INTRODUCTION BY EDITOR

The article following is perhaps unique among the many
cations, in both the policy and technical areas, having been pre- papers published thus far in this column. It covers not only the
sent and working at Comsat Corporation, as well as later at development of some of the technology required to turn the
Intelsat, during much of the period under discussion. We plan to dream of commercial satellite communications into reality, but
follow this article with one focusing more on the communication describes the policy decisions and politics involved in making this
technologies developed at Comsat during the early days of satel- happen in the United States and elsewhere in the world as well.
lite communications. That article will be written by one of the Policy questions raised and discussed include, first, the question
engineers working at Comsat at the time. In the meantime, I am of whether satellite communications in the United States should
sure all readers will enjoy this article. Note that a number of be government-run or a commercial enterprise; followed by the
readers of previous articles in this column have responded with issue of how control should be manifested in international com-
letters to the editor commenting on, or expanding on, those arti- munication satellites. These policy questions in modern times are
cles. We urge you to send in your comments and or/questions probably unique to satellite communication systems.
about this article or any of the earlier articles as well. Joe Pelton, the author, is well positioned to write an account
—Mischa Schwartz of the early days of satellite communications in all of its ramifi-

THE START OF COMMERCIAL SATELLITE COMMUNICATIONS

JOSEPH N. PELTON, FORMER DEAN, INTERNATIONAL SPACE UNIVERSITY, FOUNDING PRESIDENT OF THE SOCIETY OF SATELLITE PROFESSIONALS INTERNATIONAL, AND FORMER DIRECTOR OF STRATEGIC POLICY, INTELSAT

INTRODUCTION

John Logsdon, the long time director of the Space Policy Institute at George Washington University, when he talks about the history of space, often starts by saying: “The policy people and not the engineers always win.” The mean- ing of his statement is that the engi- neers can design wonderful technology, but it is the politicians and the govern- mental officials who ultimately decide how, when, where, and why it is actual- ly used. This, in many ways, is certainly the case with regard to the early devel- opment and use of satellite communi- cations technology for global communications. The evolution of satellite communications technology came rather quickly in the late 1950s and early 1960s, but international poli- tics related to the Cold War shaped how this technology was deployed and how quickly it was used. U.S. efforts to recover from the global impact of the Sputnik launch by the Soviet Union placed great emphasis on developing all forms of space technologies. Thus, the U.S. government placed great polit- ical importance on the creation of a global satellite system with a U.S. launch vehicle and spacecraft technolo- gy leading this new venture.

This is the early story of how satel- lite communications began, and how these amazing devices revolutionized global communications and helped to realize the electronic global village we live in today. The first applications of communications satellite began with the relay of international telecommu-
nications services (i.e., telephone, telex, and television) — essentially as

THE HISTORY

an extension of terrestrial national net-
Ever since Sir Isaac Newton discovered works. Over time the technology and

gravitation and wrote down the Law of Gravity, it has also been scientifically known that the launch of artificial satellites in Earth orbit would be technically possible. How do we know this? Isaac Newton's own publications showed illustrations of how an object fired with enough velocity could be launched into Earth orbit. The idea that an artificial satellite might be put to practical use is also centuries old. Everett Edward Hale, as early as 1867 when he wrote *The Brick Moon*, speculated on the use of artificial satellites for communications, navigation, and remote sensing. Indeed, he envisioned that such satellites would go into a medium Earth orbit. He specified an orbit that would cross over the North and South Poles orbit with a period of about 90 minutes and that after a number of revolutions these satellites would "see" the entire world below. Today's commercial remote sensing satellites are deployed in much the same manner. Lest we give him too much credit for technical sophistication, he also thought that a crew (for some reason consisting of 17 men and two women) could live in outer space and could communicate by jumping up and down to create messages in Morse code. It was not until 1945, however, that a detailed and specific technical concept emerged about how to deploy an artificial satellite for telecommunications purposes in geosynchronous orbit.

This was in an article that appeared

applications matured. This led ultimately to the creation of national satellite systems for domestic television, radio, and telecommunications, the creation of maritime satellite systems to provide services to ships at sea, the offering of aeronautical mobile satellite services to aircraft, land mobile satellite services to supplement cell phones, and direct broadcast satellite systems to beam television and radio to individual subscribers. In some ways evolving satellite technology competed with terrestrial submarine cable, and in some ways these systems worked in tandem. In later decades, other commercial satellite applications also emerged. These now include remote sensing, Earth observation, space navigation, and meteorological services.

The complete story is too complex to relate in a single article. The focus here, therefore, is on the early years and the creation of the Communications Satellite Corporation in the United States and the creation of the International Satellite Communications Consortium (Intelsat) from which other commercial satellite systems have evolved. To complete the story, however, some of the more important evolutionary steps that have now occurred within the satellite industry to develop maritime and mobile satellites and broadcast satellites, and to use satellite for domestic as well as international purposes are noted.

HISTORY OF COMMUNICATIONS

both to advance the needed research and development and to encourage pri- vate industry to apply its resources toward the earliest practical application of space technology for commercial civil communications requirements..." [4].

This view of how to develop, deploy, and operate global satellite communica- tions did not exactly fit the vision of the newly elected Kennedy administration. Kennedy wanted "space" to be a part of his "New Frontier." He and his advisors wrestled with how to make this so amid the rigors of a Cold War conflict with the Soviet Union and specific concerns about the much discussed "missile gap." At the same time, Kennedy also had a fervent desire to galvanize the nation to a new sense of initiative and American accomplishment in many areas — par- ticularly in space. He also wanted this American space initiative to be consis- tent with his other global initiatives such as the Peace Corps.

He thus began his administration with a number of pronouncements about new American initiatives in outer space. He, his staff, and the National Space Council sent a flurry of messages to the Federal Communications Com- mission (FCC) and NASA, which had been hastily formed by an Act of Congress in 1958 in response to the Sputnik and other early Soviet launch- es. Kennedy also communicated with industry about what urgent research goals were to be pursued and about what role industry might play [5].

in October 1945 in *Wireless World*, a U.K. publication. Here Arthur C. Clarke explained for the first time how three space stations in geosynchronous orbit could provide virtually total world- wide communications coverage. He explained the physics of this "magic orbit" whereby a satellite can seem to hover exactly above the Earth's equator all the time. With detailed calculations, he showed why there was only one unique circular orbit some 22,230 miles (or 35,870 km) above the Earth's sur- face where this was true. The required orbital speed needed at this altitude, based on the Earth's gravitational mass, plus the need to match the world's side- real rotation of 23 hours and 56 min- utes (i.e., the Earth rotates on its axis every 24 hours, but it also advances around the sun four minutes every day), produces a single solution.

This article was published after Clarke had circulated the essential con- cepts and technical calculations in June 1945 in a detailed letter to colleagues. At the time most considered the idea to be science fiction. Indeed, the Clarke article on global communications space stations in *Wireless World* was not even the cover article for the October 1945 edition [1]. Arthur Clarke's daily calen- dar for the year reveals that this article — which in some ways gave birth to an industry that represents over $100 bil- lion in revenues today — produced a paltry royalty payment of only 15 pounds sterling [2].

1940s through the creative work of William Bradford Shockley, John Bardeen, and Walter Houser Brattain at Bell Labs [3]. This fundamental breakthrough led to many innovations from the transistor radio to the modern computer; indeed, it spawned the entire "Silicon Valley" culture that has served to transform the world in almost every conceivable way over the past half cen- tury. Certainly the transistor trans- formed the concept of a communications satellite and the practi- cal utilization of outer space from a far- off dream to a practical reality — and it did so in less than a decade.

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The launch of Sputnik by the Soviet Union in October 1957 in a single stroke convinced the world that the launch of artificial satellites was now a practical engineering feat. It also stirred global Cold War politics into a new state of frenzy. President John F. Kennedy's election in November 1960 can, in part, be attributed to the "mis- sile gap" that the United States public viewed with some concern as the U.S.S.R. deployed ever more sophisti- cated and larger capacity rockets, including launchers with cosmonauts aboard. This concern over the U.S. mis- sile gap was a subject of concern to the American public in the late 1950s and early 1960s as the embryonic U.S. rock- et program seemed to be having great difficulty getting off the ground in every sense of these words.

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At the very end of the Eisenhower administration, in December 1960, a very "lame duck" President Eisenhower delivered a speech that addressed the future prospects of communications satellite systems and how they might be deployed on a commercial and private- enterprise-led basis, presumably with American technology leading the way. Eisenhower, on December 30, 1960, well after the election of John F. Kennedy over Richard M. Nixon had been decided, set forth his views as fol- lows:"The commercial application of communications satellites, hopefully within the next few years, will bring all the nations of the world closer together in peaceful relationships as a product of this nation's program of space applica- tions... This nation has traditionally fol- lowed a policy of conducting international telephone, telegraph, and other communications services through private enterprise, subject to Govern- ment licensing and regulation... I have directed the National Aeronautical and Space Administration (NASA) to take the lead within the Executive Branch

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What most people remember of this time was the President's speech to a Joint Session of Congress on May 25, 1961. This speech, known formally as the "Special Message to Congress on Urgent National Needs," was the one in which he issued the special challenge of sending astronauts to the moon and returning them within the decade. This speech and what became the challenge to go to the Mmoon is one of the best- known elements of the Kennedy legacy. However, in that speech Kennedy also called for other space achievements that included the Rover nuclear launch system and the rapid development of satellite communications technology and systems. He explicitly called for $50 million dollars (which in those days was still real money) for "accelerating the use of space satellites for worldwide communications." He ended his speech by emphasizing the need: "...to move forward, with the full speed of freedom, in the exciting adventure of space" [6]. Clearly the stupendous goal of sending people to the Moon and returning them safely was the headline, but the

When I talked to Arthur Clarke in the mid-1980s at Barnes Place, his home in Sri Lanka, about his seminal article, he explained that in 1945 he did not consider the idea practical any time soon — and certainly not worth patent- ing. Indeed, he conceded that publish- ing the article in *Wireless World* alone actually served to eliminate the possibil- ity of a patent. At the time he published the article in 1945, Clarke envisioned that the space stations would need a full-time crew whose round-the-clock function would be to replace burned out radio tubes and perform other maintenance functions. Of course in 1945 the transistor, which made possi- ble the electronic computers necessary to compute orbits and provide reliable solid state electronics to replace radio tubes, had not yet been invented. In short, Clarke did not seek to patent the concept of communications satellites in geosynchronous orbit because he envi- sioned that such a system would be many years in the future.

The breakthrough invention of the transistor actually came in the late

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Kennedy administration in this speech and in the United Nations speech that followed saw the potential of satellite communications as an instrument of peace, a Cold War symbol of American leadership, and an opportunity for one- upmanship on the Soviet Union.

It was in September 1961 that Presi- dent Kennedy went to the General Assembly of the United Nations and called for the establishment of a single global satellite system that would: "...benefit all countries, promote world peace, and allow non-discriminating access for countries of the world" [7]. This speech set the stage for the United Nations to adopt resolution 1721 Sec- tion P, formally establishing that "com- munications by means of satellite should be available to the millions of the world as soon as possible on a glob- al and nondiscriminatory basis" [8].

Thus, the creation of global satellite communications became at once part of the United States' initiative to show its expertise and competence in space tech- nology. It also became a part of the U.S. effort to demonstrate leadership toward world peace and assistance in many areas from the establishment of the Peace Corps to the championing of a global satellite system that would be available to all nations on a non-dis- criminatory basis. These dual objectives later complicated Kennedy's effort to get the Communications Satellite Act of 1962 through the U.S. Congress. Communication satellites were on one hand an attempt to fight a Cold War with the Soviet Union and to champion "free enterprise" and world class Amer- ican technology over communism; but on the other hand it was to promote the cause of a peaceful world and glob- al intergovernmental cooperation.

THE DEVELOPMENT OF SATELLITE TECHNOLOGY

As all of this political activity was tran- spiring, a lot had been happening in terms of developing new launch systems and satellite communications technolo- gy-and in a remarkably short period of time. After several failures, the first successful U.S. launch was led by Wern- er Von Braun who oversaw the launch- er development. But it was American scientist James Van Allen who took the lead in designing the Explorer 1 experi- mental satellite that rode on the Von Braun vehicle. Van Allen installed a Geiger counter within the Explorer satellite along with a radio relay. The Explorer 1 was able to detect extremely high-energy radiation surrounding the

 Earth in concentrated belts. These quickly became known, of course, as the "Van Allen Belts." The existence of these belts proved quite important to the deployment of future communica- tions satellites since the radiation from these belts could knock out satellite communications electronics. Thus satel- lites were deployed to avoid these belts and also shielding was added to protect the satellite electronics.

With the creation of the National Aeronautics and Space Administration (NASA) in 1958, a new civil American space capability was built within the U.S. government. In parallel, capability was developed within the U.S. military and within industry. American telecom- munications companies such as ATT, ITT, RCA, Western Union, and West- ern Union International as well as aerospace companies such as Hughes Aircraft, TRW, Ball Aerospace, Gener- al Dynamics, McDonnell-Douglas, Lockheed Martin, General Electric, and North American Aviation also began to expand their capabilities.

Within the telecommunications industry, a good deal of attention was quickly focused on the practical com- mercial uses of space — particularly in the context of communications satel- lites. From 1958 through 1965 there were in quick succession a number of experimental launches that advanced knowledge and engineering capabilities in space.

The first U.S. artificial satellite that might be characterized as a "communi- cations satellite" was really almost a publicity stunt to capture world press attention and to indicate that American technology in this area was starting to move forward. This was the U.S. Signal Corps' SCORE satellite that was launched on an Atlas rocket on Decem- ber 18, 1958. It was a low-power "broadcasting satellite" that continu- ously sent out a recorded message from President Eisenhower, simply proclaim- ing: "Peace on Earth, Goodwill to Men." This small satellite had only enough battery power to last 12 days to the end of the year [9].

On August 12, 1960 a meteorologi- cal satellite called Echo-1 was launched to conduct some ionospheric experi- ments. Dr. John Pierce, an engineer at Bell Labs who later designed the Tel- star communications satellite, had the inspiration to suggest that the Echo-1 100-ft inflated metallic balloon could also be used to test the idea of a pas- sive reflector for communications sig- nals. This idea had been tested by bouncing signals off the moon in the

1940s, but here was a much more viable experiment. The result of the Echo-1 and Echo-2 experiments was to con- clude that a passive reflector would not produce sufficient throughput capacity to support a commercially viable telecommunications service. The lesser- known U.S. military experiment known as "West Ford" similarly concluded that bouncing signals off of a passive space- based reflector without active amplifica- tion was essentially a non-starter — again because the achievable through- put was too low [10].

The first two-way interactive com- munications satellite was the Courier 1 B launched in October 1960. This satel- lite's capacity was limited to only 16 teletype channels. Although this was a miniscule capability, it led the way to more sophisticated communications with the ability to receive, translate to other frequencies, and retransmit ampli- fied signals back to Earth [11].

By 1962, the experimental satellites had become increasingly sophisticated. John Pierce and his team at Bell Labs had designed the Telstar satellite, while RCA had designed the Relay satellite. Both of these satellites were launched by NASA into low Earth orbit. These were active repeater satellites capable of supporting multiple voice channels and even low- quality television transmissions. There were even experimental television broadcasts to Tokyo. Although the Sovi- et Union was launching quite large satellites into orbit by this time, the United States was showing significant technical advances in building increas- ingly complicated and functional satel- lites with micro-electronics.

The Relay and Telstar satellites demonstrated the feasibility of solar cell and battery powered systems, tracking and command, active space antennas for reception and transmission, radio system filters, and amplifiers. The abili- ty to launch such satellites — at least into low Earth orbit — was clearly established as well (Fig. 1).

The only major open question was whether artificial communications satel- lites could be successfully deployed into the more difficult geosynchronous orbit, almost a tenth of the way to the moon. There were also questions about the huge path loss that would occur when a satellite transmitted from such a high orbit so far above the Earth. It was the opinion of many that only high gain antennas with accurately pointed beams could successfully operate from so far out in space.

There was also the open political question as to what entity would pro-

History of Communications

Figure 1. *The Telstar Satellite prior to launch in 1962. (photo xourtesy of NASA).*

antenna tracking a medium orbit satel- lite must move and follow an orbiting satellite, while a ground antenna oper- ating to a low Earth orbiting satellite must track very fast or have a low-gain "omni-antenna" that can receive at all angles above the ground.

When the Comsat Bill was passed in 1962, the projected cost of a communi- cations satellite plus its launch was assumed to be between $5 and $10 mil- lion; thus, a capitalization of $200 mil- lion seemed reasonable at the time. In this case, however, technology inter- vened to provide a more efficient result [12]. The passage and signing into law of the Comsat Act of 1962 spurred both technical and political action. On the technical front, Dr. Harold Rosen and his team at Hughes Aircraft embarked on the design and launch of a series of three experimental satellites. This satel- lite series was known as Syncom — or, if you will, a type of satellite that could operate from geoSYNchronous orbit.

Rosen and his team thus conceived of a type of satellite that could achieve Arthur C. Clarke's vision by being suc- cessfully launched into geosynchronous orbit. The first in this series, Syncom 1, ended up as a NASA launch failure, but Syncom 2 was successfully launched in 1963, and demonstrated that this type of launch and deployment into an equatorial circular orbit 22,230 miles (35,870 km) above planet Earth was possible. Then Syncom 3 launched in 1965. The success of Syncom 2 very sig- nificantly caught the attention of the officials of the newly formed Comsat Corporation. They quickly contracted with the Hughes Aircraft company (Contract HS 303) to build an upgrad- ed version of the Syncom satellite. This new satellite would have the effective capacity of 240 two-way voice circuits or one low-quality black and white monochrome television channel. Since the transatlantic submarine voice cables, such as the TAT-1 cable first laid in 1956, had a capacity of 36 voice circuits and no live television capabili- ty, a satellite with this type of capability seemed to represent a major break- through indeed. (Note the TAT-1, TAT-2 and TAT-3 submarine cables were later upgraded with time assign- ment speech interpolation [TASI] and other technologies to achieve higher capacity, but they were still far less capable than the Intelsat satellites, especially Intelsat III satellites with 1200 voice circuits plus two television channels launched in 1968 and 1969. Today, however, things have switched

task of drafting a "compromise" version of the Comsat Act of 1962 that bridged the gap between a "private approach" and a “public approach.” The Kennedy White House version that emerged was essentially to mandate the creation of a “Communications Satellite Corpora- tion” to be capitalized at $200,000,000 as a public corporation. Half of the stock would be sold to the public at $20 per share, and half of the stock would be apportioned (at the same price) to the telecommunications companies AT&T, RCA, ITT, Western Union, and Western Union International. In a nod to Senator Kefauver, the President would appoint three directors to the COMSAT board in addition to the six who would come from the telecommu- nications companies and six from the publicly held stockholders. Further- more, the FCC, the State Department, and the then existing Office of Telecommunications Policy in the White House would give guidance to that corporation with regard to matters of national interest and national policy. In addition, NASA was designated under the bill to provide technical advice and input. This compromise (closer to the Sen. Kerr and industry approach than the Kefauver public approach) was able to win enough votes for passage.

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One of the “assumptions” inherent in the bill was that the communica- tions satellite system to be deployed would be a low Earth constellation with several dozen satellites deployed in this manner in order to provide global coverage. The physics of satel- lite orbits are such that the closer a satellite is to the Earth’s surface, the less total coverage of the globe is pos- sible. (One can take a basketball and shine a flashlight on it from several feet away and illuminate it all. As one moves the flashlight closer to the bas- ketball, the area illuminated gets stronger in intensity, but the beam also shrinks to a smaller and smaller area. The same physics applies to a satellite beaming signals to Earth.) Thus, a low Earth orbit constellation requires many dozens of satellites to provide com- plete and continuous global coverage. About a dozen satellites can cover the Earth from medium Earth orbit, and only three satellites in geosynchronous (or geostationary) orbit can cover vir- tually the entire inhabited world with only the polar regions not having com- plete coverage. Also, the Earth station antennas on the ground can be contin- uously pointed in the same direction to a geosynchronous satellite. A ground

vide communications satellite services on behalf of the United States and how these services would be provided inter- nationally in terms of institutional arrangements. The telecommunications industry had organized, and, with the particular support of the powerful Sen- ator from Oklahoma, Robert S. Kerr, they introduced a bill that would make the U.S. space telecommunications ser- vices a strictly private and commercial venture, under governmental licensing and regulations. On the other side of the issue, Senator Estes Kefauver, who had run for Vice President with Adlai Stevenson on the Democratic Presiden- tial ticket, had a much different take on how the future should unfold. He intro- duced a bill that would make satellite communications a governmentally oper- ated service. His logic was that the U.S. government had developed much of the space technology at public expense and that the public should benefit from this new development as owners and opera- tors. The Kennedy Administration, which was eager to launch the technology and show a clear space success, found itself on the horns of a dilemma. Kerr and Kefauver were both Democrats, and this was threatening to blow up into a full-scale political wrangle with threats of a prolonged filibuster. John A. John- son, then NASA General Counsel (and my boss for the five years I spent at the Communications Satellite Corporation) was called to the White House. He was asked to help rescue the situation. John- son had been detailed to Senator Kerr’s staff by NASA to draft the “private only” version of the Comsat Act of 1962. Kennedy’s team assigned him the

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vide communications satellite services on behalf of the United States and how these services would be provided inter- nationally in terms of institutional arrangements. The telecommunications industry had organized, and, with the particular support of the powerful Sen- ator from Oklahoma, Robert S. Kerr, they introduced a bill that would make the U.S. space telecommunications ser- vices a strictly private and commercial venture, under governmental licensing and regulations. On the other side of the issue, Senator Estes Kefauver, who had run for Vice President with Adlai Stevenson on the Democratic Presiden- tial ticket, had a much different take on how the future should unfold. He intro- duced a bill that would make satellite communications a governmentally oper- ated service. His logic was that the U.S. government had developed much of the space technology at public expense and that the public should benefit from this new development as owners and opera- tors. The Kennedy

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ing as manager for the system. (The
nas, and a stabilized platform to allow name Intelsat was adopted sometime
accurate orientation and pointing of later, after the so-called Interim Com-
these improved antennas. munications Satellite Committee
Despite the successful deployment [ICSC] met to discuss a more succinct
of Syncom and Early Bird, the overall name.)
architecture of the Intelsat global satel- During the negotiations that lasted
lite system was still a subject of some through the summer of 1964, France, in
debate. The Initial Defense Satellite particular, argued for the possibility of
Communications System (IDSCS) that regional systems and suggested that the
was also deployed by the United States United States should play a less domi-
military in 1965 was actually a low nant role in the ownership, and argued
Earth orbit constellation of simpler for international management of the
satellites that were easier to launch system — particularly when final
and deploy. A study carried out by the arrangements were negotiated between
ITT Corporation outlined how a low 1969 and 1973 [15].
orbit constellation might be deployed Comsat, even before it had been for-
to provide nearly continuous global mally designated the Intelsat system
coverage. However, the Japanese and manager, had contracted with Hughes
Australian representatives to the Intel- to design and launch the satellite that
sat ICSC strongly argued against such the world would come to know as Early
a low orbit system because they both

Figure 2. *The Intelsat I (F-1), known in the world's press as "Early Bird." (Photo courtesy of the Comsat Legacy Project).*

Bird. In April 1965 this satellite was
believed the geosynchronous technolo- successfully launched — a low-power
gy had been well demonstrated. Fur- 85-pound cylinder surrounded by solar
thermore, they stressed that their cells and with a squinted beam antenna
countries, in particular, would be sub- that, instead of being completely omni-
ject to gaps in live and continuous cov- beam, was able to concentrate six times
erage for minutes at a time. again with very-high-capacity fiber optic
more power back toward Earth. This
After serious debate, the design submarine cables being deployed across
satellite, shown being assembled in Fig.
specifications for the next generation of the oceans [13].)
2, although modest in size and perfor-
Intelsat satellites began. The result of On the political level, officials of the
mance by today's standards, became the
this system optimization process was a Comsat Corporation and the U.S. State
world's first commercial communica-
new satellite design that would have a Department began to visit other coun-
tions satellite.
much larger solar cell array on the out- tries to discuss an arrangement for
The satellite had a very low-gain
side of the spacecraft, electronics that international institutional agreements
antenna and only 100 W of power. The
would support a throughput capacity of about how satellite services would be
result was a very power-limited satel-
1200 voice circuits plus two television provided. Early discussions with Japan

lite that needed to work to very high-
channels, and a spinning body design and Australia went well, but in Europe
gain ground antennas to close the link
that would allow a higher-gain antenna a “game-changing” event occurred. The
budget. As of spring 1965 there were
to be continuously oriented to Earth. U.S. “model” for a series of bilateral
less than a handful of the very-high-
This would be a “spinner” satellite with agreements between the United States
performance C-band radio frequency
the outside drum with solar cells spin- and other countries was firmly rejected
(RF) Earth station antennas available
ning at some 60 rpm, and the interior by the European members of the Euro-
to receive the faint signal that this tiny
electronics and antenna system spinning pean Council on Post and Telecommu-
and low-power Intelsat I (F-1) satellite
in the opposite direction to maintain nications (CEPT). The Europeans
was able to generate. These giant
continuous stability and pointing accu- insisted that there would need to be an
ground antennas with cryogenically
racy to the desired subsatellite point on international entity to oversee global
cooled amplifiers were located in
the world below. Since submarine cable satellite telecommunications. They also
remote locations where there was a
systems were still at less than 100 voice indicated that they felt the United
minimum of RF interference. After all,
circuit capacity and no live television States should not be in a position to
the “power” of the faint signal from
transmission capacity, this design with exploit its technological advantage with
Early Bird, by the time it reached
1200 voice circuits plus color television regard to launch systems and satellite
Earth, was less than the power repre-
channels would vault satellite communi- technology to dominate these service
sented by a single snowflake falling to
cations into a dominant technological agreements [14].
the ground.
position. Rancorous discussions followed, and
The initial Intelsat locations were
This design was advancing forward these lasted for almost two years. Euro-
thus in places such as Goonhilly Downs,
when the U.S. government, and NASA pean officials insisted that the Agree-
United Kingdom, Pleumeur Bodou,
in particular, came forward and said ments signed in Washington, D.C. on
France, and Andover, Maine. Most of
they needed to have satellite capability August 20, 1964 be “interim arrange-
these early antennas were 30 m diame-
to communicate with ships at sea that ments” to be renegotiated after five
ter parabolic antennas, but at Andover,
would be tracking and communicating years of experience had been gained.
AT&T Bell Labs engineers designed a
with the Gemini space launches that After a series of compromises, these

rather exotic gigantic horn-shaped
were the predecessor U.S. manned international agreements indeed did
antenna (Fig. 3). System optimization
space program to the Apollo moon lead to the creation of the International
studies clearly indicated that the next
mission. They offered to compensate Telecommunications Satellite Consor-
generation of Intelsat satellites should
Intelsat for the cost of launching, on tium with the Comsat Corporation act-
have greater power, higher-gain anten-
an accelerated schedule, a satellite that

Then, after the Intelsat III satellites had been up a short while another dis- aster occurred. The key to the de-spun platform was the satellite antenna that constantly pointed to Earth. This depended on a very sophisticated rotat- ing bearing and power transfer assem- bly (BAPTA) that transferred power between the outside drum with the solar cells and the crucial interior reverse spinning satellite antenna sys- tem. The disaster was that the bearing system froze up on one of the Intelsat III satellites. This satellite essentially became instantly useless.

Emergency meetings of the ICSC, plus a meeting of the ICSC Technical Subcommittee, where I was then serv- ing as Secretary in 1969, were convened with great urgency. Meetings of the ICSC Technical Committee lasted past midnight amid heated discussions. Engineers from Ball Aerospace were called to discuss the problem, since it was they that had designed and manu- factured the bearing system as a sub- contractor to TRW. These engineers and Comsat personnel explained how they could re-engineer the bearings to provide greater tolerances between the bearing and the bearing housing, and also change the lubricants. The design changes were rapidly approved, and the rest of the Intelsat III satellites were successfully launched. These actually performed well and met all specifica- tions. In June 1969, just before the moon landing, Intelsat engineers com- manded an Intelsat III satellite to fire its thrusters in order to transfer this satellite from the Pacific to the Indian Ocean. As of a few weeks before the July 1969 moon landing, Intelsat, for the first time since its creation in 1964, had achieved its goal of achieving truly global communications.

Thus, there were now Intelsat satel- lites spanning not only the Atlantic and Pacific Oceans, but the Indian Ocean as well. Suddenly the globe was fully con- nected via a network of satellites for global communications across all the continents. Over 500 million people across the world were able to watch the Moon Landing in July 1969 — live via satellite. The signal came back from the moon to an Australian radio telescope; from there it was relayed to an Aus- tralian Intelsat Earth station at Carnar- von, and from there around the world on Intelsat satellites. Intelsat had become truly global less than two weeks before. As a small part of the overall process, I must confess I felt an ele- ment of pride for what Comsat and Intelsat had accomplished.

Figure 3. *The AT&T designed 30-m Andover, Maine Earth station as photographed in 1966 (courtesy of Comsat Legacy Project).*

on best price and performance with international participation only to be considered if all other elements were equal. The Early Bird (Intelsat I) con- tract had been awarded to Hughes Air- craft prior to the formal creation of Intelsat. The accelerated program to meet NASA needs also went to Hughes since the so-called Intelsat II program was only a slightly modified version of Intelsat I. Thus, what became known as the Intelsat III satellites — the larger- capacity "spinner" satellites with a high- er-gain antenna and increased power — were the first true international com- petitive spacecraft contract award by Intelsat. After approving a formal per- formance specification, international bidding, and a review by the Technical and Finance Subcommittees, the ICSC decided to award the Intelsat III con- tract to the American firm of TRW.

This Intelsat 3 series was less than the stunning success for which Intelsat had hoped. Matt Gordon, the public relations head for Comsat, acting as Intelsat manager, decided that names like Intelsat 1 (F-1) (for flight model), and Intelsat II (F-1) and (F-2) had, in a word, a lack of "pizzazz." He con- vinced Comsat management and the ICSC that the first Intelsat III, which was to be launched in 1968 just prior to the Mexico City Olympics, should be called "Olympico." It was a great pub- lic relations idea, but there turned out to be a major flaw in the plan. The first Intelsat III was a launch failure. After that embarrassment, it was decided to just give Intelsat satellites number des- ignations.

could provide communications to a ship in the Atlantic Ocean off the coast of Africa so as to maintain communi- cations. After considerable debate within the Intelsat Board (then still known as the ICSC) with the Swiss Delegate, Dr. Reinhart Steiner, in par- ticular, making strong interventions that U.S. interests were overriding the best interests of Intelsat, the decision was made to have an "intermediate" Intelsat II satellite constructed and launched. This satellite would, unlike Early Bird, be able to support multi- destination uplinks and downlinks, but otherwise would be much like Intelsat I (Early Bird).

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HISTORY OF COMMUNICATIONS

ital Communications Company (DCC) that became MA Com. MA Com even- tually evolved into the corporation known today as Hughes Network Sys- tems (HNS). Dr. Sekimoto returned to Japan, and became the President and Chairman of NEC.

THE PAST, THE PRESENT, AND THE FUTURE

As one looks back on the past 50 years of satellite communications develop- ment, those early years were quite remarkable. In this short initial period of commercial satellite services the total amount of global communications capacity went from a few hundred voice circuits to many tens of thousands. Likewise, during this period the in- orbit capacity increased by hundreds of times, and the cost of service dropped by more than a factor of ten. Techno- logical advances of these early years included:

•Moving from low Earth orbit launches to geosynchronous satel- lite operations

• Transitioning from low-gain nearly omni antennas to high-gain satel- lite antennas

• Shrinking the size of Earth station giants from 30 m antennas to increasingly smaller ground units

• Moving away from “all analog operations” to TDMA and SPC digital systems

• Leaving behind inefficient FM car- riers for thin international links to more efficient SPADE and SPC operations

• Abandoning satellite designs with non-stabilized platforms with no “antenna pointing capability” to “spinners” and now on to 3-axis body stabilized satellites with much greater pointing accuracy and the ability to support more efficient solar arrays

• Transitioning from exclusive reliance on wide-coverage but low- power global beams to higher- power and more efficient spot beam, and to cross polarization for frequency reuse

• Shifting away from quite inefficient power-limited satellites to today’s frequency limited satellites

• Moving from no frequency reuse capabilities to highly efficient mul- tiple frequency reuse capabilities through cross-polarization and spot beam separation techniques

All in all, the first years of satellite communications were an exciting time of enormous technological innovation,

Despite TRW’s recovery, they did not receive another spacecraft contract from Intelsat in the decades that fol- lowed. The next generation of satellites, the Intelsat IV and IVA, went back to the “proven supplier” Hughes Aircraft. As we moved from the Intelsat III series of satellites to the IV series, the whole vision of what Intelsat was and hoped to be changed in significant ways. Early Bird (Intelsat I) was one small experi- mental satellite of some 240 voice cir- cuits and could provide limited television capacity only when all voice service was surrendered. With the Intel- sat IV series in the 1970s, we deployed eight satellites, each with 4000 two-way voice circuits and two television chan- nels, and the IVA that followed had 6000 voice circuits. Then the Intelsat Vs, with three-axis body stabilization and large solar array wings, had a capacity of 12,000 voice circuits plus television channels. These huge increas- es in capacity restructured our thinking about service options, and we began offering domestic transponder leases, first with Algeria and then with scores of other countries.

International telephone, data, and television capacity in the 1970s was now expanding exponentially, and costs were dropping rapidly. We were mov- ing from analog to digital services that were much more cost efficient. We were approving ever smaller and more cost-efficient Earth stations whose costs were dropping even faster than the per circuit cost of a satellite chan- nel. We had set the stage for the worldwide deployment of over 100,000 very small aperture terminals (VSATs) around the globe on international, regional, and domestic systems that we see today.

Two other fundamental shifts in the satellite industry also occurred in the 1970s. National satellite systems began to be deployed. The U.S.S.R.-based Molniya satellite system deployed in the 1960s along with Intelsat was used to combine the various Soviet Socialist Republics and other Communist coun- tries such as Cuba, and thus was a sort of Cold War alternative to Intelsat. The Canadian satellite system, known as Anik (Inuit for “brother”), was thus the first truly domestic satellite system, but other systems followed in the United States, Japan, various European coun- tries, Australia, and even developing countries like Indonesia. Intelsat, start- ing with Algeria, began leasing spare capacity on a transponder-by-transpon- der basis to meet the needs of countries lacking the level of traffic needed to

support the deployment of complete satellite networks. Today, scores of countries still lease capacity from Intel- sat and other satellite systems to meet domestic needs.

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Perhaps even more significantly as we moved into the 1980s, satellite sys- tems were designed to meet mobile satellite communications needs. The so-called “Marisat” system was designed, built, and deployed to meet the communications needs of the U.S. Navy. The Comsat General Corpora- tion, which operated this satellite, also used additional capacity to meet com- mercial maritime communications needs. Also, Intelsat decided to include maritime satellite packages on three of the Intelsat V series of satellites to meet maritime communications needs.

Furthermore, the European Space Agency designed some of its Experi- mental Communications Satellites (ECS) to provide maritime mobile satellite services as well. These satel- lites were known as the Maritime ECS series or MARECS satellites. When the Inmarsat Organization was formed in 1979 (initially called the Interna- tional Maritime Satellite Organization) it combined the Marisat system, the Intelsat V maritime communications Subsystem (IS V MCS) and the MARECS satellites to operate the first truly global commercial maritime satel- lite network.

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One of the challenges Intelsat sought to meet as they deployed larger and more powerful satellites was to find a new set of technologies that would allow more cost-effective communica- tions for the thin-route traffic associat- ed with developing and island countries. These new thin-route services were called SPADE (for single channel per carrier [SPC] demand assigned ser- vices). SPADE was followed by the sim- pler SPC services. These new digital services, introduced on the Intelsat sys- tem in the 1970s, were followed in the 1980s by the world’s first satellite-based time-division multiple access (TDMA) service [17].

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Clearly, today we have moved quite far in the world of commercial satellite operations. There are today around 20,000 satellite television channels in operation worldwide-many of these sup- port HDTV service. Millions of satellite voice and data circuits are in service around the globe in over 200 countries and territories. The Inmarsat I-4, Thu- raya, New Iridium and Globalstar mobile satellite networks today provide mobile services around the globe. These satellite services connect to user termi-
nals that have shrunk down in size from the multi-ton, huge 30-meter earth sta- tions of the 1960s staffed 24 hours a day by dozens of employees to actual hand-held battery-powered units oper- ated by individuals.

In short, the era of satellite commu- nications, now going on fifty years in length, has in many ways only just begun. Perhaps one day we will see broadband commercial satellite systems operating to support telecommunica- tions services for the Moon and Mars. But the excitement of the early years will be hard to beat.

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BIOGRAPHY

Biography

JOSEPH N. PELTON (joepelton@verizon.net) was manager of ICSC Affairs at Comsat and Secre- tary of the ICSC Technical Committee. He was special assistant to the director general and director of strategic policy at Intelsat. He was the founder of the Arthur C. Clarke Foundation in 1983 and also the Founding President of the Society of Satellite Professionals International. He is the former dean of the International Space University and director emeritus of the Space & Advanced Communications Research Institute at George Washington University. He is currently President of the Comsat Retirement Association (COMARA), and is the author of 31 books about space, satellites, and technology impact on soci- ety. His latest book, coedited with Dr. Angie Bukley, on behalf of the International Space Uni- versity is entitled *The Farthest Shore: A 21st Century Guide to Space* (Apogee Books).

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