocket technology continued to be developed under utmost secrecy because of the obvious military implications. USA, with a much greater open publicity and with the import of German V2 rocket specialists, appeared to be well in front to achieve the first successful launch of an artificial earth satellite, although some Western European countries were also working in this field through the European Launcher Development Organization (ELDO). It was also understood that USSR would have a significant interest, although they played their cards close to their chest as far as the rest of the world was concerned.

Early Satellites.

The launching of USSR's Sputnik satellite in October, 1957, in advance of USA's efforts, clearly caught the majority of the world by surprise. This satellite was in low earth orbit and carried only basic radio equipment which could transmit radio signals at 20mHz and also 40mHz which could be accessed by any appropriate receiving equipment on earth but could not be used to relay radio signals between two points on earth.

Nevertheless, apart from gaining USSR a huge publicity victory over USA, Sputnik also re-kindled the possibility of Arthur C Clarke's prediction on telecommunications via satellite becoming reality.

Perhaps as a premonition of what was to come in later years, OTC played an interesting part in providing information to the Australian public in regard to Sputnik. Although this is not really relevant to later events involving communication via satellite, it is interesting to record a few paragraphs about this historic event as contained in Attachment 1.

USSR's success with Sputnik spurred USA and, separately the Europeans, into a higher level of activity on satellites. USA was able to launch its own first satellite, Explorer 1, early in 1958, and the National Aeronautics and Space Administration (NASA) was also established by the US government in that year to take over, from the military, the front line running of space technology in USA.

The Western Europeans had established ELDO and the European Space Research Organisation (ESRO), and Australia had become a sort of junior partner in ELDO by virtue of our launch facility which ELDO had negotiated with Australia to be located at Woomera in South Australia. Probably because of the massive technological brakes applied on Germany immediately after World War 2, the Europeans were well behind USSR and USA in launcher development in these early stages.

By the end of 1961, there was considerably more activity, particularly in USA towards setting up satellite communications. This led to the UN adopting a resolution that global satellite communications should be made available on a non-discriminatory basis. This set the scene for a number of events.

With the continuing development of launcher capability in USA, it did not take long for US telecommunications companies to move quickly to develop spacecraft to be launched by NASA and used to relay telecommunications. While The US government passed an act in 1962 to establish the Communications Satellite Corporation (COMSAT), it was still the American telegraph and Telephone Company (A,T&T) which initiated the design of an experimental satellite TELSTAR 1 (1962) which was launched by NASA to allow experiments in the relay of voice, data and television signals across the Atlantic. The satellite had a medium altitude orbit with an orbital period of about six hours. A further Telstar satellite followed.

Britain, France and the Federal Republic of Germany (and later Italy and Spain) built experimental satellite earth stations to co-operate with USA in testing these satellite communications links across the Atlantic, with some success. Japan also established an experimental earth station which initially conducted experiments across the Pacific with USA through the RELAY satellite, designed by the Radio Corporation of America (RCA). This medium altitude satellite was used experimentally to relay some sporting events from the Tokyo Olympic Games (1964) to be shown on USA television.

With this growing interest in satellites for telecommunications, the British Commonwealth telecommunications entities held a conference in London in 1962 in an endeavour to establish future attitudes towards the establishment of a British Commonwealth telecommunications satellite system. At that stage, Britain favoured a phased equatorial system of multiple satellites at orbital distances of 3,000 to 5,000 kilometres, following each other in orbit around the equator.

The broadly estimated cost figures of around £500M Stg. for an initial British Commonwealth satellite system were somewhat alarming to governments and, in Australia's case, there was a specific instruction from our Government forbidding any further international discussions on this subject without specific Government approval and briefing.

In Australia any progress on this matter was also complicated by the existence of an internal question as to where any authority and responsibility for the development of satellite communications should be placed. There were three possible contestants for this position - Department of Supply, PMG's Department and OTC.

The Department of supply was the Australian Authority on the ground at Woomera, where they also operated NASA deep space communications stations. PMG were the Department of State for communications and already had microwave experience. OTC, although we were the authorized international telecommunications carrier, were at that stage, still mainly involved in telegraph type communications, with the actual operation of the Short Wave (HF) radio telephone service still controlled by the PMG at the operator level. In other words, OTC simply provided the HF radio circuits.

In the early stages, OTC was considered by the two Departments to be merely a potential user. Nevertheless, with the ability to move faster and more flexibly in the light of rapid world developments, OTC successfully emerged with Government Approval to be the authorised Australian entity to participate in an international satellite telecommunications system.

The story of this struggle is outlined in more detail in Attachment 2.

As outlined in the attachment, OTC created a special position to follow up the satellite question in detail and appointed Cyril Vahtrick into this position. After a few months of intensive study into satellite technology and general global satellite developments Cyril, accompanied by Harry de Dassel (OTC's Representative in London) joined the large Australian delegation, 14 in all, to the 1963 Extraordinary Administrative Radio Conference (Space) in Geneva. This was the first definitive international gathering to accord official recognition to the claims for formal allocation in the radio frequency spectrum for public telecommunication via satellite.

One important outcome from the Conference was to agree, amongst other things, to the global allocation of the four and six gigahertz frequency bands (until then allocated only to terrestrial point-to-point microwave systems) to satellite systems on a shared basis with these terrestrial systems.

The Geneva Conference also offered opportunities for OTC to make new contacts with other entities interested in satellite communications, including the Communications Satellite Corporation (COMSAT). Useful contacts were also made with representatives of the US State Department and the Federal Communications Commission.

<u>First definitive global moves to establish an international satellite communications organization .</u>

<u>Rome Meeting January 1964.</u>
It did not take long after the Geneva Conference for new moves to take place aimed at establishing plans for a practical international satellite telecommunications system. Probably the most important international conference to shape the as yet unknown future of public international telecommunications via satellite was held in Rome in January, 1964.

The European member Governments of ELDO invited USA at Government level to a meeting in Rome to discuss plans for a possible jointly sponsored international satellite public telecommunications system. USA had exhibited reluctance to having discussions exclusive to Government representatives. It was finally agreed that COMSAT representatives would also be there representing practical technical and commercial interests. USA also asked that Canada be invited to send representative to provide a small measure of trans-Atlantic balance.

When we heard this, Australia persuaded a rather reluctant Britain to ask for our admission to the conference because of Australia's ELDO connections and similarly, OTC worked on the British Post Office to get them to sponsor us to the meeting. The invitation to OTC came through at the eleventh hour and Cyril Vahtrick found himself on a plane to Rome on the same day. He was to be part of an Australian Delegation led by the Australian Deputy High Commissioner to UK Sir Allen Brown. Department of Supply and PMG Department representatives were also present. Significantly, no doubt because the "Cold War" was at its height, no Eastern Bloc country was invited to the Rome conference.

The conference appointed an Italian Ambassador as chairman and the Europeans had indicated that they would be speaking with one voice at this conference. Their major points were that international telecommunications satellite systems should remain under exclusive Government control and that long range planning for any systems should ensure an equitable sharing of technological developments among member nations. Furthermore, formal inter-Governmental agreements should be drafted to reflect these points.

> The US reply was blunt and rather unexpected in its scope and timing.
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> <u>Firstly</u> it was pointed out that the US Government could not, under their laws, participate in any financial ownership of a public commercial satellite communications system. Therefore, there was no point in discussing further any US Government ownership in any system.
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> <u>Secondly</u>, COMSAT, a Statutory Corporation, had been established expressly for this purpose and would be the US entity for any satellite agreement which would therefore need to be commercial in nature.
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> <u>Thirdly</u>, COMSAT was well advanced in its plans and proposed to enter into contracts to have detailed studies conducted on two possible alternative satellite systems.

The first study would look at having 50 or so satellites launched in medium altitude orbits in random motions. The satellites would be relatively simple and, by having earth stations switching between them, reasonably continuous coverage could be expected.

The second study would look at more complex satellites in controlled medium altitude orbits travelling around the equator. Some 12 or so would be required, travelling at accurately spaced orbits separated by about two hours.

In addition, COMSAT had also contracted to have an experimental/ operational telecommunications satellite constructed by Hughes Aircraft Company and placed into synchronous orbit over the Atlantic at the earliest possible time.

It was estimated that the initial development costs, including the cost of this first experimental/operational telecommunications satellite would come to about US $200M. Furthermore, COMSAT was planning a public share issue to cover the whole of this amount so that COMSAT could go it alone if necessary.

Other countries were, however, invited to participate in this COMSAT activity by sharing in the investment if they so desired. There was no practical scope for widespread sharing of space segment technology at this early stage, but there was ample scope for individual countries to develop their own earth segment equipment.

The direction in which the conference was heading appeared to be very disappointing to the Europeans who had set it up with relatively high level diplomatic people, virtually relegating their aerospace and telecommunications representatives into the role of advisors. It seemed probable that they had expected a long round of diplomatic discussions with an inter-Governmental treaty as the final objective.

Against this however, the US tactic was persuasive. While the US Government continued to stand flat-footed against any direct financial participation by it in the space segment, COMSAT had its Government's mandate and was already proceeding and would continue to do so with or without early non-US participation. The conference finally concluded without any significant change in the US position and with the Europeans looking for additional time to reconsider their position, but recognising that they would very shortly run out of time in view of COMSAT's activity.

Tokyo Meeting February 1964.

During the corridor breaks in Rome, Cyril Vahtrick held useful talks with Joe Charyk, (President of COMSAT) whom he had met in Geneva in 1963, and other COMSAT representatives. These talks resulted in COMSAT proposing a three-way Pacific Region Satellite Conference in Tokyo in a few weeks' time between USA, Japan and Australia. The meeting in Tokyo was duly held in February, 1964, at the US Embassy with OTC being represented by Cyril Vahtrick and Edgar Harcourt (Director International Arrangements). There were also other Australian departmental representatives from PMG, Department of Supply and Treasury, with Sir Allen Brown again leading the delegation.

USA was probably seeing this meeting as an avenue for bringing Japan into the picture in order to receive support for its formal position in dealing with the Europeans. Nevertheless, the occasion also presented the opportunity for COMSAT to put forward some of its preliminary operational views on how they saw satellite communications as working.

At that time, COMSAT was evidently favouring a system of multiple satellites of relatively simple design in medium altitude random orbit. A persuasive factor for COMSAT in this thinking was the interest being shown by the US military in taking up and hence paying for up to half the capacity of such a system.

The idea was to have around fifty uncontrolled satellites in purely random orbits at medium altitude, resulting in orbital periods of, say, six to eight hours. Computer simulations performed by COMSAT indicated that there would be at least one satellite in common view between earth stations across the North Atlantic for over ninety-nine percent of the time. While numbers of short duration gaps in coverage could be expected, longer gaps of say an hour's duration would be relatively infrequent.

It was clear to OTC, however, that there was a major operational flaw in such a system when it came to its use for public telecommunications. As random short gaps could be expected fairly frequently, the question was, "during the very numerous gaps, when there was no mutually visible satellite, how would COMSAT propose to deal with perhaps hundreds of subscriber dialled telephone conversations which would be interrupted during each of these outages?"

The position was even more impossible because of the greater distances involved in trans-Pacific relations. Setting aside for a moment the practical complexity of providing banks of high-speed tracking antennas which would be required on the ground to access these satellites, COMSAT advised that their computer simulations showed that an Australian earth station complex located at Cooktown (which was COMSAT's choice) relayed through back-to-back earth stations at Hawaii and thence again to the US mainland via a second satellite hop, would provide randomly distributed time coverage for some eighty-six percent of the time between Australia and the US mainland west coast. Not to worry, however, said COMSAT - such a system would only attract eighty-six percent of the standard space segment charge!

COMSAT representatives were somewhat taken aback when OTC indicated, in no uncertain terms that such a system would be totally unsaleable anywhere in the world. COMSAT's strategic thinking was then put forward. They envisaged a simple bilateral contractual arrangement between the space segment owners and each individual user. The space segment owners would make available satellite capacity, measured in terms of power/bandwidth subdivisions to be called "Units of Utilization". Each user would be charged in accordance with the number of units of utilization provided. How each user made use of such units, what sort of antennas were used and with whom communication took place would be of no concern to the space segment owners.

Therefore, the OTC question on telephone connections was irrelevant in that context and was a problem to be solved by the user. This attitude was probably indicative of the fact that COMSAT had been building its technical strength around space technologists and, at that stage, they had nobody with any commercial telecommunications experience.

Back on the other side of the world, proposals and counter-proposals for draft agreements covering a global satellite system were passing to and fro across the Atlantic with the Europeans quickly coming to the conclusion, albeit reluctantly, that if they wished to participate in the initial establishment of a global satellite system, it would need to be on the basis of investment with no specific guarantees concerning any sharing of technology.

Satellite Traffic Forecast Meeting Montreal April 1964.

With regard to investment shares in the system, US had already indicated its firm stand that voting on decisions in relation to the satellite system would be weighted in accordance with investment. In the formative stages, US expected to remain the major investor with an absolute majority in shares. When full global coverage had been achieved they envisaged investment by all participants would always be in proportion to use. This raised the question as to how initial investment shares should be determined.

To address this question, in April 1964, the Canadian Government convened a meeting in Montreal to look at traffic forecasts as a possible basis for establishing initial investment shares in the proposed space segment. Cyril Vahtrick and George Maltby represented OTC at that meeting, with the Australian delegation being led by a PMG's Department representative.

It was decided at the Montreal conference that broad forecasts should be obtained for public telecommunications traffic which traversed a minimum of 2,500 km. and might thus be suitable traffic for satellite links. US proposed that these figures should include any domestic traffic which traversed that distance. Having accepted these criteria, the Europeans found that the US domestic east-west traffic swamped everything else. Australian and Canadian domestic traffic also brought in relatively high figures; while in Europe virtually all traffic over 2,500 km was truly international.

The Montreal meeting turned out to be a pragmatic affair the sole purpose of which was to clear the air for subsequent investment negotiations. COMSAT had no difficulty in retaining a majority initial shareholding in its own right in the final wash-up.

Finalizing agreements.

London Meeting May 1964.

Across the Atlantic, diplomatic exchanges had produced tacit agreement that an international telecommunications satellite system would be established and this would be covered by two international agreements and that these agreements should be interim in nature to be replaced in five years' time by definitive documents.

In May, 1964, a meeting was convened in London to draft the two documents.

"The Interim Agreement" to be signed at Government level outlining undertakings and responsibilities of governments;

"The Special Agreement" to be executed by the actual investors in the space segment and to cover all technical, operational and commercial matters.

At the London meeting, USA, and the European countries formally invited Canada, Australia and Japan to join in the Meeting as fully recognized entities rather than as observers as we had previously been. Cyril Vahtrick represented OTC at this meeting with Dick Butler representing the PMG and Frank Stanton representing the Treasury. (Frank later joined OTC).

Both USA and the Europeans prepared their own versions of each document for consideration by the meeting. The European drafts provided for the major substantive space segment decisions to be made at Government level by an Assembly of Parties, leaving the purely operational decisions for the space segment investors.
On the other hand, the US sponsored document sought to retain all the significant functional decision-making in the hands of the investors, with only political type functions for the Governments. Australia and Canada supported the principles underlying the US proposals in the discussions.

The London meeting eventually produced nearly completed drafts of the two agreements. Both these drafts represented compromises from the stands being taken by the opposing parties at the start of the meeting, but mainly accorded with the US position.

Final investment meeting Washington June/July 1964.

While the drafts as they now stood had resolved most of the outstanding issues, a final significant task remained - the resolution of precise initial investment shares, taking the Montreal traffic figures as a guide. The level of investment share by each signatory would be recorded on a schedule annexed to the special agreement document. An important yardstick was agreed - all investors with 2.5 percent investment or more would have a seat on the decision-making body of the organization. This body was to be called the “Interim Communications Satellite Committee” (ICSC).

One significant change was achieved to the incoming US position – ownership of the whole system would rest with the international body and the shareholding would be with that body rather than with COMSAT . The initial capitalization proposed was US$200 million and, to formalise the investment shares and to then to initial the texts of the finalised agreements, another meeting was called in Washington in June/July, 1964. This meeting was attended by OTC General Manager, Trevor Housley, assisted by Edgar Harcourt. This meeting resolved the question of investment shares with OTC successfully achieving its desired objective of having a 2.5 percent initial investment share allocated to Australia. This would achieve foundation membership and a seat on the decision-making body.

The agreements were then made open for signature in Washington on the 20th August 1964. Australia was among the foundation Signatories. There were eleven foundation signatories:-

USA, UK, France, Germany, Italy, Spain, Switzerland, Netherlands/Belgium, Canada, Australia and Japan. All these entities also held sufficient investment shares to have a seat on ICSC.

Since this was a difficult period of the "Cold War" no invitation was extended to USSR or any other Eastern European country to consider participation.

Interim Communications Satellite Committee (ICSC)

Inter alia, the agreements established the Interim Communications Satellite Committee (ICSC) as the decision-making body for the global satellite communications system. Also included in this agreement was the appointment of COMSAT as the manager of the system. COMSAT was also the majority shareholder in the venture and it was also agreed that a COMSAT representative John E Johnson would hold the initial Chairmanship of ICSC.

Meanwhile, back in Australia, the necessary Government approvals for Australia's participation in ICSC had been put in train by OTC. Having participated in the action to date and having a strong view of OTC's role as Australia's international telecommunications carrier, OTC put forward that we were the logical body to be our Signatory to the Special Agreement, with the Department of Foreign Affairs to sign the inter-government Interim Agreement.

As outlined in Attachment 2, the Australian Government's decision to nominate OTC as the Australian investor effectively settled the long-standing question among the PMG's Department, the Department of Supply and OTC as to which organisation would be responsible for public international telecommunications via satellite and the issue did not rise again, although the PMG continued to study the feasibility of a future domestic satellite system.

Briefly, OTC sought and received Government approval for Australia to become party to the interim satellite agreements, with OTC as signatory to the Special Agreement, carrying an obligation in our case to contribute 2.5 percent of the capital requirements for establishing the initial space segment of a global satellite communication system.

Voting in the ICSC was in accordance with the previously agreed investment shares and COMSAT at that stage held in excess of two-thirds of the total investment share in its own right thus giving it the power of veto. However, under the Agreement, COMSAT required the support of at least three other Signatories to effect any major decision to go forward.

The ICSC, initially comprising the eleven international members, moved quickly into action. After the usual spate of suggestions, arguments etc. it was finally agreed that the new organization would be called "INTELSAT". The Europeans had managed to bring in a requirement for simultaneous interpretation in English, French and Spanish, in true United Nations style. Documents were also circulated in the three languages.

Early Satellite Developments.

As INTELSAT's manager, COMSAT was still a fledgling organization at that stage, but it announced that, in advance of ICSC being established, it had already entered into three important contracts with US space companies in its own name and now wanted ICSC (INTELSAT) to take these over as owner.

Briefly the contracts entailed the following:

1. A comprehensive study by industry experts of a multi-satellite system entailing about 50 satellites in random medium altitude orbit with an orbital period of about six hours. These satellites would be of relatively simple design but would require at least two fast tracking earth station antennas at each location, handing over to each other;
2. A similar study of a multi-satellite medium altitude equatorial phased orbit system (i.e. the satellites followed each other around the equator at fixed intervals). At least twelve satellites would be required for one-hop continuous coverage over intercontinental distances. This system would also require at least two fast tracking earth station antennas at each location;
3. A contract with Hughes Aircraft to construct and launch an experimental/operational satellite (similar to the successful experimental SYNCOM satellite) to be placed in synchronous orbit over the Atlantic with a target date early in 1965. With this type of satellite, only a single earth station antenna would be required at each location. For synchronous satellites, the drive mechanisms of the huge antennas would also be much simplified because fast tracking would not be necessary.

COMSAT's proposal was that a final decision on the first global system should be left until the studies had been completed and some operational experience had been acquired from the (hopefully successful) Hughes satellite in orbit. Nevertheless, the very short timetable inherent in these proposals caught everybody else by surprise. The Europeans appeared to have been forecasting among themselves that nothing tangible could be expected before the end of the 1960's decade.

The ICSC eventually adopted COMSAT's recommended course of action but not without some heated argument from some of the European delegates. After an inaugural ICSC meeting to set up its procedures, attended by Trevor Housley and Edgar Harcourt, Cyril Vahtrick became OTC's regular ICSC representative for the first few years, also attending the Technical and Finance Committee meetings at which he was assisted from time to time by Barry Lancaster and, later Ron Knightley and others. At these meetings OTC sought and gained the assistance of colleagues from Britain and Canada to press for the adoption of recognized international public telecommunications technical standards for the proposed satellite system.

In the beginning, COMSAT remained adamant that it was not necessary for the space segment owners to have anything to do with how satellite capacity was used, all that was necessary was for each user to state how many "units of utilisation" would be required and the user would be charged accordingly.

During ICSC discussions, OTC observed that the majority of initial revenue was almost certainly going to come from the provision of circuits for the public overseas telephone service. A logical question from any operating organisation likely to be a potential space segment customer would be "how much is a telephone circuit going to cost?"

If the only answer to that question was a dissertation on power/bandwidth, units of utilisation and alternative antenna options which could result in a different charge per telephone circuit for each destination depending on the earth station equipment performance at each end, the potential user would more than likely go away in a state of confusion.

Finally after considerable debate at ICSC and its technical sub committee, OTC, supported by the representatives from Britain and Canada, made some positive proposals. [It is interesting to note here that as well as COMSAT in USA, most of the European ICSC representatives belonged to aerospace and like organizations, whereas the representatives from Australia, Britain and Canada (and Japan), were all from our international telecommunications bodies.]

Having discussed the situation among ourselves, Australia, Britain and Canada made the following proposals:-

. firstly, INTELSAT should adopt CCITT telecommunications technical standards and make it known that it was offering service to these standards;

. secondly, INTELSAT should formally specify and designate a “Standard Earth Station” at, or near the top of, known “state of the art” earth station technical performance capability in order to maximise satellite circuit capacity;

. thirdly, the "unit of utilisation" should then be specified as the satellite capacity required to provide one CCITT standard telephone circuit between two Standard Earth Stations operating to an INTELSAT satellite. (For charging purposes the unit would be split in half for each end).

This was a new concept for COMSAT's space technologists and lawyers and the proposal appeared to make them uncomfortable but try as they would, they could not find a practical formulation for their own ideas. They even tried removing bandwidth as a parameter from their "unit of utilisation" by proposing that that the "unit" would be defined as so many microwatts per square metre at the earth's surface. OTC pointed out to them that these microwatts would be picked up by any antenna pointing at the satellite and, for that matter, by such objects as Australia's massive lines of rabbit-proof fences - how would COMSAT propose to determine which cases attracted space segment charges?

In the light of these observations, COMSAT finally had to accept the inevitable. Charges had to be geared to the measured use being made of the space segment and the measure of such use must involve the recognition by the space segment owners that two or more separate earth station entities needed to be connected together via the satellite. In order that such use could be properly identified and quantified, it needed to be in the form of allocated telephone channels in the system.

INTELSAT's formally stated service offerings and its system of charging finally evolved around these original proposals by Australia, Britain and Canada. OTC took this opportunity to make private representations to COMSAT at executive level, pointing out the need for stronger practical telecommunications expertise in their organisational set-up which, up to now, was focused on rocket and spacecraft technology. It was suggested to COMSAT that it should consider establishing a separate technical arm to deal with the telecommunications operational aspects of the global satellite system. This suggestion was taken up by COMSAT and an Operations Division was duly formed. It was interesting to note that all of the established major telecommunications carriers in USA appeared to keep well away from COMSAT’s activities during these early stages.

Meanwhile, INTELSAT's first satellite was successfully launched by Hughes over the Atlantic in April, 1965. The satellite was named "Early Bird" by COMSAT reflecting the keen unofficial rivalry between USA and USSR to be first in orbit with an operational communications satellite. USSR had yet to launch the first of their Molniya series at that stage.

It might be interesting to digress for a moment and consider the implications of Arthur C Clarke’s proposition of satellites in “synchronous orbit”. Clarke correctly calculated the dynamics of a 24-hour orbit which required satellites to orbit some 36,000 km above the earth's surface. This was a huge step up from Sputnik's 100km orbit and subsequent experimental satellites which were launched in the range 3-4,000 km. Furthermore, not only did synchronous orbits have to be accurate in diameter to provide a precise 24-hour orbit for the satellite to appear stationary, but the satellite also had to be at the precisely correct geographic position.

This problem was successfully solved by a brilliant young space scientist Harold Rosen, who worked for the Hughes Aircraft Company (later Hughes Aerospace Company). Rosen used a small rocket engine with a very accurate solid fuel propellant, giving a very accurate total specific energy output. The small engine, called the "apogee kick" motor was mounted in the body of the spacecraft while the initial launch phases put the spacecraft into a highly elliptical orbit with an apogee of 36,000 km. This "parking orbit" was then accurately measured over a number of passes and computer calculations worked out exactly at which point and at which angle the apogee kick motor should be fired to produce the desired synchronous orbit and the desired orbital location. The latter could then be fine tuned with additional tiny rocket points which were capable of providing controlled bursts of a few milliseconds at a time.

The Swedish Government decided to make an award for outstanding work in international telecommunications similar in status to the Nobel Prize. Harold Rosen was the first recipient of this award.

Working with the best available "state of the art" earth station antennas at each end, Early Bird was designed to be capable of carrying 240 simultaneous telephone circuits, or, alternatively, an acceptable standard of television signal.

Although the satellite performed up to these expectations, it was recognised that it could not be utilised in multiple access mode (i.e. with more than one earth station antenna at each end) without serious diminution of total capacity. Some of the linearity problems in the satellite transponder design had not been solved and multiple access use would have resulted in bandwidth wastage caused by the need to provide wide guard bands in the frequency modulated system between the multiple users, with consequential substantial loss in circuit capacity.

In practice to avoid multiple access interference problems, a time schedule was developed for the experimental/operational use of Early Bird and this allowed earth stations in Britain, France, Germany and later Italy, to take turns at accessing the satellite to communicate with the USA earth station which was located at a place called Andover in the State of Maine.

There was still considerable unease, expressed by AT&T and other international public telephone operating authorities that the relatively long loop time delay inherent in synchronous orbits (because of their orbital distance of some 36,000km) might prove unacceptable to the telephone user public. The satellite price structure for a telephone circuit was also very high (US $32,000 per unit of utilisation payable at each end). This all resulted in somewhat desultory use of the satellite.

While the "Early Bird" satellite was being built, the other two system design options under study - namely, medium altitude random orbits and medium altitude phased equatorial orbits - were kept open although OTC**,** strongly supported by Japan, continued to oppose the random orbit option as being operationally totally unacceptable for trans-Pacific and similar distances. COMSAT continued to speak out in favour of the random orbit option for financial reasons, based on their hope that half the system would be used and paid for by the US military. The latter had indicated that only a random orbit system would meet their military security requirements.

Most of the European ICSC members, on the other hand, were fundamentally opposed to any exclusive US military use of the satellite system. The situation had all the elements of an impasse with more or less only token use of "Early Bird", no unequivocal operational acceptance of the long loop delay phenomenon and COMSAT strongly opposed by at least Australia and Japan, in its preference for the random orbit system.

It seems probable that at this stage the US Government took its own stock of this situation and then devised a course of action which had the effect of getting INTELSAT really on the move. One important step the US Government took was to withdraw its military interest in using INTELSAT satellites, thus removing the major perceived economic advantage of the otherwise operationally messy random orbit system.

A new stimulus then came from a formally announced NASA requirement for a satellite global communication network to support the Apollo "Man on the Moon" Programme. This led to the urgent development of the INTELSAT II satellite system. This project is outlined in detail in Attachment 3.

Here again, COMSAT's lack of practical telecommunications understanding led to their trying to embark on a totally unrealistic exercise in relation to establishing satellite earth stations in their own name in foreign territories. OTC for Australia and Cable & Wireless for Ascension Island (two of the required sites) combined to convince COMSAT that what they had tacitly agreed with NASA, which involved COMSAT as sole provider, would not work and that ownership and operation of earth stations on non-US territories must vest with the authorised entities at those places. Again, this is dealt with in more detail in Attachment 3.

Having finally been convinced that the OTC/C&W plan was the only practicable course to follow, COMSAT accepted our plan to establish our own earth station and agreed to support our proposal that ICSC should be asked to reduce the standard unit of utilisation charge from US$32,000 to US$20,000, with the understanding that this new charge to be applicable to the circuits to be used by NASA in the INTELSAT II satellites.

It is interesting to note this background to ICSC's first reduction in space segment charges. When the global system ultimately became fully operational, it was envisaged that future space segment charges should be tailored to meet all expenses plus a 14% “compensation for the use of capital” payable pro-rata to all investors. Space segment charges came to be progressively reduced as the result of applying this formula as usage increased over the ensuing years.

As the early uncertainties of having a practical satellite system reduced, membership of INTELSAT progressively increased, first with Brazil, Argentina and Venezuela joining, followed by other countries from Asia and Europe. At that stage , no Eastern Bloc country sought to join. In the initial years, the financial mechanism for this was simple; the new applicant was allotted a small shareholding and all existing shareholdings were reduced pro rata to maintain 100%. Once a full global system was established, shareholdings were all modified to be proportional to each country’s paid use of the system. Thus investment shares continually fluctuated, requiring constant adjustment.

Returning to INTELSAT II, with the difficulties cleared, work on the space and earth segments for the Apollo Communications support programme proceeded apace. Hughes Aerospace Company was given the contract to construct four spacecraft with the objective of having three in orbit, one each in the Atlantic and Pacific Ocean areas, and a third in orbit essentially as a spare.

OTC gave Cyril Vahtrick the overall responsibility for the Carnarvon Earth Station Project and he led a team of engineers including Graham Gosewinckel and Barry Lancaster to specify and procure the necessary equipment. The NASA requirement included the provision of tracking, telemetry and command services for the launch of the satellites, together with direct communication links between the NASA Apollo Support Station at Carnarvon and mainland USA.

Despite the many problems which were encountered in such a short lead time, the OTC Carnarvon Satellite Earth Station was available on schedule to provide tracking, telemetry and command services for the launch of the first INTELSAT 11 Spacecraft which occurred on the 26th October, 1966.

Unfortunately, there was an apogee motor failure in this first INTELSAT II Satellite resulting in the satellite failing to reach synchronous orbit. The satellite was capable of receiving and transmitting signals in its twelve hour elliptical orbit and the OTC earth station not only successfully tracked it, but also established temporary communication links for the first time via satellite with both the Earth Station in Paumalu, Hawaii, and Goonhilly in UK.

Another significant historical milestone which occurred with this particular satellite was that it was the vehicle for the first ever exchange of television signals between Australian and another country when the Carnarvon station arranged to exchange signals with Goonhilly. This occurred on 25th November, 1966, and represents one of the many OTC historical events. An account of this is given in Attachment 4.

The replacement INTELSAT 11 F2 satellite was successfully launched in January, 1967 and was located over the Pacific enabling Australia's first commercial satellite communications service to begin between Carnarvon in Western Australia and Brewster Flat in the State of Washington, USA, on 4th February, 1967.

It is perhaps significant to note that, since Carnarvon was equipped with tracking, telemetry and command equipment, it is reasonable to claim that the world’s first ever fully operational communication satellite (the INTELSAT II F2 Pacific satellite) was launched into its final orbit by command signals transmitted by OTC from Carnarvon.

The INTELSAT II F2 satellite also provided Australia's initial public telecommunications links to go over satellite to Japan and USA. These links were established through the OTC Earth Station at Moree, NSW**,** which was opened on 29th March, 1968.

Further operational experience with the long loop delay inherent with synchronous satellites led to the conclusion that satisfactory telephone calls could be made, provided that echo suppression systems were put in place. Although there were some teething problems, this led ICSC to the decision to continue with the development of a global system exclusively based on synchronous satellites. [Later development of echo cancelling techniques further improved the loop delay phenomenon].

While the INTELSAT II program was unfolding, the ICSC moved its attention to the next phase. With the rapid pace of development of space technology, greater operational performance and capacity in new generation spacecraft was actively sought.

A fundamental problem with the initial INTELSAT satellites was that, because it was essential to spin the satellites to produce gyroscopic stability to stop them from "wafting" about, the fixed, small antenna had to be omni-directional and most of the radio frequency energy was dissipated into the cosmos, with only a very small percentage coming towards earth.

The INTELSAT III satellites incorporated a new concept – the received and transmitted signals would be accomplished through a horn antenna which could focus the major part of the signal to point directly at earth and thus just cover the globe. In order to achieve this, it was necessary to install a small motor to "de-spin" the horn at a rate equal to the satellite spin rate. This was a tricky operation requiring accurate tracking and synchronising.

An unexpected but interesting problem arose after the first INTELSAT III satellite had been operating for a couple of months. The de-spin mechanism stopped and the main communications capability was lost as the antenna started spinning with the main body of the satellite. Telemetry and control contact was maintained through an omni-directional antenna and it was ascertained that the lubricant in the rotating joint had frozen.

It then dawned on the experts that the antenna mounting was orientated in the northern hemisphere and over the months, the sun had shifted south of the equator, creating a winter climate for the antenna section of the satellite! With the absolute zero temperature of outer space away from the sun's rays, despite the physical connection of the rotating joint with the main body, the temperature of the joint was low enough for the lubricant to freeze.

[Note: a similar temperature phenomenon was also responsible for the failure of the apogee motor firing in INTELSAT II F1. Following a last-minute design change to add a crimp to the base plate of F1 for additional strength – this crimp was just enough to expose the apogee motor nozzle welded joint to the low temperatures which occurred during the initial "parking orbit". The weld fractured and the nozzle blew off during the final firing].

Returning to the INTELSAT III satellite. The spacecraft contained a number of small controlled rocket motors to allow accurate positioning (and re-positioning) of the orbit. A configuration of firing of these rockets was worked out and the spacecraft was literally turned upside down. With the rotating joint back in the sunlight the lubricant soon warmed up and the horn de-spinning (and service) were restored.

The considerable additional gain offered by the INTELSAT III horn antenna allowed increased circuit capacity and also allowed simultaneous relay of television. The deployment of these satellites provided full global satellite coverage for the first time in February, 1969 with the launch of the third INTELSAT III satellite over the Indian Ocean.

The OTC earth station established at Ceduna, South Australia, provided a direct satellite link to UK and Europe to close an important telecommunications link for Australia.

To meet growing traffic demands, a further five INTELSAT III launches took place, with two of these failing at launch, providing a salutary lesson that INTELSAT was pushing advanced technology to its limit.

While the INTELSAT III program was being accomplished, COMSAT was already pursuing further considerable advances in satellite antenna technology with the idea of providing "spot beams" directed at strategic locations around the globe. This would open up the potential to have simpler earth stations thus making satellite communications available to a greater number of developing nations.

In 1969, INTELSAT placed orders for the INTELSAT IV series of satellites, the first to be launched in 1971. These satellites would incorporate antennas with multiple steerable spot beams. Launcher technology had also developed at a rapid rate and thus the aim was to have a substantially larger spacecraft with greater power capability.

By this time, the Europeans had lobbied hard to have more meaningful participation in the construction of INTELSAT spacecraft. In theory, the INTELSAT Agreement entitled all investors to seek participation in the construction of spacecraft components in proportion to their investment share "provided that the price and performance were satisfactory". In practice, up to and including the INTELSAT IV series, non-US participation was fragmentary.

OTC managed to get a contract for CSIRO to undertake development work in Australia on the multiple spot beam antenna system and they performed commendably in carrying out this task. Unfortunately, bureaucratic inertia among Canberra's Departments prevented this good work from going further into future development work with INTELSAT.

The INTELSAT IV series proved to be highly successful and, with rapidly growing world wide demand, a series IV A was also commissioned. By this stage, the Europeans had re-grouped themselves from ELDO to ESA – the European Space Agency. With increased voting power in INTELSAT generated by rapidly growing use of INTELSAT capacity, ESA also demonstrated technical capability and they were able to secure the major construction work for the INTELSAT V series in the later part of the 1970's leading to a first launch in 1980.

The V series incorporated a different approach to the inherent design of the spacecraft. It was fully recognised that gyroscopic spin was required to stabilise the satellite in orbit, but with INTELSAT V this was achieved by simply having a spinning mass within the body of the satellite. This avoided the need for "de-spinning" and having rotating joints between the antennas and the transponder equipment. In addition' the solar cells were arranged on huge wings and all the cells could be continuously directed at the sun at the best angle. [In the first four series of INTELSAT satellites the solar cells rotated with the body of the spacecraft and thus were out of the sun for half of each revolution and had only brief exposures to the sun at the very optimum angle].

A further change in the dominance of US occurred with the first launch, in October 1983, of an INTELSAT V Satellite by a European Ariane launcher from the launch site at Kourou, an island in French Guiana. This site, much closer to the equator, offered significant advantages for launches into geo-synchronous orbits.

With the European success with INTELSAT V, it appeared that there was going to be a contest between ESA and COMSAT to see who could produce the biggest and cleverest satellites at the forefront of satellite technology. As possibly one more thrust, OTC had not yet finished its influence on INTELSAT. Cyril Vahtrick and Graham Gosewinckel confronted COMSAT technical planners indicating concern that not enough focus was being directed to specific telecommunications needs. They were informed that COMSAT's view was that operational use should adapt to the advances in satellite technology which they saw as the driving force.

After approaches to COMSAT's top management, they were finally convinced that satellite communications should be integrated with other global telecommunications facilities and that future satellites should be planned and designed on the basis of detailed global traffic needs. To achieve this OTC proposed that a specific telecommunications planning unit should be established.

The matter was put before INTELSAT and agreement was reached to initiate a planning group to produce information on global needs. Graham Gosewinckel was appointed as the first Chairman of the newly formed INTELSAT Satellite Planning Committee which called for long term regional traffic forecasts in the three major ocean regions in order to be able to specify the required satellite capacity. Regional traffic meetings ensued and reliable data was produced to enable suitable "tailoring" of new satellites and satellite systems.

COMSAT sought and succeeded in getting agreement from INTELSAT to defer the application of these traffic planning criteria until after the contracting of the INTELSAT VI series. Six INTELSAT VI satellites were launched between 1989 and 1991.

Thus the INTELSAT VII series was the first to have satellites specifically designed to meet telecommunications needs in the various ocean areas. The first INTELSAT VII satellite was launched in October, 1993.

The INTELSAT Planning Committee formed the basis of satellite planning into the future and many more generations of INTELSAT satellites followed.

The original INTELSAT Agreements were defined as interim, to be replaced by "Definitive Agreements" which were negotiated in Washington in 1969, terminating the role of the ICSC which was taken over by the INTELSAT Board of Governors.
A major change in the overall administration was the replacement of COMSAT as Manager with a permanent INTELSAT organisation based in Washington DC headed by a Director General. The first Director General was Santiago Astrain from Chile and the organisation specifically encouraged staff recruitment from non-US members as well as from US.

The new agreement also provided for a "meeting of Signatories" to be conducted in the nature of a "shareholders' meeting". For obvious practical reasons, this body had very limited powers and was more for providing information for newer participants.

The late Randy Payne (OTC) was one of the early Chairmen of the Board of Governors, which still held all the major decision-making powers. Also John Hampton from OTC was appointed to a senior permanent position in the permanent INTELSAT organization, where he reported directly to the Director General.

In addition to our considerable involvement in INTELSAT space activities, OTC also had the challenge of establishing satellite earth stations to link up with our major traffic destinations. Because of the technical complexity involved it was necessary for planning of our earth stations to start well before the actual space segment configuration had been decided.

Even while the early Carnarvon project was under way we had already begun detailed planning to have a full "state of the art" earth station in eastern Australia to provide urgently needed back-up for the COMPAC cable. Earth stations form part of the satellite story and Attachment 5 provides some details.

Over the ensuing years, INTELSAT continued to evolve in structure and direction, but that is another story.

Attachment 1

First Artificial Earth Satellite – Sputnik

News of Sputnik's launch came on the Saturday of the October Long Weekend in 1957 and one detail of the announcement caused some OTC people to prick up their ears - Sputnik would be transmitting signals at just over 20 MHz (also 40 MHz). It’s amazing to realize that this was over 50 years ago!

Graham Gosewinckel, then an engineer at OTC's international receiving station at Bringelly NSW immediately began to search for the signals and was able to pick them up with a sensitive HF receiver, coupled with suitably chosen rhombic aerials. The satellite's orbital period (96 minutes) entailed some dexterity in keeping track of the signals during the relatively short period when the satellite was over our part of the globe. Graham informed Chief Engineer Bob Long of his discovery and all other OTC receiving stations were alerted including Rockbank Vic. and the Coast radio Station in Hobart which quickly picked up signals and, by comparing signal strengths and times, a pretty good idea of the satellite's orbital period was obtained.

Bob was discussing with Cyril Vahtrick the fact that observations indicated that each succeeding satellite orbit seemed to have precessed by some 20 degrees or more westward. Then suddenly it dawned on us - we were of course communicating with an extraterrestrial object - our world was rotating under the orbit of this object. A brief calculation showed that the earth was rotating precisely 24 degrees eastwards per each 96 minute satellite orbit. This meant that the satellite returned to the same relative position over us every fifteenth orbit.

On the second day, Hobart Radio telephoned Bob and reported not only signals from the satellite at the predicted time but also an actual sighting of the satellite in the evening sky . Since this was the first reported sighting in the world that we were aware of, it became of considerable interest to the whole country. With our by now fairly accurate calculations of the satellite's orbital path (about a 65 degree angle to the Equator) Bob Long decided to contact the news media and forecast that the satellite would be arriving at a precise time in the early evening and that it might be seen in the south western sky over Sydney at that time.

This prediction proved to be accurate and a large number of Sydney people were able to observe the satellite in the sky. As all this happened over the long weekend, there appeared to be nobody available in Government departments or the military to comment on this newsworthy event. As a consequence, it seemed as if the whole media world descended on OTC for information. In fact the normal OTC business seemed almost to come to a standstill for a day or so during the height of interest in Sputnik. We were besieged by calls and as people reported satellite or UFO sightings all over the place, Cyril Vahtrick and Ron Knightley rigged up an orbital indicator on an office globe, with a slide representing Sputnik. By rotating the globe from a known time reference and moving the slide on its fixed orbit we had a reasonably good slide rule which could tell us where Sputnik was at any time.

There was one telephone call where a country newspaper reporter had heard that a "flaming object" had plummeted to the ground near a town in western N.S.W. Bob asked him what time this had happened and, with a quick flick of our makeshift orbital calculator Bob solemnly announced that, at that time, Sputnik would have been over Afghanistan!

Graham Gosewinckel made many recordings of the bleep, bleep, bleep, coded signals transmitted by Sputnik, quite unintelligible to us or course, but naturally the media wanted recordings to broadcast to the public. One amusing phone call we received was from somebody who declared that he could distinctly hear the Sputnik sounds emanating from his bed springs!

On the serious side, we attempted to use the satellite to perform some 20MHz ionospheric propagation tests and to have a general look at our rhombic aerial radiation patterns, but it was difficult to set up other than qualitative tests. OTC's involvement in satellites temporarily receded after Sputnik, with pressures from the real world of HF radio and the exciting prospect of submarine telephone cables which were now on the drawing board.

Attachment 2
Australia’s Responsible Entity
For Satellite Communications

With developments around the world indicating that communications systems via satellite were on the horizon, some early thinking in Australia brought out the need to consider what kind of entity should be responsible not only for establishing any earth station facilities but also for participating in overall system planning on a global basis. Initially there were two conflicting claimants for this responsibility in Australia.

Firstly the Department of Supply was Australia's signatory to the European Launcher Development Organization (ELDO) and had the responsibility for the chosen Woomera complex in Australia. This included the provision of launch support facilities. In addition, DOS had already entered into an agreement with NASA to provide staff to operate large deep space tracking antennas and this activity was growing and could include providing similar antenna facilities for communication via satellite.

Secondly the PMG’s Department was the Department of State for Communications and also, as the domestic telecommunications entity, it had large technical resources and background experience in the microwave technology which satellites used. Therefore it saw itself as the logical Australian entity to participate in global negotiations on satellite communications.

The existing Australian overseas telecommunications system at the time entailed the international telephone service (via HF radio) being operated by the PMG’s department, with OTC simply providing the HF transmitting and receiving facilities for PMG operators. Therefore, from PMG’s point of view, OTC was simply regarded as a potential user of overseas satellite telecommunications capacity to provide telegraphic services.

Nevertheless, with strong lobbying from OTC, the Postmaster-General proposed that a high level Committee should be set up to report on the question of the responsible Australian authority for international satellite telecommunications. The committee comprised the Director-General, Posts and Telegraphs, the Secretary, Department of Supply and the General Manager of OTC (Trevor Housley).

The Committee realized quickly that it had very little hard information on which to proceed with its task and the first decision it reached was to agree to nominate two officers, one from the PMG's Department and one from the Department of Supply to be sent to the UK. The PMG representative to be attached to the British Post Office and the DOS representative to the Royal Aeronautical Establishment for the purpose of studying and gaining experience on satellite telecommunications technology and reporting back to the Committee.

While there was routine but brief formal reporting to the Committee from these two officers, OTC felt that it was missing out on more general feed-back including personal reporting by the officers on informal contacts.

At the same time, OTC's interest in satellites started to increase sharply soon after the trans-Pacific COMPAC submarine coaxial telephone Cable came into service in 1963 because it created an even higher than expected increase in telephone and telex traffic from Australia to major overseas destinations.

The existing HF radio backup system operated by PMG operators, was being augmented against the possibility of cable failure, but even so, this rapidly became less credible as a fallback position because of its lack of anywhere near the capacity to handle the traffic volumes being experienced since the opening of COMPAC. This cable system had the capacity to provide 80 telephone circuits and was rapidly filling.

OTC therefore took the view that, if a viable global satellite telecommunications system came into being in the near future, the answer to proper diversity for Australia's overseas telecommunications services lay in that direction, with OTC as the logical provider.

OTC's strong interest in participating directly in satellites was also reinforced by events arising from our experience with the COMPAC project. The PMG's Department was initially adamant that OTC's interest in COMPAC should stop at the point where the cable was terminated on land, with the full bandwidth of the cable being handed over to PMG for providing the telephone service. Their idea was that COMPAC would simply become an extension to their domestic trunk telephone system.

In the event, after OTC proved that the PMG domestic trunk telephone signalling system would be incompatible with other international systems, OTC took the decision to establish an international gateway switching and signalling system at the Paddington overseas telecommunications terminal to be operated by OTC. In the event, this was reluctantly accepted by PMG because they had no other viable answer at that time. With the advent of subscriber dialling on international calls, this meant that, to destinations served by COMPAC, OTC de facto operated the international telephone service and not just the telegraphic services.

This line of thought prompted Trevor Housley and Bob Long to re-evaluate OTC's "junior partner" position which appeared to exist in Australia vis-a-vis PMG and DOS in regard to satellite matters. The outcome was a recommendation to the OTC Commission to create a special senior position to be clearly identified as having responsibility for satellite communications and to promulgate this to other interested parties. OTC appointed Cyril Vahtrick to this position with a general commission to find out what was going on globally in satellite communications, to establish international contacts and to acquire as much information as was available on technological developments.

For the time being, all the initial international satellite meetings leading up to the final proposal to establish a system had been attended by representatives from PMG, DOS and Treasury, as well as OTC. In the end, back in Australia, the necessary Government approvals for Australia's participation in the proposed international satellite communications system were put in train by OTC. Having participated in the action to date and having a clear understanding of our role as Australia's international telecommunications carrier, OTC put forward, in a Cabinet Submission, that we were the logical body to be the Australian Signatory to a proposed international operating agreement to establish a satellite telecommunications system. A covering Inter-government agreement would be signed by the Department of Foreign Affairs.

At the last stage, however, the PMG's Department, in its role as Ministerial Adviser, opposed OTC's recommendations to the Minister and substituted itself in its role as the Department of State for Communications, as the recommended investor and signatory for the Satellite agreement. OTC's role would then become that of user only.

OTC became aware of this change in the Commission's recommendations to the Minister and, through some energetic representations to the Minister which were supported by Treasury and other Departments, OTC managed to restore itself to the recommended role of signatory and investor. Briefly, OTC sought and received Government approval for Australia to become party to the Interim Satellite Agreements, with OTC as signatory to the Special Agreement, carrying an obligation in our case to contribute 2.5 percent of the capital requirements for establishing the initial space segment of a global satellite communication system. This percentage entitled OTC to a seat on the ICSC, enabling us to participate in decisions made by the body.

The Australian Government's decision to nominate OTC effectively settled the long-standing question among the PMG's Department, the Department of Supply and OTC as to which organisation would be responsible for public international telecommunications via satellite, although the PMG continued to study the feasibility of a future domestic satellite system.

Attachment 3
NASA Apollo Support Program - INTELSAT II

The NASA requirement to support the development of the Apollo "man on the moon" project was for a virtually tailor-made global communications satellite system spanning the Atlantic and Pacific oceans to connect the NASA stations providing tracking, telemetry and control for the various manned space missions leading up to the first manned moon landing. This would also provide additional satellite capacity above the NASA requirement and this could be put to ordinary public telecommunications use.

Specifying a time frame of only twelve months from October, 1965, for both space and earth segments for the communications system, this brought forward by a considerable period the date by which a fully operational INTELSAT satellite system had been previously envisaged. This timetable also effectively eliminated, through lack of time, the design and construction of any system other than one based on the type of synchronous satellite already in orbit.

COMSAT indicated that Hughes had developed from their earlier Syncom design (used in "Early Bird") a larger bodied spacecraft with greater solar power and with much better multiple access capabilities.

COMSAT announced to the INTELSAT Committee (ICSC) that it had negotiated an agreement in its own right with NASA to provide a total satellite communications system, including earth stations at various selected locations around the world. On the additional basis that the system design would envisage some spare capacity on the satellites for commercial use, COMSAT proposed that INTELSAT should formally accept the task of providing and owning the space segment.

After some debate, ICSC agreed to proceed with the space segment subject to satisfying itself that the proposal appeared economically viable while noting that, with the relatively short life span of these early satellites, this project would not have the effect of deferring the overall plans for a more comprehensive global system which ICSC had scheduled for completion in 1968.

When this agreement was settled, ICSC decided that it should be logically naming its satellites, so it started by replacing the existing "Early Bird" with the name "INTELSAT I". The next generation of satellites would then be named "INTELSAT II with F1, F2," etc. denoting each satellite in the series.

Turning to the subject of establishing and operating the specific earth stations required for the NASA project however (which were not an INTELSAT responsibility) the COMSAT proposal, that it should construct, own and operate all the earth stations in the proposed NASA support system, including the three on non-US Territory, met opposition from those entities concerned.

OTC (Carnarvon), Cable & Wireless (Ascension Island) and Spain (Canary Islands) made it clear that, under their domestic telecommunications laws, COMSAT would not be permitted to establish and operate commercial telecommunications facilities in their Territories. These entities also indicated that they could see no reason why they should not establish, own and operate their own earth stations. They would then negotiate directly with NASA in regard to the charges payable for the services rendered.

COMSAT tried to argue against this concept, indicating privately to OTC and Cable & Wireless that it had already virtually agreed with NASA on the charges for the whole package. However, under further pressure from OTC and C&W, COMSAT began to see the difficulties it would face in non-US Territories and privately revealed the overall financial deal it had with NASA - basically it was an all-up total amount for satellites, earth stations, tracking and telemetry and for providing communications facilities to NASA for up to 10 years.

With this total confidential figure in hand, OTC's Cyril Vahtrick and C&W's Archie Willett (later to become Managing Director of C&W) sat down one night in Washington and, with the aid of some complex mathematics, postulated an overall solution based on equitable division of the NASA payment among the direct participants in both space and earth segments. One of the terms of the proposal was that ICSC should agree to reduce their standard space segment charge from US$32,000 to US$20,000 per unit of utilization.

Assuming this space segment charge and the resultant division of revenues from NASA between the earth and space segments, both OTC and C&W saw that they could develop service offerings to NASA which could be kept within the framework of their own respective standard leased circuit rentals.

OTC was fully aware (as was C&W) of the potential precedent which would be created by giving the US Government, through NASA, any kind of special deal for leased circuits. Governments, especially our own, were already leased circuit customers of OTC at standard rates and serious long range problems could arise from any such precedent.

The above course of action was seen by OTC and C&W to have many practical and domestic political advantages. Having come to this conclusion, the following plan was then privately outlined to COMSAT:

- the earth stations in the proposed NASA Network which were in non-US Territories be constructed, owned and operated by the respective entities for these Territories;
- OTC in Australia and C&W on Ascension Island would be the duly authorised entities accessing the space segment from their respective Territories and paying the appropriate space segment charges to INTELSAT. Neither COMSAT nor NASA would have any role in this part of the procedure;
- a standard space segment charge of US$20,000 per unit of utilization should be proposed to ICSC.
- assuming agreement on the above points, OTC and C&W would make service offerings direct to NASA, based on our respective standard leased circuit procedures and rates. These would allow equitable distribution of the overall NASA payments (contracted by Comsat with NASA) among the earth station participants and INTELSAT, for the space segment.

Again there would be no role for COMSAT as "middle man" in these arrangements and COMSAT would be simply regarded as the corresponding overseas carrier at the US end.

Spain was not represented during these discussions but later indicated general agreement with this course of action. Neither COMSAT nor NASA initially welcomed these proposals but quickly recognised that the tight overall schedule left no time to spend on trying to sort out international legal problems.

NASA's stated reason for initially opposing the OTC/C&W plan was that it would be administratively messy to have to deal with an additional three entities in this exercise, and it would be much cleaner just to deal with COMSAT. This stance was quickly abandoned against logical arguments put up by OTC and C&W.

OTC gave Cyril Vahtrick the overall responsibility for the Carnarvon Earth Station Project and he led a team of engineers including Graham Gosewinckel and Barry Lancaster to specify and procure the necessary equipment. The requirement also included the provision of tracking, telemetry and command services for the launch of the communications satellites, together with direct communication links between the NASA Apollo Support Station at Carnarvon and mainland USA.

Despite the many problems which were encountered in such a short lead time, the OTC Carnarvon Satellite Earth Station was available on schedule to provide tracking, telemetry and command services for the launch of the INTELSAT 11 F1 spacecraft which occurred on the 26th October, 1966.

Unfortunately, there was an apogee motor failure in the INTELSAT II F1 satellite resulting in the satellite failing to reach synchronous orbit. The satellite was capable of receiving and transmitting signals in its twelve hour elliptical orbit and the OTC earth station not only successfully tracked it, but also established temporary communication links for the first time via satellite with both the Earth Station in Paumalu, Hawaii, and Goonhilly in UK.

Another significant historical milestone which occurred with this particular satellite was that it was the vehicle for the first ever exchange of television signals between Australian and another country when the Carnarvon station arranged to exchange signals with Goonhilly. This occurred on 25th November, 1966, and represents one of the many OTC historical events.

Attachment 4

The NASA requirement leading to the establishment of a satellite earth station at Carnarvon led to a particularly unusual and interesting piece of telecommunications history. The name "Lani Bird" will have totally receded into history long ago. It was concocted by a Comsat public relations man who had achieved some fame with his naming of "Early Bird", which was the very first public telecommunications satellite to be launched and put into experimental/operational service.

To digress a little, the background of Early Bird is also interesting. Having been unexpectedly upstaged by USSR with the launch of Sputnik in October 1957, USA was keenly looking to regain its space supremacy, including by being the first to achieve a viable public telecommunications satellite system.

After a number of satellite experiments by USA companies, including Echo, a large reflecting sphere (which crumpled like a prune); and Relay (RCA); and the better known Telstar (AT&T); the most interesting prospect appeared to be Syncom, a geo-synchronous satellite designed and launched by Hughes Aircraft Company.

Comsat already had a head of steam going and had contracted with Hughes for a synchronous experimental/operational satellite, based on Syncom, to be launched over the Atlantic to provide USA - Europe communications. Intelsat was persuaded by Comsat to take over the responsibility for this exercise and the satellite was successfully launched on April 6th, 1965. The satellite had been identified by its contractual name "HS 303" and was finally known as INTELSAT I.

It was well known that USSR was also moving towards a satellite communications system based on the "Molniya" satellite series, and , therefore, there was intense rivalry between USA and USSR to see who could be first in this field. With a clear victory to the new Intelsat satellite, constructed and launched by USA industry, it was ceremoniously named "Early Bird" by Comsat.

While Intelsat was still getting into its stride, the US national space agency NASA approached Intelsat in October 1965, to provide a satellite communication system to back up the Apollo man on the moon project. A number of links straddling the globe would be required, including one from the NASA tracking station at Carnarvon (W.A.) to USA. The target date was October, 1966.

OTC accepted the challenge to provide an earth station facility at Carnarvon, with a lead time of less than 12 months, starting from scratch! In view of the very short time available, we decided to place a follow-on order for similar equipment to that which had been already chosen by Comsat for earth stations which they were establishing in USA for the same purpose. Hence the installation of the "sugar scoop" (casshorn) antenna at Carnarvon.

Many OTC people who participated in getting Carnarvon going will remember all the trauma in trying to meet an almost impossible time target. However, it can be safely said that we were ready when the first of the new Intelsat II satellites was launched on 26th October,1966.

This satellite was due to be positioned over the Pacific to provide a link between Carnarvon - (where there was a NASA Apollo Telemetry, tracking and command station) and USA as a critical link in the Apollo global communication network. The spacecraft was also designed and built by Hughes Aircraft, based on Syncom, but somewhat larger with increased power capacity and somewhat better performance.

Both Intelsat I and Intelsat II satellites were drum shaped and embodied an "apogee kick" solid fuel rocket motor which was not fired until after the satellite had been initially launched into a preliminary parking orbit and had its trajectory accurately measured. The firing of the apogee kick motor at a precise point then propelled the satellite into its final synchronous orbit position. (Provided it worked correctly).

In the case of the first Intelsat II satellite, after it had been successfully launched into its parking orbit and with its ultimate destination planned to be over exotic islands in the Pacific, Matt (Comsat) declared for the media that it would be called "Lani Bird". Unfortunately, during the firing of the apogee kick rocket motor, the rocket nozzle blew off and the satellite failed to reach its destined synchronous orbit, remaining in a loop which brought it round every twelve hours or so.

Carnarvon was able to track and monitor signals from the satellite and also briefly establish communications with the Comsat station at Hawaii. The UK earth station at Goonhilly also exchanged signals with Carnarvon when the satellite came round to the right place.

At this stage, international television relay was a novelty, so the successful transmissions achieved via satellite across the Atlantic were still very much on an experimental basis. There had also been some experimental transmissions in 1964 across the Pacific between USA and Japan via the RCA Relay satellite during the Tokyo Olympic games.

With the possibility of television still in mind in 1966, when it was found that OTC Carnarvon could contact Goonhilly using the faulty Lani Bird satellite, OTC conceived the idea of trying to make history by arranging a television hookup. [We had learned that the Department of Supply and NASA were planning to use the NASA station at Cooby Creek in Queensland for an international television hookup within a few months, so this provided an incentive to get there first.]

This is a quote from an article written by Jim Robertson, who was a sectional engineer with OTC at the time:-

... "Despite my protestations that the Carnarvon station was not equipped for television signals... Tom (Minta) and I were shot off to Carnarvon again to try and get some pictures from the BBC.

We begged, borrowed and stole various amplifiers and control and test equipment from my erstwhile friends in the ABC, put the whole lot in a temporary tin shed near the sugar scoop, the nickname used for the odd-shaped (Cassegrain) antenna. All the equipment was tied together with string and faith and we pressed a button and up came the BBC's test pattern!

Following hectic negotiations and prayers a session was arranged for the several migrant families living near Carnarvon to confront their relatives and friends face to face in Britain. Because it was unrehearsed, a very strong, natural half-hour programme eventuated totally between Carnarvon and London. At that stage, Carnarvon had no microwave link for TV to anywhere else in Australia - only to Land's End!

The ABC did however record this historic event, the first live TV programme in and out of Australia with the British or with anyone else, and it was re-broadcast later on their main network programmes."...

[This needs to be qualified slightly - the television picture received at Carnarvon was of low quality because of the smaller antenna and lower satellite antenna performance (caused by the satellite antenna being skewed), but the reception at Goonhilly was quite reasonable.]

This event occurred in December, 1966 and preceded the Department of Supply/NASA international satellite hook-up event by several months.

The first regular international relay of TV programs to and from Australia began from the OTC Moree satellite earth station in 1968.

Attachment 5

Early OTC Satellite Earth Stations.

This is an account of the history of establishing the first Australian satellite telecommunications relay earth stations to operate with the INTELSAT global satellite system.

Going back in history, experimental earth stations had been established early in the 1960's by the American Telegraph and Telephone Company (AT&T) at a remote unpopulated spot at Andover, Maine in USA and also by the British Post Office at Goonhilly Downs in Cornwall. The Andover antenna was a giant horn (30 metre aperture) enclosed in a radome because of winter snow. The BPO antenna was a conventional 30 metre parabolic dish with no outer weather protection. These experimental earth stations and others which were established in France and Germany were used to conduct tests across the Atlantic with the AT&T Telstar and other experimental telecommunications relay satellites.

All of these earth stations originally used ruby MASER detector/amplifiers which operated at the extremely low cryogenic temperatures which required the periodic application of liquid hydrogen. While the MASER performance stretched the state of the art in terms of sensitivity, the liquid hydrogen exercise was hardly suitable for a continuous 24-hour telecommunications system.

Nevertheless, given the obvious problems of introducing greater complexity into spacecraft, earlier satellite communications system designs sought to limit complexity in space and conversely, earth station design was expected to be at the best available technological performance in order to maximize the overall telecommunications capacity available via the satellite.

For OTC's first earth station, because of the very tight time constraints put on us by the NASA Apollo program, OTC decided that an order for our Carnarvon earth station would be placed in USA as an extension to the COMSAT order for four such stations which they planned to install for themselves for the same Apollo program. These earth stations had somewhat smaller antennas than those at the foremost of technology and overall their performance was at a somewhat lower level than that of the very high performance results of the experimental installations mentioned above.

The Carnarvon earth station receiver used parametric amplifiers which needed to be cryogenically cooled to the temperature of liquid nitrogen. This had to be achieved with an on-line cryogenic system to maintain operational continuity. OTC Carnarvon staff had to become proficient in coping with this technology.

The earth station installation was ready for the attempted launch of the first INTELSAT II spacecraft (F2) in October, 1966 but the apogee kick solid state rocket motor malfunctioned and the satellite failed to reach

synchronous orbit.
Attachment 4 provides a narrative of what turned out to be an historical event for Australia with the first exchange of television signals from an overseas destination.
The Carnarvon earth station first started full time service for the NASA Apollo project with the successful launch of INTELSAT II F2 in January, 1967.

When it came to planning an eastern Australian earth station to access a Pacific Ocean satellite, OTC faced a quandary. There was still no decision from INTELSAT as to the type of system it would finally choose, and with COMSAT at that stage favouring a multiple satellite random orbit system, it was still possible that OTC may need fast tracking 360 degree earth station antennas.

In line with the international convention requiring no interference to domestic microwave systems, the PMG insisted that it was necessary for OTC to go far afield to Moree to install a satellite earth station in NSW in order to avoid possible interference to possible planned domestic microwave systems. Since the PMG were also the communications regulator, they made sure that OTC was well out of the way of any possible future land microwave links.

OTC immediately realized that it needed to establish a culture among potential earth station contractors to understand that the station needed to be totally and continuously operational all the time. This culture was not necessary, for example, in previous antennas which had been designed and installed around the world for deep space communications in connection with NASA space projects. These antennas could be regularly taken off service for maintenance and adjustments as the earth station site, with the earth's rotation, moved away from the direction of the deep space target and another antenna, at a different geographic location, took over.

It was not until after OTC had already been committed to the site at Moree that INTELSAT decided to abandon the random orbit option. Nevertheless, this still left the possibility of the phased equatorial orbit as an option, albeit looking less likely. Therefore the specification OTC wrote for the Moree station did not include fast tracking over 360 degrees but still allowed for tracking for a phased equatorial orbit if this was to prove necessary.

Cyril Vahtrick, helped by Barry Lancaster, wrote a comprehensive specification for the Moree earth station, drawing on parallel criteria applying to the COMPAC submarine cable system to emphasise extremely high reliability as well as high performance. Designers of large antennas, whose previous experience rested with space research systems, had to come to terms with the requirement for a continuous 24-hour operation and no time off for routine maintenance and repairs. This entailed full duplication of essential equipment, no-break power supplies, etc. (for reasons of cost, this did not initially include on-site duplication of the actual antenna structure but this did come some time later).

After tenders were called, a system embodying an unusual "polar" antenna mount was chosen for Moree, keeping an eye on the possibility still, that INTELSAT may decide on a phased equatorial orbit.

OTC contracted with an American company…Collins Radio to build and erect the antenna and to provide the transmit and receive system. The station was rigorously tested by OTC staff before it was accepted as our first major international satellite earth station.

The Moree earth station was formally opened by the Postmaster-General on 29 March, 1968 with a television program exchanged with KDD in Japan. This was the beginning of the first regular overseas public satellite communications service from Australia, providing service initially to Japan and USA via the INTELSAT II F2 satellite located over the Pacific Ocean.

The next step was to look westwards for a link across the Indian Ocean to UK and Europe. By 1968, INTELSAT had firmed up on the first fully global satellite system based on the INTELSAT III series.

To permit access to the satellite by UK at its Goonhilly site, INTELSAT calculated that the extreme easterly location of the Indian Ocean INTELSAT III satellite should be at 62.5 degrees East Longitude. This also just gave eastern coverage from this satellite for Japan. Unfortunately, this coverage did not extend to the main international traffic centres in eastern Australia.

Since the vast majority of Australia's overseas telecommunications traffic came from our eastern States, this posed a problem for the location of a suitable earth station for this traffic. Our experience with the PMG on landline extension costs, led us to the conclusion that we should choose a site as far east as the satellite coverage would allow, to minimize landline extension costs.

This, of course, led us to Ceduna in South Australia. Even with Ceduna's remoteness, the PMG still had its say on the precise location. By now, INTELSAT had decided that the global satellite system would be based entirely on synchronous satellites, so the possibility of all round rotation of the antenna was gone. Nevertheless, because of the very low angle at which the antenna would need to operate at Ceduna, the PMG said they were concerned about possible interference to some of their possible future microwave links across the Nullarbor plains. So they insisted that the Ceduna earth station should be well out of town.

When it came to OTC establishing an earth station at Ceduna, INTELSAT had by then established key performance values for their "Standard Earth Station". The concept of a "Standard" earth station was originally put to INTELSAT by OTC, supported by Britain and Canada. The performance requirements of such an earth station was directly linked to the space segment charge to earth station operators, of a CCITT standard telephone circuit carried via satellite.

With the publication of specifications for a "Standard Earth Station" by INTELSAT and the growth of demand for earth stations around the globe, there was a considerable increase in commercial interest for tendering for the establishment of these stations. We in OTC still prepared our own specifications in detail, but made sure that the end result would meet the INTELSAT specification.

We had some very interesting experiences at Ceduna with the selected Japanese contractors. This was a new venture with Japan needing to seek Australian Government approval for Japanese engineers to work in Australia, albeit for a specific project. This produced some interesting experiences with the diversity of cultures.

In the end, the finished product at Ceduna met our specifications and the earth station entered into service in 1969. The Ceduna and Moree earth stations strongly ushered OTC and Australia into the international telecommunications service via satellite.

This story ends here, as an account of the early stages. As with all technology, advances continued to occur. That is another story for somebody else.